PUBLIC VERSION

FINAL REPORT

Smart Grid Regulatory Framework for Mexico
for
Comisión Reguladora de Energía

September 2014

Prepared by

ESTA International, LLC
2214 Rock Hill Road, Suite 180
Herndon, Virginia, 20170-4234
USA

www.ESTAInternational.com

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ESTA team members for this project include:

Mr. Nader Farah
Dr. Parviz Adib
Mr. Ron Binz
Dr. Eddie Dehdashti
Ms. Sandra Guill
Mr. Francisco Holguin
Mr. David Shpigler

All inquiries should be addressed to

Mr. Nader Farah
ESTA International, LLC
nader.farah@ESTAinternational.com

TABLE OF CONTENTS

FIGURES AND TABLES

TABLES

EXECUTIVE SUMMARY

We begin with our conclusion: ***Implementing the Smart Grid will bring substantial economic, social and environmental benefits to Mexico. It will enable the integration of larger amounts of renewable energy, improve electric system operations and enable consumer choices. Successful implementation depends upon the careful coordination of efforts among many public agencies and private sector players. The recently enacted Energy Reform and the Electric Industry Act has strengthened Mexico's ability to implement the Smart Grid by giving clear authority to the Comisión Reguladora de Energía (CRE).***

In Mexico, Smart Grid development will be closely linked to the growth of renewable energy resources. There are two reasons for this close link. First, the Smart Grid will enable the integration of much larger amounts of variable generation resources like wind and solar generation. Second, new responsibility for the Smart Grid and for approval of renewable projects is posited in the same agency – CRE. For these reasons, the reader will find references to CRE's role in developing mechanisms for expanding renewable energy resources woven into the discussion of the agency's responsibilities for the Smart Grid.

This project commenced before the new Energy Reform was passed into law. Throughout the project, the team identified the key regulatory strategies that could facilitate the implementation of Smart Grid in Mexico. We understood the limitations on CRE's power when the project commenced and nevertheless identified areas that CRE could provide the regulatory leadership if it had certain authorities and powers.

The Energy Reform and corresponding Electric Industry Act have granted many of the authorities and powers to CRE found by the team to essential in promoting Smart Grid in Mexico. As such, the recommendations are valid despite the changed authorities of CRE.

Financial support for this report was made possible by a grant from the United State Trade Development Agency (USTDA) and cost-sharing by ESTA International. However, the content and production of this report would not have been possible without the kind assistance of the Commissioners and Staff of the Comisión Reguladora de Energía (CRE) and the generous cooperation of the management of SENER, and Comisión Federal de Electricidad (CFE).

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The objective of this project was to develop a regulatory framework for a path to regulate the electric sector in the presence of Smart Grid. In establishing the Framework the ESTA/CRE team performed the following key activities:

- Initial assessment of the Mexican power sector and the potential for implementation of Smart Grid in view of international Smart Grid Experiences
- Developed a Smart Grid Regulatory Roadmap
- Assessed opportunities recommended activities to attract private Investment
- Conducted a preliminary environmental and development impacts study
- Perform economic analysis and developed preliminary implementation plan
- Identify sources of implementation financing

Initial Review and Assessment

As part of the initial feasibility study, ESTA conducted a "SWOT" analysis (Strengths, Weaknesses, Opportunities, and Threats) of the Mexican power sector to determine the applicability of Smart Grid to Mexico and what may be expected as larger amounts of renewable energy are added. In this analysis, ESTA reviewed Power System

Characteristics, Renewable Regulatory Process, Interconnection Process Experience, Transmission Planning, Pricing Transmission Services, Optimization of Planning and Operation Systems, Transmission Planning Core Process, Real Time Operations, New Technology, Staffing/Organizational, and Training.

Based on the SWOT analysis, site visits, meetings and discussions with CFE, CRE, SENER, CENACE, as well the review of numerous documents, and lessons learned from international experiences, ESTA International was able to make a set of initial recommended actions for improving aspects of the Mexican power sector. These recommendations are presented with three levels of priority. Highest among these recommended actions are those that deal with the integration of high levels of renewable generation, based on ESTA's experience in several U.S. states and other countries.

Regulatory Roadmap

Our review of the Mexican electricity sector (prior the Energy Reform) demonstrated the distribution of authorities among multiple players in government. While such division of authority may be a strength -- encouraging various parties to build consensus -- it may also result in possible inefficiencies and ineffectiveness, especially when players are tasked with potentially conflicting objectives.

We have identified major areas where regulatory rules are absent or require further clarification to enhance a Smart Grid initiative. Much will change as the Electricity Industry Act is implemented. Agencies like CRE, SENER, CENACE and CFE will have modified roles that will continue to evolve as Mexico discovers exactly how to implement the Reform. The recommendations of this portion of the Report should be read to require certain outcomes, regardless of how the authorities are affected by the Energy Reform.

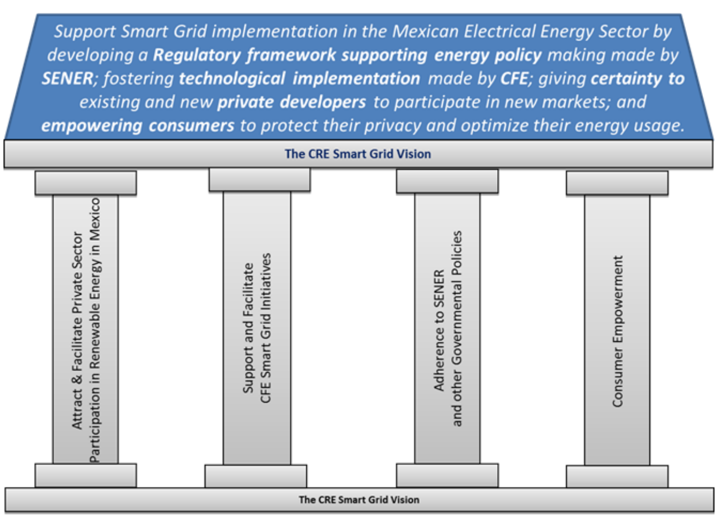
Entities involved with Mexican Electricity Sector

SENER *(Ministry of Energy)*
SHCP *(Ministry of Treasury)*
SE *(Ministry of Economy)*
SFP *(Ministry of Controller)*
CFE *(Modernization, Distribution, Customer Services, Operations),*
CENACE *(Planning, Transmission, Generation)*
CRE
CONUEE *(Energy Efficiency Commission)*
PROFECO *(Consumer Protection Agency)*
NOM *(Standards Organization)*
Others

The Vision

In close cooperation with CRE and using the ESTA International Road-mapping methodology, the CRE Smart Grid vision was defined as:

"Support Smart Grid implementation in the Mexican Electrical Energy Sector by developing a Regulatory framework supporting energy policy making made by SENER; fostering technological implementation made by CFE; giving certainty to existing and new private developers to participate in new markets; and empowering consumers to protect their privacy and optimize their energy usage."



The pillars of CRE Smart Grid vision are: Consumer Empowerment; adherence to SENER and governmental policies; attracting Private Sector participation; and support and facilitate CFE Smart Grid programs aligned to energy policy

The timeframe for Smart Grid spans three phases. The phases are aligned with the goals set forth by SENER and the phases identified by CFE in its Smart Grid Plan. During each phase, policies and regulations should be introduced to achieve the carbon reduction goals set forth for 2050 by Mexico.

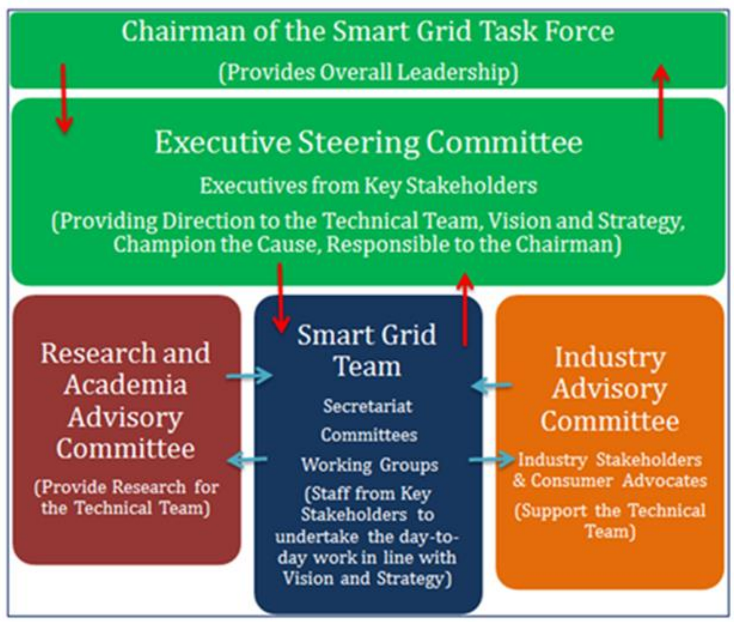
Phase 1 – 2013-2016 will set the foundation for the most urgent actions. This project is a part of the foundation.
Phase 2 – 2017-2020 will develop the basis to achieve the ultimate goals of Renewable Energy in Mexico.
Phase 3 – 2021-2026 will facilitate the achievement of the National Policy goals.

Priority Recommendations

In creating the Regulatory Roadmap, ESTA International provided 42 recommendations, addressing seven focus areas: 1) CRE and CFE; 2) Third party providers; 3) Renewable Resources; 4) End-Users; 5) Smart Grid costs and benefits; 6) Customer privacy; and 7) Legislative recommendations. We present our top five recommendations:

Priority Recommendation 1: CRE should support the creation and execution of a multi-party planning process for Smart Grid planning and implementation.

Successful deployment of Smart Grid technologies and services will require the coordinated efforts of many parties, both inside and outside of government. For this reason, our top recommendation is that Mexico establishes a government and industry-wide voluntary group to advise the government on the implementation of Smart Grid – The Smart Grid Task Force. The governance structure of a Smart Grid Task Force should follow and mimic the existing overall governance arrangements for the energy industry and the power sector.



Based in part on this recommendation in the draft version of this Report, a formal smart grid working group was established in Mexico in April 2014. This group was created to coordinate all efforts on Smart Grid in Mexico and to ensure that an integrated planning process (encompassing policy, regulation and technology deployment) is considered to develop the Smart Grid. The charter members of the Task Force are SENER, CFE and CRE. We hope and expect that the Task Force will be expanded to include participation by industry vendors and research and academic resources.

Priority Recommendation 2: CRE should require CFE to make "no regrets" Smart Grid investments that emphasize detection of outages, poor power quality, distribution transformer conditions before failure, etc. The Smart Grid investments that attract less media attention are those we have termed "wholesale" investments, made on the utility's side of the meter. These investments include installation of sensing devices to improve telemetry, giving the utility "visibility" into all operational aspects of the grid. Such investments can be made alone or in concert with Advanced Metering Infrastructure (AMI) devices. The principal benefits include: Outage Detection, Voltage Management, Restoration, Power Quality Monitoring, Transformer Preventative Maintenance, Precision and time-stamped meter reading, Precision and time-stamped consumption information, and Real-time operational and locational information.

Because these investments can be made in a way that will be consistent with a variety of future courses that the retail Smart Grid might take, we call them "no regrets" investments. Importantly, the Smart Grid Task Force will be well-suited to assist CFE and CRE to identify and prioritize such investments.

We recommend that CRE require CFE to develop a schedule and begin deploying all cost effective wholesale smart grid investments in a way that leads to "no regrets" as the Smart Grid develops.

Priority Recommendation 3: In concert with other Mexican consumer rights agencies, CRE should develop a Consumer Bill of Smart Grid Rights detailing privacy, access to information, and consumer control over the use of consumer energy data.

Privacy concerns loom large in many countries that are developing the Smart Grid. It is very important to address this issue at the beginning of Smart Grid development, before the "genie is out of the bottle." A very good place to start is developing a Consumer Bill of Smart Grid Rights.

CRE has the power, working with SENER and CFE to issue the needed directives, and could be supported by IFAI and the Ministry of Economy. This action should be coupled with a code of conduct for Smart Grid vendors that details how permission, protection and use of customer data will be implemented by players in the Smart Grid.

Priority Recommendation 4: Define Competitive Renewable Energy Zones by technology (i.e. wind and solar) and make this information publicly available.

Development of a strong, competitive renewable energy industry in Mexico requires, among other things, the coordination of transmission build out and renewable development. Third party developers must know where transmission infrastructure will be built and on what schedule. Transmission owners must know where the wind and solar resources are and tailor their transmission planning to meet the need.

Competitive Renewable Energy Zones (CREZs) are a tool to proactively facilitate the development of renewable resources. In cooperation with CFE, such information should be developed and be available to resource developers, reflecting the priorities set by CRE for the type of technology and appropriate locations to expand such resources in the most economical way. Correctly implemented, CREZ will be a successful case of "build in and they will come."

Priority Recommendation 5: Budgetary steps should be taken to ensure that CRE has adequate financial resources to obtain the expertise and skills required to address the complexity of Smart Grid initiatives.

CRE will have responsibility for regulatory aspects of electric power sector in Mexico that generates approximately $15 billion of revenue annually. The implementation of smart initiatives has the potential resulting in an investment of $1.0 billion to $4.0 billion in the next thirteen years. The regulatory oversight of such a major undertaking and fast technological advances in Smart Grid requires adequate financial resource as well as experienced and skilled personnel to effectively perform their responsibilities. Simply put, a few million dollars spent prudently at a regulatory agency with a mission to review and guide Smart Grid investments could avoid costly mistakes in deploying Smart Grid.

Simply put, a few million dollars spent prudently at a regulatory agency like CRE with a mission to review and guide Smart Grid investments could avoid costly mistakes in deploying Smart Grid.

Opportunities for Private Investment and Implementation Financing

ESTA provided 36 recommendations concerning incentives for Renewable Energy, Distributed Generation, and Non-Utility companies. They include Regulatory Strategies 1) Regarding Market Segments; 2) To Encourage the Development and Integration of Small-scale Distributed Renewable Generation Projects; 3) To Encourage the Development and Integration and End-user Scale Projects; 4) To Encourage the Development and Integration of Non-Utility Small Scale Projects; 5) To Encourage the Development and Integration of Utility Scale Projects; 6) To Encourage the Development of Energy Management and Demand Response Activities by Third Parties; and 7) To Encourage the Development of Energy Management and Demand Response Activities for Consumers.

ESTA also assessed the potential role of financial institutions in providing debt and equity financing or loan guarantees for smart grid projects in Mexico. These financial institutions include the Inter-American Development Bank, the World Bank (including the International Bank for Reconstruction and Development for public sector projects and the International Finance Corporation for private sector projects), and the Export-Import Bank of the United States.

Preliminary Environmental and Development Assessment

ESTA conducted preliminary environmental and development assessment of Smart Grid deployment and increased use of renewable energy in the Mexican power portfolio as required by the USTDA grant that funded the effort.

The value to society of these resources, manifested in their capacity for stimulating economic development and their impact on the emissions of greenhouse gas and other pollutants, far overshadows any environmental risks and costs measured at the local level.

The analysis was carried out on two levels: 1) the micro-level of a single renewable energy project; and 2) at the macro-level of Mexican society. At the micro level, we consider the environmental concerns that may arise in the development of wind, solar and projects and outline preventative or reparative measures that can be taken to offset environmental concerns. At the macro societal level, we consider the link between Smart Grid and deeper penetration of renewable energy and assess how the growth in renewable energy will help Mexico meet its environmental goals.

Economic Analysis and Implementation Plan

One aspect of this study is to assess the financial impact in Mexico of implementing the Smart Grid and significantly increasing the amount of renewable energy used in the country. Bottom line, evaluation of the Smart Grid and renewable energy programs in Mexico suggests that significant value can be created.

In developing a dedicated renewable energy program, we see large potential benefits stemming from reductions in fuel cost expenditures. Beyond that, we see significant benefits coming from deferral of distribution network requirements and reductions in requirements for synchronized reserves and frequency regulation.

The total value for the smart grid program and the renewable energy initiative together exceeds MXN $50 thousand million pesos relative to a "do nothing" strategy. Based on the high value proposition of these programs, we recommend further operational efforts to commence.

For the Smart Grid initiative, the largest benefits stem from the opportunities associated with automation of distribution operations. The single largest source of value stems from automating the meter reading process, moving from a manual read to an automated process with a digital architecture. We did not quantify the customer benefits of Smart Grid. From other countries, we know those benefits will also be large.

We close by reiterating that ***implementing the Smart Grid will bring substantial economic, social and environmental benefits to Mexico. The recently enacted Energy Reform and the Electric Industry Act has strengthened Mexico's ability to implement the Smart Grid by giving clear authority to the CRE.***

1 INTRODUCTION

Comisión Reguladora de Energía (CRE) launched a project to develop Smart Grid Regulatory Framework for Mexico. CRE engaged ESTA International (ESTA), an Energy Intelligence, Strategy, and Technology Advisory firm, to support CRE with this Project. Funding support has been provided through the US Trade and Development Agency (USTDA) and cost sharing by ESTA International.

This project encompasses seven tasks as shown in Figure 1-1:

Figure 1-1: Project Tasks

1.1 ORGANIZATION OF THIS REPORT

This report is organized into the following Chapters:

Chapter 1 Provides a brief introduction to the project.
Chapter 2 Describes the landscape of the Mexican power sector prior to the Energy Reform.
Chapter 3 Documents the work performed for Task 1: Initial Review and Assessment. It includes:

- Overview of the Smart Grid initiatives around the globe. It highlights the variations in definitions of Smart Grid and reviews the key drivers, barriers, and challenges associated with deployment of Smart Grid as well as the benefits and lessons learned. In addition to utility perspectives, this Report also provides an overview of consumer and end use issues.
- Review the Mexican power sector with special focus on Smart Grid activities and assesses the suitability and readiness of the transmission and distribution networks to support potential Smart Grid deployments.
- Strength, Weaknesses, Opportunities, and Threats (SWOT) analysis of the Mexican Transmission Grid to support extensive Renewable Energy integration.
- Recommended plan of action for Task 1.

Chapter 4 Documents the work performed for Task 2: Regulatory Roadmap. This chapter includes:

- Regulatory vision and the pillars for Smart Grid development in Mexico. They form the foundation for Smart Grid regulatory implementation in Mexico while addressing potential industry and structural challenges.
- Review of the Mexican power sector with special focus on regulatory features related to Smart Grid activities in order to develop the baseline recommendations for Smart Grid regulatory developments. This includes:
  - Recommendations for potential regulatory incentive mechanisms and business models that would support the operation of Independent Power Generators to supply renewable energy to the Smart Grid and encourage individual consumers to participate interactively in the Smart Grid (Subtask 2.1)
  - Potential regulatory strategies that would enable sharing of the costs and benefits of Smart Grid implementation among stakeholders in Mexico (Subtask 2.2).
  - Identification of regulatory barriers; recommendations are provided for possible enhancements to the existing legal framework to facilitate the success of the proposed Regulatory Roadmap (Subtask 2.3).
- Recommendations on legislative authority.
- Highlights of the recommended institutional refinements**.**
- Interoperability, cybersecurity, and physical security issues related to Smart Grid implementation (subtask 2.4).
- Performance metrics that would enable CRE to measure the effectiveness of implementing the proposed Smart Grid Roadmap in Mexico.
- A structure for a Smart Grid Task Force to facilitate interactions among all stakeholders in the Mexican Smart Grid landscape.
- Summary of the observations

Chapter 5 Documents the work performed for Task 3: Assess Opportunities for Private Investment. This chapter includes the following:

- Identification of Potential Auction Mechanisms

- Identification of Technology Deployment Opportunities and U.S. Sources of Supply
- Incentives for Renewable Energy, Distributed Generation, and Demand Response activities by Non-Utility Companies
- Tabulated Presentation of All Recommendations for incentives

Chapter 6 Documents the work performed for Task 4: Preliminary Environmental and Development Assessment. This chapter provides:

- Brief discussion on Smart Grid and Renewable Energy from an environmental perspective.
- Preliminary Environmental Assessment. It includes a review of Mexico's Environmental Landscape, related environmental laws, as well as the impacts and mitigation strategies for solar and wind energy.
- Environmental impacts of Plug-in Electrical Vehicles, Radio Frequency are also addressed.
- Carbon Emission Credits as well as overall societal benefits are also addressed.
- Preliminary Development impacts are discussed in this section. Issues such as infrastructure, market oriented reform, human capacity building, and technology transfer are discussed.
- Provides some recommendations based on the preliminary environment and development assessments.

Chapter 7 Documents the work performed for Task 5: Economic Analysis and implementation plan. This chapter provides:

- Economic Evaluation of Renewable Energy Program
- Economic Evaluation of Smart Grid Program
- Observations and Recommendations

Chapter 8 Documents the work performed for Task 6: Implementation Financing This chapter provides:

- Overview of leading multi-lateral financing institutions (World Bank, International Finance Corporation, Inter-American Development Bank, US OPIC, and US Ex-Im Bank) and sample of projects supported by these organizations based on interviews and market research.
- Key contacts at these institutions active in Mexico
- Observations

Chapter 9 Documents the Acronyms and definitions uses in this report:

Appendix A Provides a list of Smart Grid drivers and technology options:

Appendix B Contains the Use Case for Renewable Energy Auctions for Small Production projects (associated with Task 3)

Appendix C Data gathered from CFE for Economic Analysis (associated with Task 5)

2 OVERVIEW OF THE MEXICAN POWER SECTOR

2.1 *ENERGY REFORM IN MEXICO (2013 - 2014)*

In December 2013, the Congress in Mexico passed a broad Energy Reform legislation which included amendments to Articles 25, 27 and 28 of the Mexican Constitution. The Energy Reform Act will have broad implications on the energy sector and the various energy stakeholders in Mexico. With this ratification, Mexico overturned the 1938 nationalization of its oil industry and opened its energy sector to outside investment. The Reforms are expected to rejuvenate Mexico's energy sector, stimulate economic growth and job creation, and, in time, attract substantial new resources to the energy market.

According to the law, secondary legislation and norms associated with the Energy Reform were completed within the first 120 days of 2014. In August 2014, the Mexican Congress approved 21 transitional articles (secondary legislation) proposed by the federal government through the Ministry of Energy (SENER) with assistance from other government agencies. This legislation is intended to clarify stakeholders' roles in shaping policy and stimulate investment in Renewable Energy to promotes the country's sustainable development and honor its commitment to mitigating global warming. As a result of this landmark Reform, CRE's regulatory role will be considerably expanded and strengthened to effectively oversee a newly competitive energy market.

With this new legislation in place, Mexico foresees some important changes:

> *"The public sector will be responsible, exclusively, of the strategic areas identified in Article 28, paragraph four of the Constitution, the Federal Government should maintain the ownership and control over productive agencies and state enterprises which in their case are going to be established. In regards of the planning and control of the national electricity power system, and of the public service of transmission and distribution of electricity, as well as the exploration and extraction of oil and other hydrocarbons, the Nation shall conduct these activities in terms of the provisions of the sixth and seventh paragraphs of Article 27 of this Constitution.*
>
> *In these activities the law will establishes the rules for the administration, organization, operation, procurement procedures and other legal acts that celebrate productive state enterprises, as well as the pay of their staff, to ensure effectiveness, efficiency, honesty, productivity, transparency and accountability, based on best practices, and identify other activities that may be performed."*

These rules for the administration, organization, operation, etc., which this change establishes as new mandates, redefine some of the powers and responsibilities of SENER, CRE, CFE and all stakeholders at the electric sector.

Also the separation of CENACE (Centro Nacional de Control de Energía) from CFE, to become an independent National Control Center, owned and controlled by the Government is another important change. Other relevant modifications include establishing an open wholesale market for electricity which is in progress and to increase the use of clean energy sources. This modification will be defined in the secondary legislation that is being discussed in the Mexican Congress and put in place in the next few months.

It is expected that the secondary legislation associated with the 2013 Energy Reform in Mexico will have significant impact on the operation of CRE assigning more powers and responsibilities to CRE that will directly impact the development of the Smart Grid in Mexico.

The new Electric Industry Act empowers the CRE to:

- Issue rules, guidelines and other administrative provisions on Smart Grid and Distributed Generation, based on the policy established by the SENER;
- Issue and oversee Electricity Market Rules;
- Establish mechanisms for authorization, inspection, adjustment and updating the Market Operative rules and procedures;
- Monitor the operation of the wholesale electricity market and the CENACE determinations in order to ensure the efficient functioning of the wholesale electricity market and the compliance of the market rules;
- Instruct the corrections to be made to the parameters of registered Power Plants and the guaranteed controllable demand as well as offers based on them;
- Issue contract models for interconnection of Power Plant, for connection of load centers, for the buying and selling of energy of exempt Generators, for the buying and selling of energy
- Establish the requirements to be met by suppliers and qualified users, of users with basic supply offering controllable demand and other contracts as required; participants of the market, to acquire power which enable them to supply their representing load centers as well as the requirements of electricity coverage contracts that suppliers should hold, and verify its compliance;
- Authorize the CENACE to conduct auctions to acquire power when deemed necessary to ensure the reliability of the National power system, to determine the allocation of costs resulting these auctions, and to issue protocols to manage the CENACE procurement of emergency power;
- Issue its opinion, regarding the expansion and modernization programs of the National transmission grid and the general distribution networks that are submitted by CENACE or Distributors.

2.2 Landscape of The Mexican Power Sector Prior to Energy Reform Act

In order to develop various elements of the "Regulatory Roadmap," it is helpful to review important aspects of the Mexican electric sector, its capability to meet required supply of power, and the level of customers' demand on its system.

2.2.1 Electricity and Mexican Economy

The Mexican economy grew at 2.6% per year between 1990 and 2010. It is expected to grow even faster, at 3.6% annually, through 2026. The growth in Gross Domestic Products under three different scenarios - low, medium, and high growth is provided in Figure 2-1.

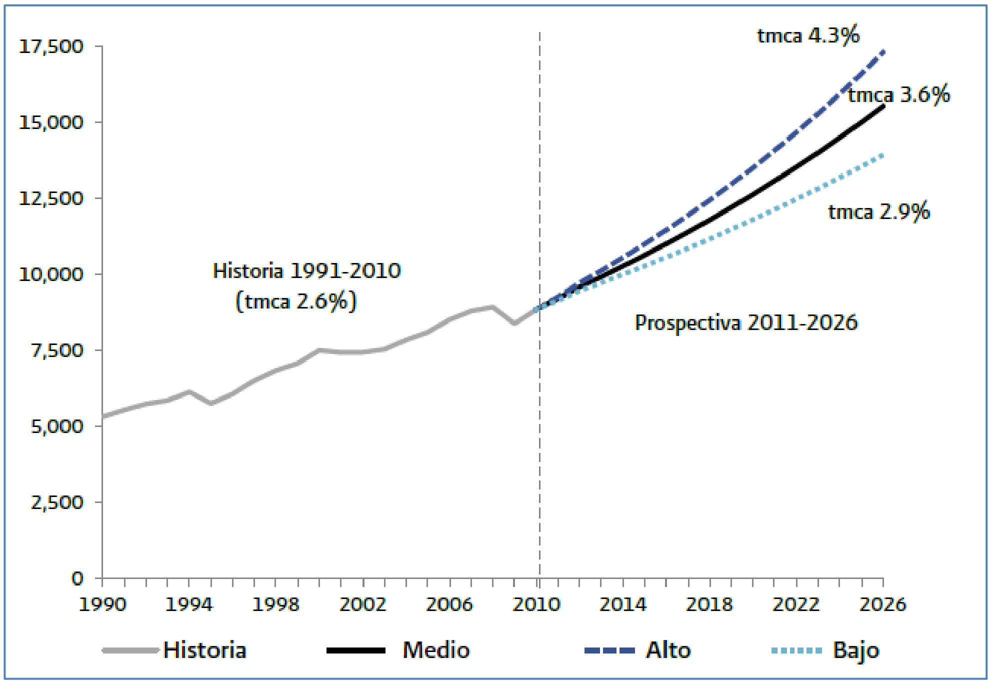


Figure 2-1: Mexico Gross Domestic Products in Billion Pesos 1990 - 2026

The Mexican electricity sector has nine (9) control areas (regions); each experiencing different growth levels. Baja California Sur and Peninsular represent the fastest growing regions in Mexico. These two regions are expected to continue to be the fastest growing regions in the next ten years as shown in Figure 2-2.

Figure 2-2: Energy Consumption Growth by Control Areas (%)

The total gross electricity consumption was 266.8 TWh in 2011; it is expected to grow to 480.4 TWh in 2026 reflecting an annual growth rate of 4.0%. Table 2-1 shows the projected gross electricity consumption in various control areas in Mexico between 2011 and 2026[1].

[1] The gross electricity consumption reported above is significantly higher than total sales of electricity to various end-users, shown in Table 2-1, because it also includes the energy consumption of all the CFE equipment and generation plants in each area, consumption by federal agencies and those consumptions for which no payment was made. Some of the consumption for which no payment was made was within the service territory of state power company Luz y Fuerza del Centro (LyFC) – LyFC has been dissolved and its operations taken over by CFE.

Table 2-1: Estimated Gross Energy Consumption by Control Areas

Estimación del consumo bruto por área de control, 2011-2026 (TWh)

Área	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	tmca % (2011-2026)
Central	56.2	59.4	61.5	63.4	65.0	66.8	68.5	71.6	74.4	77.2	80.1	83.1	86.3	89.6	92.9	97.0	3.7
Incremento %	3.6	5.7	3.5	3.1	2.6	2.7	2.5	4.6	3.9	3.8	3.7	3.8	3.9	3.8	3.6	4.4	
Oriental	42.4	44.0	45.5	46.7	47.5	48.5	49.5	51.6	53.6	55.7	58.0	60.4	63.4	66.5	69.2	72.4	3.6
Incremento %	4.7	3.8	3.6	2.6	1.7	2.1	1.9	4.3	3.9	4.0	4.0	4.1	5.1	4.8	4.0	4.6	
Occidental	58.1	60.2	62.5	64.2	65.8	67.4	69.0	72.0	74.8	77.8	81.1	84.3	88.2	92.2	95.7	99.8	3.7
Incremento %	4.6	3.5	3.8	2.7	2.5	2.5	2.3	4.3	3.8	4.1	4.2	4.0	4.7	4.5	3.7	4.3	
Noroeste	18.8	19.9	21.3	22.2	23.0	23.9	24.7	25.8	26.8	27.7	28.9	30.2	31.5	33.4	35.2	36.7	4.6
Incremento %	8.2	6.2	6.9	4.2	3.7	3.6	3.4	4.4	4.2	3.4	4.3	4.3	4.2	6.3	5.1	4.4	
Norte	21.4	22.2	22.9	23.5	23.9	24.6	25.2	26.3	27.3	28.3	29.4	30.5	31.6	32.9	34.1	35.7	3.5
Incremento %	5.1	3.5	3.0	2.6	2.1	2.7	2.6	4.2	3.8	3.8	3.7	3.7	3.8	4.0	3.8	4.5	
Noreste	45.5	47.2	49.2	51.4	53.4	55.6	57.7	60.4	63.0	65.9	69.2	72.7	76.4	79.9	83.4	87.2	4.4
Incremento %	4.8	3.8	4.1	4.4	4.0	4.1	3.8	4.6	4.4	4.5	5.0	5.0	5.2	4.6	4.4	4.6	
Baja California	12.4	12.9	13.4	13.9	14.4	15.0	15.5	16.2	16.9	17.7	18.3	19.1	19.9	20.8	21.8	22.7	4.1
Incremento %	5.2	3.6	3.7	4.1	3.8	4.0	3.3	4.6	4.3	4.5	3.9	4.0	4.5	4.5	4.4	4.6	
Baja California Sur	2.1	2.2	2.4	2.5	2.7	2.8	3.0	3.2	3.5	3.7	4.0	4.4	4.7	5.1	5.5	6.0	7.2
Incremento %	3.7	5.7	6.6	6.4	6.4	6.5	6.4	7.0	7.7	7.8	7.8	8.1	8.0	8.2	8.0	8.2	
Peninsular	9.7	10.2	10.9	11.5	12.0	12.6	13.3	14.1	15.0	15.8	16.8	17.8	18.9	20.1	21.3	22.6	5.8
Incremento %	3.4	5.2	6.5	5.5	4.9	5.1	4.9	6.5	6.1	5.8	6.2	6.1	6.1	6.1	6.0	6.3	
Subtotal	**266.6**	**278.2**	**289.4**	**299.2**	**307.9**	**317.3**	**326.3**	**341.1**	**355.3**	**370.0**	**385.9**	**402.4**	**421.1**	**440.6**	**459.0**	**480.1**	**4.0**
Incremento %	**4.7**	**4.4**	**4.0**	**3.4**	**2.9**	**3.1**	**2.9**	**4.5**	**4.1**	**4.2**	**4.3**	**4.3**	**4.6**	**4.6**	**4.2**	**4.6**	
Pequeños Sistemas [1]	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	5.2
Incremento %	0.6	3.8	4.6	3.9	2.4	3.0	3.1	5.7	5.4	5.7	6.1	6.4	6.7	6.9	7.0	6.8	
Total nacional	266.8	278.4	289.6	299.3	308.0	317.5	326.5	341.3	355.5	370.3	386.1	402.6	421.3	440.9	459.3	480.4	4.0
Incremento %	4.7	4.4	4.0	3.4	2.9	3.1	2.9	4.5	4.1	4.2	4.3	4.3	4.6	4.6	4.2	4.6	

2.2.2 OVERVIEW OF THE CHARACTERISTICS OF THE MEXICAN POWER GRID

To meet the fast growing demand for electricity, which is crucial for economic development and well-being of Mexican people, the Mexican law required that the generation of electricity for public service be carried out by the state owned utility, CFE, and by private investors through the specific schemes of self-supply, cogeneration, Independent Power Producer (IPP), small production, export and import.

For years the Mexican electricity sector has been operating with a mix of public and private entities serving electricity needs of the population. CFE, which use to hold a monopoly on electricity transmission and distribution systems in Mexico, and its various divisions, such as CENACE which still controls national transmission grid, Generation division, and Distribution division, have been responsible for the operation of electric power system in Mexico. The share of IPPs has increased significantly at the wholesale level since the passage of the Public Service Law in 1992. The growth in production by IPPs continued as the SENER National Energy Strategy called for a substantial amount of Renewable Energy to be provided by IPPs. CFE was the regulated utility serving about 37 million consumers covering the whole Mexican population in Mexico.

2.2.2.1 MEXICO'S ELECTRIC GENERATING RESOURCES

Mexico has experienced an annual growth of 2.94% in capacity between 2000 and 2013 reaching to a total generation capacity of 53,455 MW for public service. This capacity is composed of 73.18% thermal, 21.53% hydro, 2.67% renewable other than hydro (mainly geothermal and wind) and 2.62% nuclear. During the same period, 9,058.3 MW of generation capacity was installed by the permit holders resulting in a total capacity of 62.51

GW[2]. Mexico has a single nuclear power plant, with a capacity of 1,400 MW which is owned and operated by CFE. The general trend in Mexico reflects decrease in use of oil for thermal generation and increase in generating resources that utilize natural gas and coal. This is despite the fact that Mexico is a net importer of natural gas. The growth in total capacity by fuel type is depicted in Table 2-2[3]. Similarly, the growth in total electricity generation by fuel type is depicted in Table 2-3[4].

CFE along with IPPs have continuously increased their generation capacity to serve growing demand in Mexico. Table 2-4[5] shows electric power capacity owned by CFE by fuel type in 2013.

More recently, the IPPs in Mexico have developed power plants based on combined cycle natural gas based technology. As of the end of 2011, use of such technology by IPPs accounted for 11,458 MW of capacity.

The growth in Renewable Energies, owned by IPPs, has been at much slower pace; it accounted for about 450 MW in recent years. Table 2-5[6] shows total capacity at various plants owned by IPPs in 2013.

At the end of 2011, the gross generation in Mexico was 292 TWh and 59.7% of this energy was produced by CFE, 29.1% by IPPs and 11.2% by permit holders[7]. The composition of this generation was 79.2% from conventional thermal sources, 13.9% from hydroelectricity, 3.9% from nuclear power and 3% from geothermal sources.

On the operational side, it is expected that the reserve margin in the National Interconnected System (SIN) will reduce for the coming years. According to Programa de Obras e Inversiones Del Sector Electrico 2012-2016 (POISE[8]), reserve margin would reduce from 19.7% to 12.9% in the period from 2014 to 2026. It was expected that from 2014, the reserve margin in the SIN would decrease to values around 29.2%, with the operating reserve reaching at 8.3%. The goals for these values are 25% and 6% respectively[9]

The energy exports in 2011 were 11,330 MW and 5,017.445 GWh; the total capacity used for imports was158 MW importing a total amount of energy 59.314 GWh[10].

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[2] Source: Electric Sector Outlook 2012-2026.
[3] Source: http://egob2.energia.gob.mx/portal/electricidad.html
[4] ibid
[5] ibid
[6] ibid
[7] Permit holders: 4.9% self-supply 4.3% cogeneration, 1.7% export and import, 0.3% permits issued before 1992.
[8] POISE 2012-2026. Available at
http://www.cfe.gob.mx/ConoceCFE/1_AcercadeCFE/Lists/POISE%20documentos/Attachments/7/Poise2012_2026.zip?Mobile=1

[9] http://www.sener.gob.mx/webSener/res/PE_y_DT/pub/Prospectiva%20SE%202008-2017.pdf
[10] According to Electric Sector Outlook 2012-2026 in 2011the import was 170 MW and export 2,480 MW. The difference in values may be due that to the way project are accounted, under construction vs. in operation.

Table 2-1: Evolution in the Total Installed Capacity in the Public Service (includes IPP)

SECTOR ELÉCTRICO NACIONAL
CAPACIDAD EFECTIVA DE GENERACIÓN 1_/
(Megawatts)

Año	Hidroeléctrica	Termoeléctrica 2_/	Ciclo Combinado - CFE	Ciclo Combinado - PEE's 3_/	Duales 4_/	Carboeléctrica	Nucleoeléctrica	Geotermoeléctrica	Eoloeléctrica - CFE	Eoloeléctrica - PEE's 3_/	Fotovoltaica	Total
2000	9,619	16,758	2,914	484	2,100	2,600	1,365	855	2	0	0	36,697
2001	9,619	16,806	3,733	1,455	2,100	2,600	1,365	838	2	0	0	38,519
2002	9,615	17,316	3,848	3,495	2,100	2,600	1,365	843	2	0	0	41,184
2003	9,615	17,316	3,848	6,756	2,100	2,600	1,365	960	2	0	0	44,561
2004	10,530	16,954	4,776	7,265	2,100	2,600	1,365	960	2	0	0	46,552
2005	10,536	15,715	5,005	8,251	2,100	2,600	1,365	960	2	0	0	46,534
2006	10,566	15,586	5,203	10,387	2,100	2,600	1,365	960	2	0	0	48,769
2007	11,343	15,702	5,416	11,457	2,100	2,600	1,365	960	85	0	0	51,029
2008	11,343	15,734	5,456	11,457	2,100	2,600	1,365	965	85	0	0	51,105
2009	11,383	15,616	6,115	11,457	2,100	2,600	1,365	965	85	0	0	51,686
2010	11,503	15,627	6,115	11,907	2,778	2,600	1,365	965	85	0	0	52,945
2011	11,453	14,732	6,122	11,907	2,778	2,600	1,365	887	87	0	0	51,931
2012	11,498	14,608	6,122	11,907	2,778	2,600	1,610	812	87	511	1	52,534
2013	11,509	13,980	7,420	12,340	2,778	2,600	1,400	823	87	511	6	53,455

1_/ Al término de cada período, sin incluir capacidad de cogeneradores y autoabastecedores de energía eléctrica
2_/ Incluye Ciclo de Vapor, Turbogas y Combustión Interna
3_/ Comprende la capacidad instalada de los Productores Externos de Energía (PEE's) n.a. - no aplica
4_/ Las centrales duales pueden operar con carbón o combustóleo

Fuente: Secretaría de Energía con datos de Comisión Federal de Electricidad y Luz y Fuerza del Centro / Área Central

Nota 1: A partir de agosto de 2011, no incluye 580.3 MW de plantas inoperables en el Área Central.

Nota 2: En 2013 y 2014, la capacidad efectiva y de placa de la central Laguna Verde se ajustó a 1,400 MW, en tanto CFE obtiene el licenciamiento de la repotenciación de esa central.

Table 2-2: Evolution in the Total Electricity Generation in the Public Service (includes IPP)

SECTOR ELÉCTRICO NACIONAL
GENERACIÓN BRUTA 1_/
(Gigawatts - hora)

Año	Hidroeléctrica	Termoeléctrica 2_/	Ciclo Combinado - CFE	Ciclo Combinado - PEE's 3_/	Duales 4_/	Carboeléctrica	Nucleoeléctrica	Geotermoeléctrica	Eoloeléctrica - CFE	Eoloeléctrica - PEE's 3_/	Fotovoltaica	Total
2000	33,075	95,539	16,417	1,295	13,569	18,696	8,221	5,901	8	0	0	192,721
2001	28,435	96,317	20,789	4,589	14,109	18,567	8,726	5,567	7	0	0	197,106
2002	24,862	86,250	22,217	21,852	13,879	16,152	9,747	5,398	7	0	0	200,362
2003	19,753	81,432	22,437	31,645	13,859	16,681	10,502	6,282	5	0	0	202,596
2004	25,076	69,715	24,797	45,855	7,915	17,883	9,194	6,577	6	0	0	207,019
2005	27,611	67,215	26,011	45,559	14,275	18,380	10,805	7,299	5	0	0	217,160
2006	30,305	54,312	30,120	59,428	13,875	17,931	10,866	6,685	45	0	0	223,568
2007	27,042	53,287	30,067	70,982	13,375	18,101	10,421	7,404	248	0	0	230,927
2008	38,892	47,362	31,824	74,232	6,883	17,789	9,804	7,056	255	0	0	234,096
2009	26,445	48,322	35,533	76,496	12,299	16,886	10,501	6,740	249	0	0	233,472
2010	36,738	45,208	36,376	78,457	15,578	16,485	5,879	6,618	166	0	0	241,506
2011	35,796	53,126	34,449	84,006	15,396	18,158	10,089	6,507	106	252	0	257,884
2012	31,317 R	61,334 R	37,382 R	80,175 R	16,234 R	17,724 R	8,770 R	5,817 R	188 R	1,556 R	2 R	260,498 R
2013	27,444	52,688 R	42,930	83,468 R	15,584 R	16,044	11,800	6,070	190	1,624	13	257,855

1_/ No incluye cogeneración ni autoabastecimiento de energía eléctrica
2_/ Incluye Ciclo de Vapor, Turbogas y Combustión Interna
3_/ Comprende la energía neta entregada a la red por los Productores Externos de Energía (PEE's)
4_/ Las centrales duales pueden operar con carbón o combustóleo

Fuente: Secretaría de Energía con datos de Comisión Federal de Electricidad y Luz y Fuerza del Centro / Área Central

Table 2-3: Electric Power Capacity by fuel type - CFE

DATOS TÉCNICOS DE LAS PRINCIPALES CENTRALES DE CFE EN OPERACIÓN EN 2013

Central	Tecnología	Estado	No. de Unidades	Capacidad MW	Generación GWh	Factor de Planta (%) *
Petacalco (Plutarco Elías Calles)	Dual	Guerrero	7	2,778	15,584	64.0
Chicoacén (Manuel Moreno Torres)	Hidroeléctrica	Chiapas	8	2,400	5,195	24.7
Tuxpan (Adolfo López Mateos)	Termoéléctrica	Veracruz	6	2,100	7,605	41.3
Tula (Francisco Pérez Ríos) **	Termoéléctrica	Hidalgo	11	2,095	11,851	64.6
Manzanillo I (Manuel Álvarez Moreno)	Termoéléctrica	Colima	10	2,054	7,828	43.5
Laguna Verde	Nucleoeléctrica	Veracruz	2	1,400	11,800	96.2
Carbón II	Carboeléctrica	Coahuila	4	1,400	7,939	64.7
Río Escondido (José López Portillo)	Carboeléctrica	Coahuila	4	1,200	8,106	77.1
Infiernillo	Hidroeléctrica	Guerrero	6	1,160	3,480	34.2
Presidente Juárez (Rosarito)	Termoéléctrica	Baja California	10	1,093	5,310	55.5
Malpaso	Hidroeléctrica	Chiapas	6	1,080	2,884	30.5
Valle de México	Termoéléctrica	México	7	999	5,247	59.9
Aguamilpa (Solidaridad)	Hidroeléctrica	Nayarit	3	960	575	6.8
Angostura (Belisario Domínguez)	Hidroeléctrica	Chiapas	5	900	1,979	25.1
Altamira	Termoéléctrica	Tamaulipas	4	800	1,903	27.2
El Cajón	Hidroeléctrica	Nayarit	2	750	326	5.0
Manzanillo Dos	Termoéléctrica	Colima	2	700	3,110	50.7
Villa de Reyes	Termoéléctrica	San Luis Potosí	2	700	2,538	41.4
Puerto Libertad	Termoéléctrica	Sonora	4	632	3,375	61.0
El Encino (Chihuahua II)	Termoéléctrica	Chihuahua	5	619	4,666	86.0
Mazatlán II (José Aceves Pozos)	Termoéléctrica	Sinaloa	3	616	2,717	50.3
Caracol (Carlos Ramírez Ulloa)	Hidroeléctrica	Guerrero	3	600	1,313	25.0
Cerro Prieto	Geotermoeléctrica	Baja California	13	570	3,996	80.0
Salamanca	Termoéléctrica	Guanajuato	2	550	2,521	52.3
Samalayuca II	Termoéléctrica	Chihuahua	6	522	4,161	91.0
Río Bravo (Emilio Portes Gil)	Termoéléctrica	Tamaulipas	4	511	2,362	52.7
Guaymas II (Carlos Rodríguez R.)	Termoéléctrica	Sonora	4	484	1,380	32.5
El Sauz	Termoéléctrica	Querétaro	7	454	3,363	84.6
Dos Bocas	Termoéléctrica	Veracruz	6	452	2,138	54.0
Huinalá II	Termoéléctrica	Nuevo León	2	450	3,121	79.1
Huites (Luis Donaldo Colosio)	Hidroeléctrica	Sinaloa	2	422	624	16.9
Peñitas	Hidroeléctrica	Chiapas	4	420	1,625	44.2
San Lorenzo Potencia	Termoéléctrica	Puebla	3	382	2,552	76.2
Huinalá	Termoéléctrica	Nuevo León	6	378	2,255	68.2
Temascal	Hidroeléctrica	Oaxaca	6	354	1,313	42.3
Topolobampo II (Juan de Dios Bátiz)	Termoéléctrica	Sinaloa	3	320	1,284	45.8
Samalayuca	Termoéléctrica	Chihuahua	2	316	727	26.3
Francisco Villa	Termoéléctrica	Chihuahua	5	300	1,657	63.0
Zimapán	Hidroeléctrica	Hidalgo	2	292	1,223	47.8
Otras Centrales			463	5,636	17,924	36.3
T O T A L			**654**	**39,850**	**169,553**	**48.6**

Table 2-4: Independent Power Producers in Mexico

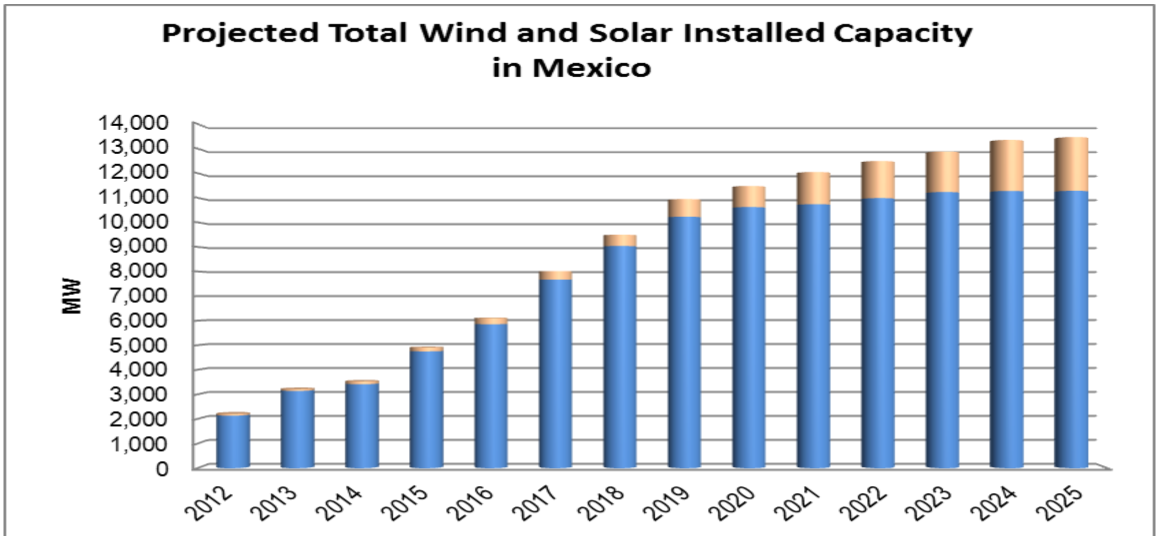
DATOS TÉCNICOS DE LOS PRODUCTORES EXTERNOS DE ENERGÍA EN OPERACIÓN

Central	Municipio	Estado	Fecha de Entrada en Operación	Capacidad Demostrada MW
CC Tamazunchale	Tamazuchale	San Luis Potosí	01/06/2007	1,135
CC Altamira V	Altamira	Tamaulipas	01/11/2006	1,121
CC Altamira III y IV	Altamira	Tamaulipas	24/12/2003	1,036
CC Tuxpan III y IV	Tuxpan	Veracruz	23/05/2003	983
CC Valladolid III	Valladolid	Yucatan	01/06/2006	525
CC Río Bravo IV	Valle Hermoso	Tamaulipas	01/04/2005	500
CC La Laguna II	Gómez Palacios	Durango	22/04/2005	498
CC El Sauz (Bajío)	San Luis de la Paz	Guanajuato	09/03/2002	495
CC Río Bravo II (Anahuac)	Valle Hermoso	Tamaulipas	18/01/2002	495
CC Río Bravo III	Valle Hermoso	Tamaulipas	01/04/2004	495
CC Altamira II	Altamira	Tamaulipas	14/05/2002	495
CC Tuxpan II	Tuxpan	Veracruz	15/12/2001	495
CC Tuxpan V	Tuxpan	Veracruz	01/09/2006	495
CC Mexicali (Rosarito IV)	Mexicali	Baja California	20/07/2003	489
CC Mérida III	Mérida	Yucatán	09/06/2000	484
CC Norte Durango	Durango	Durango	07/08/2010	450
CC Monterrey III	San Nicolás de los Garza	Nuevo León	27/03/2002	449
CC Norte II	Chihuahua	Chihuahua	19/12/2013	433
CC Chihuahua III	Ciudad Juárez	Chihuahua	09/09/2003	259
CC Naco Nogales	Agua Prieta	Sonora	04/10/2003	258
CC Campeche	Empalizada	Campeche	27/06/2003	252
CC Hermosillo	Hermosillo	Sonora	01/10/2001	250
CC Saltillo	Ramos Arispe	Coahuila	19/11/2001	248
CE La Venta III	Santo Domingo Ingenio	Oaxaca	03/10/2012	103
CE Oaxaca III	Juchitán de Zaragoza	Oaxaca	30/01/2012	102
CE Oaxaca II	Santo Domingo Ingenio	Oaxaca	06/02/2012	102
CE Oaxaca IV	Juchitán de Z. y Santo Domingo I.	Oaxaca	05/03/2012	102
CE Oaxaca I	Juchitán de Zaragoza	Oaxaca	26/09/2012	102
T O T A L				12,851

CC - Ciclo Combinado CE - Central Eólica

Fuente: Comisión Federal de Electricidad

According to the National Energy Strategy issued by SENER in 2013, Mexico is expected to add 18,715 MW of new generation resources by 2025. Wind and solar resources are projected to account for 13,467 MW or about 72% of all additional capacity. More than 17% of total additional capacity, or 3,276 MW, includes distributed generation resources to be located within population centers. Figure 2-3 shows the wind and solar capacity that should be installed between 2012 and 2025.



	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Solar	71	74	117	159	253	345	459	717	857	1,310	1,508	1,648	2,074	2,185
Wind	2,137	3,143	3,415	4,750	5,855	7,669	9,035	10,226	10,618	10,734	10,982	11,228	11,274	11,279

Figure 2-3: Projected Wind and Solar installed Capacity

When fully implemented, this capacity expansion, dominated by intermittent resources, may result in significant operational and planning challenges that would have been addressed by the former system operator CFE. Furthermore, 3,000 MW of distributed generation would be added, which may further complicated CFE's operation and resulted in additional operational and planning challenges. Within the new energy context, the implementation of Smart Grid can enhance CENACE's capabilities to address the above and other challenges**.**

The implementation of Smart Grid can enhance CENACE's capabilities to address complexities arising from increasing amounts of distributed generation and other challenges.

Electricity generation has increased in Mexico at an annual growth rate of 2.27% between 2000 and 2013 reaching to a total generation of 257,855 GWh. The growth in total electricity generation by technology type is depicted in Table 2-5[11].

In 2011, IPPs accounted for 33% of total generation in Mexico. IPPs also accounted for about 49% of all fossil fuel based (hydrocarbons) generation in 2011.

In addition, Small Power Producers (permit holders excluding IPP's) added 9,058 MW of new capacity as of the end of 2011 reflecting an annual growth of about 8.2% for period 2000 – 2011. The amount of electricity generation by Small Power Producers (SPPs) reached 32,863 GWh in 2011 reflecting an annual growth of about 10% for the same period.

Mexico is also involved in import and export of electricity with other countries. The energy exports in 2011 accounted for 11,330 MW reflecting 5,017,445 GWh of sales. Similarly, energy imports accounted for 158 MW reflecting 59,314 GWh of power purchases.[12]

[11] Source: http://egob2.energia.gob.mx/portal/electricidad.html
[12] According to Electric Sector Outlook 2012-2026 in 2011the import was 170 MW and export 2,480 MW. The difference in values may be due that to the way project are accounted, under construction vs. in operation.

Table 2-5: Electricity Generation 2000 - 2013

SECTOR ELÉCTRICO NACIONAL
CAPACIDAD EFECTIVA DE GENERACIÓN 1_/
(Megawatts)

Año	Hidroeléctrica	Termoeléctrica 2_/	Ciclo Combinado - CFE	Ciclo Combinado - PEE's 3_/	Duales 4_/	Carboeléctrica	Nucleoeléctrica	Geotermoeléctrica	Eoloeléctrica - CFE	Eoloeléctrica - PEE's 3_/	Fotovoltaica	Total
2000	9,619	16,758	2,914	484	2,100	2,600	1,365	855	2	0	0	36,697
2001	9,619	16,806	3,733	1,455	2,100	2,600	1,365	838	2	0	0	38,519
2002	9,615	17,316	3,848	3,495	2,100	2,600	1,365	843	2	0	0	41,184
2003	9,615	17,316	3,848	6,756	2,100	2,600	1,365	960	2	0	0	44,561
2004	10,530	16,954	4,776	7,265	2,100	2,600	1,365	960	2	0	0	46,552
2005	10,536	15,715	5,005	8,251	2,100	2,600	1,365	960	2	0	0	46,534
2006	10,566	15,586	5,203	10,387	2,100	2,600	1,365	960	2	0	0	48,769
2007	11,343	15,702	5,416	11,457	2,100	2,600	1,365	960	85	0	0	51,029
2008	11,343	15,734	5,456	11,457	2,100	2,600	1,365	965	85	0	0	51,105
2009	11,383	15,616	6,115	11,457	2,100	2,600	1,365	965	85	0	0	51,686
2010	11,503	15,627	6,115	11,907	2,778	2,600	1,365	965	85	0	0	52,945
2011	11,453	14,732	6,122	11,907	2,778	2,600	1,365	887	87	0	0	51,931
2012	11,498	14,608	6,122	11,907	2,778	2,600	1,610	812	87	511	1	52,534
2013	11,509	13,980	7,420	12,340	2,778	2,600	1,400	823	87	511	6	53,455

1_/ Al término de cada período, sin incluir capacidad de cogeneradores y autoabastecedores de energía eléctrica
2_/ Incluye Ciclo de Vapor, Turbogas y Combustión Interna
3_/ Comprende la capacidad instalada de los Productores Externos de Energía (PEE's) n.a. - no aplica
4_/ Las centrales duales pueden operar con carbón o combustóleo

Fuente: Secretaría de Energía con datos de Comisión Federal de Electricidad y Luz y Fuerza del Centro / Área Central

Nota 1: A partir de agosto de 2011, no incluye 580.3 MW de plantas inoperables en el Área Central.

Nota 2: En 2013 y 2014, la capacidad efectiva y de placa de la central Laguna Verde se ajustó a 1,400 MW, en tanto CFE obtiene el licenciamiento de la repotenciación de esa central.

2.2.2.2 TRANSMISSION AND DISTRIBUTION SYSTEM

CFE has expanded its transmission network to accommodate increasing electric power capacity, particularly by IPPs, in recent years. This resulted in Mexico's transmission and distribution systems to increase by about 2.5 percent each year between 2000 and 2011 reflecting more than 845,200 kilometers (kms.) of lines. In particular, the high voltage transmission lines at 400 kV had the fastest annual growth at 5.2 percent during the same period.

According to SENER's 2012-2026 Electric Sector Outlook Report, Mexico's power grid consists of 845,201 kms. of transmission and distribution lines. Out of this total, 98,749 kms are high voltage, 402,857 kms are medium voltage, 257,152 kms are low voltage and 86,443 kms is classified as other.

Mexico's transmission system utilizes 400 kV, 230 kV, 161 kV, 138 kV, 85 kV and 69 kV. A map of Mexico's power grid covering 69 kV to 400 kV can be seen in Figure 2-4.

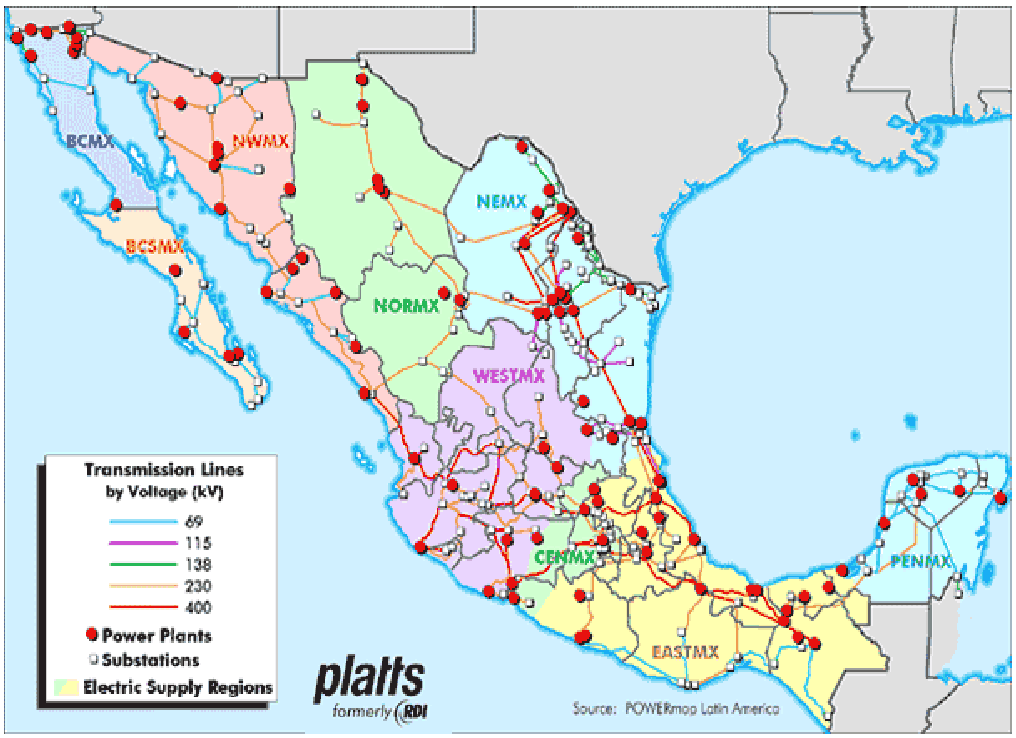


Figure 2-4: Mexican Power Grid

Mexico's distribution system consists of 34.5 kV, 23 kV, 13.8 kV, 6.6 kV, 4.16 kV and 2.4 kV distribution lines as shown in the Table 2-6 below.

Table 2-6: Transmission Voltages and Lengths in Mexico

Líneas de transmisión, subtransmisión y baja tensión, 2000-2011 (Kilómetros)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	tmca (%)
SEN	**643,930**	**661,863**	**675,385**	**727,075**	**746,911**	**759,552**	**773,059**	**786,151**	**803,712**	**812,282**	**824,065**	**845,201**	**2.5**
CFE[1]	**614,653**	**632,025**	**644,892**	**658,067**	**676,690**	**688,420**	**700,676**	**712,790**	**729,299**	**737,869**	**748,399**	**758,758**	**1.9**
400 kV	13,165	13,695	14,503	15,999	17,831	18,144	19,265	19,855	20,364	20,900	22,272	22,880	5.2
230 kV	21,598	22,644	24,058	24,776	25,886	27,147	27,745	28,164	28,092	27,801	27,317	26,867	2.0
161 kV	508	516	614	470	486	475	475	547	547	549	549	549	0.7
138 kV	1,029	1,051	1,086	1,340	1,358	1,369	1,398	1,418	1,439	1,470	1,477	1,485	3.4
115 kV	34,971	36,199	38,048	38,773	40,176	40,847	42,177	43,292	42,701	42,295	42,358	43,821	2.1
85 kV	186	186	140	140	140	141	141	141	77	77	83	201	0.7
69 kV	3,441	3,360	3,381	3,364	3,245	3,241	3,157	3,067	3,066	2,995	2,982	2,946	-1.4
34.5 kV	60,300	61,756	62,725	63,654	64,768	66,287	67,400	69,300	70,448	71,778	72,808	73,987	1.9
23 kV	23,756	24,663	25,826	26,366	27,435	27,940	28,568	29,095	29,841	30,694	31,161	31,665	2.6
13.8 kV	239,748	246,304	251,771	257,462	264,595	269,390	273,249	278,119	286,306	289,090	293,323	296,984	2.0
6.6 kV	428	429	429	429	429	411	411	411	411	138	142	142	-9.5
4.16 kV	60	49	49	49	16	16	16	16	17	17	17	17	-10.8
2.4 kV	94	94	98	98	61	62	39	50	54	62	62	62	-3.7
Baja tensión	215,369	221,079	222,164	225,147	230,264	232,950	236,635	239,315	245,936	250,003	253,848	257,152	1.6
Ex. Ly FC[2]	**29,277**	**29,838**	**30,493**	**69,008**	**70,221**	**71,132**	**72,383**	**73,361**	**74,413**	**74,413**	**75,666**	**86,443**	**10.3**
Líneas subterráneas	8,065	9,039	9,737	10,946	12,443	14,447	16,626	19,031	20,271	23,002	23,002	23,002	10.0

[1] Incluye líneas subterráneas a partir de 2001.

Along with its line expansion, Mexico increased its substation capacity in MVA at about 3.5% annually between 2000 and 2011. The amount of substation capacity at the transmission and distribution system by year is shown in Table 2-7.

Table 2-7: Installed Capacity in MVA (Substations 2000 – 2011)

Capacidad instalada en subestaciones de transmisión y distribución, 2000-2011 (MVA)

Subestaciones	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	tmca (%)
Sistema Eléctrico Nacional	184,753	197,656	209,584	217,774	225,615	234,530	240,202	248,694	253,531	262,826	263,979	269,662	3.5
CFE	164,916	173,305	183,783	191,711	198,508	205,773	210,488	218,028	222,580	231,875	236,358	241,041	3.5
Distribución	57,070	59,749	64,076	66,638	69,667	71,066	73,494	76,340	78,786	84,742	81,872	84,475	3.6
Subestaciones	31,673	33,078	36,232	37,702	38,775	39,706	41,036	42,673	43,739	43,522	44,567	46,286	3.5
Transformadores	25,397	26,671	27,844	28,936	30,892	31,360	32,458	33,667	35,047	41,220	37,305	38,189	3.8
Transmisión	107,846	113,556	119,707	125,073	128,841	134,707	136,994	141,688	143,794	147,133	154,486	156,566	3.4
LyFC[1]	19,837	24,351	25,801	26,063	27,107	28,757	29,714	30,666	30,951	30,951	27,621	28,621	3.4

The Mexican distribution grid has an annual growth rate of 1.40 percent. In 2011 the number of substations was 1,725 with a total capacity of 269,662 MVA[13]. The annual energy sales was 200,946 GWh, with an annual growth of 8.3% by 35,392,198 customers.

The global average price, paid by the customers in 2011 at the domestic, agriculture and municipal services was 142.7 Mexican cents per kWh.

[13] Source: Electric Sector Outlook 2012-2026.

Total electricity losses in 2010 were 44,252 GWh (18%)[14] for CFE and as high as 32% for the Mexico City metropolitan area.

In 2011, the duration of interruptions per customer was 55.9 minutes[15]. In comparison, in 2001 the duration of interruptions in distribution was about 100 minutes. The average time to connect new services was 0.83 days in 2011. The complaints for every 1000 users went down from 4.47 in year 2010 to 4.34 in year 2011.

2.2.2.3 Interconnections with Other Countries

CFE is a partial member of the North American Electric Reliability Corporation (NERC)[16] and the Western Electric Coordinating Council (WECC) and is interconnected to various states in the U.S. CFE transmission system in northern Baja California is connected to WECC in the State of California in the U.S. via two interconnections. CFE also has seven interconnections in the northern part of its system to the State of Texas across the border with the U.S.

The external electricity trade is carried out through the aforementioned nine interconnections between the U.S. and Mexico; one interconnection with Guatemala (two parallel lines) and one interconnection with Belize. These connections have primarily been used to import and export electricity during emergencies. Mexico's external interconnections can be seen in Figure 2-5[17].

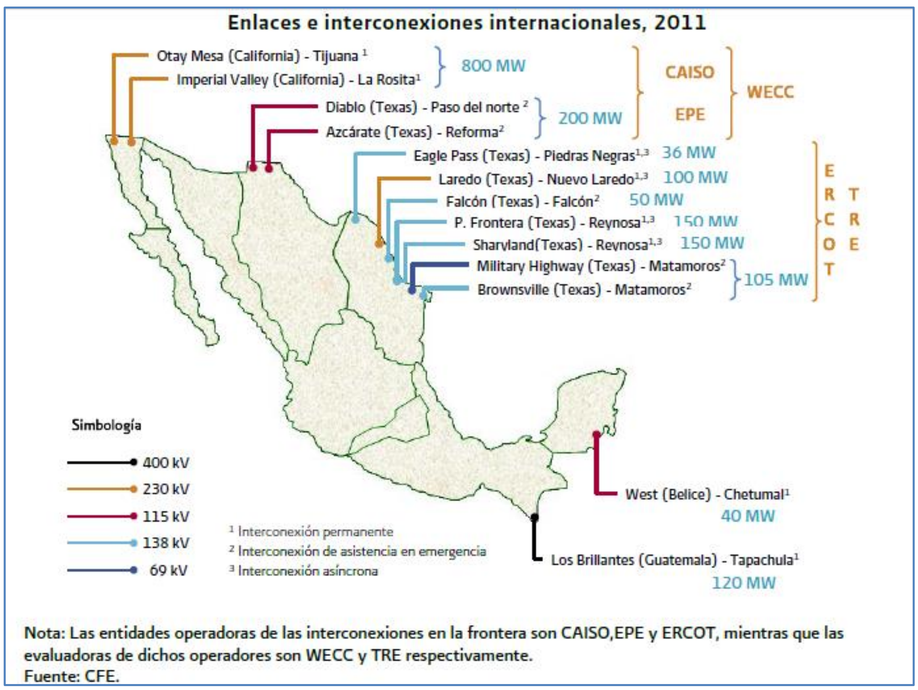


Figure 2-5: Major Interconnections with the neighboring countries

[14] Source: POISE 2012-2026
[15] ibid
[16] Only CFE's northern portion of Baja California is included in NERC – CFE is not a full member.
[17] Source: *Prospectiva del Sector Eléctrico 2012-2026* available at http://www.sener.gob.mx/res/PE_y_DT/pub/2012/PSE_2012_2026.pdf

Recent studies in Mexico have concluded that interconnecting Baja California with the SIN would be technically viable and economically justifiable. This interconnection would allow reserve sharing and enables serving peak demand in the Baja California system with generation resources from the SIN. Conversely, during low demand in Baja California, surplus electricity from base load (i.e. geothermal and combined cycles) may be exported to the SIN. As a result of this interconnection, Mexico would benefit from reduced investment in generating resources and transmission infrastructure as well as reduction in operating costs of Mexico's power grid. Further, this interconnection facilitates further exchanges with power utilities in State of California and Texas through existing interconnections. According to POISE[18] this interconnection is expected to be ready by 2018 and will have a capacity of 300 MW. The interconnection would use a submarine cable crossing the Sea of Cortes.

Recently, private companies have built power plants near the U.S. - Mexico border with the aim of exporting generation to the U.S. In Central America, the 400 kV interconnection line, Mexico – Guatemala, was commissioned in April 2010 and has an estimated transmission capacity of 120 MW from Mexico to Guatemala and 70 MW in the opposite direction. Guatemala is part of the Sistema de Interconexión Eléctrica de los Países de América Central (SIEPAC) that serves six Central American countries.

The concept of integrating the electricity grids of Mexico, the U.S., and Canada is gaining popularity. Numerous transmission lines already connect the U.S. and Canada, though few (nine) span the U.S.-Mexico border. Companies built power plants in northern Mexico to generate electricity to satisfy rapid demand growth from industrial and residential users. In view of a variety of favorable economic conditions, it is possible that more power plants will be planned in northern Mexico to help satisfy the energy needs of both northern Mexico and southern California.

2.2.2.4 DEMAND (END USERS)

CFE is considered among some of the largest electric utilities serving end-use customers in the world. As shown in Table 2-9, CFE had more than 37 million customers served at the end of 2013. The historical electricity consumption by end-use customers between 2000 and 2013 is shown in Table 2-10.

Table 2-8: Number of End-Use Customers by Sector Served by CFE between 2000 and 2013

SECTOR ELÉCTRICO NACIONAL 1_/
USUARIOS DE ENERGÍA ELÉCTRICA 2_/
(Miles de Usuarios)

Año	Doméstico	Comercial	Servicios	Agrícola	Empresa Mediana	Gran Industria	Total
2000	21,055	2,492	123	94	117	0.53	23,881
2001	21,872	2,622	131	97	128	0.56	24,851
2002	22,784	2,751	139	99	139	0.58	25,912
2003	23,692	2,864	145	102	151	0.60	26,954
2004	24,615	2,966	152	105	165	0.64	28,003
2005	25,484	3,056	158	107	180	0.66	28,986
2006	26,348	3,121	164	110	196	0.70	29,940
2007	27,476	3,250	162	113	212	0.73	31,213
2008	28,591	3,353	168	115	225	0.75	32,451
2009	29,455	3,420	174	117	236	0.81	33,403
2010	30,372	3,476	180	119	244	0.82	34,393
2011	31,289	3,544	186	121	257	0.86	35,397
2012	32,190	3,625	190	124	270	0.89	36,400
2013	33,135	3,696	193	127	283	0.93	37,434

1_/ Comisión Federal de Electricidad y Luz y Fuerza del Centro / Área Central
2_/ Al Final de cada Periodo

Fuente: Secretaría de Energía con datos de Comisión Federal de Electricidad

[18] POISE 2012-2026. Available at http://www.cfe.gob.mx/ConoceCFE/1_AcercadeCFE/Lists/POISE%20documentos/Attachments/7/Poise2012_2026.zip?Mobile=1

Table 2-9: Historical Electricity Consumption by End-Use Customers by Sector Served by CFE between 2000 and 2013

SECTOR ELÉCTRICO NACIONAL 1_/
VENTAS INTERNAS DE ENERGÍA ELÉCTRICA
(Gigawatts - hora)

Año	Doméstico	Comercial	Servicios	Agrícola	Empresa Mediana	Gran Industria	Total
2000	36,128	11,691	5,873	7,901	53,444	40,311	155,349
2001	38,344	12,185	5,954	7,463	54,722	38,535	157,204
2002	39,032	12,547	6,057	7,216	56,185	39,166	160,203
2003	39,861	12,825	6,132	7,338	56,874	37,355	160,384
2004	40,733	12,926	6,270	6,968	59,148	37,465	163,509
2005	42,531	13,007	6,431	8,067	61,921	37,799	169,757
2006	44,452	13,229	6,577	7,959	65,266	37,887	175,371
2007	45,835	13,408	6,789	7,804	67,799	38,833	180,469
2008	47,451	13,645	7,057	8,109	69,100	38,551	183,913
2009	48,540	13,417	7,787	9,299	67,630	34,794	181,465
2010	48,700	12,991	7,707	8,600	70,024	38,617	186,639
2011	51,771	13,591	8,068	10,973	73,431	43,112	200,946
2012	52,030	13,920	8,371	10,816	75,836	45,507	206,480
2013	52,370	13,743	9,261	10,282	76,378	44,095	206,130

1_/ Comisión Federal de Electricidad y Luz y Fuerza del Centro / Área Central

Fuente: Secretaría de Energía con datos de Comisión Federal de Electricidad

The sales of electricity by the Public Service to end-users grew at an average annual rate of %2.2 in the last thirteen years and its growth is projected to increase to more than 4% annually up to 2026. According to CFE estimates, the number of customers will grow annually by 1 million in the coming years. The industrial sector, which accounts for 58.4% of the electricity sold by the Public Service, is expected to maintain its share by 2026. In contrast, the residential sector share of total electricity sales is expected to slightly increase from 25.4% in 2013 to 25.5% in 2026. While this may appear counterintuitive in a fast growing economy like Mexico, the technological advances and greater reliance on Smart Grid deployment, which will result in more efficient use of electricity, will slow down growth in electricity sales to this sector. Finally, the commercial sector is expected to show the fastest growth averaging 7.12% between 2013 and 2026. Table 2-10 shows the projected electricity consumption by various sectors in Mexico through 2026.

Table 2-10: Projected Consumption per Consumer Class

Ventas totales del Servicio Público por sector 2011[1]-2026
(TWh)

Sector	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	tmca 2011-2026
Total (incluye exportación)	**199.8**	**209.1**	**215.8**	**222.2**	**229.4**	**237.8**	**245.1**	**257.6**	**272.2**	**288.2**	**304.7**	**322.1**	**340.9**	**360.7**	**381.0**	**399.6**	**4.7%**
Ventas del servicio público	198.2	207.5	214.2	220.6	227.9	236.2	243.5	256.0	270.6	286.6	303.1	320.5	339.3	359.1	379.5	398.0	4.8%
Residencial	50.7	52.3	54.5	55.2	54.9	55.1	55.3	58.5	62.7	67.2	72.1	77.3	83.1	89.3	96.0	102.0	4.8%
Comercial	13.6	14.3	15.0	15.6	16.3	17.0	17.5	18.4	19.9	21.6	23.5	25.4	27.6	29.8	32.3	33.6	6.2%
Servicios	7.7	8.0	8.4	8.5	8.7	8.8	8.9	9.3	10.0	10.8	11.6	12.5	13.5	14.5	15.6	16.1	5.0%
Industrial	117.2	123.6	126.7	131.5	138.0	145.2	151.6	159.5	167.4	176.0	184.6	193.5	203.2	213.1	222.7	233.2	4.7%
Empresa Mediana	74.4	79.1	83.4	87.7	91.9	96.3	100.5	105.4	110.3	115.5	120.8	126.3	132.0	137.9	143.8	149.8	4.8%
Gran Industria	42.8	44.5	43.3	43.8	46.1	49.0	51.1	54.1	57.1	60.6	63.9	67.3	71.2	75.1	78.9	83.4	4.6%
Bombeo Agrícola	9.1	9.3	9.6	9.8	9.9	10.1	10.1	10.3	10.6	11.0	11.3	11.7	12.0	12.4	12.9	13.1	2.5%
Exportación	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	0.0%

Mexico has 43 separate electric rates, based on the consumer class and location. While it is efficient to reflect some measure of production costs in designing rates, many of the 43 separate rates in existence in Mexico do not fully reflect production costs. These rates reflect some amount of subsidies, defined as the difference between the price of electricity paid by consumers and the average cost of supply. Subsidies in CFE's rates are funded by the Federal Government by deducting taxes and fees that otherwise CFE would pay to the Federal Government.

Many of the 43 separate rates in existence in Mexico do not fully reflect production costs.

In Mexico, the subsidy is implicit in domestic and two agricultural rates. Domestic rates are subsidized depending on temperature and season in which they apply. These are structured into three ranges in order to subsidize the users based on their level of consumption and the temperatures in of their region. Thus, in regions of higher temperature, consumption blocks are larger. High consumption users are charged the applicable rate for Doméstica de Alto Consumo (DAC)[19] and receive no subsidy. At the end of 2011, the amount of subsidies granted to users with domestic rate rose to 85,801 million of pesos (US $6.6 billion).

Figure 2-6 shows the historical tariffs charged to major consumer classes in Mexico from 1993 to 2011. Commercial and services classes paid the highest tariffs among all classes. In contrast to tariffs for residential consumers, Commercial and Industrial tariffs do not reflect subsidies and are aimed to cover the full costs of supply[20]. Most agricultural users are beneficiaries of the incentives established in the Rural Energy Act. These rates carry a very high level of subsidy, an amount that has remained fixed since its inception in 2003 (2 cents per kWh and 1 cent per kWh for the nightly rate). In 2011, the subsidy to agricultural rates amounted to 12,522 million pesos (12.48% of total, US $1 billion). These subsidies were channeled mostly through incentive fees, which covered, in 2010, only 24% of the total cost of supply.

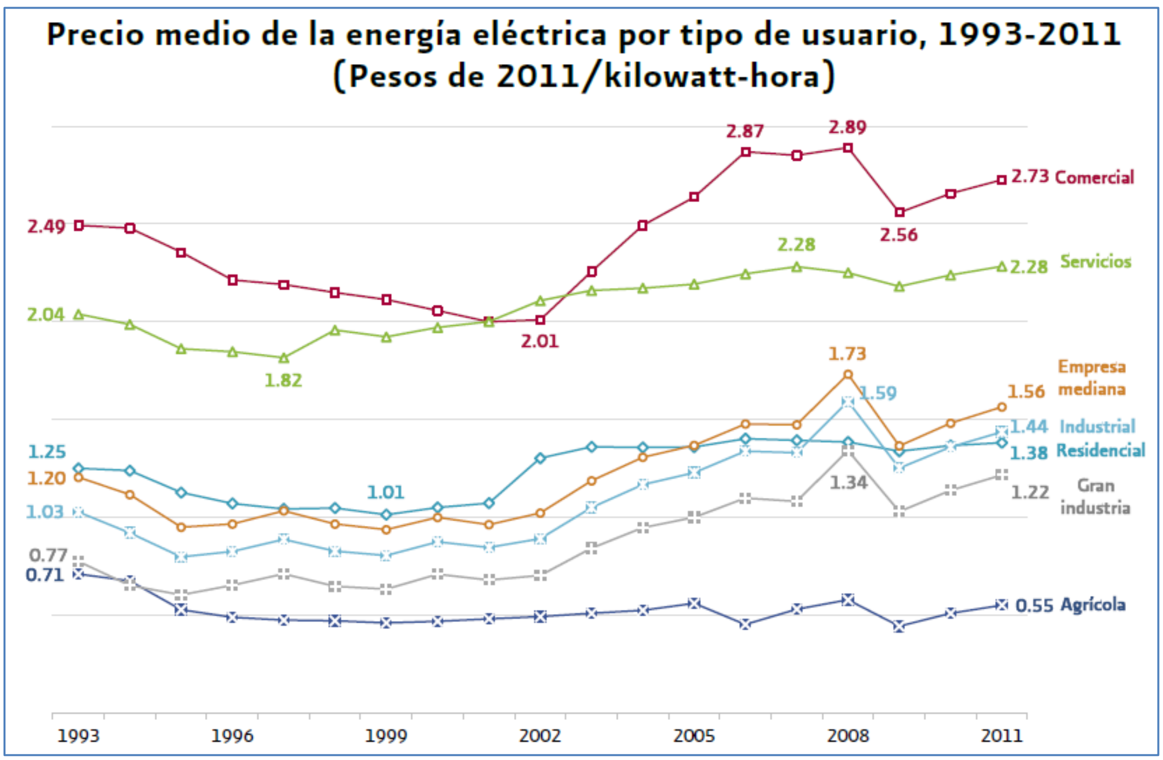


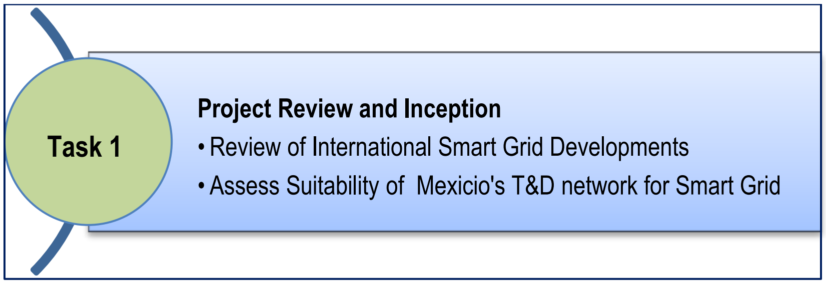
Figure 2-6: Average Price of Electric Energy (Pesos MXN/kWh)

[19] This tariff refers to residential consumer with high consumption

[20] These rates in Mexico do not include subsidy and the marginal cost differences seen in Figure 2-6 are due to the differences regarding the accounting costs of CFE, which usually remain above the long-run marginal costs

The Mexican electric power sector losses (both technical and non-technical) accounted for about 17% of total electricity generation in 2011. Non-technical losses, that includes mainly electricity use by end-users who do not pay for their electricity use, is considered the most important issue with the highest priority to be addressed in the coming years. Other areas include inefficient use of energy, reliability concerns in certain areas, low quality of services, and pollution. To that, we can add the need for higher consumer satisfaction and improvement in the way the utility interacts with end-use consumers. These potential areas for improvement can be addressed under Smart Grid implementation.

3 TASK 1 – INITIAL REVIEW AND ASSESSMENT



The objectives of Task 1 are two folds and include the following two subtasks:

- Subtask 1.1 Review of International Smart Grid Projects and Identification of Success and Failure Factors

The key objective of this subtask is to review the progress of Smart Grid implementation around the world and identify the key success and failure factors with special attention to experiences in countries that have a similar electric power structure to Mexico's.

- Subtask 1.2 Assess Suitability of Transmission and Distribution Infrastructure

The key objective of this Task is to perform a Strengths, Weaknesses, Opportunities, and Threats ("SWOT") analysis of Mexico's transmission and distribution infrastructure to assess its suitability and readiness for a wide range of Smart Grid applications. This Task will highlight immediate and short-term opportunities as well as longer term barriers toward an effective Smart Grid implementation. The Federal Electricity Commission's (Comisión Federal de Electricidad, "CFE") objectives regarding Smart Grid implementation in Mexico, as outlined in CFE's "Programa de Obras e Inversiones del Sector Eléctrico (POISE) 2011-2025"[21] document are considered during this assessment.

This chapter provides:

- An overview of the Smart Grid initiatives around the globe. It highlights the variations in definitions of Smart Grid and reviews the key drivers, barriers, and challenges associated with deployment of Smart Grid as well as the benefits and lessons learned. In addition to utility perspectives, this chapter also provides an overview of consumer and end use issues.
- Reviews the Mexican power sector with special focus on Smart Grid activities and assesses the suitability and readiness of the transmission and distribution networks to support potential Smart Grid deployments.
- Provides a Strength, Weaknesses, Opportunities, and Threats (SWOT) analysis.
- Summarizes the recommended plan of action for Task 1.

[21] ESTA used the latest version of POISE OISE 2012-2026 available at:
http://www.cfe.gob.mx/ConoceCFE/1_AcercadeCFE/Lists/POISE%20documentos/Attachments/7/Poise2012_2026.zip?Mobile=1

3.1 OVERVIEW THE INTERNATIONAL SMART GRID INITIATIVES

In this section we provide: a brief overview of Smart Grid concepts; how it is visualized by various entities around the globe; characteristics of Smart Grid; Smart Grid benefits; and Smart Grid drivers in the various region. Furthermore, we provide an overview of select international Smart Grid programs for countries with similar structures to that of Mexico. We finally summarize some of the lessons learned by European and US institutions.

CRE has expressed interest in Privacy Programs, and as such a sub-section to Smart Grid Privacy issues has been included.

3.1.1 SMART GRID CONCEPTS

Smart Grid is a concept that spans over the complete chain of power supply, transmission, delivery, and consumption. By the very definition, it has the flexibility to meet the particular needs of a region, country, or utility service company. Below are representative definitions of Smart Grid by various U.S. and international organizations:

The Smart Grid European Technology Platform

The Smart Grid European Technology Platform defines Smart Grid as an electricity network that can intelligently integrate the actions of all users connected to it – generators, consumers, and those that do both, in order to efficiently deliver sustainable, economic and secure electricity supply.

The US Department of Energy

In the US Department of Energy (DOE) definition, a Smart Grid uses digital technology to modernize the electric system—from large generation, through the delivery systems to electricity consumption—and is defined by seven enabling performance-based functionalities:

- customer participation,
- integration of all generation and storage options,
- new markets and operations,
- power quality for the 21st Century,
- asset optimization and operational efficiency,
- self-healing from disturbances, and
- resiliency against attacks and disasters

The World Economic Forum

The World Economic Forum defines Smart Grid through seven key characteristics such as:

- self-healing and resilient,
- [integrating] advanced and low-carbon technologies,
- asset optimization and operational efficiency,
- customer inclusion,
- heightened power quality,
- market empowerment

The International Energy Agency

> The International Energy Agency (IEA) states that a Smart Grid is an electric network that uses digital and other advanced technologies to monitor and manage the transport of electricity from all generation sources to meet the varying electricity demands of end-users. Smart Grids coordinate the needs and capabilities of all generators, grid operators, end-users and electricity market stakeholders to operate all parts of the system as efficiently as possible, minimizing costs and environmental impacts while maximizing system reliability, resilience and stability.

While there are common areas in the definition of Smart Grid among all four organizations, the definition of Smart Grid for each entity will be based on the unique requirements of the entity while leveraging the lessons learned from other nations.

3.1.2 VISUALIZATION OF SMART GRID

Figure 3-1 below, from the IEA Smart Grid Technology Roadmap published in 2011[22], is a graphical representation of a Smarter Electric System. It shows the transition from the past to present and the future of the electric energy sector. In this vision, the advances in the Power System Technology, Communications Technology, Solar Energy, Electrical Vehicles, and Energy Storage to name a few, enable a more efficient, environmental friendly electric energy sector while providing consumers more options and choices for the energy usage.

As noted by IEA, "the smartening of the electricity systems is an evolutionary process and not a one-time event."

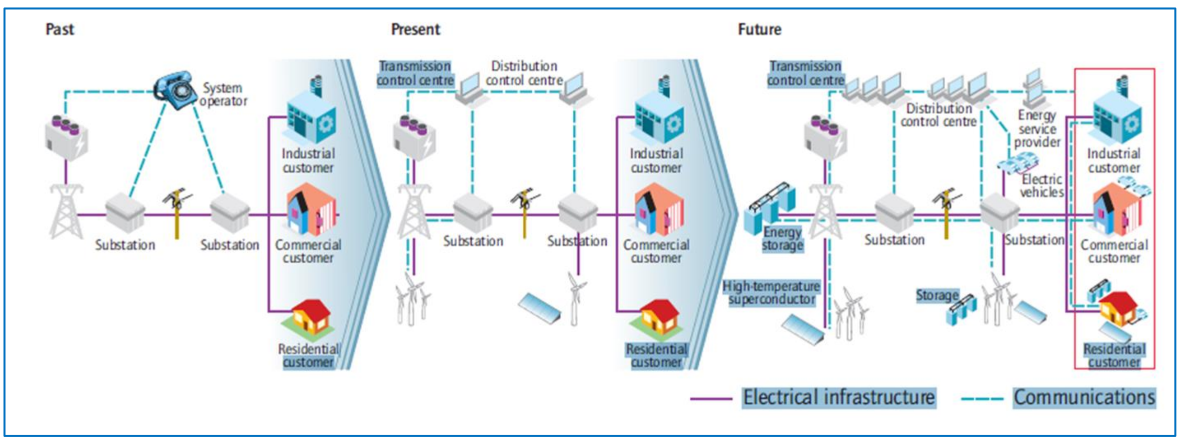


Figure 3-1: IEA Smarter Electric System

Figure 3-2 depicts the view of Smart Grid and the necessary infrastructure and technology/capability required for the realization of Smart Grid benefits as identified by the Major Economies Forum (MEF) on Energy and Climate Change Smart Grid Technology action plan[23].

[22]Source: http://www.iea.org/publications/freepublications/publication/smartgrids_roadmap.pdf
[2323]Source: http://www.majoreconomiesforum.org/images/stories/documents/MEF%20Smart%20Grids%20TAP%2011Dec2009.pdf

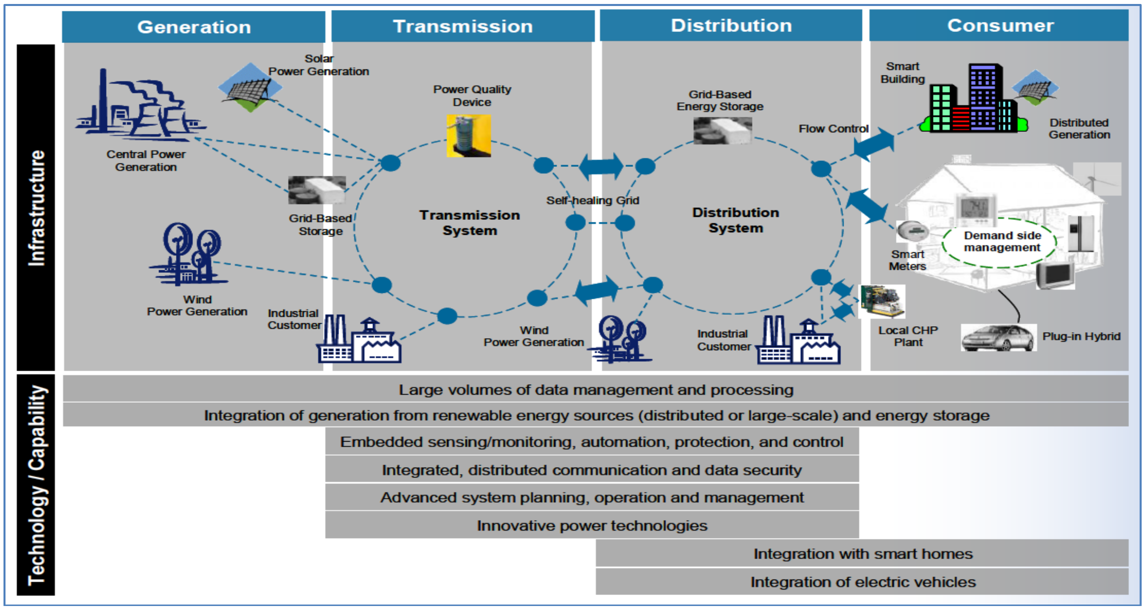


Figure 3-2: MEF view of Smart Grid

Figure 3-3 below shows the visualization of Smart Grid from CFE's perspective[24].

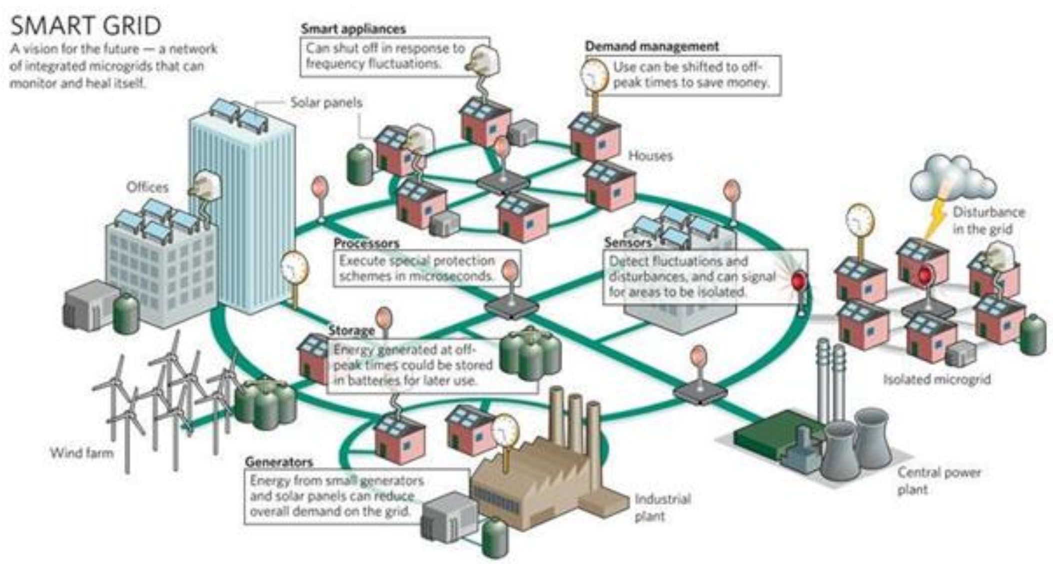


Figure 3-3: CFE visualization of Smart Grid

The common theme in all visualization points to the fact that Smart Grid concept is all encompassing and a holistic and broad approach must be adopted. It should include a variety of generation sources; improve system reliability, enhance business practices; empower consumers; and help meet societal obligations.

[24] Source: Presentation by CFE and CRE/CFE/SENER/ESTA meeting in Mexico City, October 2012.

3.1.3 CHARACTERISTICS OF SMART GRID TECHNOLOGY

The Smart Grid can have different characteristics based on the above proposed vision. As an example, the United States Department of Energy (DOE) identifies the characteristics of Smart Grid as following:

1. Increased use of digital information and controls technology to improve reliability, security, and efficiency of the electric grid;
2. Dynamic optimization of grid operations and resources, with full cyber-security;
3. Deployment and integration of distributed resources and generation, including renewable resources;
4. Development and incorporation of demand response, demand-side resources, and energy efficiency resources;
5. Deployment of "smart" technologies (real-time, automated, interactive technologies that optimize the physical operation of appliances and consumer devices) for metering, communications concerning grid operations and status, and distribution automation;
6. Integration of "smart" appliances and consumer devices;
7. Deployment and integration of advanced electricity storage and peak-shaving technologies, including plug-in electric and hybrid electric vehicles, and thermal storage air conditioning;
8. Provision to consumers of timely information and control options;
9. Development of standards for communication and interoperability of appliances and equipment connected to the electric grid, including the infrastructure serving the grid; and
10. Identification and lowering of unreasonable or unnecessary barriers to adoption of smart grid technologies, practices, and services."

The DOE further defines the functions of Smart Grid as:

- Enabling Informed Participation by Customers
- Accommodating All Generation and Storage Options
- Enabling New Products, Services, and Markets
- Providing the Power Quality for the Range of Needs in the 21st Century
- Optimizing Asset Utilization and Operating Efficiently
- Operating Resiliently Against Disturbances, Physical and Cyber Attacks, and Natural Disasters

Figure 3-4 from IEA highlights how Smart Grid can link the electricity system stakeholder objectives. It provides an opportunity to link policy and regulations, technology, financial and societal objectives[25].

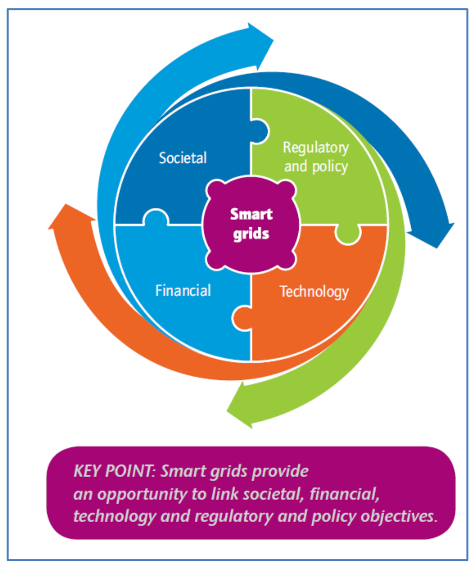


Figure 3-4: Smart Grid Stakeholder objectives

[25] Source: http://www.iea.org/publications/freepublications/publication/smartgrids_roadmap.pdf

3.1.4 SMART GRID BENEFITS

Smart Grid can offer numerous benefits at various levels. Some of the benefits may include:

- **Reliability —** by reducing the cost of interruptions and power quality disturbances and reducing the probability and consequences of widespread emergencies and blackouts;
- **Economics** — by keeping downward pressure on wholesale and retail prices on electricity, reducing the amount paid by consumers as compared to the "business as usual" (BAU);
- **Environmental —** by reducing emissions when compared to BAU by enabling a larger penetration of renewables and improving efficiency of generation, delivery, and consumption;
- **Efficiency**— by reducing the cost to produce, deliver, and consume electricity;
- **Consumer Choice –** by providing options to consumers for price sensitive use of their energy;
- **Security —** by reducing the probability and consequences of manmade attacks and natural disasters;
- **Safety —** by reducing injuries and loss of life from grid-related events; and
- **Creation of Jobs** – new technologies will require new training and skills.

Table 3-1 shows the benefits of Smart Grid realized by the various stakeholders from the US DOE's perspective. Table 3-2[26] shows the Smart Grid benefits realized by the various functions and enabling energy resources published by the US DOE.[27] These benefits are provided as an example. It must be noted that for each country and entity the benefits could be different; the benefits will be consistent with the ability of Smart Grid to address existing constraints and bridge the gaps to future needs for that country or entity.

[26] Reproduced from the reference
[27]Source: Guidebook for ARRA SGDP/RDSI Metrics and Benefits http://www.smartgrid.gov/sites/default/files/pdfs/sgdp_rdsi_metrics_benefits.pdf

Table 3-1: Benefits of Smart Grid for each Stakeholder

Potential and Real Benefits to be Realized by Building and Implementing a Smart Grid						
Benefits	Stakeholders					
	Utility	Independent Generator	Residential	Commercial	Industrial	Future Generation
System Reliability and Economics						
Smart Grid technologies allow faster diagnosis of distribution outages and automated restoration of undamaged portions of the grid, reducing overall outage times with major economic benefits.	X		X	X	X	
Smart Grid's automated diagnostic and self-healing capability prolongs the life of the electric infrastructure.	X					X
Distributed generation is supported because the grid has the ability to dynamically manage all sources of power on the grid.	X	X	X	X	X	X
Price-sensitive peak shaving defers the need for grid expansion and retrofit.	X					
Price-sensitive peak shaving reduces the need for peaking generation capacity investments.	X		X	X	X	
Smart Grid technologies may allow better utilization of transmission paths, improving long distance energy transfers.	X	X				
Positive Environmental Impact						
Smart Grid can reduce distribution losses, thus reducing power generation demands.	X		X	X	X	X
Grid integration of high levels of renewable resources as called for in many state RPS standards will require Smart Grid to manage extensive distributed generation and storage resources.	X	X	X	X	X	X
A high penetration of PHEV [Plug-in Hybrid Electric Vehicle] will require Smart Grid to manage grid support of vehicle charging. Potential use of PHEV as Vehicle to Grid will absolutely require Smart Grid technologies.	X		X			X
A Smart Grid enables intelligent appliances to provide feedback through the system, sense grid stress, and reduce their power use during peak demand periods.	X		X			
Advanced metering technology can be used to help measure electricity use and calculate the resulting carbon footprint.			X	X	X	X
Increased efficiency of power delivery						
Direct operating costs are reduced through the use of advanced metering technology(AMR/AMI) such as connects/disconnects, vehicle fleet operations and maintenance, meter reads, employee insurance compensation ,etc.	X					
Smart Grid technologies, such as synchrophasors, offer the promise of reducing transmission congestion.	X	X	X	X	X	
Economic Development						
Standards and protocols supporting interoperability will promote product innovation and business opportunities that support the Smart Grid concept.	X	X	X	X	X	X
Consumer Choice						
Provide consumers with information on their electric usage so they can make smart energy choices.			X	X	X	X

Potential and Real Benefits to be Realized by Building and Implementing a Smart Grid						
Benefits	Stakeholders					
	Utility	Independent Generator	Residential	Commercial	Industrial	Future Generation
Real-time pricing offers consumers a" choice" of cost and convenience trade-offs that are superior to hierarchical demand management programs.			**X**	**X**	**X**	
Integration of building automation systems offers efficiency gains, grid expansion deferral, and peaks having.	**X**			**X**		

Source: Table created for *Smart Grid: Enabler of the New Energy Economy* by EAC Smart Grid Subcommittee 2008

Table 3-2: Smart Grid Benefits Realized by Functions and Enabling Energy Resources:

Benefits			Functions													Energy Resources		
			Fault Current Limiting	Wide Area Monitoring, Visualization, and Control	Dynamic Capability Rating	Power Flow Control	Adaptive Protection	Automated Feeder Switching	Automated Islanding and Reconnection	Automated Voltage and VAR Control	Diagnosis & Notification of Equipment Condition	Enhanced Fault Protection	Real-time Load Measurement & Management	Real-time Load Transfer	Customer Electricity Use Optimization	Distributed Generation	Stationary Electricity Storage	Plug-In Electric Vehicles
Economic	Market Revenue	Arbitrage Revenue															•	
		Capacity Revenue															•	
		Ancillary Services Revenue															•	
	Improved Asset Utilization	Optimized Generation Operation		•													•	•
		Deferred Generation Capacity Investments													•	•	•	•
		Reduced Ancillary Services Cost		•						•			•		•	•	•	•
		Reduced Congestion Cost		•	•	•									•	•	•	•
	T&D Capital Savings	Deferred Transmission Capacity Investments	•	•	•	•									•	•	•	•
		Deferred Distribution Capacity Investments			•								•	•	•	•	•	•
		Reduced Equipment Failures	•		•						•	•						
	T&D O&M Savings	Reduced Distribution Equipment Maintenance Cost									•							
		Reduced Distribution Operations Cost						•		•								
		Reduced Meter Reading Costs											•					
	Theft Reduction	Reduced Electricity Theft											•					
	Energy	Reduced Electricity Losses								•			•	•	•	•	•	
	Electricity Cost Savings	Reduced Electricity Cost													•	•	•	•
Reliability	Power Interruptions	Reduced Sustained Outages					•	•	•		•	•	•			•	•	•
		Reduced Major Outages		•					•				•	•				
		Reduced Restoration Cost					•	•			•	•						
	Power Quality	Reduced Momentary Outages										•					•	
		Reduced Sags and Swells										•					•	
Environmental	Air Emissions	Reduced CO_2 Emissions				•		•		•			•		•	•	•	•
		Reduced SO_x, NO_x, and PM-10 Emissions				•		•		•			•		•	•	•	•
Security	Energy Security	Reduced Oil Usage (not monetized)						•			•		•					•
		Reduced Wide-scale Blackouts		•	•													

3.1.5 INTERNATIONAL DRIVERS FOR SMART GRID

There are varying reasons for different countries to develop Smart Grid. Drivers, such as reliability and power quality improvements, reducing operation and maintenance costs, and improved revenue collections and loss reduction are among the main reasons for such deployments. While there are many common drivers, there are also several differences as each region and country has its unique reasons for the deployment of Smart Grid. Appendix A contains Smart Grid drivers identified by the International Smart Grid Action Network (ISGAN)[28] and other organizations such as ESTA International.

In a study and survey of international drivers, ESTA International identified some of the main drivers as depicted in Figure 3-5. The respondents include participants from six continents. The study showed that drivers for countries with more developed power systems (including policy and regulation), such as Canada, European countries, and those in Oceania, indicated higher emphasis on integration of Renewable Energy, demand response, environmental concerns, and consumer choice while other regions are more focused on the basics of improving reliability, power restoration, and reduction of various losses.

Table 3-3 below shows the top five drivers in each region under study. The color-coding depicts the common drivers among the various regions.

[28] International Smart Grid Network (ISGAN) was established under the auspice of the Clean Energy Ministerial (CEM) of the International Energy Agency (IEA). As of 2014 it has membership from 25 countries.

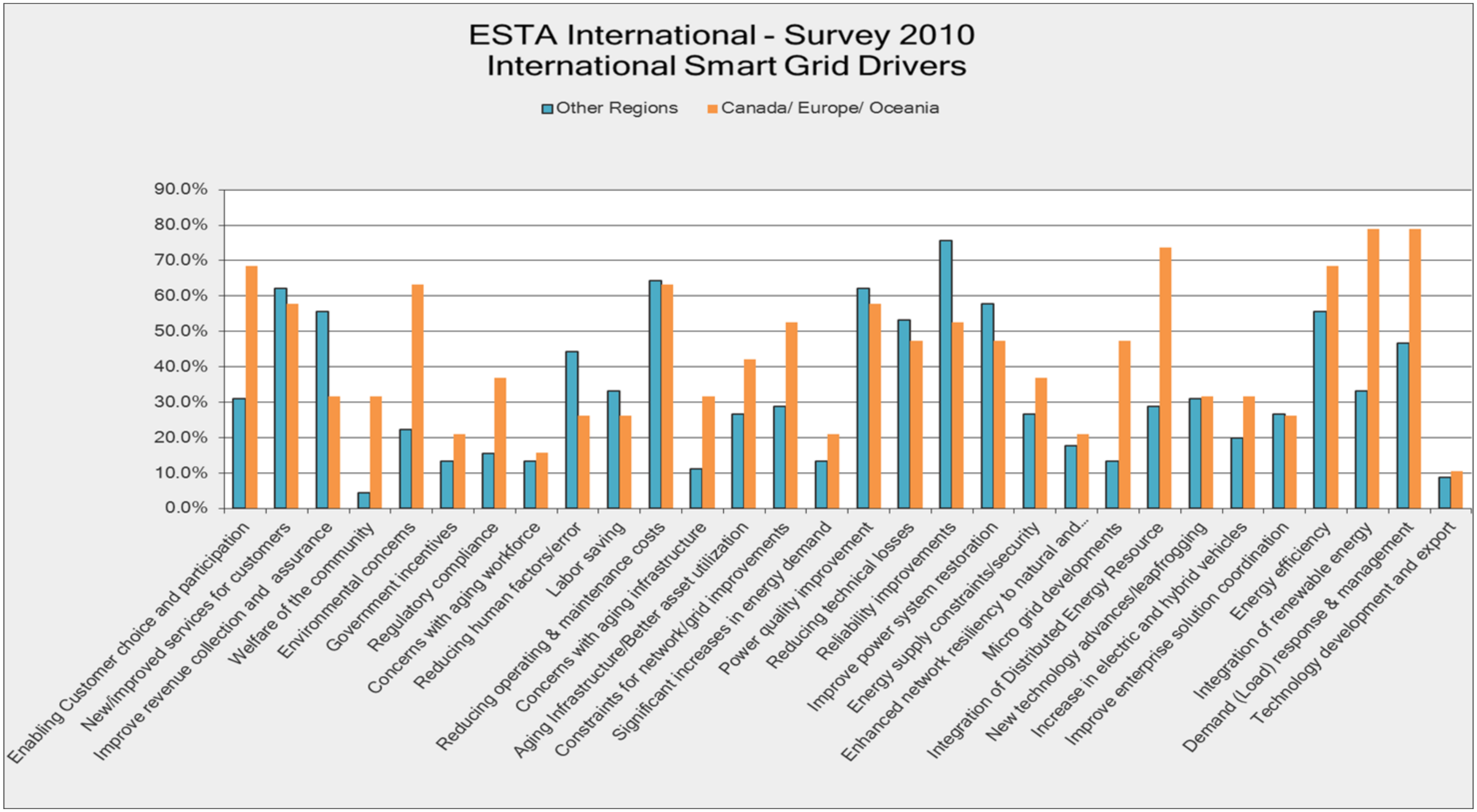


Figure 3-5: Smart Grid Drivers for more developed and developing power systems

Table 3-3: Top 5 Smart Grid drivers in each geographical region[29]

	Latin America and the Caribbean	Europe and Eurasia	Middle East and Africa	Asia & Oceania
1	Reliability Improvements	Integration with Renewable Energy	Optimizing Energy Consumption	Reliability Improvements
2	Power Quality Improvements	Demand Response and Management	Reducing Operating and Maintenance Costs	Power Restoration Improvements
3	Improving revenue collection and assurance; reduction of commercial losses	Reducing Operating and Maintenance Costs	Reducing Losses	Optimizing energy Consumption
4	Power System Restoration Improvements	Integration of Distributed Energy Resources	New and Improved Services for the Customer	Reducing Operating and Maintenance Costs
5	Energy Efficiency	Power Quality Improvements	Improved Revenue Collection and Assurance	Power Quality Improvements

[29] Source: ESTA international survey of International Smart Grid drivers

3.1.6 SELECTED INTERNATIONAL SMART GRID PROGRAMS

The following sections provide information about select international Smart grid programs. Focus has been on countries that have similar power structure to that of Mexico; each has a single utility responsible for transmission and distribution of electricity across the country, one regulator, and IPP programs. In particular, we have highlighted China, France, Ireland, Korea, and Saudi Arabia.

3.1.6.1 CHINA

China has made significant advances in Smart Grid with at a very fast pace. Some have attributed this fast pace of accomplishments to the central decision making approach. Below, we highlight some of the salient features of China's Smart Grid program called "Developing Strong & Smart Grid".

"In China, clean energy has been developing at an unprecedented speed since 2005. The installed capacity of wind power grew from 1270 MW to 17580 MW in 2009, with a remarkable annual growth rate of 92%. The installed capacity of solar energy is also developing very fast, at 44% per year, doubling every two years. The Chinese government pledged to reduce C02 emissions per unit of GDP by 40-45% by 2020, and increase the proportion of non-fossil fuel in primary energy source to 15%. To meet the target, an additional of 130 GW wind power, and 19.70 GW solar power need to be installed, which will require an annual growth of 20% and 40% respectively. In the next decade, clean energy will continue to grow at high speed."

Source: SGCC Framework and Roadmap –Strong & Smart Grid

The Chinese power sector is served by three entities: the State Grid Corporation of China (SGCC), the China Southern Power Grid Company, Ltd., and the Inner Mongolia Power Group.

The SGCC, which is the largest of the three, is responsible for 26 of 31 provinces in China. SGCC has developed a three phase Smart Grid Plan; Phase I (2009-2010) was for planning and pilot projects (trail phase), Phase II (2011-2015) for construction and Phase III (2016-2020) for upgrading and enhancing. Highlights of Smart Grid activities in China include:

- Development of Wide Area Measurement Systems and installation of PMUs at all generation over 300MW and all 500kV substations.
- Implementation of Fiber to the home (FTTH) pilot project in Shenyang, Liaoning Province for communication to meters and intelligent devices in homes
- Building of Electric Vehicle Charging stations in 27 regional and provincial companies as well as 75 public charging stations, 6,209 AC charging spots.
- SGCC released standards to regulate the Smart Grid technology and related equipment production on June 29, 2010 covering areas such as power generation, intelligent transmission, substations, distribution, utilization and dispatch for the implementation of its Smart Grid project.

China has announced 22 criteria for Smart Grid technology, which cover power generation, intelligent transmission, substations, distribution, utilization and dispatch. The announcement also included a 25 billion Yuan investment in 228 Smart Grid pilot projects.

State Grid Corporation of China has focused its Smart Grid vision on the development of a "Strong & Smart" Grid based on an Ultra High Voltage (UHV) grid backbone to:

- optimize energy resources allocation
- improve clean energy access
- meet power demand growth

Figure 3-6 shows China's visualization of Smart Grid[30].

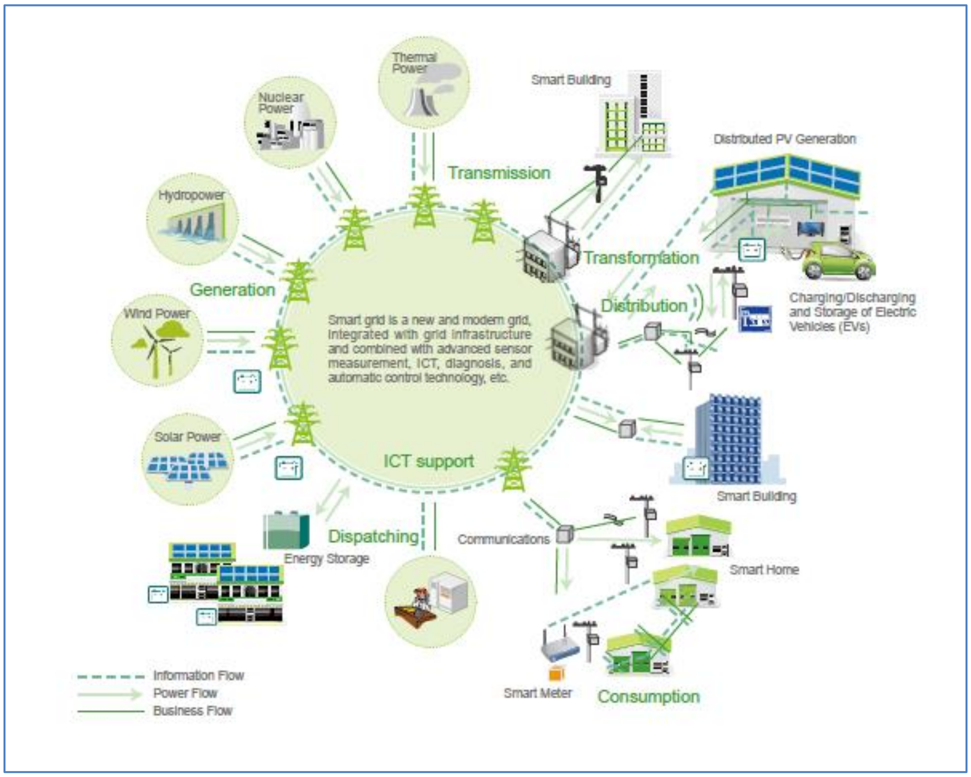


Figure 3-6: China's visualization of Smart Grid

The SGCC proposed UHV grid backbone is coordinated development of subordinate grids at all levels; each being IT-based, automated and interactive.

Figure 3-7, Figure 3-8, Figure 3-9 and Figure 3-10 below from "*Developing Strong & Smart Grid roadmap- the Best Practice of State Grid Corporation of China*" show the various aspects of the envisaged SGCC Smart Grid program.

[30] *Developing Strong & Smart Grid roadmap- the Best Practice of State Grid Corporation of China*"

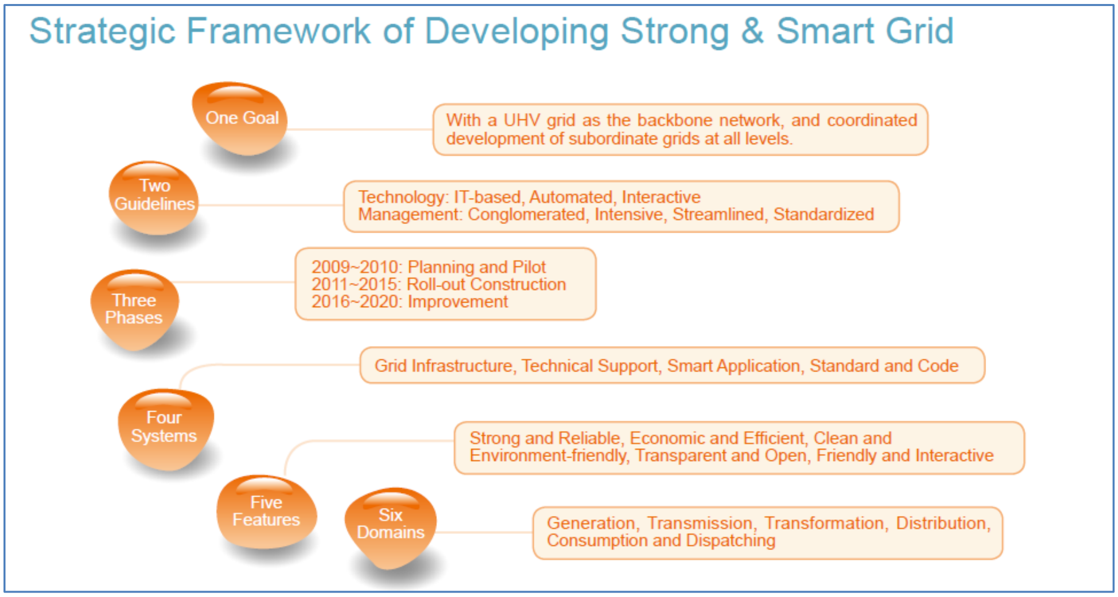


Figure 3-7: China Smart Grid Strategic Framework

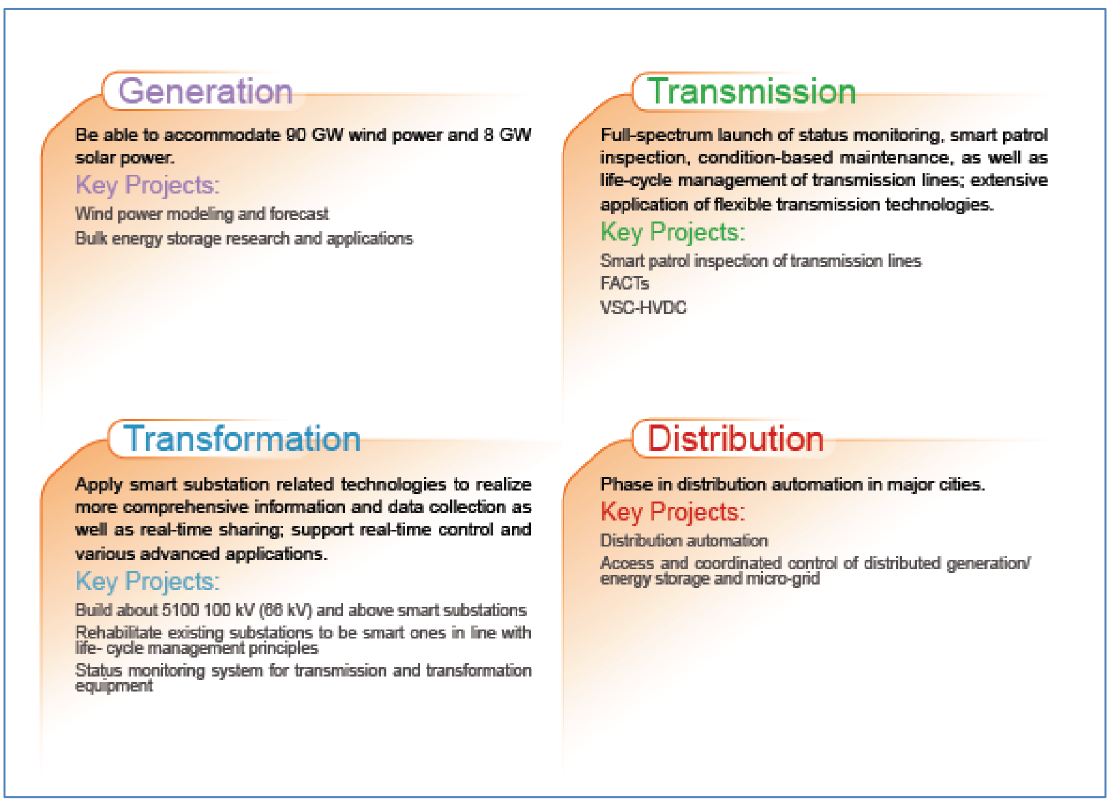


Figure 3-8: China key projects 2011-2015

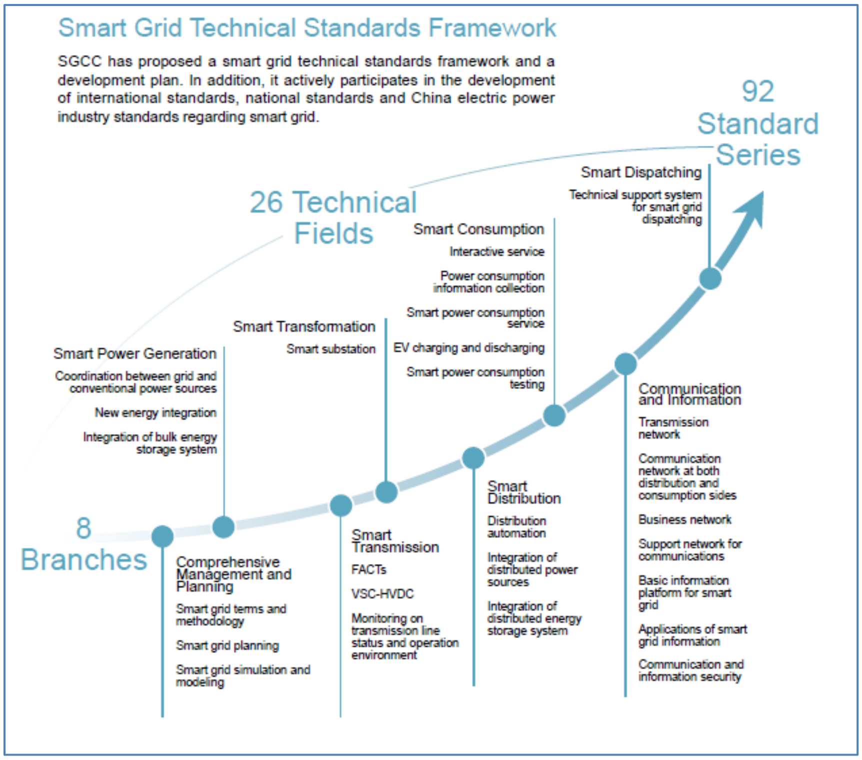


Figure 3-9: China proposed Smart Grid Standards

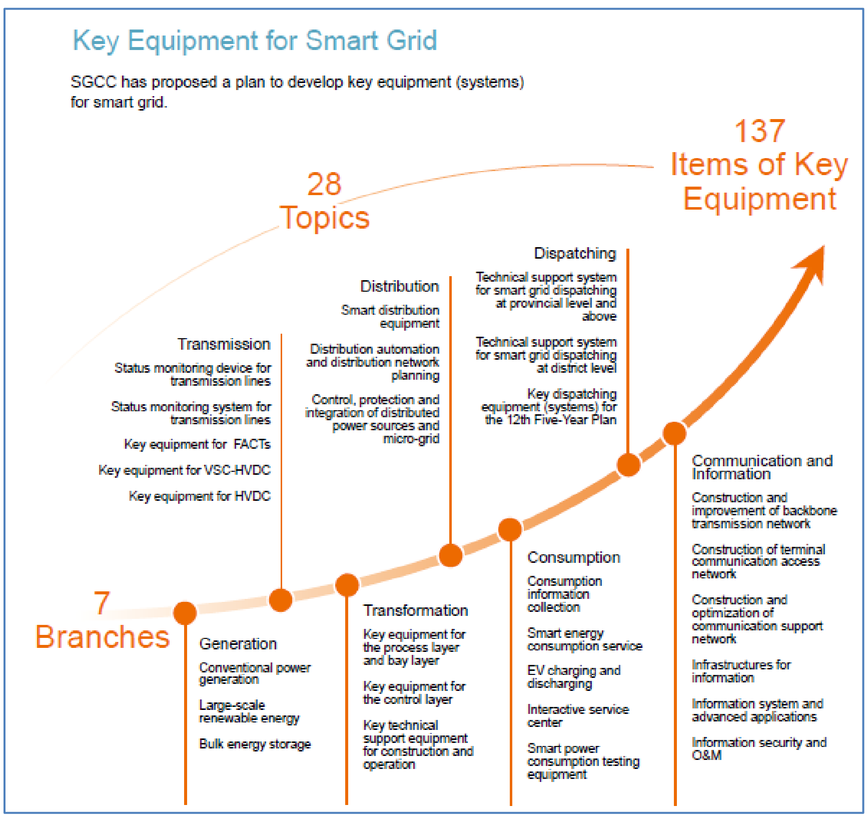


Figure 3-10: China proposed key equipment for Smart Grid

3.1.6.2 FRANCE

The electricity sector in France also has many similarities with the structure of the Mexican electricity sector. In the published Roadmap titled "Roadmap *for smart grids and electricity systems integrating renewable energy sources*"[31] four broad challenges are identified that provide the framework for the vision, bottlenecks, and the need for research and development. These challenges are as follows:

- Challenge 1: Attain emissions reduction objectives for greenhouse gases set for 2020 (20% reduction) and for 2050 (factor 4), notably via energy efficiency schemes;
- Challenge 2: Compliance with European objectives for the integration of renewable energy;
- Challenge 3: Maintain quality and security of supply in the electricity system, and
- Challenge 4: Consideration of social issues related to electricity supply.

The Roadmap considers two timeframes – up to 2020 and up to 2050.

- The time frame up to 2020 is focused on attaining European objectives (20/20/20)[32] while maintaining high quality supply and system security, and

- The 2050 time frame allows for contrasting representations of future electricity networks and systems, based on the unfolding of trends identified in the 2020 time frame, subject to different regulatory options envisioned for grids and electricity systems.

The Roadmap identifies three key drivers that, in the long term, will play a determining role in the form and nature of Smart Grids and electrical systems.

1. The degree of intelligence in the electricity system and grids, and the range of products and services associated with this capacity;
2. The degree and type of decentralization in the system and grids, and
3. Regulatory choices, business models and the role of players affecting Smart Grids and electrical systems.

Variation in the parameters of the different key drivers (intelligence, decentralization, regulation) leads to four contrasting visions of the electricity system and networks. Two visions for the 2020 timeframe and two visions for the 2050 timeframe as follows:

1. Vision 2020 – 1: Demand flexibility and storage facilities coupled to large-scale intermittent generating capacity;
2. Vision 2020 – 2: Demand flexibility and management of dispersed storage;
3. Vision 2050 – 1: Demand flexibility, storage and Distributed Energy Resources (DER) in a centralized grid architecture, and
4. Vision 2050 – 2: Demand response and DER in smart clusters.

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[31] Source: http://www2.ademe.fr/servlet/getBin?name=EA7316C69FBD6C4A1AF9FD685A474A941260278372367.pdf

[32]The EU Energy and Climate Package that passed in 2008, establishes 20-20-20 targets for 2020 in three key areas of: CHG emissions (20% reduction compared to 1990 – up to 30% if other developed nations mandate), Renewable Energy (20% renewable energy in the EU 27 energy mix), and Energy Efficiency (20% reduction in primary energy usage from 2020 forecasts). This package and the European 3rd Liberalization package (passed in 2009) which, mandated implementation of Smart Meters for 80% of the customers by 2020 if possible, have accelerated the developments in Smart Grid in Europe

3.1.6.3 IRELAND

The Irish electricity industry has many similarities with that of the Mexico. It has one regulator for the country, it has one main dominant electricity supplier – ESB - with more than 95% government ownership, and it has one Transmission Operator[33]. It is a single buyer market. Ireland has published three related roadmaps:

1. Roadmap for Smart Grid
2. Roadmap for Wind Energy
3. Roadmap for Electrical Vehicles

Ireland defines Smart Grid as "*A Smart Grid is an electricity network that can cost efficiently integrate the behaviour and actions of all users connected to it – generators, consumers and those that do both – in order to ensure economically efficient, sustainable power system with low losses and high levels of quality and security of supply and safety*."

The Smart Grid objectives include:

- *"Decarbonisation of electricity - with annual savings of over 13 million tonnes of CO_2 by 2050. Eight million tonnes of this will be derived directly from the implementation of smart grid. A further five million tonnes will come from the displacement of fossil fuels due to the electrification of transport and thermal loads, facilitated by the smart grid;*
- *Greater integration of indigenous renewable energy sources will see a net reduction in energy imports in excess of 4.3 Mtoe[34], [equating to savings of €3.2-7.2 billon in direct fuel offset by 2050];*
- *Increasing the electrification of thermal loads in the residential and services sector will see an annual demand in this sector in excess of 28,000 GWh by 2050;*
- *Electrification of transport, predominately in the domestic sector, will be expected to provide an annual demand close to 8,000 GWh by 2050;*
- *Overall annual electrical final energy demand will be in excess of 48,000 GWh by 2050 with a corresponding peak demand of 9 GW. On-shore wind generation will be able to supply up to 33,000 GWh of the total demand;*
- *By 2025 Ireland will have 1.4 GW of interconnection. Our analysis indicates that a further 1.6 GW of interconnection will be required by 2040;*
- *More than 10,000 Irish jobs will be created by implementation of smart grid infrastructure and its associated technologies.*"

Figure 3-11 below shows the Smart Grid overview for Ireland.

[33] More information about the Irish Electricity Supply Industry could be found in http://per.gov.ie/wp-content/uploads/Document-112-7-12-10.pdf
[34] Million Tons of Oil Equivalent

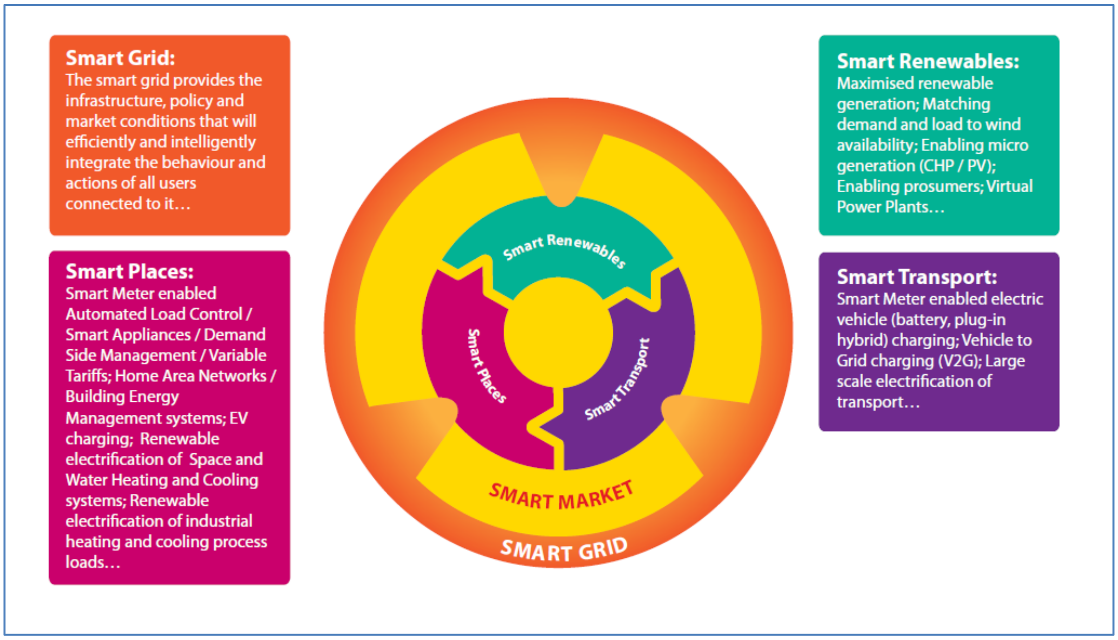

Figure 3-11: Ireland Smart Grid Components

The main components of the Irish Smart Grid Roadmap to achieve the stated de-carbonization goals include:

1. Peak and load shifting and demand side management
2. Reduced line losses, infrastructure improvements, and volt/VAR management
3. Integration of renewable resources
4. Electrification of transport
5. Electrification of heating, cooling, and hot water
6. Electrification of industrial heating/cooling loads

Furthermore, the Smart Grid Roadmap for Ireland calls for the following actions within the next 10 years.

- Establish a test bed facility, strengthening Ireland's position as a leader in smart grid technology research;
- Develop and deploy training courses in smart grid systems and technologies;
- Review of policies dealing with energy and CO_2 ratings of buildings to encourage electrification;
- National rollout of smart meters with DSM and variable Time of Use (ToU) tariffs;
- Develop interoperability standards and secure communications and data protocols;
- Continue grid investment programs, Grid-West, Grid 25, and
- Develop an overlay of secure, high-speed communications onto the electricity system.

3.1.6.4 KOREA

The Republic of South Korea has developed and published Smart Grid Roadmap 2030[35]. The Roadmap has a planned investment of $21.6 billion USD and addresses the following five sectors:

1. Smart Power Grid
2. Smart Consumer
3. Smart Transportation
4. Smart Renewable Resources
5. Smart Electricity Services

Three phases have been identified as follows:

- Phase 1 (2010-2012) Demonstration Complex Development and Operation (Technical Verification)
- Phase 2 (2013-2020) Wide Area Extension (Consumer Intelligence)
- Phase 3 (2021-2030) National Smart Grid Completion (Whole Power Grid Intelligence)

In August 2009, the Korea Smart Grid Institute (KSGI) was established as the secretariat of Smart Grid Initiatives and projects in Korea[36].

Ten Power IT Projects have been linked with Smart Grid Initiatives in Korea. They include:

1. Development of Korean Energy Management System
2. IT Based Control for Bulk Power Transmission
3. Development of Intelligent Transmission Network Monitoring and Operations System
4. Development of Digital Technology based next generation Substation System
5. Development of Intelligent Distribution Management System
6. Development of Power Active Telemetrics for Facility monitoring
7. Development of Consumer Integrated Resource Management System for high value-added power services
8. Development of Power Line Carrier (PLC) ubiquitous technology
9. Development of Power Semiconductor Technology for Distribution Generation and its application in industrial inverters
10. Development of integration EMS for microgrid and application technology to real site.

The Korea Smart Grid Alliance (KSGA) was established in 2009 and brings together over 160 Korean entities. Its goals are to facilitate projects for the establishment of Smart Grid Infrastructure, conducting Smart Grid research and analysis, acting as the mediator between government and private-sector stakeholders, and establishing a system for standardization[37].

Korea is constructing a Smart Grid Test-bed in Jeju Island. KSGI reports that the Smart Grid Test-bed at Jeju Smart Grid will become the world's largest Smart Grid community. It will allow testing of the most advanced Smart Grid technologies and Research and Development (R&D) results, as well as the development of business models. 64.5 billion Won ($58 million USD) was earmarked for investment between 2009 and 2013. Ten consortiums in five areas will participate in testing technologies and developing business models. The grid will incorporate two 10 MW substation transformers and four power

[35] Source: Korea Smart Grid Institute. Green Tech Media Web site.http://www.greentechmedia.com/images/wysiwyg/News/SG-Road-Map.pdf
[36] Source: http://www.smartgrid.or.kr/10eng2-1.php
[37] Source: http://www.globalsmartgridfederation.org/korea.html

distribution lines located near an area with 3,000 households, commercial districts and green energy facilities that include a wind farm to see how Smart Grids can change everyday life.

South Korea has earmarked 9 trillion Korean won ($7.75 billion USD) to build a 1-gigawatt offshore wind project in the Yellow Sea – the largest offshore wind power complex in the country. The South Korean government will build an initial wind complex consisting of 200 wind turbines, each with a capacity of 5 MW, for a total estimate capacity of 1,000 MW, according to the Ministry of Knowledge Economy as reported by Yonhap News Agency[38].

Korea has also taken an active role in the Major Economies forum on Energy and Climate and along with Italy are the co-authors of the Smart Grid Technical Action Plan[39] published in December 2009.

Several Korean entities including Korean Ministry of Knowledge Economy, Korea Smart Grid Institute, Korea Smart Grid Association, KT, LG, and Samsung have signed a Memorandum of Understanding (MOU) for collaboration with the Illinois Science and technology coalition. Korean partners are providing the initial round of funding for projects in Illinois. These include: Illinois Smart Building Project, Building Energy Management Systems and Distributed Energy Resource Integration, Cyber Security and Grid Trustworthiness, and Global Workforce Training and Development[40].

[38] Source: http://www.ecoseed.org/en/wind-energy/article/8-wind-energy/8026-south-korea-allots-$-7-75-billion-for-massive-offshore-wind-complex
[39]Source: http://www.smartgrid.or.kr/10eng8-2.php
[40] Source: http://www.iti.illinois.edu/news/press-releases/iti-collaborate-korea-smart-grid-security

3.1.6.5 SAUDI ARABIA

The Kingdom of Saudi Arabia (KSA) has recently embarked on a program to develop a Smart Grid technology roadmap with the help of the World Bank. The roadmap is still in its preliminary stages and under detailed review.

The KSA has a similar power structure to that of Mexico at the present. It has one electric utility – they Saudi Electricity Company (SEC). SEC is 75% government owned with 60% generation and all distribution. A newly established Transmission company provides transmission services. Several IPPs provide the remaining power generation needs. As an example, the various stakeholders in the Saudi Arabia power sector include:

- Ministry of Water and Electricity
- Ministry of Finance
- Ministry of Petroleum and Minerals
- Electricity and Co-generation Regulatory Authority (ECRA) – single Regulator
- Saudi Electricity Company
- Saudi Energy Efficiency Center (SEEC)
- Saudi Communications and Information Technology Commission (CITC)
- Saudi Standards, Metrology, and Quality Organization (SASO)
- King Abdullah City Atomic and Renewable Energy (KA-CARE)
- Saudi Aramco (major oil company)
- SABIC(a diverse manufacturing company)

As can been seen, there are many parallels with the Mexican Power sector.

In the draft KSA roadmap, the following have been identified the vision of the KSA Smarter Grid was defined as follows:–

> "*The KSA Smarter Grid increases the efficiency and reliability of electricity system; achieves significant energy efficiency gains among all classes of consumers; empowers consumers; develops local industry and workforce, and enables integration of renewable energy.*"

The Pillars are:

- Enable integration of large scale renewable energy
- Enable effective energy efficiency and demand response programs
- Improve system efficiency and reliability
- Consumer Empowerment
- Local Industry and Workforce development

Time frame for KSA is defined as: Phase I (2014-2017), Phase II (2018-2020), Phase III (2021-2032)

3.1.7 LESSONS LEARNED FROM INTERNATIONAL PROGRAMS

Certain international markets have been deploying Smart Grid technology to achieve regional and local energy efficiency goals. Given its new technology and a lack of regulatory, financial and even social frameworks in these countries have gone and are still going through a pivotal learning phase. Through our research we come across major markets such as the US and the European Union that have not only started implementing Smart Grid technology but have documented their success stories and failures in order to learn from them. Below are a number of key lessons learned from the deployment of Smart Grid technology.

3.1.7.1 THE EUROPEAN MARKET

In 2011 the Joint Research Center (JRC) from the European Commission, launched the first comprehensive inventory of Smart Grid projects[41] to understand the level of investment and current development status of these projects in all its member countries. The report focuses on three main areas of investment; Smart Grid research, development and demonstration projects. In 2013 a new and up-dated version of the report was published as well[42]. Below are a number of key findings which highlight key lessons for consideration.

- **Project Investment and Scale**
    - Total budget collected for projects have been over €5 Billion; a conservative estimate puts Smart Grid investment by 2020 at €56 Billion;
    - Smart meters cover the "lion's share" on investment with about 56%; R&D and demonstration account for a smaller share (€4.4million and €12million respectively);
    - Creating a business case for private investors is still a challenge; about 55% of the total budget comes from various sources of funding (national, EC, regulatory) while 45% from private capital;
    - Smart meter investment in member countries is over €4 Billion, with Italy and Sweden leading the way and projected capacity of over 170 million smart meters by 2020;
    - The price per smart meter varies widely due to scale, functionality communication technology and location conditions; between just under €100 to €400;
    - Distribution System Operators (DSO)'s intervention is crucial on deployment with 27% of all projects and 67% of investment.

- **Geographical distribution**
    - The fact that these projects are not uniformly distributed across Europe makes trade and cooperation more difficult and could jeopardize the timely achievement of the EU energy policy goal.

- **Multidisciplinary Cooperation**
    - Due to the increased complexity, these type of projects need multidisciplinary cooperation to share competencies and reduce risks;
    - As a result, there has been good number of cooperation agreements between utilities, private investors, universities and research institutions, manufacturers and IT and Telecommunication companies;

[41] Source: JRC Report 2012
http://ses.jrc.ec.europa.eu/sites/ses/files/documents/smart_grid_projects_in_europe_lessons_learned_and_current_developments.pdf
[42] Source: JRC Report 2013 http://ses.jrc.ec.europa.eu/sites/ses.jrc.ec.europa.eu/files/documents/ld-na-25815-en-n_final_online_version_april_15_smart_grid_projects_in_europe_-_lessons_learned_and_current_developments_-2012_update.pdf

  - Multi-utility configurations (combining water, gas and electricity) have been tested but there is still uncertainty on the additional benefits in comparison to the cost.

- **System Integration**
  - Benefits are systemic in nature and come from the combination of technological, regulatory, economic and behavioral changes;
  - A significant investment has been made on projects that address the integration of different Smart Grid technologies and application;
  - Most technologies are known but the integration of these is the challenge.

- **Role of Regulation**
  - Current regulation provides incentives to improve cost efficiency by reducing operation costs rather than upgrading to a smarter system; this should be revised to change incentives;
  - Regulation should ensure a fair sharing of costs and benefits in the set-up of service-based market platforms; current regulation states that the network owner/ operator must sustain the majority of the upfront investment whereas several players might get benefits when market platforms become operational.

- **Consumer Awareness and Participation**
  - Most projects highlight the involvement of consumer towards the beginning of the project to give them the freedom to choose their level of involvement and to ensure data privacy and protection;
  - While the majority of projects are focusing on consumer engagement (pilot studies with under 2000 consumers; some are volunteers and not representative of the actual population) there is still a significant amount of consumer resistance;
  - While the main reasons that motivate consumers are reduction of their electricity bill and environmental concerns, below are some other not typical yet important reasons:
    - Energy savings;
    - Reduction of outages;
    - More transparent and frequent billing information;
    - Participation in the electricity market via aggregators;
    - A better business case for the purchase of electric vehicles, heat pumps and smart appliances.

- **Contribution to Energy Policy Goals**
  - These projects are a great contributor to EU energy policy goals;
  - These projects reduce CO_2 emissions and enable the integration of large scale RE projects and increase energy efficiency;
  - Consumers are able to produce power; improves the competitiveness of the system
  - Contributes to the security and quality of supply;
  - Information-sharing and dissemination between projects and regions is critical to keep growing and advancing forward.

- **Obstacles**
  - The most important obstacles to implementation of these projects come from the lack of policy-related, social or regulatory framework, rather than from the technical side;
  - There is still some uncertainty over the role and responsibilities of key players.

- **Privacy and Security (for more information see section 2.8)**

- Addressing interoperability, data privacy and security is a priority requirement;
- Standardization developments.

Smart Metering in the European Union[43]

The private sector has been very active in the pursuit of Smart Grid investment in the European Union. These organizations are investing in this technology at different levels of their value chain and are capturing great benefits such as, reducing their operating expenses and are better prepared to serve their customers.

Other benefits include:

- Reduction of nontechnical losses
- Introducing remote reading, activation and deactivation of service
- Switching or simplifying billing
- Reduction of power theft
- Improved management of bad-payers
- Faster power outage detection
- Future benefits from dynamic pricing to consumer have not yet been achieved but may be expected to materialize in the future.

Examples of Smart Meter investments in Europe;

- *The **Telegestore project**; Enel has gained approximately €500 million in yearly savings, with a 5 year payback period, and a 16% internal rate of return;*
- ***Storstad Smart Metering project**; The period for settlement of balance power was reduced from 13 to 2 months after the delivery month;*
- ***Telegestore**; Contribution to a decrease in the SAIDI index (System Average Interruption Duration Index) from 128 min to 49 min, and a consequent decrease of cash cost/customer from €80 to €48 from 2001 to 2009;*
- *With the **Telegestore** Project, Enel managed 3,027,000 bad payers in 2008;*
- ***Project AMR**; Lead time for exporting meter readings to suppliers was shortened from 30 days to 5 days;*
- ***Storstad Smart Metering project;** Over a two year period, the number of calls for both meter-reading and invoice related issues dropped by 56%*

[43] Source: JRC Report 2012 http://ses.jrc.ec.europa.eu/sites/ses/files/documents/smart_grid_projects_in_europe_lessons_learned_and_current_developments.pdf

3.1.7.1.1 European Union Regulatory Framework; Lessons Learned

In 2011, the Council of European Energy Regulators (CEER) published results of a study conducted to understand the regulatory framework and potential issues when developing Smart Grid projects. The report focuses on gathering and analyzing information about the regulatory approaches to demonstration and deployment of Smart Grid networks. [44] CEER developed an internal survey to identify the challenges for different Smart Grid stakeholders. The following are categories which could represent challenges or barriers to Smart Grid technology deployment.

I. Terms for taxes, financial inducements and incentives[45]

Three (3) potential challenges related to incentives:

1. Encourage the network operators to choose investment solutions which offer the most cost-effective solution to all network users;
2. Encourage the network operators to choose innovative (i.e. having higher risk) solutions;
3. Encourage efficient use of electricity and/or renewable electricity production.

Smart Grid technology must provide on the one hand, a business case for the investment companies to support power suppliers and on the other hand an economically feasible solution for the public.

II. Involvement and role of different stakeholders and interest groups[46]

Four (4) issues are presented:

1. The roles and responsibilities of relevant stakeholders who do not encourage or block the introduction of new services or markets;
2. Greater active participation in the development of Smart Grids by the stakeholders;
3. Greater involvement in network innovation by research and development institutes; and
4. Lack of involvement of retail suppliers and energy service companies.

III. General conditions and framework (e.g. standardization, regulation elements, implementation mechanisms)[47]

Eleven issues were identified related to standardization, regulation and implementation mechanisms:

1. Existing standards or lack of standards on Smart Grid technology;
2. Regulatory mechanisms that encourage network operators to pursue "business as usual" practices;
3. The existing regulatory framework which does not allow the integration of new services in the electricity networks;
4. Elements of regulation which are not technology neutral;
5. Difficulty for network operators to introduce more advanced structures in their network tariffs to incentivize more efficient network use;
6. The need for improved definition and assignment of roles and responsibilities to stakeholders;
7. Data security and privacy issues;
8. The need to enhance the definition of national objectives and policies at political level,

[44] CEER report with the objective of to gather and analyze information about the regulatory approaches to demonstration and deployment of SG.
[45] Source: http://www.energy-regulators.eu/portal/page/portal/EER_HOME/EER_PUBLICATIONS/CEER_PAPERS/Electricity/2011/C11-EQS-45-04_SmartGridsApproach_6%20July%202011.pdf
[46] ibid
[47] ibid

9. Ineffective implementation of unbundling;
10. Lack of a definition of minimum functionalities of Smart Grid solutions; and
11. Safety legislation unintentionally constraining innovation.

IV. Know-how of market participants[48]

Five issues where identified as follows:

1. The need to enhance the capability of network operators to identify and address the possibilities and limitations of new technologies;
2. The need to enhance the understanding of network operators in relation to the challenges faced, e.g. due to introduction of renewable electricity production;
3. The need to enhance the understanding of retail suppliers and energy service companies of both the possibilities and limitations of new technologies;
4. The need to enhance the understanding of network users (consumers and producers) of both the possibilities and limitations of new technology; and
5. The availability of skilled workforce (especially in terms of knowledge of innovative solutions).

Review of Issues

The following were major concerns across all countries:

- Dealing with incentive to improve cost-effectiveness;
- The need to enhance the definition of national objectives and policies and the significant role this plays as well;
- How to encourage operators to choose the most innovative solutions;
- The inadequacy of existing standards on Smart Grid technology.

Other Recommendations presented by the Commission

Recommendation 5 - to encourage the deployment of smart grid solutions, where they are a cost-efficient alternative for existing solutions, and as a first step in this direction, to find ways of incentivizing network companies to pursue innovative solutions where this can be considered beneficial from the viewpoint of society.

Recommendation 6 - to evaluate the breakdown of costs and benefits of possible demonstration projects for each network stakeholder and to take decisions or give advice to decision-makers based on societal cost benefit assessment which takes into account costs and benefits for each stakeholder and for the society as a whole.

Recommendation 7 - to ensure dissemination of the results and lessons learned from the demonstration projects in case they are (co-)financed by additional grid tariffs or from public funds to all interested parties, including other network operators, market participants, etc.;

[48] bid

3.1.7.2 THE USA

In July 2011, the Department of Energy's Office of Electricity Delivery and Energy Reliability (OE) co-sponsored, together with electric utilities from the Northeast, a series of workshops with the intent to engage all major Smart Grid stakeholders. In a series of dialogues, this group highlighted major areas of concern and key lessons learned from the existing technology[49].

- **Improved Outage Management Systems**; typical response time to outages are decreasing and options for managing demand are growing;
  - New technology allows for syncing GIS, SCADA and meters allowing for better and more granular information;
  - Technology has been able to help utilities with the "*it's the utility fault*" problem; customer service professionals are able to obtain more granular data and explain to their clients the reasoning behind high-billing.

- **One size does not fit all**; some markets are more developed than others and have grown organically by making a business case based on cost savings. While not all technology is alike when deploying Smart Grids, the approaches to implementation are very similar.

- **Engaging the customer** is important and crucial to the potential energy savings. Successful programs have informed the customer of the new changes that are taking place and the benefits they will get from these necessary changes. Some recommendations were:
  - A successful campaign called *"Voice of the Customer"* looks to address customer's issues and inform them of the changes. Although encountered with some resistance and pushback from customers, utilities found that the more informed and better understanding of the technology will result in customers being less likely to oppose it;
  - Utilities must understand market segmentation and develop a marketing plan that is appealing to the target population;
  - In one case, negative press from the community resulted in an opportunity for a utility to transform an opposing group by deploying credible and reliable information. Transparency is fundamental to gain the customer's trust;
  - Visibility of Smart Grid deployment in mainstream media is increasing every day and very important to engaging with the customer. Social media is another way to interact with consumers;
  - When communicating with the customer, it is important to be conservative in all savings estimates. When dealing with "*avoided cost*" the conversations are a little more complex; utility employees must be well trained in these types of conversations;
  - Some utilities have developed "*SWAT teams*" to deal with hot topics and time-sensitive questions;
  - "*address the vocal minority*" was another successful campaign;
  - Success stories of peak reduction of 17% and zero unresolved customer complaints were also shared in the meeting.

- **The changing role of utilities** to a technology systems integrator. Utilities are no longer only power providers but their role is getting increasingly more complex moving them to new operating modes.

[49] Source: http://www.smartgrid.gov/sites/default/files/Northeast_Regional_Report.pdf

  - Utilities have been increasingly dealing with Smart Grid vendors; understanding the vendor's roadmap and where they are in the development life cycle would make technology integrations easier;
  - Utility employees should be trained in different areas of the business as these technologies permeate across the organization. Some utilities are training their employees in outage management, understanding in-home devices and so on;

- **Identifying New Metrics:** These Smart Grid stakeholders have identified new metrics that will lead to a more comprehensive and more objective measurement of success when deploying Smart Grid projects; these metrics are[50]:
  - Energy (kWh) and dollars;
  - Rates of complaints and opt-outs;
  - Awareness levels (measured via focus groups / surveys). The question was raised about how to build this into long-term plans, and how to use it to establish important strategic partnerships with key stakeholders;
  - Number and usage of customer service products and programs;
  - The running ratio of call rates versus web-based customer interactions; and
  - Relative customer satisfaction to outage response (compared to previous baselines).

Investing in the US Economy; Stimulus Package:

In 2012, the US DOE released a report on the *Economic Impact of American Reinvestment and Recovery Act (ARRA) Investment in the Smart Grid*[51]. The key objective of this study was to understand the flow of funds through the Smart Grid projects and related industries and vendors who benefited from these funds as well as to get a better understanding of the economic impact this investment in Smart Grid technology had on the US economy as a whole. This investment serves a dual purpose;

1. Provide economic stimulus and job creation in the US;
2. Further support DOE's mission to modernize electricity infrastructure to advance the nation's economic prosperity and security.

Key Findings

- As of March 2012 the total investment was of $3 billion, generating at least $6.8 billion in total economic output;
- Smart Grid deployment positively impacted employment and labor income;
  - Over 47,000 full time equivalent jobs were supported by the investment, of these, 12,000 jobs were directly impacted and 35,000 indirectly impacted.
- Investment in core Smart Grid industries supported high-paying jobs;
  - Examples of benefited industries include computer system design, technical and scientific services and consulting and electrical/ wireless equipment and components manufacturing.
- The GDP multiplier for Smart Grid investment is higher than many forms of government investments. For every $1 million invested, GDP increased by $2.6 million; one of the highest multiplier effects on the economy.

[50] Source: http://www.smartgrid.gov/sites/default/files/Northeast_Regional_Report.pdf
[51] Source: http://www.smartgrid.gov/sites/default/files/doc/files/Smart%20Grid%20Economic%20Impact%20Report.pdf

3.1.7.3 LATIN AMERICA AND THE CARIBBEAN

The ESTA International survey offered a selection of 32 possible drivers for Smart Grid in Latin America and the Caribbean (LAC). The 17 participants from 9 countries[52] identified the following as the top drivers for Smart Grid programs at their respective organizations:

1. Reliability Improvements
2. Power Quality Improvements
3. Improving revenue collection/assurance and reduction of commercial losses
4. Power System Restoration Improvements
5. Energy Efficiency

There is no full-scale implementation/roll-out of Smart Grid in LAC to date. While there are a select number of demonstration/pilot programs underway, most utilities are currently in the initial phases of Smart Grid and reviewing their Smart Grid programs. ESTA International survey showed that while 25% of the participants have Smart Grid demonstration/pilot programs under way, nearly 50% are at the early stages of reviewing their Smart Grid programs. The remaining 25% are at the other stages (plan to initiate, develop strategy, and develop implementation plan). Most utilities within LAC expect full-scale implementation after 2020.

Top barriers to Smart Grid in LAC are reported to be lack of regulatory incentives for Smart Grid investments, lack or inadequacy of regulatory policies, and difficult cost benefit justification of Smart Grid in various nations.

While the technology components used for Smart Grid used vary, a majority of Smart Grid programs in LAC include Advance Metering Infrastructure (AMI), Smart Meters, communications network upgrades, substation upgrades, and Advance Distribution Management tools.

The expected challenges of Smart Grid implementation in LAC include concerns for data management and analysis of additional data, integration with other corporate and legacy systems, and speed of the development and adaption of standards.

Within the overall corporate programs and initiatives at utilities in LAC, Smart Grid has mostly medium or high priority. An importance of an initiative can also be measured by the resources and focus applied to the initiative. Several utilities have a dedicated Smart Grid Manager and many are led from the office of CEO/COO/President. Other leaders of Smart Grid programs are the Revenue Protection Group and the Engineering and Planning Department.

Most programs are self-funded while others are cost shared with governmental support. As an example, in Brazil, Federal Law No. 9.991 passed in 2000 and later revised in 2004 mandates that 1% of each utility's net revenues be used for R&D program. For Distribution Companies, 50% of this amount is for Energy Efficiency programs, 20% for R&D programs directly for the utility with approval of the Brazilian Electricity Regulatory Agency (ANEEL), and remaining 30% contribution to governmental R&D programs. For Transmission and Generation companies, in lieu of energy efficiency programs, 40% of this fund is for R&D directly for the utility and the remaining 60% for governmental R&D programs. The CEPEL was created through such funds. The directly related R&D programs are becoming a source of funding for Smart Grid innovation in Brazil.

[52] Participants from LAC included: Mexico, Colombia, Ecuador, Peru, Brazil, Argentina, Jamaica, Barbados, Trinidad & Tobago

The World Bank and Inter-American Development Bank have also financed Smart Metering projects in the region. The role of government varies within the LAC countries. While a few are central drivers for Smart Grid policies and provide grants, most are analyzing Smart Grid and have not made any directives yet. Most Smart Grid activities have been driven by utilities.

Most utilities look to international organizations such as the Institute of Electrical and Electronics Engineers (IEEE) and the International Electrotechnical Commission (IEC) as well as local institutions for standards.

3.1.7.4 ASIA AND OCEANIA

Electric utilities in Asia and Oceania serve nearly one-half of the world population. The total consumption for the region is nearly 6,000 billion kWh per annum – nearly 1.5 times that of the USA. China leads the region with 2,834 billion kWh of annual consumption[53], followed by Japan (1,007 billion kWh), India (568 billion kWh), South Korea (386 billion kWh), and Australia (221 billion kWh). These five countries account for nearly 80% of the total consumption in the region.

The power sector in the region has undergone varying levels of deregulation/liberalization. Some countries have fully deregulated/liberalized with various stakeholders at generation, market, and retail level (e.g., New Zealand, and New South Wales and Western Australia). Others are government owned under central government control (China). Several countries continue to operate with vertically integrated utilities (Japan), yet others have a mix of governmental entities and private sector entities.

Literature research and the results of the ESTA International survey show that Smart Grid is an important element of power system strategies in the region and many utilities and national governments have actively championed Smart Grid programs. Governmental entities in China, India, Japan, South Korea, Singapore, Australia, and New Zealand have all taken active roles in promoting Smart Grid development in their respective countries. Industry, especially in Japan, and Korea play an import role in Smart Grid as well. In other countries, Electric Service Providers drive Smart Grid initiatives.

The ESTA International survey offered a selection of 32 possible drivers for Smart Grid. Over 50% of the 20 participants from 12 countries identified the following drivers as the top drivers for Smart Grid programs at their respective organizations:

1. Reliability Improvements
2. Power Restoration Improvements
3. Optimizing Energy Consumption
4. Reducing Operating & Maintenance Costs
5. Power Quality Improvements
6. Reducing Technical Losses
7. Energy Efficiency
8. Demand Response and Management
9. New/improve services for customers
10. Integration of Distributed Energy Resources
11. Improve revenue collection and assurance

[53] Source: http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=2&pid=2&aid=2

In 2010, the Asia and Oceania region, nearly one-third of the survey participants were implementing pilot projects. Eighteen percent (18%) were reviewing Smart Grid while 22% planned to initiate Smart Grid Programs. Others were developing their strategy or have a plan of action in place.

Top barriers to Smart Grid were reported as: difficult economic benefit justification, lack of regulatory incentives, lack of or inadequacy of policy, technology maturity, and shortage of knowledgeable local resources as the top five barriers.

A majority of Smart Grid programs in Asia and Oceania include: Smart Meters, communications network upgrades, AMI, Substation upgrades, Advance Distribution Management tools, Demand Response Program and Distribution Networks upgrade.

Many respondents expressed concerns for integration with other corporate and legacy systems, integration with other functions, availability of technology, compatibility of equipment, and data management and analysis of additional data as challenges for Smart Grid implementation in the region.

Within the overall corporate programs and initiatives at utilities in Asia and Oceania, Smart Grid has mostly high priority. An importance of an initiative can also be measured by the resources and focus applied to the initiative. Several utilities have a dedicated Smart Grid Managers with active contributions from IT, Engineering, Maintenance, and corporate strategy groups. Some respondents noted the office of CEO and the office of corporate strategy leading their Smart Grid efforts.

Sixty percent (60%) of the programs were self-funded while 35% are cost shared with governmental support. Other sources of funding include international development agencies.

The role of national governments differs in various countries. An equal percentage of participants reported and active government role in providing incentives for Smart Grid deployment as those reporting no government directives as of yet. Most Smart Grid activities have been driven by utilities.

The majority of the participants[54] look to international organizations such as IEEE, and IEC, as well as NIST and local institutions for standards development. Minor local government involvement in standards was reported in the region. Literature research however, reveals active governmental involvement in China, Japan, and South Korea.

3.1.7.5 MIDDLE EAST AND AFRICA

Middle East is home to over 212 million inhabitants in 14 countries who collectively consume 590 billion kWh of electric energy per annum[55]. Saudi Arabia and Iran lead the region with 165 and 153 billion kWh each, UAE, Israel, and Kuwait roundup the top five energy consumers in the region

Africa is home to 1.033 billion inhabitants in 55 countries with a total electric energy consumption of 515 billion kWh. South Africa leads the region with 215 billion kWh of annual consumption, more than twice the consumption of Egypt with 104 billion kWh. Algeria, Libya, Morocco, and Nigeria each with between 20-28 billion are the other larger consumers in the region[56].

54 Participants did not include Japan and Korea
55 Source: http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=2&pid=2&aid=2
56 ibid

The ESTA International survey offered a selection of 32 possible drivers for Smart Grid in Middle East and Africa. The participants identified the following as the top drivers for Smart Grid programs at the respective organizations:

1. Optimizing Energy Consumption
2. Reducing Operating and Maintenance Costs
3. Reducing Losses
4. New and Improved Services for the Customer
5. Improved Revenue Collection and Assurance.

Most participants are reviewing Smart Grid programs or are currently engaged in related studies. The most advanced program in the region is the Masdar city program under implementation in UAE.

Top barriers to Smart Grid deployment in the region are reported to be high costs, difficult cost benefit justification, and lack of regulatory incentives for Smart Grid investments. Customer education, Smart Meters, Energy efficiency programs, and substation upgrades are reported as the top components of Smart Grid programs in the Middle East and Africa. The expected challenges of Smart Grid implementation in the regions are concerns for customer acceptance, customer awareness, and integration with legacy systems as well as training of staff. Within the overall corporate programs and initiatives at utilities in the region, Smart Grid has mostly medium priority. All programs are self-funded thus far and the governments have not played a role in Smart Grid projects in the region except for South Africa.
Most utilities in this region look to international organizations such as IEEE and IEC as well as NIST and European entities for standards.

3.1.8 International Smart Grid Privacy Programs

This section addresses Privacy and Security concerns when deploying Smart Grids technology; below international case studies and policy recommendations are presented.

A Smart Grid deployment brings many advantages to customers, yet these advantages often can only be realized with the collection of data and other sensitive information concerning consumers' energy usage. This compilation and access to customers' data introduce concerns about privacy. Customer energy data is extremely valuable, as it is foundational to customer engagement, energy efficiency, demand response, enhanced outage management and grid operation. As such, customer energy data is vital for the realization of benefits from Smart Grid investments and stimulating the market. However, the potential for the data to be misused and legitimate customer privacy concerns make adequate protection of customer energy usage data critical is.

Smart Grid projects and smart meters have faced considerable resistance from a small but noisy group of concerned citizens from Germany to Texas. In Europe, which will have an estimated 206 million smart meters by 2020, the concerns vary by country but tend to be more centered on privacy, whereas in the U.S., the anger and confusion is around higher bills and health concerns.[57]

Four dimensions of privacy are considered:[58]

1. Personal information—any information relating to an individual, who can be identified, directly or indirectly, by that information and in particular by reference to an identification number or to one or

[57] Tweed, Smart Grid Concerns: A European View, Aug 26, 2011, www.greentechmedia.com/articles/read/smart-grid-concerns-a-european-view
[58] NIST, Guidelines for SG Cyber Security – Vol 2, Privacy and the SG, Aug 2010

more factors specific to his or her physical, physiological, mental, economic, cultural, locational or social identity

2. Personal privacy—the right to control the integrity of one's own body
3. Behavioral privacy—the right of individuals to make their own choices about what they do and to keep certain personal behaviors from being shared with others; and
4. Personal communications privacy—the right to communicate without undue surveillance, monitoring, or censorship.

Most Smart Grid entities directly address the first dimension, because privacy of personal information is what most data protection laws and regulations cover. However, the other three dimensions are important privacy considerations as well and should be considered by Smart Grid entities.

When considering how existing laws may deal with privacy issues within the Smart Grid, and likewise the potential influence of other laws that explicitly apply to the Smart Grid, it is important to note that, while Smart Grid privacy concerns may not be expressly addressed, existing laws and regulations may still be applicable. Nevertheless, the innovative technologies of the Smart Grid pose new issues for protecting consumers' privacy that must be addressed by law or by other means.

General recommendations to institutions working in Smart Grids have included:[59]

- Conduct pre-installation processes and activities for using Smart Grid technologies with utmost transparency
- Conduct an initial privacy impact assessment before making the decision to deploy and/or participate in the Smart Grid
- Provide regular privacy training and ongoing awareness communications and activities to all workers who have access to personal information within the Smart Grid
- Develop privacy use cases that track data flows containing personal information to address and mitigate common privacy risks that exist for business processes within the Smart Grid
- Educate consumers and other individuals about the privacy risks within the Smart Grid and what they can do to mitigate them
- Share information with other Smart Grid market participants concerning solutions to common privacy-related risks
- Additionally, manufacturers and vendors of smart meters, smart appliances, and other types of smart devices, should engineer these devices to collect only the data necessary for the purposes of the smart device operations

Several case studies of how countries[60] approach the Smart Grid privacy issue are reviewed with a short summary of main points preceded by a table summary. The following case studies identify institutions involved in Smart Grids in those countries as well as the ways in which the different countries have addressed the above mentioned privacy consequences.

[59] Ibid
[60] For USA, Canada, and Australia select states and provinces with privacy programs are presented.

Country	Consumer Control of Data	Opt-in Policy	Requirement of Notice to Consumers	Data has lifespan and then must be deleted	Aggregation Model
European Union	X	X			
USA (Federal level through DOE)	X	X			Varies per state
USA: State of California;	X	X	X	Being considered	
Canada: Ontario Province	X	X			
United Kingdom	X	X		13 months on meter	Being considered
Australia: Victoria Province	X		X		

3.1.8.1 European Union

The European Union has a Task Force headed by European Commission with a committee of multiple government regulatory and private sector energy industry representatives pooled into expert groups. The European Union's Third Energy Package requires member countries to prepare a time table for the introduction of smart metering systems. For electricity, at least 80% of consumers should be equipped with smart meters by 2020 if possible. Yet, every country has to adopt its own Smart Grid regulatory framework. In the case of the Netherlands, the mandate was initially blocked in the Parliament due to privacy concerns.

European Commission Smart Grid Task Force Recommendations[61]

As a base rule, the EU Commission on Smart Grid Task Force is recommending using the approach of Privacy by Design and ensuring that control over data sits with the consumer. This simply means consumers have the right to deny access to third parties, and it is recommended that third parties must wait for consumer affirmation of allowing them access (opt-in policies) rather than the default being consumers must deny allowing third party access (opt-out).[62]

Additional specific recommendations for protecting privacy:[63]

1. Adequate measures must be deployed to physically protect the contents and nature of data related to the consumer in order to protect that consumer
2. The EU should perform a form of Privacy Impact Assessment related to Smart Grid development to determine upfront if a development causes a privacy impact to the public
3. Minimizing the amount of data only to the necessary ones
4. Determine deadlines and timeframes for storage of the data and different types of data usage
5. Procedures for removing / deleting the data
6. Anonymous/ "anonymzing" data approach
7. There must be transparency in all processes and work

[61] Expert Group 3: Roles and Responsibilities of Actors involved in the Smart Grids Deployment, April 2011, http://ec.europa.eu/energy/gas_electricity/smartgrids/doc/expert_group3.pdf
[62] Source: Eurelectric, Regulation for Smart Grids, Feb 2011
[63] Source: Recommendation to EU Commission SG Task Force, Essential Regulatory Requirements and Recommendations for Data Handling, Data Safety, and Consumer Protection, pg. 4.

8. Usage of privacy certifications systems by regulatory bodies over any actor that will have access to the data

3.1.8.2 UNITED STATES OF AMERICA

Task Force headed by US DOE with a committee of many other federal departments. DOE Recommendations:[64]

- Smart Grid technologies can generate very detailed energy consumption information. Because of its detailed nature, such information should be accorded privacy protections.
- DOE notes that consumer education about the benefits of Smart Grid and the use of Smart Grid technologies will be of significant importance to the success of Smart Grid. The pace of deployment will also be important and should not outpace consumer education.
- While utilities need access to this energy consumption data for operational purposes, both residential and commercial consumers should be able to access their own energy consumption data and decide whether to grant access to third parties.
    - Commenters to this proceeding generally agreed that these conditions should include a prohibition on disclosure of consumer data to third parties in the absence of affirmative consumer authorization, and that the authorization should specify:
        - The purposes for which the third party is authorized to use the data
        - The term of the authorization
        - The means for withdrawing an authorization
    - Commenters also generally agreed that authorized third parties should be required to protect the privacy and security of consumer data and use it only for the purposes specified in the authorization, and that states should define the circumstances, conditions, and data that utilities should disclose to third parties.

The US DOE recently conducted a Smart Grid Privacy Workshop[65] with different stakeholders from the electricity industry to outline which "best practices" are currently in place and identify key aspects to address, concerning consumer access and data privacy, during smart grid technology deployment in the US. The following is an outline of key findings:

- The Federal Government should facilitate the development of a consumer data privacy framework. The framework should:
    - Provide guidelines not mandates
    - Be developed through a Collaborative process involving all stakeholder groups
    - Define jurisdictional lines (state versus federal)
    - Define consumer consent
- Develop and compile an information library of ongoing activities that can be used and accessed by all stakeholders
- Determine and promote best practices
- Provide education to consumers to help them understand the value of the data, what consent means and the reason for grid modernization efforts
- Compile and disseminate lessons learned
- The Federal Government should act as a convener to bring together stakeholders to discuss key issues surrounding privacy and share information and solutions

[64] Source: US DOE, Data Access and Privacy Issues Related to Smart Grid Technologies, Oct, 2010
[65] Source: http://www.smartgrid.gov/sites/default/files/doc/files/Privacy%20report%202012_03_19%20Final.pdf

An outline of current activities taking place in the US to address consumer access and data privacy is as follows[66]:

- Establishing a framework for “third-party” access to consumer-specific energy use data
  - General consensus was reached to provide consumer education and empowerment and consumer’s right to control third-party party access.
  - States such as California, Texas and Colorado are now implementing these policies.
- NIST Smart Grid Interoperability Panel
  - The Smart Grid interoperability panel is a public/private partnership of over 700 organizations which draft recommendations to address privacy issues such as “Third-Party” access and a set of “train the trainer” slides to train utilities on the importance of privacy issues.
- Green Button Initiative
  - A technology to provide consumers with simple online access to their energy usage information; this access to information empowers consumers to better manage their energy usage.
- Department of Commerce
  - Working to ensure data privacy, security and copyright while encouraging free flow of information; Published a report- *Commercial Data, Privacy and Innovation in the internet economy: A Dynamic Policy Framework*
    - Establish a “Bill of Rights” to online consumers
    - Develop enforceable privacy codes of conduct
- Future of Privacy Forum
  - An Industry supported think tank which is creating a third party enforcement and seal program to provide additional oversight and assurance for secondary uses of energy data collected from consumers.
  - Provides consumers with an avenue for complaint handling and resolution while providing regulators with another avenue to protect the consumers.
- State Energy Efficiency Action Network (SEE Action)
  - Promotes the use of energy information and feedback to change consumer behavior and achieve greater energy savings by providing tools and resources for regulators and policymakers on data access and privacy issues and by educating, engaging and supporting energy efficiency program adoption.
- National Association of Regulatory Utility Commission (NARUC)
  - Provides a forum where Federal and State Regulators can discuss Smart Grid and Demand Response policies as well as share best practices and technologies.
- Privacy by Design
  - Advocates for embedding privacy principles into an organization’s operations; not only relying on the regulatory framework; with 7 Foundational Principles such as: Proactive-not Reactive, Not trading off privacy for security and end-to-end life cycle protection.

The following were identified as the most significant privacy issues to be resolved to ensure consumer trust and acceptance[67]:

- The need to educate consumers, not just about privacy but the value of data; consumers will need to understand their choice and feel comfortable
- Create privacy protections without stifling the market and innovation

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[66] Ibid
[67] Ibid

- How to “police” the bad actors that don’t protect data
- What does “informed consent” looks like? Who owns the data? Who maintains it? For how long?
- What are the touch points as the data moves? Who has jurisdictional oversight?
- Federal versus State jurisdictional oversight
- Define baseline privacy protection requirements
    - What does informed consent mean? What does it look like?

The USA has also been developing a Voluntary Code of Conduct (VCC) for the industry through the Smart Grid Task Force (SGTF). This VCC is being develop by multiple stakeholders in the industry and will serve as guidelines to address key privacy issues concerning consumer data.

Objective of VCC[68] are as follows:

- Foster consumer trust
- Establishing a common set of practices around data privacy to stimulate the market for energy related products and services.
- Provide a voluntary mechanism that, if adopted by companies, would be legally enforceable through the Federal Trade Commission (FTC) within their existing jurisdiction but would not infringe on or supersede existing state law or regulation.
- Provide privacy protections for consumers with regard to access, use, and sharing of electricity usage and related data.
- Address how currently regulated customer data would be treated or utilized with third party products and services.

The VCC will be a highly visible sign to consumers, signaling that the code adherent is using practices that safeguard customer privacy. Adoption of the VCC code will affect enforcement of applicable laws by the Federal Trade Commission, as explained in this Disclaimer from the FTC on the VCC:

> *“As a point of clarification, regardless of if a company adopts the VCC, the (Federal Trade Commission) FTC can still enforce action if they have jurisdiction over the company. However, the FTC will consider any representation that the company has made or anything the company failed to say. Adoption of the VCC could show that the company has made efforts to handle sensitive data and might be considered favorably.“*

3.1.8.3 USA, State of California

Pursuant to Senate Bill 1476, California became the first State to adopt privacy rules for customer data. At the core of the privacy rules are the concepts set forth in the Fair Information Practice (FIP) principals which were adopted by the Department of Homeland Security (DHS), and are the basis for many other privacy rules. [69]

- These rules apply to electrical corporations, electrical corporations’ third-party contractors, and any other third-parties that access customer data directly from the electrical corporation (i.e., via a utility backhaul network).
- The rules require that electrical corporations provide customers with a privacy notice, detailing the purpose for which data is collected and shared, how the data may be used by the utility, how long the data will be retained, how a customer can dispute errors in the data, and how a customer can authorize a third party to access their usage data.

[68]Proposed Key Elements for the VCC can be found at:
https://www.smartgrid.gov/sites/default/files/Outline_Key%20Elements%202013_3_01finalv2.pdf
[69] California Smart Grid Annual Report to Governor

- The rules require that upon a security breach affecting more than 1,000 customers, the electrical corporation must notify customers within two weeks of such a breach.
- The rules require that electrical corporations annually file a report on all security breaches of customer information, as well as reports on the number of third-parties accessing customer data and the number of times the utility or third-party was not in compliance with the rules with the California Public Utility Commission (CPUC).

Additional description of core outcomes of this Bill[70] is as follows:

- Disclosure - Utilities that collect meter data may not share customers' energy information with any third party without the customer's consent. The only exception is if this data is part of an energy efficiency or demand response program in which the customer participates. In that case, the third party must sign a contract agreeing to implement data protection measures.
- Data security/protection - Utilities and energy service providers must provide security "to protect the personal information from unauthorized access, destruction, use, modification, or disclosure." Also, they must "prohibit the use of the data for a secondary commercial purpose not related to the primary purpose of the contract without the customer's consent."
- Liability - Utilities that release data to a third party with customer consent "shall not be responsible for the security of that data, or its use or misuse" unless the utility has a business relationship with the third party. This removes a major liability concern for utilities.
- Continued use - Utilities are explicitly granted permission to continue using customer energy data for analysis, reporting, and program management.

3.1.8.4 CANADA, ONTARIO PROVINCE

Privacy issues in Ontario are reviewed by the Office of the Information and Privacy Commissioner of Ontario (IPC), an independent body whose role is to "uphold and promote open government and the protection of personal privacy in Ontario" (Information and Privacy Commissioner, 2010). To ensure that privacy is part of the core functionality of the Smart Grid, the Information and Privacy Commissioner of Ontario has advocated that local utilities adhere to Privacy by Design principles (PbD).[71]

The goal of PbD is to ensure "the protection of privacy through the use of privacy enhancing technologies—embedding them into the design specifications of information technology, business practices, physical environments and infrastructure—making privacy the default"[72]. The ultimate goal in Ontario is to have PbD incorporated into the design and infrastructure of Smart Grid systems as a means of protecting Personal Identifiable Information (PII). Policy framework:[73]

1. Smart Grid systems should feature privacy principles in their overall project governance framework and proactively embed privacy requirements into their designs, in order to prevent privacy-invasive events from occurring;
2. Smart Grid systems must ensure that privacy is the default — the "no action required" mode of protecting one's privacy — its presence is ensured;

[70] emeter.com, California's New Landmark Smart Meter Privacy Law, http://www.emeter.com/smart-grid-watch/2010/californias-new-landmark-smart-meter-privacy-law/
[71] Information and Privacy Commissioner, Ontario, Canada, Smart Privacy for the Smart Grid: Embedding Privacy into the Design of Electricity Conservation, Nov 2009.
[72] (Cavoukian, Polonetsky, & Wolf, Smart Privacy for the Smart Grid: embedding privacy into the design of electricity conservation, 2010, p. 276)
[73] Information and Privacy Commissioner, Ontario, Canada, Operationalizing Privacy by Design: The Ontario Smart Grid Case Study, Feb 2011

3. Smart Grid systems must make privacy a core functionality in the design and architecture of Smart Grid systems and practices — an essential design feature;
4. Smart Grid systems must avoid any unnecessary trade-offs between privacy and legitimate objectives of Smart Grid projects;
5. Smart Grid systems must build in privacy end-to-end, throughout the entire life cycle of any personal information collected;
6. Smart Grid systems must be visible and transparent to consumers — engaging in accountable business practices — to ensure that new Smart Grid systems operate according to stated objectives;
7. Smart Grid systems must be designed with respect for consumer privacy, as a core foundational requirement.

3.1.8.5 THE UNITED KINGDOM

There is clear sensitivity of data on consumers' energy usage and the potential to raise privacy concerns for individuals. The UK Program has taken a rigorous and systematic approach to assessing and managing the important issue of data privacy. It is intended to build on safeguards already in place, notably the Data Protection Act 1998, to develop a privacy policy for smart metering data.[74]

The UK approach to privacy is being delivered through:[75]

- The development of a Privacy Impact Assessment for the program
- The development of a privacy policy framework by the program which will protect the interests of consumers and provide them with assurance on privacy
- A Privacy Charter to be developed by suppliers to provide transparency about the new arrangements
- Implementing the framework, for example through changes to licenses.

The UK plans to utilize the PbD approach toward developing these policies. Overall, in relation to data privacy, the following has been proposed as a principle - that consumers should be able to choose how their consumption data is used and by whom, except where data is required to fulfill regulated duties.

This comes with a number of specific proposals to policy:[76]

- From privacy perspective, consumers have a right to expect that any personal data they might have processed about them is kept secure and cannot be accessed inappropriately.
- In particular, we have concluded that there should be a functional requirement for thirteen months of consumption data to be stored within the meter.
- For the majority of smart metering data, it is only when the consumption data is accessed and can be combined with other information relating to an individual that it becomes personal data. The programmer will explore whether there are opportunities for the benefits of accessing this data to be realized without combining it in such a way that it becomes personal data. (“anonymising”).
- The Prospectus proposed the introduction of a privacy charter to address privacy concerns associated with the rollout of smart metering and in line with best practice as identified by the Information Commissioner’s Office (ICO). The Prospectus proposed that the program would work with stakeholders in order to develop this.

[74]United Kingdom, Department of Energy and Climate Change, GB-wide smart meter roll out for the domestic sector, pg. 67
[75]United Kingdom, OFGEM, Department of Energy and Climate Change, DECC, Smart Metering Implementation Programme: Response to Prospectus Consultation, Data Access and Privacy, Pg. 1
[76]Ibid

3.1.8.6 AUSTRALIA, VICTORIA PROVINCE

Energy businesses in Australia must comply with the Federal Privacy Act (1988), which includes the National Privacy Principles. These Principles set clear restrictions on the use, disclosure and storage of personal information. Access to electricity usage data and other information is restricted – compliance with the Act and Principles, including security processes and staff security checks, are mandatory. The collection, use and disclosure of metering data by electricity companies is also subject to strict confidentiality rules set out by the Essential Services Commission's licensing framework and the National Electricity Rules[77].

An independent investigation into privacy issues around Smart Meters, conducted by Lockstep Consulting[78], uncovered no unauthorized disclosures from the collection of personal information associated with the implementation of the Smart Meter program. The report found that:

- Privacy controls are strong and metering data is suitably protected
- The security of Smart Meters is well designed – all wireless links are encrypted and this cannot be disabled, and there are strong security governance practices to prevent access to metering data by third parties without consumer consent
- The industry has adopted good information security standards and practice
- In light of the extra data that will be generated as new applications become available, the study made recommendations about ensuring future compliance with the privacy regime

Other secure mechanisms are:

- Smart Meters, and the associated communication networks being rolled out in Victoria, are equipped with security features to prevent unauthorized access.
- The wireless links between the meters, distributors and home area networks (HAN) are encrypted and this cannot be disabled. The encrypted wireless link between the meter and the distributor does not use the internet, providing further security.
- Electricity companies also have strong management practices in place to prevent access to metering data by third parties without customer consent.

Proposed revision of National and International standards concerning privacy for consumer data:

- IEC/TS 62351 (Parts 1 to 7 inclusive)- Power systems management and associated information exchange – Data and communications security
- IEC/TS 62351 – 8 (work in progress)
- ISO/IEC 2700- Information technology – Security techniques – Information security management systems – Requirements
- ANSI/ISA-99- Security for Industrial Automation and Control Systems
- ITU-T (possibly via ACMA)

3.1.8.7 OBSERVATIONS

Although countries are at different levels of policy development, a common thread for each of the countries reviewed here is (i) maintaining that the consumer is the owner of the data, and (ii) that use of their data should require an opt-in action (the consumer affirmatively approving access to their information) in order to use that data. Other important trends not yet fully determined, are the lifespan of data retention, what data

[77] Source: http://www.standards.org.au/Documents/120904%20Smart%20Grids%20Standards%20Road%20Map%20Report.pdf
[78] Source: http://www.dpi.vic.gov.au/smart-meters/privacy

to include as a set in order to determine the level of personal identification that set gives, and what level of transparency the process of managing this data will have.

3.2 SMART GRID IN MEXICO

CFE, SENER, and CRE each have visions for Smart Grid programs in Mexico. Below is a very concise summary of each program. ESTA has highlighted some observations in 3.2.4.

3.2.1 CFE PROGRAM

CFE developed a draft Smart Grid Roadmap[79] based on five key perspectives:

- **Client** - Enable the Client with better information, in real time and tariff options to be able to manage their consumption and benefit from it
- **Resource Management** - Optimize the use of existing infrastructure and increase process efficiency
- **Operation of the Grid** - Manage the automated operation of the network with information from advanced systems of dynamic analysis and control
- **Sustainability** - Facilitate the integration of renewable generation, electric vehicles and energy storage schemes
- **Information and Communications Technologies** - Implement an efficient business architecture for info and communications technologies, aligned to processes with interoperability and security

The CFE Roadmap envisaged three stages:

- Short-term (up to 2015)
- Medium–term (2016-2020)
- Long-term (2021-2026)

CFE identified activities for each perspective area in each timeframe. Based on its vision and objectives, CFE identified five key priority projects as follows:

1. Lowering power losses in the national system
2. Enterprise Architecture for Information and Communications Technologies
3. Strengthening the customer communications systems
4. Asset Management Systems
5. Institutional system of Geographical Information Systems (GIS)

In the CFE Smart Grid implementation plan, the deployment of electronic meters were envisaged; however, only a fraction in phase II (medium-term) were expected to be AMI-ready with Smart Meter capabilities.

CFE Smart Grid Roadmap plans were placed on hold after the change of leadership which resulted from the presidential elections.

3.2.2 SENER PROGRAM

SENER vision for Smart Grid is based on the National Energy Strategy published by SENER. It highlights:

- Increasing the reliability, safety, sustainability and efficiency of power plants, transmission and distribution lines, structuring and consolidating a set of programs, projects and actions that will make a Smart Grid roadmap.
- Operating under international standards of reliability and efficiency to provide flexibility and to interconnect all types of generation and storage, with a preference for renewable energy.

[79] CFE presented the highlights of the draft to SENER, CRE, and ESTA at the October 2012 Smart Grid meeting in Mexico City.

- Promote the transformation of business processes, based on the development of human capital, as well as an architecture and information infrastructure in a reliable and comprehensive manner to achieve greater customer satisfaction, allowing clients to access various options to services and rates that improve efficiency in consumption.
- Transforming management and traditional operation through the ability to acquire data from devices on the power grid, and then communicate and sort for real-time operational implementation.

SENER further identifies the areas of implementation of the Smart Grid within the National Energy Strategy as

- System Operation
- Generation
- Transmission
- Distribution

National Energy Strategy considers that the Smart Grids could boost the interconnection of renewable energy and reduce the impact on the environment.

In the Distribution area, the SENER vision emphasizes the need for intelligent/Smart Meters as the primary driver for implementing Smart Grid and improving the intelligence of the distribution network.

> *"The development of a Smart Grid (REI) allows increase of the reliability, security, efficiency and flexibility of the grid, while transforming the traditional transaction management and through the ability to acquire data from devices on the power grid, then communicate and sort for real-time operational implementation. Subsequently, it is possible to analyze and convert it into useful information for decision-making, identifying trends, forecasting and strategic planning.*
>
> *In the case of Mexico, the implementation of REI help increase the reliability, quality, renewable energy interconnection and reduce costs by reducing electrical losses and reduce environmental impact."*
>
> *Source:* the National Energy Strategy

3.2.3 CRE Program

Through this project, CRE is refining the regulatory vision for Smart Grid in Mexico. Special focus will be allotted to helping improve the operation of the power system in view of the large amount of Renewable Energy Resources envisaged for the Mexican Power Sector by 2026.

3.2.4 Observations on the Mexican Smart Grid program

All entities within Mexico have a genuine desire to implement Smart Grid in the most efficient manner to improve energy security, enhance reliability, enhance consumer experience, and reduce carbon footprint. However, there are diverging views on the use of Smart Meters in Mexico and the benefits that they may provide to the electric system. While the costs of Smart Meters are still relatively high, there may be solutions and approaches to install a targeted and limited number of smart meters to realize the benefits of Smart Grid. We provide regulatory recommendations in Chapter 4 that address this issue.

In an example of a smart meter installation in Brazil, while the cost of smart meters and the associated communications systems resulted in a cost of nearly US$400 per customer, the payback period of 3 years justified the cost.

The views of CRE and CENACE[80] for integration of Renewable Energy Resources are harmonious. Both parties agree that the regulation can facilitate the introduction of Renewable Energy Resources while reducing the impact on the operation of the network.

3.3 Renewable Energy In Mexico

Renewable Energy is an integral component in a Smart Grid Program. Renewable resources can be integrated within virtually any power grid. The key challenge is the amount, type and locations where renewable resources can be integrated at the transmission, distribution and the end-use levels while playing an effective role in the implementation of a Smart Grid Program. Integration of renewable resources under the umbrella of a Smart Grid program requires a careful and systematic approach.

The discussion of Renewable Energy in this Report considers Mexico's Smart Grid Initiatives by SENER, CFE, and CRE. It also takes into account the former role of SHCP, SE, and other entities in the Mexican Power Sector. Our report also benefits from polices, strategies, and plans highlighted in National Energy Policy (NEP), National Energy Strategy (NES), and National Development Plan (NDP) publications.[81]

This Report considers renewable resource directives of Mexico's National Energy Policy as well as the suitability, readiness, and characteristics of Mexico's power grid. An effective renewable resources program under the umbrella of a Smart Grid program often requires the existence of functioning wholesale and retail markets for electricity. This Report recognizes that Mexico did not have such markets prior the Energy Reform and yet intends to administer an effective Smart Grid program. The recommendations and roadmap are based on the experiences gained by the ESTA Team in California, Texas, Colorado, Nevada and Arizona, as well as copious reports of experiences with Smart Grid around the world.

The prioritized recommendations in this Report collectively constitute the framework and roadmap for an effective implementation of a renewable resources program under the umbrella of a Smart Grid Program.

3.3.1 Suitability of Mexican Power Grid for Integration of Renewable Resources

Renewable Energy is becoming a key component in the resource portfolios of many utilities worldwide; for both large and small utilities. Renewable resources can be integrated within virtually any power grid. The key challenge is the amount and type of such resources that can be integrated at the transmission, distribution and the end-use levels by type and location in a cost effective manner. This means taking advantage of the opportunities to reduce investments in the power grid and increase total system efficiency without endangering the reliability and security of the power grid. Successful implementation of such a renewable resources integration program requires a systematic and formal approach toward integration of renewable resources in combination with various other applications of a Smart Grid program; this can result in increased complexity and increased risks in virtually every aspect of the electric power planning and operation.

The discussion on the suitability of the Mexican power grid for integration of renewable resources has been divided into three subsections. First, the utility scale development, which it is defined at 10 MW[82] or more that are connected to 69 kV or higher voltages, is assessed. Second, distribution level renewable resources

[80]Centro Nacional de Control de la Energía (CENACE).
[81]SHCP- Treasury Ministry; SFP - Controller Ministry; SE - Economy Ministry; NDP - National Development Plan; NES - National Energy Strategy; NEP - National Energy Policy
[82] The industry common lower limit of utility scale Renewable Energy is 10 MW

that are often a few MW and are connected to voltage between 2 kV and 34.6 kV are described. Third, the end-use level is presented, which essentially consists of rooftop solar power plants at service voltages.

3.3.1.1 Utility Scale Renewable Resources Development

The Mexican transmission system is well developed with 400 kV as its backbone voltage and has modern monitoring and control facilities; their staffs are knowledgeable and well trained. We do not expect insurmountable challenges for high penetration of renewable resources at the transmission level.

The Mexican power grid possesses attributes that facilitate development of renewable resources at the transmission level, including but not limited to:

Existing Renewable Resources Program: Mexico already has an established target for its renewable resources program and has a number of existing IPPs generating electricity with renewable resources. It has a process for integrating wind resources. This includes an interconnection process and an established legal framework for trade of electricity.

Experience with Renewable Resources: CENACE has been integrating, operating, and dispatching wind generation since year 2000 and has operating experience with 1,300 MW of wind resources in Southeast region of Mexico.

Advanced Load Forecasting: CENACE has an advanced load forecasting system which delivers 3-day ahead forecasts and also two hours ahead forecasts applications for wind generation and total system load.

Modern Control Center: Mexico has a modern National Control Center with advanced EMS (Energy Management System) and SCADA (Supervisory Control and Data Acquisition System) applications which enable CENACE to monitor the performance of its power grid continuously from the National Control Center in Mexico City with fall back and fail over capabilities. In addition, CENACE has eight regional control centers with similar advanced applications overlooking the national transmission system. Therefore, operational and electrical impacts that are associated with the renewable resources can be detected at early stages and remedial measures can be developed.

Automatic Generation Control (AGC): Mexico's Control Center has an AGC function. It can help reduce the impacts of intermittency that is associated with the operation of renewable resources. It should be noted that many countries do not have AGC and use Load Frequency Control where the impacts of intermittency are more observable.

Ancillary Services: Mexico's Control Center maintains adequate ancillary services and continuously monitors its regulation reserves in both up and down directions. Regulation is the key ancillary service in managing intermittency and the non-dispatchability that are associated with renewable resources. Therefore, any degradation in regulation reserves due to the operation of the renewable resources can be detected at early stages and timely remedial measures can be developed.

Hydro Resources: Mexico has a significant amount of hydro resources. Hydro resources generally have high ramping capability. When water is available, these resources can help manage the intermittency that is associated with renewable resources.

Synchro-Phasors Technology: Mexico has a number of Phasor Measurement Units (PMUs) and a Wide Area Measurement System (WAM) which help the grid operator to observe, monitor, and record events on the transmission system. This system has been in operation for more than two years with high-speed communication backbone capable of collecting time-stamped data from 25 PMUs collecting data at a rate of 50 milliseconds. Additionally, CFE has installed more than 290 PMUs and/or relays that are equipped with a PMU card. The experience gained with the use of PMUs, will be very useful to implement an operative WAM in CENACE to help the secure and stable operation of the SEN. Therefore, degradations that are associated with intermittency can once again be detected and remedial measures can be developed.

Wide and Diverse Geography: Mexico has vast and diverse geography with multiple climatic zones and is surrounded by two oceans. It offers ample primary fuel such as sun and wind for renewable resources both inland and off shore. Mexico's vast geography also offers plenty of opportunities for interconnecting renewable energy resources to its grid.

The Mexican power grid attributes that can create challenges in the development of utility scale renewable resources as well as other Smart Grid applications include but are not limited to the following:

Absence of Wholesale Energy Price Reference: Prior the Energy Reform, Mexico was under a single buyer [83] structure for dealing with IPPs and renewable resources and did not have a competitive wholesale market for trading electricity[84]. Therefore, there was no formal market price signal that could be provided to developers of renewable power. However, CFE calculated a nodal marginal cost called *"Costo Total de Costo Plazo"* (CTCP). CTCP is a variable marginal cost that encompasses generation and transmission. The transmission costs include energy losses and congestions due to the interconnection of the new power plant. CTCP calculations are limited from 69 kV up to 400 kV nodes. The CTCP calculation considers the cost of fuels (natural gas, oil, coal or diesel etc.) including their transport as well as operation and maintenance costs (mainly water consumption, chemical products, ash disposal, lubricants, etc.).

The CTCP does provide some guidance to the developers of renewable power for locating their power plants. However, it is recommended that Mexico develop a "Proxy Locational Marginal Price" or (PLMP) that only considers cost of energy, congestion and losses. Calculation of PLMP does not require a wholesale market and can be accomplished by developing a Full Network Model of Mexico's transmission and distribution systems along with representative costs for year around production for electricity. These calculations must include all nodes from 400 kV all the way to 2.4 kV on at least an hourly basis. The costs associated with operation and maintenance, transportation etc. can remain included in PLMP calculations. Addressing price reference for energy is not only fundamental for the development of renewable resources program, but is also needed for virtually every other function of an effective Smart Grid Program, including offering tariffs based on various pricing options to customers and encouraging them to participate in demand response activities.

Absence of Ancillary Services Price Reference: Similar to energy, Mexico does not have a wholesale market for ancillary services. Many sources of Renewable Energy are not capable of providing ancillary services similar to a traditional generator and will have to rely on the grid operator to provide these services. Experience in the U.S. and elsewhere shows that renewable resources may need a significant amount of ancillary services. It is therefore recommended that Mexico define and establish per unit costs for various ancillary services similar to energy described above based on its own historical incurred costs. These costs could be considered in the context of the new electricity wholesale market as a result of the Energy Reform.

[83] The single buyer scheme applies exclusively to PPA and the new under 30 MW RE PPA.
[84] This doesn't affect at all the Self-supply scheme, which was 15,458.25GWh in 2012

Absence of Transmission Expansion Index: Mexico does not have a transmission expansion cost structure that reflects cost of expanding at various points within the power grid. This can lead into avoidable network upgrades. Once this is calculated, the renewable resources can be credited for locating in areas that have high cost of expansion and require extensive network upgrade.

Absence of Defined Competitive Renewable Energy Zones: Mexico has not yet defined Competitive Renewable Energy Zones (CREZs). Using PLMPs and Transmission Expansion indices, CREZ can be developed for various types of renewable resources such as wind and solar. Mexico can position itself to take advantage of renewable resources to unload its overloaded transmission lines and load transmission lines that have available capacity. This will reduce total investment requirement in Mexico's transmission infrastructure.[85]

Overloaded Transmission System: Overloaded transmission lines can create a challenge in integration of renewable resources. Mexico can unload its overloaded transmission system by instituting a program that recognizes its CREZ for various types of renewable resources.

Little experience with Solar Technology[86]: The current industry trends indicate that utility scale solar technology will be a dominant player among renewable resources technologies. Solar technology comes in various forms including, photo voltaic, concentrated solar power, and solar thermal. The impact of these technologies on the power grid can vary greatly. CFE does not have experience with utility scale solar technology. However, CFE does have experience with small distribution system solar installations. Absence of experience with utility scale solar generation can serve as a major shortcoming as it is expected that solar technologies prevail all other renewable technologies.

Electrical Island in Baja California: Baja California's power grid is not connected to Mexico's main power grid while it is monitored by Mexico's Control Center. Due to absence of this connectivity, its ability to absorb a large amount of renewable resources will be limited. Mexico's plans to connect Baja California to the rest of Mexico's power grid should not only reduce operating costs, but also provide further opportunities for placement and integration of utility scale renewable resources.

Sub-synchronous Resonance: Mexico's 400 kV transmission system is series compensated. Induction type of wind generation and other sources of variable reactive power such as a Static VAR Compensator near transmission lines that are series compensated can potentially create sub synchronous resonance. Sub synchronous can damage the shaft of thermal power plants by creating torsional forces on the shaft of thermal generators and cause it to fracture. An analytical study is needed to determine whether sub synchronous resonance will be an issue for Mexico's power grid.

Voltage and Reactive Power: Many renewable resources are passive sources of generation that lack magnetic flux. Therefore, they cannot support voltage and provide reactive power similar to conventional rotating generators. Most solar resources and gearless type of wind generators are controlled by power electronics equipment which lack overload capability as well as any reactive

[85]Competitive Renewable Energy Zones are established in various places to proactively facilitate the development of renewable resources. In particular, Texas is the pioneer in this area in the United States where the completion of the first set of transmission lines by the end of 2013 will increase transfer capability by about 10,000 MW from west Texas to various population centers.
[86] Most of the experience is in the Distribution area. The vast majority of the solar capacity in Mexico is composed by small generation projects. Nowadays CFE/Distribution is administrating around 1700 contracts which represent 10.4 MW of capacity.

support capability when fully loaded. Therefore, it is recommended that Mexico conduct a study to ensure that providing reactive support is a key component of its renewable integration program.

3.3.1.2 Distribution Level Development

The distribution system within Mexico follows international standards and has primary and secondary voltages and uses voltage regulation equipment at both the substation level as well as line regulators near the actual load to control voltage. We do expect some challenges for high integration of renewable resources at the distribution level. The following includes a list of such challenges when integrating renewable resources at distribution level:

Reverse Power Flow: Integration of renewable resources at the distribution level can cause the flows that are traditionally from substation toward load to reverse on occasions especially during off-peak conditions. The entire distribution system protective equipment and relays are designed based on flows from substation toward the load. With high penetration of renewable resources the distribution system relays and protection must be modified to consider reverse power flows.

Voltage Regulation: The voltage regulation equipment at the substations are also designed to compensate for voltage drop when the flows are from the substation toward the load. Reversal of flows causes the voltage regulation equipment such as tap changers and line regulators to not function properly. Therefore, the distribution engineers must review their voltage regulation facilities and implement the necessary modifications.

Voltage Flicker and Power Quality: Presence of renewable resources near load can cause visible voltage flickers to end-users and power quality issues. The current voltage range in Mexico is +/-10 Volts. It is suggested that Mexico re-examine this standard to account for intermittent nature of many renewable resources.

Limit for Renewable Resources: It is commonly practiced by utilities to impose limits on the amount of renewable resources to be integrated into their distribution levels. This has to do with the fact that renewable resources can cause voltage flickers, reverse flows into the substation and cause voltage regulation devices to malfunction. California utilities limit the amount of renewable resources that can be integrated into their distribution system for reasons that range from power quality to stressing the protective equipment. For example this limit is set at 1 MW for 4 kV systems, 2 MW for 12 kV systems and 5 MW on 20 kV systems. It is suggested that Mexico also develop a similar standard based on the characteristics of its own distribution system to prevent such adverse impacts.

3.3.1.3 End-Use Renewable Development

The consumers around the world are very interested in rooftop solar power development. With rapid price drops, it is expected that many consumers will take advantage of this technology to reduce their electricity consumption. Experiences in California as well as various European countries have shown that high levels of renewable resources penetration at the end-use level can cause the following issues:

High Voltage: Significant roof-top renewable resources can result in high voltages at the consumer end even higher than the substation. This can cause increased reactive power flows and increase losses. A study needs to be performed to determine the maximum amount of renewable resources that can be integrated by the feeder and neighborhood.

Voltage Flicker: Significant penetration of roof-top renewable resources can create visible voltage flicker at the consumer end. Mexico's current distribution system power quality standard of +/-10 Volts may have to be revised. Once again a study needs to be performed to determine the maximum amount of renewable resources that can be integrated by feeder without causing visible voltage flicker.

3.3.2 CHALLENGES IN GRID PLANNING

The planning of the power grid and interconnection of the renewable resources can present a number of unique challenges. Often, the renewable resources are built by private developers that have no obligation to actually construct the power plant and can withdraw their plans at any time. Nevertheless, the obligation to plan and provide reliable and secure services remains on the shoulders of the host utility. The renewable resources do present a number of opportunities to the host utility as well. For example, CFE can use renewable resources to reduce its technical losses, defer investment in new transmission facilities and even eliminate the need for building new transmission and distribution infrastructures. Therefore, the host utility has a vested interest in guiding the developers to select sites that can result in projects that are not only economically viable, but can also have positive impacts on economics of the host power grid. The following is a list of key challenges in integrating mutually beneficial renewable resources:

Creation of Competitive Renewable Energy Zone (CREZ): The host utility such as CFE has the ultimate knowledge on its transmission system. Developers generally do not possess such knowledge and can potentially initiate projects that are not physically and/or economically viable. CFE can define renewable energy zones where transmission capacity is available, the network upgrade requirements are minimal, the transmission expansion is not costly, technical losses can be reduced and the local system can absorb the resulting intermittency. CREZ encourages the developers to locate their power plants in the designated areas, hence encouraging development of electrically and economically viable projects. The concept of CREZ has proven to be highly successful in Texas. The CREZ for Mexico can be defined in consideration of the followings:

1. Proxy Locational Marginal Price or PLMP
2. Transmission Expansion Cost Index to identify areas where expansion is costly
3. Available interconnection and transmission capacity;
4. Requires additional transmission capacity in the near future;
5. High cost of providing services;
6. New power plants can reduce technical losses, and
7. Does not require additional resources such as ancillary services to manage intermittency

Divestment and Retirement Plan: CFE plans for divestment and retirement of 11,707 MW of old and inefficient power plants can also be used by developers to either locate at or near these power plant sites or take advantage of the transmission capacities that becomes available. This information guides the developers to initiate projects that are viable and have minimal impact on Mexico's power grid.

Open Season: CRE already has an Open Season process in place for accepting interconnection applications. The purpose of Open Season process is to create order and the opportunity for the host utility to study interconnection in groups or clusters as opposed to serial and on a case-by-case basis.

Viable Project Identification: One of the challenges of the CFE will be the ability to differentiate viable and serious projects from non-viable and non-serious ones. Experience in California has shown that by conducting studies in phases and requiring posting of substantial security deposits along the way, the host utility can eliminate non-viable and non-serious projects. For example, for Phase I, the feasibility of the individual phases can be studied. In Phase II, a group or cluster of renewable resources will be studied. In Phase III, only the viable and serious projects remain for the final round of study. The participants of this Phase will be required to post a substantial amount of security deposit. This mechanism has proven to be successful in California.

Network Upgrade Financing: Integration of renewable resources can trigger reinforcement of the transmission system beyond the point of interconnection. This is referred to as Network Upgrade. The issue is the financial responsibility for the Network Upgrades costs. In California, Network Upgrade costs are financed initially by the developers and refunded back over a five-year period. The Network Upgrade costs are then passed to the end consumers as a part of the rate base. In Texas, Network Upgrade costs are directly passed on to the ratepayers. In Mexico, the Regulators must decide on a mechanism for financing and capturing network upgrade costs. If the Network upgrade costs are somehow passed on to the developers, a methodology needs to be developed to allocate these costs among the renewable resources that create the need for the Network Upgrade.

Open and Standardized Interconnection Study[87]: The concept of open interconnection study means that the developer is provided with a standard list of studies that the utility will conduct. By openness, the developer is provided with an opportunity to adjust project size to make the intended project economically viable. For example a project at 150 MW may not be economically viable due to significant Network Upgrade requirement while at 125 MW it can become viable.

Deliverability Assessment: Under the Open Season regime, Mexico must ensure that the previously approved renewable resources are not adversely impacted by the interconnection of new renewable resources in following rounds of the Open Season processes. This is referred to as deliverability. Ensuring and preserving deliverability requires the development of a separate methodology. This area has been addressed by CFE.

Interconnection Standards: Most utilities have their own construction standards and CFE is not an exception. For renewable resources new construction standards may be needed. For example, a renewable resource can be interconnected via a tap on a transmission line, a loop or even a breaker-and-half scheme. It is important that the developer understands the type of interconnection that is acceptable to CFE. We understand that CFE already has an Interconnection Handbook. We recommend that this handbook be expanded and to include various renewable technologies and be updated on regular basis to make it more useable for developers of renewable resources. Experience in the U.S. has shown that developers of renewable resources cannot develop accurate cost models for their investment without having well-defined utility interconnection standards. Handbooks are updated as needed to meet the changing needs.

Equipment Certification: Manufacturer and countries have different specification and requirements for renewable resources. It is recommended that Mexico develop a list of equipment that it considers to have the performance that it needs and requires. For example, the California Energy Commission (CEC) has a list of approved inverters for solar power plants.

[87] CFE will be proposing a methodology to determine the cost of this study for approval by CRE

Construction Options: Private construction companies can often build transmission and distribution facilities per host utility standards that are cheaper than the host utility itself. This issue may have not been addressed in Mexico. It is recommended that CFE certify a list of construction companies that can build the power plant as well as interconnection facilities per CFE standards.

Technical Loss Reduction: Renewable Resources have different impacts on the total system losses. In order to encourage development of projects in locations that reduces technical losses, it is necessary to provide the necessary incentives. For example, resources can be credited for their contribution to reduction of losses or penalized when they increase losses. Therefore, CFE may need to develop and administer a "Loss Compensation" program for its renewable program. The proposed PLMP calculation can be the basis for creating a Loss Compensation Program.

Coordination in Long-Term Planning and Integration of Renewable Resources: Experiences with integration of renewable resources in Texas, California and elsewhere have shown that long-term planning of the transmission system and the integration of the new renewable resources should be closely coordinated. This leads into development of least cost and best-fit options to reinforce the transmission infrastructure.

Justification of New Investments in Transmission: Transmission facilities have three basic justifications: 1) for load growth, 2) for reliability and security, 3) for economics. The traditional economic justification for these three categories needs to consider integration of renewable resources. For example, can the need for transmission system capacity be met by placing renewable resources next to it? Can the reliability of the transmission system be enhanced by strategic placement of renewable resources? Can renewable resources lead into more economic operation of the power grid? Overall, the electric utilities and the regulators should develop new methodologies and guidelines that can not only accommodate new renewable resources but also help reduce investment requirements in the transmission system and reduce the cost of utility's daily operation. Further, given the uncertainties that are associated with the development of new renewable resources, the economics of transmission plans have to consider a shorter justification horizon.

3.3.3 CHALLENGES IN GRID OPERATION

Interconnection of large scale renewable resources creates its most challenges in real-time operation of the power grid. While most renewable resources sell their energy under bi-lateral contracts, the host utility remains the backup as well as provider of power, energy and ancillary services to ensure coherent operation of the power grid. The exact challenges that renewable resources place on grid operations are utility specific. However, the key challenges can be categorized as follows:

Forecasting: Short-term forecasting the power and energy from wind and solar power plants is quite challenging. Mexico already has a specialized forecasting tool for projecting wind generation. Forecasting the day-ahead output of solar power plants can be complex and may require specialized tools and methodology. Even with advanced tools and methodologies a simple cloud movement can reduce the output of a solar power plant by 20% or more. This presents significant challenges in planning daily operations and actual operation in real time from both complexity and increased risks perspectives.

Non-Dispatchability: The most common types of renewable resources, such as wind and solar, are not dispatchable, and yet, variable. Therefore, the grid operator needs to account for these non-dispatchable and variable resources and the associated challenge in its daily operation.

Intermittency: The intermittency of most common renewable resources can not only create power quality issues but also increase complexity in real time operation. The grid operator has to ensure that it has adequate ancillary services to manage in intermittency. The ancillary services include governor response, regulation in both up and down directions, spinning reserve etc.

Load Following and Frequency Management: The combination of non-dispatchability, variability and intermittency of renewable resources and removal of conventional rotating generation from the power grid can create considerable challenges in following load. The grid operator may have to commit conventional resources for their high ramp rates in order to be able to follow load and maintain acceptable frequency.

Over-Generation: Power production by renewable resources especially wind is often not coincident with load. This means power production from wind resources can peak during times that the power grid needs it the least. Therefore, there may be periods with more renewable generation than load in the area that may not transfer to the rest of the system. Therefore, the grid operator must develop curtailment plans to request reduction in renewable power production or other less economical resources during over-generation conditions.

Reactive Power Management: The most common types of renewable resources such as solar PV and induction and gearless type of wind generators are passive resources and do not have excitation systems similar to conventional rotating generators. These renewable resources can require up to three stages of voltage transformation prior to the point of interconnection. Every stage of transformation requires reactive power. This problem, intensifies at maximum power production levels since many inverters and power electronics equipment cannot produce any reactive power at maximum output levels. As a result renewable resources often cannot regulate their power factor in an acceptable range, say between 0.95 lag and 0.95 lead, and will drain the power grid from reactive power and can cause overloads that are caused by reactive power and not real power. Therefore, the grid operator must account for locational and system-wide needs for reactive power in real time operations. This will require development of a voltage criteria and a methodology for reactive power management.

Dynamic Performance: As conventional resources are replaced by renewable resources such as solar power plants, rotating equipment will replace rotating equipment with passive and non-rotating resources. This reduces the inertia of the power grid. In addition, unusual flow patterns and even bi-directional flow patterns can emerge. The net impact is that the power system can become less responsive to recovery following disturbances and more prone to under frequency and under voltage load shedding. Therefore, the grid operator must frequently review and revise its operating criteria as the penetration of renewable resources increase.

Increased Forced Outage: The renewable resources do not have the same construction standards as utility equipment and their maintenance is not under the grid operator control. Therefore, the grid operator should expect to see increased forced outages and de-rates that are associated with renewable resources. The grid operator must account for reserves to make up the potential for loss or de-rate of these resources in its daily operation. Alternatively, more coordinated outage scheduling has to be established to improve unit performance and minimize the probability of such forced outages.

Increased Complexity and Operational Risks: The net impact of the above issues is that the grid operator needs to prepare itself for increased complexity and increased risks in daily operation. These increased complexity and risks can be managed by reliance on continuous review and adjustment of the grid operator operating practices. In addition, further cooperation and joint planning with renewable resource developers can enhance daily operation.

3.3.4 Managing Increased Complexity In Mexican Power Sector

The most common sources of renewable, namely wind and solar, produce power intermittently. The penetration of Smart Grid technologies at the end-use level creates loads that are intermittent in nature as well. Therefore, the combination of intermittent generation and intermittent loads create flows in the transmission and distribution systems that will be highly intermittent. This increased intermittency results in increased unpredictability in virtually every aspect of planning and operation of a power grid.

The power industry is currently going through a state of flux with respect to dealing with intermittency. The transition is from an era where planning and operating the power grid was virtually deterministic to a one where every aspect of planning and operating the power grid becomes probabilistic. Probabilistic events by their very nature are more complex to analyze than deterministic events and introduce an element of risk in supporting decisions in planning and operating a power grid.

The electric power industry must manage the additional complexities and the associated risks in planning and operation by relying on the followings:

New Skill Training: The current staff of the electric power industry should be provided additional training to manage the increased complexity of decision-making that is expected as a result of integrating new renewable resources.

Hire New Staff: CENACE may also consider hiring new staff that is skilled in optimization modeling as well as in econometrics/statistical and probabilistic analyses to complement the skills of their existing staff. These skills are needed to address issues related to intermittency, increased complexity and increased risks that are associated with the integration of renewable resources.

New Think Tank: CENACE can benefit from creating a new department or group consisting of staff with new training or new hires that can perform complex problems that are expected to arise as a result of integrating large amounts of renewable resources. This Think Tank can be created by using the services of El Instituto de Investigaciones Eléctricas (IIE).

Higher Reliance on Technology: Additional complexities require precision sensing, monitoring, data collection and analyses of real-time data. The current state of technology makes this possible. The challenge will be the actual implementation of workable solutions and systems.

Develop New Core Processes: The electric power industry in Mexico should develop new core processes that consider risks in the decision support systems. For example with probabilistic analyses, the analysis horizon needs to be much shorter than deterministic analysis with more reliance on actual field data.

Develop Risk Handbook: A Risk Handbook is not a new concept in the power industry and is commonly used in energy trading. A Risk Handbook for planning and operation of an electric utility basically outlines the types of risks various groups within an organization are allowed to take to support planning and operation. The Risk Handbook needs to consider an electric utility's obligation to serve load, quality of service and Loss of Load Probabilities.

3.3.5 Technology Needs for Integration of Renewable Resources

Integration of renewable resources into the Mexican power grid creates a considerable number of challenges for planning and real time operations. Modern technologies can help overcome some of these challenges. This section outlines a list of technologies that can help manage the aforementioned challenges:

Additional Communication: Interconnection of renewable resources into the Mexican power grid will require a strong communication infrastructure using fiber optics with T1, T2 type throughputs. These communication systems will be bi-directional and will be used to monitor the status and output of renewable resources on a second-by-second basis and issue various instructions from the Control Center including curtailments to the individual renewable plants. Likewise, the renewable resources can use these communication lines to submit schedules, provide weather data, report outages etc. For cyber security considerations, it is recommended that all communications on the public internet be encrypted to avoid interception. Installation of a Remote Intelligent Gateway (RIG) is recommended.

Precision Power Plant Output Metering: Operation of a typical Energy Management System (EMS) requires metering the output of renewable resources on a second-by-second basis. High quality precision transducers, Current Transformers (CTs) and Potential Transformers (PTs) will be needed for precision calculation of each power plant output. The EMS will use the communication infrastructure to collect power plant data.

Outage Management System: The renewable resources must inform the Control Center on their general availability, planned as well as forced outages in real time. This requires an Outage Management System. The renewable resources use this system to inform the Control Center on the start and end dates and times of their maintenance schedule, outages, de-rates etc. The Control Center uses this information for internal scheduling purposes.

Scheduling Protocol and Systems: The renewable resources need a system to present their daily schedules to the control center. This requires a scheduling system. The scheduling system can be internet based or be developed by the host utility. The actual scheduling can take place by a scheduling agent, or the renewable resource itself. The protocol for this exchange of information needs to be defined by the host utility for development of APIs (Application Programming Interface).

Weather Data Reporting: The renewable resources are often required to provide locational real-time weather information from the site of their power plant. This weather information is used by the Control Center to account for last minute changes in weather and make necessary corrections to the schedules that have been provided the previous day. Transmittal of this information uses the same communication system that links the power plant to the Control Center.

Forecast of Output: The renewable resources are required to forecast the output of their power plants in MW and MWh a day in advance for scheduling purposes. This requires software and data collection system that the developer needs to either develop or purchase commercially. As an alternatively, CENACE can perform this function for the developers, which is the norm in Texas dealing with renewable resources.

Monitoring Intermittency: The most common sources of renewable resources, such as wind and solar power plants, create intermittency. Therefore, there is a need for monitoring the extent and severity of intermittency and to develop solutions for managing it. The most promising technology to monitor intermittency is the Synchro-Phasor technology and PMUs. PMUs must be strategically placed to monitor and measure intermittency. Software and methodology must be developed to monitor intermittency based on the location of renewable resources and proximity to load centers.

Management of Intermittency: The key challenge here is to measure degradations in intermittency. Unacceptable intermittency and shielding it from load centers can be managed into three ways: first, pricing and committing regulation resources; second, by retrofitting existing resources such as modern Digital Electro Hydraulic (DEH) governor systems, Static Excitation Systems and high response Automatic Voltage Regulators (AVRs); and third, by employing new technologies such as battery and storage, flywheels, Flexible AC Transmission Systems (FACTS) etc. The costs of these improvements may be partially allocated to the renewable resources.

Settlement Quality Meters: The actual financial settlement of wholesale energy transactions must be based on Settlement Quality Meters. These meters are highly precise and can be polled remotely by the Control Center on a routine basis using the communication infrastructure. Settlement Quality Meters are tamper proof and store large amounts of precision information. In addition, they calculate parameters such as reactive power flow that is used to settle related transactions.

Settlement System and Charge Codes: The host utility needs to charge and credit renewable resources for various activities that occur in daily operation. Every activity needs to be defined and a charge code needs to be assigned. At the end of every month the renewable resource needs to be presented with a bill that shows charges or credits that is allocated to the individual renewable resource. This requires a settlements system. Settlement Systems are generally custom made.

Banking and Credit Management: The actual transactions and transfer of funds require a banking and credit management system. This system ensures that the financial obligations are cleared by the required dates and ensures that scheduling of energy is only conducted when the renewable resource have available credits.

3.4 Strength, Weakness, Opportunities, and Threats of the Mexican Power Sector for Implementation of Smart Grid

Prior to the Energy Reform, the authority of CRE laid on the Renewable Energy sector. ESTA has focused on the SWOT analysis of the Mexican Power Sector as it applies to Renewable Energy.

Realization of full benefits from renewable resources requires a careful and methodical approach with proper regulatory oversight. There is no one-fits-all type of solution. Each country needs to conducts its own evaluation and develop a plan that takes advantage of its strengths, exploits opportunities while working around its weaknesses and minimizing possible threats. The following SWOT analysis provides our perspective and complements our roadmap which is a collection of our recommendations on how to develop a successful renewable resources program.

The Strengths of the Mexican power grid which facilitate development of a successful renewable resources program were described in previous sections and are summarized below:

1. Knowledgeable and skilled staff;
2. Availability of marginal costs known as CTCP.
3. Experience with 1,300 MW of wind generation
4. Advanced short-term load forecasting system
5. Strong power grid with a 400 kV backbone transmission system;
6. Significant hydro generation which can dampen intermittency effects;
7. Existing interconnection study process;
8. Modern national and regional control center with advanced applications;
9. Development and testing of precision monitoring by synchro-phasors technology;
10. Automatic Generation Control function to manage intermittency and variance of renewable resources;
11. Utilization and availability of ancillary services and reserve monitoring;
12. Large and diverse geography providing ample natural fuel for renewable resources; and
13. Access to two Pacific and Atlantic oceans for off shore renewable power plant applications.

The weaknesses of the Mexican power grid that may present challenges and impact the full realization of benefits from a renewable resources program were defined in previous sections and summarized as follows:

1. Occasional overloads on the bulk transmission system;
2. Inadequate Reference Price for energy and ancillary services
3. Absence of defined Transmission Expansion Indices;
4. Absence of defined Competitive Renewable Energy Zones (CREZ);
5. Under-developed regulatory and oversight process specific to integration and monitoring of utility scale renewable resources;
6. Absence of a tariff for interconnection of renewables with clear rules[88] and compliance measures.
7. No mechanism for identifying viable and serious projects;
8. Current Interconnection handbook[89] is not specific to any particular renewable technology.
9. Little experience with planning and operating utility scale solar technologies;

[88] Rules pertain to the regulation surrounding the interconnection process of renewable and participation in wholesale transactions. The rules are generally defined by regulatory and oversight agencies in a document called the Interconnection Tariff. The Interconnection Handbook defines the hardware and physical interconnection requirements of the host utility. The interconnection handbook is prepared by the host utility based on its own practices.
[89] The Tariff is generally updated as issues are brought on to the regulators and oversight agencies attention which tends to be continuous. The Interconnection Handbook is revised as technologies change and as the host utility experiences issues with its existing practices.

10. A wide range of variation in power quality and voltage fluctuation;
11. Potential for sub-synchronous resonance;
12. Absence of communication systems that encompasses all of Mexico;
13. Absence of a scheduling system for renewable resources;
14. Absence of settlement quality metering;
15. Absence of a settlement system for renewable resources;
16. Absence of banking and credit system for renewable resources;
17. Absence of testing procedures for integration of wind resources into the system;
18. Absence of resource coordination programs to encompass hydro and wind resources;
19. CENACE does not have the necessary software tools[90] to extract knowledge from the available data sources for incorporating uncertainty in its decision analysis process; and
20. Needed training and formal processes to address increased complexities in planning and operation and increased risk introduced by integration of renewable energy sources.

A well designed and implemented renewable resources program can provide a number of opportunities to benefit the Mexican power grid. These opportunities were defined in previous sections and are summarized below:

1. New government can provide regulatory enhancements and a refined vision
2. Environmental and greenhouse gas reduction;
3. Increased asset utilization;
4. Alleviate and eliminate known congestion on the transmission system
5. Defer or eliminate new investments in transmission infrastructure;
6. Reduce technical losses;
7. Potential for creation of useful microgrid areas;
8. Encourage private investment in the Mexican generation sector;
9. Early retirement of old, polluting and inefficient power plants;
10. Improved air quality in populated areas such as Mexico City by providing renewable energy for electric transportation, heating, cooking etc.;
11. Provide renewable energy for electric or hybrid transportation;
12. Use of wind and solar sources of energy in black starts, if they have own energy storage
13. Creation of Competitive Renewable Energy Zones; and
14. Create opportunities to export renewable power to the U.S. and other countries.

A renewable resources program without proper regulation and adequate oversight can create threats for Mexican power grid. These threats were described in previous sections and are summarized below:

1. High network upgrade costs;
2. Potential for the need to increase retail rates;
3. Increased need for subsidies by the Mexican Treasury;
4. Possible degradation in transmission system performance;
5. Possible degradation in under-voltage and under-frequency load shedding;
6. Emergence of new forms of congestion in previously non-congested areas;
7. Potential for local over-generation conditions;
8. Increased need for curtailment of renewable resources;
9. Increased overall operating costs;
10. Increased need for ancillary services, especially regulation;

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[90] These may include software tools to manage intermittency and non-dispatchability of renewable resources in calculating operating reserve requirements

11. “Must Run” resource commitment in order to maintain load following capability;
12. Distribution voltage regulation issues and requiring major equipment modification, and
13. Power quality and voltage flicker issues.

The SWOT Analysis findings are summarized in the Table 3-4 below:

Table 3-4: Summary of SWOT Analysis

SWOT Analysis Area	Strengths	Weaknesses	Opportunities	Threats
Characteristics	Wide geography Well-developed transmission and distribution systems A modern Control Center Extensive hydro generating resources Many possibilities for placement and interconnection Ample renewable fuel sources 400 kV strong backbone transmission system	Seasonal and occasional Overloads of 400 kV system	Greenhouse gas emissions reductions Increased Asset Utilization Energy for electric transportation Air quality improvements Early retirement of old and inefficient generating resources	
Renewable regulatory process	Existing regulatory process	Distributed authority among players Under-developed roles and rules with respect to renewables Non-participatory decision making Regulation not specific to renewables		Over investment in transmission and distribution systems Increased pressure on retail rates Non-viable Renewable Projects Potential for conflicts
Interconnection process	Existing interconnection Process	Not specific to different renewable technologies	New government opportunity of the new administration to enhance vision and regulation	Increased operational issues

Table 3-4: Summary of SWOT Analysis

SWOT Analysis Area	Strengths	Weaknesses	Opportunities	Threats
	Marginal costs (CTCP)	Ability to identify serious projects Handling complex planning and operational problems Handling additional risk Handbook for interconnection of renewables		Increased planning issues
Experience	1300 MWs of wind generation Existing PMU infrastructure	Experience with utility scale solar generation Experience with energy storage		
Transmission planning studies	Existing Interconnection Process	Sub Synchronous Resonance Interconnection of renewables based on technology		
Pricing transmission services		Locational energy pricing Locational ancillary services pricing Area transmission expansion costs Undefined CREZ		
Optimization of planning and operation			Technical loss reduction Investment deferral Investment elimination	

Table 3-4: Summary of SWOT Analysis

SWOT Analysis Area	Strengths	Weaknesses	Opportunities	Threats
			Increase asset utilization Eliminate congestion Create export opportunities	
Systems	Load Forecasting for Wind Modern control center PMU and WAM	Forecasting for Solar power plants No settlement system Communication infrastructure Scheduling for renewables Metering for settlements Banking and credit management	Manage intermittency Manage additional complexity Increase revenues	Degradation in transmission performance Loss of revenue
Transmission planning core process	Open Season Existing process for long and short-term plans Retirement plan for old and inefficient resources	Coordination with renewable interconnection process		Transmission performance Under-voltage Load shedding Under-frequency load shedding New forms of congestion
Real time operations	Ancillary services reserve monitoring AGC Modern control center PMUs and WAMs	Definition of various ancillary services		Must-Run resources Power quality issues Increased operating costs More ancillary services

Table 3-4: Summary of SWOT Analysis

SWOT Analysis Area	Strengths	Weaknesses	Opportunities	Threats
				Reactive power management Voltage regulation Increased curtailments Over-generation Load following and frequency control New forms of congestion
New technology	PMUs and WAMs		Energy Storage Solar /Solar Thermal/Concentrating	
Staffing/organizational	Knowledgeable and experienced staff	Specialization in renewables Think Tank for complex issues		
Training		Integration of solar resources Interconnection of renewables by technology Probabilistic analysis		Increased risks in planning and operating

3.5 RECOMMENDED PLAN OF ACTION

Site visits, meetings and discussions with CRE, SENER, CENACE etc. as well as the examination of documents that has been provided enables ESTA International to make the following recommendations with three levels of priorities which is described below:

Priority I (near term):

The following suggested recommendations have high priority and are suggested to be implemented on a short-term basis:

1. Define various types of ancillary services.
2. Price energy and ancillary services for the entire transmission and distribution systems.
3. Develop Transmission Expansion Cost Index for various areas.
4. Define CREZ;
5. Develop interconnection handbook for various types of renewable technologies.
6. Coordinate the transmission planning and integration of renewables processes.
7. Re-examine the horizon of analysis and justification for new transmission facilities.
8. Define standards and develop tools for assessing Intermittency and its impacts.
9. Improve Mexico's existing Open Season process to distinguish serious projects.
10. Create standard study process that is open and provides flexibility to the developer.
11. Enhance regulatory roles and responsibilities with respect to renewables.
12. Install precision, settlement quality wholesale meters.
13. Modify the outage management system to accommodate renewables.
14. Re-examine power quality standards for distribution system.
15. Define standards for limiting renewable on distribution systems.

Priority II (medium term):

The following suggested recommendations are required, but may be implemented on medium-term basis.

1. Conduct transmission system performance analysis with various penetration levels of renewables.
2. Conduct reactive power management studies.
3. Conduct load following performance analysis and identify must-run resources.
4. Conduct analyses to identify over-generation potential.
5. Conduct sub-synchronous Resonance studies near series compensated transmission lines.
6. Expand communication infrastructure to include areas that have potential for renewable resources.
7. Enhance forecasting system to include prediction of generation from solar resources.
8. Examine existing operating procedures and the required modifications with significant penetration of renewables.
9. Conduct training on probabilistic and econometric analyses for planning and operation.
10. Hire additional professional staff.

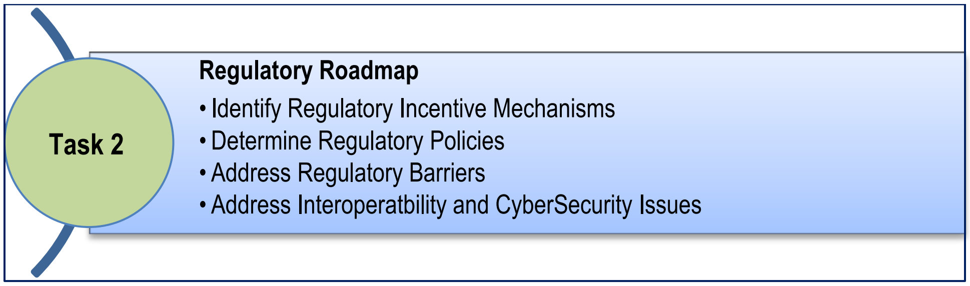
Priority III (long term):

The following suggested recommendations are not required but their long-term implementation can provide Mexico with benefits:

1. Create a scheduling system for renewables and IPPs.

2. Create a settlement system for renewables and IPPs.
3. Enhance metering infrastructure.
4. Create “Think Thank” organization for solving complex issues.
5. Create banking and credit management system for renewables and IPPs.
6. Explore the option-to-build of Network Upgrades for the developers of the renewables.
7. Certify equipment such as wind turbines and inverters to avoid building power plants with substandard equipment.

4 TASK 2 – REGULATORY ROADMAP



The primary objective of Task 2 is to formulate a preliminary Regulatory Roadmap based on the recommendations of Task 1 in consultation with CRE. Task 2 encompasses four subtasks as highlighted below:

- Subtask 2.1 Identify Regulatory Incentive Mechanisms

  The objective of this subtask is to identify regulatory incentive mechanisms and business models that would support the operation of independent power generators to supply power to the Smart Grid and would encourage individual consumers to participate interactively in the Smart Grid. It assesses the success of such regulatory incentive mechanisms, based on the evaluation of lessons learned from other countries.

- Subtask 2.2 Determine Regulatory Strategies

  The objective of this subtask is to identify potential regulatory strategies that would allow for the sharing of the costs and benefits of Smart Grid implementation among stakeholders in Mexico. Recommendations shall be based on best practices and the findings of what has been successful or unsuccessful in other countries, while taking into account the requirements of Mexican stakeholders.

- Subtask 2.3 Address Regulatory Barriers

  The objective of this subtask is to review CRE's applicable legal framework to identify the regulatory barriers that may hinder the deployment of Smart Grid technology in transmission and distribution systems, or may cause incentives for Smart Grid implementation to be ineffective. If required, suggestions may be offered to enact changes regarding the applicable legal framework that will be necessary to the success of the proposed regulatory roadmap. On this context, it is relevant to take into consideration that the Energy Reform will help on the deployment of a Smart Grid policy based on the new proposed energy legislation.

- Subtask 2.4 Address Interoperability and Cyber security Issues

The objective of this subtask is to address interoperability, cyber security, and physical security issues related to Smart Grid implementation, and provide suggestions based on lessons learned from other countries.

For the CRE project, ESTA International brings to this assignment extensive experience in the regulation of public utilities, as well as substantial knowledge of the capabilities of Smart Grid technologies and the details of implementing those technologies. We have supplemented our first-hand knowledge with research into the policies and activities involving Smart Grid deployment in many other countries.

The result of our research and analysis allows us to describe a set of best practices for regulators such as CRE to use in bringing forth the Smart Grid in Mexico. We make these recommendations with knowledge of the Mexican electric sector, with an understanding of the government's preferred direction and with knowledge gained through identification of lessons learned from other countries. In short, our recommendations are tailored to Mexico while leveraging lessons learned from other countries. These recommendations constitute the Regulatory Roadmap.

In contrast to the idealized regulatory practices we describe, CRE's authority was constrained in several ways in the former legal framework prior to the Energy Reform. Some needed authorities were posited in other agencies of government; some decisions were left to the utilities themselves; and some issues, unique to Smart Grid, may not yet had been addressed by the government at all. To closely follow the recommendations in this report, particularly those unique to Smart Grid implementation, ESTA proposed that either the authority of CRE should be expanded or its expertise and feedback should support other Mexican authorities to achieve the desired goals.

> *To closely follow the recommendations in this report, particularly those unique to Smart Grid implementation, either the authority of CRE should be expanded or its expertise and feedback should support other Mexican authorities to achieve the desired goals.*

With this background, we develop the following information in this Task:

1. A description of "best practices" regulatory strategies needed for successful Smart Grid deployment

2. A discussion of the limitations on CRE's authority within the legal framework prior to the Energy Reform, compared to the identified best practices

A set of recommendations that include potential modifications to CRE's powers will be presented as well as other accommodations in government organization that will allow Mexico to proceed with full implementation of Smart Grid initiatives.

This Chapter:

- Describes the regulatory vision and the pillars for Smart Grid development in Mexico. They form the foundation for Smart Grid implementation in Mexico while addressing potential industry and structural challenges.
- Reviews the Mexican power sector with special focus on regulatory features related to Smart Grid activities in order to develop the baseline recommendations for Smart Grid regulatory developments. This includes:
  - Recommendations for potential regulatory incentive mechanisms and business models that would support the operation of independent power generators to supply renewable energy to the Smart Grid and encourage individual consumers to participate interactively in the Smart Grid (Subtask 2.1)
  - Potential regulatory policies that would enable sharing of the costs and benefits of Smart Grid implementation among stakeholders in Mexico (Subtask 2.2).

    - Identification of regulatory barriers; recommendations are provided for possible enhancements to the existing legal framework to facilitate the success of the proposed regulatory roadmap (Subtask 2.3).
- Provides recommendations on legislative authority/powers.
- Highlights recommended institutional refinements**.**
- Addresses interoperability, cybersecurity, and physical security issues related to Smart Grid implementation (subtask 2.4).
- Identifies the performance metrics that would enable CRE to measure the effectiveness of implementing the proposed Smart Grid Roadmap in Mexico.
- Proposes a structure for a Smart Grid Task Force to facilitate interactions among all stakeholders in the Mexican Smart Grid landscape.
- Summarizes the observations
- Provides a table of all recommendations.

4.1 LEGISLATIVE AND REGULATORY SETTING PRIOR TO ENERGY REFORM ACT OF 2013

Prior to Energy Reform Act of 2013 and the Electric Industry Act, the Political Constitution of the United Mexican States (CPEUM), ARTICLE No. 27, Paragraph 6, clearly indicates that:

"... is solely for the Nation to generate, conduct, transform, distribute and supply the electricity which is intended for public service. In this area there shall be no concessions ..."

In the electric energy sector, there are the following three major functions to be realized:

1) Development of public policy
2) Regulation
3) Operation

The energy policy framework is established by the laws passed by the Mexican Congress; the specific definition of energy policy is a power of SENER; and economic regulation relates mainly to the CRE. Finally, the operation of electric system and provision of providing public service is handled by CFE in all regions of Mexico.

By law, three Ministries have authorities to mandate various aspects that affect the operation by CFE. Figure 4-1 identifies the broad scope of authority by each Ministry and provides major statistics on CFE.

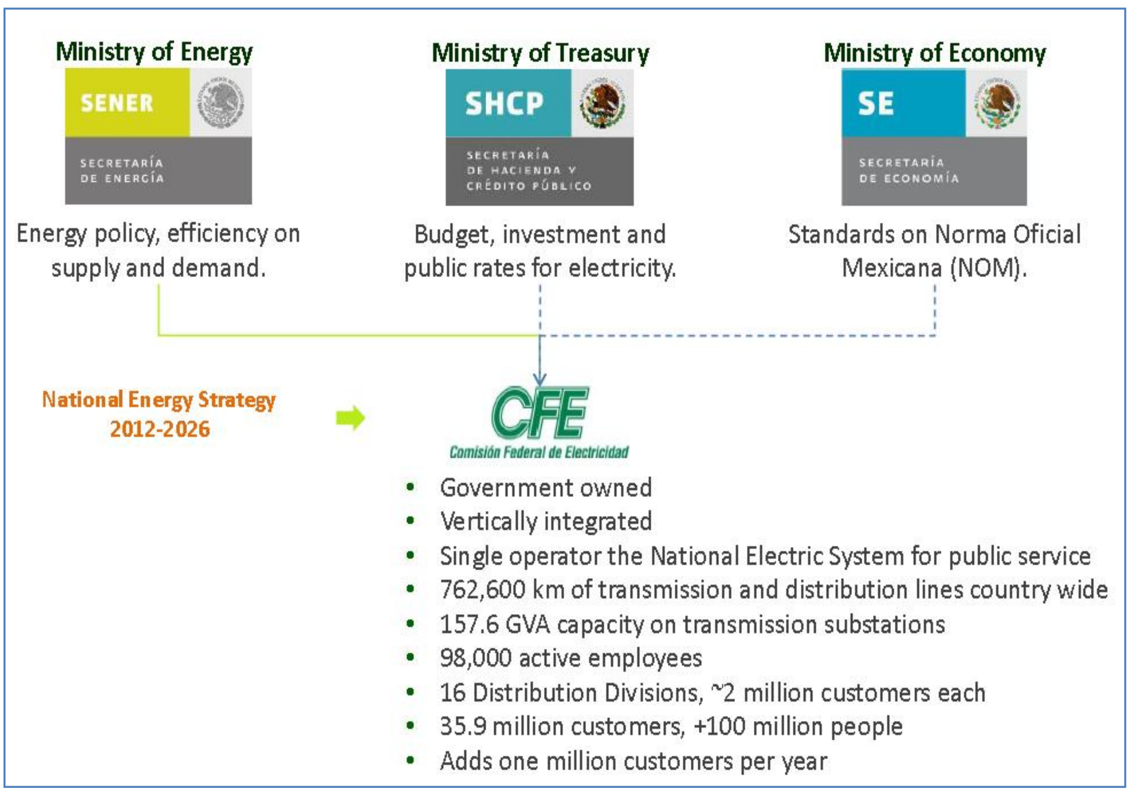


Figure 4-1: CFE and Governmental Ministries

The Smart Grid initiatives' process and support mechanism is more complicated within the Mexican power sector than presented in the above figure. Consistent and coordinated steps must be taken by various organizations during the development of National Energy Policy (NEP), National Development Plan (NDP), and National Energy Strategy (NES) to ensure effective progress toward full implementation of Smart Grid initiatives Figure 4-2 identifies a more detailed scope of authority by each Ministry prior to the Energy Reform Act in the way CFE's Smart Grid initiatives could be implemented.

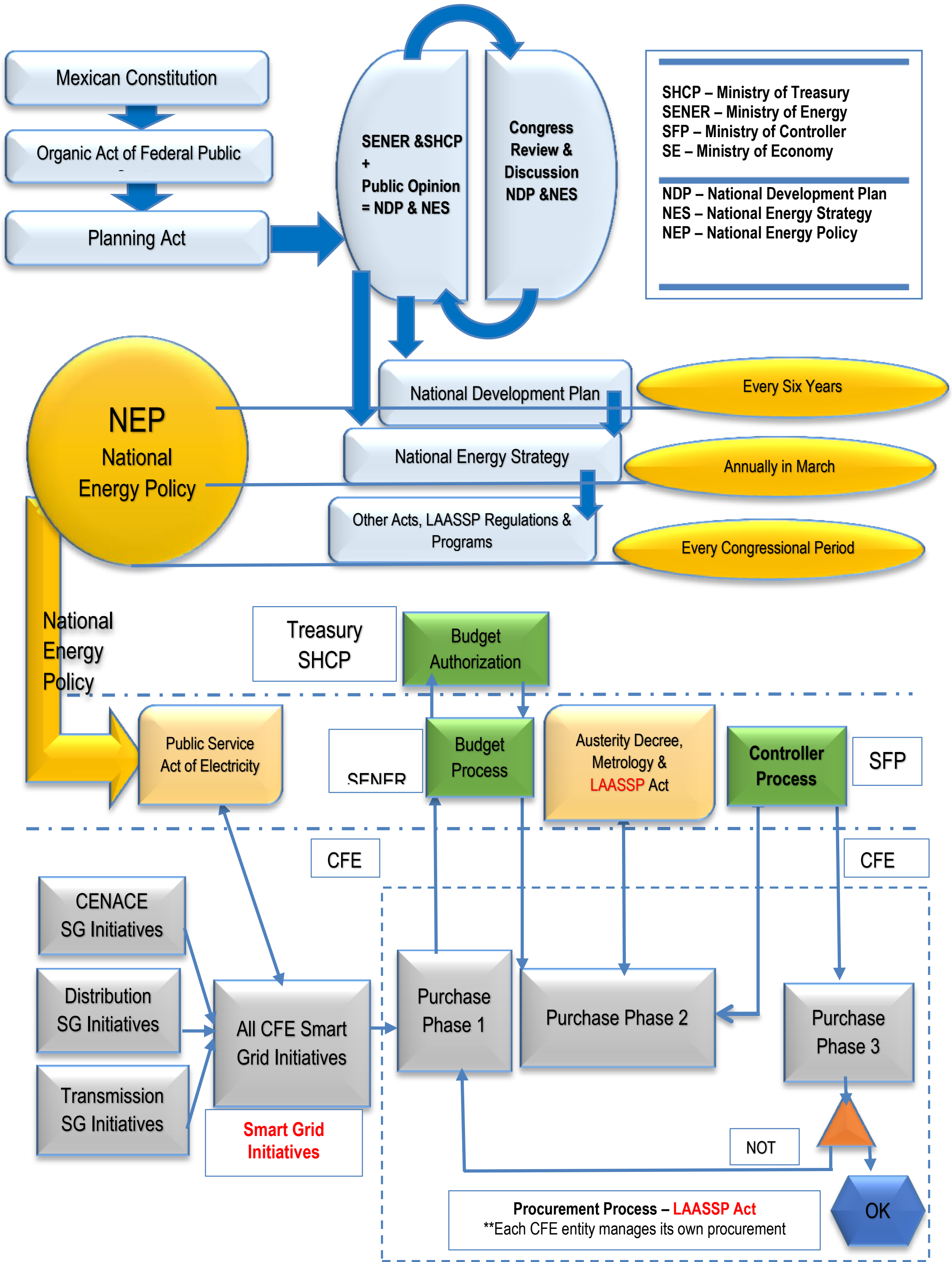


Figure 4-2: Mexico Smart Grid Process Prior to Energy Reform Act

Under the former legislative and regulatory framework, it is possible to make certain observations regarding the CRE's authority with respect to Smart Grid initiatives. CRE analyzed the various aspects of the regulation and found broad interpretations to support some actions or policy initiatives needed to address some aspects of Smart Grid initiatives. For example, according to Energy Regulation Regulatory Commission Act (LCRE (1995), the agency had some powers on renewable energies and private generation projects. CRE could participate (give opinion but not decide) on the development program for the energy sector; on the needs of growth and replacement of generation capacity; on the role that CFE or the private sector plays in developing specific generation projects; and, if applicable, on the terms and conditions corresponding to public bids for those projects. In other words, there was no explicit legislation to provide CRE specific powers related to Smart Grid in fostering the implementation. Rather, CRE could leverage various broad topics to support implementing Smart Grid initiatives. Even such indirect authority regarding certain issues related to Smart Grid initiatives was very limited.

There was no explicit legislation to provide CRE specific powers related to Smart Grid in fostering the implementation. Rather, CRE could leverage various broad topics to support implementing Smart Grid initiatives. Even such indirect authority regarding certain issues related to Smart Grid initiatives was very limited.

At present, CRE does not have specific powers in transmission[91] nor distribution planning. However, in the new legal framework, that CRE can provide its opinion regarding the expansion programs approved by SENER. Also, it is expected that CRE have financial and personnel resources to effectively foster Smart Grid initiatives to meet national goals set for the next ten years. Finally, prior to the Energy Reform, CRE was not given a mandate to address a current institutional shortcomings, namely to coordinate regulatory policies and actions with those of other stakeholders that include SHCP, SENER, CFE and industry.

The most recent National Development Plan (NDP) was published on May 20, 2013. This Plan is a five-year plan and covers the period up the end of 2018. It is updated annually, for the remaining years of the presidential period.

CRE included the following two general objectives in its contributions to the NDP:

- Support for Renewable Energy
- Regulation to support energy efficiency

CRE Contributions to the NDP included two general objectives:

- *Support for Renewable Energy*
- *Regulation to support energy efficiency*

The CRE has explicitly mentioned the Smart Grid as a course of action, to support energy efficiency with additional benefits in reducing energy losses, providing greater network control, and improving reliability.

Some of the most common drivers for the Smart Grid initiatives on the international arena are also present in the legal context that covers the Mexican NDP 2013-2018. The Plan also defines the lines of action, objectives and action plans that should be accomplished by the federal administration entities in regard to electric energy production, consumption and climate change resulting in ultimate sustainable development.

The Plan indicates that: "There is an opportunity for us to be more productive". As an action plan, the agencies are expected to "eliminate the obstacles that are limiting the country's productive potential'. The productivity of an economy depends not only on the availability and quality of production inputs, but also the way they interact. In this regard, it is essential to ensure clear rules that encourage the development of a competitive domestic market, where the main source of differentiation between firms lies in the quality and

[91] CRE does not have specific powers on transmission planning although it has participated in coordinating Open Seasons.

price of their products and services. Regulation will be privileged to inhibit monopolistic practices and encourage companies to produce better products and services in a more efficiently way.

President Enrique Peña Nieto has decided that the increase in productivity is established as the core of the policy of his government. Thus, CFE and Union of Electrical Workers of the Mexican Republic (SUTERM) have recently agreed a framework of freedom, plurality and solidarity with the strategic lines of the National Development Plan, help democratize power sector productivity.

The areas in which CFE and SUTERM immediately act in a coordinated manner are:

- The precise definition and with a view to future of electric power generation in the country, including primary sources and modes and methods for their production, distribution and marketing, in order to define the outlines of the new power generation policy in Mexico.
- CFE will use its experience and infrastructure to promote the modernization of the electricity sector through the efficient use of fiber optics, to accessing digital schemes for controlling operation and availability of energy.
- An agreement is proposed to reform the billing system of the company, through the use of fiber optics technology, the unification of the multiple systems and care settings to more than 37 million consumers.

The NDP has also proposed to supply energy to the country with competitive prices, quality and efficiency along the supply chain. This involves increasing the capacity of the state to ensure the supply of crude oil, natural gas and gasoline demanded by the country, strengthen the rational supply of electricity, promote the efficient use of energy and the use of renewable resources by adoption of new technologies and the implementation of best practices, in addition to strengthening the development of science and technology in priority to the energy sector.

Mexico has shown great commitment to the international agenda for environment and sustainable development, and participates in more than 90 agreements and protocols in place, to be a leader on issues such as climate change and biodiversity. However, the country's economic growth is also closely linked to the emission of greenhouse compounds, excessive generation of solid waste, air pollutants, untreated sewage and loss of forests and jungles. In this context, generation technologies using renewable sources of energy should greatly assist Mexico in addressing the challenges of energy security and diversification. Despite the potential and rapid growth in the use of this type of energy, in the present, its contribution to the national energy supply is only around 2% of the total.

The NDP requires the Mexican authorities to “strengthen the national climate change and environmental care policies for the transition to a competitive, sustainable, resilient and of low-carbon economy”. In particular, the Plan requires:

- Accelerating the transition to a low carbon development in primary production sectors, industrial and construction, as well as urban services, tourism and transport.
- Promoting the use of advanced technologies and systems, energy efficient and low or no generation of pollutants or greenhouse compounds.

Furthermore, the NDP requires the Mexican authorities to ensure access to electricity with quality at the lowest cost over the long run. As one of its objectives, the NDP expects supplying power to the country with competitive prices, quality and efficiency along the supply chain. In particular, the Plan requires rational electricity supply throughout the country by:

- Promoting cost reduction in electricity generation to reduce fees paid by companies and Mexican families
- Standardizing the conditions of electricity supply in the country
- Diversifying the composition of electricity generation by considering the expectations of energy prices in the medium and long term
- Modernizing transmission and distribution of electricity
- Promoting the efficient use of energy and the use of renewable sources, by adopting new technologies and implementing best practices
- Promoting the training of new human resources in the sector, including those specializing in nuclear.

In summary, to realize the achievable productivity, the National Development Plan expects Mexican authorities to:

- Ensure access to electric energy with quality and at the lowest long term cost
- Permanently promote regulatory reforms to reduce operating costs of enterprises, increase competition and expand access to inputs at competitive prices

To encourage cooperation in achieving such national goals, the present Directors of various agencies, in accordance to an existing mandate in Article 22 of the Planning Act, are expected to develop various programs, including Sector Program regarding Environment and Natural Resources as well as Energy Sector Program. The Directors at SENER and CRE should include in the Energy Sector Program their best recommendations regarding the Smart Grid concept in Mexico.

Regarding smart meters implementation, which is often a critical component of Smart Grid concept; CFE does not have an explicit charge for energy meters. This cost is recovered through electric tariff. As shown in the following Articles, of the Energy Public Service Act, it may be assumed that the Mexican Laws had no explicit directives prohibiting the installation of smart meters.

> ARTICLE 29 (as amended, DOF 24/08/2012) - When the electric service is provided in the low voltage side, proceed as follows, in accordance with the technical specifications of the supplier:
>
> i. The applicant must build the necessary structure for the connection of the aerial service line if this is the case or all the necessary infrastructure if the service line is underground, being responsible for the installation of the base structure to support the pipelines and the respective electrical cables, and
>
> ii. The applicant must install a base or board on which it will be placed the measuring equipment, or it allocate a space inside the building in which the electric service will be delivered, to allocate the necessary equipment to provide the information on the electric energy consumption.

CFE would have needed a legal instrument that permits them to buy and install more capable and expensive smart meters than a regular meter utilized actually. Alternatively, CFE could be permitted to charge the cost of the smart meter to the user in the billing process.

Mexican regulations or secondary laws established that CFE shall provide the metering equipment to the residential end user. CFE would have needed a legal instrument that permits them to buy and install more capable and expensive smart meters than a regular meter utilized actually. Alternatively, CFE could be permitted to charge the cost of the smart meter to the user in the billing process.

4.2 POTENTIAL REGULATORY AND ELECTRICITY SUPPLY INDUSTRY CHALLENGES

4.2.1 REGULATORY CHALLENGES

In very fundamental ways, the development of the Smart Grid will change the relationship between the utilities and their consumers. In the earliest stages, the Smart Grid will be about smart meters and relatively small changes in how utilities operate and consumers relate to the utility. In the longer run, the Smart Grid will enable consumers (and their devices) to be much more integrated into the utility's network. Successful development of the Smart Grid will require modifications to the utility business model and changes in how utilities are regulated.

Successful development of the Smart Grid will require modifications to the utility business model and changes in how utilities are regulated.

Prior the Energy Reform, CRE did not have a clear authority on many aspects of electric utility regulation. Jurisdiction over aspects of electric service was spread across several ministries in Mexico. For example, SHCP is in charge of retail rates, SENER had oversight over CFE operations and budget and approved costs, SFP had authority to approve the auction documents and the Purchased Power Agreement (PPA) model developed by CRE and agreed with Investment projects financed. Finally, the -SE also exercised some authority over certain aspects of electric power sector.

Within the new proposed legal framework, energy efficiency programs are handled by Energy Efficiency Commission (Comisión Nacional para el Uso Eficiente de la Energía -CONUEE) and consumer protection related issues are under the jurisdiction of the Consumer Protection Agency (Procuraduría Federal del Consumidor -PROFECO). Some interaction between aforementioned and CRE is foreseen.

Mexico will need a responsive regulatory regime where the various authorities, if not posited in a single agency like CRE, must work closely together. Regulation of rates, design of tariffs, strategies with Smart Grid investment, generation market design, consumer service and privacy regulation, to mention only a few aspects, are all linked in the Smart Grid. Later we will discuss how the lack of clear authority at CRE might be remedied or worked around.

Regulation of rates, design of tariffs, strategies with Smart Grid investment, generation market design, consumer service and privacy regulation, to mention only a few aspects, are all linked in the Smart Grid.

Generally, CRE either did not have explicit authority or, needed further clarification on its authority to:

- Approve retail prices
- Approve retail rate design
- Analyze the impacts of CFE's capacity expansion plan on environment, assess potential cost impacts, and evaluate prudency of expansion plan implementation
- Determine the optimal fuel diversification that could be achieved with the help of non-conventional resources through the effective implementation of Smart Grid initiatives
- Oversee a public planning process for CFE's implementation of Smart Grid
- Oversee and enable entry of third parties in various markets in addition to power supply
- Assess the quality of CFE's services[92]
- Promote CFE's integration of its Smart Grid activities with other demand side programs including energy efficiency, demand response, energy management, and dynamic pricing
- Assess CFE's implementation plans and their projected costs and benefits; evaluate the prudence of CFE's expenses[93], and approve prudent cost recovery

[92] E.g., at the Distribution level it could include number of outages, number of interruption minutes, Voltage quality, frequency quality, etc.

- Require CFE to initiate Smart Grid activities or rely on new technologies that meet certain minimum standards
- Provide consumer incentives to enhance distributed renewable resources
- Require CFE to construct new transmission lines to address increasing amount of renewable services to be integrated into the grid in the near future

The uncertainty about CRE's authority in the Smart Grid arena was important not only to CFE and its consumers but also to potential investors. Billions of pesos will be invested in Smart Grid technologies by companies other than CFE, and these investors will require certainty, transparency and predictability in the Smart Grid market place. Their success and the resulting benefits to consumers will materialize only with the active management of Smart Grid by Mexico's regulators and policy makers.

Therefore, it will be important to address these shortcomings through legislation or through mandates from SENER. Alternatively, close cooperation with other government entities and CFE should be established under the leadership of SENER to address the above regulatory shortcomings.

4.2.2 POTENTIAL ELECTRICITY SUPPLY INDUSTRY STRUCTURAL CHALLENGES

Successful deployment of the Smart Grid in Mexico will rely on the joint effort and collaboration of the nation's utility, CFE, the regulator, private sector investors and both established and entrepreneurial Smart Grid companies. As evidenced elsewhere, the Smart Grid can prove to be a substantial contributor to economic development in Mexico, modernizing the electric sector, improving the nation's energy utilization, lowering greenhouse gas emissions and empowering consumers.

From experiences in other countries, we know that Smart Grid can develop and flourish in a variety of market structures. The Smart Grid is being developed in countries with market structures ranging from unregulated generation markets and competitive retail markets to investor-owned or government-owned vertically integrated utilities. Mexico's electric utility sector was a vertically-integrated state-owned monopoly provider with increasing reliance on independent power producers at the generation level.

In the longer run, the Smart Grid will enable participation of third party providers at the retail level, even if the delivery of electricity would have remained a monopoly.

[93] Unlike investor-owned utilities, it is probably not possible to "disallow" any expenses or capital investment incurred by CFE. Yet, the regulator should review those investments and attempt to answer the question, "At the time they were made, and given what was known at the time, were these investments the ones that should have been made, given estimates of costs, capabilities, consistency with approved plans, and compatible with expected future requirements? Even if there is not a financial penalty associated with imprudent decisions, CRE's criticism (if warranted) would likely have a desirable effect on CFE.

4.3 CRE Smart Grid Vision, Pillars, and challenges in Mexico

4.3.1 Overview of the Deployed Methodology for CRE

The ESTA methodology for the development of the Smart Grid Roadmap involves eight (8) steps as shown in the Figure 4-3 below. This methodology was developed after extensive review of the various methodologies uses around the globe for development of Smart Grid Roadmaps[94]. It must be noted that Road-mapping is a process that should continue throughout the years as CRE and the Mexican Power Sector continue their Smart Grid journey.

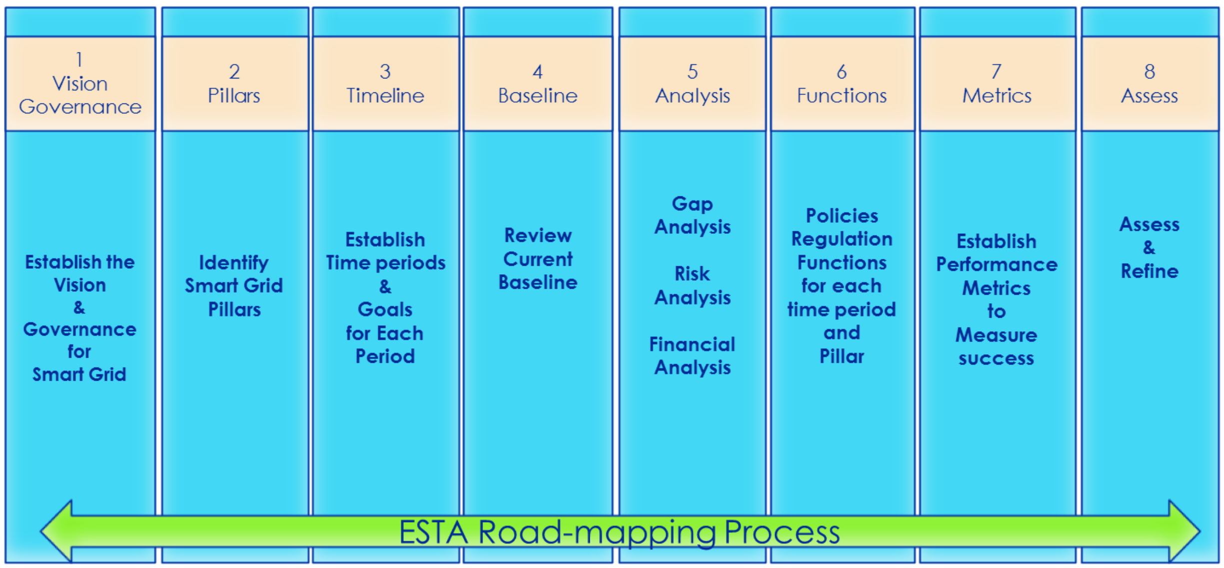


Figure 4-3: ESTA International Technology Roadmap Development Process

This methodology can be applied to Regulatory, Policy, and Technology Road-mapping. Typically in a framework document, steps 1, 2, and 3 are detailed while other steps are discussed at a high-level. During an implementation Roadmap, detailed analysis is conducted for each step and technology functions are supported by benefit and cost analysis.

In this report, in close cooperation with our colleagues at CRE, SENER, CFE, and other Mexican institutions, we have undertaken the following:

- Developed the vision and recommended the governance in the form of a Task Force
- Identified the drivers and pillars of Smart Grid at CRE
- Determined the timeframe (phases) to each the desired goal
- Reviewed the current regulatory state regarding Smart Grid
- Performed regulatory gap analysis
- Identified potential policies that will be needed as well as the incentive mechanism.
- Identified potential performance metrics to measure the success of the project.

[94] ESTA International reviewed Smart Grid Roadmap methodologies developed by the International Energy Agency (IEA), the Electric Power Research Institute (EPRI), as well as several roadmaps published by regulatory agencies, associations of energy suppliers, and electric utilities. Lessons learned were used to refine the ESTA international Smart Grid Roadmap methodology. This methodology has been accepted for use by the World Bank Group.

To establish the path for Smart Grid in Mexico it is necessary to establish the ultimate vision and identify the necessary pillars to support this vision. This section highlights the vision and pillars for Smart Grid in Mexico.

4.3.2 The CRE Smart Grid Vision, Pillars, and Timeframe

The Vision

A Vision statement is a succinct articulation of the goals and objectives of Smart Grid for the nation or an entity engaging in Smart Grid. The vision is established by reviewing the overall objectives at national and regional levels. It embraces governmental objectives as well as policy and energy Acts. It addresses current as well as future challenges. It serves as the beacon for Smart Grid planning and deployment.

During meetings with CRE technical staff and Commissioners several themes in the vision of Smart Grid became apparent.

- Empower consumers
  - Information Security for Consumers
  - Education of consumers on optimized energy usage

- Attract IPP and private developers into the Renewable Energy sector
  - Supplier Diversity for Renewable Energy Power Producers (more firms active in RE generation)
  - Desire for Supply Diversity (Mix of energy sources – wind, PV, etc.)
  - Facilitate integration of renewable energy to the Grid
  - Attract Investment to the Mexican Power Sector
  - Workforce development (creation of local jobs)

- Support CFE
  - Desire to support CFE initiatives and technology developments (not complicate their operations)
  - Help CFE mitigate challenges associate with introducing of large amounts of renewable energy to the network
  - Maintain high standards of reliability
  - Prudent investments based positive benefit costs

- Adherence to Governmental Objectives and Policies
  - Adhere to Energy Fuels Policy set forth by SENER in accordance with NDP, NES and other Acts and Federal Programs
  - Adherence to Climate Change goals established by the Mexican government

Based on the above a potential Smart Grid vision for CRE can be articulated as:

> *Support Smart Grid implementation in the Mexican Electrical Energy Sector by developing a regulatory framework supporting national energy policy making by SENER; fostering technological implementation by CFE; giving certainty to existing and new private developers to participate in new markets; and empowering consumers to protect their privacy and optimize their energy usage.*

The Pillars

Based on the above common themes the pillars of CRE Smart Grid vision can be identified as:

- Consumer Empowerment

- Adherence to SENER and governmental Policies
- Attracting Private Sector participation
- Support and Facilitate CFE Smart Grid Programs aligned to energy policy

Figure 4-4 depicts the CRE Smart Grid Vision and Pillars.

The Timeframe

The timeframe for CRE Smart Grid can span across three phases. The phases are aligned with the goals set forth by SENER and the phases identified by CFE in their Smart Grid Plan. During each phase policies and regulations should be introduced to achieve the carbon reduction goals set forth for 2050 by the government of Mexico.

- Phase 1 – spanning from 2013-2016 will set the foundation for the most urgent actions. This project is a part of the foundation.
- Phase 2 – from 2017-2020 will develop the basis to achieve the ultimate goals of Renewable Energy in Mexico.
- Phase 3 - from 2021-2026 will facilitate the achievement of the National Policy goals.

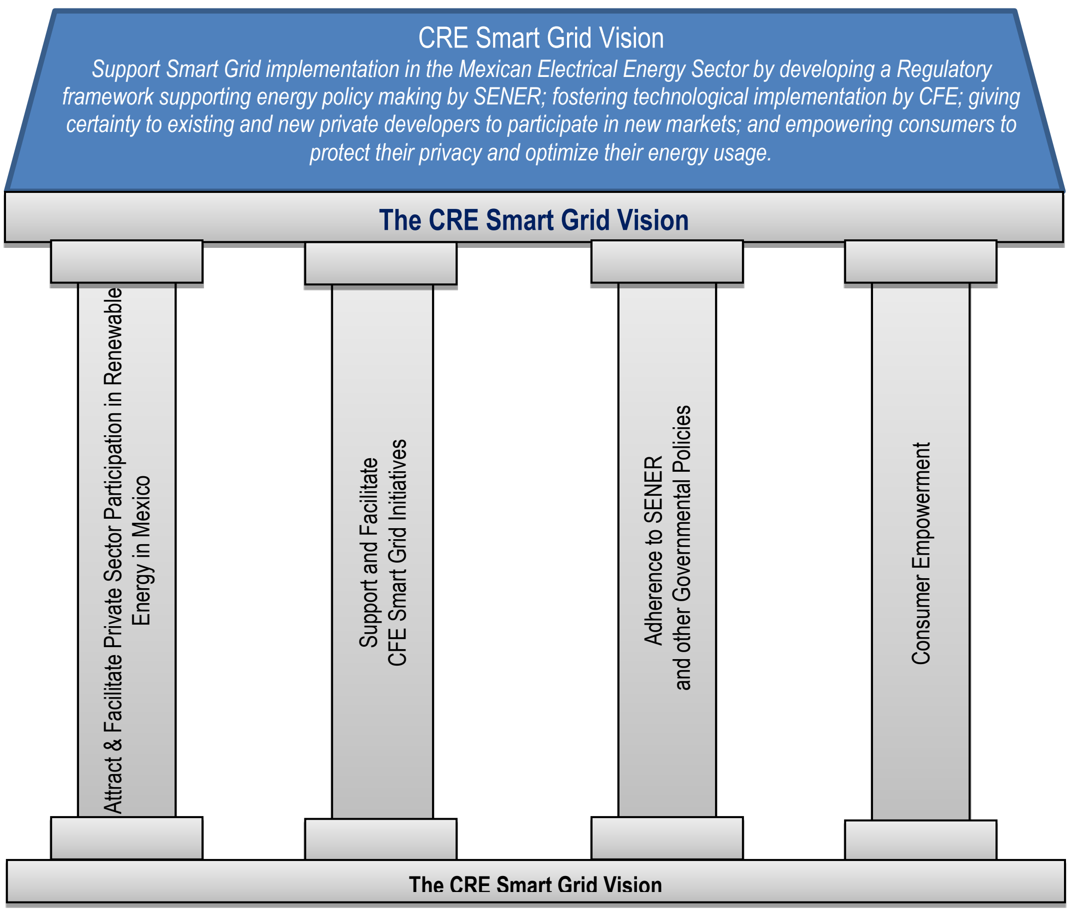


Figure 4-4: CRE Smart Grid Vision and Pillars

4.4 REGULATORY AND INDUSTRY MEASURES TO ENABLE SMART GRID DEVELOPMENT

This section describes a set of regulatory practices and incentives that will be important in spurring the development of Smart Grid in Mexico.[95] Collectively, these practice and incentive mechanisms will comprise a "Regulatory Roadmap" for Mexico's implementation of the Smart Grid.

ESTA provides regulatory recommendations for CRE designed to enable and enhance the growth of Smart Grid investment in Mexico. These recommendations address actions that SENER and CRE can take that would require or encourage action by CFE, third party providers, consumers (end-users) and by the CRE itself.

First, a brief background further explains the Smart Grid and its complexities. Then, recommendations are identified with regard to the operation of CFE, third-parties, and end users as well as appropriate cost allocation mechanism among stakeholders. Recommendations to address consumer information privacy issue will follow. At the end, incentive mechanisms are discussed that will encourage participation by CFE, third parties, and end users in Smart Grid initiatives.

Our approach will be to develop first an "idealized" version of the Regulatory Roadmap, not constrained by the limits of authority posited at CRE. After presenting the idealized roadmap, we turn to the question of CRE's actual authority (prior to the Energy Reform) and what the agency could accomplish within its existing authority. Following that discussion, we will discuss recommendations for changes to CRE's authority and develop suggestions for inter-agency cooperation that will facilitate Smart Grid investment to move forward.

4.4.1 BACKGROUND

The term "Smart Grid" refers to many things and means different things to different stakeholders. In its most basic sense, "Smart Grid" means the aggregate of the applications of information technology (IT) to electricity production, transmission, distribution and end use. An often-used shorthand description is the "intelligent grid" or the "energy internet." A Smart Grid-enabled electrical grid will greatly enhance the efficiency of the grid, increase the grid's flexibility and reliability, enable the integration of new supply-side and demand-side technologies, and, finally, provide consumers with new products and services. It is useful to mention that "*While … Smart Grid deployment can occur in a monopoly setting, it is not clear that the full array of benefits will be achieved unless customers are enabled to make fully informed decisions and choices regarding the acquisition and use of energy*."[96]

It is helpful to think of the Smart Grid as existing in two separate but connected realms. We might speak of "wholesale" versus "retail" Smart Grid or perhaps "utility" versus "consumer" applications. The main point of this distinction is that some grid enhancements that comprise the Smart Grid are visible and meaningful to the consumer, others are not.

Consider two examples of "wholesale" Smart Grid technologies: The deployment of "smart" breakers in distribution substations or synchrophasors in the transmission grid might greatly improve grid operations, but will not be seen or understood by consumers as the "Smart Grid." Similarly, enhanced grid telemetry may help the grid operator detect or even prevent outages, but service will otherwise be unchanged from the consumer's perspective.

"Retail" Smart Grid applications include consumer-accessible information about instantaneous demand, the integration of appliance operation into real time operation of the grid, smart charging for electric vehicles, more detailed billing, in-home energy monitoring and control systems. In the longer run, we might add to this list "smart prices" – utility tariffs that reflect the real-time or near-real-time prices of electricity. The result

[95] We discuss privacy policies separately due to their primacy and special characteristics.

[96] Brown, Ashley (2010). Smart Grid Issues in State Law and Regulation. Galvin Electricity Initiatives, September, p. 7.

is an informed consumer making informed decisions that may include behavioral change in the way the consumer uses electricity.

We expect that the “retail” Smart Grid will be segmented between commercial and industrial consumers (C&I) versus residential consumers. Finally, we expect to see a qualitative distinction in the approach to the retail Smart Grid from large residential consumers compared to small consumers. Putting these market segments together, it will be useful to think of the following segmentation of Smart Grid applications as shown in Figure 4-5 below:

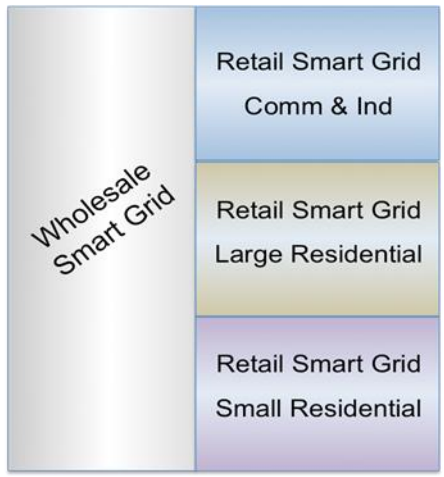


Figure 4-5: Smart Grid Market Segments

Smart Grid implementation will significantly impact both CFE’s operations and its interaction with consumers. Further, implementing Smart Grid technologies will change the way non-utility players interact with CFE and, more importantly, with CFE’s consumers. Here are some of the most general impacts of Smart Grid that will require examination of Mexico’s regulatory policies:

- **Utility operational impacts**- Significant changes will be seen by electric utilities in the way they operate; efficiency gains in operations will result in lower costs.
- **Consumer engagement**- Unprecedented engagement by consumers with their use of energy products and services, their energy demand and usage patterns, and their interaction in real time with utilities operations through distributed resources.
- **Integration of new generation resources**- Approaches to the operational challenges resulting from integrating significant amount of non-conventional and intermittent resources into the grid; managing consumers’ increasing engagements that may introduce unintended consequences if not managed properly; and ensuring that both new and old equipment is operating effectively and reliably and interact instantaneously under Smart Grid system.
- **System complexities**- A Smart Grid enabled system will efficiently handle the increasing complexity from the unprecedented interactions by consumers through their various distributed resources.
- **Creation of new markets**-Both the supply and demand sides of the existing markets will change significantly. Consumers will supply a larger share of their electricity needs through distributed generation. Further, consumers will take a proactive role through energy management and demand response activities that are integrated into the utility’s operations.

4.4.2 Regulatory Strategies

As explained earlier in this report, electric power sector was operated by CFE with oversight from three Mexican Ministries with authority over various aspects of operation and oversight from CRE in the economic regulation of Renewable Energy. This report does not take a position on how these various authorities should be arranged. However, coordination across the variety of entities must be achieved in order for a transition to Smart Grid to be successful. Later in this report, we discuss two possible approaches to ensure closer coordination:

- A multi-secretariat and multi-agency Smart Grid working group; or
- The transfer of selected authorities to a single agency.

We must be realistic about the pace at which Smart Grid is likely to be understood and embraced by consumers. Utilities and regulators need to be "smart' themselves about approaching consumers and involving them in the retail Smart Grid. CRE should target the commercial and industrial consumers first[97], followed by the largest residential and small business consumers, those that offer the greatest potential grid savings and the largest potential consumer savings. Of course, Smart Grid technologies should be available at all times to all consumers, but the "value proposition" will be greatest for the largest consumers in each consumer class.

Strategies to improve efficiency in operation by various players and appropriate incentives to further engage these players in Smart Grid initiatives are addressed in the following subsections.

4.4.2.1 Strategies to Enhance the Operation of the Electric Power System by CFE

Summary of Recommendations

- **CRE should support the creation and execution of a multi-party planning process for Smart Grid planning and implementation**
- **CRE should require that all power sector actors, in collaboration with the industry and with existing standards bodies, adopt and publish standards for Smart Grid, building on successful experiences in other countries**
- **CRE should support CFE in its efforts to identify, evaluate and schedule for implementation all available cost effective "wholesale" Smart Grid measures available to the company**
- **CRE should support CFE in developing and publishing a schedule for installation of smart meters at the consumer end, pursuant to an approved transition plan**
- **Jointly with CRE and other stakeholders, CFE should develop and publish a detailed transition plan for moving consumers with smart meters to tariffs that employ dynamic pricing**
- **CRE should support CFE to develop a plan to integrate wholesale settlement quality smart meters in the wholesale settlement process to accurately compensate generation from resources at the consumers' premises during high production cost periods**
- **CRE should identify remaining marketplace barriers and recommend legislation to SENER**

All recommendations for supporting the operational efficiency of CFE are preceded by "CFE" in the following discussions.

[97] Commercial and industrial users will generally be more sophisticated energy users, with more familiarity with their energy uses, accustomed to taking measures to reduce costs in their operation, and often with better access to capital than smaller consumers. Further, they are often much larger users, allowing CFE more easily to justify fixed investments in Smart Grid. In short, commercial and industrial consumer will provide CFE with faster return on investment.

4.4.2.1.1 *Recommendation CFE- 1: CRE should support the creation and execution of a multi-party planning process for Smart Grid planning and implementation.*

The successful development of the Smart Grid will require the coordinated activity of multiple entities. A strategic plan for Smart Grid should be developed in an open, participatory process to ensure that all the best ideas are considered and that Mexico secures the interest and involvement of investors.

As a starting point, it is reasonable for CFE to propose a draft strategic plan in line with the National Energy Strategy, with the oversight and involvement of SENER, CRE, SHCP, and SE[98]. Then, importantly, the plan should be examined in a public process, with the comments, discussion and critiques solicited from many parties. The process should involve not only government entities, but also stakeholders such as Smart Grid vendors, renewable energy suppliers, privacy advocates, appliance manufacturers, research institutes, academia, etc. The object of the public process will be to develop a strategic plan that is transparent to the Smart Grid community and reflects, to the extent possible, the considerations offered by the parties. Without ceding authority to these other parties, CFE, SENER, CRE, SHCP and SE can adopt modifications and improvements to the proposed plan that will produce an improved product. Further, the public process will signal to third parties Mexico's commitment to developing the Smart Grid and encourage the involvement of national and international Smart Grid players and investors.

> *The object of the public process will be to develop a strategic plan that is transparent to the smart grid community and reflects, to the extent possible, the considerations offered by the parties*

The plan should include proposed Smart Grid standards, developed with assistance from standard bodies, to cover technologies, their expected minimum features, and communication capabilities.

Among other items, the plan should address these issues:

- A comprehensive vision for Smart Grid implementation in Mexico
- A proposed schedule for Smart Grid deployment
- Delineation of CFE's relationship with Smart Grid suppliers
  - Standards
  - Acquisition practices
- Access of consumers and consumer-designated[99] vendors to Smart Grid data
- A path for moving to "smart" consumer tariffs that will enable the "retail" Smart Grid market
- Smart Grid Data privacy polices

4.4.2.1.2 *Recommendation CFE- 2: CRE should require that all power sector actors, in collaboration with the industry and with existing standards bodies, adopt and publish standards for Smart Grid, building on successful experiences in other countries.*

Over the years, standards have been developed in the electric industry to assure the successful electrical interconnection of the many elements and devices that compose the electric grid and its operation. And now, the implementation of the Smart Grid brings to the electric industry an entirely new set of challenges related to interconnection of the elements. Applying IT technology to the electric grid introduces many of the

[98] Ministry of Economy is responsible for Official Mexican Standards (Normas Oficiales Mexicanas)
[99] Through a variety of channels (in appliances, on the internet, through energy service companies, etc.) consumers will make arrangements with smart grid vendors to help them manage energy usage. (There will be many variations that we cannot predict. Consider how music and entertainment is delivered today through many modes.) One essential characteristic of all these channels will be that the consumer will have to give permission for the smart grid provider to have access to usage data. Sometimes that will be real-time data; sometimes it will be historic data with much less granular data. In order for all this to work, the utility must have in place a system that makes access to the data easy, but only for those vendors that have been designated (approved) by the consumer.

same challenges that have been successfully addressed in the telecommunications and computer industries.

For example, we take for granted the ability of a consumer to purchase a computer or wireless phone and have that device successfully integrate into the Internet or the public telecommunications network. Standards and agreed protocols give computer device manufacturers the assurance that their devices will communicate with other computers.

If the Smart Grid is to become similarly "plug and play," standards must be agreed, published and adopted by all power sector actors. CRE should lead the effort in Mexico to require all industry players to participate in a standards process.[100] The industry players in Mexico need not invent the standards process, of course; they may build on what has gone before. There many examples of electric industry Smart Grid standards efforts, including the process led by the National Institute of Standards and Technology in the United States and standards organization in Europe, Canada, Japan, China, and other countries.

4.4.2.1.3 Recommendation CFE- 3: CRE should support CFE in its efforts to identify, evaluate, and schedule for implementation all cost effective "wholesale" Smart Grid measures available to the company

Around the world, the news media have focused on the "flashier" aspects of the coming Smart Grid: smart homes, sentient refrigerators, consumers having remote access to control their homes, etc. In practice, such "retail" Smart Grid applications will develop only in response to consumer demand, and not faster than that. This means that each Smart Grid investment decision, especially at this early stage, must be made with an eye toward future consumer involvement, even if the instant investment is not predicated on such consumer involvement. In other words, the prudent utility and prudent regulator will anticipate these future market developments and attempt to "future proof" today's investments.

Meters that are installed in 2013 to accomplish certain objectives (e.g., remote connect and disconnect) should be capable of Back Office functions and should be designed so that they can grow to accommodate greater levels of consumer data, to be accessible to consumers, even if there is little interest from consumers today.

Meters that are installed in 2013 to accomplish certain objectives (e.g., remote connect and disconnect) should be capable of Back Office functions and should be designed so that they can grow to accommodate greater levels of consumer data, to be accessible to consumers, even if there is little interest from consumers today.

The Smart Grid investments that attract less media attention are those we have termed "wholesale" investments. These include installation of sensing devices to improve telemetry, giving the utility "visibility" into all operational aspects of the grid. These investments can be made alone or in concert with Advanced Metering Infrastructure (AMI) devices. The principle benefits include[101]:

- Outage Detection
- Voltage Management
- Restoration

[100] Mexico has a National Committee to issue standards on electric infrastructure (for public service). This Committee is chaired by SENER and vice-chaired by the National Certification Association (ANCE). This Committee includes representatives from the federal government, industry organizations, services providers, national research institutes and academia. Furthermore, there is also another National Committee devoted to issue standards on energy efficiency (these may include appliances, electrical infrastructure for buildings). CRE could trigger discussion through both Committees.

[101] While benefits of Smart Meter are many, they may be of varying importance to different entities and utility departments such as operations, revenue collection, etc.

- Power Quality Monitoring
- Transformer Preventative Maintenance
- Precision and time-stamped meter reading
- Precision and time-stamped consumption information
- Real-time operational and locational information

This list of expected benefits could be refined in consultation with CFE (CENACE, Transmission, Distribution, and Modernization sub-directorates as well as others), SENER, and working committees to determine the minimum features expected from various Smart Grid devices.

4.4.2.1.4 Recommendation CFE- 4: CRE with approval from SENER should support CFE in developing and publishing a schedule for installation of smart meters, pursuant to an approved transition plan

AMI meters are distinguished from other classes of meters by three characteristics:
1) they measure electric usage on a sub-hourly basis;
2) they have a two-way communications channel; and
3) they can provide real-time or near real-time data to the utility as well as consumption information to consumers

Electronic digital electric meters are the keystone investment in Smart Grid technologies for engaging consumers. Many of the features of the Smart Grid will depend on the presence of an intelligent gateway into the home or business. The Smart Grid is sometimes identified with smart meters. In reality, such meters are only a part, but an essential part, of the Smart Grid.

Across the world, utilities have begun installing new electronic meters that belong to a class of devices known as AMI. These meters are distinguished from other classes of meters by three characteristics: 1) they measure electric usage on a sub-hourly basis; 2) they have a two-way communications channel; and 3) they can provide real-time or near real-time data to the utility as well as consumption information to consumers. Beyond this set of defining properties, AMI meters may offer numerous other features including remote connect/disconnect capabilities, over/under voltage reporting, sophisticated data storage capacities, multiple communications platforms, tamper detection, etc.

When utilities relied exclusively on electro-mechanical meters, there were no real policy issues raised by the selection of meters except for accuracy and resistance to tampering. With the proliferation of meter features and the connectivity required by the Smart Grid, this has changed. Additional capabilities of meters come with a cost and there are many options for communications channels. This means that the selection of meters has implications for the architecture of the entire electrical grid. Here are some of the considerations that now must be made in decisions about metering infrastructure:

By moving to a Smarter Grid, Mexico will be inviting many new market players whose market entry will be driven by the business plan of CFE. These considerations lead us to find it prudent that CFE make public its plans for installation of AMI metering devices.

- Cost of the meters
- Capability of the meters
- Communication mechanism
- Technological life of the meters
- Upgrade capability
- Interconnection of services providers
- Forward-compatibility with evolving Smart Grid design
- Backward compatibility with other utility systems
- Compatibility with communications network

The technology choice and deployment schedule of AMI meters will affect the deployment of the larger Smart Grid in many ways, from communications infrastructure to consumer level applications. By moving to a Smarter Grid, Mexico will be inviting many new market players whose market entry will be driven by the business plan of CFE. These considerations lead us to find it prudent that CFE make public its plans for installation of AMI metering devices. Finally, meters are a specific example of the larger issue (discussed later) of the need to develop and publish standards for the Smart Grid in Mexico[102].

The importance of this concept is underscored as we examine a meter installation program undertaken recently by CFE. CFE has begun installing electronic meters as part of its strategy to reduce non-technical losses on the distribution grid. There is nothing wrong ***per se*** with the pursuit of this goal. However, the meters being installed are not AMI meters; they simply record consumer data and make it available to meter readers to download into a hand-held device carried by a meter reader. Unless these meters can be upgraded in the future, CFE and its consumers may not realize the many benefits expected in the future from Smart Grid initiatives.[103]

The challenge is how to motivate CFE to develop and act on a plan for meter installation that serves short-term needs while being consistent with a long-term vision of Smart Grid.

The challenge is how to motivate CFE to develop and act on a plan for meter installation that serves short-term needs while being consistent with a long-term vision of Smart Grid. Developing both positive incentives and negative incentives is necessary. But without authority, it's hard to see how those are developed.

A more straightforward approach would be to pass legislation that creates a simple directive such as the following:

> *CFE must develop and execute, in consultation with SENER, CRE and other stakeholders, a plan to implement all cost effective Smart Grid technologies. Cost effectiveness will be determined by CRE, based on analysis of data provided by CFE and other stakeholders.*

4.4.2.1.5 Recommendation CFE- 5: Jointly with CRE and other stakeholders, CFE should develop and publish a detailed transition plan for moving consumers with smart meters to tariffs that employ dynamic pricing

It has been demonstrated that dynamic pricing for residential electricity use can bring significant advantages to utilities and their consumers. The consumer response elicited by time-of-use rates will lower overall system cost, to the benefit of all consumers. Properly implemented, time of use rates are fairer and will induce consumers to use electricity more efficiently.

However, utilities and their regulators have moved very slowly toward dynamic pricing for residential consumers, even in cases where AMI meters are in place. The reasons for this slow progress include lack of information and fears of consumer resistance. Consumer education and demonstration projects can address these concerns and improve consumer acceptance of new technology and result in consumers' behavioral change to achieve energy efficiency. But the pressures to move to dynamic pricing are mounting and the foregone benefits are adding up. There are several ways in which regulators might introduce time-sensitive rates in a way that will be acceptable to consumers.

There are various ways of making rates sensitive to time of use. Some are simple, others are complex. Consumer acceptance of a rate structure different than the familiar 'flat' rate structure will depend on the consumer's ability to understand the structure and respond to it.

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[102] AMI could be a good starting point for issuance of Smart Grid standards.
[103] A sophisticated estimate of costs and benefits of Smart Grid investment over time will be necessary. The costs are straightforward; the benefits will include system operation, reliability, outage response, energy efficiency, etc.

A fixed-period, fixed-rate time-of-use rate is the simplest and is where we recommend regulators start. For example, rate levels are x/kWh from 11 AM until 8 PM, and then y/kWh all other hours of each day. A more sophisticated structure (but harder to remember and thus harder to gain comfort with) would have three rate periods, peak, shoulder and off-peak. A further complication would be to change the prices or the periods for different seasons of the year (assuming cost changes), adding more complexity.

Another option is moving to 'real time pricing' in which the price varies with system costs in each hour. While this might be acceptable to sophisticated energy users, it almost certainly will be hard for small consumers to accept.

In our view, the biggest move is from flat rates to something else. Two-period TOU rates move closer to reflecting marginal costs and improve economic efficiency, if not as fully as real time prices. But importantly, a simple TOU rate is much more likely to be embraced by small consumers. Sophistication in the rate structure can be added later.

4.4.2.1.6 Recommendation CFE- 6: CRE should support CFE to develop a plan to integrate settlement quality smart meters in the wholesale settlement process to accurately compensate generation from resources at the consumers' premises and demand responses during high production cost periods

It is critical to take necessary steps to inform consumers of the real cost of electricity production. In particular, it is important for consumers to learn more about the variability of production costs when the system demand and supply tighten and a scarcity condition occurs during peak demand periods. Similarly, actions taken by consumers, such as lowering their demand or using their distributed resources, during such peak demand should be compensated accordingly using real time wholesale prices.

Several countries in Europe and South America, as well as some states in the United States have restructured their electric power sectors to have competitive wholesale markets where fluctuations in productions cost are directly reflected in electricity prices during daily operations.[104] While there is no competitive wholesale electricity market in Mexico, CFE has full information on its system marginal production costs and should be able to communicate such information to end-use consumers. As part of this process, CFE should ensure that the information collected by smart meters is incorporated into its settlement process facilitating accurate measurement of electricity production and consumption.

CFE has full information on its system marginal production costs and should be able to communicate such information to end-use consumers. As part of this process, CFE should ensure that the information collected by smart meters is incorporated into its settlement process facilitating accurate measurement of electricity production and consumption.

4.4.2.1.7 Recommendation CFE- 7: CRE should identify outstanding marketplace barriers and recommend legislation to SENER

In response to the submission of a Smart Grid strategic plan and its successful review, CFE could be offered the following incentives by SENER and SHCP:

- Allow shorter depreciation lives for Smart Grid investment by CFE

[104] For example, the wholesale prices in most restructured wholesale electricity markets in U.S. may rise to $1,000 per MWh. Such wholesale prices in the Electric Reliability Council of Texas (ERCOT) may even reach to $5,000 per MWh. The Australian electricity market is an exception where wholesale prices can reach above $12,000 per MWh.

- Provide assurance of cost recovery for approved Smart Grid investments[105]
- Institute a public process to develop a Smart Grid vision and assess progress[106]

Furthermore, the implementation of Smart Grid will offer many opportunities for enhancements in services at consumer level. Some of such enhancements could be achieved through installation of smart meters, use of efficient appliances, increasing reliance on electric vehicle, improvements in consumer services (including connection/disconnection and service restoration), improvements in move in and move out requests processing, demand responses (pricing options, direct load control, etc.), reductions in peak hour energy use and demand, offering prepaid services, and offering assistance to consumers for analytics and energy management services. To allow full advantage of Smart Grid initiatives, CRE could take complementary steps to create level playing field by establishing rules to:

Working with SENER, CRE could take complementary steps to create level playing field by establishing rules.

- support investment by CFE to further implement Smart Grid technologies
- support CFE's calls for reduction of losses, both technical and non-technical, to be considered as the main priority
- call for detailed plan of implementation covering various locations with clear timeline to milestones to achieve
- encourage pilot programs in various districts to identify areas with the greatest needs[107]
- encourage CFE to develop performance measures for and report frequently on efficiencies and cost reductions obtained in operation
- With support from SHCP allow faster capital cost recovery for various investments

[105] By SCHP
[106] Recommend to be undertaken by SENER
[107] CRE, based on the outcomes of the programs, could provide important feedback to SENER and SCHP to develop policies and to justify budgetary proposals.

4.4.2.2 Regulatory Strategies to Enhance the Operation of Independent Third Party Industry Participants

Summary of Recommendations

- **CRE should develop and articulate its vision of third-party involvement in the retail Smart Grid**
- **CRE should develop regulation and establish rules that recognize the increasing reliance of the Mexican power grid planning and operation on third-party renewable resources such as hydro, wind, solar, biomass, etc., with varying characteristics.**
- **CRE should develop regulation and establish rules requiring more reliance on third-party supplemental resources such as demand response, energy storage facilities, and back-up natural gas generation resources**
- **CRE should establish pricing options and payment incentive mechanism to attract non-conventional resources (capacity and energy payment vs. energy payment alone)**
- **Under the direction of SENER, CRE should develop and articulate regulation respecting third-party access to consumer data**
- **CRE should make legislative recommendations to encourage Smart Grid investment through informed tax and investment policy**
- **CRE should support SENER in developing proposals to legislation to remove any barriers to interconnection of Smart Grid suppliers**

All recommendations for supporting the operational efficiency of Third Party Providers are preceded by "TPP" in the following discussions.

4.4.2.2.1 Recommendation TPP- 1: CRE should develop and articulate its vision of third-party involvement in the retail Smart Grid

In recent years the Mexican electric power sector has evolved to allow independent power producers to supply generation to consumers through Power Purchase Agreements (PPAs) with CFE at the wholesale level. Similar activities at the retail level have not yet materialized. However, as the Smart Grid develops, there will be opportunities for third parties to provide services to consumers at the other end of the delivery system – at the consumer's premises.

On the supply side, we expect that third-party suppliers will provide residential and small commercial consumers with distributed generation and storage, chiefly solar photovoltaic and solar thermal energy. Larger commercial and industrial consumers will be offered distributed generation, but also combined heat and power (CHP) installations.

On the demand side, we predict third-party provision of traditional energy efficiency measures, but also home energy management services. Further along in time, many household electrical devices will be able to provide CFE with ancillary services. All this will require the development of a third-party marketplace, where investors perceive an opportunity to earn on their investments. This leads to the primary way in which CRE can spur the development of the Smart Grid: by ensuring that there are few regulatory barriers to third-party involvement.

> *Working with SENER, it is reasonable for CRE to establish rules to create a level playing field for third parties to engage in some aspects of Smart Grid initiatives.*

Working with SENER, it is reasonable for CRE to establish rules to create a level playing field for third parties to engage in some aspects of Smart Grid initiatives.

Smart Grid initiative and system modernization takes many years and requires significant amount of investment. Historically, many governments have maintained and expanded their electric industry through public funding. However, more and more, governments are relying on public/private partnerships and the private sector, both local and international, to participate in new investment. Mexico has followed this trend for many years and third parties are engaged in investment to expand electric industry. This is a policy that brings new investment and can even encourage more targeted approach toward certain types of technology such as non-conventional resources and distributed generation options.

While reliance on such non-conventional resources can complement the operation of the existing generation resources, other challenges could be expected. In particular, renewable resources, particularly wind generation, can create unique transmission planning and operational challenges; wind often blows the most during periods of low electricity demand, wind generation introduces variability and uncertainty, and wind is typically more abundant in remote locations away from population centers. Therefore, as discussed in the Chapter 3 operators must find new ways to address operational issues regarding dispatching, forecasting and ancillary services requirement, accurate modeling, and interconnection standards.

It is recommended that CRE, in cooperation with CFE, identify the differences in integration requirements between non-conventional resources and Mexico's existing generation resources. Then, appropriate rules and regulations should be established to enhance integration of the new resources into the grid without imposing any impediments to such integration. In particular, under certain conditions, operational exemptions could be established for the new resources for a limited amount of time to reduce financial impacts for new renewable energy resource developers.

> *It is recommended that CRE, in cooperation with CFE, identify the differences in integration requirements between non-conventional resources and Mexico's existing generation resources.*

Furthermore, CRE should develop rules to:

- encourage private sector, both local or international, to participate in new investment in Smart Grid initiatives and non-conventional generation resources
- encourage more targeted approach toward certain types of technology, such as distributed generation options, and in various districts with the greatest needs for electric services
- recommend that SENER and SHCP allow faster capital cost recovery for various investments by the third-party investors[108]
- work with CFE to enhance integration of the new resources into the grid by eliminating impediments to such full integration
- work with CFE to identify operational differences that exist between new resources and its existing generation resources and require exempting non-conventional resources from certain planning and operational requirements without compromising system reliability and security
- expect CFE, under certain conditions[109], to exempt new resources from major operational requirements for at least the first few years of their operation

4.4.2.2.2 Recommendation TPP-2: CRE should develop regulation and establish rules that recognize the increasing reliance of the Mexican power grid planning and operation on third-party renewable resources such as hydro, wind, solar, and biomass with varying characteristics

[108] There is similar capability in the legislation with respect renewable energy; this could be extended to Smart Grid.
[109] These conditions are explained in section 4.2.4.6

Recent technological advances have improved operational characteristics and reduced investment requirements of renewable resources. As a result, renewable resources are now viewed as an integral component of utility source portfolios while addressing national environmental objectives. Therefore, appropriate rules and regulations should be established that recognize the characteristics and limitation of these resources without imposing any operational and investment impediment to integration of these resources[110]. In particular, under certain conditions, operational exemptions could be established for the new resources for a limited amount of time to reduce financial burdens for new resource developers.

4.4.2.2.3 Recommendation TPP-3: CRE should develop regulation and establish rules recognizing reliance on third-party supplemental resources such as demand response, energy storage facilities, and back up natural gas generation resources.

Advances in communication and automation technologies have provided unique opportunities for third-parties to increase efficiency in electricity use through consumer responsiveness to various financial incentives. Appropriate rules and regulations should be established to eliminate any barriers that discourage third-party vendors to offer market based solutions to consumers.

4.4.2.2.4 Recommendation TPP-4: CRE should establish pricing options and incentive mechanism to attract non-conventional resources (capacity and energy payments vs. energy payment)

Additional incentives may not be needed for some of the alternative resources, such as large renewable resource plants, to be attracted for expansion in Mexico. However, smaller renewable resources, particularly those that need to be located in population centers within the distribution system may require financial incentives, such as fixed rates for a long period of time. For such resources, it may even be possible to establish some compensation for available capacity[111] accompanied with a stream of payments for energy as electricity is generated over a long period of time. Such policies could be refined overtime to meet short-term as well as long-term national goals set by legislators.

4.4.2.2.5 Recommendation TPP-5: Under the direction of SENER, CRE should develop and articulate regulation respecting third-party access to consumer data

Third-parties will require access to consumer data. The successful development of the Smart Grid means that there must be a balance between access and protection of that data, which might be considered very sensitive by consumers. If data is too hard to access and use, the growth of third-party involvement in Smart Grid will be stifled[112]. If consumer protections are inadequate, abuse of third-party access or data security breaches will depress consumer acceptance and involvement in the retail Smart Grid.

In summary, while consumer information privacy is essential, necessary steps should be taken to allow timely access to such information if consumer permission is obtained in advance. In particular, CRE should

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[110] CRE is currently working on new regulation for recognizing the credit of renewable energies with respect to system's reliability.
[111] CRE is developing new regulation that recognizes capacity credit of solar PV plants. This recognition has a positive economic impact for private projects
[112] One of the big drivers of rapid cell phone growth and handset marketing is the ability of Telco providers to provide consumers new service instantly, number changes on-the-spot, service and plan changes immediately, etc. Compare that to the installation and repair of land line telephones. Growth in the 'retail' Smart Grid will rely on similar ease of use. If the interface between CFE and third-party vendors resembles the land line telephone business, consumer acceptance and growth will be dampened. If, instead, CFE provides a platform in which the integration of third-party service providers is more seamless, growth will be accelerated.

ensure that the process to obtain consumer permission is not burdensome and CFE provides such information within a reasonable period of time.

4.4.2.2.6 Recommendation TPP-6: CRE should make legislative recommendations to encourage Smart Grid investment through informed tax and investment policy

Mexico has an ambitious goal of implementing Smart Grid initiatives and achieving over 16,000 MW from renewable resources by 2026. While renewable resources will be providing significant amount of diversity to the country's fuel mix and improve environmental quality, some renewable resources have economic difficulties in competing with major well established fossil fuel based resources. Small-scale renewable resources, particularly those that best fit the needs of population in urban areas, may require more financial assistance for several years before becoming self-sufficient. Financial incentives must be established by SENER and SHCP through mandates by legislation to foster Smart Grid implementation and increase the amount of capacity by renewable resources. As is done in U.S. and some European countries, such incentives could be given for a limited number of years to ensure success in implementing such programs.

> *Small-scale renewable resources, particularly those that best fit the needs of population in urban areas, may require more financial assistance for several years before becoming self-sufficient.*

4.4.2.2.7 Recommendation TPP-7: CRE should support SENER in developing legislation to remove barriers to interconnection of Smart Grid suppliers

There are various barriers to the development of Smart Grid that should be identified and eliminated. For example, transmission bottlenecks are the main barrier for large scaled renewable resource plants that are located far away from population centers.

Furthermore, expecting Smart Grid suppliers- many of them representing intermittent resources- to meet similar operational requirements as expected from conventional generation resources may deter such resources from interconnection into Mexican grid.

There are also barriers that discourage locating distributed renewable generation resources in urban areas. Similarly, lack of appropriate pricing options or adequate compensation for consumers' responses are deterrents to fostering an effective demand response program in any utility service territory. Steps must be taken to study these Smart Grid resources, identify barriers to their interconnection, and implement policies that further encourage more interconnection of such resources into Mexican grid.

> *Steps must be taken to study these Smart Grid resources, identify barriers to their interconnection, and implement policies that further encourage more interconnection of such resources into Mexican grid.*

4.4.2.3 Regulatory Strategies to benefit the Development of Renewable Resources

Summary of Recommendations

- **Develop price reference for energy and various ancillary services and make this information publicly available**
- **Develop transmission Expansion Cost Index by Area, Zone etc. and make this information publicly available**
- **Define CREZ by technology (i.e. wind and solar) and make this information publicly available**
- **Define cost responsibility for network upgrades that are triggered as a result of interconnection of renewable resources**
- **Create a public list (Queue) for currently operational and planned renewable resources, their locations, point of interconnection, expected commercial date of operation, etc. and the latest status of each planned project**
- **Require revision in CFE's existing Interconnection Handbook to address various renewable technologies**
- **Require revision in CFE's Interconnection Agreement which address and/or exempt renewable resources from certain obligations by technology type**
- **Develop new methodology and justification of new transmission facilities based on coordination of transmission planning process and renewable interconnection**

All recommendations for supporting the Development of Renewable Resources are preceded by "DRR" in the following discussions.

4.4.2.3.1 Recommendation DRR-1: Develop price reference for energy and various ancillary services and make this information publicly available

To enhance the development of renewable resources by third parties in Mexico, market transparency and easy access to market related information is crucial. In particular, proxy locational prices should be developed to reflect electricity and ancillary services in various locations within the CFE system[113]. These prices should be publicly available and easy to access by interested parties. Regarding ancillary services there is no market where private developers could participate and the only price reference is the CFE's back-up tariff. This lack of ancillary services market is a great opportunity to create new options for private participation.

4.4.2.3.2 Recommendation DRR-2: Develop transmission Expansion Cost Index by Area, Zone etc. and make this information publicly available

In order to construct the most economical renewable resources, new power plant developers will need to know the cost differences and the need for transmission that may result based on their selected locations. Such information should be calculated by CFE and be readily available to developers[114].

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[113] Price reference for energy has been discussed in Task 1 Report. We have now the CTCP calculation and we understand the advantage of having the proposed Proxy LMP.

[114] CFE (Planning Department) should be equipped with the necessary information and tools to do so.

4.4.2.3.3 Recommendation DRR-3: Define CREZ by technology (i.e. wind and solar) and make this information publicly available

In cooperation with CFE, CREZ information should be developed and be available to resource developers reflecting the priorities set by CRE on type of technology and appropriate locations to expand such resources in the most economical way.

Competitive Renewable Energy Zones (CREZs) are established in various places to proactively facilitate the development of renewable resources. In particular, Texas is the pioneer in this area in the United States where the completion of the first set of transmission lines by the end of 2013 will increase transfer capability by about 10,000 MW from west Texas to various population centers. Similarly, CREZ could be defined in Mexico reflecting the highest potential for particular type of technologies such as wind or solar. In cooperation with CFE, such information should be developed and be available to resource developers reflecting the priorities set by CRE on type of technology and appropriate locations to expand such resources in the most economical way.

4.4.2.3.4 Recommendation DRR-4: Define cost responsibility for network upgrades that are triggered as a result of interconnection of renewable resources

The new power plant developers should have investment quality information about the need for transmission upgrades that vary based on their selected locations to construct the most economical new renewable resources. Such information should be collected by CFE and be easily available to developers.

4.4.2.3.5 Recommendation DRR-5: Create a public list (Queue) for currently operational and planned renewable resources, their locations, point of interconnection, expected commercial date of operation, etc. and the latest status of each planned project

Public list should be collected by CFE and be easily available to developers.

To assist new power plant developers to select the most economical location for their project, a public list should be developed reflecting all existing renewable resources, resources under construction, and planed for near future with useful information reflecting each project. Such information should be collected by CFE and be easily available to developers.

4.4.2.3.6 Recommendation DRR-6: Require revision in CFE's existing Interconnection Handbook to address various renewable technologies

Establish limits requirements versus project capacity

CFE should refine its existing Interconnection Handbook to reflect the differences that exist between various types of renewable technologies. It is important to establish limits requirements versus project capacity. The refinements should provide clarity in various technical and operational requirements expected by CFE and enhance decision making by new developers to select the most economical resources to install[115].

[115] Discussed in Chapter 3

4.4.2.3.7 Recommendation DRR-7: Require revision in CFE's Interconnection Agreement which address and/or exempt renewable resources from certain obligations by technology type

Regulators, in cooperation with electric system operator, should identify the differences between non-conventional resources and the existing generation resources. Appropriate rules and regulations should be established to enhance integration of new resources into the grid without imposing any impediment to such full integration. In particular, under certain conditions, operational exemptions could be established for the new resources for a limited amount of time to reduce financial impacts for new resource developers.

CFE has taken into consideration some of the operational differences in renewable resources to develop its Interconnection Agreement. However, it has not clearly identified various differences among varying renewable resources and set requirements accordingly. The existing Interconnection Handbook and Interconnection Agreement should be revised to clearly identify requirements by technology. An attempt must be made to exempt some of these resources from certain obligations if such action will not compromise system operation and reliability.

4.4.2.3.8 Recommendation DRR-8: Develop new methodology and justification of new transmission facilities based on coordination of transmission planning process and renewable interconnections

The potential areas for the most economical wind resources are usually located far from population areas. In contrast, urban areas have a great potential for roof-top solar development. In both cases, the existing transmission and distribution network must be enhanced to address the development of nationally targeted goals for renewable resources. This could be achieved by developing new methodology and justification of new transmission facilities based on coordination of transmission planning process and renewable interconnections.

4.4.2.4 REGULATORY STRATEGIES TO BENEFIT END-USERS AND IMPROVE SATISFACTION

Summary of Recommendations

- **CRE should require CFE to make "no regrets" Smart Grid investments that emphasize detection of outages, poor power quality, distribution transformer conditions before failure, etc.**
- **CRE should oversee development by CFE of "plug and play" technical standards for Smart Grid devices to enable consumer involvement**
- **Provide additional consumer billing information, including potentially providing selected consumers with innovative and expanded billing information such as that offered by a number of providers that contract with utilities**
- **At CRE's direction, CFE should consider contracting with a Smart Grid platform provider for a large scale trial**
- **CRE should consider promoting demand response options to price sensitive consumers to participate in energy and ancillary service markets**
- **CRE should consider pricing options and incentive mechanism for end-use consumers to attract small-scale renewable resources (capacity payment vs. energy payment)**
- **CRE should develop regulation to encourage distributed resources in population areas (Distributed Generation, Energy Storage, Appliances, and Electric Vehicles)**
- **CRE, in cooperation with other authorities, should begin introducing new rate structures: a Smart Grid requires "smart rates"**
- **CRE should begin publicizing Smart Grid impacts on consumer outages in areas with significant Smart Grid penetration**
- **CRE should plan and execute consumer education programs to introduce the benefits of Smart Grid initiatives**

All recommendations for benefit of end-users are preceded by "USER" in the following discussions.

4.4.2.4.1 Recommendation USER-1: CRE should require CFE to make "no regrets" Smart Grid investments that emphasize detection of outages, poor power quality, distribution transformer conditions before failure, etc.

New policies are often introduced to address shortcomings identified when earlier consumer services were evaluated. This includes policies to improve efficient use of energy, enhance environmental quality, and achieve long-term savings for consumers. These policies range from the reliance on distributed renewable resources to pricing options to encourage more efficient use of electricity as well as policies to restore outages or addressing request for service in a timely manner.

Smart Grid technology provides significant opportunity to engage consumers while improving their experience with electricity consumption. Rules and regulation should be refined to take full advantage of such opportunities. For example, consumers could be encouraged to engage in demand response activities through their price sensitiveness and passive responses in participating in energy and ancillary service markets. Some consumers may be encouraged to install distributed resources (distributed generation, energy storage, etc.) on their premises, use more efficient appliances, or purchase electric vehicles which rely on off-peak generation to charge their batteries.

> *To allow for better pricing and more proactive consumer participation in energy management, consumers should be aware of price fluctuations at the wholesale level.*

To allow for better pricing and more proactive consumer participation in energy management, consumers should be aware of price fluctuations at the wholesale level. As discussed above, this could be done by integration incorporating the information collected by smart meters in the wholesale CFE's settlement process. CRE should proactively promote the following policies:

- provide attractive incentives to consumers to participate in demand response activities, energy and ancillary service markets;
- provide attractive incentives to consumers to install distributed resources (distributed generation, energy storage, etc.) on their premises, use more efficient appliances, or purchase electric vehicles which rely on off-peak generation to charge their batteries;
- support CFE to develop service quality performance measures and to report frequently the time that it takes to restore outages and/or address consumer requests for services under Smart Grid environment; and
- require CFE to incorporate the information collected by smart meters in its settlement process and inform consumers of price fluctuations.

4.4.2.4.2 Recommendation USER-2: CRE should oversee development by CFE of "plug and play" technical standards for Smart Grid devices to enable consumer involvement

Success with the Smart Grid will depend, among other things, on the ability of numerous actors to coordinate their activities in technical areas: utilities, manufacturers, vendors, energy services companies, retail outlets, and, finally, consumers. This requirement naturally leads to the notion of standards for the Smart Grid.

Lack of clear technical standards for Smart Grid devices will create a bottleneck for investment in the Smart Grid when giant players like Siemens, IBM, Cisco, ABB, Alstom, General Electric and Schneider Electric, plus hundreds of smaller firms, are developing their investment strategies around Smart Grid.

The need for clarity in technical specifications applies to the entire value chain: from "wholesale" and "retail" Smart Grid hardware, to communications equipment and protocols, to control systems, smart appliances and consumer devices. Consider the challenge facing manufacturers if communications protocols and interconnection standards vary from area to area.

The situation in Smart Grid is similar to the challenges faced by many other industries, including the computer industry, the telecommunications industry, or even the Internet itself. It is a well-understood phenomenon that consumer adoption explodes if and only if devices are easy to connect.

Agreeing on technical specifications in standards will ensure that the Smart Grid becomes "plug and play" in much the same way that computer systems have become. It will protect consumers by making less likely an item they purchase will become a dead-end technology or require change-out of other equipment in order to function. Standards will also encourage investment by giving participants the assurance that their products will fit into a predictable hardware and software regime.

Unfortunately, there are already examples in the Smart Grid that serve as cautionary tales in this area. One example is Smart Grid City in Boulder, Colorado. The utility pursued a vendor-driven installation in which many of the features were proprietary to the project. After a promising start, the project withered as it became more and more non-standard compared to the rest of the industry, which had been proceeding on a standards-based path. The result is a Smart Grid installation that doesn't have the needed industry support.

4.4.2.4.3 Recommendation USER-3: Provide additional consumer billing information, including potentially providing selected consumers with innovative and expanded billing information such as that offered by a number of providers that contract with utilities

Information about consumption behavior and its analysis can be shared with consumers to enhance their decision making process and result in more efficient use of electricity. Such information can be provided to consumers through monthly bills or through direct communication at real time with consumers. Providing detailed consumption data and analysis to consumers, particularly in comparison with some average users in a particular service area, has shown to be effective in encouraging consumers to use electricity wisely.[116] Similarly, instant messaging and internet communication with consumers can provide useful information regarding the status of electric system, occurrences of high prices, and possibilities of emergencies which may encourage consumers to reduce their consumption or further engage in their energy use management.

4.4.2.4.4 Recommendation USER-4: At CRE's direction, CFE should consider contracting with a Smart Grid platform provider for a large scale trial

Numerous international firms have developed software platforms to enable consumer engagement in Smart Grid. These software platforms also provide the utility with an information management system, allowing utilities to undertake useful analyses of the large amounts of information typically collected routinely by smart meters.

CFE should examine the costs and benefits of employing such software in connection with the installation of smart meters in a sufficiently large trial. The software platform will provide an opportunity for CFE's consumers to engage quickly in aspects of the "retail" Smart Grid. The trial will also inform CFE's eventual decision whether to expand the use of such software or to develop such software internally.

4.4.2.4.5 Recommendation USER-5: CRE should consider promoting demand response options to price sensitive consumers to participate in energy and ancillary service markets

A healthy electric power sector requires effective consumer responses through well thought-out and effective programs. Such a system results in the most efficient use of electricity and avoids unnecessary capacity expansion while providing system operators adequate tools to reliably and securely manage their electric systems. CRE can follow policies currently implemented in different countries to enhance consumer responses. Such policies include introducing pricing options such as time of use or dynamic pricing; allowing demand response as a resource available to operator to manage need for energy and ancillary services; and providing incentives to encourage consumers to rely on distributed services to meet their electricity needs or sell power to CFE.

Through its rules, the CRE should encourage demand response by end-users to meet system demand for electricity and ancillary services. To incentivize consumers, CRE may require CFE to compensate demand response activities at high market prices during tight market conditions or system emergencies. Such policies could be refined over time to meet short-term as well as long-term national goals.

4.4.2.4.6 Recommendation USER-6: CRE should consider pricing options and incentive mechanism for end-use consumers to attract small-scale renewable resources (capacity payment vs. energy payment)

Smaller renewable resources, particularly those that need to be located in population centers within the distribution system, may require financial incentives to incentivize consumers to install such distributed generation resources. Roof top solar PVs and some small back up generation resources are good

[116] Energy management service companies have been very successful in various U.S. cities by working with regulated utilities to inform consumers of their consumption behavior and encouraging them to take proactive role to use electricity more efficiently.

examples of such resources. Incentives such as fixed rates for an extended period of time may be effective for end-use consumers. For such resources, it may even be possible to establish some compensation for available capacity accompanied with stream of payments for energy as electricity is generated over a long period of time[117]. Such policies could be refined overtime to meet short-term as well as long-term national goals.

4.4.2.4.7 Recommendation USER-7: CRE should develop regulation to encourage distributed resources in population areas (Distributed Generation, Energy Storage, Appliances, and Electric Vehicles)

Similarly, end use consumers, who meet certain level of demand, could be encouraged by rules established by CRE to install/sell their excess generation to system operator to meet system demand for electricity and ancillary services. To incentivize consumers, CRE may require CFE to establish net metering capabilities and even compensate such resources at high market prices during tight market conditions or system emergencies. Such policies could be refined overtime to meet short-term as well as long-term national goals set by legislators.

> *To incentivize consumers, CRE may require CFE to establish net metering capabilities and even compensate such resources at high market prices during tight market conditions or system emergencies*

4.4.2.4.8 Recommendation USER-8: CRE, in cooperation with other authorities, should begin introducing new rate structures: a Smart Grid requires "smart rates"

For many decades electricity consumers had no real information about prices to manage their electricity consumption. In contrast, Smart Grid technology provides a unique opportunity to allow consumers to respond to electricity prices and better manage their electricity budget and improve their experience with electricity consumption. In fact, the investment in the retail Smart Grid will not be effective if the utilities continue their services based on "dumb prices". New pricing options or "smart rates" and incentive mechanism should be introduced to interested consumers to improve efficient use of electricity. These smart rates may include pricing options such as Time of Use (TOU), Peak Time Pricing (PTP), Real Time Pricing (RTP), and Dynamic Pricing. These pricing options are better based on market conditions and production costs and can be offered to consumers with smart meters. It is possible and preferable to introduce such pricing options in a way that will be acceptable to consumers. CRE should proactively promote the following policies:

> *Smart rates may include pricing options such as Time of Use (TOU), Peak Time Pricing (PTP), Real Time Pricing (RTP), and Dynamic Pricing*

- develop a locational wholesale electricity prices every five minutes or so and make these prices available publicly
- require pricing options, that may be based on wholesale electricity prices, to be developed in cooperation with the SHCP , for consumers to encourage more efficient use of electricity

4.4.2.4.9 Recommendation USER-9: CRE should begin publicizing Smart Grid impacts on consumer outages in areas with significant Smart Grid penetration

[117] CRE is developing new regulations to recognize capacity credit from Solar PV

Acceptance and engagement by consumers of the "retail" Smart Grid will require significant efforts to educate consumers. An effective component of that education effort will be to explain the favorable outcomes of the Smart Grid observed in pilot Smart Grid programs. If Smart Grid is properly implemented, there should be many "good news" stories about improvement in power quality, reduction in the number of outages, etc. CRE, SENER and CFE should ensure that those stories are told to the public.

4.4.2.4.10 Recommendation USER-10: CRE should plan and execute consumer education programs to introduce the benefits of Smart Grid initiatives

It is crucial for CRE to engage in consumer education programs to inform consumers of the benefits of Smart Grid implementation and ways in which consumers can take advantage of Smart Grid technology.

Information has been demonstrated to assist consumers to make informed decisions regarding their use of various commodities and services. Electricity is not exempt from this rule and, in a Smart Grid era, information will play a crucial role to enhance decision making by consumers. However, before widespread use of smart meters by consumers, it is crucial for CRE to engage in consumer education programs to inform consumers of the benefits of Smart Grid implementation and ways in which consumers can take advantage of Smart Grid technology.

CRE should obtain feedback from consumers and other stakeholders to establish a consumer education program with specific milestones and performance measures to assess its progress

4.4.2.5 REGULATORY STRATEGIES TO SHARE COSTS AND BENEFITS OF SMART GRID

Summary of Recommendations

- **Develop "avoided cost" value for savings from retail Smart Grid applications**
- **Consider phasing in a "top 20" rate structure change to ToU tariff as AMI meters are introduced**
- **Target initial installation of AMI meters to mandated TOU consumers and make TOU service available to any consumer who elects to have an AMI device**

All recommendations for regulation to share costs and benefits of Smart Grid are preceded by "CBSG" in the following discussions.

4.4.2.5.1 Recommendation CBSG-1: Develop "avoided cost" value for savings from retail Smart Grid applications

Properly implemented, the Smart Grid will prove to be a very effective means of improving the efficient use of the power grid. For both "wholesale" and "retail" Smart Grid applications, knowing the avoided cost of a kilowatt-hour conserved or shifted will help induce economic behavior in consumers.

> *For both "wholesale" and "retail" Smart Grid applications, knowing the avoided cost of a kilowatt-hour conserved or shifted will help induce economic behavior in consumers.*

The marginal or avoided cost will vary by location in the electric grid. Having real time cost information at various locations in the grid will produce advantages for operations in the short-term and for planning and the value of new renewable projects in the longer term.

4.4.2.5.2 Recommendation CBSG-2: Consider phasing in a "top 20" rate structure change to TOU tariff as AMI meters are introduced

In discussions with CRE, CFE and SENER, it has become clear that the plethora of retail electric tariffs in Mexico is in need of reform. This is a long-term project that will require very agile decisions.

Development of the Smart Grid will both motivate and enable improvements in the precision and sophistication of rate structures faced by consumers. Within the residential sector, smart meters will allow CFE to record demand and energy use in real time, in contrast to the situation where a meter reader records only energy use and only monthly. Given the variance in system costs within a day and across the seasons, the Smart Grid will permit CFE to offer (or require) the use of a tariff with time differentiated rates. Charging prices that reflect the varying costs over time will present consumers with the true costs of the energy at the time it is used.

The twenty percent (20%) of residential consumers with the highest electricity use will, in aggregate, consume a disproportionate fraction of electricity used by the entire residential consumer class. The distribution of residential consumers by usage is skewed and we would predict that the "top 20" percent of consumers will use at least 40% of the residential class total kilowatt-hours. Time-sensitive rates will be most relevant to those largest users of electricity in the residential class, since these are generally (but not exclusively) the consumers with the largest houses and the financial means to employ energy conservation and load-shifting techniques. For that reason, CFE is likely to find that the combination of AMI devices and "smart prices" targeted to this group of larger users will be highly cost effective from the system perspective.

Although the Smart Grid will enable the use of very sophisticated tariff structures, we recommend that the initial dynamic pricing tariffs should be relatively simple and easy for the consumer to understand. For example, a tariff with fixed peak, shoulder and off-peak prices during fixed time periods would be a reasonable first step for a dynamic pricing tariff. Over time and after public understanding and acceptance of TOU rates have been achieved, more sophisticated rate structures can be considered.

The "top 20" approach will be an effective way to lay the foundation on dynamic pricing. Some research suggests that most consumers prefer time of use rates after they have experience with them. Following the introduction of the rates for the largest consumers, that may result in some socialization, voluntary subscription by smaller consumers will likely increase.

4.4.2.5.3 *Recommendation CBSG-3: Target initial installation of AMI meters to mandated TOU consumers and make TOU service available to any other consumer who asks to have an AMI device*

As explained above, the most cost-effective application of smart meters will be with largest electricity users in any consumer class. Aligning smart meters installation and a TOU tariff with the largest consumers in a class is a reasonable way to target AMI installation to its most cost effective use.

Installation of smart meters to reduce non-technical losses should follow same pattern: ensure that largest consumers get smart meters. Wireless mesh networks will allow "skip" installations of smart meters.

On the other hand, there is no reason to restrict the TOU tariff to the largest consumers in a class of consumers. Consumers not in the top echelon of users should be able to elect receiving a smart meter and should be able to elect to have TOU rates.

4.4.2.6 REGULATORY STRATEGIES TO PROTECT END-USER INFORMATION AND PRIVACY

4.4.2.6.1 Overview of Mexican Laws and Regulations Prior to the Energy Reform

Prior to the Energy Reform Act of 2013, there were no regulation that governed Smart Grid activities in Mexico and, therefore, the protection of privacy and personal information as related to Smart Grid has not been regulated either.

ESTA examined the general legislation and regulation in force at the time of the study in order to first determine the competent entity to issue specific regulations and, afterwards establish a framework for general obligations and the path that must be followed to carry out said regulation.

Generally speaking, Article 1 of the Political Constitution of the United Mexican States (CPEUM)[118] incorporated within its text, on June 10th, 2011, the concept of Human Rights, with the purpose of providing a scope and relevance that was not present until that time.
Likewise, article 6, sections II and III, of the CPEUM establishes the principles and foundations for exercising human rights to information and privacy in the following manner:

> *II. Information regarding private life and personal information will be protected under the terms and with exceptions determined by law.*
>
> *III. Every person, without need for proving any interest or justifying its use, will have free access to public information, to his/her personal information, or to correction of such.*

Article 1 of the Federal Law for the Protection of Personal Information Possessed by Private Parties (LFPDPPP[119]) indicates the following:

> *Article 1.- This Law is of public interest and of general enforcement throughout the entire Republic (Mexico) and has as its purpose the protection of personal information possessed by private parties, with the goal of regulating its legitimate use, monitored and informed, in order to guarantee privacy and the people's right to informed self-determination.*

It can be deduced from the foregoing that the LFPDPPP regulates only the personal information possessed by private parties; however, article 40 of this legislation indicates the following:

> *Article 40- This Law shall constitute the regulatory framework that the dependencies must observe, in the scope of its own responsibilities, for issuing the corresponding regulations with support from the Institute.*

Regarding such, articles 77 and 78 of the Federal Law for the Protection of Personal Information Possessed by Private Parties (RLFPDPPP[120]) establish the following:

> *Article 77. When the competent dependency, responding to the noticed needs regarding the sector it regulates, determines the need to regulate the handling of personal information possessed by private parties, it may, within the scope of its responsibilities, issue or modify specific regulation with support from the Institute.*

[118] Constitución Política de los Estados Unidos Mexicanos (CPEUM)
[119] Ley Federal de Protección de Datos Personales en Posesión de los Particulares (LFPDPPP).
[120] Reglamento de la Ley Federal de Protección de Datos Personales en Posesión de los Particulares (RLFPDPPP).

Likewise, when the Institute, as a result of exercising its responsibilities, notices the need to issue or modify specific regulation to regulate the handling of personal information in a determined activity or sector, it may propose a preliminary plan to the competent dependency.

> *Article 78. For preparation, issuance, and publication of the regulation referenced in article 40 of the Law, the dependency and the Institute will establish the corresponding coordination mechanisms.*
>
> *In every case, the dependency and the Institute, in the scope of its responsibilities, will determine the regulations that regulate the handling of personal information in the corresponding sector or activity.*

It is important to take into consideration that these powers that arise from the LFPDPPP and the RLFPDPPP are limited to the issuance of regulation related to personal information possessed by private parties in the scope of the particular responsibilities of the competent authorities.

Nevertheless, CRE also has the authority to establish guidelines to agree with the regulated subject's self-regulation mechanisms in the area of protecting personal information possessed by private parties in accordance with article 44 of the LFPDPPP which establishes:

> *Article 44.- Individuals or legal entities may agree amongst themselves or with government or civil organizations, national or foreign, self-regulation guidelines related to the area, that complement what is set forth in this Law. Said guidelines must contain mechanisms to measure its efficiency in protecting information, effective corrective measures, and consequences in case of non-compliance.*
>
> *Self-regulation guidelines may be translated in good professional practice or ethical codes, seals of confidence, or other mechanisms and will contain specific standards or rules that allow for coordinating information handling carried out by participants and ease the exercise of holder rights. Said guidelines will be simultaneously notified to the corresponding sector authorities and the Institute.*

In other words, a general regulation framework exists, which regulates the protection of personal information as well as the privacy of certain information. However, specific regulation must be issued.

In order to do so, it is necessary to define the regulatory framework that is applicable and determine which entity has the specific authority to issue such regulation.

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Likewise, article 33 of the Fundamental Law of the Federal Public Administration (LOAPF[121]) through sections I, III, X, and XII regulates the various responsibilities and powers of the Ministry of Energy regarding the development and implementation of the Smart Grid. Such sections establish the following:

> *I. Establish and direct the country's energy policies, as well as supervise its fulfillment with*

[121] Ley Orgánica de la Administración Pública Federal (LOAPF).

priority placed on energy diversification and security, energy savings, and environmental protection, through which it may, among other actions and under terms of applicable regulations, coordinate, carry out, and promote programs, projects, studies, and investigations regarding subjects within its responsibility;

III. Direct and supervise the activity of the separate public entities in the Ministry, as well as programming the exploration, exploitation, and transformation of hydrocarbons and generation of nuclear and electrical energy, adhering to the applicable regulations;

X. Promote energy savings, regulate and, where applicable, issue official Mexican regulations regarding energy efficiency, as well as carry out and support studies and investigations regarding energy savings, structures, costs, projects, markets, prices and rates, assets, procedures, rules, regulations, and other related aspects;

XII. Regulate and, where applicable, issue official Mexican regulations regarding productions, commercialization, buying and selling, quality conditions, energy supply, and other aspects that promote sector development, modernization, and efficiency, as well as monitor and oversee its due fulfillment;

Said authority is exercised by SENER through the Energy Regulatory Commission (CRE) which, in accordance with Article 1 of the Energy Regulatory Commission Act (LCRE[122]), is an independent body of SENER, which has decisive, management, operative, and technical autonomy. Therefore, it is necessary to refer to CRE powers on Smart Grid issues.

In regard to sections I to IV, as well as the final paragraph of article 2 of the LCRE indicate that CRE will maintain as its purpose, the promotion of efficient development for the following activities:

I. The supply and sale of electrical energy to public service users;

II. The generation, exporting, and importing of electrical energy, that private parties carry out;

III. The acquisition of electrical energy destined for public service;

IV. The electrical energy delivery, transformation, and directing services, between the entities in charge of providing electrical energy public services, and between these entities and holders of permits for the generation, exporting, and importing of electrical energy;

In fulfillment of its purpose, the Commission will contribute to safeguard the provision of public services, encourage healthy competition, protect the users' interests, contribute to adequate national coverage, and attend to confidence, stability, and security in the services' supply and provision.

Likewise, article 3 of the LCRE establishes that in order to fulfill its purpose, CRE will have various responsibilities, of which emphasis is placed on what is set forth in sections I to VI, XII to XVI, and XXII, relating to the development of regulations regarding the Smart Grid, including that related to the protection of personal information as well as information privacy.

[122] Ley de la Comisión Reguladora de Energía (LCRE).

I. Participate in determining the rates for the supply and sale of electrical energy[123];

II. Approve the criteria and foundations for determining the contribution amount from governments of federal entities, city halls, and beneficiaries of the electrical energy public service, in order to carry out specific works, expansions or modifications to existing works, requested by such for the supply of electrical energy;

III. Verify that in the provision of electrical energy public service, the acquired provision is that which results in a lower cost for the entities in charge of public service provision, as well as offers optimal stability, quality, and security for the national electrical system;

IV. Approve the methods for calculating compensation for the acquisition of electrical energy destined for public service;

V. Approve the methods for calculating compensation for electrical energy delivery, transformation, and direction[124].

VI. Provide opinions, upon request from the Ministry of Energy, regarding the formulation and follow-up of separate programs in energy matters; regarding the needs for growth or substitution of generation capacity for the national electrical system; regarding the convenience on which the Federal Electricity Commission implements projects or private parties are called upon to supply electrical energy and, where applicable, regarding the terms and conditions of the notifications and foundations of corresponding bids;

XII. Grant and revoke permits and authorizations that, according to applicable legal regulations, are required to carry out regulated activities;

XIII. Approve and issue agreement models and adhesion contracts to carry out regulated activities;

XIV. Issue and oversee the fulfillment of general administrative regulations, applicable to persons who carry out regulated activities;

XV. Propose updates to the legal framework in the scope of its responsibilities to the Ministry of Energy, as well as terms under which the Commission can participate with competent dependencies in the formulation of initiative projects in laws, decrees, statutory regulations, and official Mexican regulations regarding regulated activities;

XVI. Maintain a declaratory registry and for marketing purposes, regarding the regulated activities.

XXII. Others conferred by the regulatory laws of the 27th Constitutional Article and other

[123] Although CRE has the right to participate in the process to determine the electrical tariffs, this is not an obligation, therefore the CRE has not been able to exercise its right so far because the obligation is under other Government Agencies, such as the Ministry of Treasury (Secretaría de Hacienda y Crédito Público SHCP).
[124] This applies only for IPPs.

applicable legal regulations.

In order to issue the regulation applicable to the Smart Grid, article 8 of the LCRE must be taken into consideration, which establishes the following:

> *ARTICLE 8. - The general administrative regulations that the Commission dictates, such as general application criteria, general guidelines and methods, that persons who carry out regulated activities must comply with, may be issued through the public enquiry procedure that is established by the statutory regulations.*

According with the regulation set forth in articles 36 through 39 of the Energy Public Service Act, SENER, considering the criteria and guidelines of the national energy policy and hearing the opinion of CFE, will issue the permits of regulated activities through the CRE for self-supply, cogeneration, independent production, small production, importation and / or exportation of electricity.

Therefore, CRE may clearly issue general administrative regulations that are related to the development and operation of the Smart Grid, but also that related to the adequate handling of personal information that is obtained or exchanged.

The following is the just cause, with the purpose of considering CRE as an entity that develops the regulatory framework that allow for adequate regulation of Smart Grid operations and services:

a) Use and application of the Smart Grid in the National Electrical System (SEN) will generate a high impact on determining the rates for the supply and purchase of electrical energy. CRE participates in setting forth said rates.

b) Use of the Smart Grid in SEN will allow CRE to verify that in provision of electrical energy public service, that which results in a lower cost for the entities in charge of public service provision is effectively acquired, and guarantees optimal stability, quality, and security for SEN.

c) Through the Smart Grid, CRE can approve the method for calculating compensations for acquisition of electrical energy destined for public service.

Some mechanisms through which CRE could indirectly regulate the Smart Grid, are the following: i) Interconnection Agreement for Renewable Energies and the small and medium scale Cogeneration Energy System, ii) Methods for determining the capacity support of renewable sources to SEN, and; iii) Interconnection Agreement.

If for that matter, the LFPDPP specifically refers to information possessed by private parties, there is such specific regulation for the protection of personal information that applies to government entities. Said specific regulation is very concise and is found in Chapter IV of the Federal Law of Transparency and Access to Government Public Information (LFTAIPG[125]) relating to Protection of personal information. Articles 20 to 26, of the said chapter indicate the following:

> *Article 20. The liable parties[126] will be responsible for personal information and, relating to such,*

[125] Ley Federal de Transparencia y Acceso a la Información. (LFTAIPG).

[126] Article 3. For effects of this Law, it will be understood that:
…XIV. Liable parties.
a) The Federal Executive Branch, the Federal Public Administration, and the Mexican Attorney General's Office;

must:

I. Adopt adequate procedures to receive and respond to information correction and access requests, as well as train public servants and make known information regarding their policies related to the protection of such information, in accordance with the related guidelines that the Institute establishes or equivalent requests foreseen in Article 61;

II. Handle personal information only when this is adequate, pertinent, and not excessive in relation with the purposes for which they have been obtained;

III. Place at the disposal of individuals, from the time at which personal information is collected, the document in which its handling purposes are established, under terms of guidelines established by the Institute or the equivalent request referred to in Article 61;

IV. Ensure that the personal information is exact and up-to-date;

V. Substitute, rectify, or complete, ex-officio (automatically), the incorrect personal information, whether total or partially so, or incomplete, at the moment they are made aware of this situation, and

VI. Adopt necessary measures that guarantee the security of personal information and avoid their alteration, loss, transmission, and unauthorized access.

Article 21. The liable parties may not disseminate, distribute, or commercialize the personal information contained in the information systems, developed in the exercise of their functions, unless by expressed consent, in writing or by means of similar verification, from the individuals referenced in the information.

Article 22. Consent from individuals for providing personal information is not required in the following cases:

I. (Repealed).

II. That which is necessary for general interest, scientific, or statistical reasons foreseen by law, following procedures through which personal information cannot be associated with the individual it references;

III. When it is transmitted between liable parties or between dependencies and entities, as long as the information is used in the exercise of authority belonging to such.

IV. When there is a court order;

V. To third parties when they are hired for provision of a service that requires handling personal information. Said third parties cannot use personal information for purposes

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b) The Federal Legislative Branch, composed of the Chamber of Deputies, the Chamber of Senators, the Permanent Commission and any of its bodies;
c) The Federation Judicial Branch and the Federal Judiciary Counsel;
d) The autonomous constitutional bodies;
e) The federal administrative courts, and
f) Any other federal body.

other than those for which they are transmitted, and

VI. In other cases that the law establishes.

Article 23. The liable parties that possess, for any title, personal information systems, must make it known to the Institute or of the equivalent requests foreseen in Article 61, those who will maintain an updated list of the personal information systems.

Article 24. Notwithstanding what is set forth in other laws, only interested parties or their representatives may request that a contact unit or its equivalent, upon accreditation, provide them with personal information contained in a personal information system. The contact unit must deliver, in a period of ten business days starting upon submission of the request, in a format comprehensible to the requesting party, the corresponding information, or instead, provide the requesting party with written notice writing that the personal information system does not contain the referenced information.

Delivery of personal information will be at no cost, the individual must only cover the costs of delivery in accordance with applicable rates. However, if the same person submits a new request in regard to the same personal information system in a period less than twelve months from the last request, the costs will be determined in accordance with what is established in Article 27.

Article 25. The interested persons or their representatives may request, upon accreditation, from the contact unit or its equivalent, that their information contained in any personal information system be modified. For such purposes, the interested party must submit a modification request to the contact unit or its equivalent, which indicates the personal information system, indicating the modifications to be carried out and providing the documentation that details the motive for their request. The contact unit must deliver to the requesting party, in a period of 30 business days from the submission of the request, a paper recording the modification or instead, duly justifying the reasons for which the modifications were not made.

Article 26. Upon failure to deliver or correct personal information, the formulation of the resource referenced in Article 50 will proceed. It will also proceed if there is no reply within the periods referenced in articles 24 and 25.

Besides what is established in the LFTAIPG, there is also additional regulation applicable to the dependencies and entities of the Federal Public Administration such as the following:

1. Regulation of the Federal Law of Transparency and Access to Government Public Information.
2. Guidelines that must be observed by the dependencies and entities of the Federal Public Administration, in the receipt, processing, procedure, resolution, and notification of requests for the correction of personal information made by private parties (Official Federation Newsletter, dated Tuesday, April 6th, 2004)'
3. Guidelines for Protection of Personal Information (Official Federation Newsletter, dated Friday, September 30th, 2005).

International regulations that could be considered as best practices are mentioned in the Overview of the International Smart Grid Initiatives of this Report.

The Smart Grid allows for collection, transfer, use, and availability of personal information that flows through SEN and that undoubtedly demands the issuance of general administrative regulations in the area of personal information protection and privacy on behalf of CRE, with support from the Federal Institute for Access to Information and Protection of Information (IFAI[127]),

In accordance with article 40 of the LFPDPPP and article 77 of the RLFPDPPP, not only because the regulated sector has specific needs, but because the exercise of human rights to privacy and protection of their information is guaranteed, established in the 6th article of the Constitution.

4.4.2.7 RECOMMENDATIONS

Consumer information and privacy should be an integral part of any successful policy to encourage Smart Grid development. This section identifies the minimum requirements to ensure consumer privacy and information security while allowing access to market information that could be used by the third parties (vendors) to assess consumers' needs and introduce innovative products and services.

Summary of Recommendations

- **In concert with other Mexican consumer rights agencies, CRE should develop a Consumer Directive of Smart Grid Rights detailing privacy, access to information, and consumer control over the use of consumer energy data**
- **CRE should guide CFE in creating a consumer education campaign treating Smart Grid consumer issues, especially privacy issues**
- **CRE should develop an industry Voluntary Code of Conduct, available to CFE and all providers of Smart Grid services.**
- **CRE and CFE should examine the applicability in Mexico of an initiative similar to the US "Green Button" initiative.**
- **Ensure that consumer consumption information history will be easily accessible by third parties and energy management vendors if permission is granted by consumer**

Discussion of Recommendations

4.4.2.7.1 Recommendation PRIV - 1: In concert with other Mexican consumer rights agencies, CRE should develop a Consumer Directive of Smart Grid Rights detailing privacy, access to information, and consumer control over the use of consumer energy data

Privacy concerns loom large in many countries developing the Smart Grid. It is very important to address this issue at the beginning of Smart Grid development, before the "genie is out of the bottle."

National laws concerning the use of a consumer's privacy rights have typically been developed prior to development of the Smart Grid technologies[128]. As we have stressed, the growth of the Smart Grid will require a balance between consumer access to data, authorized vendor access to that data, and the protection of that data. Making access to data very difficult might result in keeping data out of the hands of vendors, even those authorized by consumers to use the data on their behalf.

127 Instituto Federal de Acceso a la Información (IFAI).

128 As an example this year, IFAI has imposed fines for USD $ 2 million to one individual and four private entities, including a major Bank (Banamex) and a sport fitness club (Sport City) among others.

CRE has the powers to issue the directives, and could in any case be supported by IFAI and Ministry of Economy. This action should be coupled with a code of conduct, discussed below, that details exactly how permission, protection and use of the data will be implemented by players in the Smart Grid. CRE should work with SENER and CFE in achieving this objective.

4.4.2.7.2 Recommendation PRIV-2: CRE should guide CFE in creating a consumer education campaign treating Smart Grid consumer issues, especially privacy issues

Over time, the Smart Grid will significantly change the way consumers think and act about energy. The industry visionaries predict an electric sector that is changed by the Smart Grid in much the same way that the Internet has changed the way we communicate, get our news, shop, do our banking, purchase entertainment, listen to the radio etc.

Consumers are not yet very familiar with the concepts of the Smart Grid: we are at the beginning of a long period of development in consumer understanding. Without attempting to convey the eventual impact of the Smart Grid, it is important to begin to convey to consumers the basic outline of what is coming. It is critical to shape that message before control of the message goes to others. This is especially true of the privacy issue, which will have serious unintended consequences if not addressed adequately.

We recommend that CRE provide guidance and support to CFE in creating a long-term consumer education campaign to educate consumers about aspects of the Smart Grid, especially having to do with the handling of private consumer data.

4.4.2.7.3 Recommendation PRIV-3: CRE should assist in the development an industry Voluntary Code of Conduct, available to all providers of Smart Grid services

The CRE must always balance ease of access to consumer data with privacy and security protections. If this balance is not achieved, either the Smart Grid will be stunted (most likely) or there will be abuses of consumer information.

We recommend that CRE lead an effort to develop a Voluntary Code of Conduct that can be adopted by any public or private entity that participates in the Smart Grid. As consumer interest and awareness of the "retail" Smart Grid begins to develop, it will be most helpful to have a stakeholder-driven code of conduct to assure consumers about the data handling practices of the code adherents.

Consumer information and privacy are among the main issues when it comes to smart meters implementation. At the same time, access to consumer consumption information, particularly by third parties and vendors, is key for consumers to learn about electricity consumption and identify ways to improve energy efficiency that will result in savings and environmental benefits. The key challenge for regulators is to achieve the right balance among these two important factors.

According with article 44 of the Federal Law for the Protection of Personal Information Possessed by Private Parties (LFPDPPP[129]) CRE not only has the powers to issue the regulation related to the Smart Grid activity, but as well it has the powers to agree with individuals or private entities to issue self-binding schemes of the regulated activities regarding information possessed by private parties. The self-binding schemes must include provisions that comply with the LFPDPPP and mechanisms that measure the effectiveness of privacy data protection and the effective remedial actions in case of default. In this case it is important that self-binding schemes being developed in conjunction with the Smart Grid industry. We expect that an

[129] Ley Federal de Protección de Datos Personales en Posesión de los Particulares (LFPDPPP).

initiative such as this will draw a lot of interest from industry players. It will signal the Mexican government earnestness about developing the Smart Grid while protecting consumer rights.

The US Department of Energy is currently hosting a process in which industry players, consumer leaders, utilities and regulators are developing a voluntary code of conduct. The code will be available for voluntary subscription by any industry participant in the Smart Grid: from utilities, to communications carriers, to meter manufacturers, software vendors and energy service companies. Using the US DOE initiative as a base, the following list elements will be addressed in the VCC for Mexico.

1. **Rights of the Consumers –** Elements that relate to the rights that the consumers have according with laws and regulations.
2. **Obligations of the third parties and vendors** – Elements that relate to the rights that the consumers have according with laws and regulations.
3. **Management And Accountability –** Elements that relate to the credibility of the utility and/or third party's privacy function.
4. **Notice And Purpose** – Elements that relate to communicating applicable policies, and related choices, to consumers.
5. **Choice And Consent –** Elements that relate to the consumer's granting of authorization for the release/sharing of his or her data.
6. **Collection And Scope –** Elements that relate to the scope of consumer data that is collected, and potentially shared.
7. **Use And Retention** – Elements that relate to how long consumer data should be kept, and when it should be destroyed.
8. **Individual Access** – Elements that relate to the consumer accessing his or her own data.
9. **Disclosure And Limiting Use –** Elements that relate to how consumer data is shared with third parties
10. **Security And Safeguards** – Elements that relate to how consumer data should be protected from un-authorized disclosure.
11. **Accuracy And Quality** – Elements that relate to the maintenance of accurate and complete consumer data.
12. **Openness, Monitoring, And Challenging Compliance –** Elements that relate to consumer education and complaints.

4.4.3 Regulatory and Industry Incentive Mechanisms

Innovative regulatory and market incentives are needed to facilitate progress toward the medium-term and long-term national energy sector goals in Mexico. Such mechanisms may include faster investment cost recovery, financial rewards or tax incentives, such as investment and production tax credits, resulting in measurable achievements toward Mexico's national goals.

The development of the Smart Grid will require identifying various incentive mechanisms to enhance progress toward different local and national goals. In particular, these incentives must be tailored toward attracting major players with variety of interests, which may include utilities, third parties, and end-users, to pursue activities that facilitate achieving those local and national goals.

4.4.3.1 Possible Incentives for CFE

Regulation can be introduced to address shortcomings in the existing incentive mechanism under which the utilities operate. This may also include those to improve system planning for infrastructure development, operating cost effectiveness, or timely restoration of outages. Incentives could include:

- Higher allowances for certain targeted investments (Smart Grid installations, T&D automation and investments in demand response and storage technologies)
- Operational efficiency gains that could be reinvested to support the implementation process.
- Peak demand savings that could be reinvested to support the implementation process.
- Generation efficiency improvements and reduction of losses
- Management and employee bonuses for meeting Smart Grid milestones
- Performance-based decisions to encourage improvements in efficiency and effectiveness in operation. Such performance-based decisions may include policies to improve system planning for infrastructure development, operating cost effectiveness, or timely restoration of outages.
- Fund R&D programs and require testing key program design options with pilots implemented particularly in desired locations in great need of improvements.
- Explore incentive programs for electric vehicles and implementation of smart charging stations

4.4.3.2 Possible Incentives for Third Party Industry Participants

The third party participation in various aspects of the electric power sector has been expanding in many countries and regions; innovative incentive mechanisms have played a critical role in attracting such participation. As previously stated, Mexico has non-utility participation in its electric power sector; this has happened with almost no serious financial incentives. Independent power producers have relied on long-term purchased power agreements and some technical exemptions from operational requirements. Third party participation beyond the capacity expansion and into Smart Grid implementation may require financial incentives to achieve national goals.

Third party participation beyond the capacity expansion and into Smart Grid implementation may require financial incentives to achieve national goals.

In order to establish such incentives, two categories of mechanisms are recommended. These categories include:

1. Developing innovative regulatory and market incentives to facilitate progress toward the medium-term and long-term national goals set by decision makers in Mexico[130]; and
2. Establishing policies to improve system planning for infrastructure development and create level playing field for all renewable energy power developers.

The first category could include:

- Financial rewards or tax incentives resulting in measurable achievements toward national goals.
- Income and property tax exemptions for limited number of years
- Standardize medium to long-term purchased power agreements
- Rewards for pursuing certain type of projects or in disadvantaged locations with great electrical needs
- Cost sharing for research and development pilot projects addressing non-conventional generation resources

The second category, which should focus on improving infrastructure development and level playing field, may include:

- Proactively improving infrastructure, particularly with regard to transmission network to create transmission capacity for interconnection of renewable resources
- Establishing interconnection requirements and standards
- Setting interconnection costs at a fair and equitable level
- Setting predictable transmission access and usage charges based on cost-causation principles
- Exempting smaller projects from extensive interconnection requirements
- Exempting small projects from operational requirements that are pertinent to large power plants
- Encouraging renewable distributed resources installed at consumers' premises to reduce expansion requirements

Our recommendations for possible exemptions from interconnection or operational requirements apply only to situations which do not compromise the safety, reliability, and the security of the system. This practice can encourage more renewable resources development due to the fact that such exemptions relieve developers from the need to spend significant capital and timeline to meet such requirements. It is typical to allow such exemptions for the early years of operation and identify some future dates by which a full compliance could be expected[131]. This will postpone some expenses and further encourages developers to engage in investments associated with renewable resources. Some of the areas with potential for exemptions include:

- General Exemptions: such as accuracy in scheduling and strict performance measures against uninstructed deviations
- Forecast: CFE can provide generation forecast related to renewable resources specially wind resources
- Ramp Rate: allowing faster ramp rates to improve economic operations for renewable resources
- Frequency Response and Load Following: could be exempt for the first few years.
- Voltage Support and Reactive Power requirements to be modified to meet the capabilities set by the renewable resource manufacturers

Similarly, steps could be taken by CRE and CFE to enhance planning process by identifying network bottlenecks and congestion proactively and engage in concrete actions to address them in a timely manner. As a part of this process, feedback should be sought from non-utility resources developers and other

[130] The current rationale of fostering RE in Mexico is to create regulation to level the field with respect to conventional generation instead of creating financial rewards.
[131] CFE would have to determine the limit in capacity before grid reinforcement would be required.

interested players to improve the effectiveness of the planning process. Finally, Mexican authorities may want to explore the possibilities for the private sector to participate in infrastructure development. If such policy is desired, CRE must establish clear rules and expectations regarding the following concerns:

- Standards-setting
- Clarity in rules for third-party access to consumer data
- Provide reasonable assurance of investment recovery, possibly through legislative declaration
- Engage equipment and appliance manufacturing

To enhance such regulation, actions must be taken to address the following areas:

- Allow private sector to engage in certain infrastructure development
- Define areas where such participation is encouraged
- Allow CFE to enter into joint venture with the third parties to implement pilots in areas with a great need for infrastructure improvements
- Rely on competitive auction to select developers for specific projects[132]
- Provide financial incentives for specific category of projects and/or in certain regions

4.4.3.3 Possible Incentives for End-Users

In this section, we identify various incentives mechanisms to encourage more consumer participation in achieving medium-term and long-term national goals. Such incentive mechanisms can range from the reliance on distributed renewable resources to pricing options that encourage more efficient use of electricity. Careful analysis of costs and benefits of various retail Smart Grid initiatives may justify certain actions to be taken by CRE to incentivize consumers to engage in Smart Grid initiatives:

> *Incentive mechanism may range from the reliance on distributed renewable resources to pricing options to encourage more efficient use of electricity.*

- Rebates and incentives to residential consumers to install renewable resources, such as rooftop solar panels, at their premises
- Rebates and incentives to commercial and industrial consumers to install distributed renewable generation resources, such as backup generation, in their facilities
- In collaboration with CONUEE allow reward and payments for energy efficiency programs implemented by consumers in their premises and facilities
- Reward consumers for demand response activities that help CFE to better handle scarcity conditions or system emergencies[133]

Smart Grid implementation opens the possibilities for offering a variety of services to consumers and enhancing consumer satisfaction. In particular, the following major areas focus on providing new products and services to consumers:

- Demand response activities (pricing options, direct load control, etc.)
- Time of Use and other pricing options
- Peak hour energy use and demand reduction
- Prepaid services
- Analytics and energy management services

While it may take many years to fully address all these areas, certain actions could be taken as a starting point to enhance such strategies. In particular, the followings are recommended as the starting points:

[132] As the regulator, CRE must promote transparent and fair mechanisms in which private developers may want to participate.
[133] These Rewards could include Critical Peak Pricing, Critical Peak Rebate, and other possible incentives.

- Develop voluntary Critical Peak Pricing tariff
- Develop voluntary TOU tariff
- Focus on 20% of consumers who are most interested in what Smart Grid offers.
  - Consider mandatory TOU with AMI installation for top 20%
  - Consider informational shadow billing[134] for one year
- Establish a prepaid services for low income or consumers who are willing to manage their electricity budget

If a group of consumers are switched from flat rate billing to TOU without changing the revenue requirement of the group, about half the consumers will be "winners" and half will be "losers." Properly implemented, neither the wins nor the losses will be very large.

"Shadow billing" could be instituted one year before a consumer group is switched from flat rates to TOU rates. The shadow bill will show the winners that they will be better off next year, actually building some support for TOU rates. The losers will see that the "losses" are in the future (and not large) and might motivate them to find ways to employ better energy management practices.

[134] Shadow billing is the concept of showing the consumer how much they are paying under their current rate/tariff and how much they would be paying if they switched to an alternative rate/tariff.

4.4.4 Regulatory Barriers and Market Barriers

This section describes various barriers, especially regulatory barriers, which should be overcome in order to maximize the benefits of Smart Grid initiatives. The discussion is based on preliminary review of CRE's legal framework and of the structure of the Mexican energy sector prior to the Energy Reform. In addition to regulatory barriers, this section also lists some of the market barriers that should be addressed. These may hinder the deployment of Smart Grid technology in transmission and distribution systems, or may cause incentives for Smart Grid implementation to become ineffective. Recommendations are provided for possible enhancements to the existing legal framework to facilitate the success of the proposed regulatory roadmap.

4.4.4.1 Regulatory barriers

Despite good intentions to serve consumers and improve operational efficiencies, regulation may impose barriers to achieving the best economic outcome. Eurelectric, a union of electric industry in Europe, conducted a survey of regulatory barriers in sixteen European countries where adequacy of rate of return on investment and stability of regulatory environment were listed among the most important barriers to address in order to enhance Smart Grid initiation.[135]

The most important regulatory barrier is regulatory uncertainty. Such uncertainty may be reflected in various forms, including costs recovery associated with investment in innovation or timely mechanism to introduce proper incentives to enhance innovation and new technologies. Some additional typical regulatory barriers are listed below:

> *The most important regulatory barrier is regulatory uncertainty.*

- Lack of timely transmission expansion to accommodate non-conventional resources
    - Costly process
    - Lengthy process
- Lack of timely investment cost recovery, particularly for Smart Grid projects
- Uncertainty in environmental regulations and emission limits
- Lack of a unified voice by government agencies to keep the momentum on Smart Grid and help stimulate its development
- Lack of clarity in roles and responsibilities of various government agencies versus utilities
- Lack of funding for R&D and pilot projects
- Inadequate certainty and transparency in competitive bidding processes
- Uncertainty associated with purchased power contract terms and conditions and a need for longer term contracts
- Lack of performance-based incentives to improve efficiency

These and other regulatory barriers should be addressed to enhance progress in implementing Smart Grid initiatives within the Mexican electric industry sector. In particular, the roles and responsibilities of various government agencies should be clarified and a unified position developed for each issue.

4.4.4.2 Market barriers

Market barriers can impact all aspects of electric industry operation, especially for non-conventional resources such as renewable resources. Research and development is a good example of a component that must be seriously considered by decision makers and not left to the market forces, at least during the early development phase of such resources. Enhancing infrastructure, particularly transmission and

[135] Eurelectric (2011). Regulation for Smart Grids, February, Brussels, Belgium.

distribution facilities, is another area that could not be left to the conventional market forces. Additional typical market barriers include:

- High cost of Smart Grid implementation
- Uncertainty regarding the future of Smart Grid technology
- Lack of adequate interoperability standards
- Non-conventional resources are usually located away from population centers
- Lack of adequate information about the benefits of non-conventional resources
- Mixed incentives in rental (apartment) market to invest on new technologies
- Public perception and lack of adequate understanding of the benefits of Smart Grid (consumer acceptance)
- Pricing mechanism that is not based on real-time cost of delivering electric power services
- Technological gaps and lack of proper smart meters to allow offering various pricing options to consumers
- Integrating competitive suppliers into traditional monopoly market
- Consumption data privacy and lack of available aggregate system data

These and other market barriers should be addressed to enhance progress in implementing Smart Grid initiatives within the Mexican electric industry sector. Affirmative legislative and regulatory steps must be taken to fully address these market barriers; actions should be taken to create a level playing field to foster implementation of Smart Grid initiatives.

4.5 LEGISLATIVE MEASURES

4.5.1 LEGISLATIVE POWERS RECOMMENDATIONS

Prior the Energy Reform and the Electric Industry Act, CRE's powers with respect to Smart Grid were somewhat limited and indirect. CRE's main official regulatory connection to Smart Grid concerned how renewable energy was obtained by CFE and the terms under which consumers my exercise self-supply options. The connection between distributed renewable generation and the Smart Grid is a two-way street: Smart Grid technology will enable greater penetration of distributed renewable generation; and concentrations of distributed renewable generation will affect grid operations in a way that will require an intelligent grid. This connection means that CRE must have a "seat at the table" as the Smart Grid is developed so that the agency can fulfill its legal obligations with respect to renewable energy.

As we have emphasized in this report, successful implementation of the Smart Grid in Mexico will require a number of policy and regulatory changes. However, only some of the affected policies were within the authority of the CRE itself. Aspects of utility regulation in Mexico were spread across a number of departments and ministries. As an example, no less than three ministries (plus the CRE and CFE) had some authority or interest in the selection and deployment of utility meters: SENER, SHCP and SE all had distinct authorities and roles to play.

Because "smart meters" are such an integral component of the Smart Grid, it will be necessary for these authorities to work closely together on the development of the Smart Grid. Ideally, these secretariats and agencies will share a common vision of the Smart Grid, understand the new responsibilities of each entity and endorse a common strategy for Smart Grid development.

However, operation under such an ideal situation was difficult to expect. Therefore, it was necessary to change CRE's powers to ensure that the path toward an effective Mexican Smart Grid implementation will not be derailed. Specific recommendations are provided in this Report to address CRE's limited authority with regard to Smart Grid initiatives. These recommendations were developed in the context of the previous Energy Sector structure; however they prevail suitable since now CRE has a clearer idea about how to consider them within the new energy scenario provided by the Energy Reform.

Given its short history, it is not surprising to see that CRE faced significant challenges to effectively operate under the current mandated authority. There were a few Mexican laws with specific mandates defining various responsibilities that could be assigned to CRE. These responsibilities did not include major functions such as rate setting or overseeing capacity expansion. Absence of such powers prevented CRE of the need for resources to establish an effective regulatory environment that ensures reliability and pursues technological advances while meeting increasing demand for electricity by residential and commercial end-users to pursue economic prosperity.

Mexican Laws define various responsibilities that could be assigned to CRE. However, these responsibilities did not include major functions such as rate setting or capacity expansion.

To establish an effective regulatory environment with capability to enhance the implementation of Smart Grid initiatives, legislative actions should be taken to address the shortcomings identified in this report. Prior the Energy Reform, the following options were available to achieve the expected goals:

1. New laws and further amendments in the existing laws are needed to address the shortcomings identified in this report with the objective of enhancing CRE's authority to achieve national goals through full Smart Grid implementation

2. Each party's responsibilities must be clearly defined and an agency (or inter-agency task force) should be identified with a clear mandate to lead and coordinate works required to achieve national goals through full Smart Grid implementation

Several steps should be taken to clarify CRE's powers related to Smart Grid and provide adequate financial and human resources to obtain required expertise and skills needed to effectively implement Smart Grid initiatives. In particular, the following four recommendations are provided:

Several steps should be taken to clarify CRE's authority related to Smart Grid.

- In addition to current authority regarding renewable energies and private generation projects, CRE needs to be given specific powers related to Smart Grid
- SENER and CRE need specific powers to collaborate in policy and regulatory decisions related to transmission, distribution, and end-user issues.
- Budgetary steps must be taken to ensure that CRE has adequate financial and human resources to obtain the required expertise and skills required to address the complexity of Smart Grid initiatives
- CRE needs specific mandate to coordinate electricity related regulatory actions among all stakeholders such as SENER, SHCP, CONUEE, CFE and the industry

We strongly recommend the first option to fully authorize CRE to regulate Smart Grid in order to achieve national goals through full Smart Grid implementation. However, if the second option is selected, further amendments to the law are required to allow SENER to:

- Establish cooperation among various players (CRE, CFE, etc.), particularly in early stages of planning to facilitate path toward full implementation of Smart Grid.
- Empower CRE and corresponding stakeholders to implement projects and policies that benefit the society.
- Clarify and expand mandates to enhance effective regulation by CRE.

Summary of Recommendations

- ***In addition to current authority regarding renewable energies and private generation projects, SENER and CRE need specific powers related to Smart Grid.***
- ***SENER and CRE need specific powers to make participate in respective policy and regulatory decisions related to transmission and, distribution, and end-user planning issues.***
- ***Budgetary steps should be taken to ensure that CRE has adequate financial resources to obtain the required expertise and skills required to address the complexity of Smart Grid initiatives***
- ***CRE needs a specific mandate to lead and coordinate electricity regulatory actions among all stakeholders such as SENER, SHCP, CONUEE, CFE, and industry.***

4.5.1.1 Recommendation LEG -1: In addition to current authority regarding renewable energies and private generation projects, CRE needs specific powers related to Smart Grid[136].

As was mentioned earlier, CRE may need to rely on various broad topics as a point of entry to the issue of implementing a broad range of Smart Grid initiatives. Even such indirect authority is very limited. We recommend legislative actions to clarify CRE's powers related to Smart Grid and equip the agency with a clear mandate to effectively foster Smart Grid initiatives.

4.5.1.2 Recommendation LEG-2: SENER and CRE need specific powers to participate in policy decisions related to transmission and, distribution, and end-user planning issues.

Issues may include, but not limited to dealing with the development programs for the energy sector, the needs for additional capacity to meet the growth and replacement of generation capacity, the breakdown of capacity expansion by either CFE or private sector developers, and the terms and conditions for to public bids for those projects. Large scale renewable resources are located remotely from population centers and worldwide experiences have demonstrated that transmission bottlenecks are the most important deterrent in implementing such renewable resources project. CRE and SENER need specific power to participate in policy and regulatory decisions related to transmission, and distribution, and end-user planning issues. In particular, CRE should collaborate with SENER to determine Competitive Renewable Energy Zones (CREZs) and have the power to require CFE to initiate such projects[137].

4.5.1.3 Recommendation Leg-3: Budgetary steps should be taken to ensure that CRE has adequate financial resources to obtain the expertise and skills required to Address the complexity of Smart Grid initiatives.

CRE is expected to have responsibility for regulatory aspects of electric power sector in Mexico that generates approximately $15 billion of revenue annually. The implementation of smart initiatives has the potential resulting in an investment of $1.0 billion to $4.0 billion in the next thirteen years. The regulatory oversight of such a major undertaking and fast technological advances in Smart Grid requires adequate financial resource as well as experienced and skilled personnel to effectively perform their responsibilities. CRE should be provided resources to train the existing Staff and hire other expertise, which are in great demand worldwide, to ensure that its Smart Grid initiatives will be implemented as envisioned by the existing national goals.

4.5.1.4 Recommendation LEG-4: CRE needs a specific mandate to lead and coordinate electricity regulatory actions among all stakeholders such as SENER, SHCP, CONUEE, CFE, and industry.

Currently, CRE does not have a clear mandate and shares the oversight of various aspects of electric power system with several Mexican Ministries and organizations. To achieve more efficiency and effective regulation, it may be necessary to further clarify CRE's authority and responsibility, allowing it to become the sole regulator of certain major aspects of electric power sector including the implementation of Smart Grid initiatives in Mexico and setting of electricity rate structures.

[136] CRE has been provide with specific powers in the Electric Industry Act
[137] CREZs should take into account the information in the National Inventory of Renewable Energy

4.6 INSTITUTIONAL REFINEMENT RECOMMENDATIONS

The most efficient and effective way for CRE to fully execute its regulatory responsibilities will be to provide CRE with oversight of various regulatory aspects of electric power sector, including the implementation of Smart Grid initiatives. However, as previously stated, aspects of electric sector are now under the jurisdiction of several Mexican Ministries and organizations (CFE, SENER, the Ministry of Finance, etc.). The desired regulatory environment could be achieved by identifying major aspects of electric regulation that are currently under the jurisdiction of other Ministries and Organizations and transfer these functions, as required, to CRE to enhance and improve its effectiveness in successfully implementing Smart Grid. Alternatively, we recommend that CRE be empowered to provide input to the other organizations.

The desired regulatory environment could be achieved by identifying major aspects of electric regulation that are currently under the jurisdiction of other Ministries and Organizations and transfer these functions, as required, to CRE to enhance and improve its effectiveness in successfully implementing Smart Grid.

Therefore, it may be necessary to change CRE's authority and responsibility to ensure consistent and effective implementation of Smart Grid initiatives in Mexico. In particular, CRE as a regulatory agency in charge of electric sector could support the following additional activities:

- Rate setting, including rate design
- Service offering approval
- CFE budget authorization and cost approval
- Overseeing CFE's operational and planning activities covering
    - Generation, Transmission and distribution plan
    - New technology (including Smart Grid initiative) implementation plan
- Electric energy efficiency and conservation programs
- Peak demand reduction and demand response programs to be offered at both the wholesale and retail level
- Electricity-related consumers protection, including complaints

In the absence of such refinements in CRE's roles and responsibilities, CRE could be given the authority (in consultation with SENER) to request other agencies to take certain actions that are consistent with the plan to be implemented by CRE. This alternative requires significant cooperation with a various agencies[138].

[138] The Energy Reform and Electric Industry Act have given CRE specific authority.

4.7 SMART GRID INTEROPERABILITY AND CYBERSECURITY (TECHNOLOGY)

4.7.1 STANDARD REQUIREMENTS

Smart Grid has impacted the complete spectrum of the electricity supply industry and sparked significant investments in the industry from generation to devices inside consumer homes.

A key to the success of Smart Grid investment is the availability of Smart Grid interoperability standards that reduce the need for customized integration of the new equipment and its associated costs, and ensures that devices deployed today will readily work with devices and systems in the existing grid as well those deployed in the future[139].

In the USA, the 2007 Energy Independence and Security Act (EISA) (section 1305 of Title XIII) tasks the National Institute of Standards and Technology (NIST) with the development of interoperability standards framework to support Smart Grid. Through its Smart Grid Priority Action Plans (PAPs) NIST is addressing gaps and overlaps among the existing standards and supporting the acceleration of standards development. In the framework documents developed by NIST (version 1.0 and version 2.0) several standards have been listed and reviewed for possible consideration by NIST. NIST has developed a Catalog of Standards that currently has over 56 approved standards listed[140] and several more are under consideration.

The European Commission through its Smart Grid Mandate M/490 tasked the European Standards Organizations (CEN/CENELEC/ETSI)[141] to work on Smart Grid Standards. They published their first set of standards guide in November 2012[142] The guide includes about 24 types of Smart Grid systems, more than 400 standard references, coming from more than 50 different bodies.

China, Japan, Canada, and several other countries have embarked on programs to develop Smart Grid standards to meet their local needs. China has 92 planned by 2015.

A recent study by the DKE[143] of Germany shows the various standards activities as shown in Table 4-1 and Table 4-2[144]

The International Renewable Energy Agency (IRENA) in March 2013 published its report on "*International Standardisation in the Field of Renewable Energy*"[145]. The IRENA's study identifies over 570 standards in the current renewable energy technologies (RET). Figure 4-6 from this report is an excellent summary of the stakeholder requirements for standards.

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[139] Interoperability is already considered in the Mexican legal framework for telecommunications. CRE could take advantage of this and make easier the proposal of developing interoperability standards when talking with SENER, SE and CFE.
[140] http://collaborate.nist.gov/twiki-sggrid/bin/view/SmartGrid/SGIPCoSStandardsInformationLibrary
[141] CEN- European Committee for Standardization; CENELEC = European Committee for Electrotechnical Standardization; ESTI= European Telecommunications Standards Institute
[142] ftp://ftp.cen.eu/EN/EuropeanStandardization/HotTopics/SmartGrids/First%20Set%20of%20Standards.pdf
[143] DKE is the national organization responsible for the creation and maintenance of standards and safety specifications covering the areas of electrical engineering, electronics and information technology in Germany.
[144] Source VDE & DKE Report http://www.vde.com/en/dke/std/KoEn/Pages/tgres20.aspx
[145] http://www.irena.org/menu/index.aspx?mnu=Subcat&PriMenuID=36&CatID=141&SubcatID=318

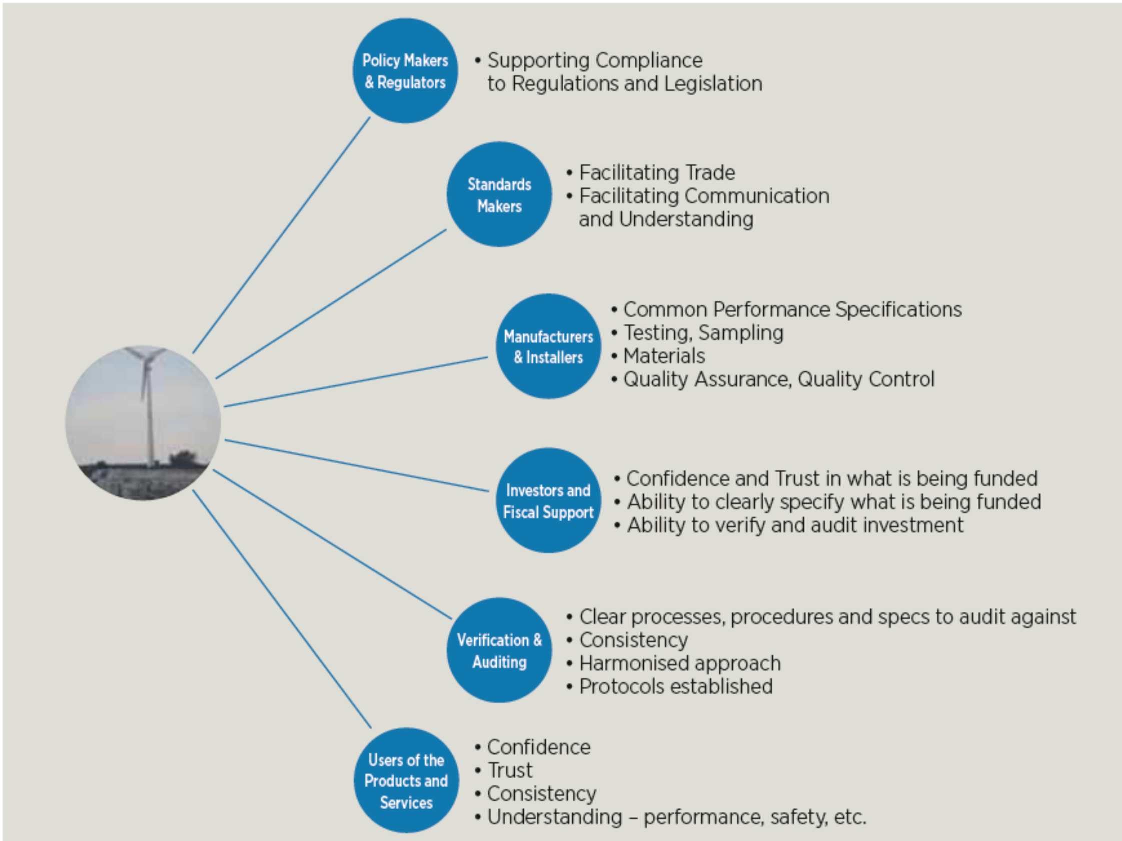

Figure 4-6: Stakeholders requirements from standards

Table 4-1 Comparison of various Smart Grid Standardization efforts - 1 of 2

Approaches													Standard	Description
ElectriNet	SGAM, Sustainable Pro-cesses and FSS M/490	IT Architecture Development and Recommendations	NIST 2.0 High = Add (ok)	Future Energy Grid	SIA	DKE Standardization Roadmap Smart Grid 1.0	NIST / IOP / Roadmap	SMB SG 3 / IEC	BMWi / E-Energy	BDI – Internet of Energy	Microsoft / SERA	CIGRE / D2.24	Standard	Description
		■					■				■		AMI-SEC System Security Requirements	Advanced metering infrastructure (AMI) and SG end-to-end security
■			■				■				■		ANSI C12 Suit : (C12.1, C12-18, C12-19/MC1219, C12-20, C12-21/IEEE P1702/MC1221, C12.23, C12.24)	Revenue Meter Information Model
■			■				■			■	■		BACnet ANSI ASHRAE 135-2008/ISO 16484-5	Building automation
						■			■				Digital meters / home gateways	Attention is drawn here to competitive solutions and to EU Mandate M/441
■							■				■		DNP3	Substation and feeder device automation
									■				EDIXML	Market communication with a slow transition from EDIFACT to modern, CIM-capable technologies
	■	■	■	■	■	■			■			■	IEC 60870	Established communications
■	■	■		■	■	■		□				■	IEC 60870-5	Telecontrol, EMS, DMS, DA, SA
■	■	■	■	■	■	■	■	□			■	■	IEC 60870-6 / TASE.2	„Inter-control center communications TASE.2 Inter Control Center Communi-cation EMS, DMS"
■	■	■		■	■			□	■	■	■	■	IEC 61334	DLMS
	■	■	■	■		■		□	■	■		■	IEC 61400-25	„Wind Power Communication EMS, DMS, DER"
									■				IEC 61499	PLC and automation, profiles for IEC 61850
■	■	■	■	■	■	■	■	■	■	■	■	■	IEC 61850 Suite	Substation automation and protection, distributed generation, wind farms, hydro power plants, e-mobility
■	■	■	■	■	■	■		□				■	IEC 61850-7-410	„Hydro Energy Communication EMS, DMS, DA, SA, DER"
■	■	■	■	■	■	■		□				■	IEC 61850-7-420	„Distributed Energy Communication DMS, DA, SA, DER, EMS"
			■			■		□					IEC 61851	„EV-Communication Smart Home, e-Mobility"
■	■	■	■	■	■	■		■		■		■	IEC 61968	Distribution Management, System Interfaces for Distribution Management Systems, DCIM (CIM for Distribution)
■	■	■	■	■	■	■	■	■	■	■	■	■	IEC 61968/61970	Application level energy management system interfaces, CIM (Common Information Model), Domänenontologie, Schnittstellen, Austauschdatenformate, Profile, Prozessblueprints, CIM (Common Information Model) EMS, DMS, DA, SA, DER, AMI, DR, E-Storage
■	■	■	■	■	■	■		■		■		■	IEC 61970	Energy Management, Application level energy management system inter-faces, Core CIM
						■		□					IEC 62051-54/58-59	„Metering Standards – DMS, DER, AMI, DR, Smart Home, E-Storage, E-Mobility"
■	■		■					□	■	■			IEC 62056	„COSEM – DMS, DER, AMI, DR, Smart Home, E-Storage, E-Mobility"
													IEC 62325	Market communication using CIM
■	■	■	■	■	■	■	■	■	■	■	■	■	IEC 62351	Information security for power system control operations, security profiles
	■	■		■	■	■	■	■	■			■	IEC 62357	IEC 62357 Reference Architecture – Service-orientierte Architektur, EMS, DMS, Metering, Security, Energy Management Systems, Distribution Management Systems
		■	□							■			IEC 62443 (ISA 99)	Procedure model for establishment of IT security for industrial automation and control systems
				■		■					■	■	IEC 62541	OPC UA (Automation architecture)
■	■	■		■									IEC PAS 62559	Requirements development method covers all applications
■			■				■				■		IEEE 1547	Physical and electrical interconnections between utility and distributed generation (DG)
			■				■				■		IEEE 1686-2007	Security for intelligent electronic devices (IEDs)
■			■				■				■		IEEE C37.118-2005	This standard defines phasor measurement unit (PMU) performance specifications and communications for synchrophasor data
				■						■			ISO / IEC 14543	KNX, BUS
			■										MultiSpeak	A specification for application software integration within the utility operations domain; a candidate for use in an Enterprise Service Bus
		■	■				■				■		NERC CIP 002-009	Cyber security standards for the bulk power system
			■				■				■		NIST Special Publication (SP) 800-53, NIST SP 800-82	Cyber security standards and guidelines for federal information systems, including those for the bulk power system
			■				■				■		Open Automated Demand Response (Open ADR)	Price responsive and direct load control
			■				■				■		OpenHAN	Home Area Network device communications, measurement, and control
	■	■											The Open Group Architecture Framework (TOGAF)	TOGAF is a framework – a detailed method and a set of supporting tools – for developing an enterprise architecture
				■			■				■		ZigBee/HomePlug Smart Energy Profile	Home Area Network (HAN) Device Communications and Information Model
			□	■									Z-wave	A wireless mesh networking protocol for home area networks

Table 4-2: Comparison of various Smart Grid Standardization efforts - 2 of 2

	SGAM domains					Criteria: Added Value Area								TC 57 Reference Architecture				
	Bulk Generation	Transmission	Distribution	DER	Customer Premise	Production	Energy Trading	Sales	Transmission	Storage	Distribution	Measurement	Application	Integration of Business Partners	Integration of Applications	Integration of Devices and Plants	Security	Data Management
			■									■			■	■	■	■
			■		■							■	■					
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	■	■	■	■	■	■	■	■	■	■	■	■	■				■	
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					■								■		■	■	■	■
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					■								■					

4.7.1.1 STANDARDIZATION IN MEXICO

Article 63 of the Federal Law on Metrology and Standardization[146] establishes that the competent agencies, in accordance with the guidelines issued by the National Standards Commission, are responsible for organizing the Advisory Committees and will set the rules for its operation, i.e. coordination and development of standards. In this case, the competent agency is SENER.

The Association for Standardization and Certification (ANCE)[147] is responsible for optional or non-mandatory technical standards.

The standards issued by ANCE (Mexican Standards, NMX) are optional. The standards issued by SENER (Mexican Official Standards, NOM) are mandatory and verifiable by an accredited verification unit.

Article 62 of the Federal Law on Metrology and Standardization establishes that the Advisory Committees are responsible for developing Mexican Official Standards (NOM) and promoting their compliance. These Advisory Committees shall be composed of technical personnel of the competent agencies itself, industrial organizations, service providers, traders, research centers or technological, professional and consumer associations.

CRE has participated in the Smart Grid Interoperability Panel (SGIP) as an observing member since October 2010. CRE also desires to consider core Standards by IEC Standards[148].

[146] Ley Federal de Metrología y Nomalización. Disponible en: http://www.diputados.gob.mx/LeyesBiblio/pdf/130.pdf
[147] www.ance.org.mx
[148] http://www.iec.ch/smartgrid/standards

4.7.2 CYBERSECURITY REQUIREMENTS

Cybersecurity is being addressed by CFE for its automation systems. CRE's perspective on Cybersecurity is on the privacy issues. This could include oversight of CFE's actions when collecting data. These could include guidelines such as:

- CFE would have to explain to consumers what data is going to be collected.
- The purpose of collecting that data
- CFE's liability in managing this data
- How long is going to keep it
- How is going to be deleted
- Etc.

Section 4.4.2.6 contains an extended discussion on Privacy issues and recommendations for CRE.

In the sections below, we provide an overview of Cybersecurity issues considered in the various regions.

A number of standards and other documents can be used to assist in designing adequate cyber security for power system operations. Some of these sources include[149]:

- ISO/IEC 27001 and 27002, as well as the sector-specific ISO/IEC 27019 that is currently being standardized.
- NIST IR 7628 Guidelines for Smart Grid Cyber Security (August 2010):
- Volume 1: Smart Grid Cyber Security Strategy, Architecture, and High-Level Requirements
- Volume 2: Privacy and the Smart Grid
- Volume 3: Supportive Analyses and References
- IEC 62351 series of cyber security standards for IEC 61850, IEC 60870-5, IEC 60870-6, and other standards
- IETF RFCs for cyber security including TLS 1.2 and IPsec
- US NERC Critical Infrastructure Protection (CIP) 002-009
- IEEE 1686 Substation IED Cyber Security Capabilities (being updated)
- ISA SP99 Cybersecurity mitigation for industrial and bulk power generation stations
- IEC 62443-2-4 Security for industrial process measurement and control – Network and system security: Certification of IACS supplier security policies and practices
- NIST SP 800-53 Recommended Security Controls for Federal Information Systems and Organizations
- NIST SP 800-82 Guide to Industrial Control Systems (ICS) Security

[149] Source: Frances Cleveland, Xanthus Consulting International, Convener of IEC TC57 WG15 (Information Security)- developing the IEC 62351 cyber security standards.

The European Commission Smart Grid Information Security (SGIS) working group under the European Commission Smart Grid Mandate, M/490 Standardization Mandate to European Standardization Organizations (ESOs), to support European Smart Grid deployment published it Smart Grid Security Report in November 2012[150]. The following figures and tables (Figure 4-7, Table 4-3, and Table 4-4) all from Smart Grid Security report depict the European view of the business interoperability layers, domains, and zones for the power system. Furthermore, five security levels are established with level five for the highly critical and level one for low level security. The report also provides guidance for the personal and system data security

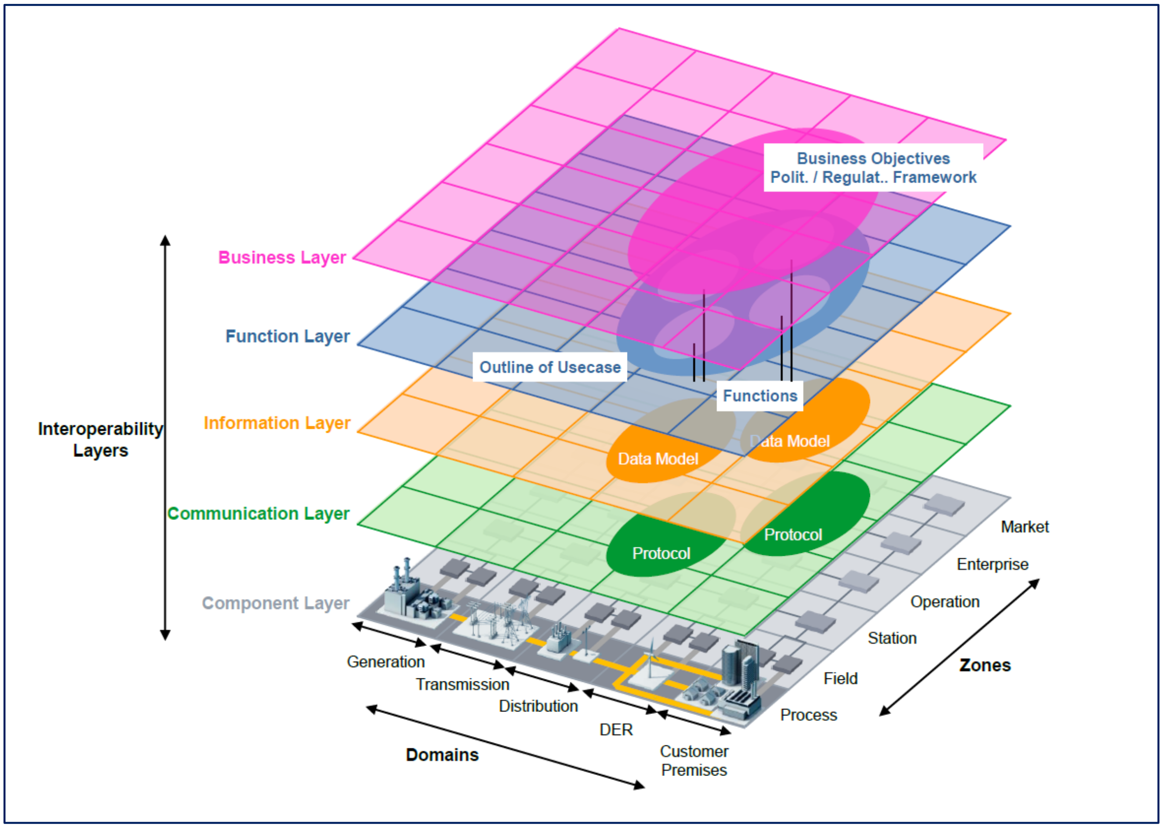

Figure 4-7: European View of Smart Grid Architecture Model

150 ftp://ftp.cen.eu/EN/EuropeanStandardization/HotTopics/SmartGrids/Security.pdf

Table 4-3: European Commission Smart Grid Information Security - Security Levels

Security Level	Security Level Name	Europeans Grid Stability Scenario Security Level Examples
5	Highly Critical	Assets whose disruption could lead to a power loss above 10 GW Pan European Incident
4	Critical	Assets whose disruption could lead to a power loss from above 1 GW to 10 GW European / Country Incident
3	High	Assets whose disruption could lead to a power loss from above 100 MW to 1 GW Country / Regional Incident
2	Medium	Assets whose disruption could lead to a power loss from 1 MW to 100 MW Regional / Town Incident
1	Low	Assets whose disruption could lead to a power loss under 1 MW Town / Neighborhood Incident

Table 4-4: European Commission Guidance for the various domains

Example for Guidance SGIS-SL per SG-DPC

		Generation	Transmission	Distribution	DER	Customer Site	Customer Internal Domains
SG-DPC 1 Personal Information	Sensitive Personal information	3 – 4	5	3 – 4	3	2 - 3	2 - 3
	Personal informatiion	3 – 4	5	3 – 4	3	2 - 3	2 - 3
	De-personalized Pseudonymized Personal information	3 – 4	5	3 – 4	3	2 - 3	2 - 3
	No Personal information	3 - 4	5	3 – 4	3	2 - 3	2 - 3
SG-DPC 2 System Information	System Data (i.e. Firmware) Configuration Data, Customer Credentials Private & Public Keys Roles /Actor IDs	3 – 4	5	3 – 4	3	2 - 3	2 - 3
	Governance & Reporting Information Logging and Audit Information	3 – 4	5	3 – 4	3	2 - 3	2 - 3
	Audit & Log required information	3 – 4	5	3 – 4	3	2 - 3	2 - 3
	Information to administrate remotely	3 – 4	5	3 – 4	3	2 - 3	2 - 3
	Information to operate remotely (Control signals)	3 – 4	5	3 – 4	3	2 - 3	2 - 3
	Business Information	3 – 4	5	3 – 4	3	2 - 3	2 - 3
	Measurement data	3 - 4	5	3 – 4	3	2 - 3	2 - 3

Zone Operation / all Layers

DOMAINS

Information assets used in Use Case to be classified to above 2 SG-Data Protection classes (both apply to one information asset) – not all will be used in a specific Use Case – e.g. Sensitive personal information may not be available in most use cases.

4.8 PERFORMANCE METRICS

Smart Grid deployment promises to generate significant benefits to society. Research organizations, such as the Electric Power Research Institute (EPRI) and the Joint Research Centre in the European Union, have developed methodologies to estimate the benefits and costs of Smart Grid projects.[151] To ensure success in the implementation of any roadmap, performance metrics and output measures should be identified, along with corresponding milestones and indices to assist in judging the progress toward predetermined goals.

To ensure success in the implementation of any roadmap, certain performance metrics and output measures should be identified

Some Key Performance Indices (KPI) have been developed to measure the benefits expected from implementing Smart Grid within the electric power system. The European Commission, relying on the methodology developed by EPRI (2010), takes a broad approach and recommends KPIs be developed with regard to benefits of Smart Grid initiation to cover the following eleven major areas:[152]

1. Increased sustainability
2. Adequate capacity of transmission and distribution grids for “collecting” and bringing electricity to consumers
3. Adequate grid connection for access to all kinds of grid users
4. Satisfactory levels of security and quality of supply
5. Enhanced efficiency and better service in electricity supply and operation
6. Effective support of transnational electricity markets by load flow control to alleviate loop flows and increased interconnection capacities
7. Coordinated grid development through common European, regional and local grid planning to optimize transmission grid infrastructure
8. Enhance consumer awareness and participation in the market by new players
9. Enable consumers to make informed decisions related to their energy to meet the EU Energy Efficiency targets
10. Create a market mechanism for new energy services such as energy efficiency or energy consulting for consumers
11. Consumer bills are either reduced or upward pressure on them is mitigated

The US DOE takes a more general approach by identifying the following six major areas:[153]

1. Enables Informed Participation by Consumers
2. Accommodating All Generation and Storage Options
3. Enables New Products, Services, and Markets
4. Provides Power Quality for the Range of Needs
5. Optimizing Asset Utilization & Operating Efficiency
6. Operates Resiliently to Disturbances, Attacks, & Natural Disasters

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[151] EPRI (2010). Methodological Approach for Estimating the Benefits and Costs of Smart Grid Demonstration Projects. January

[152] Joint Research Center, European Commission (2012). Guidelines for conducting a cost-benefit analysis of Smart Grid projects. Annex IV – Key Performance Indicators and Benefits [EC Task Force for Smart Grid], pp. 58-60. The report identifies 54 specific KPIs to cover these eleven major areas.

[153] U.S. Department of Energy (2012). 2010 Smart Grid System Report: Report to Congress, Washington, D.C., (February), pp. 19-69. The report identifies 21 specific metrics, presented in Table 2.1 at pages 14-15 to cover these six major areas.

Regardless of which approach is selected, performance metrics and output measures should focus on various aspects of Smart Grid, meet certain criteria, and be flexible enough to be refined over time as desired. In particular, such measures should be developed with the following factors in mind:

- Create milestones, outcomes, and measures to demonstrate its successful implementation
- Special attention should be given to the success of plan in meeting its predetermined national and local goals
- Mid-course correction actions should be taken, if necessary, to ensure the expected outcomes
- Measures should be clear and cover various objectives and segments of operation

Each performance metric or output measure, given its focus, can fall into one of the following categories:

- Goal-oriented measures
- Operational achievements
- End-user related measures

4.8.1 Goal-Oriented Measures

The goal-oriented measures demonstrate the degree of success toward national and/or local goals. They should be established with an end in mind and should result in continuous progress over time in achieving the desired goals. These measures may include:

- Number and share of smart meters implemented
- Number of renewable projects implemented
- Number of generation permits issued (with Smart Grid involved)
- Total number of interconnection agreements with the National Electric System (SEN)
- The amount of additional capacity in MW added as distributed generation
- Total reduction in greenhouse gases
- Total investment attracted to private sector
- Number and share of new renewable projects (MW) as part of total installed capacity
- Total amount and share of energy (MWh) generated from renewable resources
- Total amount of private investment in renewable projects
- Average percentage improvements in technical and non-technical losses
- Average number of minutes to restore outages
- Total number of jobs created by renewable projects

4.8.2 Operational Achievements

The operational achievement measures demonstrate the degree of success toward achieving efficiency and effectiveness in various aspects of operation. They should be established with a focus on areas of operation in which inefficiencies and other shortcomings have been identified. The goal is to address such inefficiencies first resulting in reduction in costs and improving the quality of services offered to consumers. These indicators may include:

- Reduction in transmission congestion achieved by Smart Grid technologies
- Reduction in line losses (both technical and non-technical)
    - Indices showing improvements in ways losses are measured more accurately
    - Indices showing success of mitigation measures to reduce losses
- Reduction in outages (transmission and distribution)
    - Indices to measure reduction in the number of outages
    - Indices to measure the amount of time taken to restoring such outages (by regions)

  - Indices that may distinguish ways outages could be addressed at the generation, transmission, or distribution levels
- Reduction in maintenance and operating costs
- Improvement in system efficiency (including load factors)

4.8.3 End-User Related Measures

The end-user related measures are focused on improved interactions with consumers and improved consumer satisfaction with electricity services. These measures may include:

The end-user related measures are focused on improved interactions with consumers and improved consumer satisfaction with electricity services.

- Improved interactions with consumers through number of consumer centers
- Percentage of total electricity consumption by end-users served by advanced meters
- Increase in end-user choices for Smart Grid engagement, such as number of pricing options and/or programs encouraging demand response
- Annual increase in number of residential, industrial and commercial consumers using energy management services to achieve more efficiency
- Indices measuring improvement in consumer satisfaction with electricity services
- Number and average duration of outages for each consumer class
- Average outage restoration time
- Average time to address a request for service
- Annual percentage reduction in number of consumer complaints
- Annual percentage changes in prices

Such measures could be developed by various zones and/or by consumer classes. Zonal variations may assist regulators and utilities to identify areas where help is urgently needed and encourage more reliance on technologies to address such urgencies in a timely manner.

4.9 SMART GRID TASK FORCE

It is recommended that a SGTF be established in Mexico (MX-SGTF)[154]. Such Task Forces have been used in numerous countries (e.g.US, India, others) to bring focus to the Smart Grid program within each country and have proven very valuable.

The governance structure of a Smart Grid Task Force should follow and mimic the existing overall governance arrangements for the energy industry and the power sector. In general higher level roles for the implementation of a Smart Grid are as follows:

Policymaking Body (Ministerial level) to provide overall policy inputs, to define and formally issue a sector-level Road Map. This is formally endorsing and issuing the Road Map Framework in this document.

Regulatory Body to issue specific regulations when the specific Smart Grid applications require it.

Power Utility to implement Smart Grid activities in coordination with consumers, private sector participants, vendors, and other entities.

Standards and Norms entities to issue standards as required for specific Smart Grid applications and to ensure interoperability. Such standards could include standards for testing metering accuracy requirements, or standards for inter-operability of devices such as appliances or other devices in the electricity chain.

Suppliers and Manufactures to provide and interject information about the state of the technology and the industry's ability to implement various initiatives and actions within the desired timeframes.

Academia and Research institutions to support special research and development that may be required for implementing Smart Grid in Mexico

4.9.1 HIGH LEVEL ROLES AND RESPONSIBILITIES

Figure 4-8 depicts an example of a potential Smart Grid Task Force structure for Mexico. The various responsibilities are briefly highlighted in the following paragraphs.

Smart Grid Task Force Chairman provides overall direction and leadership to the MX-SGTF.

Smart Grid Executive Steering Committee is comprised of executives from governmental Stakeholders. This committee provides direction to the technical team. It is responsible to the MX-SGTF Chairman and is champion of Smart Grid in Mexico. It will refine the vision and strategy for Smart Grid in Mexico as needed. Potential list of members include executives from the following:

- SENER (Ministry of Energy)
- SHCP (Ministry of Treasury)
- SE (Ministry of Economy)
- SFP (Ministry of Controller)

[154] In October 2012 SENER, CFE and CRE jointly discussed Smart Grid for the first time during the kick-off meeting of the CRE Smart Grid Regulatory Roadmap project.

- CFE (Modernization, Distribution, Customer Services, Operations), CENACE, Planning, Transmission, Generation)
- CRE
- Energy Efficiency Commission (CONUEE)
- Consumer Protection Agency (PROFECO)
- Standards, Metrology, and Quality Organization

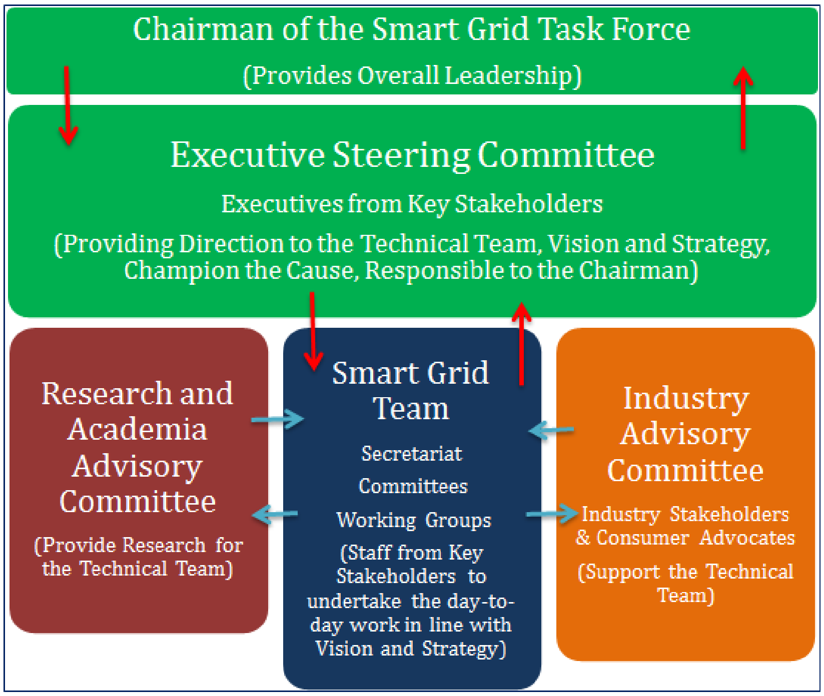

Figure 4-8: Possible Smart Grid Task Force Structure

Smart Grid Technical Secretariat and Technical Committee - A technical secretariat should be established. The technical secretariat has the role to coordinate all the day-to-day activities at the technical levels with regard to implementation and monitoring of the various Smart Grid applications in support and direction of the Technical Committee. This Technical Committee undertakes the day-to-day work in line with the vision and strategy. The Technical Committee seeks input from Advisory Committees (Industry and Research) and reports to the Smart Grid Task Force Steering Committee. In addition, the Technical Committee could have a technical work-stream for each Pillar of the Smart Grid for Mexico. Potential list of members include Subject Matter Experts from each of the entities above.

Technical Working Groups - The Working Groups lead the implementation of each specific Smart Grid application. Some leaders of the working groups are expected to serve as part of the Technical Committee above.

At the Working Groups specific Smart Grid application or technical and regulatory aspect will be addressed. This includes performing detailed project design, costing, and implementation.

Within the work of standards undertaken by the US National Institute of Standards and Technology (NIST) several actions were taken as follows:

- *Creation of Working Groups – these included WG for*
  - *Smart Grid Architecture,*
  - *Smart Grid Implementation methods*
  - *Smart Grid Testing and Certification*
  - *Smart Grid CyberSecurity*
  - *Smart Grid Domain Expert Working Groups (DEWG)*
- *NIST Smart Grid Domain Expert Working Groups (DEWG) further had specialized working groups as follows:*
  - *Building-to-Grid/B2G*
  - *Business and Policy/BnP*
  - *Distributed. Renewables, Generation, and Storage/DRGS*
  - *Home-to-Grid/H2G*
  - *Industry-to-Grid/I2G*
  - *Transmission and Distribution/TnD*
  - *Vehicle-to-Grid/V2G*

As an example, the US National Institute of Standards and Technology (NIST) established several working groups supporting its task for Smart Grid Standards. This approach has proved very effective for NIST and the US industry.

Given the specific characteristics of the challenges and the vision for the Smart Grid Mexico it is recommended that the following Working Groups be established. These groups are expected to be needed for Phase I and Phase II of the Smart Grid road map. Working Groups could be dissolved or new ones created as implementation advances. The Working Groups are listed by areas of action:

- **Regulation and Policy Working Group** (R&P) consisting of representatives of SENER and CRE
- **Consumer Engagement, Demand Side and Energy Efficiency Working Group**
  - Demand Side Technology Solutions Working Group (DS)
  - Energy Efficiency Working Group (EE)
  - Consumer Engagement Working Group (CE)
- **Renewable Energy Integration Working Group**
  - Large Scale Renewable Energy Integration Working Group (LRE)[155]
  - Small Scale RE (e.g. roof-top solar) Integration Working Group (SRE)
- **Transmission and Distribution Working Group**
  - Transmission System Development and Automation Working Group (TX)
  - Distribution Automation and Protection Working Group (DA)
- **Communications and Standards Working Group**
  - Communication Support and Development Working Group (COM)
  - Standards Working Group (STD)

Industry Advisory Committee is comprised of industry players interested and active in Smart Grid in Mexico. It provides input and advice on related Smart Grid industry developments to the Technical Committee as needed. The committee includes members from bulk power users, manufacturers, consumer advocates, etc.

Research and Academia Advisory Committee supports the Smart Grid Technical Committee and is comprised of Subject Matter Experts from leading research institutions and academia – e.g., Instituto de Investigaciones Eléctricas (IIE). When requested it will undertake specialized research for the Technical Committee.

[155] A similar group may exist within CFE

4.9.2 INTEGRATION OF THE MEXICAN SMART GRID TASK FORCE GROUP

The Smart Grid is not a new topic in the Mexican context since CFE had already started some specific actions. For instance, in 2010 CFE made an assessment on the readiness of distributions networks to develop the Smart Grid. For this purpose, CFE applied the Smart Grid Maturity Model developed by Carnegie Melon Software Engineering Institute. This was the first Smart Grid formal approach in Mexico.

Regarding CRE's actions, some studies were performed in order to investigate the most relevant regulatory actions around the globe related to the development of the Smart Grid. As a consequence of this research, CRE identified the need of having a suitable strategy for implementing this new philosophy in Mexico. This was the inception of the Roadmap later developed with the assistance of the USTDA and the specialized support from ESTA International.

At the beginning, the Smart Grid actions were somehow based on isolated efforts. However more dialogue was present between all government stakeholders SENER, CFE and CRE. As stated in this Roadmap, in October 2012 was the first time that Smart Grid was formally discussed by those government entities. Since then, there exists permanent interaction and information exchange between them. As a consequence of this and following the recommendation elaborated by ESTA, in April 2014 a formal group was established. This group was created to coordinate all efforts on Smart Grid in Mexico and to ensure that an integral planning process (encompassing policy, regulation and technology deployment) is considered to develop the Smart Grid in Mexico.

4.10 Observations

Our review of the Mexican electricity sector prior the Energy Reform, clearly demonstrates distribution of authorities among multiple players. While such division of authority may be a strength -- encouraging various parties to build consensus -- it may also result in possible inefficiencies and ineffectiveness without strong cooperation or when conflicting objectives are pursued by different players. In the latter circumstances, the problem could be exacerbated if the regulator lacks adequate authority to make effective decision.

Throughout this Report, we have identified major areas where regulatory rules are absent or require further clarification to enhance Smart Grid initiative. In response, various recommendations are provided covering utility operation, private sector participation, and consumer protection. Several recommendations have been provided to address the need for regulatory, legislative, and institutional actions to clarify regulatory authority or modify responsibilities by various institutions to enhance the efficiency and operation of the electric sector.

Under the previous Mexican Laws, the CRE was provided limited authorities. For example, the Renewable Energy Act allowed CRE to enhance the use of renewable resources to reduce pollution. Similarly, CRE could encourage the implementation of Smart Grid to reduce pollution. In addition, CRE keeps the authority to determine the amount of payment to self-supply entities, including consumers who install roof-top solar PV projects. Further, CRE may be able to address Demand Response; however, it has not done so. CRE also may have some indirect impact requiring CFE to take certain actions through recommendations to SENER. While important, a limited and indirect authority reduces the capability of CRE to effectively regulate electric sector and take solid steps to enhance Smart Grid initiatives.

International experience shows that the regulatory agency in charge of electricity needs certain minimum authority if it is to provide an effective regulatory environment that ensures reliability while meeting increasing demand for electricity by residential and commercial end-users to pursue economic prosperity. In particular, a regulatory agency in charge of electric sector should have authority over the following areas:

- Rate setting, including rate design
- Consumer Protection
- Generation, Transmission and Distribution expansion
- Energy Efficiency and Renewable Portfolio Standards
- Market Oversight
- Compliance and Enforcement
- Establishing rules and regulation including Smart Grid

CRE, with support from the Ministry of Energy, could be the agency in lead of regulating electric sector and overseeing the full implementation of Smart Grid initiatives for Mexico. CRE could be best positioned to define broad expectations and facilitate CFE Smart Grid activities toward achieving national goals. CFE plans for implementation should fully reflect feedbacks from CRE in addition to SENER and other responsible authorities. CFE should provide regular reports outlining progress.

In the absence of such refinements in CRE’s roles and responsibilities, SENER may need to lead the effort with extensive support from CRE to ensure adequate policy and regulatory guidance to foster Smart Grid initiatives in Mexico.

4.11 Summary of Recommendations

This section contains the summary of recommendations presented in this report. The numbers in the table below correspond to the recommendation numbers throughout the report.

Table 4-5: Regulatory Strategies to Enhance Operation of the Electric Power System by CFE

NO.	RECOMMENDATION
CFE - 1	CRE should support the creation and execution of a multi-party planning process for Smart Grid planning and implementation.
CFE - 2	CRE should require that all power sector actors, in collaboration with the industry and with existing standards bodies, adopt and publish standards for Smart Grid, building on work done in other countries.
CFE - 3	CRE should support CFE in its efforts to identify, evaluate, and schedule for implementation all cost effective "wholesale" Smart Grid measures available to the company.
CFE - 4	CRE should support CFE in developing and publishing a schedule for installation of smart meters, pursuant to an approved transition plan
CFE - 5	Jointly with CRE and other stakeholders, CFE should develop and publish a detailed transition plan for moving consumers with smart meters to tariffs that employ dynamic pricing.
CFE - 6	CRE should support CFE to develop a plan to integrate settlement quality smart meters in the wholesale settlement process to accurately compensate generation from resources at the consumers' premises and demand responses during high production cost periods.
CFE - 7	CRE should identify outstanding marketplace barriers and recommend legislation to SENER.

Table 4-6: Regulatory Strategies to enhance operation of independent third parties

NO.	RECOMMENDATION
TPP - 1	CRE should develop and articulate its vision of third-party involvement in the retail Smart Grid.
TPP - 2	CRE should develop regulation and establish rules that recognize the increasing reliance of the Mexican power grid planning and operation on third-party renewable resources such as hydro, wind, solar, and biomass with varying characteristics.
TPP - 3	CRE should develop regulation and establish rules recognizing reliance on third-party supplemental resources such as demand response, energy storage facilities, and back up natural gas generation resource.
TPP - 4	CRE should establish pricing options and incentive mechanism to attract non-conventional resources (capacity and energy payments vs. energy payment).
TPP - 5	CRE should develop and articulate regulation respecting third-party access to consumer data.
TPP - 6	CRE should make legislative recommendations to encourage Smart Grid investment through informed tax and investment policy.
TPP - 7	CRE should support SENER in developing legislation to remove any barriers to interconnection of Smart Grid suppliers.

Table 4-7: Regulatory Strategies to Benefit Development of Renewable Resources

NO.	RECOMMENDATION
DRR - 1	Develop price reference for energy and various ancillary services and make this information publicly available.
DRR - 2	Develop transmission Expansion Cost Index by Area, Zone etc. and make this information publicly available.
DRR- 3	Define CREZ by technology (i.e. wind and solar) and make this information publicly available.
DRR - 4	Define cost responsibility for network upgrades that are triggered as a result of interconnection of renewable resources
DRR - 5	Create a public list (Queue) for currently operational and planned renewable resources, their locations, point of interconnection, expected commercial date of operation, etc. and the latest status of each planned project.
DRR - 6	Require revision in CFE's existing Interconnection Handbook to address various renewable technologies.
DRR - 7	Require revision in CFE's Interconnection Agreement which address and/or exempt renewable resources from certain obligations by technology type.
DRR - 8	Develop new methodology and justification of new transmission facilities based on coordination of transmission planning process and renewable interconnections.

Table 4-8: Regulatory Strategies to Benefit End-Users and Improve Satisfaction

NO.	RECOMMENDATION
USER - 1	CRE should require CFE to make “no regrets” Smart Grid investments that emphasize detection of outages, poor power quality, distribution transformer conditions before failure, etc.
USER - 2	CRE should oversee development by CFE of “plug and play” technical standards for Smart Grid devices to enable consumer involvement.
USER - 3	Provide additional consumer billing information, including potentially providing selected consumers with innovative and expanded billing information such as that offered by a number of providers that contract with utilities.
USER - 4	CFE consider contracting with a Smart Grid platform provider for a large scale trial.
USER - 5	CRE should consider promoting demand response options to price sensitive consumers to participate in energy and ancillary service markets.
USER - 6	CRE should consider pricing options and incentive mechanism for end-use consumers to attract small-scale renewable resources (capacity payment vs. energy payment).
USER - 7	CRE should develop regulation to encourage distributed resources in population areas (Distributed Generation, Energy Storage, Appliances, and Electric Vehicles).
USER - 8	CRE, in cooperation with other authorities, should begin introducing new rate structures: a Smart Grid requires “smart rates”.
USER - 9	CRE should begin publicizing Smart Grid impacts on consumer outages in areas with significant Smart Grid penetration.
USER - 10	CRE should plan and execute consumer education programs to introduce the benefits of Smart Grid initiatives.

Table 4-9: Regulatory Strategies to Share Costs and Benefits of Smart Grid

NO.	RECOMMENDATION
CBSG - 1	Develop "avoided cost" value for savings from retail Smart Grid applications.
CBSG - 2	Consider phasing in a "top 20" rate structure change to TOU tariff as AMI meters are introduced.
CBSG - 3	Target initial installation of AMI meters to mandated TOU consumers and make TOU service available to any other consumer who asks to have an AMI device.

Table 4-10: Regulatory Strategies to Protect End-User Information and Privacy

NO.	RECOMMENDATION
PRIV - 1	In concert with other Mexican consumer rights agencies, CRE should develop a Consumer Bill of Smart Grid Rights detailing privacy, access to information, and consumer control over the use of consumer energy data.
PRIV- 2	CRE should guide CFE in creating a consumer education campaign treating Smart Grid consumer issues, especially privacy issues.
PRIV - 3	CRE should assist in the development an industry Voluntary Code of Conduct, available to all providers of Smart Grid services.

Table 4-11: Legislative Authority Recommendations

NO.	RECOMMENDATION
LEG - 1	In addition to current authority regarding renewable energies and private generation projects, CRE needs specific powers related to Smart Grid.
LEG- 2	SENER and CRE need specific powers to participate in policy and regulatory decisions related to transmission and, distribution, and end-user planning issues.
LEG - 3	Budgetary steps should be taken to ensure that CRE has adequate financial resources to obtain the expertise and skills required to address the complexity of Smart Grid initiatives.
LEG - 4	CRE needs a specific mandate to lead and coordinate electricity regulatory actions among all stakeholders such as SENER, SHCP, CONUEE, CFE and industry.

5 TASK 3 – ASSESS OPPORTUNITIES FOR PRIVATE INVESTMENT

The primary objective of Task 3 is to identify opportunities for private investments and actions necessary to facilitate such investments. This Task relies on the recommendations of Tasks 1 and 2 and consultations with CRE. Also, it is understood that Mexico does not yet have a wholesale or retail electricity market. However, it is moving in the direction of establishing a more competitive environment[156] within its electric power sector. Therefore, our referral to wholesale electricity markets pertains to yet to be developed wholesale markets. Overall, Task 3 encompasses several subtasks:

- Subtask 3.1 Identification of Potential Auction Mechanisms

  The objective of this subtask is to devise a potential procurement auction mechanism that provides incentives for the development of renewable energy projects under 30 MW.

- Subtask 3.2 Identification of Technology Deployment Opportunities and U.S. Sources of Supply

  The objective of this subtask is to identify opportunities for deploying the following smart grid technologies:
  - Smart meters and advanced metering infrastructure ("AMI");
  - Data flow, information management, information technologies, and SCADA;
  - Cyber security equipment; and
  - Software upgrades for improved customer service, asset management, utility operations, and transmission and distribution operations.

  This subtask will also include identification of prospective U.S. sources of supply for these technologies in accordance with Clause I of Annex II of the Grant Agreement. The list of prospective U.S. sources of supply shall be shared the Grantee and CFE.

- Subtask 3.3 Incentives for Renewable Energy, Distributed Generation, and Non-Utility Companies

[156] The Constitutional Energy Reform approved in late 2013 allows private entities to be hired by the Nation in order to provide the distribution service. Congress will make adaptations to the legal framework in order to regulate the modes of contracting, so that private entities, on behalf of the Nation, may perform, among other activities, the financing, installation, maintenance, management, operations and expansion of the necessary infrastructure to provide the public service of transmission and distribution of electric energy.

The objective of this subtask is to explore and identify potential regulatory incentives to encourage the development and integration of small-scale renewable energy projects and the integration of existing distributed generation into Mexico's national grid. This subtask will include identification of possible regulatory incentives to encourage creation and administration of demand response programs for non-utility generators.

This chapter includes the following:

- Identification of Potential Auction Mechanisms
- Identification of Technology Deployment Opportunities and U.S. Sources of Supply
- Incentives for Renewable Energy, Distributed Generation, and Demand Response activities by Non-Utility Companies
- Tabulated Presentation of All Recommendations for incentives

We do not discuss specific legislative recommendations and potential institutional changes in Task 3. Instead, the recommendations developed in Task 2 regarding such changes apply to subject matter under consideration in this Task 3.

5.1 IDENTIFICATION OF POTENTIAL AUCTION MECHANISMS

The importance of renewable resources in generation portfolio around the world has been rising in the last ten years, primarily due to their effectiveness in reducing the negative impacts of conventional resources on the environment. In particular, small-scale distributed renewable resources have seen significant expansion because they can be located in population centers where end-users are located and avoid the need for significant investment in transmission and distribution often required when power comes from distant large power plants. Auction mechanism based on competitive markets has been the dominant choice for many countries in procuring their desired level of renewable resources.

In Mexico, the price that is paid for renewable energy is eventually passed on to the end user or the SHCP. In order to control the rise in end-user prices and the potential burden on the SHCP, it is important that procurements are conducted in a competitive manner with proper incentives that not only promote development of renewable resources but also minimizes future investment[157] in transmission and distribution systems as well as daily operating costs. Therefore, the renewable industry in Mexico can benefit from improvements in its existing auction mechanism to achieve these objectives. Different auction types provide different regulatory incentives which should be considered prior to adoption of any specific auction mechanism.

In this subtask we identify various elements of common procurement auction mechanisms that incentivize and foster the development of renewable energy projects under 30 MW. Such projects are important because they can be located close to customers, complementing the distribution system, improving system reliability, reducing investment in the transmission grid while enhancing environmental quality.

The Mexican legal framework prior the Energy Reform, established that the generation of electricity for public service had to be carried out by the state owned utility CFE and by private investors through the specific schemes of self-supply, cogeneration, independent power production, small production, export and import. The Congressional Energy Reform approved in December 2013 calls for major changes to the

[157] It could include use of distributed resources to eliminate the need for additional transmission and distribution expansions. Generation sector has been fully liberalized and any private developer may participate in the generation sector. The impact on traditional schemes (self-supply, IPP, etc.) is not clear but it is expected that permits granted by CRE will still be needed.

energy sector including roles and responsibilities of the various stakeholders in the Mexican energy sector.[158]

The Mexican government has adopted a policy of diversification of generation resources based on promoting the development of renewable energy. In 2008, the Act on Renewable Energy (RE Act) delegated specific powers to CRE in order to develop various incentives to promote private investment and renewable energy penetration into the Mexican power grid. Among others, CRE's goal is to refine rules and regulations to further enhance electricity production through promotion of renewable power production up to 30 MW.[159]

5.1.1 International Experience with Auction Mechanisms for Renewable Energy

To encourage more reliance on small distributed renewable resources while obtaining the most economical and efficient technologies, government authorities and regulated utilities often rely on market-based auction mechanism to procure such resources. Various different auction mechanisms are used to obtain the most competitive offers from renewable resource developers.

The International Renewable Energy Agency's (IRENA)[160] analysis of Renewable Energy Auctions in developing countries[161] notes that in 2013 at least 44 countries used renewable auction mechanisms; 30 of those are developing countries. The IRENA report highlights popular auction mechanisms used in developing countries, including the "sealed-bid auction" (most common), "multi-round descending-clock auction" and a hybrid of the two. Table 5-1 (adapted from the IRENA report with adjustments from ESTA) highlights the two main approaches.

Table 5-1: Common Auction Mechanism for Renewable Energy Auctions

Sealed-Bid Auctions	Descending Clock Auctions
Bidders simultaneously submit confidential bids with disclosed offer of price and quantity. Bids that meet all of the requirements are ranked by price. Offers are then selected in ascending order until the procurement volume of the auction is met.	The auctioneer offers a public high price that is expected to create excess supply. Bidders state the quantities they would supply at this price. While there is still excess supply, the auctioneer decreases the price until target supply volume is met.
It is possible to rank projects not only according to price, but including other criteria such as bid adders and bid subtractors to account for location attributes.	No project ranking. The auction results in offered quantities for determined price
Limited volume auctioned, selection of a number of bids to match the procurement volume.	Limited volume auctioned, selection of a number of bids to match the volume target
Ceiling price used for the selection process. No inherent process for price discovery.	Price (ceiling) discovery at the end of the process
Average price not necessarily disclosed at the end of the auction round.	Average price disclosed at the end of the auction round.
Results in limited competition among bidders.	Causes the bidders to actively compete.

[158] For example, Generation is no longer considered as public service.
[159] The Public Service Electricity Law (LSPEE Act) referred to "small production" as that which does not exceed 30 MW of installed capacity and whose electricity generated is offered to CFE in its entirety.
[160] "The International Renewable Energy Agency (IRENA) is an intergovernmental organisation that supports countries in their transition to a sustainable energy future, and serves as the principal platform for international cooperation, a centre of excellence, and a repository of policy, technology, resource and financial knowledge on renewable energy. IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy in the pursuit of sustainable development, energy access, energy security and low carbon economic growth and prosperity" - Source: IRENA website.
[161] Renewable Energy Auctions in Developing Countries, 2013, http://www.irena.org/DocumentDownloads/Publications/IRENA_Renewable_energy_auctions_in_developing_countries.pdf

The World Bank's[162] review of design and implementation of policies to promote Renewable Energy development in six developing countries highlights various approaches, including: Feed-in Tariff (FiT) Policy, Renewable Portfolio Standards (RPS), Renewable Energy Certificates, and Competitive Procurement (Bidding and Auction Mechanisms)[163]. Each has its specific investments risks, effectiveness/efficiency, and complexity. Table 5-2 shows the World Bank's summary of these three dimensions for Competitive Procurement (Bidding and Auction Mechanisms).

Table 5-2: Dimensions of Competitive Procurement

COMPETITIVE PROCUREMENT (AUCTIONS, BIDDINGS)		
Investment Risks	**Effectiveness/Efficiency**	**Complexity**
• Moderate to high price risk (depends on contract design, market rules) • Stop-and-go nature creates uncertainty • Less predictable revenue streams require higher IRRs • Awarded contracts provide predictable revenue streams • Participation in bids may entail high transaction costs • More difficult to secure financing	• If competition is effectively fostered, delivers low prices (entire supply chain) • Allows for strategic support of different types of RE • High deployment risk (project delays or no implementation at all due to difficulties in financial closure, administrative or licensing barriers, weak rule of law or weak enforcement of contracts or project completion guarantees)	• Design of auction mechanism may be complex (depends on type of market and market conditions) • Requires high institutional and administrative capacity • Requires robust rule of law, enforcement of contracts • Regulatory stability is crucial (stable auction rules) • Requires proper design of Project completion guarantees and penalties for delays and under performance.

Countries in Latin America such as Peru[164] and Brazil have conducted several renewable energy auctions. The lessons learned in these countries can be valuable feedback to policy makers in Mexico as CRE refines the existing auctions in further procuring renewable resources with the understanding that those auctions span various renewable energy sizes and are not limited to Small Scale Renewable Energy programs.[165] Table 5-3 and Table 5-4 highlight the programs in Peru and Brazil, respectively.[166]

[162] Design and Performance of Policy Instruments to Promote the Development of Renewable Energy: Emerging Experience in Selected Developing Countries; Energy and Mining Sector Board Discussion Paper No. 22, April 2011

[163] Mexico will use the RPS (35% clean energy by 2024 established within the NES) and Competitive Procurement process. The Feed-in Tariff approach is not preferred.

[164] CRE has received advice from Peruvian Consultants in designing an auction mechanism tailored for the Mexican power sector.

[165] Auction examples, covering Argentina, Brazil, Chile, Colombia, Peru, and Uruguay, are discussed in a 2013 IIT Working Paper by Paolo Mastropietro, Carlos Batlle, Luiz A. Barroso, and Pablo Rodilla and titled: "Electricity Auctions in South America: Towards Convergence of System Adequacy and Res-E Support." Also available at: http://www.iit.upcomillas.es/batlle/Publications/2013%20Electricity%20auctions%20in%20South%20America%20_%20Mastropietro%20et%20al.pdf .

[166]IRENA Report on Renewable Energy Auctions in Developing Countries, 2013.

Table 5-3: Characteristics of Renewable Energy Auctions in Peru

CHARACTERISTICS OF THE RENEWABLE AUCTIONS IN PERU	
Legal basis	Supreme Decree No. 1002 adopted in 2008, amended by Supreme Decree No. 012-2011-EM in 2011
Authorities in charge	Ministry of Energy and Mines (MEN) Energy and Mines Regulator (OSINERGMIN)
Eligible technologies	Technology-specific auctions targeting solar, biomass and waste, wind, small hydro and geothermal
Selection process	Selection in one round without a prequalification phase based on price and quota of energy; Ceiling price (undisclosed) defined by OSINERGMIN and quota defined by MEN. The bidder must submit proof of a range of technical requirements, provide resource assessments for a period not less than one year, and submit a pre-feasibility study for each project.
Agenda of auctions	First auction: 2009-2010; Second auction: 2011; Third auction envisaged for 2013.
Duration of tariff	20 year PPA
Compliance	Use of performance bonds deposited by the project developers in order to secure completion of projects. Compliance with volume of energy generation contracted is ensured by penalizing shortages. In the case of delays, extension can be granted and/or performance bond value is increased. Contract is terminated if failure to complete.

Table 5-4: Characteristics of Renewable Energy Auctions in Brazil

CHARACTERISTICS OF THE RENEWABLE AUCTIONS IN BRAZIL	
Legal basis	Laws 10,847 and 10,848 adopted in 2004
Authorities in charge	Government: Ministry of Energy and Mines (MME) Executive body: Electricity Regulatory Agency (ANEEL)
Eligible technologies	Auctions can be technology-specific (e.g. biomass-only auction in 2008 and wind-only auction in 2009 and 2010), alternative energy auctions (wind, small hydro and biomass in 2007 and in 2010) and technology-neutral auctions (carried out regularly since 2005, where all RETs have been participating since 2011). ANEEL determines which RETs are eligible in auctions and they can compete with conventional power (as in the case of 2011 auction).
Selection process	Pre-requisite to bid for projects: prior environmental license; grid access approval; technology specific documents (such as fuel contracts for biomass and certified production for wind). Selection in 2 stages: Stage 1 descending price clock auction; Stage 2: final pay-as-bid auction.
Agenda of auctions	New energy auctions annually based on forecast energy capacity needs. These auctions are technology neutral but the government can determine the eligible technologies, thus allowing exclusive participation of RE. Reserve auctions are held at the discretion of the MME. Typically one reserve energy auction is held for RE-based power generation every year but this is not the rule.
Duration of tariff	Typically lasts 20 years for wind; 20 years for biomass; and 30 years for hydro.
Compliance	Long list of technical documents to participate. Bidders have to deposit several guarantees, including a bid bond of 1% of project's estimated investment cost and a project completion bond of 5% of project's estimated investment cost. Penalties for delays and under production. Contract termination for delays greater than one year.

Brazil and Peru have been very successful with their auction system in being able to obtain reduced prices and establish technology preferences for Renewable Energy. IRENA also reports on the importance of price ceilings in South Africa. The first pass of auctions in South Africa was not successful in obtaining reduced prices as the disclosed price ceilings were high. During the next round price ceilings were not disclosed and reduced prices were received.

5.1.1.1 INFLUENCE OF AUCTION MECHANISMS ON TECHNOLOGY AND LOCAL DEVELOPMENT

Technology preferences, site preferences, and local labor force development in line with government policy and market goals, play important roles in design of country-specific auction mechanisms. Auction mechanisms designed with such objectives are often used by countries to promote various regulatory and policy initiatives, as shown below.[167]

Technology

Technology Specific Auctions help promote a specific technology and increased price competitiveness within the Renewable Energy context. For example, China's focus on wind energy resources helped develop the wind energy in China as was the case with biomass-only and wind-only auctions in Brazil.

Technology Neutral Auctions promote the least expensive technologies within the country and allow for a mix of resources.

Site Specific

Site Specific Auctions promote renewable energy at particular locations to improve transmission reliability, better use of resources to reduce operating costs, or promote local industries.

Local Content

Local Content Requirements (LCRs) in auction mechanisms also play an important role in the development of specific domestic technologies and manufacturing expertise. The primary goal is to create local industry, increase employment, and gradually becoming competitive in certain areas overtime. This may also have an impact on reduction of the overall costs due to lower materials and labor cost in the long run.

5.1.2 REGULATORY POLICY CONSIDERATION OF AUCTION MECHANISMS

In the report entitled *Assessing Reverse Auctions as a Policy Tool for Renewable Energy Development*[168], based on the study of the systems in UK, Brazil, and China, author Paolo Cozzi notes that "we *can extrapolate some policy guidelines to consider if and when designing a reverse auction. Among these are policy interaction, permitting, deposits and penalties, and how the increase in demand can be translated into growth of a component manufacturing industry."*

Cozzi highlights some of the following points:

- An auction mechanism can be used to complement other policies directly, such as Clean Development Mechanism (CDM) or indirectly, such as promotion of domestic wind turbine

167 Auction examples, covering Brazil, China, Morocco, Peru, and South Africa, are provided in a 2013 report by the International Renewable Energy Agency and titled: Renewable Energy Auctions in Developing Countries. Also available at: http://www.irena.org/Publications/ReportsPaper.aspx?mnu=cat&PriMenuID=36&CatID=141 .

168 Published by The Center for International Environment & Resource Policy (CIERP) and the Energy, Climate and innovation program, The Fletcher School, Tufts University, Paolo Cozzi

manufacturing.

- Environmental permitting played a key role. In the UK, it was an obstacle to development while in China through governmental rental of land and permitting it was less of an issue. He notes that in Brazil, the bidder was required to obtain permits and undertake feasibility studies prior to submitting a bid. It also helped refine the bidders that were more serious.

- "Bidders need to have a financial stake in following through on a won bid." The UK system did not have a penalty clause. With a penalty clause or a large deposit, companies may provide the best scenario cases giving themselves options for development and prevent others from wining contracts.

- Policies for local content can result in development of domestic manufacturing. The report quotes Lewis and Wiser[169] "Direct support for local manufacturing — through local content requirements, financial and tax incentives … — has proven particularly beneficial in countries trying to compete with dominant industry players." Lewis and Wiser have noted before having local content requirement for wind energy, China had only one manufacturer ranked 15th in 2004. Through these policies, in 2010, China had four of the top wind energy manufacturers. Cozzi notes that "While LCRs appear to violate both Article III of the General Agreement on Tariffs and Trade (GATT) ("National Treatment of Internal Taxation and Regulation") and Article XI on quantitative restrictions, thus far few disputes have been brought against them."

Based on the several case studies of renewable energy auctions in developing countries, IRENA identifies some key regulatory and policy considerations of successful auction mechanisms as shown below:

- Adequate regulatory framework that offers security to investors.

- Well defined, fair and transparent rules and obligations for all the different stakeholders.

- Clear communications of any additional information or adjustments to all the competitors equally.

- Rules that should include:
    - Conditions for granting access to the grid and sharing the costs of connection, grid expansion and grid reinforcement.
    - Rules and obligations for transmission system operators must also be clearly defined and implemented.

- Decision makers should avoid stop-and-go cycles by establishing a transparent and adequate long-term agenda for the planned auctions and auctioning rounds.

- Setting a plan for the auctions would also give project developers the chance to plan ahead and to provide all the data requirements.

- Facilitate the administrative procedures on investors
    - Adequate, streamlined and slim permitting procedures (requirements for environmental impact assessment, requirements for local stakeholder engagement, etc.).
    - Simplified Administrative procedures by creating a one stop shop or an automated system

[169] Lewis, Joanna, and Ryan Wiser (2007). "Fostering a Renewable Energy Technology Industry: An International Comparison of Wind Industry Policy Support Mechanisms." Energy Policy 35 (March): 1844–1857. doi:10.1016/j.enpol.2006.06.005.

- Manpower and skills needed to evaluate bids should be carefully estimated to reduce the risk of experiencing delays in the evaluation stage[170].

5.1.3 PROCUREMENT MECHANISMS FOR SMALL DISTRIBUTED RENEWABLE RESOURCES IN MEXICO

The development of small scale power production in Mexico has been limited by low investment profitability, driven by the current level of electricity prices. To promote small distributed renewable resources, CRE has embarked on a program to develop a procurement mechanism that works efficiently and promotes development through a competitive process.

On November 14, 2012, CRE issued "Guidelines for Renewable Auctions for electricity generation through Small Production Projects" (Auction Guidelines). These guidelines were developed to enable CFE to meet the targets defined in its Special Program, via a simplified and market-based auction mechanism for renewable energy projects that is tailored for small power plants. This document defines the general framework that CFE should follow for carrying out auction processes for small production projects. Efforts are in progress to refine the guiding principles that CFE should follow.

It is envisaged that the auction mechanism to procure small distributed renewable resources can achieve the following objectives:

1. Accomplish the short and long term goals of the Renewable Energy Special Program.
2. Ensure electricity supply through small renewable production projects.
3. Enhance Mexico's environmental quality through more reliance on cleaner sources of electricity.
4. Reduce the amount of information required and the transaction costs to improve participation by developers of small production projects.
5. Promote competition and assist CFE to achieve the lowest possible costs.
6. Direct the development and promotion of small renewable energy resources to geographic locations with high potential for renewable resources in Mexico.
7. Reduce the need for investment in the transmission and distribution network in areas where the existing facilities are insufficient to take out the electricity generated.
8. Reduce the operating costs in areas where more expensive transmission lines are needed to provide reliable service[171].
9. Provide a market signal for developers building new generation facilities.
10. Offer investment security through long-term PPAs.
11. Increase the predictability of renewable energy supply and assist CFE´s budget control.

[170] "For example offers received as a response to the South African request for tenders took much more time to process than anticipated. Given limited resources, the auctioneer could also reduce the number of bids to be evaluated by increasing the bidding requirements. In Peru, the number of bidders was limited by requiring high participation fees and imposing stringent compliance rules such that only large companies with the required financial capabilities could participate." Source IRENA Renewable Energy Auctions in Developing Countries. Also available at: http://www.irena.org/Publications/ReportsPaper.aspx?mnu=cat&PriMenuID=36&CatID=141 .

[171] There are areas in a transmission system that cannot be served reliably unless certain high cost generators remain on line. In California, they are called "Must-Run" resources. In Texas, a similar terminology is also used. Likewise, there may be areas that load may not be able to serve reliably beyond a certain level unless a high priced generator is committed. These areas have significant contribution to daily operating costs. Placing renewables in these areas can reduce operating costs above all other benefits.

Annex A provides a Use Case developed for the preliminary auction mechanism developed by CRE. A pilot project will be implemented in the near future using this mechanism. As with any pilot project, lessons will be learned and combined with lessons from other nations, it will set the base for robust auction system to meet CRE and Mexico's policy, regulatory, and social objectives.

Current Experience

As part of the full implementation of the auction mechanism, preparations for a pilot auction for Small Production photovoltaic projects are underway. It will be based on the planning auction program developed by the Auction Working Group.

Following the auction process described above, CFE will publish auction documents for the pilot solar auction. They required some minimal adjustments in the Guidelines. It has been foreseen the process will enhance transparency and result in trust among new small- to medium-size participants in pilot auction. Through this process, the pilot auction will be carried out as expected considering the schedule and the auction´s documents published by CFE. CFE will award more than one solar project with long-term PPAs and awarded projects must meet their committed commercial operation dates.

A long term planning auction program is planned by the Auctions Working Group by Ministry of Energy, CFE and CRE.

5.1.4 Recommendations for Refinement of the Small Scale Renewable Energy Auction Mechanism Process For Mexico

In the Mexican context, an auction mechanism should have, at a minimum, these characteristics:

- Be tailored to Mexico's needs while leveraging "best practices" and lessons learned from other countries
- Be effective even if no new laws are passed[172]
- Require minimum regulatory oversight

Desired features for an auction mechanism for Mexico are summarized in Table 5-5.

[172] In implementing the desired Auction Mechanism, CRE should rely on its own existing authority or expand its expertise and feedback to support other Mexican authorities to achieve the desired goals.

Table 5-5: Desired Features of an Auction Mechanism for Mexico

Feature	Reason
Simple-to-understand processes that are transparent to participants and easy to implement	Prevent discrimination
A Standardized Interconnection Agreement that may exempt small distributed renewable resources from certain planning and operational obligations	Prevent discrimination and lower the development costs for small players
A "Fast Track" process for required interconnection studies for Small Power Plants.	Lower development costs for Small Power Plants.
A mandate that the utility purchase a portion of its annual energy need from small production renewable projects[173]	To "jump start" the market
Incorporating "best practices" regulatory policies from other Countries	Faster than trial and error in Mexico
Minimized standardized information requirements and transaction costs for small scale and renewable projects.	Facilitate Participation and give more certainty to CFE
Promote projects located close to customers while complementing the distribution system, improving system reliability, and enhancing environmental quality[174]	Achieve "best cost" outcome
Provide flexibility for CFE to identify locations with urgent needs for improvements in return for additional financial benefits[175]	Provide incentive to CFE to get greatest value
Publicizing bid adders and subtractors to locate power plants in areas that minimize total investment in Mexico's power grid infrastructure.	Obtain highest value using competition
Develop Standardized Power Purchase Agreement for standard projects[176]	Lower administrative costs
Financial and non-financial incentive schemes to promote private investment and the development of small scale projects.[177]	Grow the market
Strengthen market-based multi-dimensional procurement mechanisms so that the most suitable offers are selected[178]	Get highest value
Provide transparency in the auction process and maintain ease of access to information	Prevent discrimination
Require strong guarantees and impose stiff penalties to discourage project delays and completion failure	Guard against completion failures. Protect consumers

In developing an auction mechanism for Mexico, CRE should take into consideration the desired features identified in Table 5-5. Similarly important, CRE must actively seek feedback from various parties affected by the implementation of an auction mechanism.

One of the most important considerations in Table 5-5 is that the auction procurement mechanism needs to identify, value, and recognize the multi-dimensional attributes of the resources. For example, reducing operating costs, deferral of the need for new transmission and distribution facilities, cost of expansion of existing transmission and distribution facilities, filling in for retirement of older less efficient generating resources are among the important attributes of the value to the CFE that need to be considered.

Some steps are already underway to establish an Auction Working Group (AWG) that will help create an auction mechanism that is suitable for Mexico. The most important aspect in establishing and using such a significant group is to ensure that the process of developing an auction mechanism is inclusive and reflects the interests of all major stakeholders.

[173] To be considered for the first Pilot Auction System.
[174] Through SENER renewable special program the goals to implement renewable energy are established.
[175] The Energy Reform Act of 2013 may address this.
[176] This is an ongoing process at CRE.
[177] These include financial and non-financial incentives or inducements. For example, some waivers may include streamlining some of the requirements while others may help emphasize and put focus on preferred projects by providing long term contracts. Another example could be to allow private sector to install rooftop solar and enter into 20-year contract with the current and future homeowners.
[178] This could mean a mechanism that selects the best resources not only based on price but also on other criteria such as placement in a preferred geographical location, help reduce transmission congestions, etc.

In addition to seeking involvement and getting feedback from relevant government agencies, CRE relied on expertise from CFE, obtained feedback from experts who had been involved in the development of small-scale renewable resources[179], sought advice from financial and market experts, and reflected concerns identified by various end-users. Such interaction and feedback will make success of an auction mechanism more likely, facilitate informed decision, and ensure that Mexico-specific concerns are addressed.

Responsibilities for information exchange at various points in the process of developing and implementing the auction mechanism should be determined.

As part of this process, the roles of various stakeholders must be agreed at the outset. Furthermore, responsibilities for information exchange at various points in the process of developing and implementing the auction mechanism should be determined. Finally, the process should develop a consensus procedure for conducting a pilot auction before full auction mechanism is implemented.[180]

Before full implementation, the auction process should be tested in a pilot program where each auction could be aimed at procuring electricity from more than one renewable energy project. The total amount will be determined by CFE where no project can exceed 30 MW.

In the medium term, a market for Small Production projects through renewable resources will be developed, promoting competition among small- to medium-size investors while the selection of Small Production projects result in the lowest possible costs for CFE.

Over a longer term, the number of Small Production permits will be increased based on the interest of investors in auctions while the amount of total installed capacity for such projects can increase up to the needed amount of capacity set in the goals defined in the Renewable Energy Special Program.

While the work on developing an auction mechanism for small renewable resources has already begun in Mexico, it will take several more years to design a mechanism with all of the desired features discussed above. Hence, the process should be considered as an evolving one that continuously faces changes and refinements to ensure that the national targets and policies on small renewable resources are met in a timely manner.

[179] Peruvian experience on designing renewable energy auctions was taken into account through an expert´s visit for discussing lessons learned and experience based on the main characteristics CRE was looking for implementing a renewable energy auction scheme in Mexico.
[180] CRE has already taken steps to identify stakeholders' roles, information exchange, and step-by-step actions that should be taken in implementing auction mechanism to procure small distributed renewable resources. See Annex A for more details.

5.2 IDENTIFICATION OF TECHNOLOGY DEPLOYMENT OPPORTUNITIES AND U.S. SOURCES OF SUPPLY

CRE, SENER and CFE are all active in Smart Grid programs in Mexico, each with focus on a different element of Smart Grid. CRE has focused on Regulatory Framework and Instruments; SENER has commenced work on Smart Grid Policy Framework; and CFE has focused on technological aspects of Smart Grid. Through period meetings that first commenced at CRE offices in 2012, CRE, SENER, and CFE have shared developments to ensure a harmonious path for Smart Grid in Mexico.

The Modernization Directory spearheaded the Smart Grid program at CFE starting in 2009. It formed a group with interdisciplinary subject matter experts from different CFE Sub-Directions and departments. This group developed CFE's preliminary vision for Smart Grid in Mexico and identified some key initiatives. Highlights of CFE's preliminary vision are presented later in this section.

The 2012 presidential elections in Mexico, as is often the case during any change in government, resulted in new appointments at various levels of government and government-owned entities. These included changes at SENER, CRE and CFE. These changes came into effect in early 2013 prior to the release of the preliminary CFE Smart Grid Roadmap. New leadership at CFE through the Director General office has begun an assessment and review of the modernization and infrastructure improvement programs, including the Smart Grid plans for CFE. This review must take into account the recent changes of Articles 25, 27 and 28 of the Mexican Constitution passed by Congress at the end of 2013 –as part of the Energy Reform being in place and also the secondary Acts and Norms - and must be finished within the first 120 days of 2014. As a result, the preliminary roadmap developed by CFE is currently under review and will be updated and released in the near future.

While the CFE Smart Grid program review is underway, ESTA international, with support from CRE was able to obtain some initial information regarding CFE's Smart Grid vision using the guidelines developed by the International Smart Grid Action Network (ISGAN)[181]. Mexico is an active member of ISGAN. The CFE response to the information request is summarized in Section 5.2.2.

In compliance with the requirements of the terms of reference for this project, ESTA has identified potential US sources of supply for each key component identified by CFE. In addition, ESTA has compiled a list of companies active in development of Renewable Energy.

[181] The International Smart Grid Action Network (ISGAN) is one of fourteen initiatives under the Clean Energy Ministerial (CEM) program. CEM was formed by ministers and high-level officials form twenty-four countries, jointly representing over 90% of global clean energy investment and more than 80% of global Green House Gases (GHG) emissions, with the aim of active collaboration on policies and programs to accelerate global transition to clean energy technologies. CEM member countries include: Australia, European Commission, Brazil, Canada, China, Denmark, Finland, France, Germany, India, Indonesia, Italy, Japan, Korea, Mexico, Norway, Russia, South Africa, Sweden, Spain, United Arab Emirates, United Kingdom, and United States.

5.2.1 CFE Smart Grid initiatives

CFE plans to optimize the use of energy infrastructure through automation, construction, pilots, and other activities. CFE aims to move toward a more flexible, resilient, efficient and sustainable power grid that will address the energy challenges of the country, and to provide better service to customers and developers. Furthermore, CFE goals are to operate the Grid under international standards of reliability, security, sustainability, quality and efficiency; improve the integration of renewable energy and address electric vehicles (no mandate yet); and improve the use of information technology by establishing a platform to ensure interoperability while eliminating redundancies.

Within the Smart Grid context, CFE considers five key perspectives;

1. Clients
2. Resource Management
3. Network Operations
4. Sustainability
5. Information and Communications technology.

CFE's preliminary plans called for five priority programs:

1. Lowering Power Losses in the National Energy System.
2. Enterprise Architecture for Information and Communications Technology (ICT) Making the design and infrastructure of information technology reliable and safe.
3. Strengthening and improve commercial and invoicing system
4. Implementation of an Asset Management System
5. Geographical Information Systems to collect and obtain more accurate locational information

As noted earlier, these programs are currently under review within the overall CFE modernization program.

Aside from the above, CFE has already undertaken some key initiative:

Electronic Metering

In recent years, CFE has implemented a series of pilot projects of automatic meter reading (AMR) and of AMI, in 13 of its 16 distribution divisions.
Through these projects CFE has tested different meters and communications systems. These pilots include various CFE services areas from urban to rural, mountainous terrain and Plains, in different climates, large and short distances, with interfaces connected to the billing system of the CFE, among other features. CFE has installed by the mentioned pilots, more than 400,000 customers nationwide operating with smart metering, of which 58% has the functionality of switching on and off remotely, through two-way communication. The means of communication, in 66% of cases, is done through radio frequency. In the remaining 34% is done through other technologies such as PLC, GPRS, TCP/IP or conventional phone line.

CFE is conducting a Smart Grid pilot project to monitor and control electric power within the distribution grid in the metropolitan area of the Valley of Mexico. CFE is supplying electric energy to the central part of the country through three Distribution Divisions with more than 6.2 million of customers at an annual growth of 1.86% in energy demand, which represents almost 20% of the national consumption in Mexico. The losses of electrical energy regarding distribution grid in this area during 2009 were approximately 30.83%, from which 8.03% refers to technical losses whereas the remaining 22.8% refers to non-technical losses. For the rest of the country, electrical losses were about 12.5% from which 9.5% are due to technical losses whereas 3% are due to non-technical losses[182].

Within this context, CFE launched a pilot project to install 60,000 smart meters to residential clients in the areas of Polanco and Lomas, this project had an estimated cost of 30 million dollars. The project uses wireless data radios to monitor and control crucial electric power applications in order to reduce the losses in the distribution grid. After CFE selected Elster Group's EnergyAxis smart grid solution in April 2010 to power the utility's first advanced metering infrastructure project, CFE has chosen FreeWave Technologies to provide wireless data radio applications, such as power consumption and substation monitoring, as well as control and monitoring of power networks.

In Acapulco, CFE has implemented electronic metering program for over 67,000 customers. In Acapulco, CFE uses the Two-Way Automatic Communications System (TWACS) technology provided by Aclara (US firm based in St. Louis, MO). The TWACS pole-mounted and socket-type AMI technology is used.

Automation

CFE has network of automation systems both at the National Control Center Level (CENACE) as well as the 13 divisions. The last CENACE system including the support services was upwards of $80 Million US dollars and was awarded to the ABB network automation division in Sugarland Texas. With support from IIE, CFE is preparing technical specifications on the state of the art technology for a replacement project. In addition to ABB US, other US companies such as Open System International and OSIsoft have some automation related projects with CFE.

CFE has been active in automation of substations for transmission and distribution of CFE for many years. CFE Advances in this area include the automation and remote control of 100% of over 450 transmission substations of the grid; as well as a majority of the over 1,700 distribution substations[183].

Synchrophasor Technology

CFE is actively implementing Synchrophasors[184] for select transmission lines and buses. CFE's Sistema de Medición de Sincro-frasores (SIMEFAS) is comprised of 293 PMU, interconnected by communications in optical fiber into hubs of data at the Regional and national Transmission levels, thus enabling the utilization of the information from the Regional Transmission Areas for postmortem analysis. CENACE's Sistema de Monitoreo Dinámico y Control del Sistema Eléctrico Nacional[185] (MoDiCoSEN) real-time applications uses directly some of the operational PMUs by means of other communication media(fiber optics), to provide the means for analysis, monitoring and historicizing data of Syncro-phasor Units (PMUs) and showing the dynamic behavior of the National Grid in Real Time , using 50 milliseconds as a time frame for the data acquisition, with a focus on the supervision and control of the stability of the national interconnected system. The real time applications of CENACE are running on the OSISoft Software technology and also some are in house developments on the OSISoft LabVIEW platform.

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[182] By comparison, the US average non-technical losses range between 2% -2.5%.
[183] In Comparison, less than 50% of distribution substations in the USA are automated.
[184]Synchrophasors are devices for wide area measurement to sample the voltage and angles of power system at various stages. A typical SCADA/EMS system receives information at the rate of one sample per 2 second at the best. Synchrophasors allow up to 120 samples per second thus providing significant details regarding the power system behavior. It is one of the most important Smarter Grid Technologies for transmission networks. The US ARRA stimulus funds resulted in over $300 million US dollars investment in this technology (US DOE and matching) at the transmission level with 10 projects totaling over 800 installations of PMUs. The US is a leader in Synchrophasor technology.
[185] Dynamic monitoring and Control of the system electric national real-time application.

Other CFE Efforts

- CFE is developing the Sistema de Monitoreo de Calidad de Energía (SIMOCE) for monitoring of quality of energy. It is installed at 8,715 points of measurement in medium and high voltage points, at levels from 13.8kV to 161kV in the 16 divisions of distribution. The SIMOCE allows the traceability of measuring logs specific to power quality that can be applied to decision-making in the processes associated with the planning and operation of distribution.
- CFE has developed Sistema de Seguimiento de la Confiabilidad del Equipamiento de Distribución (SISCOED) for monitoring the reliability of the distribution equipment. It analyzes the useful life of the equipment of distribution to estimate the reliability of the equipment at any time during its life. SISCOED is being adapted to the Transmission Network as well. Through a project called Centros de Monitoreo de Datos de Activos de Transmision (CEMODAT) a pilot project for diagnosis of transmission assets of transmission and maintenance programs at the Central and Northwest regional transmission managements is underway.
- CFE Distribution has made efforts to provide field staff more accurate information and better tools for the performance of their duties. Ninety percent of the readings throughout Mexico are performed using portable terminals that allow greater precision and efficiency. CFE's Sistema Integral de Administración de Distribución (SIAD) allows the use of portable terminals for work order management.
- CFE with support from IIE has developed a system for the short-term wind energy forecast. The system integrates a combination of various statistical models of prognosis.
- CFE has plans for Sistema de Atención integeral a Clientes (SAIC), a comprehensive customer service program to improve the CFE customer services. As part of infrastructure improvements, consolidation of 118 call centers was carried out in 13 contact centers using IP telephony.
- Telecommunications have been and continue to be a determining factor in the modernization of electric network operation and the daily management of the company. CFE has installed more than 35,000 km of optical fiber in a network with national coverage. This network provides services of data transmission for substations, online monitoring of critical assets, network protection, and monitoring and control of wide area networks. In addition this infrastructure is used for the needs of the CFE data network.

5.2.2 ISGAN Smart Grid Applications Under Consideration by CFE

Mexico is an active member of ISGAN, one of fourteen initiatives under the Clean Energy Ministerial (CEM) program. CEM was formed by ministers and high-level officials from twenty-four countries, jointly representing over 90% of global clean energy investment and more than 80% of global Green House Gases (GHG) emissions, with the aim of active collaboration on policies and programs to accelerate global transition to clean energy technologies.

ISGAN has identified five major areas as follows:

- End-Users
- Cross-cutting (applying to more than one area)
- Distribution
- Transmission and Substation
- Generation

The timeframes under consideration by CFE are as follows. Please note that with the upcoming electricity reform, these priorities may change.

Term	Start Year	Completion Year
Short-Term	2014	2017
Medium-Term	2018	2022
Long-Term	2023	2028

Several applications are considered under each heading. The following tables in the highlight ISGAN technologies in each of the area identified by ISGAN and Mexico's envisage implementation of the various applications.

Table 5-6: ISGAN End-User Smart Grid Technologies under consideration by CFE

End-User Smart Grid Technologies Under Consideration by CFE	Near Term	Medium Term	Long Term	Does Not Apply
Tools for planning, operation, analysis	√	√	√	
System wide monitoring, measurement, and control	√	√	√	
Information and communications technology	√	√	√	
Power electronics-based devices, including intelligent electronic devices (switches, relays, breakers, reclosers, transformers, capacitor banks), short-circuit current limiters, inverters & converters, regulators & circuit improvement	√	√	√	
Distributed energy resources		√	√	
Energy storage			√	
Demand response			√	
Standards and conformance testing		√	√	
Cyber security		√	√	
Electromagnetic compatibility			√	
Novel market models				√
Operator training tools and emergency procedures	√	√	√	

Table 5-7: ISGAN Cross-Cutting Smart Grid Technologies under consideration by CFE

Cross Cutting Smart Grid Technologies Under Consideration by CFE	Near Term	Medium Term	Long Term	Does Not Apply
Residential consumer energy management (including in-home displays, home area networks, consumer behavior integration, software tools, smart appliances)		√	√	
Building energy management and automation				√
Distributed energy resources integration	√	√	√	
Electric vehicles and associated supply equipment				√
Microgrids and minigrids				√
Local sustainable energy				√

Table 5-8: ISGAN Distribution Smart Grid Technologies under consideration by CFE

Distribution Smart Grid Technologies Under Consideration by CFE	Near Term	Medium Term	Long Term	Does Not Apply
Distribution management systems and Outage Management systems		√	√	
Distribution feeder circuit automation	√	√	√	
Fault detection, identification, and restoration (FDIR)	√	√	√	
Direct load control				√
Condition-based monitoring and maintenance		√	√	
Local sustainable energy			√	
Voltage & VAR control		√	√	
Capacitor automation	√	√	√	
Advanced metering infrastructure (AMI)	√	√	√	
Enterprise back office system – geographic information system (GIS), outage management system, customer information system, meter data management system	√	√	√	

Table 5-9: ISGAN Transmission and Substation Grid Technologies under consideration by CFE

Transmission and Substation Smart Grid Technologies Under Consideration by CFE	Near Term	Medium Term	Long Term	Does Not Apply
Resource planning, analysis, and forecasting tools	√	√	√	
Large size variable renewable energy sources integration	√	√	√	
Phasor measurement systems	√	√	√	
Substation & transmission line sensors	√	√	√	
High-voltage DC technologies				√
Flexible alternating current transmission system (FACTS) devices		√	√	
Voltage & VAR control	√	√	√	
Dynamic-thermal circuit rating			√	
Advanced conductors for transmission lines			√	
High temperature superconducting devices (e.g. SFCL, cables etc.)			√	
High-voltage AC transmission lines			√	

Table 5-10: ISGAN Generation Smart Grid Technologies under consideration by CFE

Generation Smart Grid Technologies Under Consideration by CFE	Near Term	Medium Term	Long Term	Does Not Apply
Clean Coal, e.g., integrated gasification combined cycle (IGCC)			√	
Natural gas combined cycle	√	√	√	
Nuclear		√	√	
Wind	√	√	√	
Solar photovoltaic and solar thermal energy	√	√	√	
Hydro power	√	√	√	
Tidal power			√	
Ocean thermal energy			√	
Wave energy			√	
Geothermal	√	√	√	
Biomass	√	√	√	
Biogas	√	√	√	

5.2.3 US SMART GRID SUPPLIERS

ESTA study of Smart Grid Initiatives around the globe showed that many countries look to the US technology for Smart Grid Deployment in many areas as depicted in the Figure 5-1 below.

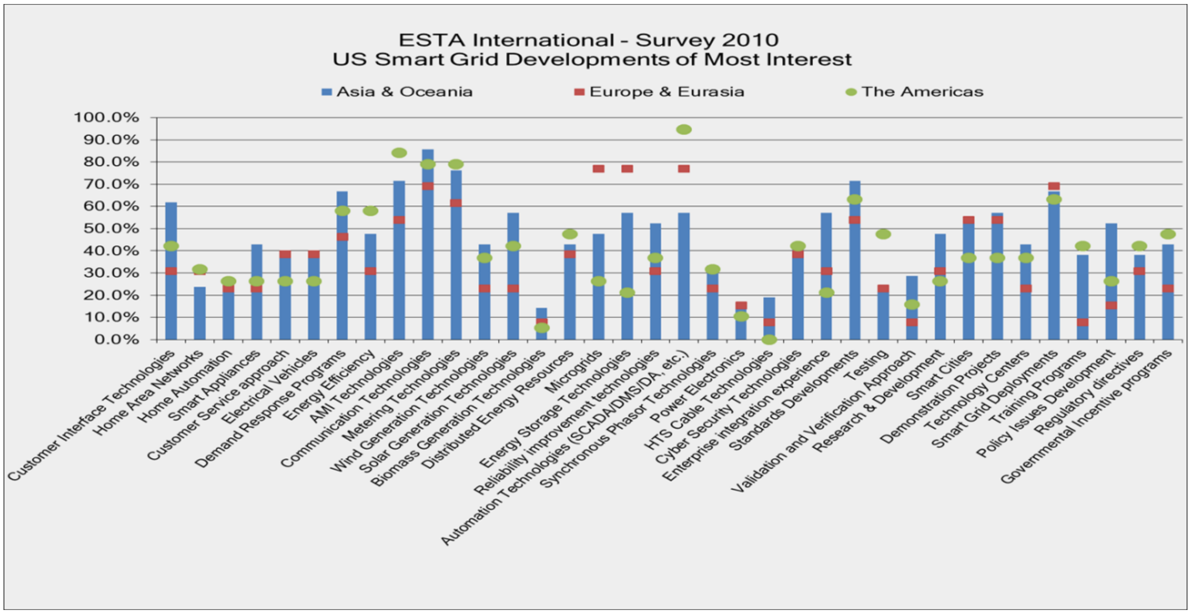

Figure 5-1: International Interest in US Smart Grid Products

As shown in Figure 5-1, Latin American companies consider the US as a leading source for Smart Grid technology solutions, more so than any other region. Within the technology areas, Automation technologies, AMI, communications, are the top three interest areas

In the ESTA survey of a select group of US Smart Grid suppliers, Mexico was considered as a key focal country for future expansion. Figure 5-2 shows the areas where US Smart Grid suppliers are active (blue color) and the markets they plan to expand to (red). As can be seen, Mexico and Canada are the top expansion markets for US firms.

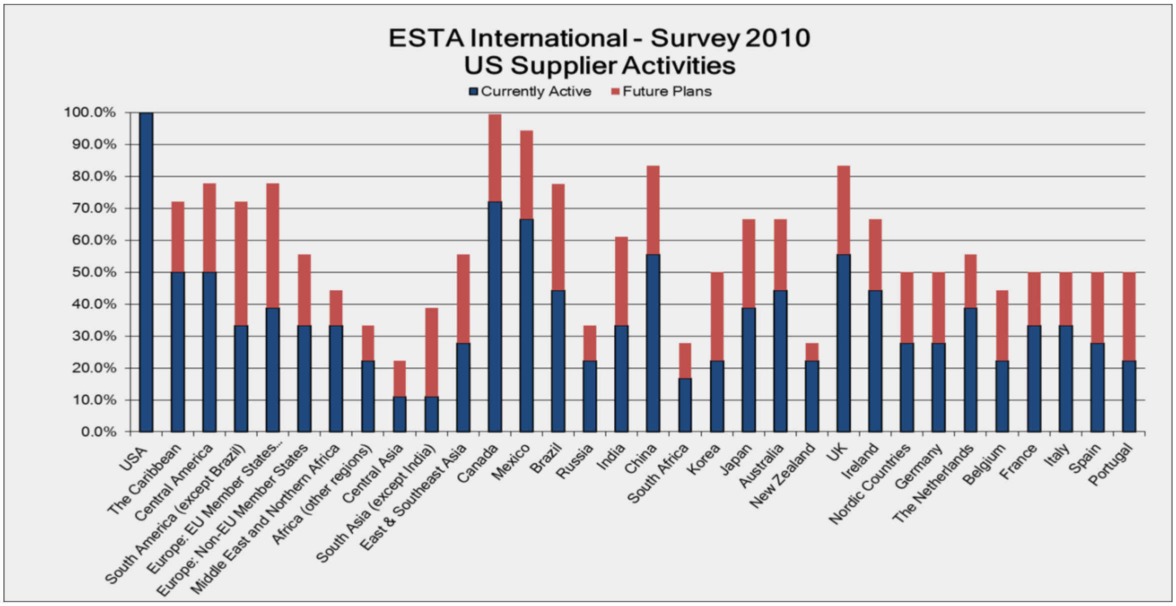

Figure 5-2: US Smart Grid Suppliers Current and Future International Market Expansion

The Smart Grid Vendor ecosystem encompasses a broad range of vendors providing an array of products from generation to the consumer. Figure 5-3 below from "*the Smart Grid in 2010: market segments, applications and industry players",* published by The GreenTech Media Inc. (GTM Research) in 2010 shows some of the suppliers in each segment. Since the report was published, some mergers have taken place and new suppliers have entered the marketplace.

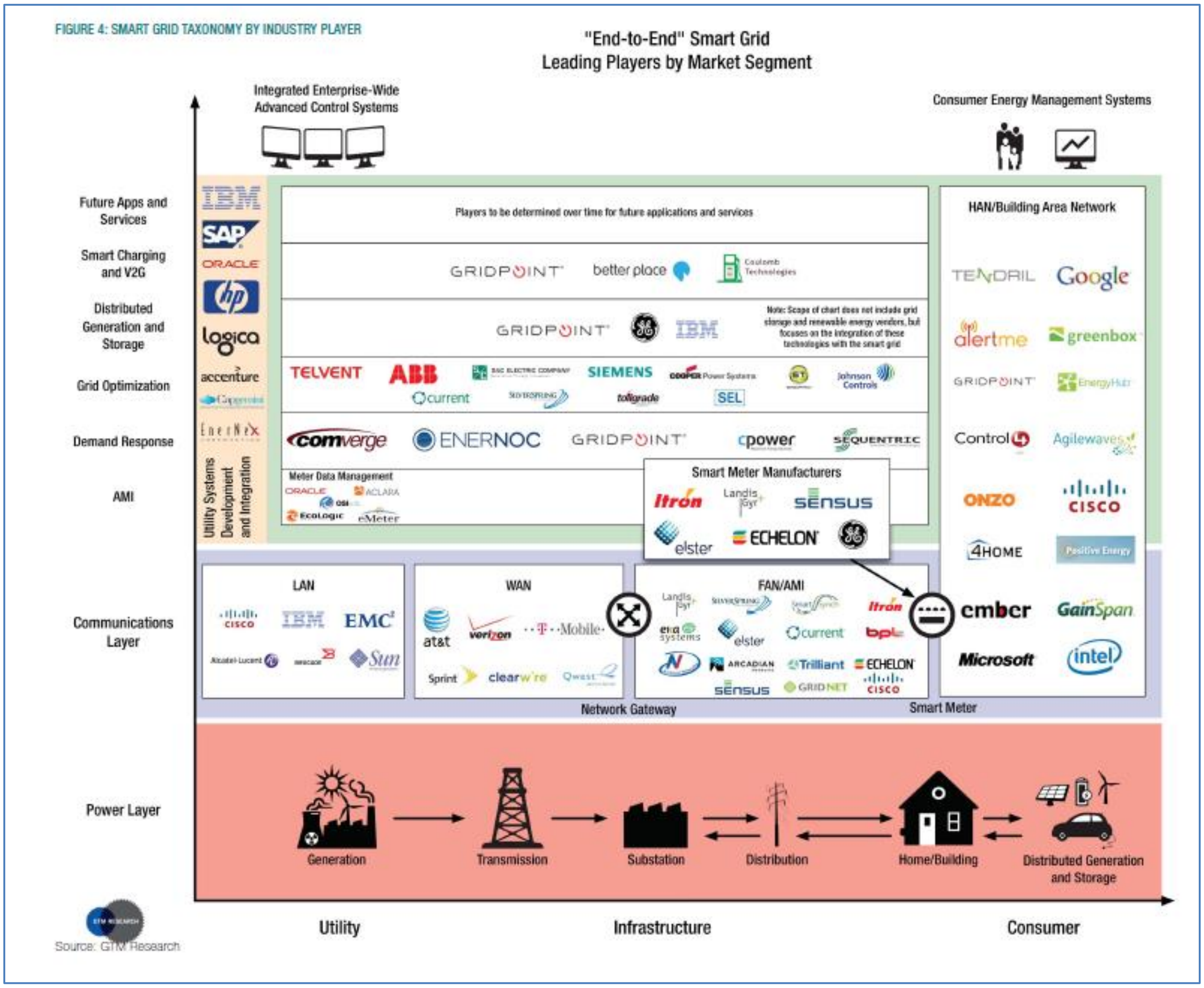

Figure 5-3: Smart Grid Suppliers by Market Segment - GreenTech Media

For this project, ESTA has categorized the suppliers into Smart Grid technology suppliers, Wind Energy, and Solar Energy suppliers.

5.2.3.1 SMART GRID TECHNOLOGY SUPPLIERS

The ARRA stimulus funds jump-started Smart Grid activities in the US and as a result many companies are now providing solutions at the various levels from transmission networks and storage to distribution to home automation services. Table 5-11 lists the US suppliers who self-proclaim as providers of Smart Grid solutions in alphabetical order[186]. ESTA international is not affiliated with any of the companies nor does it endorse any of the listed companies over others.

[186] The list has been compiled from the list of US exhibitors at the 2013 DistribuTECH conference.

Table 5-11: US Based Suppliers of Smart Grid Solutions

COMPANY	STREET ADDRESS	CITY, ST ZIP Code	PHONE
ABB INC	29801 EUCLID AVE.	WICKLIFFE, OH 44092	440 585 7076
ACLARA	945 Hornet Dr.	Hazelwood, MO 63042	314 895 6523
ALCATEL-LUCENT	67 Whippany Road-3A182	Whippany , NJ 07981	973 386 6047
ALERTENTERPRISE INC.	4350 Starboard Drive	Freemont, CA 94538	510 897 6795
Alligator Communications	317 Brokaw Rd.	Santa Clara, CA 95050	408 327 0800
Alpha Industrial Power	3767 Alpha Way	Bellingham, WA 98226	360 647 2360
Alstom Grid	175 Addison Road	Windsor, CT 06095	860 285 2458
Ambient Corporation	7 Wells Ave, Ste 7	Newton, MA 02459	617 614 6739
Ametek Inc.	150 Freeport Rd.	Pittsburgh, PA 15238	610 889 5278
Apex Covantage	198 Van Buran, Suite 200	Herndon, VA 20170	571 294 1826
Applied Communication Sciences	150 Mt. Airy Rd.	Basking Ridge, NJ 07920	908 748 2700
Arbiter Systems Inc	1324 Vendels Cir, Suite 121	Paso Robles, CA 93446	805 238 5717
AT&T	5600 Glenridge Dr. Mailstop G-221	Atlanta, GA 30342	404 847 4808
Autodesk Inc	111 Mcinnis Pkwy	San Rafael, CA 94903	415 507 6242
AutoGrid	960 San Antonio Road, Suite 201	Palo Alto, CA 94303	408 319 7307
BARCO	3059 Premiere Pkwy, Suite 300	Duluth, GA 30097	678 512 6150
Badger Meter	4545 W Brown Deer Rd. PO Box 23099	Milwaukee, WI 53223	414 371 5776
Bay Metal	4100 Congress Parkway W	Richfield, OH 44286	216 701 7159
Beckwith Electric	6190 118th Ave. N	Largo, FL 33773	727 544 2326
Bentley Systems	685 Stockton Dr.	Exton, PA 19341	610 458 2943
Bidgely	440 N Wolfe Rd.	Sunnyvale, CA 94085	415 350 7780
BPL Global Ltd.	Foster Plaza 6 681 Anderson Drive	Pittsburgh, PA 15220	724 933 7704
Byram Laboratories Inc.	1 Columbia Rd.	Somerville, NJ 08876	908 252 0852
CALAMP	299 Johnson Ave., Ste. 110	Waseca, MN 56093-2515	507 835 8819
Calico Energy	14565 Christen Dr.	Jacksonville, FL 32218	312 590 1914

COMPANY	STREET ADDRESS	CITY, ST ZIP Code	PHONE
Campbell Scientific Inc.	815 W 1800 N	Logan, UT 84321-1784	435 753 2342
Canary Labs	195 Bean Hill Rd.	Martinsburg, PA 16662	814 793 3770
CISCO	170 West Tasman Drive	San Jose, CA 95134	408 526 5239
Cleaveland/Price Inc.	14000 Route 993	Trafford, PA 15085-9550	760 309 0401
Comverge Inc.	5390 Triangle Parkway, Suite 300	Norcorss, GA 30092	678 802 7373
Cooper Power Systems by Eaton	1000 Cherrington Pkwy	Moon Township, PA 15108	412 813 4630
COPA-DATA USA Corp.	116 Village Blvd, Suite 200	Princeton, NJ 08540	646 255 7928
Core Logic	1 CoreLogic Drive	Westlake, TX 76262	817 699 7113
CORIX	126 N Jefferson St., SUITE 300	Milwaukee, WI 53202	414 291 6524
Corporate Systems Engineering	1215 Brookville Way	Indianapolis, IN 46239-1049	317 375 3600
CRAVE INFOTECH	33 Tower Road	Edison, NJ 08820	253 241 6704
Crystal Group Inc.	850 Kacena Rd.	Hiawatha, IA 52233	800 378 1636 est 281
Cyberlock Inc.	1105 NE Circle Blvd	Cornvallis, OR 97330	541 738 5500
DAQ Electronics LLC	262-B Old New Brunswick Rd., Suite B	Piscataway, NJ 08854-3756	732 981 0050
Data Comm for Business, Inc.	PO Box 6329	Champaign, IL 61826-6329	217 897 6600
DIGI International	11001 Bren Road East	Minnetonka, MN 55343	952 912 3045
Doble Engineering Company	85 Walnut Street	Watertown, MA 02472	617 927 4900
DVI	PO Box 27007	Richmond, VA 23261	804 771 4375
Dynamic Ratings, Inc.	1275 Wisconsin Avenue	Pewaukee, WI 53072	262 746 1230
EATON	1045 Hickory Street	Pewaukee, WI 53072	262 691 8241
EDX Wireless Inc.	PO Box 1547	Eugene, OR 97440	541 515 2394
EFACEC Advanced Control Systems	2755 N Woods PKWY PO Box 922548	Norcross, GA 30010-2548	770 446 8854
EFERGY USA	7516 NW 55 Street	Miami, FL 33166	305470 9716
Electro Industries/Gaugetech	1800 Shames Dr.	Westbury, NY 11590-1730	516 334 0870
Electrometer America LLC	21101 SE 5th Street	Sammamish, WA 98074	425 985 8984
Electroswitch	180 King Avenue	Weymouth, MA 02188	781 607 3326
Electsolve Technology Solutions & Services, Inc.	14101 HWY 290 Suite 1400-B	Austin, TX	877 221 2055
Elster	208 S Rogers LN	Raleigh, NC 27610-2144	919 212 5067
Encore Networks	3800 Concorde Parkway Suite #1500	Chantilly, VA 20151	703 318 4366

COMPANY	STREET ADDRESS	CITY, ST ZIP Code	PHONE
EnerNOC Inc.	75 Federal St., Ste. 300	Boston, MA 02110	617 398 2215
ENOSERV	7780 E 106TH ST	Tulsa, OK 74133	918 622 4530
EnTek Systems	600 Starlight Dr.	Sautee Nacoochee, GA 30571-3330	770 331 4780
ERICSSON	6300 Legacy Drive	Plano, TX 75024	972 583 6524
ESRI	380 New York ST	Redlands, CA 92373	909 793 2853
ETAP	17 Goodyear	Irvine, CA 92618-1812	949 462 0100
Exeleron Software, Inc.	5440 Harvest Hill Road Suite	Dallas, TX 75230	972 852 2796
Freewave Technologies Inc.	1800 S Flatiron CT, Ste. F	Boulder, CO 80301-2823	303 444 3862
G & W Electric	305 W. Crossroads Pkwy	Bolingbrook, IL 60440	708 388 5010
GE Digital Energy	1400 Wildwood Pkwy	Atlanta, GA 30339	403 214 4568
GeoDigital	930 Blue Gentian Rd., Ste. 1300	Eagan, MN 55121-1675	651 251 3005
Grid One Solutions	700 Turner Way Road, Suite 205	Aston, PA 19014	813 394 0343
Grid Sentry LLC	3915 Germany Lane	Beavercreek, OH 45431	937 974 3838
GRIDiant Corporation	Stratford Hall 1009 Slater Road, Ste 300	Durham, NC 27703	919 674 0883
Gridium Inc.	405 El Camino Real Suite 301	Menlo Park, CA 94025	855 900 4736
Gridmaven Utility Solutions	150 Mathilda Place, Suite 450	Sunnyvale, CA 94086	408 328 2913
GridSense, Inc.	2568 Industrial Blvd, Suite 100	West Sacramento, CA 95691	561 306 5124
HAI by Leviton	4330 Michoud Blvd	New Orleans, LA 70129	800 229 7256
HD Electric Company	1475 Lakeside Dr.	Waukegan, IL 60085	847 473 4980
Hubell Power Systems	210 N Allen St.	Centralia, MO 65240	573 682 5521
iFactor	60 E Rio Salado Pkwy Suite 715	Tempe, AZ 85281	480 584 3041
IMCORP	50 Utopia Road	Manchester, CT 06042	860 783 8000
Infineon Technologies	19111 Victor Parkway	Livonia, MI 48152	734 779 5058
INSTEP Software	55 E Monrose St., Ste. 2710	Chicago, IL 60603-5735	312 894 7845
Intergraph Corporation	170 Graphics Blvd.	Madison, AL 35758	256 730 8558
ITRON	2111 N Molter Rd	Liberty Lake, WA 99019	509 891 3678
Kisters North America	7777 Greenback LN, Suite 209	Citrus Heights, CA 95610	916 723 1441
Landis+GYR	30000 Mill Creek Ave., Ste. 100	Alpharetta, GA 30022-1555	678 258 1500
Lightspeed Technologies	106 Augusta Drive	Lincrift, NJ 07738	703 842 7355

COMPANY	STREET ADDRESS	CITY, ST ZIP Code	PHONE
Livedata Inc.	810 Memorial Dr.	Cambridge, MA 2139	617 576 6900
Lockheed Martin Energy Solutions	9231 Corporate Blvd.	Rockville, MD 20850	301 978 9756
Lufkin Industries Inc.	5825 N Sam Houston Pkwy W, Ste. 500	Houston, TX 77086	281 873 3851
Master Meter	101 Regency Pkwy	Mansfield, TX 76063-5093	817 842 8115
Maxwell Technologies, Inc.	3888 Calle Fortunada	San Diego, CA 92129	858 503 3428
Milsoft Utility Solutions	PO Box 5726	Abilene, TX 79608	325 695 1642
Mobile Mark, Inc.	3900-B River Road	Schiller Park, IL 60176	847 671 6690
Mobile Mounting Solutions, Inc.	1904 University Business Drive, Suite 310	McKinney, TX 75071	972 569 6927
Nighthawk	6116 N Central Expressway, Suite 710	Dallas, TX 75206	210 858 5121
Novatech, LLC	11500 Cronridge Dr. Suite 110	Owings Mills, MD 21117	410 753 8300
OATI	3660 Technology Drive NE	Minneapolis, MN 55418	763 201 2062
OMICRON	230 3rd Avenue	Waltham, MA 02451	781 672 6200
On-Ramp Wireless	10920 Via Frontera, Ste. 200	San Fransisco, CA 92127	858 312 6198
Open Systems International, Inc. (OSI)	3600 Holly Ln. N Suite 40	Minneapolis, MN 55447-1286	612 551 0559
Opower	1515 N Courthouse Rd. 6th Floor	Arlington, VA 22201	978 590 0720
OptiSense Network, LLC	1308 10th Street	Bridgeport, TX 76426	940 683 5469
Oracle Corporation	400 Crossing Blvd. 6th Floor	Bridgewater, NJ 08807	908 547 6192
OSISOFT LLC	777 Davis St. Suite 250	San Leandro, CA 94577	510 297 5824
Paygo Electric	333 North Point Center East #250	Alpharetta, GA 30022-1555	678 235 6511
Planar Systems	1195 NW Compton Drive	Beaverton, OR 97006	503 748 6724
Planet Ecosystems, Inc.	201 Spear Street, Suite 1100	San Fransisco, CA 94105	650 218 4000
Power Delivery Products Inc.	2658 Holcomb Bridge Rd., Suite 100	Alpharetta, GA 30022-6822	770 587 9044
Proximetry Inc.	909 W Laurel Street, Suite 200	San Diego, CA 92101	619 704 0020
RCS Technology	11481 Sunrise Gold Circle, Suite 1	Rancho Cordova, CA 95742	916 635 6784
Reliatronics Inc.	1858 Ranch Road 3232	Johnson City, TX 78636-4359	830 868 9400
RFL Electronics Inc.	353 Powerville Rd	Boonton, NJ 07005-9151	973 334 3100
RLH Industries Inc.	936 N Main Street	Orange, CA 92867	714 532 1672
ROLTA	5865 North Point Parkway	Alpharetta, GA 30022	678 942 500

COMPANY	STREET ADDRESS	CITY, ST ZIP Code	PHONE
RouteSmart Technologies Inc.	914 Bay Ridge Road, Suite 180	Annapolis, MD 21403	410 216 9447- 108
S&C Electric Company	6601 N Ridge Blvd.	Chicago, IL 60626	773 338 1000
Saft America Inc.	107 Beaver Court	Cockeysville, MD 21030	410 568 6453
SAP America	3999 W Chester Pike	Newton Square, PA 19073	610 661 4187
SATEC Inc.	10 Milltown Ct.	Union, NJ 07083-8108	908 686 9510
Schweitzer Engineering Laboratories	2350 NE Hopkins Ct.	Pullman, WA 99163	509 334 5089
Secucontrol Inc.	2873 Duke St.	Alexandria, VA 22314	703 838 7677
Semtech Corporation	15015 Avenue of Science	San Diego, CA 92128	805 389 2755
SENSUS	8601 Six Forks Road	Raleigh, NC 27615	855 473 6787
Sentient Energy, Inc.	880 Mitten Road, Suite 105	Burlingame, CA 94010	650 759 0543
SIEMENS	7000 Siemens Rd.	Wendell, NC 27591	919 365 2253
Silver Spring Networks	575 Broadway	Redwood, CA 94063	650 298 4200
SISCO Inc.	6605 19 1/2 Mile Road	Sterling Heights, MI 48314	586 254 0020
Smart Grid Solutions	908 E 5th Street, Suite 114A	Austin, TX 78702	512 782 9698
Space - Time Insight	1850 Gateway Dr., Suite 125	Sanmateo, CA 94404	605 513 8550
Spacenet Inc.	1750 Old Meadow Rd.	McLean, VA 22102	703 848 1141
Symmetry Electronics	5400 West Rosecrans Avenue	Hawthorne, CA 90250	310 643 3480
Taehwatrans America Inc.	2400 E Denver avenue, suite 220	Des Plaines, IL 60018	847 299 5182
Thinkeco Inc.	303 5th Avenue, 1801	New York, NY 10016	212 684 2085
Tensing	9900 Belward Campus Drrive, Suite 225	Rockville, MD 20850	240 403 6001 ext: 106
Tollgrade Communications	11951 Freedom Drive, Suite 301	Reston, VA 20190	724 720 1334
Triangle Microworks Inc.	2840 Plaza Pl. Suite 205	Raleigh, NC 27612-6343	919 781 1193
TRILLIANT	1100 Island Drive	Redwood City, CA 94065	650 204 5000
Trimark Associates Inc.	193 Blue Ravine Rd. Suite 120	Folson, CA 95630	916 357 5970
UNITECH	565 Clyde Ave. Suite 610	Mountain View, CA 94022	650 965 1228
Varentec Inc.	1531 Atteberry Lane	San Jose, CA 95131	408 385 2087
ViaSat Inc.	6155 El Camino Real	Carlsbad, CA 92009	760 476 2200
Wireless Glue Networks Inc.	1900 Addison Street, Suite 200	Berkeley, CA 94704	925 465 2202
Xeno Energy	96 Brookview Circle	Watertown, CT 06795	860 945 1177

5.2.3.2 Solar Energy Suppliers

The list below contains the list of Large Scale US Solar suppliers[187].

AMONIX™	Amonix is the recognized leader in designing and manufacturing concentrated photovoltaic (CPV) solar power systems that require no water in power production, use land better, and produce more energy per acre than any other solar technology. With the longest track record of real-world CPV deployments in the industry, Amonix is proven to be the best choice for solar power systems in sunny and dry climates. Amonix is headquartered in Seal Beach, California. www.amonix.com .
BrightSource	BrightSource Energy, Inc. provides clean, reliable and low cost solar energy for utility and industrial companies worldwide. The BrightSource Energy team combines nearly three decades of experience designing, building and operating the world's largest solar energy plants with world-class project development capabilities. The company now has contracted to sell more than 2,600 megawatts of power to be generated using its proprietary solar thermal technology. BrightSource Energy solar plants are designed to minimize their impact on the environment and help customers reduce their dependence on fossil fuels. Headquartered in Oakland, Calif., BrightSource Energy is a privately held company with operations in the United States and Israel. To learn more about BrightSource Energy and solar thermal energy, visit www.brightsourceenergy.com
First Solar.	First Solar Series 2 Photovoltaic (PV) Modules are used in large scale, grid-tied free field solar power plants ranging from hundreds of kilowatts to tens of megawatts in size. For more information, visit www.firstsolar.com/en/index.php.
NEXTera® ENERGY RESOURCES	NextEra Energy Resources stands out as a leader in producing electricity from clean and renewable sources and is among the nation's most disciplined competitive power generators. NextEra is also the largest U.S. generator of solar energy through operations at the Solar Electric Generating Systems (SEGS) in California's Mojave Desert. Through these facilities, NextEra now operates an unprecedented 315 megawatts, with ownership of approximately 152 megawatts of solar generation. For more information, visit www.nexteraenergyresources.com.
NRG SOLAR an NRG Energy Company℠	NRG Solar is responsible for developing, constructing, financing and operating a multi-technology portfolio of solar power assets in North America. As part of this strategy, NRG is co developing the largest photovoltaic field in California and the largest solar thermal facility in the world. NRG also owns the largest currently operating photovoltaic solar project in California, a 21 MW facility in Blythe. For more information on NRG Solar, visit www.nrgsolarenergy.com.
RECURRENT ENERGY	Recurrent Energy is a leading solar project developer marketing clean power to utilities and large energy users. The company is meeting rising energy demand by building a portfolio of clean power plants located where they are needed most. Recurrent Energy is a US subsidiary of Sharp Corporation. Additional details are available at www.recurrentenergy.com.
SunEdison® simplifying solar	www.sunedison.com.
SUNPOWER	SunPower designs, manufactures and delivers the highest efficiency solar electric technology worldwide. Based on more than 20 years of innovation, we deliver proven solar performance to residential, commercial, and utility-scale power plant customers. Our customers benefit from lower electric bills, meaningful financial returns and maximum carbon emissions savings. us.sunpowercorp.com.

[187] The list was extracted from Large Scale Solar Association website (http://www.largescalesolar.org/members.php) .

5.2.3.3 Wind Energy Suppliers

Wind Energy involves many components. The following are the types of components that are purchased directly as well as through integration.[188]

TOWER:
- Towers
- Ladders
- Lifts

ROTOR:
- Hub
- Nose Cone
- Blades
  - Composites
  - Blade Core
- Pitch Mechanisms
- Drives
- Brakes
- Rotary Union

NACELLE:
- Nacelle Cover
- Nacelle Base
- Heat Exchanger
- Controllers
- Generator
- Power Electronics
- Lubricants
- Filtration
- Insulation
- Gearbox
- Pump
- Drivetrain
- Ceramics
- Shaft

FOUNDATION:
- Rebar
- Concrete
- Casings

OTHER:
- Transformers
- Bolts/Fasteners
- Wire
- Paints and Coatings
- Lighting
- Lightning Protection
- Steelworking/Machining
- Communication Devices
- Control and Condition Monitoring Equipment
- Electrical Interface and Connections
- Batteries
- Bearings
- Brakes

[188] Source: 2011 Wind Energy Industry Manufacturing Supplier Handbook.

Table 5-12 shows the wind turbine OEM and Tier one suppliers in the United States.[189]

Table 5-12: Wind Turbine and Tier One Suppliers in the USA

Wind Turbine OEM and Tier One Suppliers in the United States*

OEM COMPANY	US HEADQUARTERS	STATE	WEBSITE
Acciona Energy	West Branch	IA	www.acciona-na.com
American Tower Co.	Shelby	OH	www.amertower.com
Ameron	Rancho Cucamonga	CA	www.ameronwindtowers.com
Broadwind Energy	Naperville	IL	www.bwen.com
Clipper Windpower	Cedar Rapids	IA	www.clipperwind.com
Danotek	Canton	MI	www.danotekmotion.com
DMI Industries	Fargo	ND	www.dmiindustries.com
DMSE/Dewind	Round Rock	TX	www.dewindco.com/eng
Dragon Wind	Lamar	CO	www.modernusa.com/dragonproducts/dragonwind
Fuhrlaender	Bristol	RI	www.fuhrlaender.de/index_en.php
Gamesa	Langhorne	PA	www.gamesacorp.com/en
GE Energy	Atlanta	GA	www.gepower.com
Goldwind	Chicago	IL	www.goldwindglobal.com
Katana Summit	Columbus	NE	www.katana-summit.com
LM Wind Power	Grand Forks	ND	www.lmwindpower.com
Mitsubishi	Newport Beach	CA	www.mpshq.com
Molded Fiber Glass	Ashtabula	OH	www.moldedfiberglass.com
Nordex	Chicago	IL	www.nordex-online.com/en
Nordic Windpower	Berkley	CA	www.nordicwindpower.com
Northern Power Systems	Barre	VT	www.northernpower.com
REpower	Denver	CO	www.repower.de/index.php?id=347&L=1
SIAG Aerisyn	Chattanooga	TN	www.siag.de
Siemens Wind Power	Orlando	FL	www.energy.siemens.com/entry/energy/us
SMI & Hydraulics Inc.	Porter	MN	www.smihyd.com
Suzlon	Chicago	IL	www.suzlon.com
TBailey	Anacortes	WA	www.tbailey.com
Thomas & Betts Corp.	Memphis	TN	www.tnb.com
TowerTech	Oklahoma City	OK	www.towertechinc.com
TPI Composites	Scottsdale	AZ	www.tpicomposites.com
Trinity Structural Towers	Dallas	TX	www.trinitytowers.com
Upwind Solutions	Medford	OR	www.upwindsolutions.com
Vestas	Windsor	CO	www.vestas.com/en

* Only OEMs with utility-scale installations in 2009 are included on this list

[189] Source: 2011 Wind Energy Industry Manufacturing Supplier Handbook.

5.3 Incentives for Renewable Energy, Distributed Generation, and Demand Response Activities

In Mexico, renewable resources activities have made significant advances through the efforts of SENER and CRE since the Renewable Energy Development and Financing for Energy Transition Law - *Ley Para El Aprovechamiento De Energías Renovables Y El Financiamiento De La Transición Energética* (LAERFTE) went into effect in 2008. Programs that foster the development and integration of renewable generation at the distribution level could further advance this growth in Mexico. Incentives, particularly at the early stages, can play a pivotal role in enhancing development of these resources in Mexico.

Similarly, the sustainable use and energy efficiency law -*Ley Para El Aprovechamiento Sustentable De La Energía (LASE)*, which also went into effect in 2008, has had significant impacts through the efforts of CONUEE and Fideicomiso Parea el Ahorro de Energía Eléctrica (FIDE).

Demand Response, however, is still in the early stages of development. Efforts should be taken, particularly with small commercial and residential customers, to foster the development of Demand Response programs.

Unless environmental externalities are considered in the price, non-conventional resources are often not as cost-effective as conventional power plants[190]. Even though costs have fallen significantly and continue to decline, incentives are often still necessary to create financially viable investment opportunities for non-conventional resources. Such incentives may be needed to attract customers to small renewable distributed resources as well as for private investors to invest in distributed resources. The need for incentives will likely decline over time as the industry reaches maturity (e.g., within 5 to 10 years).

Not all incentives will be financial[191]. In particular, private investors require:

- Legislative and regulatory certainty
- Clear and transparent rules, procedures, and processes
    - Regulatory (dealing with CRE and other governmental authorities)
    - Operational (dealing with CFE)
- Guidance in locating generation resources
- Manageable financial risks (no surprises in expected costs)
- Clear incentive durations and investment recovery horizon
- Fair and comparable treatment and even playing field for all
- Clearly established roles and responsibilities
- A dispute resolution process to address conflicts in a timely manner
- Various incentives can be developed, depending on the needs and requirements of each market segment and the desired penetration level target. Each market segment is technically and economically different and may require different treatments to achieve Mexico's national renewable energy goals. The following list, while not comprehensive, provides examples of incentives that can be considered by Mexican authorities. Regulatory streamlining
- Financial and tax breaks
- Public land use offering
- Clear interconnection process
- Expedited permitting and environmental impact approvals[192]
- Exemption from (some) operational requirements

[190] According to the Mexican framework, SENER has the responsibility of publishing a methodology to evaluate environmental externalities. This methodology is used by CFE when elaborating expansion strategies.
[191] Mexico preferred approach is based on non-financial incentives.
[192] Other impacts such as the cost of upgrades on transmission and distribution, could be included.

- Payments for capacity and ancillary services
- Opportunity to participate in special programs
- Exemption from (some) competitive market rules
- Exemption from (some) curtailments

CRE's authority with respect to renewable power plants was limited to plants with capacity of 30 MW or less. This range encompasses a number of market segments. The opportunities for investment, regulatory, financial and policy incentives to promote renewable energy development vary by each market segment. Therefore, the following three market segments are recommended:

1. End Users (small and medium projects - less than 500kW)
    a. Residential and Small Commercial Customers up to 30kW (small projects; no permit required)
    b. Medium size Commercial Customers up to 500 kW (medium projects; no permit required)

2. Non-Utility Small Scale Projects (more than 500 kW and up to 10 MW)
    a. Large Commercial and Industrial Customers – a few MW
    b. Large farms and processing plants- a few MW
    c. Distributed generation – up to 10 MW connected to the distribution system

3. Utility Scale Projects (more than 10 MW and up to 30 MW)
    a. Heavy energy users such as data centers, municipalities, and major industrial complexes – more than 10 MW
    b. Small power plants up to 30 MW connected to the sub-transmission system

In the following sections, we discuss the need for market segmentation, regulatory policies and incentives for the development and integration of Small Scale Distributed Renewable Generation projects, regulatory policies and incentives for the development of Energy Management and Demand Response Activities.

5.3.1 Analysis and Evaluation of Potential Desired Targets for Renewable Resources for Various Market Segments

It will be beneficial for CRE to evaluate and refine the definition of individual market segments under its jurisdiction and also develop a target and implementation plan for each segment.

Summary of Recommendations

- **CRE should refine the individual market segments under its jurisdiction.**
- **CRE should develop an implementation plan with timeline and participation target levels for each market segment to achieve its national renewable goals.**

Discussion of Recommendations

5.3.1.1 Recommendation MKSEG- 1: CRE should refine the individual market segments under its jurisdiction.

As indicated in Chapter 2, Mexico is expected to add 18,715 MW of new generation resources by 2025. More than 17% of total additional capacity, or 3,276 MW, includes distributed generation resources to be located within population centers. While the national goal is determined, no specific targets are set for each market segment. CRE can achieve its national renewable goals through any combination of market segment participation levels under its jurisdiction. To make an informed decision, CRE should study and analyze the market potential for each market segment.

5.3.1.2 Recommendation MKSEG-2: CRE should develop an implementation plan with timeline and participation target levels for each market segment to achieve its national renewable goals.

CRE should set participation goals in terms of MW by various market segments such that the overall integration costs and investment requirements are optimized[193]. Further, these timelines and participation levels should be revisited every few years as circumstances change so appropriate adjustments can be made.

CRE should conduct a study and determine how to distribute the national goal among the three market segments identified above. The incentives must be designed to achieve the desired penetration levels.

CRE should consider options for how to distribute the national goal among the three market segments identified above. Incentives must be designed to achieve the desired penetration levels.

To have an effective program, CRE should establish regulatory and financial incentives and take action to enhance the development of small-scale renewable distribution resources.

Some incentives should focus on mitigating risks associated with small scale renewable projects. The main risks here include regulatory risks, investment risks associated with interconnections with CFE, and delays due to lengthy proceedings in the permitting and environmental approval processes. To minimize such risks, CRE should consider exempting smaller projects (e.g., projects smaller than 10 MW) from many of the wholesale market, interconnection and planning, and operational requirements.[194] For example, renewable resources cannot compete with conventional resources in the wholesale markets and therefore should be procured by bi-lateral contracts. In addition, Fast Track approvals will be needed in the area of

[193] It is understood that while participation goals and target can be determined by CRE, the participation will depend on the private sector and where needed, CRE should have the flexibility to adjust targets in a transparent manner.

[194] CRE and CFE should engage developers through public consultations to better determine possible exemptions. Some examples of exemption may include: registration and certification costs, short approval process (e.g. 1 to 3 months), ancillary services requirements, load forecast, etc.

interconnection and permitting. Further, depending on technology of the renewable resources, they may not be able to participate in the operation of the grid similar to conventional resources. The exact type exemption is recommended to be determined through a stakeholder process. Examples of these exemptions have been discussed in section 5.3.2 and section 5.3.5 .Knowing the expected contribution by each market segment toward the national goal allows CRE to establish specific policies and develop regulatory rules to enhance the penetration of small renewable resources. Furthermore, the progress toward national goals could be monitored over time and corrective actions could be taken, if needed, to ensure national goals are achieved economically and in a timely manner.

5.3.2 Development and Integration of Small-Scale Distributed Renewable Generation Projects

CRE can institute incentives to encourage the development and integration of small-scale distributed renewable generation projects. The recommendations in this section apply to all market segments. Subsequent subsections focus on each of the three segments noted above (End User, Non-Utility Small Scale Projects, and Utility Scale Projects)

Summary of Recommendations

- **CRE should develop and articulate its vision of third-party involvement in the development of small scale distributed renewable projects such as hydro, wind, solar, biomass, etc. with varying characteristics.**
- **CRE should remove possible regulation that could potentially impede development of renewable resources under 30 MW.**
- **CRE should develop regulation and establish rules requiring more reliance on third-party supplemental resources such as energy storage facilities and back-up natural gas generation resources.**
- **CRE should develop rules and regulatory mechanisms that recognize the technology differences and operational limitations of various technologies.**
- **CRE should require CFE to develop a plan to fully integrate the existing distributed generation plants into the national grid.**
- **CRE should make legislative recommendations and craft rules to permit ownership and encourage investment in third-party small distributed renewable resources through informed tax and investment policy.**
- **Require CFE to develop a standardized Fast Track Interconnection study process with set timelines and clear responsibility for the cost of network upgrades.**
- **Require CFE to develop Standardized Interconnection Agreement which exempt small distributed renewable resources from certain planning and operational obligations.**
- **Require CFE to open its transmission and distribution planning process, studies and conclusions with clear indication of geographical areas which can accommodate low cost interconnections.**
- **Require CFE to provide a public information website to disseminate all necessary information regarding the transmission and distribution system, existing power plants, and the future resource expansion and retirement.**
- **Develop a Standardized Purchase Power Agreement for small distributed renewable resources.**

Discussion of Recommendations

5.3.2.1 Recommendation SSDRG-1: CRE should develop and articulate its vision of third-party involvement in the development of small scale distributed renewable projects such as hydro, wind, solar, biomass, etc. with varying characteristics.

As stated under the Task 2 Report, while the Mexican electric power sector has allowed independent power producers to supply generation to CFE at the wholesale level, similar activities at the retail level have not yet materialized. However, as the costs continue to fall, there will be increasing opportunities for third parties to provide distributed services to customers at the other end of the delivery system – at the customer's premises. We expect that third-party suppliers will provide residential and small commercial customers with distributed generation and storage, chiefly solar photovoltaic and solar water heating. Larger commercial and industrial customers will be offered distributed generation, but also combined heat and power (CHP) installations.

All this will require the development of a third-party marketplace, where investors perceive an opportunity to earn on their investments. Working with SENER, it is reasonable for CRE to establish rules to create a level playing field for third parties to engage in small renewable resource projects.

5.3.2.2 RECOMMENDATION SSDRG-2: CRE SHOULD REMOVE REGULATION THAT COULD POTENTIALLY IMPEDE DEVELOPMENT OF RENEWABLE RESOURCES UNDER 30 MW.

CRE should take regulatory actions to foster further development of small-scale renewable distribution resources. In particular, CRE should develop policies and rules to:

- encourage private sector, both local or international, to participate in new investment in small renewable resources
- encourage more targeted approach toward certain types of technology, such as distributed generation options, and in various districts with the greatest needs for electric services
- recommend that SENER and SHCP allow faster capital cost recovery for various investments by the third-party investors[195]
- encourage CFE to exempt small renewable resources from major operational requirements (such as ancillary services requirement, voltage support, load forecast, etc.)

5.3.2.3 RECOMMENDATION SSDRG-3: CRE SHOULD DEVELOP REGULATION AND ESTABLISH RULES RECOGNIZING RELIANCE ON THIRD-PARTY SUPPLEMENTAL RESOURCES SUCH AS ENERGY STORAGE FACILITIES AND BACK-UP NATURAL GAS GENERATION RESOURCES.

Advances in communication and automation technologies have provided unique opportunities for third-parties to increase efficiency in electricity use through customer responsiveness to various financial incentives[196]. Appropriate rules and regulations should be established to eliminate any barriers that discourage third-party vendors to offer market based solutions to customers directly.

5.3.2.4 RECOMMENDATION SSDRG-4: CRE SHOULD DEVELOP RULES AND REGULATORY MECHANISMS THAT RECOGNIZE THE TECHNOLOGY DIFFERENCES AND OPERATIONAL LIMITATIONS OF VARIOUS TECHNOLOGIES.

In cooperation with CFE, CRE should identify the differences in integration requirements between small renewable resources and Mexico's existing generation resources. In particular, under certain conditions, operational exemptions could be established for small renewable resources to reduce financial impacts for resource developers.

5.3.2.5 RECOMMENDATION SSDRG-5: CRE SHOULD REQUIRE CFE TO DEVELOP A PLAN TO FULLY INTEGRATE THE EXISTING DISTRIBUTED GENERATION PLANTS INTO THE NATIONAL GRID.

Increasing amount of distributed generation plants have been relied upon by various end-users during the recent years. In particular, commercial customers, such as hospitals and industrial customers of various sizes have been active in this regard. An accurate inventory of such distributed generations sources should be created by SENER. CRE may use the inventory as input to develop achievable targets for each segment and region. CFE should develop a transition plan to integrate all such resources into the national grid. This

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[195] There is similar provision in the legislation with respect to Renewable Resources. This could be extended to Smart Grid initiatives.
[196] Examples may include thermostat optimization, sending alarms to reduce consumption during high demand or high price periods, etc.

may also include a requirement for CFE to purchase services from small scaled and renewable projects.[197] Such policy can further enhance CFE's ability to integrate most of such existing resources into its system.

5.3.2.6 Recommendation SSDRG-6: CRE should make legislative recommendations and craft rules to permit ownership and encourage investment in third-party small distributed renewable resources through informed tax and investment policy.

Small-scale renewable resources, particularly those that best fit the needs of population in urban areas, may require more financial assistance for several years before becoming self-sufficient. Financial incentives should be established by SENER and SHCP through mandates to foster Smart Grid implementation and increase the amount of capacity by renewable resources. Such policies may include, but not limited to, production tax credit, investment tax credit, property tax credit, or providing land for third-party small scaled and renewable projects. As is done in the U.S. and some European countries, such incentives could be given for a limited number of years to ensure success in implementing such programs.

5.3.2.7 Recommendation SSDRG-7: Require CFE to develop a standardized Fast Track Interconnection study process with set timelines and clear network upgrade cost responsibility.

The process of identifying the impact of renewable power plants on CFE's can become a prolonged process and may discourage investments. The reason is that new power plants have individual, clustered and aggregated impacts on the transmission and distribution systems. CRE should require CFE to provide specific timelines to provide its conclusions to the developers in a proactive manner.

CRE should require CFE to provide specific timelines to provide its study's findings and conclusions to the developers in a proactive manner.

5.3.2.8 Recommendation SSDRG-8: Require CFE to develop Standardized Interconnection Agreement which exempts small distributed renewable resources from certain planning and operational obligations.

In cooperation with electric system operator, regulators should identify the differences that between non-conventional resources and the existing generation resources. Appropriate rules and regulations should be established to enhance integration of small renewable resources into the grid without imposing any impediment to such full integration. In particular, planning and operational exemptions should be established for small renewable resources to reduce financial impacts for such resource developers.[198] For example, small scale renewable resources should be exempted from Network Upgrade which benefits all consumers. In addition, requirement for external facilities for services such as regulation, voltage support, loaf following and energy storage needs to be waived. The benefits that these external facilities can potentially provide needs to be accommodated by CFE's operations in real time through commitment of additional resources by conventional resources.

CFE's existing Interconnection Handbook and Interconnection Agreement should be revised to clearly exempt small renewable resources from certain obligations.

CFE's existing Interconnection Handbook and Interconnection Agreement should be revised to clearly exempt small renewable resources from certain obligations.

[197] This could be included in the new energy reform legal framework.
[198] CRE is working with CFE to develop interconnection rules for solar PV. CRE's vision is to eliminate some operational requirements, especially for small-scale projects.

5.3.2.9 RECOMMENDATION SSDRG-9: REQUIRE CFE TO OPEN ITS TRANSMISSION AND DISTRIBUTION PLANNING PROCESS, STUDIES AND CONCLUSIONS WITH CLEAR INDICATION OF GEOGRAPHICAL AREAS WHICH CAN ACCOMMODATE LOW COST INTERCONNECTIONS.

Transmission planning has often been a closed process in many countries, including Mexico. Successful development of renewable resources requires full knowledge of CFE's transmission plans and how those plans can create opportunities for investment for renewable resources. Opening the transmission and distribution planning process opens the door to the developers to study investment opportunities. In addition, such information will reduce renewable resource developers' exposure to unknown costs. Furthermore, CFE should be required to provide a geographical map where Competitive Renewable Energy Zones (CREZ) are identified and transmission cost bid adders and subtractors are defined. This information facilitates creation of projects that are not only cost effective but also reduce the investment requirement in the transmission and distribution system. Utilities in California use Google Earth to disseminate this information.199

> *CFE should be required to provide a geographical map where Competitive Renewable Energy Zones (CREZ) are identified and transmission cost bid adders and subtractors are defined.*

5.3.2.10 RECOMMENDATION SSDRG-10: REQUIRE CFE TO PROVIDE A PUBLIC INFORMATION WEBSITE TO DISSEMINATE ALL NECESSARY INFORMATION REGARDING THE TRANSMISSION AND DISTRIBUTION SYSTEM, EXISTING POWER PLANTS, AND THE FUTURE RESOURCE EXPANSION AND RETIREMENT.

Developers of renewable resources need and require up-to-date information on existing generation resources and their locations as well as the existing and planned new transmission and distribution systems. In particular, the information should include all necessary information regarding the existing and planned renewable resources with emphasis on the development stage of each project under 30 MW. Developers use this information to avoid competing against one another for transmission and distribution capacity. In addition, such information assists developers to locate areas that power plant construction does not require significant network upgrade and provides favorable bid evaluations. Last, but not least, causes of failure of a project can provide valuable information to other developers such that the same mistakes are not repeated.[200]

5.3.2.11 RECOMMENDATION SSDG-11: DEVELOP A STANDARDIZED PURCHASE POWER AGREEMENT FOR SMALL DISTRIBUTED RENEWABLE RESOURCES.

To enhance the development of small renewable resources by third parties in Mexico, market transparency and easy access to market-related information is crucial. In particular, suppliers need to know the terms and conditions under which they offer their electricity into the grid in various locations within the CFE system. These prices with terms and conditions, which should be established by rules developed by CRE, should be publicly available and easy to access by interested parties.

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[199] Southern California Edison (SCE) Google Earth based Transmission and Distribution mapping: http://maps.google.com/maps?f=q&source=s_q&hl=en&geocode=&q=http:%2F%2F02d46c9.netsolhost.com%2Fkml%2FSCE_SPVP_Areas.kmz&sll=33.865854,-117.780304&sspn=0.524539,0.837021&safe=on&ie=UTF8&z=8 .

[200] SENER has launched a web site to disseminate information about RE potential which is in its early stages. This concept can be used by CFE to leverage lessons learned in developing a similar CFE web site. Some utilities in the US have used Google Earth to show the transmission lines, their capacities, as well as the capacities available. The link for Southern California Edison (SCE) is: http://maps.google.com/maps?f=q&source=s_q&hl=en&geocode=&q=http:%2F%2F02d46c9.netsolhost.com%2Fkml%2FSCE_SPVP_Areas.kmz&sll=33.865854,117.780304&sspn=0.524539,0.837021&safe=on&ie=UTF8&z=8 .

One well-known example of such pricing policy is feed-in tariff (FiT[201]), which is very popular in Europe and has been implemented in several States within the U.S., such as California.[202] The purpose of such policy is to enhance the development of renewable resources for various technologies. The policy takes into consideration the costs of various technologies while guaranteeing access to the grid and ensuring long term contract to renewable resource developers. Prices paid for energy generated from various renewable resources decline when the manufacturing costs for such technologies improve overtime. This can be an effective policy to enhance the development of small-scale distributed renewable resources.

5.3.3 DEVELOPMENT AND INTEGRATION OF END-USER SCALE PROJECTS

CRE does not require permits for End User scale project that are less than 500 kW, however, it can further encourage development of small scale project for end-users (less than 500 kW) through additional refinements in its regulatory policy decisions.

Summary of Recommendations

- **CRE should consider pricing options and incentive mechanism for end-use customers to attract small-scale distributed renewable resources (capacity payment vs. energy payment).**
- **CRE should develop regulation to encourage small distributed renewable resources in population areas (Distributed Generation, Energy Storage, Appliances, and Electric Vehicles).**
- **Rules should ensure that customer consumption information history is easily accessible by third parties and energy management vendors if permission is granted by customer.**
- **CRE should plan and execute customer education programs to introduce the benefits of small distributed renewable resources. CRE should also create an effective training and education program for other market participants who are expected to enter Mexican power sector.**
- **CRE should adopt rules to encourage the development of small renewable distributed projects that best fit the electricity needs of Residential and Small Commercial end-users.**
- **CRE should craft rules to permit ownership and encourage investment in third-party small distributed renewable projects through informed tax and investment policy.**

Discussion of Recommendations

5.3.3.1 RECOMMENDATION EUSP-1: CRE SHOULD CONSIDER PRICING OPTIONS AND INCENTIVE MECHANISM FOR END-USE CUSTOMERS TO ATTRACT SMALL-SCALE DISTRIBUTED RENEWABLE RESOURCES (CAPACITY PAYMENT VS. ENERGY PAYMENT).

While establishing incentives for private investors is important, similar attention should be given to incentives for end-use customers and the potential benefits that may be available to customers through the implementation of small scaled renewable distribution resources. Smaller distributed renewable resources, particularly those that need to be located in population centers within the distribution system may require financial incentives, to induce customers to install such distributed generation resources. This may also include net metering and financial compensation during peak hours if additional power is injected into CFE's distribution system. Roof top solar PVs and some small back up generation resources are good examples of such resources. Incentives such as fixed rates for a long period of time may be effective for end-use customers. For such resources, it may even be feasible to establish some compensation for available capacity accompanied with stream of payments for energy as electricity is generated over a long period of

[201] Feed-in Tariffs are not considered as an option in Mexico at this time.
[202] For a comprehensive description of such policy and its use in various jurisdictions, see Wikipedia at: http://en.wikipedia.org/wiki/Feed-in_tariff .

time[203]. Capacity payments should be scaled to reflect the intermittency of renewable resources and the fact that their peak production may not coincide with peak system demand[204].

5.3.3.2 Recommendation EUSP-2: CRE should develop regulation to encourage small distributed renewable resources in population areas (Distributed Generation, Energy Storage, Appliances, and Electric Vehicles).

End use customers who meet certain level of demand could be encouraged by rules established by CRE to install and sell their excess generation to system operator to meet system demand for electricity and ancillary services. To incentivize such customers, CRE might require CFE to establish net metering capabilities and even compensate such resources at high market prices during tight market conditions or system emergencies.

5.3.3.3 Recommendation EUSP-3: Rules should ensure that customer consumption information history will be easily accessible by third parties and energy management vendors, if permission is granted by customer, allowing customers to shop around for market based services.

As should be expected, the growth of small distributed renewable projects and energy management services will require a balance between customer access to data, authorized vendor access to that data, and the protection of that data. Making access to data very difficult might serve to keep the data out of the hands of third-parties, even those authorized by consumers to use the data on their behalf. In addition to customer permission for access to consumption information, the final decision should be clear, have a valid regulatory basis, and specify non-compliance consequences. Lack of a balanced approach to access to customer information may result in unnecessary difficulties for vendors and eventually prevent customers to shop around and take full advantage of market based products and services.

5.3.3.4 Recommendation EUSP-4: CRE should plan and execute training and education programs to introduce the benefits of small distributed renewable resources.

The effectiveness of this recommendation depends on success in attracting more customers to rely on small renewable resources. Therefore, it is crucial for CRE to sponsor training and education programs to inform customers and help them establish how they can benefit from small renewable resources. Overall, awareness needs to be created to remove, “fear of failure” and encourage discovery in ways in which customers can take advantage of such opportunities.

Creating training and education program is a process that needs continuous improvement. Therefore, CRE should obtain feedback from customers and other stakeholders to continuously update its customer education programs with specific milestones and satisfaction measures. This process could be undertaking jointly with CFE.

Training and educational programs should be designed and provided for the various classes of market participants –such as market participants, smaller developer, larger developers, and what are the options for consumers[205]. These training programs could be online and via internet.

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[203] CRE is developing new regulation to recognize capacity credit from Solar PV.

[204] For example, in California Wind energy resources receive lower capacity payments as they peak at night when the demand is lower. Conversely solar renewable energy sources receive higher payments as their peak production coincides with peak demands. However, they do not receive capacity payments similar to conventional resources usually a small percentage (10%-30%). In California there is a process for testing (occasional tests to ask a unit that has not been called upon to produce for some time) to ensure compliance, in case of non-compliance, previous payments can be resend (collect previous payments made). In Texas, in ERCOT, solar resources as well as wind resources located at Gulf of Mexico, that have their peak production coincide with ERCOT system peak, receive higher revenues compared to those renewable resources that peak at nights. In addition, ERCOT measures availability in different points in time, under various stress conditions, and some random visits. Furthermore, testing is done to ensure deliverability. The need for market monitor and compliance division to catch violators of market rules (either energy or capacity) may be necessary.

Where possible, CRE should publicize “success stories” of pilot projects to the general public.

5.3.3.5 Recommendation EUSP-5: CRE should adopt rules to encourage the development of small renewable distributed projects that best fit the electricity needs of Residential and Small Commercial end-users.

As described previously, the end-users consist of residential and small to medium commercial operations. The capacity of projects to meet the needs of end-users in this category ranges between a few kW to possibly hundreds of kW. The primary renewable technology for this market segment is rooftop solar PV panels. The end-users are connected to the Primary and possibly Secondary distribution systems that generally have limited capacity and limited expansion possibilities. Further, this market segment most likely has limited financial capacity to build renewable resources on its own. The following are examples of regulatory policies to encourage development of renewable energy for this market segment:

1. Net metering energy accounting with annual true-up process
2. Minimum buy-back prices for excess energy
3. Standardized (“No hassle”) Interconnection Agreements
4. Expedited and easy approval process
5. Financing with no upfront payment
6. Tax breaks and credits such as property tax reductions

CRE should establish rules that address these issues and create a blueprint for interested end-users to follow. Addressing these issues will increase end-users’ willingness to install solar panels on their rooftop. In addition, end-users who own such projects will be able to sell any excess production back to utility.

Furthermore, CRE should require CFE to facilitate the development of such small projects by eliminating barriers and establishing minimum requirements that are easily understood by end-users engaged in such small projects. It is reasonable to require that minimum requirements set by CFE will not deter any potential end-user from engaging in these small scale renewable projects.

5.3.3.6 Recommendation EUSP-6: CRE should craft rules to permit ownership and encourage investment in third-party small distributed renewable projects through informed tax and investment policy.

CRE should take steps to address a valid concern for many end-users in this category: the difficulty of handling the capital investment required for these projects. To address this concern, CRE may engage in one of the most effective policies, listed earlier under subsection 4.2, to permit ownership and investment by third-party vendors that install small distributed renewable resources for Residential and Small Commercial Customers. For example, solar “leasing” companies now account for the large majority of residential installations in the United States. These third-parties may invest in such projects if longer term contracts with home owners could be finalized for 15 to 20 years even if the home is sold within the contracted period.[206]

[205] Some regulatory bodies, such as the Colorado Public Utilities Commission, encouraged utilities to undertake these consumer educational activities and allowed recovery of cost. Third party activities in educational programs could also be undertaken.
[206] Solar City is one of such vendors financing rooftop PV panels for small customers. For more information, see: http://www.solarcity.com/about-us.aspx .

5.3.4 DEVELOPMENT AND INTEGRATION OF NON- UTILITY SMALL SCALE PROJECTS

Summary of Recommendations

- **CRE should develop rules to encourage the development of Non-Utility small scale renewable distributed projects that best fit the electricity needs of Large Commercial and Industrial Customers.**
- **CRE should craft rules to permit ownership and encourage investment in third-party Non-Utility small scale distributed renewable projects through informed tax and investment policy.**
- **CRE should develop regulation to encourage small distributed renewable resources in population areas (Distributed Generation and Energy Storage).**
- **CRE should require that CFE to facilitate the development of non-utility scale projects**

Discussion of Recommendations

5.3.4.1 RECOMMENDATION NUSP-1: CRE SHOULD DEVELOP RULES TO ENCOURAGE THE DEVELOPMENT OF NON-UTILITY SMALL SCALE RENEWABLE DISTRIBUTED PROJECTS THAT BEST FIT THE ELECTRICITY NEEDS OF LARGE COMMERCIAL AND INDUSTRIAL CUSTOMERS.

The Non-Utility Small Scale market segment consists of large commercial and industrial operations. Examples are oil refineries, data centers, food processing plants, storage warehouses, etc. The site capacity in this market segment ranges between 1 MW and possibly 10 MW. These Non-Utility Small Scale renewable projects may come from wind, solar, or other resources as that choice is determined by end-users as market information dictates. The point of interconnection can be the distribution system or sub-transmission system. The technology under this category is quite variable and may even consist of both power and steam. This market segment requires significant investment. The following are examples of regulatory policies to encourage development of Non-Utility Small Scale renewable projects for this market segment:

1. Net metering energy accounting
2. Locational market price references
3. Expedited (Fast Track) interconnection process and approval
4. Expedited (Fast Track) environmental impact and permitting process
5. Payments for energy and (some) ancillary services
6. Tax breaks such as accelerated depreciation
7. Exemption from curtailment
8. Exemption from competitive (future) wholesale markets
9. Exemption from some operational requirements based on technology
10. Opportunity to participate in special programs
11. Standardized Interconnection Agreement
12. Standardized Power Purchase Agreements (up to 20 years)

CRE should establish rules to address these issues and create a blueprint for interested large commercial and industrial customers to follow. . Addressing these issues will increase end-users' willingness to seriously consider the economics of implementing such non-utility small scale renewable projects and reduce their reliance on utility for electricity. In addition, end-users with such projects will be able to sell their excess production back to utility.

Furthermore, CRE should require CFE to facilitate the development of Non-Utility Small Scale projects by eliminating barriers and establishing minimum technical requirements that are fully understood and readily complied for by end-users engaged in this category. It is reasonable to require that the minimum requirements set by CFE are absolutely needed for operational reasons and will not deter any potential end-user to engage in these non-utility small scale renewable projects.

5.3.4.2 Recommendation NUSP-2: CRE should craft rules to permit ownership and encourage investment in third-party Non-Utility Small Scale distributed renewable projects through informed tax and investment policy.

Although these customers may be more financially capable of handling the investment in generation projects, compared to smaller customers, CRE may want to offer third-party ownership options for customers as well. Such third-parties may invest in such projects if they can reach agreement with customers for purchased power contracts lasting for 15 to 20 years.[207]

5.3.4.3 Recommendation NUSP-3: CRE should develop regulation to encourage small distributed renewable resources in population areas (Distributed Generation, Energy Storage, and Electric Vehicles).

Non-Utility Small Scale Project developers who meet certain level of demand could be encouraged by rules established by CRE to install and sell their excess generation to system operator to meet system demand for electricity and ancillary services. To incentivize such customers, CRE might require CFE to establish net metering capabilities and even compensate such resources at high market prices during tight market conditions or system emergencies.

5.3.4.4 Recommendation NUSP-4: CRE should require that CFE to facilitate the development of non-utility scale projects

CRE should require that CFE facilitate the development of non-utility scale projects by eliminating the interconnection, operational and support facility requirements and by establishing minimum requirements that are not cumbersome or require significant investment. For example, most renewable technologies cannot perform operational duties of conventional resources and therefore need to be exempted from such duties. The Non-Utility scale renewable resources should also be exempted from support facilities requirements such as energy storage which can make any renewable resource project economically non-viable. The benefit that such facilities can potentially provide need to be accommodated by the operating division of the CFE (CENACE) by devising operating solutions such as creating a class of resources that are commonly referred to as "Must-Run" that provide similar electrical benefits.

[207] Solar City is one of such vendors financing rooftop PV panels for large customers. For more information, see: http://www.solarcity.com/about-us.aspx .

5.3.5 DEVELOPMENT AND INTEGRATION OF UTILITY SCALE PROJECTS

Summary of Recommendations

- **CRE should develop rules to encourage the development of Utility Scale renewable distributed projects that best fit the electricity needs of wholesale transactions.**
- **CRE should craft rules to permit ownership and encourage investment in third-party utility scale distributed renewable projects through informed tax and investment policy.**
- **CRE should develop regulation to encourage small distributed renewable resources in population areas (Distributed Generation and Energy Storage).**

Discussion of Recommendations

5.3.5.1 RECOMMENDATION USP-1: CRE SHOULD DEVELOP RULES TO ENCOURAGE THE DEVELOPMENT OF UTILITY SCALE RENEWABLE DISTRIBUTED PROJECTS THAT BEST FIT THE ELECTRICITY NEEDS OF WHOLESALE TRANSACTIONS.

The Utility Scale market segment consists of third-party developments for wholesale transactions, sales to municipalities, electric cooperatives, and industrial complexes. The site capacity in this market segment ranges between 10 MW and 30 MW. The point of interconnection will be transmission or sub-transmission systems and therefore may have significant impacts on the utility's transmission network.

The technologies under this category are quite broad and include large solar and wind power plants or other renewable resources as that choice is determined by end-users depending on resource availability and market conditions. This market segment requires significant investment and third parties will require a reasonable rate of return on their investment. The following are examples of regulatory policies that may encourage development of utility scale renewable energy for this market segment:

1. Clear and expedited ("Fast Track") interconnection process
2. Long-term Power Purchase Agreements (20 years or more)
3. Locational price accounting with a price escalation opportunity
4. Power plant location guidance
5. Credits[208] for favorable power plant locations
6. Public land use offering
7. Exemption from Network upgrade responsibilities
8. Investment grants and tax credits
9. Accelerated depreciation of facilities
10. Production tax credits
11. Expedited (Fast Track) permitting and environmental impact approvals
12. Exemption from (some) operational requirements based on technology
13. Payments for capacity and ancillary services
14. Opportunity to participate in special programs
15. Exemption from (some) competitive market rules
16. Exemption from (some) curtailments
17. Creation and administration of a Direct Access (Retail Wheeling) program
18. Standardized Interconnection Agreements
19. Standardized Power Purchase Agreements

[208] These may include tax incentives for several years, production tax credits, or higher per MWh payment for several years. It could also include bid adders and subtractors as part of the procurement process.

CRE should establish rules to address these issues and create a blueprint for large wholesale customers, such as municipalities and industrial complexes, to follow. Addressing these issues will increase end-users' willingness to seriously consider the economics of implementing such utility scale renewable projects and reduce their reliance on utility for electricity. In addition, end-users who own such projects will be able to sell their excess production at the wholesale market to reduce the increasing need by utility to expand generation resources.

Furthermore, CRE should require CFE to facilitate the development of utility scale projects by eliminating technical, operational and support facility requirements and establishing minimum requirements that are industry standards and can be complied without causing the overall investment to be economically not viable. Most renewable technologies cannot perform operational duties of conventional resources and therefore need to be exempted from operational requirements of conventional resources. In addition, renewable resources should be exempted from network upgrades that benefit the entire power grid infrastructure. Further, large scale renewable resources need to also be exempted from support facilities requirements such as energy storage which can make virtually any renewable resource project economically non-viable. The benefit that such facilities can provide need to be absorbed by the operating division of the CFE namely the CENACE. For Example, commitments of spinning and non-spinning reserves can accommodate the need for energy storage. Commitment of resources with regulation capability can compensate for the intermittency of certain types of renewables. Proper sizing of inverters can provide needed reactive support needs.

5.3.5.2 Recommendation USP -2: CRE should craft rules to permit ownership and encourage investment in third-party utility scale distributed renewable projects through informed tax and investment policy.

Although these customers may be more financially capable of handling the investment in generation projects, especially compared to smaller customers, CRE may want to keep the option of third-party investment available to these customers. Third-parties may invest in such projects if they can reach agreement with these customers for purchased power contracts lasting for 15 to 20 years.[209]

5.3.5.3 Recommendation USP-3: CRE should develop regulation to encourage small distributed renewable resources in population areas (Distributed Generation and Energy Storage).

Utility Scale project sponsors who meet certain level of demand could be encouraged by rules established by CRE to install and sell their excess generation to system operator to meet system demand for electricity and ancillary services. To incentivize such customers, CRE might require CFE to establish net metering capabilities and even compensate such resources at high market prices during tight market conditions or system emergencies.

[209] These projects are usually financed through various bilateral contracts. However, third-party investors, such as Solar City, may take financial responsibility for such projects. For more information, see: http://www.solarcity.com/about-us.aspx .

5.3.6 DEVELOPMENT OF ENERGY MANAGEMENT AND DEMAND RESPONSE ACTIVITIES BY THIRD PARTIES

Summary of Recommendations

- **CRE should develop and articulate its vision of third-party involvement in the development of energy management and demand response activities.**
- **CRE should make legislative recommendations and establish rules to permit ownership and encourage investment in equipment by third-party to facilitate energy management and demand response activities through informed tax and investment policy.**
- **CRE should establish regulatory incentives to allow and encourage energy management and demand response programs offered by non-utility actors.**

Discussion of Recommendations

5.3.6.1 RECOMMENDATION TPEMDR-1: CRE SHOULD DEVELOP AND ARTICULATE ITS VISION OF THIRD-PARTY INVOLVEMENT IN THE DEVELOPMENT OF ENERGY MANAGEMENT AND DEMAND RESPONSE ACTIVITIES.

As stated in chapter 4 the implementation of Smart Grid will create opportunities for third parties to provide services to customers at the other end of the delivery system – at the customer's premises. We expect that third-party provision of traditional energy efficiency measures, but also home energy management services. In addition, third-part vendors will provide commercial and industrial customers with variety of targeted energy management services and demand response activities. Further along in time, various customers will be able to provide CFE with ancillary services either directly or through aggregation.

All this will require the development of a third-party marketplace, where investors perceive an opportunity to earn on their investments. Working with SENER, it is reasonable for CRE to establish rules to create a level playing field for third parties to engage in small renewable resource projects.

Furthermore, CRE should develop rules to:

- encourage private sector, both local or international, to participate in new investment in demand response activities
- recommend that SENER and SHCP allow faster capital cost recovery for various investments by the third-party investors[210]
- CRE should require CFE to offer customer education addressing energy efficiency and demand response activities

5.3.6.2 RECOMMENDATION TPEMDR-2: CRE SHOULD MAKE LEGISLATIVE RECOMMENDATIONS AND ESTABLISH RULES TO PERMIT OWNERSHIP AND ENCOURAGE INVESTMENT IN EQUIPMENT BY THIRD-PARTY TO FACILITATE ENERGY MANAGEMENT AND DEMAND RESPONSE ACTIVITIES THROUGH INFORMED TAX AND INVESTMENT POLICY.

Advances in communication and automation technologies have provided unique opportunities for third-parties to increase efficiency in electricity use through customer responsiveness to various financial incentives. Appropriate rules and regulations should be established to eliminate any barriers that discourage third-party vendors to offer market based solutions to customers directly.

[210] There is similar provision in the legislation with respect to Renewable Resources. This could be extended to energy efficiency and demand response activities.

Energy efficiency services and demand response activities, particularly those that best fit the needs of population in urban areas, may require more financial assistance for several years before becoming self-sufficient. Legislative mandates could be sought and financial incentives established by SENER and SHCP through mandates by legislation to foster third-party engagement in such activities. As is done in U.S. and some European countries, such incentives could be provided for a limited number of years to ensure success in implementing such programs.

5.3.6.3 Recommendation TPEMDR-3: CRE should establish regulatory incentives to allow and encourage energy management and demand response programs offered by non-utility actors[211].

The development of energy management services and demand response activities will require incentive mechanisms to enhance progress toward different local and national goals. In particular, these incentives must be tailored toward non-utility actors, attracting major players with a variety of interests. These players may include third parties and end-users pursuing activities that facilitate achievement of local and national goals.

Third party and end-user participation in energy management and demand response activities requires innovative financial incentive mechanisms and ease of operational requirements. CRE should develop innovative regulatory and market incentives to facilitate implementation of such programs. In particular, monetary incentives could be provided by implementing:

- Financial rewards or tax incentives resulting in measurable achievements toward national goals.
- Income and property tax exemptions for limited number of years
- Rewards for pursuing certain type of projects or in certain disadvantaged locations with great electrical needs

5.3.7 Energy Management and Demand Response Activities for Consumers

Summary of Recommendations

- **CRE, in cooperation with other authorities, should develop rules requiring the introduction of "smart rates" for customers.**
- **Jointly with CRE and other stakeholders, CFE should develop and publish a detailed transition plan for moving customers with smart meters to tariffs that employ dynamic pricing.**
- **CRE should consider promoting demand response options to price sensitive customers and allow them to participate in energy and ancillary service markets.**
- **Develop a standard Purchase Power Agreement and clear pricing options for demand response activities.**
- **CRE should consider promoting energy management and demand response activities to price sensitive customers to participate in energy and ancillary service markets.**
- **Ensure that customer consumption information history will be easily accessible by third parties and energy management vendors if permission is granted by customer**.
- **CRE should plan and execute customer education programs to introduce the benefits of energy management and demand response activities.**

[211] This could require more authority for CRE.

Discussion of Recommendations

5.3.7.1 Recommendation COEMDR-1: CRE, in cooperation with other authorities, should develop rules requiring the introduction of "smart rates" for customers.

As stated under Task 2 Report, Smart Grid technology provides a unique opportunity to allow customers to respond to electricity prices and better manage their electricity budget and improve their experience with electricity consumption. In developing smart rates, CRE should take into consideration the adequacy and effectiveness of incentives for various customer classes as well as the possibility of such customers participating in wholesale market activities. These smart rates may include pricing options such as ToU, PTP, RTP, and Dynamic Pricing. It is possible and preferable to introduce such pricing options in a way that will be acceptable to customers. CRE should proactively promote the following policies:

- Establish pricing options to encourage efficient use of electricity (Dynamic Pricing, Time of Use, etc.)
- Introduce pricing options to address capacity needs (Peak-time pricing, emergency response, and other ancillary services)
- Develop a locational wholesale electricity prices every five minutes or so and make these prices available publically
- Require pricing options, that may be based on wholesale electricity prices, to be developed in cooperation with the SHCP, for customers to encourage more efficient use of electricity

5.3.7.2 Recommendation COEMDR-2: Jointly with CRE and other stakeholders, CFE should develop and publish a detailed transition plan for moving customers with smart meters to tariffs that employ dynamic pricing.

Dynamic pricing for residential electricity use can bring significant advantages to utilities and their customers. The customer response elicited by time-of-use rates will lower overall system cost, to the benefit of all consumers. Properly implemented, time of use rates are fairer and will induce customers to use electricity more efficiently.

But utilities and their regulators have moved very slowly toward dynamic pricing for residential customers, even in cases where AMI meters are in place. The reasons for this slow progress include lack of information and fears of consumer resistance. Customer education and demonstration project can address these concerns and improve customer acceptance of new technology and result in customers' behavioral change to achieve energy efficiency. But the pressures to move to dynamic pricing are mounting and the foregone benefits are adding up. There are several ways in which regulators might introduce time-sensitive rates in a way that will be acceptable to consumers.

5.3.7.3 Recommendation COEMDR-3: CRE should consider promoting demand response options to price sensitive customers, allowing them to participate in energy and ancillary service markets[212].

A healthy electric power sector requires effective customer responses through well designed and effective programs. Such a system results in the most efficient use of electricity and avoids unnecessary capacity expansion while providing system operators adequate tools to reliably and securely manage their electric systems.[213] CRE can follow policies, which are currently implemented in different countries, to enhance

[212] This could include new authority for CRE. It has impact on need for resources for CRE to effectively perform such responsibilities.
[213] This issue is developed more fully in the Task 2 Report of this project.

customer responses. Such policies include introducing pricing options such as time of use or dynamic pricing; allowing demand response as a resource available to operator to manage need for energy and ancillary services; and providing incentives to encourage customers to rely on distributed services to meet their electricity needs or sell power to CFE.

Demand response activities by end-users to meet system demand for electricity and ancillary services should be encouraged by CRE through rules. To incentivize customers, CRE may require CFE to compensate such demand response activities at high market prices during tight market conditions or system emergencies. Such policies could be refined overtime to meet short-term as well as long-term national goals set by legislators.

5.3.7.4 Recommendation COEMDR-4: Develop a standard Purchase Power Agreement and clear pricing options for demand response activities.

To enhance the development of demand response activities by third parties in Mexico, market transparency and easy access to market related information is crucial. In particular, these suppliers need to know the terms and conditions under which they reduce their customers' demand on electric system through energy management and demand side activities in various locations within the CFE system. These prices, with associated terms and conditions, should be established consistent with rules developed by CRE and should be publicly available and easy to access by interested parties.

5.3.7.5 Recommendation COEMDR-5: CRE should consider promoting energy management and demand response activities to price sensitive customers to participate in energy and ancillary service markets.

A healthy electric power sector can benefit from customer responses through well designed and effective end-user participation programs. Such systems results in the most efficient use of electricity and avoids unnecessary capacity expansion while providing system operators adequate tools to reliably and securely manage the electric system. Third-parties have demonstrated their effectiveness in promoting energy management services and enhancing demand response among customers in currently restructured electricity markets in U.S. and European countries.[214] CRE can facilitate the operation of third-party aggregators by introducing pricing options such as time of use or dynamic pricing; allowing demand response as a resource available to operator to manage need for energy and ancillary services; and providing incentives to encourage customers to rely on distributed services to meet their electricity needs or sell power to CFE. In particular, CRE may require CFE to compensate such demand response activities at high market prices during tight market conditions or system emergencies.

5.3.7.6 Recommendation COEMDR-6: Ensure that customer consumption information history will be easily accessible by third parties and energy management vendors if permission is granted by customer.

As should be expected, the growth of small renewable projects and demand response activities will require a balance between customer access to data, authorized vendor access to that data, and the protection of that data. Making access to data very difficult might serve to keep the data out of the hands of third-parties, even those authorized by consumers to use the data on their behalf.

[214] For example, see EnerNoc (http://www.enernoc.com/) which is active in both continents and Restore (http://www.restore.eu/) which is operating in Europe.

5.3.7.6.1 Recommendation COEMDR-7: CRE plan and execute customer education programs to introduce the benefits of energy management and demand response activities.

The effectiveness of the above recommendations depends on their success to attract more customers to further rely on energy management services or actively engage in demand response activities. Therefore, it is crucial for CRE to engage in customer education programs to inform customers of the benefits of such activities and ways in which customers can take advantage of such opportunities.

CRE should obtain feedback from customers and other stakeholders to establish a customer education program with specific milestones and performance measures to assess its progress.

5.4 Summary of Recommendations To Attract Investments

This section contains the summary of recommendations presented in this report. The numbers in the table below correspond to the recommendation numbers throughout the report.

Table 5-13: Regulatory Strategies Regarding Market Segments

REGULATORY STRATEGIES REGARDING MARKET SEGMENTS	
NO.	RECOMMENDATION
MKSEG - 1	CRE should refine the individual market segments under its jurisdiction.
MKSEG - 2	CRE should develop an implementation plan with timeline and participation target levels for each market segment to achieve its national renewable goals.

Table 5-14: Regulatory Strategies to Encourage the Development and Integration of Small-Scale Distributed Renewable Generation Projects

REGULATORY STRATEGIES TO ENCOURAGE THE DEVELOPMENT AND INTEGRATION OF SMALL-SCALE DISTRIBUTED RENEWABLE GENERATION PROJECTS	
NO.	RECOMMENDATION
SSDRG – 1	CRE should develop and articulate its vision of third-party involvement in the development of small scale distributed renewable projects such as hydro, wind, solar, biomass, etc. with varying characteristics.
SSDRG – 2	CRE should remove possible regulation that could potentially impede development of renewable resources under 30 MW.
SSDRG – 3	CRE should develop regulation and establish rules requiring more reliance on third-party supplemental resources such as energy storage facilities and back-up natural gas generation resources.
SSDRG – 4	CRE should develop rules and regulatory mechanisms that recognize the technology differences and operational limitations of various technologies.
SSDRG – 5	CRE should require CFE to develop a plan to fully integrate the existing distributed generation plants into the national grid.
SSDRG – 6	CRE should make legislative recommendations and craft rules to permit ownership and encourage investment in third-party small distributed renewable resources through informed tax and investment policy.
SSDRG – 7	Require CFE to develop a standardized Fast Track Interconnection study process with set

REGULATORY STRATEGIES TO ENCOURAGE THE DEVELOPMENT AND INTEGRATION OF SMALL-SCALE DISTRIBUTED RENEWABLE GENERATION PROJECTS	
NO.	**RECOMMENDATION**
	timelines and clear responsibility for the cost of network upgrades.
SSDRG – 8	Require CFE to develop Standardized Interconnection Agreement which exempts small distributed renewable resources from certain planning and operational obligations.
SSDRG – 9	Require CFE to open its transmission and distribution planning process, studies and conclusions with clear indication of geographical areas which can accommodate low cost interconnections.
SSDRG – 10	Require CFE to provide a public information website to disseminate all necessary information regarding the transmission and distribution system, existing power plants, and the future resource expansion and retirement.
SSDRG - 11	Develop a Standardized Purchase Power Agreement for small distributed renewable resources.

Table 5-15: Polices to Encourage the Development and Integration of End-User Scale Projects

REGULATORY STRATEGIES TO ENCOURAGE THE DEVELOPMENT AND INTEGRATION OF END-USER SCALE PROJECTS	
NO.	**RECOMMENDATION**
EUSP – 1	CRE should consider pricing options and incentive mechanism for end-use customers to attract small-scale distributed renewable resources (capacity payment vs. energy payment).
EUSP – 2	CRE should develop regulation to encourage small distributed renewable resources in population areas (Distributed Generation, Energy Storage, Appliances, and Electric Vehicles).
EUSP – 3	Rules should ensure that customer consumption information history is easily accessible by third parties and energy management vendors, if permission is granted by customer.
EUSP - 4	CRE should plan and execute customer education programs to introduce the benefits of small distributed renewable resources.
EUSP - 5	CRE should adopt rules to encourage the development of small renewable distributed projects that best fit the electricity needs of Residential and Small Commercial end-users.
EUSP - 6	CRE should craft rules to permit ownership and encourage investment in third-party small distributed renewable projects through informed tax and investment policy.

Table 5-16: Regulatory Strategies to Encourage the Development and Integration of Non-Utility Small Scale Projects

REGULATORY STRATEGIES TO ENCOURAGE THE DEVELOPMENT AND INTEGRATION OF NON-UTILITY SMALL SCALE PROJECTS	
NO.	**RECOMMENDATION**
NUSP – 1	CRE should develop rules to encourage the development of Non-Utility small scale renewable distributed projects that best fit the electricity needs of Large Commercial and Industrial Customers.
NUSP - 2	CRE should craft rules to permit ownership and encourage investment in third-party Non-Utility Small Scale distributed renewable projects through informed tax and investment policy.
NUSP - 3	CRE should develop regulation to encourage small distributed renewable resources in population areas (Distributed Generation and Energy Storage).
NUSP - 4	CRE should require that CFE to facilitate the development of non-utility scale projects.

Table 5-17: Regulatory Strategies to Encourage the Development and Integration of Utility Scale Projects

REGULATORY STRATEGIES TO ENCOURAGE THE DEVELOPMENT AND INTEGRATION OF UTILITY SCALE PROJECTS	
NO.	**RECOMMENDATION**
USP - 1	CRE should develop rules to encourage the development of Utility Scale renewable distributed projects that best fit the electricity needs of wholesale transactions.
USP - 2	CRE should craft rules to permit ownership and encourage investment in third-party utility scale distributed renewable projects through informed tax and investment policy.
USP - 3	CRE should develop regulation to encourage small distributed renewable resources in population areas (Distributed Generation and Energy Storage).

Table 5-18: Regulatory Strategies to Encourage the Development of Energy Management and Demand Response Activities by Third Parties

REGULATORY STRATEGIES TO ENCOURAGE THE DEVELOPMENT OF ENERGY MANAGEMENT AND DEMAND RESPONSE ACTIVITIES BY THIRD PARTIES	
NO.	**RECOMMENDATION**
TPEMDR - 1	CRE should develop and articulate its vision of third-party involvement in the development of energy management and demand response activities.
TPEMDR - 2	CRE should make legislative recommendations and establish rules to permit ownership and encourage investment in equipment by third-party to facilitate energy management and demand response activities through informed tax and investment policy.
TPEMDR - 3	CRE should establish regulatory incentives to allow and encourage energy management and demand response programs offered by non-utility actors.

Table 5-19: Regulatory Strategies to Encourage the Development of Energy Management and Demand Response Activities for Consumers

REGULATORY STRATEGIES TO ENCOURAGE THE DEVELOPMENT OF ENERGY MANAGEMENT AND DEMAND RESPONSE ACTIVITIES FOR CONSUMERS	
NO.	**RECOMMENDATION**
COEMDR – 1	CRE, in cooperation with other authorities, should develop rules requiring the introduction of “smart rates” for customers.
COEMDR – 2	Jointly with CRE and other stakeholders, CFE should develop and publish a detailed transition plan for moving customers with smart meters to tariffs that employ dynamic pricing.
COEMDR – 3	CRE should consider promoting demand response options to price sensitive customers and allow them to participate in energy and ancillary service markets.
COEMDR – 4	Develop a standard Purchase Power Agreement and clear pricing options for demand response activities.
COEMDR – 5	CRE should consider promoting energy management and demand response activities to price sensitive customers to participate in energy and ancillary service markets.
COEMDR – 6	Ensure that customer consumption information history will be easily accessible by third parties and energy management vendors if permission is granted by customer.
COEMDR - 7	CRE should plan and execute customer education programs to introduce the benefits of energy management and demand response activities.

6 Task 4 – Preliminary Environment and Development Assessment

Task 4

Preliminary Environmental and Development Impact Assessment
- Preliminary Environmental Impact Assessment
- Development Impact Assessment

The primary objectives of Task 4 are two folds:

1) Preliminary assessment of the Project's environmental impact and environmental compliance; and
2) Assessment of the development benefits associated with the Project.

The Subtasks identified in the Terms of Reference (TOR) are as follows:

- Subtask 4.1 Preliminary Environmental Impact Assessment

The objective of this subtask is to conduct a preliminary review of the Project's environmental impact and environmental compliance with reference to local requirements and those of multilateral development banks (such as World Bank and Inter-American Development Bank). This review shall identify potential positive and negative impacts, discuss the extent to which negative impacts can be avoided or mitigated, and develop plans for a full environmental impact assessment in anticipation of the Project moving forward to the implementation stage. This review shall assess the project's potential for earning carbon emission credits to support implementation financing.

- Subtask 4.2 Development Impact Assessment

The objective of this task is to assess the development benefits associated with the Project. The assessment shall include examples of the development benefits that would be expected in the Host Country if the Project is implemented as outlined in the technical assistance. The Contractor shall only list benefits in the categories that are applicable to the Project. The categories to be considered are:

- Infrastructure – The development, industrialization and improvement in standard of living with the implementation of this project
- Market-Oriented Reforms- Any regulations, laws, or institutional changes that are recommended
- Human Capacity Building – Type of positions that would be needed to operate the proposed project
- Technology Transfer and Productivity Improvement – Any advanced technologies that would be utilized
- Other - If applicable, any other development impact

With this background, we develop the following information in this Task 4:

1. A description of possible impacts that could occur from the development of wind and solar power and a list of mitigation options that can be taken
2. Project's potential for earning carbon emission credits to support implementation financing
3. A description of the development impact that can occur when the Smart Grid is implemented throughout Mexico.
4. A list of Recommendations

This chapter includes:

- Brief discussion on Smart Grid and Renewable Energy from an environmental perspective.
- Preliminary Environmental Assessment. It includes a review of Mexico's Environmental Landscape, related environmental laws, as well as the impacts and mitigation strategies for solar and wind energy. Environmental impacts of Plug-in Electrical Vehicles, Radio Frequency are also addressed. Carbon Emission Credits as well as overall societal benefits are also addressed.
- Preliminary Development impacts are discussed in this section. Issues such as infrastructure, market oriented reform, human capacity building, and technology transfer are discussed.
- Provides some recommendations based on the preliminary environment and development assessments.

6.1 Smart Grid and Renewable Energy

Renewable Energy can be defined as energy the come from resources that are replenished within human life time and cause no long term damage to the environment.

The International Energy Agency defines classifies the maturity of renewable technology development as follows[215]:

- First-generation Technologies – these reach back more than 100 years
    - Hydropower
    - Biomass Combustion
    - Geothermal Power and Heat.
- Second-generation Technologies – In use now and growing with continued improvements
    - Wind Energy
    - Solar Photovoltaic
    - Modern Forms of Bioenergy
- Third-generation Technologies – Under development
    - Concentrated Solar Power
    - Ocean Energy
    - Enhanced Geothermal Systems
    - Integrated Bioenergy Systems

[215] IEA (2007) Renewable Energy in Global Energy Supply: an IEA Fact Sheet-
https://www.iea.org/publications/freepublications/publication/name,3636,en.html

Use of Renewable Energy (such as wind, solar, bio-mass, hydro, etc.) to generate electricity has been used by many nations around the globe throughout the years. In fact, the first wind farm with a capacity of 0.6 MW consisting of 20 units of 30 kW each was developed in New Hampshire US in late 1980.[216]

Smart Grid Impact on Penetration of RE

At small scales the RE does not impact the operation of the power grid significantly; however, as the RE becomes a significant portion of the energy production, as envisaged for the Mexican power industry, the challenges for the power system operators to maintain system reliability could become substantial.

The International Energy Agency has identified the following characteristics that have direct impact on the integration of RE into power grids:

- Variability – wind and solar generation fluctuate based on the wind speed and solar radiations
- Resource Locations – as best locations may be far from centers of load
- Modularity – with capacities much smaller than conventional power plants
- Uncertainty – Wind speed and solar radiation forecasts are uncertain except for very short time periods
- Low operating costs – which encourages investment by non-utility entities
- Non-synchronous generation – most wind and solar sources don't operate at the frequency of the system

Traditionally, Power System Operators have been able to balance the demand with the generation by sending commands to few generation facilities to increase production or request load reductions from large consumers as necessary. Large power plants have been generally able to respond to these requests in a timely manner based on their agreement for providing the requested service (e.g., regulation support, base load, etc.). However, without Smart Grid technologies, RE resources as characterized above do not provide the System Operators with the certainty and confidence to operate the power system in a reliable and efficient manner.

Smart Grid technologies of today and those envisaged for the near future allow mitigation of some the challenges associated with the integration of renewable energy. Modern sensors, advanced control systems, more reliable communications are only a few technologies that provide the system operators the necessary tools to have better visibility of the state of power system be able to monitor and take actions in real-time. System operators will be able to adjust the balance of load and generation as the conditions change – for example, a cloud cover may impact thousands of small rooftop solar PV distributed generation that collectively exceed hundreds of megawatts in a small region (e.g., San Diego Gas and Electric has over 120 MW of solar rooftop in its system.

ESTA has discussed some of the challenges associated with large scale integration of RE into the Mexican Power Grid in its SWOT analysis of the Mexican power system in Task 1 Report.

A country's development of clean energy policies and technology often roots additional benefits. Mexico's adaptation and implementation of Smart Grid well help to achieve other specific goals such as:

- Better use of RE and efficient technologies

[216] Source: http://en.wikipedia.org/wiki/Wind_farm#cite_note-5

- Encourage private investment and participation in renewable energy.
- A higher penetration of renewable generation
- Improve efficiency and reliability through use of strategically located RE
- Improve the quality of the public service
- Reduce the cost of electricity for end users
- Create demand management programs/projects
- Create new market schemes in which private participation provides Smart Grid services
- Contribute to the de-carbonization of the Mexican economy
- Achieve benefits inherent in the Smart Grid's potential contribution to the nation's goal of mitigating climate change from reducing the carbon footprint of the electric power system

Smart Grid Societal Benefits

Often societal benefits of Smart Grid have played a pivotal role in justification of the cost of Smart Grid investment. Societal benefits not only include improvements in quality of life of the consumers through better reliability and sustained access to electricity it also has impacts on the environment.

An overall goal of Smart Grid systems is to lessen the impact on the natural environment, and greatly reduce the reliance on non-renewable natural resources. Renewable generation has the benefit of reducing environmental impacts, reducing GHG emissions, reducing dependence on local or imported fossil fuels, and increasing energy security through diversification of energy sources. As noted earlier, Smart Grid technologies can significantly reduce barriers to the integration of renewable resources and all power grids to support a greater percentage of variable renewable resources.

The IEA estimates that globally, deployment of renewables in their "New Policies scenario can save some 4.1 gigatonnes of CO_2 emissions in 2035 as compared with the 2010 fuel mix at the same level of total generation"[217]

The National Strategy on Climate Change promotes energy generation substituting for fossil fuels through clean and more efficient sources that will reduce environmental and social impacts. The mitigation objectives for 2020 show a 30% reduction in emissions of 288 $MtCO_2$ e and on 2050 the total emissions shall have a maximum level of 320 $MtCO_2$ e

In other cases, use of Smart Grid technologies such as those used for remote metering functions (reading, connect, disconnect), remote switchgear operations, condition based asset management, etc. while improving the reliability power system and the efficiency of the utility, also provide benefits to the society. These include reduction of the need for utility vehicle roll-outs they not only reduce CO_2 emissions but also reduce possibility of accidents and contribution to traffic jams. With the reduction of utility vehicles and the related travel, the environmental impact of disposal of used tires as well as scrapped vehicles can be noticeable.

Another societal benefit of RE is the possibility of providing electricity access to people in remote locations who currently do not have access to any electricity.

[217] Source WEO-2013 Chapter 6- Renewable Energy Outlook found at http://www.worldenergyoutlook.org/publications/weo-2013/

6.2 PRELIMINARY ENVIRONMENTAL IMPACT ASSESSMENT

6.2.1 MEXICO'S ENVIRONMENTAL LANDSCAPE

Mexico is located in North America bordering the Caribbean Sea and the Gulf of Mexico between Belize and the United States and bordering the North Pacific Ocean between Guatemala and the United States. The terrain ranges from high rugged mountains, low coastal plains, high plateaus and desert. Its temperature varies from tropical to desert. Mexico has a total area of 1,964,375 sq. km of which 1,943,945 sq. km is land and 20,430 sq. km is water.

Mexico is considered to be one of the twelve countries with the greatest biological diversity in the world. Demographic growth has placed increasing pressure on natural ecosystems. The Rainforest Alliance has stated that Mexico has one of the highest deforestation rates in the world – 815,000 acres or 330,000 hectares disappear every day.[218]

Mexico has experienced high rates of soil erosion and desertification due to unmaintainable agricultural practices. Fishing practices have caused over-exploitation and diminishing populations of many marine species of commercial value. Water management is an environmental problem. The government is addressing this issue by setting goals for its programs supporting sustainable resource management.

The World Bank has stated that one of Mexico's main challenges is to make urban development more environment-friendly, efficient and resilient to climate change, as well as including all stakeholders. They have also noted that because Mexico is the second largest electricity producer in Latin America, behind Brazil, the energy sector is a crucial one to reduce the footprint of Mexico's emission growth.

On the positive side, Mexico has won a Guinness world record because of the number of energy efficient light bulbs the government has managed to give out to citizens, in exchange for normal ones. It has also established energy efficient standards for household equipment.

Air Quality pollution levels have significantly declined overall in urban areas during the last ten-twelve years, including in Mexico City. However, relatively high emissions from industry, energy production and transport still remain a challenge.

Mexico is generally considered a leader in climate change mitigation and adaptation in the region. If it continues its effort, it should be able to reach the goal it has set itself in its environmental law – to halve its GHG by 2050.

[218] Rainforest Alliance Information Sheet – Community Forestry in Mexico

Figure 6-1: Ecology Map of Mexico

6.2.1.1 Environmental Law

The law governing the environment in Mexico is The General Law of Ecological Balance and Environmental Protection (*Ley General del Equilibrio Ecologico y Proteccion Ambiente*) (hereinafter Ecology Law). It is divided into Titles which regulate the environmental fields within the country.

Table 6-1: Applicable Environmental Regulations

Environmental Issue	Brief Summary
General Environmental Issues	The current legal environmental framework is set on the General Law on the Ecology Law (Ley General del Equilibrio Ecológico y la Protección al Ambiente)
Wastes	The current legal waste framework is set on the General Law for the Prevention and Management of the Wastes and its Regulations*(Ley General para la Prevención y Gestión Integral de los Residuos)*
Hazardous Waste	The current legal framework governing waste management is set forth in the Ecology Law and the Regulations to the Ecology Law on Hazardous Wastes (The Waste Regulation) and its Regulations)
Noise	The current legal framework governing noise is set forth in the Ecology Law, Section 24.2 Noise and Vibration)
Air Quality	The current legal framework governing air pollution is set forth in two laws - the Ecology Law and the regulations to *Reglamento de*

Environmental Issue	Brief Summary
	la Ley General del Equilibrio Ecológico y la Protección of Ambiente para la prevención y control de la contaminación generada por los vehículos automotores que circulan por el Distrito Federal y los municipios de su zona conurbada (the Air Regulation)
Water and Wastewater	The current legal framework governing water pollution control is set forth in two laws - the Ecology Law and *Ley de Aguas Nacionales* (the National Waters Law)
Environmental Impact Assessment	The current legal framework governing environmental impact statements is set forth in Article 28 of the Ecology Law and its Regulations on Environmental Impact *(Reglamento de Impacto Ambiental de la Ley de Equilibrio Ecológico y la Protección of Ambiente)* – the Environmental Impact Assessment (EIA) Regulation

The environmental issues are further discussed below.

Noise Law - SSA (Ministry of Health) is responsible for establishing noise restriction zones, on its own initiative or at the request of a third party. These restriction zones may be temporary or permanent and are intended to provide for stricter noise standards in areas near hospitals or residential areas.

Solid Waste Law - Article 3, paragraph XXXI of the Ecology Law states that residue (waste) is any material generated through an extraction, mining, transformation, production, consumption, use, control or treatment process, whose quality prevents it from being re-used in the very process that generated it. All non-hazardous waste, regardless of its physical form, falls under the jurisdiction of the States, the municipalities and the Federal District (Distrito Federal).

Jurisdiction over waste management issues is divided among Federal State and municipal authorities. At the federal level, the Ministry of the Environment and Natural Resources (has exclusive jurisdiction over all hazardous waste management. States and municipalities are responsible for the regulation, management, authorization and enforcement of solid and non-hazardous waste regulation.

A component of the Solid Waste Law addresses Electronic Waste (E-Waste)

E-Waste Law - Mexico generates a high volume of e-waste per capita and there is growing concern regarding its management, particularly since a national inventory of e-waste generation in 2006 was created. (Gavilan-Garcia, Roman-Moguel, Almada-Calvo & Aburto-Mejia, 2009). Waste collection systems have been required by law since 2006, but there is a lack of infrastructure. The vast majority of the Mexican municipalities do not have the legal infrastructure or the economic or human means to address the municipal solid waste (MSW) problem at this time.

The General Law on the Prevention and Integral Management of Wastes (LGPGIR) defines electronic waste, although it is not considered hazardous. The general Waste Law requires industry to submit an "environmental management plan system" for certain "technological waste", including electronics.

The United Nations Environment Program (UNEP) has cited Mexico as a country with great potential to introduce state-of-the-art e-waste recycling[219] technologies because of its small informal e-waste sector.[220] In 2006, in cooperation with the State of California, one of the few state-of-the-art electronic recycling facilities in Latin America was installed in Monterrey, the first major electronic recycling operation in Mexico (Business Wire, 2006). Mexico has ratified the Basel Convention, an international agreement to reduce the movement of hazardous waste between countries.

Hazardous Waste Law - Hazardous waste control provisions are set forth under the Ecology Law and are further developed in the Hazardous Waste Regulation. Articles 150 to 153 of the Ecology Law regulate six different areas of hazardous waste issues: the classification and determination of hazardous wastes; the responsibility for their management and final disposal; the prevention and reduction of hazardous waste generation; jurisdiction; permitting regimes; and the export and import of hazardous wastes. Hazardous wastes fall exclusively under federal jurisdiction. The federal administrative agency responsible for the control and regulation of hazardous waste laws is SEMARNAT (Secretariat of Environment and Natural Resources).

Under Article 3 of the Ecology Law hazardous waste is defined as all waste, in any physical state, which, due to its corrosive, reactive, explosive, toxic, flammable, infectious or irritating biological properties, represents a hazard for the ecological balance or the environment.

Air Quality Law - *Reglamento de la Ley General del Equilibrio Ecológico y la Protección al Ambiente para la prevención y control de la contaminación generada por los vehículos automotores que circulan por el Distrito Federal y los municipios de su zona conurbad*a known as the Air Regulation. This regulation spells out broad anti-pollution goals, as well as policy considerations.

Four Federal agencies are granted jurisdiction over air issues:

- SEMARNAT – Secretaría del Medio Ambiente y Recursos Naturales
- SCT - Secretaría de Comunicaciones y Transportes
- SSA – Secretaría de Salud
- SE – Secretaría de Economía

Under the Ecology Law, SEMARNAT is responsible for establishing air quality standards at the federal level. Although states may implement more stringent standards at the local level, the federal standards set a floor for state standards to adhere to.

SSA is responsible for issuing the official Mexican standards (*Normas Oficiales Mexicanas - NOMs*) regarding air quality assessment criteria, with respect to carbon monoxide, sulfur dioxide, nitrogen dioxide, lead, total suspended particles etc.

The Air regulation applies exclusively to those fixed sources that are under federal jurisdiction. In accordance with Article 111 bis of the Ecology Law, the electric power generating industry is considered a fixed source.

[219] The state of the art recycling chain for e-waste consists of three main subsequent steps: 1) collection, 2) sorting/dismantling and pre-processing (including sorting, dismantling, and mechanical treatment) and 3) end- processing (including refining and disposal).
[220] UNEP – Recycling – From E Waste to Resources, Final Report, July 2009

Water and Wastewater Law - Article 27 of the Political Constitution of Mexico confers inalienable rights of ownership over all national waters to the Nation and provides the foundation for water protection and management laws. In order for hydraulic resources to be exploited, the federal government, through the National Water Commission, may grant water use concession to private parties. Administration over water laws is shared by both the federal and the state governments. The National Waters Law has created an independent federal agency, the National Water Commission which has jurisdiction over hydraulic issues.

Environmental Impact Assessment (EIA) - The General Bureau of Environmental Impact and Risk (*Dirección General de Impacto y Riesgo Ambiental*) under SEMARNAT is responsible for EIA.

Whenever it is intended to carry out works or undertakings that may cause ecological imbalances or exceed the limits and conditions set forth under the applicable environmental laws and Official Mexican Standards, such works and undertakings shall be subjected to the conditions established by SEMARNAT through the Environmental Impact Assessment process.

6.2.1.2 Mexico and Climate Change

In 2012 Mexico passed the Climate Change Act in which the country sets a target to reducing GHG 30% by 2030 and 50% by 2050, relative to baseline emissions in 2000. Mexico, as a non-Annex 1 Party of the Kyoto Protocol, has the mandate of reducing greenhouse gas emissions but it is not a binding commitment. Mexico is among the top 15 countries in the world in emitting GHG, and it is among the top 20 with the highest percentage of emissions per capita. However, its global contribution is smaller than 2% of the world's total. In addition to having signed the United Nations Framework Convention on Climate Change (UNFCCC) and its Kyoto Protocol, Mexico is the only developing country to submit a third, fourth and fifth National Communication to the UNFCCC with a detailed updated inventory of its greenhouse gas emissions.

Mexico is the only developing country to submit a third, fourth and fifth National Communication to the UNFCCC with a detailed updated inventory of its greenhouse gas emissions.

The National Strategy on Climate Change promotes energy generation substituting for fossil fuels through clean and more efficient sources that will reduce environmental and social impacts. The mitigation objectives for 2020 show a 30% reduction in emissions of 288 $MtCO_2$ e and on 2050 the total emissions shall have a maximum level of 320 $MtCO_2$ e. Goal M1.3 of the Climate Change Strategy sets up the need of increasing the inclusion of renewables and losses reduction by using Smart Grid and distributed generation onto the national electric system.

It is anticipated to state that the implementation of a Smart Grid will allow the authorities to establish a relevant and adequate database to provide useful information to relevant players and stakeholders for achieving these goals. The implementation of the Mexican Smart Grid may help to analyze and translate this information into useful data for decision making processes and strategic planning.

Mexico's National Development Plan requires the Mexican authorities to "strengthen the national climate change and environmental care policies for the transition to a competitive, sustainable, resilient and low-carbon economy". The Renewables Law (LAERFTE, by its acronym in Spanish)[221] in its Second Transitory

[221] Ley para el Aprovechamiento de Energías Renovables y el Financiamiento de la Transición Energética

Article set a maximum percentage on the use of fossil fuels for power generation – for 2024 a maximum of 65%, for 2035 a maximum of 60% and for 2050 a maximum of 50%.

6.2.2 SOLAR ENERGY ENVIRONMENTAL IMPACTS AND MITIGATION OPTIONS

Mexico is endowed with diverse natural resources. It has Renewable Energy potential in wind power, geothermal, hydro and mini-hydro, biomass and solar. Although renewable energy technologies have some impact on the environment, renewables are considered environmentally preferable to conventional sources and, when replacing fossil fuels, have significant potential to reduce greenhouse gas emissions. However, their benefit must be balanced against the impact of each renewable technology on the local environment. For the purpose of this report, we focus on the possible impact of solar and wind development.

Solar power reduces the environmental impacts of combustion used in fossil fuel power generation, such as impacts from greenhouse gases and other air pollution emissions. Unlike fossil fuel power generating facilities, solar facilities have very low air emissions of air pollutants such as sulfur dioxide (SOx), nitrogen oxide (NOx), carbon monoxide, volatile organic compounds (VOC), and the greenhouse gas carbon dioxide (CO_2) during operations.

However, there are also some adverse impacts associated with the development of solar power facilities. Following are the possible potential negative impacts and suggested mitigation options.

6.2.2.1 SOLAR ENERGY WATER IMPACTS AND MITIGATION STRATEGIES

While solar photovoltaic systems do not require any water to generate electricity, utility scale parabolic and central tower solar energy systems use steam plants to produce power, often relying on water for cooling. It is possible that that these types of systems, when located in arid environments, could put a strain on local water resources. In arid settings, any increase in water demand can strain available water resources. A spill of chemicals at solar facilities (for example dust suppressants, dielectric fluids, herbicides) could result in contamination of surface water or groundwater. Water is needed for various activities in the construction phase of a solar park including:

- Concrete preparation for foundation of the support structures for solar reflectors and PV panels and buildings
- Drinking water for site workers
- Vehicle Washing
- Road Construction
- Dust Control

Both groundwater and surface water quality could be affected by construction activities. These activities include land disturbance-related soil erosion and sedimentation, fuel and chemical spills, storage and potential treatment of wastewater; and the potential application of pesticides, herbicides and dust suppressant chemicals

Improperly designed groundwater wells could create conduits for poor-quality groundwater, as well as contaminants, to move between aquifers. Chemical and fuel spills could infiltrate to groundwater and could spread by surface runoff to surface water features. Wastewater will most likely be contained in portable toilets, on-site sewage lagoons, or septic tanks with leach fields. Leaky wastewater storage containers could degrade groundwater and surface water quality and introduce pathogens.

Water Impact Mitigation Strategies

The main objectives of mitigation measures for water resources are to promote the sustainable use of water through appropriate selection and conservation practices and to protect the quality of natural water bodies (including streams, wetlands, floodplains and groundwater aquifers) in and around solar energy facilities.

Mitigation practices include:

- Identify measures to prevent potential groundwater and surface water contamination as part of a Spill Prevention and Emergency Response Plan.
- Use dust suppression techniques to minimize impacts of vehicular traffic and wind on roads and exposed soils.
- Clean and maintain catch basins, drainage ditches and culverts regularly
- Construct entry and exit pits to work areas to trap sediments from vehicles and prevent them from entering into streams at stream crossings
- Remove wastewater generated in association with sanitary facilities by a licensed hauler.

6.2.2.2 Solar Energy Land Impacts and Mitigation Strategies

The land used for a solar energy installation is of utmost importance from an environmental perspective; all other environmental sectors depend on the location of the solar or wind park. Land-related impacts common to all utility-scale projects result from changes to existing land uses within the project design and on public, state, and private lands that surround or are near solar energy facilities.

When placed on existing structure, such as the rooftop of a home or office building, solar energy systems require negligible amount of land space. However, utility scale solar farms require relatively large amounts of land to produce electricity on a commercial scale. Depending on their location, larger utility-scale solar facilities can raise concerns about land degradation and habitat loss. Total land area requirements vary depending on the technology, the topography of the site, and the intensity of the solar resource. Estimates for utility-scale PV systems range from 3.5 to 10 acres per megawatt, while estimates for concentrated solar power (CSP) facilities are between 4 and 16.5 acres per MW. This raises concerns about the potential impact of such projects on natural habitats. Solar facilities may interfere with existing land uses, such as grazing, wild horse and burro management, military uses and minerals production. Another concern is the conversion of land in and around local communities from agricultural, open space or other uses to provide services and housing for employees and families who move to the region to support solar energy development. Unlike wind facilities, there is less opportunity for solar projects to share land with agricultural uses.

Land Impacts Mitigation Strategies

Land impacts from utility-scale solar systems can be minimized by siting them at lower-quality locations such as brownfields, abandoned mining land or existing transportation and transmission corridors. Land impact mitigation strategies include:

- Minimize the amount of land disturbance and develop and implement stringent erosion and dust control policies. Whenever possible, site the project on previously disturbed or altered landscapes.
- Consider alternatives if a project might have an effect on prime agricultural land.

- Install site fencing to prevent public access and access by livestock, wild horses and burros.
- Site and design solar facilities to minimize the risk of wild land fire. Provide sufficient room for fire management with the Right-of-Way (ROW) and its facilities to minimize the risk of fire moving outside the ROW and the risk of fire threatening the facility from the outside.
- Implement a reclamation plan.
- Compensate farmers or ranchers for crop or forage losses.
- Compensate property owners for relocation of their homes, in the event that relocation is necessary.
- Develop and implement wild land fire management measures, including worker training and inspection and monitoring measures to respond to fire risk during all phases of the project.
- Provide access through or around a solar energy facility to provide for adequate public access and/or recreation.

6.2.2.3 SOLAR ENERGY HAZARDOUS MATERIALS IMPACTS AND MITIGATION STRATEGIES

Hazardous materials and waste impacts are related to the types and amount of equipment and machinery used for the project, the wastes they produce, and material shipments and construction waste.

The PV cell manufacturing process includes a number of hazardous materials, most of which are used to clean and purify the semiconductor surface. These chemicals, similar to those used in the general semiconductor industry, include hydrochloric acid, sulfuric acid, nitric acid and hydrogen fluoride. The PV panels themselves contain toxic materials.

During the construction phase, there are increased risks of fires and contamination of environmental media from improper storage and the handling leading to spills or leaks.

Construction related wastes include various fluids from the on-site maintenance construction vehicles and equipment (used lubricating oils, hydraulic fluids, glycol-based coolants, and spent lead-acid storage batteries); chemical wastes from the maintenance of equipment and application of corrosion-control protective coatings (solvents, paints, and coatings); construction-related debris (lumber, stone and brick) and packaging materials.

Potential impacts from the generation of such wastes include potential contamination of environmental media from improper collection, containerization, storage and disposal. All solar technologies can be expected to have substantial quantities of dielectric fluids contained in various electrical devices such as switches, transformers, capacitors as well as several types of common industrial cleaning agents.

Hazardous Materials Impacts Mitigation Strategies

- Develop a spill prevention and response plan for addressing storage locations of hazardous wastes, spill prevention measures, training requirements, waste-specific spill response actions, spill response kits, and notifications to authorities.
- Develop a fire management and protection plan to minimize the potential for fires associated with substances used and stored on the site, particularly the flammability of the specific heat transfer fluid used at the facility.

- Develop a storm water management plan to ensure compliance with regulations and prevent off-site migration of contaminated storm water or increased soil erosion.
- Implement plans for hazardous materials management, waste management spill prevention and response, and pesticide management. Train employees to promptly contain, report, and /or cleanup any oil or hazardous material spill.
- Designate hazardous materials and waste storage areas and facilities. Limit access to designated areas to authorized personnel only. Identify authorized users for each type of hazardous material.
- Containerize and periodically remove wastes for recycling or for disposal at appropriate off-site permitted disposal facilities.
- Keep vehicles and equipment in good working order to prevent oil and fuel leaks.
- Locate refueling areas on paved surfaces away from surface water locations.
- Plans need to be developed for the recycling or disposal of used PV panels.

6.2.2.4 Solar Energy Noise Impacts and Mitigation Strategies

There could be potential noise impacts from site characterization activities but they would be negligible because these activities are short term.

Construction activities would last several years for most solar facilities. Heavy equipment and vehicles used during construction could include chainsaws, chippers, bulldozers, cranes, end loaders, backhoes, trucks and possible temporary concrete equipment. The noise level would depend on the activity. The noise level would be highest during the early phases of construction when equipment could be used for land clearing, grading and road construction. Noise impacts may include noise along traffic routes created by delivery and support vehicles and diesel engine noise from construction equipment.

During the operation phase, noise activities from all types of solar facilities include

1. Maintenance and repair - mirror washing, replacement of broken mirrors
2. Commuter, support, delivery vehicles within and around the solar facility
3. Activities associated with administrative, warehouse facilities.
4. Diesel-fired emergency power generators and fire-water pump engines will also emit noise but their operations would only occur at certain times during the month
5. Stationary and steady noise sources from a power-block (limited to parabolic trough and solar power tower technologies).

3.4.1 Noise Impacts Mitigation Strategies

Noise-related impacts are related to the source of the noise (e.g. vehicles, construction equipment, workers, explosives, and project facility components) its proximity to the noise receptor (e.g. humans and wildlife), and the times of day at which noise-producing activities are taking place.

- Locate all stationary construction equipment (compressors and generators) as far as practicable from nearby residences and other sensitive receptors.
- Incorporate low-noise systems, such as ventilation systems, pumps, generators, compressors and fans.
- Notify nearby neighbors in advance when blasting or other noisy activities are required.
- Place noisy equipment, such as steam turbine generators, in enclosures.

6.2.2.5 Solar Energy Air Quality Impacts and Mitigation Strategies

Potential air quality impacts from site characterization activities would be negligible because these activities are short term, require minimum site disturbance and can be conducted with a small crew and small equipment.

Several operations are involved in the construction phase. These include: land clearing, on-site burning of cleared biomass, earthmoving and road construction, drilling and blasting. Fugitive dust from soil disturbances and engine exhaust from heavy equipment and delivery traffic within and around the facility could contribute to air emissions of criteria pollutants, volatile organic compounds (VOCs), GHG and small amounts of hazardous air pollutants.

For most construction projects, soil disturbance during the site preparation phase, which involves the use of heavy equipment over a short period of time, has the greatest potential for air emissions and adverse air quality impacts. Since most solar facilities are located in remote areas, construction activities would probably contribute minimally to concentrations of air pollutants at the nearest residence or business.

In general, during the operation phase, air emissions associated with generating electricity from solar technologies are negligible. Parabolic trough and power tower technologies may combust some fossil fuels during start up. Other technologies do not use fossil fuels routinely.

There are very low levels of air emissions directly from the solar fields. Emissions would include fugitive dust and engine exhaust emissions from vehicles and heavy equipment used for regular site inspections and maintenance activities (e.g. mirror washing, replacement of broken mirrors). The amounts of these emissions would be small and the impacts would be negligible.

Air Quality Impacts Mitigation Strategies

General mitigation practices and principles that could apply to any or all phases of a solar project include the following:

- Minimize on-site vehicle use and require routine preventive maintenance including tune-ups to meet manufacturer's specifications to ensure efficient combustion and minimal emissions.
- Use dust abatement techniques on unpaved, un-vegetated surfaces to minimize airborne dust during earthmoving activities; prior to clearing, before excavating, backfilling, compacting, or grading; and during blasting.
- Post and enforce speed limits to reduce airborne fugitive dust from vehicular traffic.

- Schedule construction activities during periods of low winds to reduce fugitive dust.
- Cover construction materials, storage piles, and stockpiled soils if they are a source of fugitive dust.
- Keep soil moist while loading into dump trucks and keep soil loads below the freeboard of the truck
- Cover vehicles that transport loose materials before traveling on public roads
- Shut down idling construction equipment
- Limit access to the construction site and staging areas to authorized vehicles only through designated treated roads
- Salvage topsoil from excavation and construction activities and reapply during reclamation in areas not needed for facility operations.

6.2.2.6 Solar Energy Soil Impacts and Mitigation Strategies

Common impacts on soil resources include soil compaction, soil erosion and deposition by wind, soil erosion by water and surface runoff, sedimentation and soil contamination. Implementing mitigation measures to preserve the health and functioning of soils at the project site would reduce the likelihood of soil impacts becoming impacting factors on other resources (such as air, water, vegetation and wildlife).

Ground-disturbing activities during construction would include:

- Vegetation clearing and grubbing
- Excavating for foundations, footings and trenches for buried piping and electrical connections
- Stockpiling excavated material for backfilling
- Drilling rock to set foundations and footing
- Drilling and installing groundwater supply wells
- Grading for roads and staging/laydown areas
- Installing evaporation ponds
- Soil erosion would still occur during the operation phase because soil surfaces exposed by vegetation clearing, grading and excavation during the site preparation phase would continue to be exposed throughout the life of the project

Soil Impacts Mitigation Strategies

- Clean and maintain catchment basins, roadway ditches and culverts regularly
- Minimize ground disturbing activities , especially during the rainy season
- Place barriers and sedimentation devices around drainages and wetlands to prevent contamination by sediment-laden water

6.2.2.7 SOLAR ENERGY ECOLOGY IMPACTS AND MITIGATION STRATEGIES

Solar energy development could affect a wide variety of ecological resources in the areas where it occurs; among these are vegetation and wildlife.

Potential impacts on terrestrial and wetland plant communities and habitats from the development of utility-scale solar energy projects would include direct impacts from habitat removal as well as indirect impacts such as – changes in soil moisture and temperature, changes in hydrological conditions and habitat degradation. These impacts could be incurred during initial site preparation and would continue throughout the life of the project.

All utility-scale solar energy facilities that would be constructed and operated have the potential to affect wildlife. The effects on wildlife populations would depend on the following:

- Type and amount of wildlife habitat that would be disturbed
- Nature of disturbance – long term because of project structure and access road placement; complete long term alteration due to transmission line, gas pipeline, and water pipeline placement; or temporary disturbance during construction phase.

Ecology Impacts Mitigation Strategies

- Review existing information on species and habitats in the project area. Contact appropriate agencies early in the planning process to identify potentially sensitive ecological resources that may be present in the project area.
- Conduct pre-disturbance surveys and locate staging, site facilities, and parking areas away from important ecological resources (e.g., wetlands, water bodies, important upland habitats and sensitive species populations including nesting birds, raptors, and bats. Flag areas of active nests and keep activity away from active nests.
- Avoid surface water or groundwater withdrawals that affect sensitive habitats
- Minimize the number of stream crossings when locating access roads. Design stream crossings to provide in-stream conditions that allow for and maintain movement and safe passage of fish
- Do not plant species that would attract wildlife along high-speed or high-traffic roads
- Install cattle guards and fences to exclude livestock and wildlife from project facilities and control their access to roads
- Avoid siting solar facilities near open water or other areas that are known to attract large numbers of birds

6.2.3 WIND ENERGY ENVIRONMENTAL IMPACTS AND MITIGATION

Harnessing power from the wind is one of the cleanest and most sustainable ways to generate electricity as it produces no toxic pollution or global warming emissions. Wind is also abundant. However, there are a number of environmental impacts associated with wind power generation that should be recognized and mitigated.

There are many components in a wind energy development project including wind turbines, electrical collections systems, transmission/interconnection facilities, access roads, operations and maintenance facilities, and meteorological towers[222]. There are a number of separate operations involved in construction activities including mobilization/staging, road and staging/laydown area construction, grubbing/land clearing, topsoil stripping, earthmoving, grading, ground excavation, drilling, foundation treatment, wind turbines erection, ancillary building/structure erection, digging the trench for the underground electrical cables, electrical and mechanical installation, and landscaping. All of these activities have a potential impact on the environment. These impacts are addressed in the sections below.

An infrastructure is needed to set up the wind turbines. These include equipment large enough to transport the turbine parts, access roads to install the equipment, etc.

A major area to consider in developing wind energy is the issue of setbacks. A possible hazard in wind energy is the potential of turbine rotor failure which can result in fragments of the rotor being thrown from the turbine. In the state of California, concerns over the public exposure to this risk led counties to develop setback requirements from adjacent properties and structures. The counties typically base the setback on the maximum of a fixed distance or a multiple of the overall turbine height. A common setback is three times the overall turbine height from a property line.[223]

The potential for wind power in the states of Baja California and Tamaulipas is enormous. However, it is currently held back by cross-border transmission challenges. There are ample investment opportunities for U.S. firms in both wind power generation and in supplying the equipment for wind farms. One possibility is an integrated production structure for turbines that has equipment being produced in both Mexico and the U.S. This would be easier to achieve if there was harmony in the manufacturing standards between the two countries.

The U.S. regulations allow renewable power plants to be located in Mexico. Renewable energy developers are interested in locating these power plants in the areas of the U.S./Mexico border because it makes the interconnection easy. However, the border area is used by Mexico for the growing of fruits and vegetables. Mexican authorities should be aware of the U.S. Williamson Act[224] and the impact that could have on this area. This is a U.S. example of a preventive measure to protect agricultural lands that Mexico might want to consider enacting.

6.2.3.1 Wind Energy Air Quality Impacts and Mitigation Strategies

Most air quality impacts would occur during the construction phase. Tower structures would be carried to the site in sections by truck, assembled in laydown areas, and lifted into place with a crane. Depending on environmental/logistical factors, or costs, helicopters could be used for tower transport and erections, which would significantly reduce the construction period, but could greatly increase the levels of dust for short periods.

[222] American Wind Energy Association (AWEA) 2008
[223] Permitting Setback Requirements for Wind Turbines in California, November 2006 California Wind Energy Collaboration
[224] The Williamson Act protects agricultural areas and enables local governments to enter into contracts with private landowners for the purpose of restricting specific parcels of land to agricultural or related open space use.

There are no direct air emissions from operating wind turbines because no fossil fuels are combusted[225]. Thus, wind energy facilities would generate very low levels of air emissions during the operation period. Emissions from wind energy facilities would include minor dust and engine exhaust emissions from vehicles and heavy equipment associated regular site inspections, infrequent maintenance activities (e.g. overhauls or repairs) and wind erosion from bare ground and access roads.

The operation phase associated with transmission lines to support the integration of wind energy into the transmission grid, would generate very small amounts of criteria pollutants, Volatile Organic Compounds (VOCs), Green House Gases (GHG), and Hazardous Air Pollutants (HAPs) from activities such as periodic site inspection and maintenance. All of these emissions during the operation phase would be quite small, therefore potential impacts on ambient air quality would be negligible.

Wind Energy Air Quality Impacts Mitigation Strategies

- Use surface access roads, on-site roads, and parking lots with aggregates or that maintain compacted soil conditions to reduce dust generation
- Post and enforce lower speed limits on dirt and gravel access roads to minimize airborne fugitive dust
- Limit idling of diesel equipment to no more than 10 minutes unless necessary for proper operation
- Spray stockpiles of soils with water, cover with tarpaulins, and/or treat with appropriate dust suppressants, especially when high wind or storm conditions are likely
- Cover vehicles transporting loose materials when traveling on public roads

6.2.3.2 Wind Energy Water Resources Impacts and Mitigation Strategies

Water quality degradation of both surface water and groundwater resources is an important concern for any activity that involves land disturbance. For surface water bodies (rivers, streams, lakes and wetlands), one of the leading water quality issues is sediment load. Sediment on surface water is mainly a result of soil erosion. When groundwater is disturbed, there is the potential for increased soil erosion, and, because soil has been loosened, surface runoffs in disturbed areas tend to be high in sediment content.

Wind Energy Water Resources Impacts Mitigation Strategies

Wind energy water resources impacts mitigation strategies include:

- Identify and avoid unstable slopes and local factors that can cause slope instability (groundwater conditions, seismic activity and geologic structure).
- Minimize the planned amount of land to be disturbed as much as possible; Use existing roads
- Apply erosion controls relative to possible soil erosion from vehicular traffic

225 Conventional power plants burning fossil fuels (natural gas, coal, fuel oils, coal-derived liquids and gases) are major sources of criteria pollutants, Volatile Organic Compounds (VOCs), and GHG such as CO_2

- Clean and maintain catch basins, drainage ditches and culverts regularly
- Save topsoil removed during construction and use to reclaim disturbed areas upon completion of construction activities
- Backfill any foundation and trenches, preferable with excess excavation materials generated during construction

6.2.3.3 Wind Energy Land Use Impacts and Mitigation Strategies

The land use impact of wind power facilities varies substantially depending on the site: wind turbines placed in flat areas typically use more land than those located in hilly areas. The wind turbines do not occupy all of the land. The turbines must be spaced 5 to 10 rotor diameters apart (a rotor diameter is the diameter of the wind turbine blades). The turbines themselves and the surrounding infrastructure (including roads and transmission lines) occupy a small portion of the total area of a wind facility.

Activities that occur during operation of a wind energy facility primarily include the operation of the turbines and transmission line and the maintenance of the turbines and wind facility grounds, including the associated access roads and transmission lines.

Wind Energy Land Use Mitigation Strategies

- Minimize impacts to normal farming operations by locating structures along field edges and in nonagricultural areas where possible
- Locate access roads, which cross agricultural fields, along ridge tops and following field contours, where possible, to eliminate the need for cut and fill and reduce the risk of creating drainage problems
- All vehicle and equipment traffic and parking shall be limited to the access road and/or designated work areas such as tower sites and laydown areas
- Topsoil stripped from work areas (tower sites, parking areas, electric cable trenches, along access roads) shall be stockpiled separate from other excavated material (rock and/or subsoil).

6.2.3.4 Wind Energy Wildlife and Habitat Impacts and Mitigation Strategies

The impact of wind turbines on wildlife, most notably on birds and bats, has been widely documented and studied. The National Wind Coordinating Committee, after their review of peer-reviewed research, found evidence of bird and bat deaths from collision with wind turbines and due to changes in air pressure caused by the spinning turbines.

Wind Energy Wildlife and Habitat Mitigation Strategies

Although there have been deaths of birds and bats, the National Wind Coordinating Committee found that these impacts are relatively low and do not pose a threat to species population. In Latin America, 10 bat species were represented among the 123 individual bats found dead under wind turbines in 2007-2008 at the La Venta II project in southern Mexico. In 2009, 20 different bat species were involved.[226] Despite the enormous concentrations of migratory birds that pass over or through La Venta II wind farm (over 1 million per year) monitoring data from INECOL (Instituto de Ecología A.C.) shows that more bats are being killed there than birds.[227]

Mitigation actions being studied are:

- Increasing the visibility of rotor blades
- Using white flashing lights rather than (what is usual) red flashing lights to warn air Traffic
- Keeping migration corridors free

6.2.4 Radio Frequency Levels Impacts and Mitigation Strategies

Electromagnetic fields (EMF), including radio-frequency levels, have been studied for years. Recently, the International Agency for Research on Cancer (IARC) of the World Health Organization (WHO) reviewed available research on cell phones, which use radio frequencies (RF) similar to smart meters but cause much higher levels of exposure. The agency identified cell phone use as "possibly carcinogenic", noting that "there could be some risk, and therefore we need to keep a close watch for a link between cell phones and cancer risk: The WHO report did not explicitly address smart meters; it, and the other commonly cited studies, focused on cell phones, power transmission lines, microwave ovens and other emitters of EMF.

Given that smart meters are also RF emitters, some have worried that if cell phones might pose a health risk, smart meters might do so as well. A report published by the California Council of Science and Technology in 2010 included findings from the EPRI that a person 10 feet from a smart meter would experience only a small fraction of the RF exposure – 250 to 1,250 times less – that they would be exposed to using a cell phone. So whether or not future studies find that RF's present more certain health effects, smart meters make up a very small part of a person's daily exposure.[228]

Radio-Frequency Level Impacts Mitigation Strategies

Customers concerns should be addressed proactively. Utilities and regulators nationwide might consider an opt-out provision that lets customers to turn off the technology that transmits data (leaving the option for a future resident to turn the transmitter back on). They might also give serious consideration to alternative communication networks, such as broadband, or the power lines themselves, to carry data.

6.2.5 Plug- In Electric Vehicles

The Smart Grid's single biggest potential for delivering carbon savings is in providing cost-effective and increasingly clean energy for plug-in electric vehicles (PEVs). Included within this vehicle class PHEVs, are the next generation of hybrids.

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[226] INECOL 2009
[227] *Greening the Wind* – Environmental and Social Considerations for Wind Power Development (George C. Ledec, Kennan W. Rapp and Robrto g. Aiello), December 2011
[228] http://www.ccst.us/publications/2011

PEVs are powered by an electric motor and battery alone. PEVs can actually be plugged in to a standard household electrical outlet to recharge their batteries. A car such as the 2012 Ford Focus has a 107 kilowatt electric drive motor and according to the U.S. Environmental Protection Agency can go 76 miles on a single charge. The majority of electric vehicles operating on battery power would meet the daily needs of most drivers, according to the Edison Electric Institute (EEI). Compared with a current hybrid, a PEV with an electric-only range of 20 miles could reduce fuel use by about one-third according to a report by the American Council for an Energy-Efficient Economy. EPRI estimates that the same PEV could reduce fuel consumption by about 60% compared to conventional vehicles.

Plug-in hybrid electric vehicles are powered by a gasoline engine and an electric motor. This combination allows the vehicle to use electricity, and enables the vehicle to continue driving indefinitely after the battery is discharged. Plug-in hybrids operate like hybrid vehicles but can be charged from the grid. The 2014 Chevrolet Volt drives gas free for EPA estimated 38 miles then the onboard gas powered generator provides electricity so that it can be driven a total of 380 miles on a full charge and full tank of gas. This enables 900 miles between fill-ups. On average, PHEVs will produce just one-third of the GHG emitted by conventional gasoline-fueled vehicles, tailpipe to tailpipe. According to a joint study by EPRI and the Natural Resources Defense Council (NRDC), PHEVs have the potential to reduce cumulative U.S. GHG emissions by as much as 10.3 billion tons from 2010 to 2050. PHEVs could reduce national oil consumption by as much as four million barrels of oil per day in 2050 according to that same study.

The benefits from lower electric rates accrue, however, only if these vehicles are charged strictly off-peak. On-peak would only further stress the grid. It is crucial for utilities to manage EV charging. A Smart Grid is the key to "smart" EV charging, providing the visibility and control needed to protect components of the distribution network, such as transformers, from being overloaded by EVs and to ensure that the electricity generating capacity is used more efficiently. Utilities will need to understand where consumers have EVs and distribute the charging load to prevent transformer loss or damage. With a Smart Grid, utilities can manage when and how EV charging occurs while adhering to customer preferences, collect EV-specific meter data, apply specific rates for EV charging, engage consumers with information on EV charging and collect data for GHG abatement credits.

6.2.6 Carbon Emission Credits

The burning of fossil fuels is a major source of GHG, especially for power, steel, textile and many other industries which rely on fossil fuels. The major greenhouse gases emitted by these industries are carbon dioxide, methane, nitrous oxide, hydrofluorocarbons (HFCs) all of which increase the atmosphere's ability to trap infrared energy and thus affect the climate.

Under the Kyoto Protocol, developed, or Annex 1 countries, are given a "cap" or quota for GHG. The quantity of the assigned amount is denominated in individual units called "Assigned amount units", each of which represents an allowance to emit one metric ton of carbon dioxide equivalent, and these are entered into the country's national registry.

A carbon offset is a reduction in emissions of carbon dioxide or greenhouse gases made in order to compensate for, or to offset, an emission made elsewhere. Carbon offsets are measured in metric tons of carbon dioxide equivalent and may represent six primary categories of greenhouse gases – carbon dioxide, methane, nitrous oxide, perflorocarbons, hydrofluorocarbons and sulfur hexafluoride. One carbon offset represents the reduction of one metric ton of carbon dioxide or its equivalent in other greenhouse gases.

There are two markets for carbon offsets. In the larger, compliance market, companies, governments or other entities buy carbon offsets in order to comply with caps on the total amount of carbon dioxide they are allowed to emit. In the much smaller voluntary market, individuals, companies or governments purchase carbon offsets to mitigate their own GHG emissions from transportation, electricity use, and other sources. Offsets are typically achieved through financial support of projects that reduce the emission of GHG in the short-or-long term.

Renewable energy offsets commonly include wind power, solar power, hydroelectric power and biofuel. Some of these offsets are used to reduce the cost differential between renewable and conventional energy production, increasing the commercial viability of a choice to use renewable energy sources.

A tradable credit can be an emissions allowance or it can be an offset of emissions. Such offsetting and mitigating activities can occur in any country which has ratified the Kyoto Protocol and has a national agreement in place to validate its carbon project through one of the UNFCCC's approved mechanisms. Once approved, these units are termed Certified Emission Reductions, or CERs. For trading purposes, one allowance of CER is considered equivalent to one metric ton of CO_2 emissions. These allowances can be sold privately or in the international market at the prevailing market price. Currently there are five exchanges trading in carbon allowances.

Financing of renewable energy projects via carbon credits is happening in various countries. One example is the Changbin and Taichung Wind Projects in China GHG reductions are achieved through the use of wind power to generate electricity, which otherwise would be generated by fossil fuel power plants. The cost of building the wind farms was substantial. The additional revenue from the sale of carbon credits provided the necessary incentives to justify the investment of building the wind farm.

In India the wind energy market has grown significantly and much of this growth can be attributed to government policies and innovations in financing. A 6.5 MW wind energy project in the state of Madhya Pradesh was issued 10,413 CER for offsetting GHG emissions over a 13 month period.

Mexico and the U.S. should develop a harmonized approach to carbon emissions policy. The U.S. is moving towards a low-carbon future and the possibility of a national cap and trade or carbon tax system. It would be harder to achieve this if the two countries have different carbon emissions approaches. If a carbon tax is feasible in the long term, it would make sense for the two countries to coordinate their approaches, with each other and with Canada, to ensure that all three NAFTA (North American Free Trade Agreement) partners are moving in the same direction.

Mexico and the U.S. should develop a harmonized approach to carbon emissions policy

6.3 PRELIMINARY DEVELOPMENT IMPACT ASSESSMENT

6.3.1 OVERVIEW

Mexico has the second-largest economy in Latin America and is a major oil producer and exporter; about one-third of government revenue still comes from the industry.

According to the World Bank, indigenous peoples make up nearly 11% of the population of Mexico, of which, 22% live in rural areas.[229] There is a wide socio-economic gap for many Mexicans.

Mexico has recently enjoyed billions of dollars of fresh investment into the country by foreign companies. Foreign direct investment climbed nearly 30 percent in the first six months of 2010 from a year earlier.

The Center for Global Development states that Mexico is one of three countries that have exhibited the most dramatic improvement in meeting The United Nations Millennium Development Goals

The United Nations Millennium Development Goals are a group of eight international development goals established at the Millennium Summit of the United Nations in 2000. All 193 member countries and 23 international organizations committed to achieving these goals by 2015. The Center for Global Development states that Mexico is one of three countries that have exhibited the most dramatic improvement in meeting these goals. Mexico was able to meet their goal in combating HIV/AIDS and malaria, and achieved most of the goals in the social and public health areas. They also improved their position in the area of education, in particular for primary school and gender equality.

In this section, we discuss the effects that implementation of the Smart Grid will have on Mexico in areas such as infrastructure, market-oriented reform, human capacity building and technology transfer that Mexico will need to implement the Smart Grid.

6.3.2 INFRASTRUCTURE

Transitioning to a smarter electrical grid is perhaps the most effective way in which utilities can reduce greenhouse gas emissions and thereby combat climate change. A Smart Grid can provide customers with near real time usage data which has a direct effect in promoting energy conservation. Smart Grid technologies will allow the grid to better adapt to the dynamics of renewable energy and distributed generation and help utilities and consumers more easily access these resources.

Smart Grid will have positive effects for Mexico and the Mexican economy including quality of life improvement for customers. Implementing a smart meter program can also be the model for high technology development within the country. Smart meters in homes and businesses will be at the interface between energy supply and demand and can act as an enabler for Mexico to realize technological improvements in the utility grid, in homes and businesses, and potentially in new industries and energy service markets.

A critical part to the success of the Smart Grid strategy is engaging the consumer. For consumers to be engaged, they must be motivated and enabled. Consumer participation in the power system is relatively new as a popular concept. To enable consumer participation, consumers must have the information they need to make decisions. Using AMI as the basic infrastructure enables effective consumer participation because AMI gives data on electricity price, provides customers with the ability to use electricity more

[229] World Bank Indicators Rural Population % of Total Population, 2013

efficiently and provides utilities with the ability to detect problems on their systems and consumption to customers and utilities.

There will be a dramatic increase in the amount of data that will be obtained with the Smart Grid and the infrastructure in the substations and distributions segments will need to be updated to accommodate this increase. The switches and routers deployed throughout the system will also need to adapt to the demands for increased data by supporting greater throughput and also by assisting in intelligent bandwidth.

In Mexico, the main investment burden is carried by the grid operator and the power suppliers. A fair cost-sharing model needs to be developed with the right balance between short-term investment costs and long-term profits in order to encourage the grid operators to undertake any substantial investment.

Additional infrastructure needs are:

- Developing technical standards
- Ensuring data protection for consumers
- Establishing a regulatory framework to provide incentives for Smart Grid deployment
- Guaranteeing an open and competitive retail market in the area of consumers and
- Providing continued support to innovation for technology and systems

6.3.3 Market Oriented Reform

The International Energy Agency[230] has stated in their findings that, because of the complexity, it is unlikely that the market alone will implement Smart Grid on the scale that is needed. Governments need to establish clear and consistent policies, regulations and plans for electricity systems that will allow innovative investment in Smart Grids. It will also be necessary to gain public engagement about the need for Smart Grids and the benefits they offer. Governments, the private sector and consumer and environmental advocacy groups must work together to define electricity system needs and determine Smart Grid solutions.

While price is the main barrier to renewable energy development in Mexico, there are other potential Renewable Energy barriers (regulatory, incentives, transmission access, permitting, etc.) that have been analyzed by the CRE and ESTA team and mitigation strategies and recommendations provided in Smart Grid Regulatory Framework Task 2 and Task 3 Reports.

It should be noted that according to Nobuo Tanaka, Executive Director of the International Energy Agency, rapid expansion of Smart Grids will be hindered by a tendency of governments to shy away from taking ownership of and responsibility for actively evolving or developing new electricity system regulations, policy and technology. Tanaka notes that this has led to a reduced overall expenditure on technology development and demonstration, and policy development. CRE appreciates its pivotal role in development of Smart Grid in Mexico and in collaboration with SENER and CFE has taken initiatives to address barriers and develop incentives for accelerated development of Smart Grid in Mexico.

6.3.4 Human Capacity Development

The clean energy industry is one of the fastest growing sectors in the world. In the U.S., between 1998 and 2007, clean energy jobs grew by 9.1 percent, while total numbers of new jobs grew just 3.7 percent.

[230] IEA Technology Roadmap for Smart Grid 2011

On September 12, 2011 the International Trade Administration (ITA) stated: "The Smart Grid has the potential to be the critical platform for the world's clean energy economy and we're already seeing that developing, designing, building and installing Smart Grid technology is part of job creation. According to data released by ITA, it is predicted that in the U.S. over 43,000 jobs will be created and over 61,000 current jobs will be supported by Smart Grid technologies."

Wind power has been hailed as a major source of so-called green jobs and has been credited with creating more jobs per unit of energy than traditional hydrocarbon-based electricity generation industries. Employment is created not only in the construction, operation and management of wind facilities, but in the manufacturing of wind turbines.

According to the Woodrow Wilson International Center for Scholars, there is the potential for building a Mexican wind turbine industry to provide equipment and components for the coming wind boom in the border region. The building and consolidation of such an industry would provide thousands of skilled jobs on a permanent basis for workers in the Border States, and would enable equipment and component manufacturers to develop economies of scale and greater levels of efficiency that would enable them to export to the rest of North America and beyond.[231]

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Research by the Natural Resources Defense Council (NRDC) finds that one typical wind farm of 250 MW creates 1,079 jobs over the lifetime of the project. These jobs are not just at the wind farm site but in the wind farm system – the chain of activities and businesses that, over time, constitute the building of a wind farm.[232] The research identifies 557 total non-construction workers including preplanning and development, manufacturing, sales and distribution and operations and maintenance. Construction jobs add another 522 jobs and include on-site civil works such as roads and foundations, mechanical assembly such as the installation of the wind turbines and on-site electrical work such as grid connection.

Smart Grid jobs will require a different set of skills than those required for working in the electric industry today. The Smart Grid combines electric distribution/transmission technology, IT infrastructure, and telecommunications technology. Workers in all sectors will need to understand the interdisciplinary components of Smart Grid. Smart grid is likely to change the job mix within a utility, reduce the overall number of utility jobs, change the skill requirements of utility jobs, and, at the same time, create significant numbers of jobs in the electric energy industry overall. While some relatively low skilled meter reader and clerical jobs may be lost to the automated capacities of the new technologies, many more, higher technology jobs are likely to be created in implementing the Smart Grid system, and even more in the overall economy as new markets and technologies are developed to take advantage of the Smart Grid platform.

Areas where the Smart Grid can create jobs include:

- Smart grid installation will create jobs for technicians
- Increased jobs in the area of relay technicians, communications technicians
- Cyber security
- "Behind the grid" jobs for solar and wind installers, network technicians

[231] Wind Energy Potential in Mexico's Northern Border States May 2012
[232] American Wind Farms: Breaking Down the Benefits from Planning to Production

One of the defining characteristics of the Smart Grid is increased computer control and automation. As a result, computer systems analysts, network and computer systems administrators, operations research analysts and software developers are needed to create, operate, and maintain the computer systems that the Smart Grid uses. After the design phase, engineers evaluate a design's effectiveness, cost, reliability and safety. Electrical engineers, electronics engineers, and electrical and electronics engineering technicians are needed in work.

Operating the Smart Grid requires new equipment for generating plants and substations to handle increased capacity. Other plants and substations must be upgraded with Smart Grid technologies. Equipment assemblers, power distributors and dispatchers, and power plant operators are needed to prepare and control these Smart Grid facilities.

Meter readers will be heavily affected by the implementation of the Smart Grid. Meters for the current grid are attached to houses and other buildings, where they must be periodically read and recorded by a meter reader. Smart Grid relies on advanced meter infrastructure. Meter technicians have a higher skill level than have meter readers. To avoid outsourcing these jobs, a utility must aggressively retrain meter readers. The meter technician is one position that meter readers can be retrained to fill. As a result, meter readers can be retrained for another occupation.

The electric energy industry workforce will be faced with another challenge of collecting, processing, storing, and protecting the data produced by AMI and other applications once Smart Grid communication networks are in place and operational. Meter data management, network management, and cyber security are some of the top concerns for many utilities.

6.3.5 Technology Transfer

Much in the way that a "smart" phone means a phone with a computer in it, Smart Grid means "computerizing" the electric utility grid. It includes adding two-way digital communication technology to devices associated with the grid. Each device on the network can be given sensors to gather data (power meters, voltage sensors, fault detectors, etc.) plus two-way digital communication between the device in the field and the utility's network operations center. The number of applications that can be used on the Smart Grid, once the data communications technology is deployed, is growing as fast as inventive companies can create and produce them. Benefits include improved reliability, reduced cost of delivered electricity, new products and services, opportunity for creating awareness of energy efficiency opportunities, enhanced cyber-security,handling sources of electricity like wind and solar power, and integrating electric vehicles onto the grid. The companies making Smart Grid technology or offering such services include technology giants, established communication firms and brand new technology firms.

Table 6-2: High-level Smart Grid Technology Layers

Smart Grid Technology Layers	Components
Power Layer	Power generation, transmission, substations, distribution grid and energy consumption
Communication Layer	Local area networks (LAN), Wide-area networks (WAN), field area network (FAN/AMI), and home area network (HAN) supporting IT infrastructure
Application Layer	Demand response control billing, outage control, load monitoring, real-time energy markets, and a new range of customer services

The following technology needs were identified in the *Smart Grid for Mexico Task 1 Report* prepared by ESTA. They are:

- A strong communication infrastructure using fiber optics with T1, T2 type throughputs
- High quality precision transducers, Current Transformers and Potential Transformers will be needed for precision calculation of each power plant output.
- Outage Management System
- Scheduling System
- Weather Data Reporting
- Renewable resources required to forecast the output of their power plants in MW and MWh a day in advance for scheduling purposes
- Monitoring the extent and severity of intermittency and developing solutions for managing it.
- Management of Intermittency
- Settlement Quality Meters
- Settlement System and Charge Codes
- Banking and credit management system

6.4 RECOMMENDATIONS

ESTA provides the following recommendations:

1. Mexico and the U.S. should **harmonize their manufacturing standards** for the possibility of joint cooperation in producing wind turbines.
2. In order for California to meet their renewable energy mandates, they can obtain renewable energy from Mexico. However, the California law states that this energy must meet the laws of the California Environmental Quality Act (CEQA). Mexico should have one or more **experts on this law** and the applicability to Mexico.
3. Mexico should **develop a plan for the re-cycling** and/or disposal of used PV panels.
4. Mexico should **develop an agricultural protection law,** similar to the Williamson Act to protect agricultural land adjoining the U.S./Mexico border.
5. In the European Union, smart grid services and benefits are very much linked to the European Union policy goals that are driving smart grid deployment (sustainability, competiveness and security of supply). They can therefore be considered as useful indicators to evaluate the contribution of smart grid projects toward the achievement of these policy goals. **Developing a set of indicators is a task that Mexico should consider adopting.**
6. As Smart Grid and the use of renewable energy further expands, Mexico should consider **incorporating renewable energy in public sector installations and in any national housing programs.**

Table 6-3 lists possible actions to prevent environmental incidents related to implementation of Smart Grid in Mexico.

Table 6-3: Actions to Prevent Environmental Incidents

Action	Purpose
Develop a Spill Prevention and Emergency Response Plan	To identify sources, locations and quantities of potential chemical releases (through spills, leaks or fires) and define response measures and notification requirements to be developed and followed
Develop a Fire Management and Protection Plan	To minimize the potential for fires associated with substances used and stored on the site
Develop a Storm Water Management Plan	To ensure compliance with regulations and prevent off-site migration of contaminated storm water
Develop a Vegetation Management Plan	If the facility will use pesticides/herbicides
Develop Water Contingency Plan	To prevent potential groundwater and surface water contamination or depletion
Develop a Drainage, Erosion, and Sedimentation Control Plan	To identify surface water runoff patterns and develop mitigation measures to prevent soil erosion
Prepare Dust Abatement Plan	It should be project and location-specific

7 Task 5 – Economic Analysis and Implementation Plan

Task 5 **Economic Analysis and Implementation Plan**

The focus of this task as outlined in the Terms of Reference is to develop high-level cost estimates for the phase-by-phase implementation of smart grid in Mexico, starting with CFE's ongoing smart grid pilot project. Using industry information on the costs associated with smart grid implementation, as well as the quantifiable benefits of smart grid implementation, a high-level cost-benefit analysis is performed.

7.1 Overview

Electric systems throughout the world are facing many challenges. With much of today's transmission and distribution infrastructure installed in the 1950s, 60s, and 70s, many grid components have reached the limits of useful life and will need to be upgraded to allow the bidirectional flow of energy between generation sources and consumption. Pressure on prices from increasing commodity costs, consumption growth and a decline in working inventories is expected to continue. Deployment of capital to meet load growth and reliability needs may become increasing difficult. Government mandates, carbon caps, and regulations that limit existing and new generation sources are augmenting environmental concerns.

Smart grid is about building the electric utility of the 21st century. It involves "smart" systems to measure electricity consumption at different times of the day, new communications networks to send data to and from utilities, and new database systems to manage and use the valuable new data which smart grid systems generate. It may also involve new "smart" systems that can respond to signals automatically to turn themselves on or off, up or down.

Many grid approaches are rapidly becoming reality due to the advancements in communications technologies, coupled with the reduction in cost of system components. Adherence to widely adopted industry standards for communications interfaces creates the possibility of an open architecture. Specifically, the inclusion of Ethernet interfaces in devices mounted on the electric grid can facilitate diverse, redundant access to electric infrastructure devices. For this effort, we have evaluated the potential of a smart grid implementation for CRE.

Furthermore, research and analysis conducted in recent years have demonstrated how distributed generation and energy storage assets can be included in electric utility Smart Grid plans to improve performance. Distributed generation (DG) and energy storage applications need to be considered as part of the overall Smart Grid strategy for any utility in order to react to these changes and prepare for future ones. These applications have the potential to improve asset utilization through peak shaving; enhance reliability through distributed backup units; and increase operational flexibility and efficiency through the availability of resources closer to the end consumer. Introducing a mix of these applications can also reduce the high cost of cycling peaking plants and the Greenhouse Gases emissions that come from non-renewable forms of generation. It is expected that Smart Grid will redefine the way in which utilities operate and electricity is managed and consumed.

For this project, we have also evaluated the cost-effectiveness of various implementation options and provide a basis for deciding how to optimize the deployment of a network that would achieve targeted goals for renewable energy and complementary energy storage.

This chapter provides

- Economic Evaluation of Renewable Energy Program
- Economic Evaluation of Smart Grid Program
- Observations and Recommendations

7.2 EVALUATION OF RENEWABLE ENERGY PROGRAM

Given the industry trends towards Smart Grid and the increasing challenges of energy delivery and carbon constraints (including calls for higher levels of energy efficiency programs, updated business processes and employee engagement, and increased presence of renewable energy as part of energy portfolio), the business case for system automation needs to be evaluated in order to understand the role, requirements and strategic implications of deployment options. Today, the business case behind implementing smart grid and distributed resource systems on a large-scale basis presents a challenge – one that is changing as technology develops and as regulatory uncertainty clears away. In an effort to respond to and prepare for mandatory actions, utilities are looking to integrate higher penetrations of renewable energy sources into their generation mix. Specifically, Mexico has set an ambitious goal of having 35% of all energy production derived from renewable energy sources by 2024.

In order to evaluate the business case for Smart Grid and distributed energy resources a 10-year financial model was developed in order to measure the viability of different potential system approaches.

7.2.1 MODELING APPROACH

For this analysis, we have developed a financial and operational model that allows us to measure the potential impact of a dedicated renewable energy project on Mexico's Power Grid for a time horizon of 10 years.

In order to develop the financial analysis of a potential program that features a mix of renewable energy sources (Photovoltaic and wind) and energy storage (NaS and Zinc Bromine flow batteries), a modeling approach was utilized that allows us to evaluate the potential economics of a distributed energy resource program. The key steps involved are:

1. We measured the potential benefits of this initiative according to established methods for demonstrating positive system value and through the use of established industry sources for a variety of assumptions (e.g. generation value, frequency regulation clearing price, synchronized reserve cost, etc.)
2. We evaluated the capital costs for this effort and evaluated the associated annual depreciation charges.

3. We constructed a forecast model to evaluate the overall projected economics for the enterprise.

Table 7-1 highlights the summary of benefits evaluated during this analysis.

Table 7-1: Summary of Program Benefits Evaluated

Application	Description	Benefit Calculation Methodology
Generation Deferral	Reduce system peak in order to reduce investments in generation	Peak reduction x savings per kW
Wholesale Marketing Resource Call	Reduce system peak in order to provide flexibility in generation requirements during summer peak	Peak reduction x savings per kW
Frequency Regulation	Power sources online, on automatic generation control, that can respond rapidly to system-operator requests for up and down movements	System capacity x hours per year x regulation clearing price
Synchronized Reserves	Power sources that can increase output immediately in response to a major generator or transmission outage	System capacity x hours per year x reserve cost
Supplemental Reserves	Commitments that can be immediately decreased in response to a major generator or transmission outage	System capacity x hours per year x reserve cost
Renewables Integration	Engaging in (a) smoothing, (b) shifting, and (c) shaping renewable energy sources	System capacity x hours per year x fuel cost savings
Energy Arbitrage	Opportunity to purchase energy at off-peak rates and sell at higher peak rates	System capacity x arbitrage value
Blackstart	Process of restoring a power station to operation without relying on the external electric power transmission network	System capacity x contract value per kW
Transmission Deferral	Reduce system peak in order to reduce investments in transmission	Transmission reduction x savings per kW
Voltage Support	The injection or absorption of reactive power to maintain transmission-system voltages within required ranges	System capacity x transmission and distribution savings per kW
Distribution Deferral	Reduce system peak in order to reduce investments in distribution	Distribution reduction x savings per kW
Outage Mitigation	Distributed storage capability to bridge gap in power delivery in event of outage	Outage reduction x benefit per minute of outage
Power Quality	Maintaining electric power that drives an electrical load and the load's ability to function properly with that electric power	Number of power quality events x savings per event
Distribution Loss Reduction	Dispersed functions allow existing generation to function more efficiently and improve the overall efficiency of the electric system	Line losses x improvement rate x wholesale power cost

7.2.2 MODEL ASSUMPTIONS

Table 7-2 highlights the preliminary model assumptions used for this analysis.

Table 7-2: Model Data Assumptions

Default Assumptions	Units	Assumption
Generation Deferral		
Generation Value	per kw-yr	$1,306
Generation Value Escalation Rate	per year	1.0%
Wholesale Marketing Resource Call		
Generation Value	per kw-yr	$1,306
Generation Value Escalation Rate	per year	1.0%
Frequency Regulation		
Regulation Clearing Price	per kW-month	$157.83
Regulation Clearing Price Escalation Rate	per year	3.5%
Synchronized Reserves		
Reserve Cost	per kW-month	$157.83
Regulation Clearing Price Escalation Rate	per year	-1.0%
Supplemental Reserves		
Reserve Cost	per kW-month	$25.91
Regulation Clearing Price Escalation Rate	per year	-1.0%
Renewables Integration		
Fuel Cost Savings	per kWh	$1.0226
Fuel Cost Savings Escalation Rate	per year	1.0%
Storage Enhancement Rate		100.0%
Energy Arbitrage		
Arbitage Value	per kw-yr	$0
Arbitage Value Escalation Rate	per year	0.0%
Blackstart		
Contract Value	per kw-yr	$59.81
Contract Value Escalation Rate	per year	0.0%
Transmission Deferral		
Transmission Value	per kw-month	$46.89
Transmission Value Escalation Rate	per year	1.8%
Voltage Support		
Percentage of Controllable Load	of total	25.0%
Transmission Value	per kw-month	$46.89
Distribution Value	per kw-month	$179.44
Transmission Value Escalation Rate	per year	1.8%
Distribution Value Escalation Rate	per year	0.0%
Distribution Deferral		
Distribution Value	per kw-month	$179.44
Distribution Value Escalation Rate	per year	0.0%
Outage Mitigation		
Local Outage Impact	per event	1.0%
Outage Value - Supply	per MW-minute	$1.31
Power Quality		
Impact Rate	per event	100.0%
Outage Value - Supply	per MW-minute	$1.31
Distribution Loss Reduction		
Impact Rate	per event	25.0%
Line Loss Rate	per event	7.0%
Optimization Potential	per event	10.7%
Distribution Value	per kw-month	$179.44
Distribution Value Escalation Rate	per year	0.0%

7.2.3 MODELING RESULTS

Distributed energy resources like renewable energy programs offer the potential to deliver measurable solutions for a wide variety of areas. A well designed program can deliver a variety of services, including:

- Reduce system peak in order to reduce investments in both generation and transmission
- Engaging in (a) smoothing, (b) shifting, and (c) shaping renewable energy sources
- Process of restoring a power station to operation without relying on the external electric power transmission network
- The injection or absorption of reactive power to maintain transmission-system voltages within required ranges
- Reduce system peak in order to reduce investments in distribution
- Distributed storage capability to bridge gap in power delivery in event of outage
- Maintaining electric power that drives an electrical load and the load's ability to function properly with that electric power
- Distributed functions allow existing generation to function more efficiently and improve the overall efficiency of the electric system
- The reduction of GHG emissions in order to achieve environmental benefits and comply with climate change commitments

While the results of the business case are based on assumptions in working with local subject matter experts that will ultimately need to be validated further within the scope of a deeper operational study, the results show a very strong potential scenario for the implementation of RE programs into the Mexican grid as shown in Table 7-3.

Table 7-3: Summary Financial Results

Renewable Energy Business Model

Prepared for: CRE COMISIÓN REGULADORA DE ENERGÍA

Prepared by: ESTA international

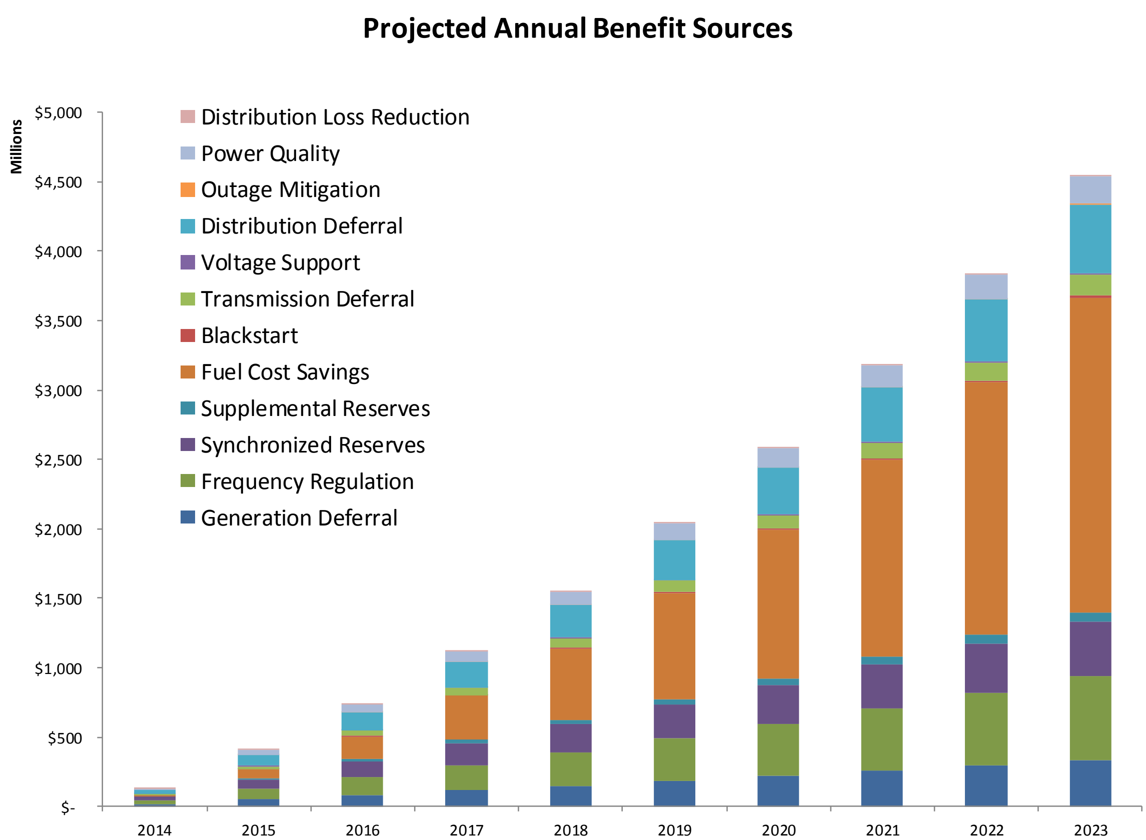
Business Case Results ($MM)

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Net Earnings	$ 128.7	$ 403.3	$ 731.3	$ 1,112.8	$ 1,548.1	$ 2,037.4	$ 2,581.0	$ 3,179.1	$ 3,832.0	$ 4,540.0
Depreciation	$ 197.7	$ 358.9	$ 492.1	$ 603.5	$ 698.1	$ 779.5	$ 850.4	$ 912.9	$ 968.6	$ 1,018.8
Net Income	$ (69.0)	$ 44.4	$ 239.2	$ 509.2	$ 849.9	$ 1,257.9	$ 1,730.6	$ 2,266.2	$ 2,863.4	$ 3,521.2
CapEx	$ 1,977.2	$ 1,612.0	$ 1,331.5	$ 1,114.7	$ 945.9	$ 813.5	$ 708.7	$ 625.0	$ 557.3	$ 502.1
Cash Flow	$ (1,848.5)	$ (1,208.7)	$ (600.3)	$ (1.9)	$ 602.2	$ 1,223.9	$ 1,872.2	$ 2,554.1	$ 3,274.7	$ 4,037.9
Cumulative Cash Flow	$ (1,848.5)	$ (3,057.2)	$ (3,657.5)	$ (3,659.4)	$ (3,057.2)	$ (1,833.4)	$ 38.9	$ 2,593.0	$ 5,867.6	$ 9,905.5
Financial Metrics										
NPV	$ 17,033.7									
Internal Rate of Return	40.2%									

We forecast that total annual benefits will grow from MXN $145 million pesos in the first year to MXN $4.870 thousand million pesos by year 10. Primarily, this benefit is achieved by recognizing opportunities to achieve cost reduction in fuel costs, with additional benefits in reducing frequency regulation and synchronized reserve costs and enabling deferral of distribution and generation capital as depicted in Table 7-4.

Furthermore, total Net Present Value (NPV) of the project is calculated at MXN $17.0 thousand million pesos while the Internal Rate of Return (IRR) is calculated to be 40.2%.

Table 7-4: Projected Annual Benefit Sources



Benefits (Annual)	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
	$ 128,729,716	$ 403,319,663	$ 731,258,359	$ 1,112,762,987	$ 1,548,059,281	$ 2,037,381,897	$ 2,580,974,805	$ 3,179,091,696	$ 3,831,996,400	$ 4,539,963,333
Generation Deferral	$ 17,186,433	$ 49,355,743	$ 82,166,720	$ 115,628,982	$ 149,752,271	$ 184,546,464	$ 220,021,566	$ 256,187,714	$ 293,055,184	$ 330,634,384
Frequency Regulation	$ 25,351,398	$ 74,426,110	$ 126,904,997	$ 182,966,234	$ 242,796,299	$ 306,590,335	$ 374,552,528	$ 446,896,502	$ 523,845,726	$ 605,633,948
Synchronized Reserves	$ 24,579,985	$ 69,327,921	$ 113,178,439	$ 156,145,015	$ 198,240,942	$ 239,479,335	$ 279,873,137	$ 319,435,114	$ 358,177,865	$ 396,113,817
Supplemental Reserves	$ 4,035,307	$ 11,381,597	$ 18,580,556	$ 25,634,399	$ 32,545,306	$ 39,315,432	$ 45,946,901	$ 52,441,809	$ 58,802,225	$ 65,030,187
Fuel Cost Savings	$ 9,373,551	$ 61,288,605	$ 163,042,111	$ 314,634,068	$ 516,064,477	$ 767,333,337	$ 1,068,440,650	$ 1,419,386,414	$ 1,820,170,629	$ 2,270,793,297
Blackstart	$ 781,716	$ 2,224,884	$ 3,668,052	$ 5,111,220	$ 6,554,388	$ 7,997,556	$ 9,440,724	$ 10,883,892	$ 12,327,060	$ 13,770,228
Transmission Deferral	$ 7,444,503	$ 21,531,046	$ 36,121,541	$ 51,229,552	$ 66,868,969	$ 83,054,014	$ 99,799,248	$ 117,119,578	$ 135,030,269	$ 153,546,947
Voltage Support	$ 370,690	$ 1,058,613	$ 1,751,786	$ 2,450,349	$ 3,154,447	$ 3,864,229	$ 4,579,847	$ 5,301,455	$ 6,029,213	$ 6,763,283
Distribution Deferral	$ 28,141,776	$ 80,095,824	$ 132,049,871	$ 184,003,919	$ 235,957,967	$ 287,912,015	$ 339,866,062	$ 391,820,110	$ 443,774,158	$ 495,728,206
Outage Mitigation	$ 224,274	$ 638,318	$ 1,052,363	$ 1,466,407	$ 1,880,451	$ 2,294,495	$ 2,708,540	$ 3,122,584	$ 3,536,628	$ 3,950,672
Power Quality	$ 11,213,699	$ 31,915,912	$ 52,618,126	$ 73,320,339	$ 94,022,552	$ 114,724,766	$ 135,426,979	$ 156,129,192	$ 176,831,406	$ 197,533,619
Distribution Loss Reduction	$ 26,383	$ 75,090	$ 123,797	$ 172,504	$ 221,211	$ 269,918	$ 318,624	$ 367,331	$ 416,038	$ 464,745

Net income turns positive in the second year of system operation as shown in Figure 7-1.

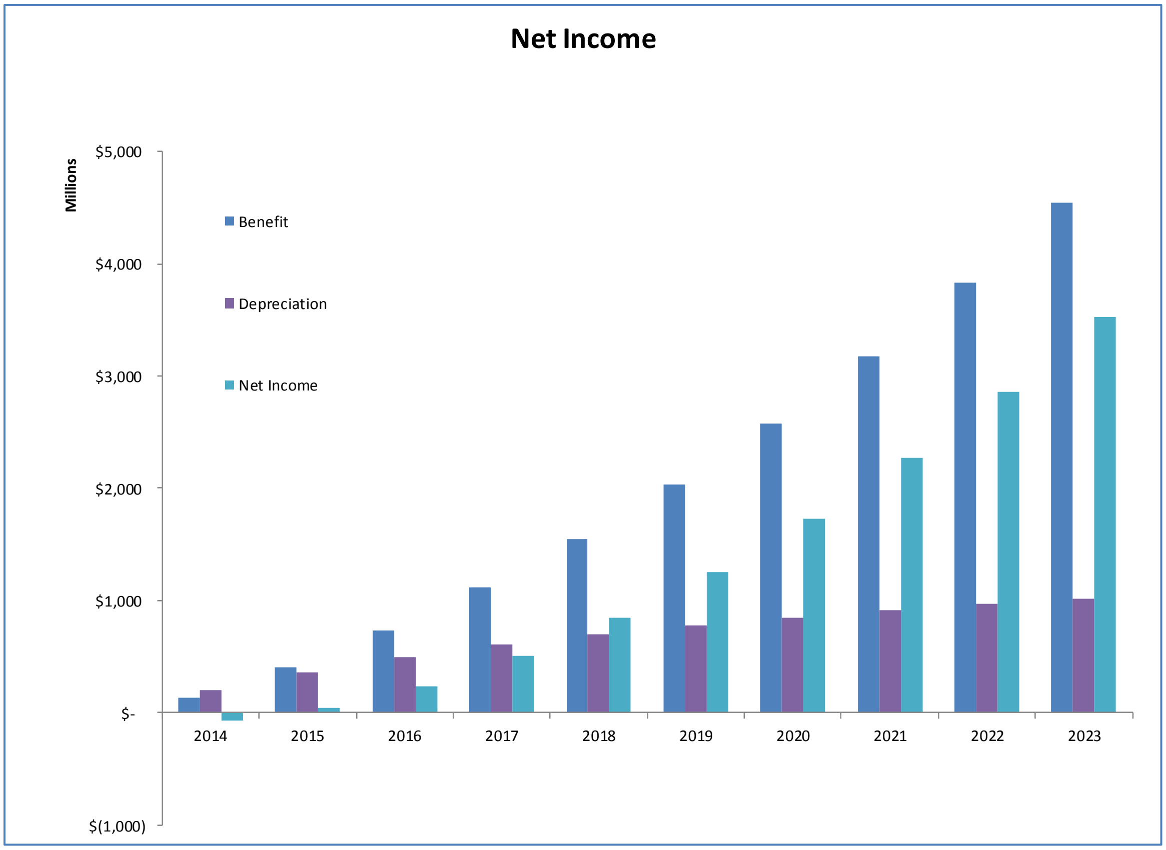


Figure 7-1: Forecasted Impact on Net Income

The forecast calls for the complete payback of all invested capital by the 7th year of operation as demonstrated in Figure 7-2 below.

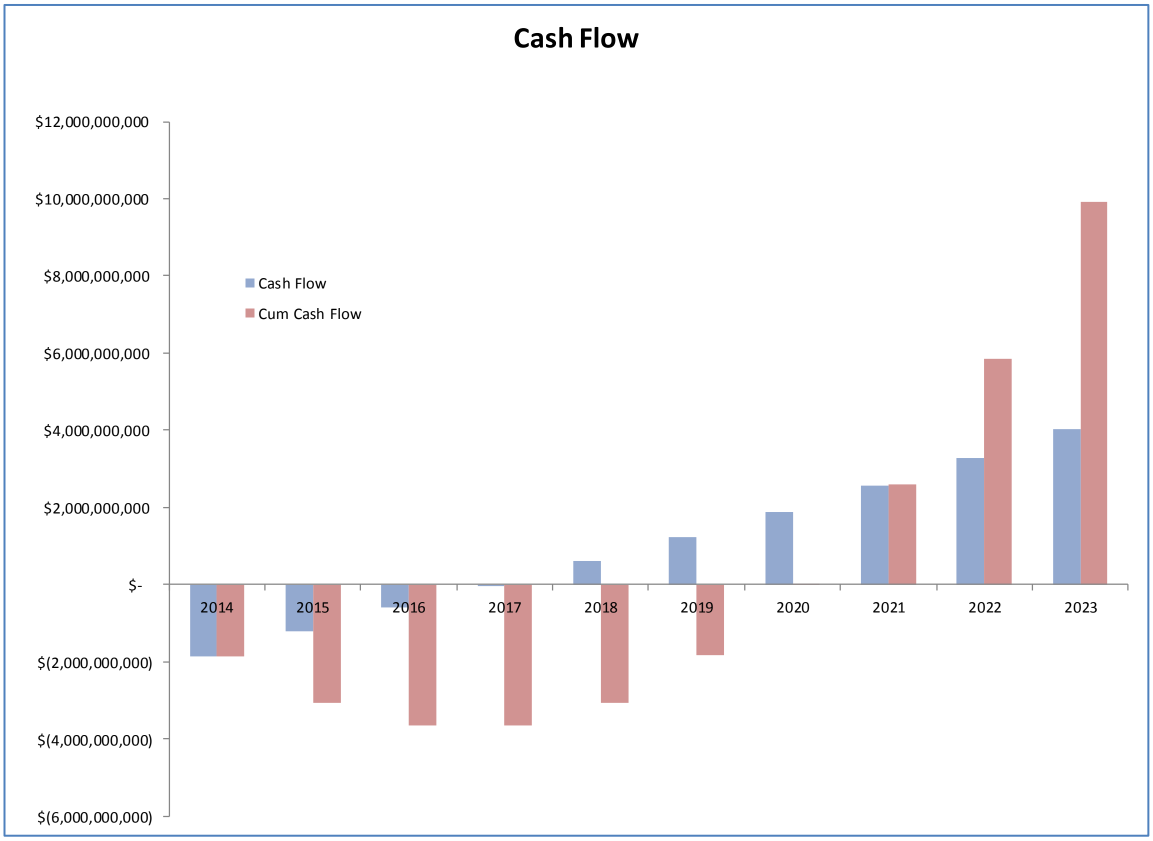


Figure 7-2: Forecasted Impact on Cash Flow

As shown in Figure 7-3 capital expenses are expected to go down over time as the cost of distributed renewable energy sources reduces on a MXN $/kW basis:

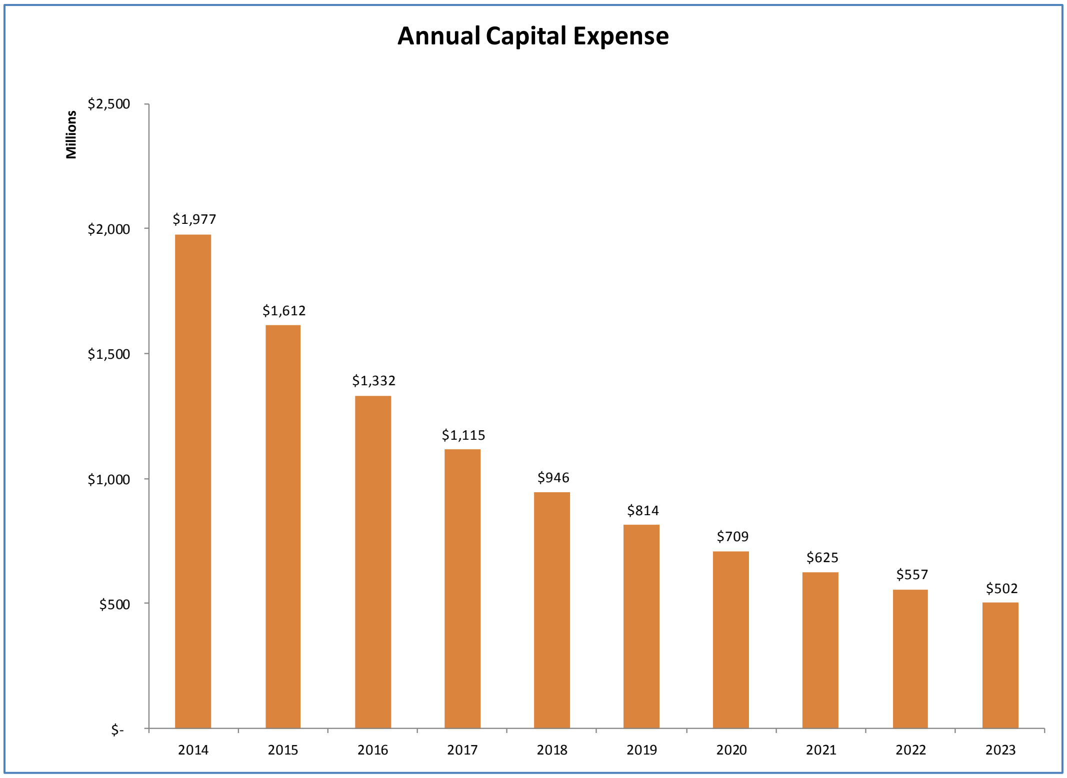


Figure 7-3: Forecasted Capital Expenses

With the findings of the study, key elements of the benefit potential of this program include:

- Fuel cost savings – By integrating renewables onto the grid in an integrated fashion (one that involves effective ramping of the resources), we can reduce the dependence on traditional fuel sources and the associated expenses
- Frequency regulation – Some Renewable Energy resources provide support for regulation.
- Synchronized reserves – The renewable energy program will allow us to power sources that can increase output immediately in response to a major generator or transmission outage
- Distribution and generation deferral – The reduction of system peak required of traditional system assets can allow for the deferral of investments in distribution networks and generation resources

Figure 7-4 and Figure 7-5 below are two illustrations of the top five benefits forecasted for such initiative:

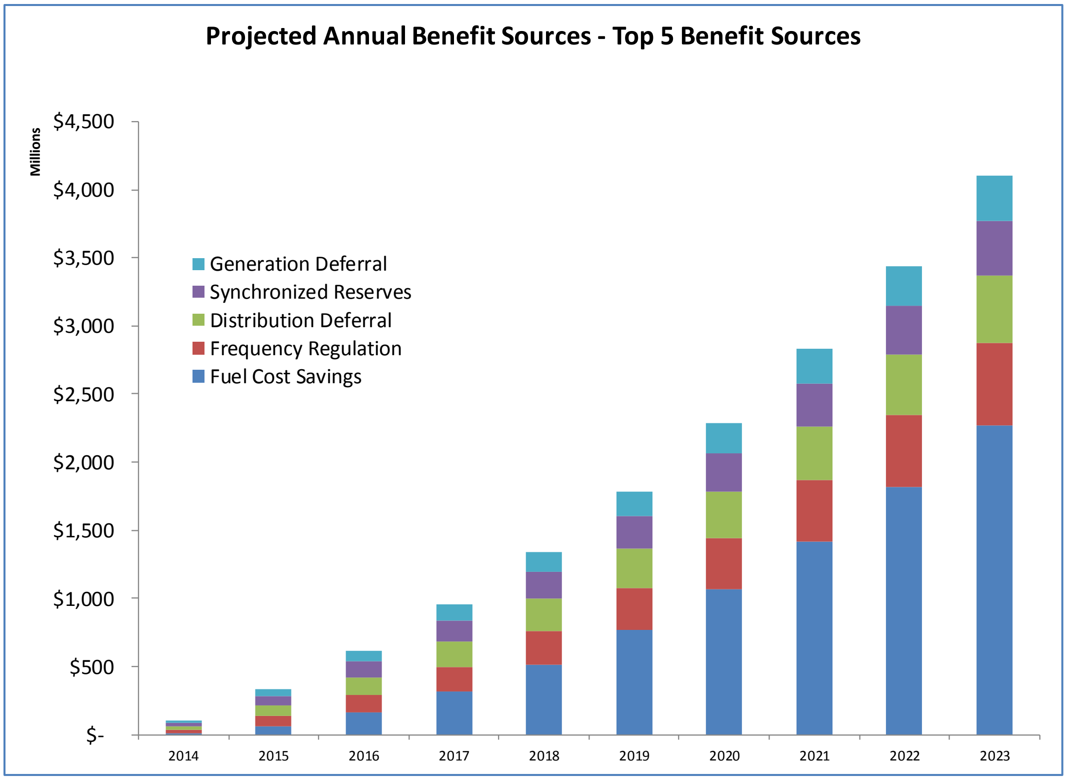


Figure 7-4: Projected cumulative annual benefits from top five benefit sources

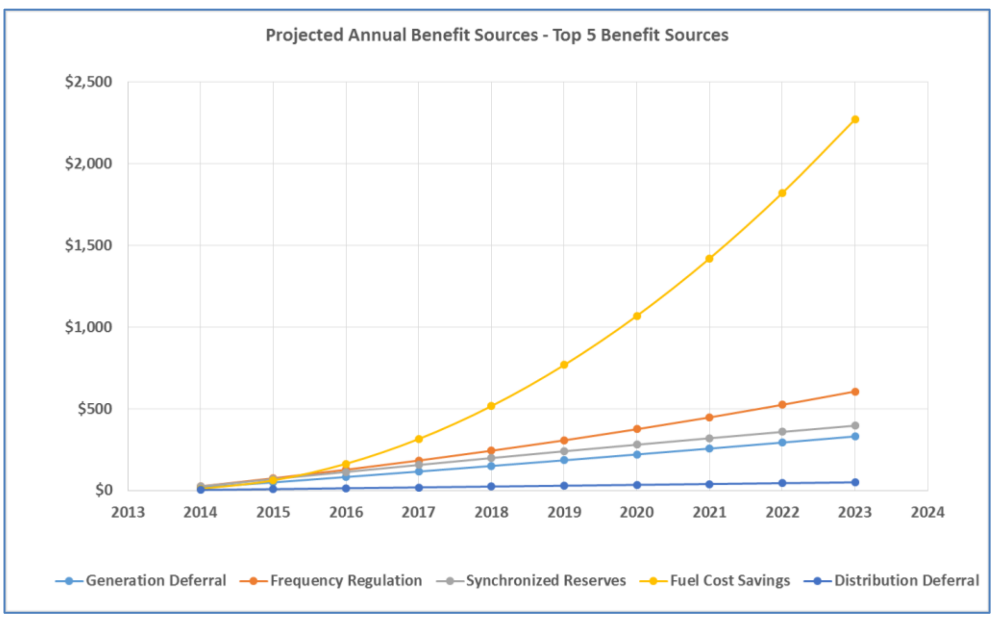


Figure 7-5: Projected annual benefits from each of the top five benefit sources

7.3 EVALUATION OF SMART GRID PROGRAM

Electric utilities have historically extracted as much value and efficiency as possible with manual controls. Today, however, we see a major shift in the thinking within the electric utility industry as it approaches the issue of building the electric infrastructure to ensure reliable and cost effective electric service given a set of challenges all occurring at the same time at the international level:

- Industry experts estimate that losses to the economy due to outages, quality disturbances and other events total in the hundreds of thousand millions annually, calling for an acceleration of turnover of capital assets, including generation, transmission, and distribution facilities.
- Challenging financial times are calling into question how electric utilities can continue to access the capital needed to keep pace with projected system requirements given the constraints of today's legacy electric grid[233].
- Fluctuating fuel costs and capacity costs from coal and natural gas prices at the same time threatens to result in a significant economic shock to consumers.
- While the presence of evolving technologies offer opportunities to explore new approaches to effectively deliver electricity to consumers, electric utilities are often hamstrung by the roadblocks presented by operating grids that are in many ways not designed to integrate with new technical approaches.

This set of issues – all occurring at the same time – presents a form of "perfect storm" that challenges the electric utility industry to identify the optimal approach for delivering cost effective and reliable electricity to customers in the 21st century. The "Smart Grid" – a way of adding intelligence and new protocols to the electric grid – is seen by many as the way to attack the challenges within the industry. While the specific components of any given smart grid can vary based on the unique needs of a given area or infrastructure, there are some common hallmarks of smart grid deployment:

- An increase in digital controls across the grid rather than a continued emphasis on electromechanical and/or analog systems
- Robust two-way communications across the grid that allows the electric operator to see and respond to events on the line
- Systems that allow the electric utility to work with distributed generation and energy storage rather than conventional central generation alone
- Systems that allow for system operators to interact with the entire electric network rather than isolated components
- Increasing numbers of monitors and sensors throughout the electric grid
- Increasing system capabilities that provide for full monitoring and an elimination of the large number of "blind" spots throughout the network
- Restoration systems that are based on real-time information that direct utility workforce to the problem at hand, rather than relying on purely manual restoration methods
- Systems that provide for adaptive protection and system islanding to avoid the tendencies toward system failures and blackouts
- Systems that remotely check equipment out on the grid and eliminate the dependence on manual inspections
- The establishment of automated decision support systems and predictive reliability

[233] For the purpose of this analysis, we assume that the entire Mexican grid would be further modernized. However, a more detailed operational analysis may suggest that a more limited modernization effort could result in a stronger business case option.

- More pervasive control systems that provide system operators with greater control over power flows
- Full price information being transmitted to customers
- Greater degree of customer choice in the consumption of electricity

The Electric Delivery System is comprised of all the physical components that produce, transport, distribute and use electricity, such as generators, transmission and distribution lines and end use devices. It also includes all the devices that sense and control the flow of electricity through the delivery system, such as switches, fault current limiters, capacitors, and other line devices.

The Information/Intelligence System is comprised of the data generated by the sensors and controls, the communications architecture used to communicate the data, and the planning and management processes (and possibly, the software systems) that use the data.

As shown in Figure 7-6 , a key feature that makes the grid "smart" is its ability to communicate seamlessly between these two parallel systems at every level, including end-use consumption.

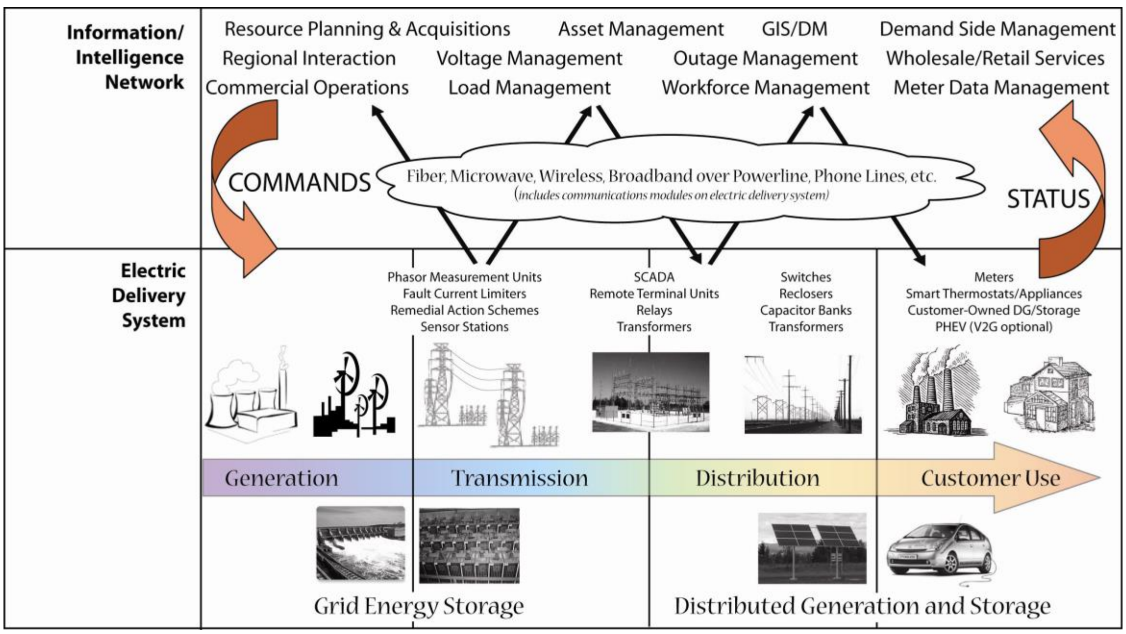


Figure 7-6: High Level Smart Grid Framework

7.3.1 MODELING APPROACH

For the smart grid evaluation, we have developed an additional financial and operational model that allows us to measure the potential impact of programs within the scope of (a) transmission, (b) distribution, and (c) customer load. Specifically, we have analyzed the opportunity as it pertains specifically to the Mexican grid. In each element of the analysis, we gathered pertinent data related to aspects of the Mexican electric grid and therefore performed modeling exercises that were pertinent to the likely opportunity in Mexico.

In order to develop the financial analysis of a potential program, a modeling approach was utilized that allowed evaluation of the potential economics of a proposed Smart Grid deployment. The key steps involved are:

1. Measured the potential benefits of each of the selected system automation programs in transmission (synchrophasors, line temperature sensing, substation predictive maintenance, SCADA upgrade), distribution (AMI, connect/disconnect, fault detection, voltage monitoring, phase and load balancing, feeder gateway temperature monitoring), and customer programs (energy demand management, distributed energy resources, customer service)
2. Evaluated the capital costs for each program and evaluated the associated annual depreciation charges
3. Constructed a 20-year forecast model to evaluate the overall projected economics for the enterprise

Table 7-5: Program Controls Built into Model

Transmission	
	On/Off
Synchrophasors	On
Line Temperature Sensing	On
Substation Predictive Maintenance	On
SCADA Upgrade	On

Distribution	
	On/Off
AMI	Sparse
Connect/Disconnect	Sparse
Fault Detection	Sparse
Voltage Monitoring	On
Phase and Load Balancing	On
Feeder Gateway Temperature Monitoring	On

Customer	
	On/Off
Energy Demand Management	On
Distributed Energy Resources	On
Customer Service	On

7.3.2 Model Assumptions

The tables below illustrate the assumptions utilized in the Smart Grid modeling analysis (note – all financial figures are listed in Mexican Pesos):

Table 7-6: Base Assumptions

Demographics		
Growth Rate		
Meters		2.8%
Load		3.5%
Substations		3.5%
Feeders		2.0%
Meters		
Residential		33,311,490
Commercial		3,701,822
Industrial		285,840
Mines		-
Other		-
Annual Sales ($MM)		
Residential	$	60,702.1
Commercial	$	40,625.8
Industrial	$	189,475.6
Mines	$	-
Other	$	-
Electric Delivery (MM kWh)		
Residential		52,557
Commercial		13,734
Industrial		120,561
Mines		-
Other		-
System Peak (MW)		
Summer		40,271.0
Winter		34,549.0

Infrastructure	
Mainline Feeders	10,148
Distribution Transformers	1,327,958
Distribution Transformers - Other	-
Substations	1,899
Substation Transformers	2,639
Generation Sites	-

Table 7-7: Transmission Assumptions

Synchrophasors		
Revenue Loss Reduction		
Customer Minutes Out		1,570,294,299
Diagnosis & Response %		60.0%
Repair %		40.0%
Reduction in Diagnosis & Response Time		10.0%
Reduction in Repair Time		10.0%
Lost Revenue Per Minute	$	0.0500
Marginal Energy Cost		36.2%
Labor Savings		
Annual Outages		10,000
Labor Hours per Outage		2.89
Labor Rate	$	250.00

Line Temperature Sensing		
Line Maintenance		
Annual Maintenance CapEx	$	60,000,000
Annual Maintenance OpEx	$	10,000,000
Reduction Rate		15.0%
Outage Impact		
Customer Minutes Out		1,570,294,299
Transmission Outage Rate		2.0%
Reduction Rate		15.0%
Lost Revenue Per Minute	$	0.0500
Marginal Energy Cost		36.2%

Substation Predictive Maintenance		
Maintenance Budget Reduction		
Annual Maintenance CapEx	$	60,000,000
Annual Maintenance OpEx	$	10,000,000
Current Predictive Maintenance Rate		20.0%
Potential Predictive Maintenance Rate		60.0%
Current Annual Savings	$	1,000,000

SCADA Upgrade		
Substation Inspection		
Annual Inspection Expense	$	8,000,000
Reduction Rate		40.0%
Capital Efficiency		
Annual Upgrade Budget	$	5,000,000
Reduction Rate		1.5%

Table 7-8: Distribution Assumptions (Part 1)

AMI		Replace		Upgrade		Sparse
Meter Reading						
Meter Reading Cost	$	6.00	$	6.00		-
Read-To-Bill						
Average Days to Accelerate Collection		2.00		2.00		0.40
Tamper						
Estimated Tampering Loss	$	13,000,000,000	$	13,000,000,000	$	13,000,000,000
Projected Billing Enhancement		25.0%		25.0%		12.5%
Meter Calibration						
Usage Lost in Faulty Calibration	$	25,000,000	$	25,000,000	$	25,000,000
Expense Reduction		75.0%		0.0%		15.0%
Vacant Premise						
Vacant Premise Revenue		1,000,000,000		1,000,000,000		1,000,000,000
Expense Reduction		30.0%		30.0%		6.0%
Faulty Meters						
Percentage of Electromechanical Meters		27.0%		27.0%		27.0%
Slow:Fast Meter Ratio		9		9		9
Average Faulty Meter Loss Rate		2.1%		2.1%		2.1%
Inaccurate Meter Rate		3.2%		3.2%		3.2%
Expense Reduction		100.0%		0.0%		20.0%
Meter Testing						
Meters Tested per Year		-		-		-
Meter Testing Cost	$	-	$	-	$	-
Expense Reduction		0.0%		0.0%		0.0%
Special Reads						
Annual Special Reads		17,736		17,736		17,736
Cost per Special Read	$	70.00	$	70.00	$	70.00
Expense Reduction		90.0%		90.0%		18.0%
OK on Arrival						
Number of OK on Arrival Visits		250,000		250,000		250,000
Cost per Truck Roll	$	250.00	$	250.00	$	250.00
Expense Reduction		50.0%		50.0%		10.0%
Fleet Savings						
Meter Reading Vehicles		2,000		2,000		2,000
Operating Cost per Vehicle	$	50,000	$	50,000	$	50,000
Vehicle Reduction Rate		90.0%		90.0%		0.0%
Emissions						
Average Number of Miles per MR Vehicle		-		-		-
Number of MR Vehicles		-		-		-
Vehicle Reduction Rate		0.0%		0.0%		0.0%
CO_2 Reduction per Mile (grams)		-		-		-

Connect/Disconnect		Replace		Upgrade		Sparse
Labor Reduction						
Annual Disconnect Activities		4,182,324		4,182,324		4,182,324
Annual Field Collector Expense	$	10,000,000	$	10,000,000	$	10,000,000
Disconnect Reduction		90.0%		90.0%		18.0%
Bad Debt Reduction						
Annual Bad Debt	$	4,608,947,650	$	4,608,947,650	$	4,608,947,650
Loss Reduction		25.0%		25.0%		5.0%
Emissions						
Field Collection Vehicles Impacted		-		-		-
Average Number of Annual Miles per Vehicle		-		-		-
CO_2 Reduction per Mile (grams)		-		-		-

Table 7-9: Distribution Assumptions (Part 2)

Voltage Monitoring

Loss Reduction		
Line Losses (kWh)		20,553,685,075
Average Cost to produce 1 kWh	$	0.500
Expected decrease in loss with automation		10.7%
Optimization Potential		25.0%
Capacity Reduction		
Line Loss Rate		11.00%
Nominal Voltage Optimization		
Voltage Basis		120.00
System Optimization Voltage Reduction		2.25
Optimization Potential		5.0%
Average Cost to produce 1 kWh	$	0.500
Emissions		
Peak Usage Impact		0.0%
Average CO_2 emissions (grams) per kWh		-

Phase and Load Balancing

Loss Reduction		
Distribution Line Losses (kWh)		20,553,685,075
Reduction in Line Losses from Phase Balancing		1.0%
Reduction in Line Losses from Load Balancing		2.0%
Average Cost to produce 1 kWh	$	0.500
Emissions		
Peak Usage Impact		0.0%
Average CO_2 emissions (grams) per kWh		-

Feeder Gateway Temperature Monitoring

Capacity Reduction	
Capacity Reduction Potential	26.9%
System Impact	10.0%
Utilization Rate	4.2%

Fault Detection

	FDIR	Sparse
Feeder Outages		
Feeder Related Outages	2,500	2,500
Labor Hours per Feeder Outage	10.00	10.00
Labor Reduction Rate	50.0%	25.0%
Labor Rate	$ 250.00	$ 250.00
Distribution Element Failure Detection		
Annual Element Failures	50,000	50,000
Failure Detection Rate	50.0%	25.0%
Replacements Conducted During Overtime	25.0%	25.0%
Labor Hours per Replacement	18.0	18.0
Normal Labor Rate	$ 250.00	$ 250.00
OT Labor Rate	$ 375.00	$ 375.00
Transformer Optimization		
Average Transformer Life	30	30
Transformer Life Extension	10.0%	5.0%
Transformer Cost	$ 140,000	$ 140,000
Conductor Repair		
Conductor Failures per Year	7,500	7,500
Cost per Conductor Splice	$ 7,500	$ 7,500
Reduction Rate	50.0%	25.0%
Outage Management		
Customer Minutes Out	1,570,294,299	1,570,294,299
Diagnosis & Response %	60.0%	60.0%
Repair %	40.0%	40.0%
Reduction in Diagnosis & Response Time	30.0%	15.0%
Reduction in Repair Time	12.0%	6.0%
Lost Revenue Per Minute	$ 0.0500	$ 0.0500
Marginal Energy Cost	36.2%	36.2%
General Outages		
Annual Outages	200,000	200,000
Labor Hours per Outage	2.89	2.89
Labor Rate	$ 250.00	$ 250.00
Reduction in Repair Time	25.0%	12.5%

7.3.3 MODELING RESULTS

Our financial modeling approach analyzed and calculated incremental financial impacts relative to the forward-looking cost structure of where CFE will be if it continues along without the smart grid (business as usual). That is, we measured financial performance relative to where the utility would be without smart grid at each point in time rather than where it is today. In effect, each stakeholder must consider the cost of a 'non-Smart grid strategy'. Once this assessment has been completed, we can consider the true value proposition of the Smart Grid versus a 'Do Nothing' Strategy.

From a technology point of view, smart grids are all about applying new technologies to reduce the cost, increase efficiency and improve the quality and reliability, of electric service. We consider five key technologies that are the essence of the smart grids, and we have adopted this same perspective to elaborate a definition of "the" smart grid. The five aspects of the smart grid effort are as follows[234]:

- **Integrated communications** - Connecting all the components of the electric grid, through open architectures, which will provide for real-time information and control of the grid and thus allowing every component to both "talk" and "listen".
- **Sensing and Measurement** – Devices that sense and measure various aspects of grid operation and thus support faster and more accurate response such as remote monitoring of voltage, current, phase angles, etc.
- **Advanced Components** – Applying the latest technologies that reduce line losses, storage that allows for the use of off-peak generation to meet peak period requirements, and power electronics and diagnostics that will improve the operation and efficiency of the grid.
- **Advanced Controls** – Monitoring essential components in real-time and thus, enabling early detection and rapid diagnosis in order to provide precise solutions appropriate to any event before they can cascade into bigger problems.
- **Improved Interfaces and Decision Support** – Improving human decision – making by providing grid operators and managers with the information and ability to enable them to operate as visionaries when it comes to seeing into their systems.

Based on the analysis conducted on data gathered from CFE, we forecast that the overall smart grid business case for CFE offers the potential to add significant value for the key stakeholders involved:

- NPV = MXN $34.0 thousand million pesos
- Internal Rate of Return = 11.9%
- 20-Year Capital Expense = MXN $169.6 thousand million pesos

Figure 7-7 through Figure 7-11 show the results of the analysis.

[234] This framework comes from the U.S. Department of Energy. While any Mexican smart grid deployment would not necessarily follow the U.S. framework, we do agree that this is a useful way to view any smart grid planning effort, regardless of geography.

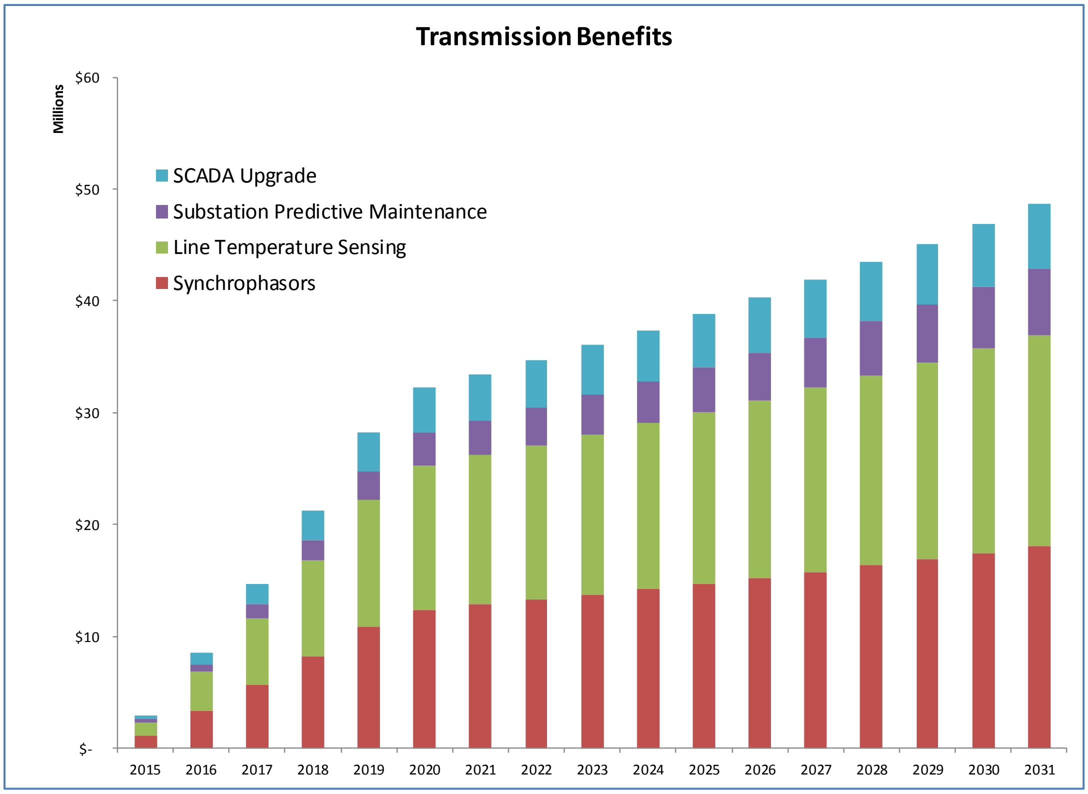


Figure 7-7: Forecasted Transmission Benefits

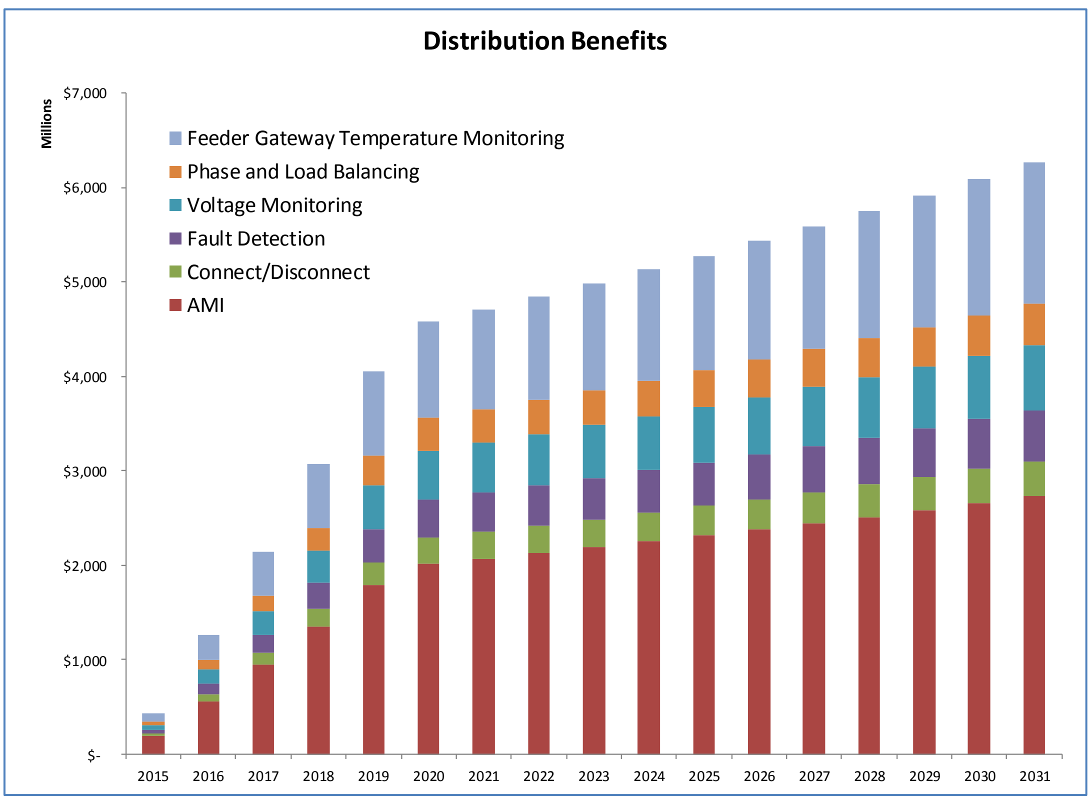


Figure 7-8: Forecasted Distribution Benefits

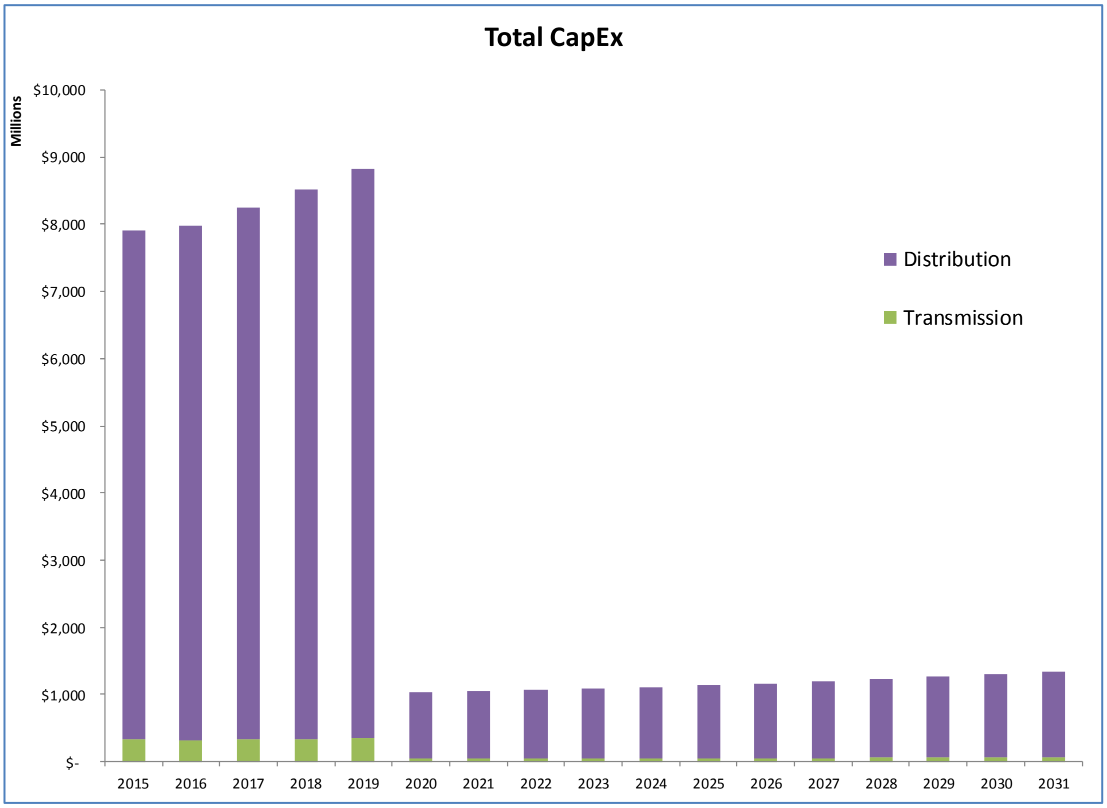


Figure 7-9: Forecasted Capital Expenses Budget

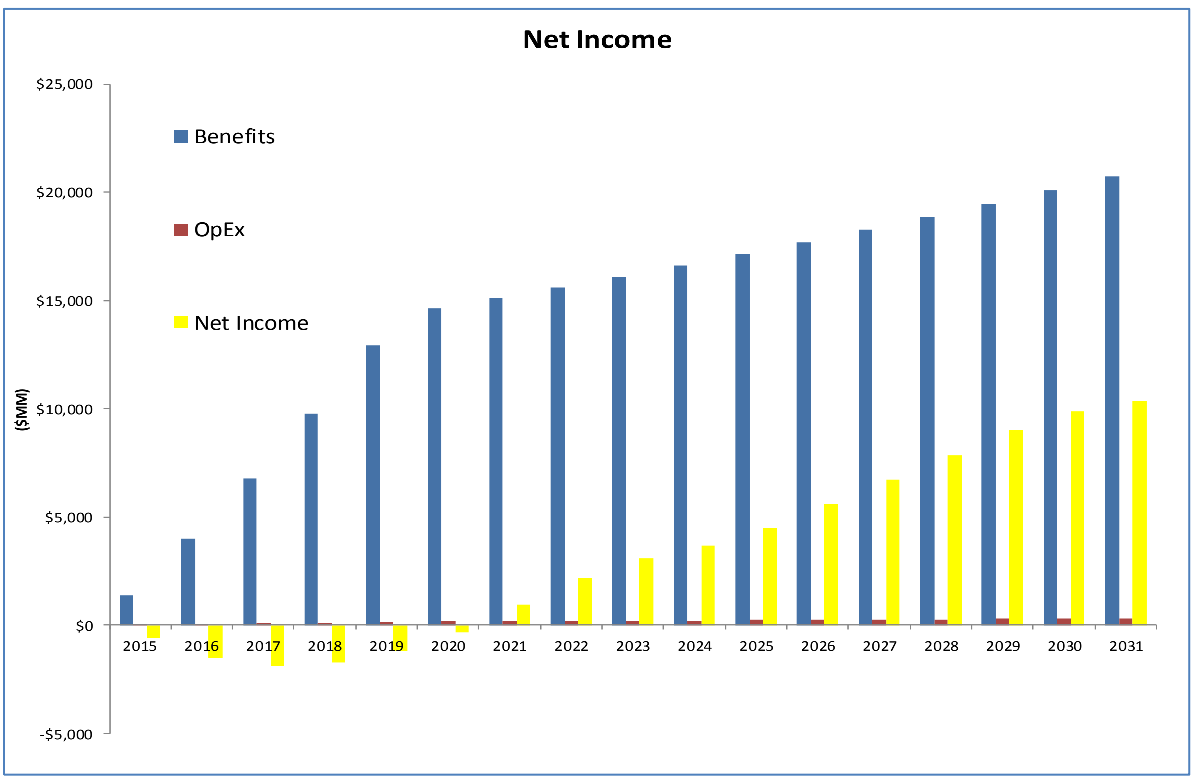


Figure 7-10: Forecasted Net Income Impact

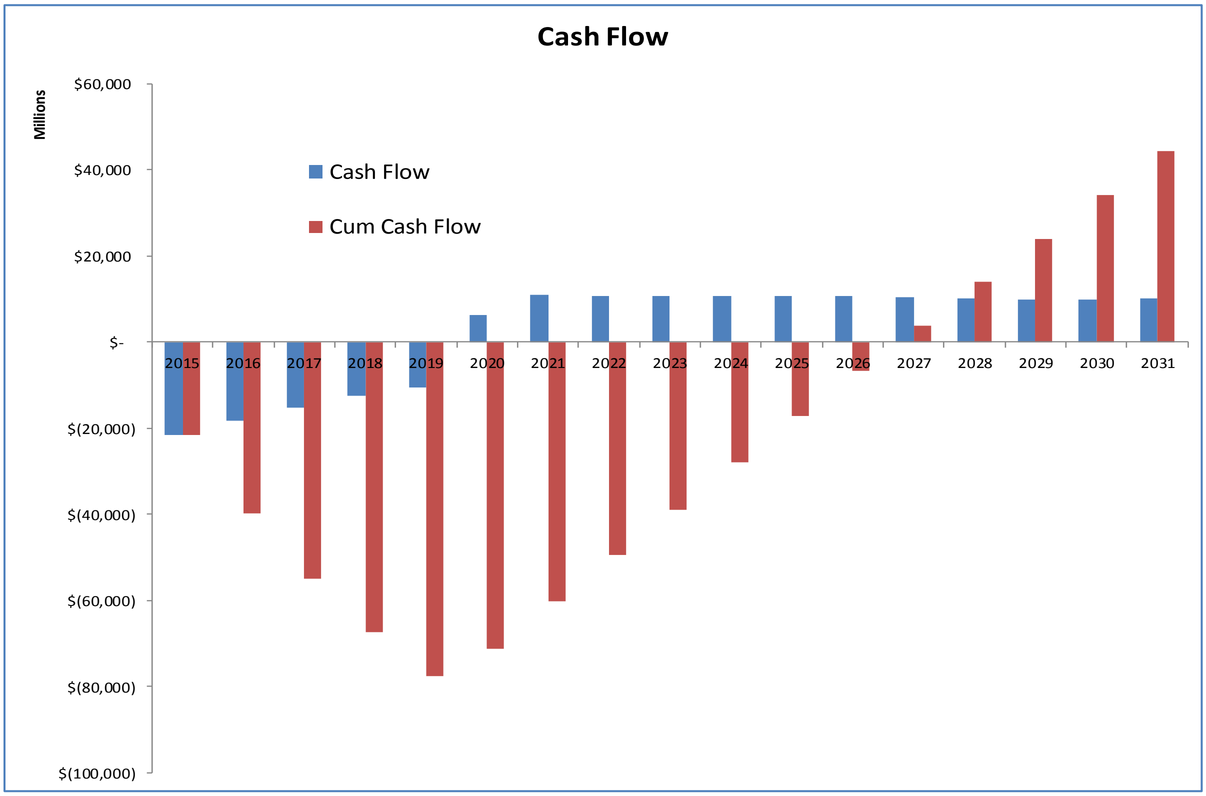


Figure 7-11: Cash Flow

7.4 OBSERVATIONS AND RECOMMENDATIONS

The evaluation of the smart grid and renewable energy programs in Mexico suggest that significant value can be created.

In developing a dedicated renewable energy program, we see large potential benefits stemming from reductions in fuel cost expenditures. Beyond that, we also see significant benefits coming from deferral of distribution network requirements and reductions in requirements for synchronized reserves and frequency regulation.

On the smart grid initiative, the largest benefits stem from the opportunities associated with automation distribution operations. The single largest source of value stems from automating the meter reading process, moving from a manual read to an automated process with a digital architecture. Other significant benefits also are derived from developing feeder gateway temperature monitoring and voltage monitoring programs, with additional value coming from fault detection and phase and load balancing. The projected benefits for the transmission network are far smaller; nevertheless there are viable opportunities in developing line temperature sensing capabilities and by deploying synchrophasors.

The total value proposition for both the smart grid program and the renewable energy initiative exceeds MXN $50 thousand million pesos relative to a “do nothing” strategy. Based on the high value proposition of these programs, we recommend further operational efforts to commence.

Task 1 SWOT analysis identified the Strengths, Weaknesses, Opportunities and Threats as related to the Mexican Power Grid. Task 2 provided Policy recommendations to facilitate development of Smart Grid while Task 3 provided recommendations to encourage Smart Grid investments in Mexico all focused on the actions that could be taken by CRE in developing Smart Grid in Mexico.

The financial analysis performed in this Task includes various Smart Grid components beyond regulatory issues. Some of the key observations and recommendations from the analysis undertaken in this report are highlighted below.

- Working with the Mexico Smart Grid Network, refine the Smart Grid vision with input from various stakeholder groups.
- Embark on a more detailed assessment of the potential of these programs based on physical infrastructure characteristics of the Mexican electric grid. This will allow us to validate the preliminary estimates and support the development of a detailed operational program.
- Use the results of the operational study to guide the implementation of planning efforts focused on specific program areas. This step provides the next level of detail that will ultimately be required to support a system implementation phase.
- Identify additional areas (beyond those already undertaken by CFE) areas where a dedicated pilot would be warranted prior to embarking on a full system-wide deployment. Since a full-scale deployment will take significant time and funds, the first step is to learn about the true system potential with a limited scale pilot phase.
- Work to ensure that programs adopted demonstrate the system's ability to interface with existing applications. The goal of any system automation effort will be to achieve system efficiencies; these efficiencies cannot manifest themselves unless new systems are successfully integrated into the existing operating environment seamlessly.
- Promote development of a telecommunications plan that will support future desired applications in both size and scope. Without a reliable communications network it will impossible to capture the benefits laid out in this study.
- Assess the current information management network and identify potential improvements for future growth; create a plan to address them. Alongside the need for a robust communications network, the integration of a complete data management system is equally important.
- Any decisions made should be vetted for their potential impact on future Smart Grid potential. Propriety systems that lock the utility out of future programs should be avoided; system flexibility is of utmost importance.
- Identify the specific areas of benefit that should be pursued and their value potential. Programs should be deployed at "the speed of value", suggesting a staggered deployment scenario.
- Test those components for compatibility, suitability, and financial impact. Each decision regarding the direction of the network deployment involves financial and technical impacts that should be considered at each step in the process.
- Track the achieved benefits to use as assumptions in the operational effort. It will important to make sure that costs and benefits are tracking with forecasts or identify challenges that are hindering this effort.
- Implement viable technologies and applications. Each system deployed should have been proven elsewhere, thereby lowering technology risks.
- Track results and maintain project alignment. This will allow for course correction at each step in the process.
- Reassess new opportunities as needed

8 TASK 6 – IMPLEMENTATION FINANCING

Task 6 **Implementation Financing**

The focus of Task 6 was to conduct preliminary inquiries with prospective financial institutions that could provide debt and equity financing or loan guarantees for smart grid projects in Mexico. These financial institutions shall include, but not be limited to, the Inter-American Development Bank, the World Bank (including the International Bank for Reconstruction and Development for public sector projects and the International Finance Corporation for private sector projects), and the Export-Import Bank of the United States.

This chapter provides:

- Overview of leading multi-lateral financing institutions (World Bank, International Finance Corporation, Inter-American Development Bank, US OPIC, and US Ex-Im Bank) and sample of projects supported by these organizations based on interviews and market research.
- Key contacts at these institutions active in Mexico
- Observations

8.1 CONTACTS AND SOURCES OF INFORMATION

8.1.1 CONTACTS

During this this tasks, ESTA international interviewed the responsible individuals at key institutions as shown in Table 8-1 below.

Table 8-1: Contacts and Sources of Information

Craig O'Connor, Director of Business Development – Alternative Energy Group Project & Structured Finance Division Export-Import Bank of the United States 811 Vermont Avenue, NW Washington, DC 20571 (O) 202) 565-3556 (direct)	Robert W. Sexton Director Overseas Private Investment Corporation 1100 New York Avenue, NW Washington DC 20527 (O) 202.408.6240 (C) 202.436.6409 E-mail: robert.sexton@opic.gov

<table>
<tr><td>E-mail: craig.oconnor@exim.gov
Web: www.exim.gov</td><td>Web: www.opic.gov</td></tr>
<tr><td>IFC International Finance Corporation WORLD BANK GROUP

Gabriel Goldschmidt
IFC Senior Manager for Infrastructure in Latin American and the Caribbean
Infrastructure Department
International Finance Corporation
2121 Pennsylvania Ave., NW
Washington, DC 20433
Tel: +1 (202) 473-7732. Fax: +1 (202) 974-4307
E-mail: Ggoldschmidt@ifc.org
Web: www.ifc.org</td><td>WORLD BANK GROUP Energy & Extractives

Guillermo Hernández González
Energy Specialist
Energy & Extractives
México City, México
T +52 (55) 5480 4210
E-mail: ghernandez9@worldbank.org
Web: www.worldbank.org</td></tr>
<tr><td>IDB Inter-American Development Bank

Arnaldo Vieira de Carvalho
Lead Energy Specialist, Energy Division
Infrastructure and Environment Sector
Inter-American Development Bank (IDB)
1300 New York Avenue, N.W.
Washington, D.C. 20577 USA
Tel: 202-623-1719
E-mail: arnaldov@iadb.org</td><td></td></tr>
</table>

8.1.2 Sources of Information

In addition to interviews with key responsible individuals at the aforementioned institutions, ESTA also preformed extensive market research. This included the use of resources available on world-wide-web as well as reports by various institutions and project descriptions related to key projects.

During this research, ESTA reviewed two excellent reports, each with a wealth of information regarding financing renewable energy projects in Mexico as listed below. Interested parties are encouraged to review these reports.

- "*Market Study of Sustainable Energy Finance in Mexico*", by the International Finance Corporation published in 2012[235]
- "*Mexico, Final Report, Product 3: Financial Mechanism*" Observatory of Renewable Energy in Latin America and The Caribbean, by Latin-American Energy Organization (Olade), UNIDO. August 2011[236]

[235] http://www.ifc.org/wps/wcm/connect/96f316004cf49988afa3eff81ee631cc/October+2012-Market+Study+of+SEF+in+Mexico-EN.pdf?MOD=AJPERES

[236] http://www.renenergyobservatory.org/uploads/media/Mexico_Product_3__Eng_.pdf

8.2 Overview of the Financial Institutions

8.2.1 International Finance Corporation

The International Finance Corporation (IFC) – www.ifc.org is a member of the World Bank Group responsible providing financing support for the public sector. IFC stated vision is twofold: 1) end extreme poverty by 2030; and 2) boost shared prosperity in every developing country. IFC finances and provides support for projects that help the environment in support of this vision. As such, Renewable Energy projects have been a global focus of IFC for the past several years.

Mexico is a key country partner for IFC where renewable energy investments have focused on wind and solar energy. The new market reform also may encourage more private investment and hence opportunities for IFC to support the development of the energy sector in Mexico.

IFC helps offer a complete financing solution by bringing other operators and financiers to support the financing of projects. Typically IFC does not finance more than 25%. Each request for funding is reviewed based on its merit and currently IFC does not have a regional funding limit such that funding in one country would reduce the potential funding for another country in the region requiring trade-off. The presence of IFC also helps gain support from other financial institutions.

Recent IFC financing activities in Mexico include

- The Aura Solar Project – US$ 25 million loan for construction and operation of US$ 75million, 30 MW greenfield photovoltaic power plant in La Paz Baja California Sur[237]. It is the first utility scale project in Mexico and the largest photovoltaic plant in Latin America. It was connected to the Mexican electric grid in March 2014. IDB is also involved with this project. It was the winner of the IDB Climate and Environment Award.[238]
- EDF La Ventosa Project[239] - US$ 31.23 million loan67.5 MW Wind power plant located in Oaxaca. This project includes $21.93 million financing from the Inter-American Development Bank[240].
- EURUS Project[241] - IFC provided US$ 75 million loan for construction of a 250.5 MW wind farm in the Juchitan de Zaragoza Municipality of the state of Oaxaca. The total cost of the project is US$600 million. For this project, IFC participated with ten other lenders including BBVA Bancomer, Banco Espirito Santo, Banco Interamericano de Comericio Exterior, Insituto de Credito Oficial (Spain), DEG (Germany), Nacional Financiera, and Proparco (France)[242].
- Optima project[243] - $10 million loan to expand energy efficiency in more hotels in Mexico.

A report titled "Market Study of Sustainable Energy Finance in Mexico", by the International Finance Corporation published in 2012 provides a wealth of information regarding energy financing in Mexico.[244]

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237 http://ifcext.ifc.org/IFCExt/spiwebsite1.nsf/0/8750F8FE100815C585257B0C0057EEB2
238 http://www.iadb.org/en/structured-and-corporate-finance/scf-360awards/winners-2014,9661.html
239 http://ifcext.ifc.org/ifcext/spiwebsite1.nsf/0/81aceb3c99869a77852576ba000e32e3
240 http://www.iadb.org/en/projects/project-description-title,1303.html?id=me-l1076
241 http://ifcext.ifc.org/ifcext/spiwebsite1.nsf/ProjectDisplay/SPI_DP28434
242 http://www.aurasolar.com.mx/Administrador/presentaciones/72.pdf
243 http://www.ifc.org/wps/wcm/connect/3bbd7780478ce176bdd5bf86d3bfc329/Optima.pdf?MOD=AJPERES
244 http://www.ifc.org/wps/wcm/connect/96f316004cf49988afa3eff81ee631cc/October+2012-Market+Study+of+SEF+in+Mexico-EN.pdf?MOD=AJPERES

8.2.2 THE WORLD BANK

The World Bank is a Multi-lateral Development Bank supporting infrastructure and development projects in middle income and low income countries around the globe. The World Bank has had active involvement in Mexico for many years and has supported projects for Renewable Energy, Energy Efficiency, Carbon Capture and Sequestration, and Global Gas Flare deduction.

The World Bank requires sovereign government guarantees for providing loans. As this has not been possible for CFE, the World Bank funding has been in conjunction with other programs and through development institutions such as NAFIN and BANOBRAS. The World Bank has mostly worked at the Federal level but is recently engaging in projects with some states and local entities such as Oaxaca and Mexico City government.

World Bank financing activities in Renewable Energy sector have included support for both solar and wind projects. Solar projects include both solar Photo Voltaic (PV) in isolated mini-grids in rural electrification and Concentrated Solar Power (CSP)

Some projects financed by the World Bank include:

- La Venta II Project which consists of two components below[245]
  - Purchase of carbon emissions reductions
  - Wind energy power plant and interconnection line
- Very successful residential energy efficiency program which included exchange of 22.9 million bulbs with Compact Florescent Light (CFL) as well as more energy efficient refrigerators and air conditioning[246]. Mexico received a Guinness world record for this effort[247].
- Urban Energy Efficiency project – to improve energy efficiency in smaller municipalities[248].
- A CCS project with two phases; capacity building and construction
- Gas Flare Project – supporting PEMEX to reduce gas flaring.
- Renewable Energy Project in the agriculture sector –Solar PV in greenhouses as well as support for agribusinesses[249,250,251].

The World Bank is also interested in Micro-grid projects in Mexico. It is supportive of projects that meet its two key mandates of reducing poverty and increasing prosperity.

8.2.3 INTER-AMERICAN DEVELOPMENT BANK (IDB)

The Inter-American Development Bank (IDB) – www.iadb.org like the World Banks is a multi-lateral Development Bank supporting infrastructure and development projects in middle income and low income countries. However, IDB focus is countries in Latin America and the Caribbean.

245 http://www.worldbank.org/projects/P080104/mexico-wind-umbrella?lang=en
246 http://www.worldbank.org/projects/P120654/mx-gef-efficient-lighting-appliances?lang=en
247 http://www.worldbank.org/en/news/feature/2012/08/01/foco-a-foco-mexico-consigue-record-guinness
248 http://www.worldbank.org/en/news/feature/2014/07/03/urban-energy-efficiency-key-to-mexicos-ambitious-goals-for-energy-and-low-carbon-growth
249 http://www.bancomundial.org/es/news/feature/2013/06/05/clean-energy-agriculture-mexico-environment
250 http://www.worldbank.org/en/news/press-release/2012/11/20/wb-mexico-promotion-green-growth
251 http://www.worldbank.org/projects/P106261/sustainable-rural-development?lang=en

IDB provides loans to private and public sectors (federal, state, and municipalities). Direct private sector loans are not possible unless through NAFIN or BANOEBRAS the leading two development banks in Mexico.

IDB has several projects under consideration at this time including over 30 solar PV systems in various regions. IDB has also supported geo-thermal projects in Mexico.
IDB also utilities Clean Technology Funds supported by funds from Australia, Japan, and countries.

Some active IDB projects in Mexico include:

- EDF-La Ventosa Wind Project – IDB is providing co-financing in the amount of US $21.93 million for a 67.5 MW wind farm in the La Ventosa region of the State of Oaxaca, Mexico. The project total estimate cost is US $190 million[252]
- EURUS Project – IDB was also a financing partner for the US $600 million EURUS project along with IFC and several other organizations.

IDB is receptive to Smart Grid and clean energy programs. It has already financed projects in Smart Grid in Chile, Ecuador, and Colombia.

While large developers are familiar with IDB, IDB is developing a mechanism to attract developers interested in smaller (less than30 MW) projects.

As with other institutions, IDB is closely monitoring the developments associate with Energy Reform. Mexico is a focus country for IDB[253].

8.2.4 EXIM BANK

The U.S. Export-Import Bank (Ex-Im Bank) www.exim.gov is the official export credit agency of the United States. Ex-Im Bank's mission is to assist in financing the export of U.S. goods and services to international markets[254]. As such, it provides financing support and loan guarantees for US manufactures and service providers[255]. Ex-Im Bank can make a credit decision about a potential project in one of three ways: as a corporate loan based on the balance sheet of the borrower; as a limited recourse project finance with a special purpose company borrower and project cash flows as the source of repayment; and, as a structured finance transaction with the borrower's balance sheet enhanced by special features[256,257].

Ex-Im Bank does not compete with private sector lenders but provides export financing products that fill gaps in trade financing. A condition for obtaining financial support from Ex-Im is the use of US products and service. Ex-Im helps to level the playing field for U.S. exporters by matching the financing that other governments provide to their exporters. It provides working capital guarantees, export credit insurance, loan guarantees, and direct loans[258]. The latter allows Mexican entities can receive loans to pay for US products

[252] http://www.iadb.org/en/projects/project-description-title,1303.html?id=me-l1076
[253] http://www.iadb.org/en/countries/mexico/mexico-and-the-idb,1048.html

[254] http://www.exim.gov/about/whoweare/
[255] http://www.exim.gov/generalbankpolicies/content/Services-Content-Policy.cfm
[256] Source: Ex-Im Bank Ex-Im Bank: Corporate, Structured, and Project Finance document
[257] http://www.exim.gov/products/loanguarantee/projectstructuredfinance/upload/intro_proj_fin.pdf
[258] http://www.exim.gov/about/whoweare/

and services. Ex-Im financing terms range from 2 to15 years for standalone energy projects and up to 18 years for Renewable Energy projects.

An example of Ex-Im support in Mexico is the US $780,000 loan to UPS Capital Business Credit to finance the export of photovoltaic solar panels by a US firm (Suniva, Inc.) to a Grupo Metal Intra S.A.P.I. de C.V. (GMI) - a leading company in the Mexican prefabricated building industry. This 10 year loan was made possible by utilizing medium-term buyer financing that is available to support smaller-scale renewable-energy projects The 500-kilowatt roof-top solar power project will be placed on the roof of GMI's main production plant in the city of Querétaro. The project will be one of the largest rooftop solar-energy facilities in Mexico[259].

8.2.5 OPIC

OPIC is the U.S. Government's development finance institution. It mobilizes private capital to help solve critical development challenges and in doing so, advances U.S. foreign policy. Because OPIC works with the U.S. private sector, it helps U.S. businesses gain footholds in emerging markets, catalyzing revenues, jobs and growth opportunities both at home and abroad. OPIC achieves its mission by providing investors with financing, guarantees, political risk insurance, and support for private equity investment funds[260].

Project funding by OPIC can range from US$10 million to $US 250 million. A condition of financial support is the presence of a US company with at least 25% equity in the project. OPIC does not work directly with state and federal authorities but with local companies to take power under long term power purchase agreements. Up to 75% of a project can be financed by OPIC.

In the energy sector, OPIC supports projects that can have environmental benefits to society, as such, it will not support project such as coal-fired power plants.

OPIC has supported projects in Mexico namely:

- Optima Energy project - OPIC has provided a US $50 million for 12 years to support development, installation, and implementation of energy efficient LED street lighting through the commercial leases with municipal customers. The Mexican recipient is Celsol S.A.P.I. de C.V. and the U.S. sponsor/partner is True North Venture Partners. The total project cost is US$67 million[261].
- Tres Mesas project[262] - It involves two wind farm projects both at the same site in the state of Tamaulipas, Mexico.
    - The first, for 62.7 MW will benefit from power purchase agreement with Sigma Alimentos S.A. OIC has provided $90 million investment guaranty with a term up to 19 years
    - The second, for 85.8 MW will benefit from power purchase agreement with Walmart de Mexico. The second project is co-financed by the North American Development Bank (NADB). OPIC has provided A $96 million OPIC local currency guaranty denominated in Mexican Pesos with a term up to 16.5 years

[259] http://www.exim.gov/newsandevents/releases/2013/ExIm-Bank-Approves-780000-Loan-Guarantee-To-Finance-US-SolarModule-Exports-to-Mexican-Rooftop-SolarPower-Project.cfm
[260] http://www.opic.gov/who-we-are/overview
[261] http://www.opic.gov/sites/default/files/files/optima-energia-info-summary-2013.pdf
[262] http://www.opic.gov/sites/default/files/files/Tres%20Mesa%201%20and%202%20Project%20Summary(1).pdf

OPIC is also monitoring the energy reform in Mexico closely.

8.3 Observations

Based on the interviews and market research the following observation can be made.

1. While the five organizations each have different chart and focus, all considered Mexico as one of their key financial partners.
2. The focus of several institutions is fund projects that improve the environment and enhance the social well-being of the Mexican citizens
3. The Energy Reform in Mexico is viewed positively – especially the potential for more private participation in the energy sector.
4. Often the institutions work in partnership with other organizations to provide financial funding. These include the Clean Investment Funds (CIF) Clean Technology Funds (CTF)), the Global Environmental Facility (GEF), Clean Development Mechanism (CDM), and others.
5. Other sources of reported funding for clean energy projects in Mexico include North American Development Bank (NADB), the German Development Bank (KfW), the European Investment Bank (EIB), Japan Bank for international Cooperation (JBIC)[263], and others.
6. Support for Renewable Energy projects, Energy Efficiency programs, Microgrids, and other related projects are of interest to all organizations.
7. Within Renewable Energy, wind and solar projects both large scale and small scale (such as roof-top solar) are of interest.
8. For public sector financing the local development banks in Mexico such as Nacional Financiera, S.N.C., (Nafin)[264] and Banco Nacional de Obras y Servicios Públicos[265], (Banobras[266]) have an important role in bridging foreign and local financing for projects.
9. One of the key barriers cited is the government subsidy of tariffs.

[263] Source: http://www.aurasolar.com.mx/Administrador/presentaciones/72.pdf

[264] "*The principal sources of Nafinsa's resources are loans from international development institutions such as the International Bank for Reconstruction and Development (IBRD) and the Inter-American Development Bank (IDB), lines of credit from foreign banks and the placement of securities in the international and domestic markets*". Source : http://www.nafin.com/portalnf/content/otros/english.html

[265] National Bank of Public Works and Services

[266] "*Banobras is the Mexican Development Bank in charge of promoting and financing infrastructure projects and public services, mainly, through sub-national government lending and project finance*". Source: http://www.banobras.gob.mx/opcionesdeayuda/Paginas/English.aspx

9 ACRONYMS AND DEFINITIONS

ACRONYM	DESCRIPTION
AGC	Automatic Generation Control
AMI	Advanced Metering Infrastructure
AMR	Automatic Meter Reading
ANCE	Asociación de Normalización y Certificación, A.C.
ANEEL	Brazilian Electricity Regulatory Agency
APIs	Application Programming Interface
ARRA	US American Reinvestment and Recovery Act
AVRs	Automatic Voltage Regulators
AWEA	American Wind Energy Association
AWG	Auction Working Group
Banobras	Banco Nacional de Obras y Servicios Públicos
BAU	"Business As Usual"
CDM	Clean Development Mechanism
CEC	California Energy Commission
CEM	Clean Energy Ministerial
CEMODAT	Centros de Monitoreo de Datos de Activos de Transmisión
CENACE	Centro Nacional de Control de la Energía
CEPEL	Centro de Pesquisas de Energia Eléctrica
CEQA	California Environmental Quality Act
CER	Certified Emissions Reduction
CFE	Comisión Federal de Electricidad
CIF	Clean Investment Funds
CITC	Saudi Communications and Information Technology Commission
CO_2	Carbon Dioxide
CONUEE	Comisión Nacional para el Uso Eficiente de la Energía
CPUC	California Public utilities Commission
CRE	Comisión Reguladora de Energía
CREZs	Competitive Renewable Energy Zones
CSP	Concentrated Solar Power
CTF	Clean Technology Funds
CTs	Current Transformers
DAC	Doméstica de Alto Consumo
DEH	Digital Electro Hydraulic
DER	Distributed Energy Resources
DG	Distributed Generation
DHS	US Department of Homeland Security
DOE	US Department of Energy
DSM	Demand Side Management
DSO	Distribution System Operators
ECRA (Saudi Arabia)	Electricity and Co-generation Regulatory Authority (Saudi Arabia)
EEI	Edison Electric Institute
EIA	Environmental Impact Assessment
EIB	European Investment Bank
EMF	Electromagnetic Fields
EMS	Energy Management System
EPRI	Electric Power Research Institute

ACRONYM	DESCRIPTION
ESB (Ireland)	Irish dominant electricity supplier
EV	Electric Vehicle
Ex-Im	U.S. Export-Import Bank
FACTS	Flexible AC Transmission Systems
FAN	Field Area Network
FIDE	Fideicomiso para el Ahorro de Energía Eléctrica
FIP	Fair Information Practice
FTC	Federal Trade Commission
FTTH	Fiber To The Home
GATT	General Agreement on Tariffs and Trade
GEF	Global Environmental Facility
GHG	Green House Gases
GIS	Geographical Information Systems
GPRS	General Packet Radio Services
HAN	Home Area Networks
HAP	Hazardous Air Pollutants
HFC	Hydroflurocarbons
IARC	International Agency for Research on Cancer
ICO (UK)	Information Commissioner's Office (UK)
ICT	Information and Communications Technology
IDB	Inter-American Development Bank
IEA	International Energy Agency
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IFAI	Federal Institute for Access to Information and Protection of Information
IFC	International Finance Corporation
IIE	El Instituto de Investigaciones Eléctricas
IP	Internet Protocol
IPC (Canada)	Office of the Information and privacy Commissioner of Ontario
IPP	Independent Power Producers
IRENA	International Renewable Energy Agency
IRR	Internal Rate of Return (measure of financial soundness)
ISGAN	International Smart Grid Action Network
IT	Information Technology
JBIC	Japan Bank for international Cooperation
JRC	Joint Research Center
KA-CARE (Saudi Arabia)	King Abdullah- City Automatic and Renewable Energy
KfW	KfW Entwicklungsbank German Development Bank
KPI	Key Performance Indices
KSA	Kingdom of Saudi Arabia
KSGA	Korea Smart Grid Alliance
KSGI	Korea Smart Grid Institute
kW	Kilowatt (measure of electric demand)
LAC	Latin America & the Caribbean
LAERFTE	Ley para el Aprovechamiento de Energías Renovables y el Financiamiento de Lla Transición Energética (Renewable Energy Development and Financing for Energy Transition Law)
LAN	Local Area Network
LASE	Ley para el Aprovechamiento Sustentable de la Energía (Sustainable Use and Energy Efficiency Law)

ACRONYM	DESCRIPTION
LCRE	Ley de la Comisión Reguladora de Energía
LCRs	Local Content Requirements
LFMN	Ley Federal sobre Metrología y Normalización
LFPDPPP	Ley Federal de Protección de Datos Personales en Posesión de los Particulares
LFTAIPG	Ley Federal de Transparencia y Acceso a la Información
LOAPF	Orgánica de la Administración Pública Federal
LSPEE	Ley del Servicio Público de Energía Eléctrica
MEF	Major Economies Forum
MEN (Peru)	Ministry of Energy and Mines - Peru
MME (Brazil)	Ministry of Energy and Mines - Brazil
MoDiCoSEN	Sistema de Monitoreo Dinámico y Control del Sistema Eléctrico Nacional
MOU	Memorandum of Understanding
Mtoe	Million Tons of Oil Equivalent
MW	Megawatt
MXN	Mexican Pesos
NADB	North American Development Bank
NAFIN	Nacional Financiera, S.N.C.
NAFTA	North America Free Trade Agreement
NARUC	National Association of Regulatory Utility Commission
NDP	National Development Plan
NEP	National Energy Policy
NERC	North American Electric Reliability Corporation
NES	National Energy Strategy
NIST	National Institute of Standards and Technology
NMX	Mexican Standards
NOM	Normas Oficiales Mexicanas (Official Mexican Standards)
NOx	Nitrogen Oxide
NPV	Net Present Value (measure of value proposition of targeted programs)
NRDC	National Resources Defense Council
NRF	Reference Standards
OE	US Office of Electricity Delivery and Energy Reliability
Olade	Latin-American Energy Organization
OPIC	U.S. Government’s development finance institution.
OSINERGMIN (Peru)	Energy and Mines Regulator - Peru
PbD (Canada)	Privacy by Design
PEV	Plug- In Electric Vehicle
PHEV	Plug-in Hybrid Electric Vehicle
PII	Personal Identifiable Information
PLC	Power Line Carrier
PLMP	Proxy Locational Marginal Price
PMUs	Phasor Measurement Units
POISE	Programa de Obras e Inversiones del Sector Eléctrico (2011-2025)
PPA	Power Purchase Agreement
PROFECO	Procuraduría Federal del Consumidor
PTs	Potential Transformers
PTs	Potential Transformers
PV	Photo Voltaic
R&D	Research and Development

ACRONYM	DESCRIPTION
RF	Radio Frequency
RIG	Remote Intelligent Gateway
ROW	Right of Way
SABIC	Saudi Arabia Basic Industries Corporation
SASO	Saudi Standards, Metrology, and Quality Organization
SCADA	Supervisory Control and Data Acquisition System
SCT	Secretariat of Communication and Transport
SE	Secretaría de Economía
SEC	Saudi Electricity Company
SEE Action	State Energy Efficiency Action Network
SEEC	Saudi Energy Efficiency Center
SEMARNAT	Secretaria del Medio Ambiente y Recursos Naturales (Secretariat of the Environment and Natural Resources)
SENER	Secretaría de Energia (Mexico)
SFP	Secretaría de la Función Pública
SGCC	State Grid Corporation of China
SGTF	Smart Grid Task Force
SHCP	Secretaría de Hacienda y Crédito Público
SIAD	Sistema Integral de Administración de Distribución
SIEPAC	Sistema de Interconexión Eléctrica de los Países de América Central
SIMEFAS	Sistema de Medición de Sincro-frasores
SIMOCE	Sistema de Monitoreo de Calidad de Energía (SIMOCE)
SIN	National Interconnected System
SISCOED	Sistema de Seguimiento de la Confiabilidad del Equipamiento de Distribución
SOx	Sulfur Dioxide
SSA	Secretariat of Health
SUTERM	Union of Electrical Workers of the Mexican Republic
SWOT	Strengths, Weaknesses, Opportunities, Threats
T&D	Transmission & Distribution
T&D	Transmission & Distribution
TCP/IP	Transmission Control Protocol/ Internet Protocol
TWACS	Two-Way Automatic Communications System
UHV	Ultra High Voltage
UNEP	United Nations Environment Program
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization
U.S.	United States
USTDA	United States Trade and Development Agency
VCC	Voluntary Code of Conduct
VOC	Volatile Organic Compounds
WAM	Wide Area Measurement System
WAN	Wide Area Network
WECC	Western Electricity Coordinating Council
WHO	World Health Organization

Appendix A SMART GRID DRIVERS AND TECHNOLOGY ENABLERS

A.1 THE INTERNATIONAL SMART GRID ACTION NETWORK (ISGAN) IDENTIFIED DRIVERS

ISGAN, a group of 22[267] countries committed to sharing information about their Smart Grid programs have identified the following drivers for Smart Grid. It must be noted that at times these drivers may not be sufficient to meet particular needs.

- ***Reliability***
  - Reliability improvements
  - Power quality improvements
  - Power restoration improvements
  - Transmission adequacy
  - Generation adequacy
- ***Efficiency***
  - System efficiency improvements (reduction in peak load, T&D losses, etc.)
  - Optimizing asset utilization
  - Energy efficiency improvements
  - Enabling new products, services, and markets
  - Enabling customer choice and participation
- ***Economic***
  - Economic advantages
  - Government incentives
  - Revenue collection and assurance improvements
  - Reducing operating and maintenance costs
- ***Environmental***
  - Renewable energy standards or targets
  - Environmental advantages
  - Regulatory compliance
- ***Security***
  - National security concerns
  - Enhanced power system resiliency to natural and human threats
- ***Safety***
  - Safety improvements
- ***Crosscutting***
  - Aging workforce concerns
  - Aging infrastructure concerns
  - Rural electrification
  - Job creation

[267] As of 2012.

A.2 DRIVERS CONSIDERED BY ESTA IN SURVEY OF SMART GRID INITIATIVES

1. Enabling Customer Choice and Participation
2. Welfare of the community
3. Improve consumer satisfaction
4. New / improved services for Customers
5. Improve Revenue Collection and Assurance
6. Environmental concerns
7. Government Incentives
8. Regulatory Compliance
9. Concerns with Aging Workforce
10. Knowledge Management
11. Reducing Human Error
12. Labor Saving
13. Reducing Operating & Maintenance Costs
14. Concerns with Aging infrastructure
15. Better Asset Utilization
16. Constraints for network/grid improvements
17. Increase in Energy Demand
18. Power Quality improvement
19. Reducing Technical Losses
20. Reliability Improvements
21. Improve Restoration
22. Generation Supply Constraints
23. Energy Supply Security
24. Enhanced Network Resiliency to natural and human threats
25. Interest in Micro Grids
26. Integration of Distributed Energy Resource
27. New Technology advances
28. Increase in Electric and Hybrid Vehicles
29. Improve Enterprise solution coordination
30. Energy Efficiency
31. Integration of renewable energy

A.3 Smart Grid Technology - ISGAN Identified Technology Enablers

The following have been identified as Technology Enablers by ISGAN

Cross Cutting
Tools for planning, operation, analysis
System wide monitoring, measurement, and control
Information and communications technology
Power electronics-based devices, including intelligent electronic devices (switches, relays, breakers, reclosers, transformers, capacitor banks), short-circuit current limiters, inverters & converters, regulators & circuit improvement
Distributed energy resources
Energy storage
Demand response
Standards and conformance testing
Cyber security
Electromagnetic compatibility
Novel market models
Operator training tools and emergency procedures

End-User
Residential consumer energy management (including in-home displays, home area networks, consumer behavior integration, software tools, smart appliances)
Building energy management and automation
Distributed energy resources integration
Electric vehicles and associated supply equipment
Microgrids and minigrids
Local sustainable energy

Generation

Clean Coal, e.g., integrated gasification combined cycle (IGCC)
Natural gas combined cycle
Nuclear
Wind
Solar photovoltaic and solar thermal energy
Hydro power
Tidal power
Ocean thermal energy
Wave energy
Geothermal
Biomass
Biogas

Distribution
Distribution management systems and outage management systems
Distribution feeder circuit automation
Fault detection, identification, and restoration (FDIR)
Direct load control
Condition-based monitoring and maintenance
Voltage & VAR control
Capacitor automation
Advanced metering infrastructure (AMI)
Enterprise back office system – geographic information system (GIS), outage management system, customer information system, meter data management system

Transmission and Substation

Resource planning, analysis, and forecasting tools
Large size variable renewable energy sources integration
Phasor measurement systems
Substation & transmission line sensors
High-voltage DC technologies
Flexible alternating current transmission system (FACTS) devices
Dynamic-thermal circuit rating
Advanced conductors for transmission lines
High temperature superconducting devices (e.g. SFCL, cables etc.)
High-voltage AC transmission lines

Appendix B USE CASE FOR RENEWABLE ENERGY AUCTIONS FOR SMALL PRODUCTION PROJECTS (ASSOCIATED WITH TASK 3)

Description

The Mexican legal framework establishes that the generation of electricity for public service has to be carried out by the state owned utility Federal Electricity Commission (CFE, by its acronym in Spanish), and by private investors through the specific schemes of self-supply, cogeneration, independent power producer, small production, export and import.

Regarding electricity generation through renewable resources, and considering the goals set forth by the Government of Mexico in its Renewable Energy Special Program, a policy of diversification of generation sources based on promoting the development of its renewable energy potential has been adopted. Therefore, by the end of 2008 the Act on Renewable Energy (RE Act) was enacted and which delegated specific powers to the Energy Regulatory Commission (CRE, by its acronym in Spanish) in order to come up with incentive schemes to promote private investment and renewable energy penetration into the grid.

The Public Service Electricity Law - Ley del Servicio Publico de Energia Electrica. (LSPEE Act) refers to “small production” as that which does not exceed 30 MW of installed capacity and whose electricity generated is entirely sold to CFE.

Energy auctions

It is important to define a mechanism that works under economic efficiency criteria and promotes the development of renewable generation through competitive processes in order to elicit the lower possible cost and which recognizes the special characteristics of intermittent and non-intermittent sources of renewable energy.

That is the case of the auction mechanism that is a simplified and market-based procurement mechanism for *small production* renewable energy projects that are eligible by the CFE, in terms of the targets defined in the Special Program. As a result of this effort, at 14th November 2012 was issued the document “Guidelines for Renewable Auctions for electricity generation through Small Production Projects” (Auction Guidelines), which defines the general framework that CFE should follow for carrying out auction processes for *Small Production* projects.

As for the main objective of the Auction Guidelines, it can be said that: This project aims at developing the guiding principles that CFE must follow to delineate each auction process for renewable electricity small production projects it will drive.

Finally, as for the implementation of the auction mechanism, a pilot auction for Small Production photovoltaic projects is planned. The auction processes will be based on the planning auction program developed by the auction working group.

I. **Scenario 1. Use of auctions for Small Production projects participating in the Mexican electricity market**. Given the facts, Small Production scheme in Mexico has been yet not entirely developed due the price of electricity an investor can afford in terms of profitability. In this case, for this scheme, auctions represent an opportunity to investors to participate under competitive conditions in order to obtain both, the best price of electricity at which they can repay their investment and the best price they can offer to CFE (in the case of auction winner).

II. **Scenario 2. Use of auctions for promoting competition and eliciting the lowest possible costs for CFE**. CFE must accomplish with its law mandate to acquire electricity at lowest cost compared with what would the cost be if CFE generates that electricity. Considering that the cost of electricity using renewable resources still remains largely higher than electricity cost using hydrocarbons, auctions will be used for promoting competition and consequently looking at eliciting the lowest possible cost of electricity supply into the grid using renewable resources for CFE.

III. **Scenario 3. Use of auctions to encourage the development of small renewable energy resources spread over the national territory.** Mexico has a large potential to generate electricity using renewable resources. Being that this potential has been detected vastly spread into the Mexican territory, it was explored the idea of making the most of this natural resources through Small Production auction projects up to 30 MW. Besides, this is a solution that contributes to the problem of increasing investment of transmission lines in zones where the current lines are insufficient to take out the electricity generated.

IV. **Scenario 4. Use of auctions for accomplishment of goals at Renewable Energy Special Program in the near and long term.** The Ministry of Energy is responsible of issuing and updating the Renewable Energy Special Program, where must be captured the national goals of electricity generation using renewable resources. Thus, for accomplishment of these goals, responsibilities have been distributed among CFE and private investors whereas in the last case it has been considered offering regulatory incentives for Small Production as the auctions processes.

V. **Scenario 5. Use of auctions to reduce information and transaction costs for stakeholders.** Currently, many countries have developed different regulatory instruments for the sake of encouraging investments in renewable resources. Thus, comparatively, auctions represents an instrument which facilitates communication and exchange of information between auctioneer and bidder, as well, it represents a low transaction cost opportunity to bidders presenting their best offer of the electricity they can generate. In the long term it is too a cost-effective possibility of acquiring electricity compared with Feed-in-tariffs, e.g.

VI. **Scenario 6. Use of auctions for providing a market signal for developers building new generation facilities.** Electricity price forecasting based on medium and long-term contracts provokes a positive reaction accordingly by building new capacity. In this case, investors would assure the return of the investment by long-term contracts at a fix price with CFE and they would be able by hedging part of their price and market risks with financial instruments.

VII. **Scenario 7. Use of auctions for offering high investor security through long-term PPA.** Renewable energy power plants represent huge investments in electricity sector, even though these are for Small Production projects up to 30 MW. Thus, return of the investment became an important issue to encourage installation of this kind of power plants. At this point, long-term PPAs, which are awarded through competitive processes as auctions, offer an excellent opportunity to define in the medium and long-term the return of the investment giving financial security for private investors.

VIII. **Scenario 8. Use of auctions for CFE´s capacity volume and budget control.** Small Production projects through auctions must be yearly planned in the CFE´s budget plan and authorized by the Ministry of Finance. Therefore, CFE can efficiently control both the bidding volume capacity in each competitive process and the budget which should be reserved to purchase electricity corresponding to that capacity.

IX. **Scenario 9. Use of auctions for ensuring electricity supply through Small Production projects using renewable energy.** Auctions provide attractive incentives to medium investors who may take advantage of the identified distributed potential by building new power plants under the Small Production scheme. In the same sense, while the mechanism more attractive, more will increase the number of Small Production projects in the medium-term. Being that these projects are committed to supply energy to CFE through long-term contracts, so increasing the number of Small Production projects will ensure the electricity supply to CFE.

X. **Scenario 10. Use of auctions for increasing the predictability of renewable energy supply.** Renewable energy projects bound by long-term contracts give certainty to CFE once those have started commercial operation. In this sense, identification of electricity generation patterns provides to the investor knowledge about the predictable behavior of the generation plant. Through this knowledge, investor is able to establish deliveries of electricity to CFE, whereas it will be as accurate as possible.

NOTE. The first scenario is analyzed under the Use Case methodology for demonstrative purposes only.

Assumptions

1. It is understood that each auction process aims at providing electricity from more than one renewable energy project, whose capacity neither is below the capacity determined by CFE through auction documents nor exceed 30 MW.
2. In the medium term a market for Small Production projects through renewable resources is developed promoting competition among medium investors.
3. In the medium term Small Production projects elicit the lowest possible costs for CFE.
4. The number of Small Production permits is increased based on the interest of investors in auctions.
5. Installed capacity of Small Production projects increases up to the needed capacity in terms of goals defined in the Renewable Energy Special Program.

Overall precondition

1. During 2013, CFE publishes auction documents for the pilot solar auction.
2. Regulatory assessment of this pilot auction shows minimal adjustments in the Guidelines.
3. Trust among new medium-size participants is built through an organized and transparent pilot auction.
4. As a result of the pilot auction and up to the total capacity auctioned by CFE, more than one solar project is awarded with long-term PPAs.
5. Awarded solar projects accomplish the committed commercial operation date.
6. Specific goals for Small Production projects are defined in the Renewable Energy Special Program by the end of 2013.
7. By the end of 2013, a long term planning auction program is carried out by the auctions working group by Ministry of Energy, CFE and CRE.

Overview of Post Conditions

In one hand, pilot auction has been carried out as expected considering the schedule and the auction´s documents published by CFE. On the other hand Small Production through renewable resources accounts with specific goals published by the Renewable Energy Special Program, as well as, the auction working group counts with a long-term planning document for carrying out competitive processes in the near future.

Stakeholder Roles

Table A- 1: Renewable Auctions Stakeholders

Actor name	Actor type	Role description
SENER - Electricity Undersecretary	Institution	Entity that establishes the *Auctions Working Group*.
SENER - Planning Undersecretary	Institution	Entity that develops the *Special Program for the Development of Renewable Energies.*
Auctions Working Group (not yet enabled)	Group	Working group which is responsible of: - Helping identify the transmission projects needed to accommodate renewable energy goals - Facilitate transmission corridor designation - Facilitate transmission and generation siting permitting - Support future energy policy related to auctions.
Program for the Development of Renewable Energies (RE Special Program)	Document	Establishes capacity and electricity goals to be accomplished through renewable energy projects developed by CFE and private participants.
Guidelines for renewable auctions for electricity generation through Small Production projects	Document	Establishes criteria which CFE shall use to carry out the call and rules of each auction process.
Pricing Methodology	Document	Establishes the method which CRE will use to set up the maximum price to be paid for bidders whose technical proposals both, accomplish CFE´s technical requirements and economic proposals are the minimum up to the maximum established by CRE. It was issued by the CRE in October 2012.
PPA – Standard contract	Document	Establishes the PPA to be signed between each winner of the auction process and CFE. It defines a buy-sell commitment for 20 years.
Electricity and Renewables Department (CRE)	Department	Entity that develops both, the document *Guidelines for renewable energy auctions for electricity generation through Small Production projects* and the PPA model.
Legal Department (CRE)	Department	Entity that legally evaluates the validity of both documents, *Guidelines for renewable energy auctions for electricity generation through Small Production projects* and PPA model.
General Management (CFE)	Assessor	It coordinates different departments which jointly participate in the design of renewable energy auctions.
Management of Renewable energy projects – Generation (CFE)	Department	Entity that prepares both, the cost – benefit analysis report and the technical specifications of renewable energy projects.
Programming – Planning (CFE)	Department	Entity that prepares both, the cost – benefit analysis report of renewable energy projects and identifies interconnection points for new renewable energy projects trough Small Production.
Investment projects financed - Legal (CFE)	Department	Entity that prepares the auction documents (call for the auction and rules).
Investment projects financed - Developing Projects (CFE)	Department	Entity that prepares the auction documents (call for the auction and rules).
Investment projects financed - Construction (CFE)	Department	

Actor name	Actor type	Role description
SHCP (Ministry of Finance)	Institution	Institution that approves the cost-benefit analysis report elaborated by CFE (Management of renewable energy projects and programming).
SFP (Ministry of Civil Service)	Institution	Institution that approves the auction documents and the PPA model elaborated by CRE and agreed with Investment projects financed – Legal and Developing Projects departments.

Information exchanged

Table A- 2 : Energy Exchange for RE Auctions

Information Object Name	Information Object Description
Renewable energy special program	Ministry of Energy defines and publishes renewable energy goals to Small Production projects by region and capacity
Cost-benefit analysis	CFE evaluates the cost-benefit of renewable energy Small Production projects to be carried out in region determined by the Ministry of Energy. Ministry of Finance approves and authorizes the budget requested by CFE
Auction documents	CFE elaborates the auction documents: call for the auction and rules; CRE elaborates the PPA model. Those documents are approved and authorize by Ministry of Civil Service and contain: • Technology, total capacity limit (project limit of 30 MW by participant), smallest capacity limit accepted by participant and maximum commercial operation data; • Compliance guarantees requested; • Calendar of key events; • Demonstration of developer experience and financial capacity; • Minimum deployment of Mexican engineering supply; • Interconnection points list, including interconnection estimated cost for MW;
Sealed bids	Each participant to the auction shall submit their sealed bid to CFE in advance of a deadline. Bids must indicate the minimum prices at which bidders are willing to generate electricity and must be integrated by both, technical and economic proposals. Participants could offer total capacity requested or a partial capacity (equal or larger than the minimal acceptable by participant)
Auction process	**First meeting**. CFE unseals technical proposals submitted by bidders and softly evaluates them to identify those which accomplish technical requirements. Before the second meeting CFE hardly evaluates technical proposals and pick up all those which accomplish technical requirements. **Second meeting**. Economic proposals corresponding to approved technical proposals are stacked up from lowest to highest offered price in order to determine the winners
Maximum price	CRE establishes the maximum price that may be paid to bidders. It is revealed during the second meeting to compare bidders´ economic proposals and is set up according to the "Pricing Methodology"
PPA	Once auction winners are determined, CFE shall sign a PPA with each one in order to establish a 20 years long-term electricity buy-sell commitment.
Generation permit	Winners of the auction process must apply for a Small Production permit at the CRE

Step-by-step actions under scenario 1: "use of auctions for Small Production projects participating in the Mexican electricity market".

Table B- 1: RE Auctions Step-by-Step

Step	Actor	Description	Notes
1	CRE	Issues the document "Guidelines for Renewable Auctions for electricity through Small Production projects". Issues the PPA model previous agreed with Investment projects financed (CFE) – Legal and Developing Projects departments.	
2	SENER – Electricity Undersecretary	Enables CFE for carrying out the pilot auction.	
3	SENER – Planning Undersecretary	Establishes renewable energy goals for Small Production through the *Special Program for the Development of Renewable Energies*.	
4	Programming – Planning (CFE)	Establishes capacity needs in the region where auction will be carried out. Defines list of interconnection points. Together with Generation (CFE) prepares cost – benefit analysis report of new renewable energy projects.	
5	Management of Renewable energy projects – Generation (CFE)	Together with Programming – Planning (CFE) prepares cost – benefit analysis report of new renewable energy projects.	
6	SHCP	Approves the cost – benefit analysis report	If SHCP approves the auction process, it continuous with point 7.
7	Investment projects financed (CFE): Legal and Developing projects	Prepare the auction documents (call for the auction and rules) with technical support of Generation (CFE).	
8	SFP	Approves the auction documents	
9	SENER	Verifies the auction documents	
10	Investment projects financed (CFE): Legal and Developing projects	Publishes the auction documents and the PPA model in different national and international media	
11	CRE	Shares the maximum price for the auction process with CFE	Unless
12	Investment projects financed (CFE): Developing projects	Carries out the auction process	It includes meetings with bidders and evaluation process of proposals
13	Investment projects financed (CFE): Developing projects	Signs the PPAs with auction winners	
14	Auction Winners	Starts commercial operation according to agreed	At the committed date

Action sequential diagram

PILOT AUCTION

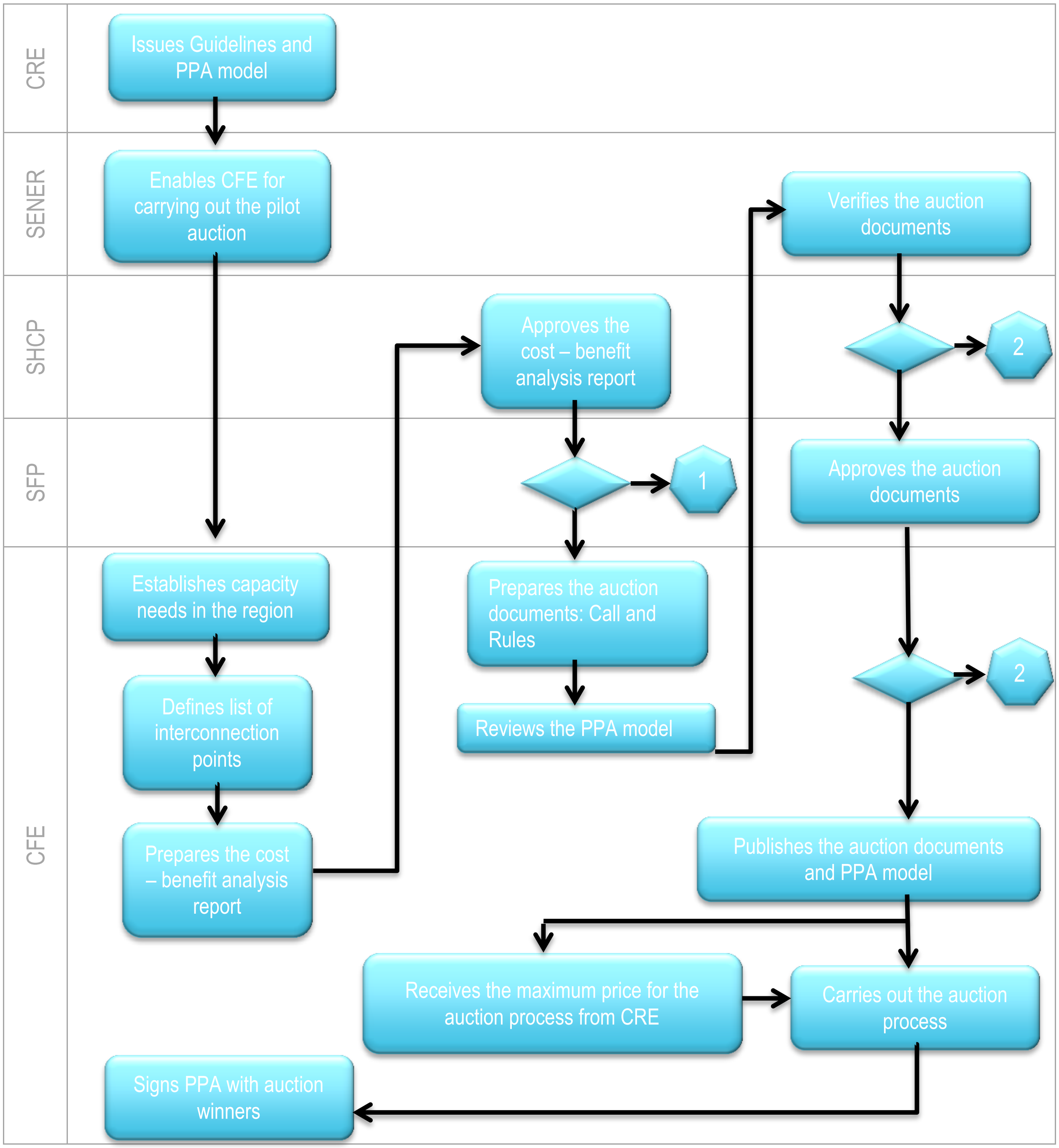

Figure B - 1: Auction System Action Sequential Diagram

1. CFE redefines cost-benefit analysis 2. CFE reviews auction documents

FOLLOWING AUCTION PROCESSES

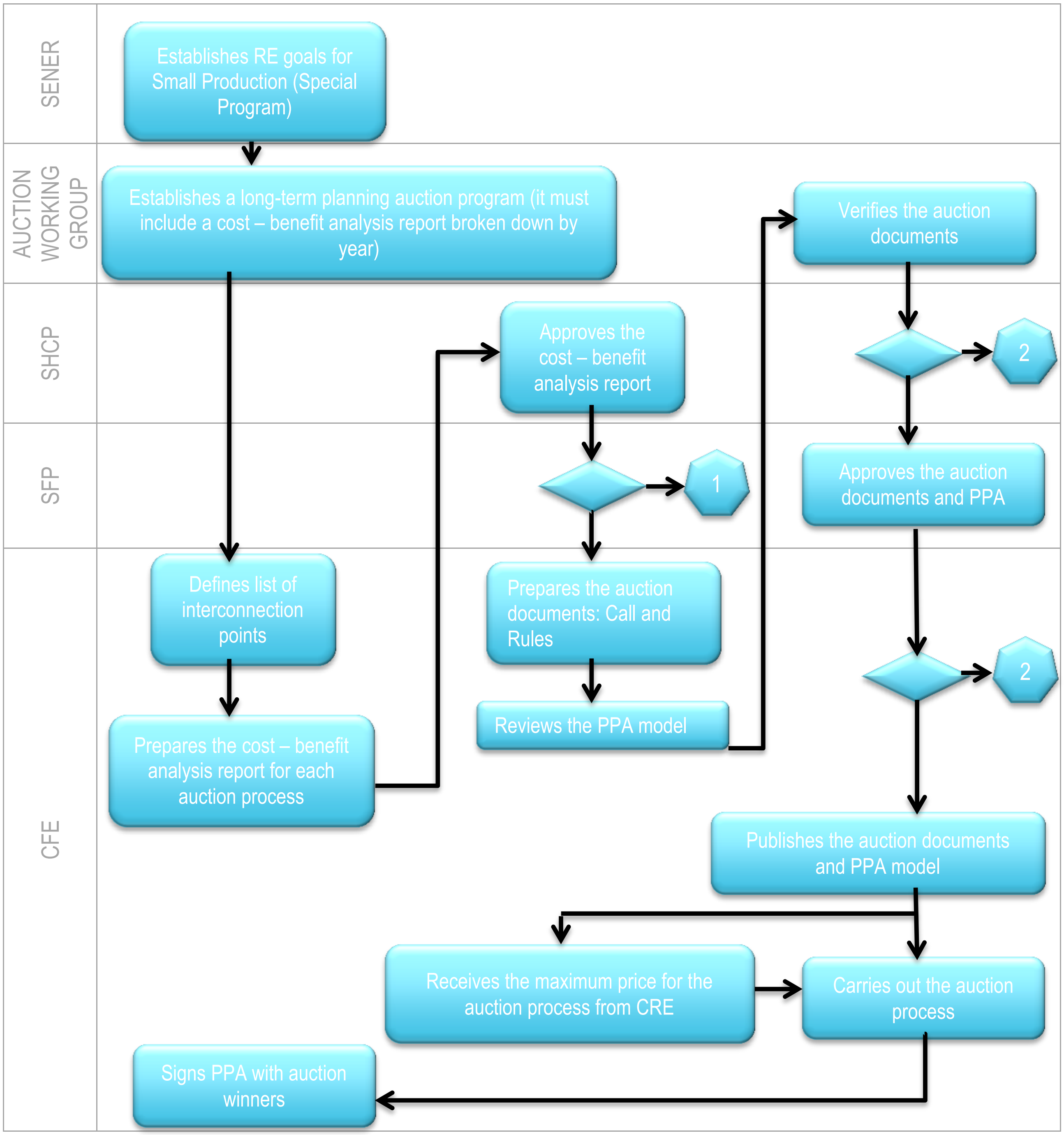

Figure B - 2: Auction Processes

1. CFE redefines cost-benefit analysis 2. CFE reviews auction documents

Appendix C DATA GATHERED FROM CFE FOR ECONOMIC ANALYSIS

Number of electric meters	
• Residential	33,311,490
• Commercial	3,701,822
• Industrial	285,840
Annual Growth Rates	
• Meter	2.8%
• Substations	3.5%
• Transformers	2.0%
Annual Sales (MXN $MM)	
• Residential	MXN $60,702.1
• Commercial	MXN $40,625.8
• Industrial	MXN $189,475.6
Energy Sales (MM kWh)	
• Residential	52,557.2
• Commercial	13,733.6
• Industrial	120,560.8
System Peak (MW)	
• Summer	40,271.0
• Winter	34,549.0
Electric Infrastructure	
• Mainline Feeders	10,148
• Distribution Transformers	1,327,958
• Substations	1,899
• Substation Transformers	2,639
System Operations Data	
• Percentage of Electromechanical Meters	27.0%
• Documented Cases of System Theft	109,171
• Annual Number of Special Reads	17,736
• Annual Meter Disconnections	4,182,324
• Annual Bad Debt	MXN $4,608,947,650
• Annual Minutes of Outage per Customer	42.1
• Average Outage Duration (Minutes)	95.0

(All other data was gathered through industry research)