INTERCHANGEABILITY

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Shell NA LNG

Introduction

- **Interchangeability**
- **Why Wobbe works**
- **Market Specifications**
- **Summary**

Interchangeability

ISO Definition of Natural Gas Interchangeability:

- A measure of the degree to which the **combustion characteristics** of one gas resemble those of another gas. Two gases are said to be interchangeable when one gas may be substituted for the other without affecting the operation of gas burning appliances or equipment.

Interchangeability Criteria

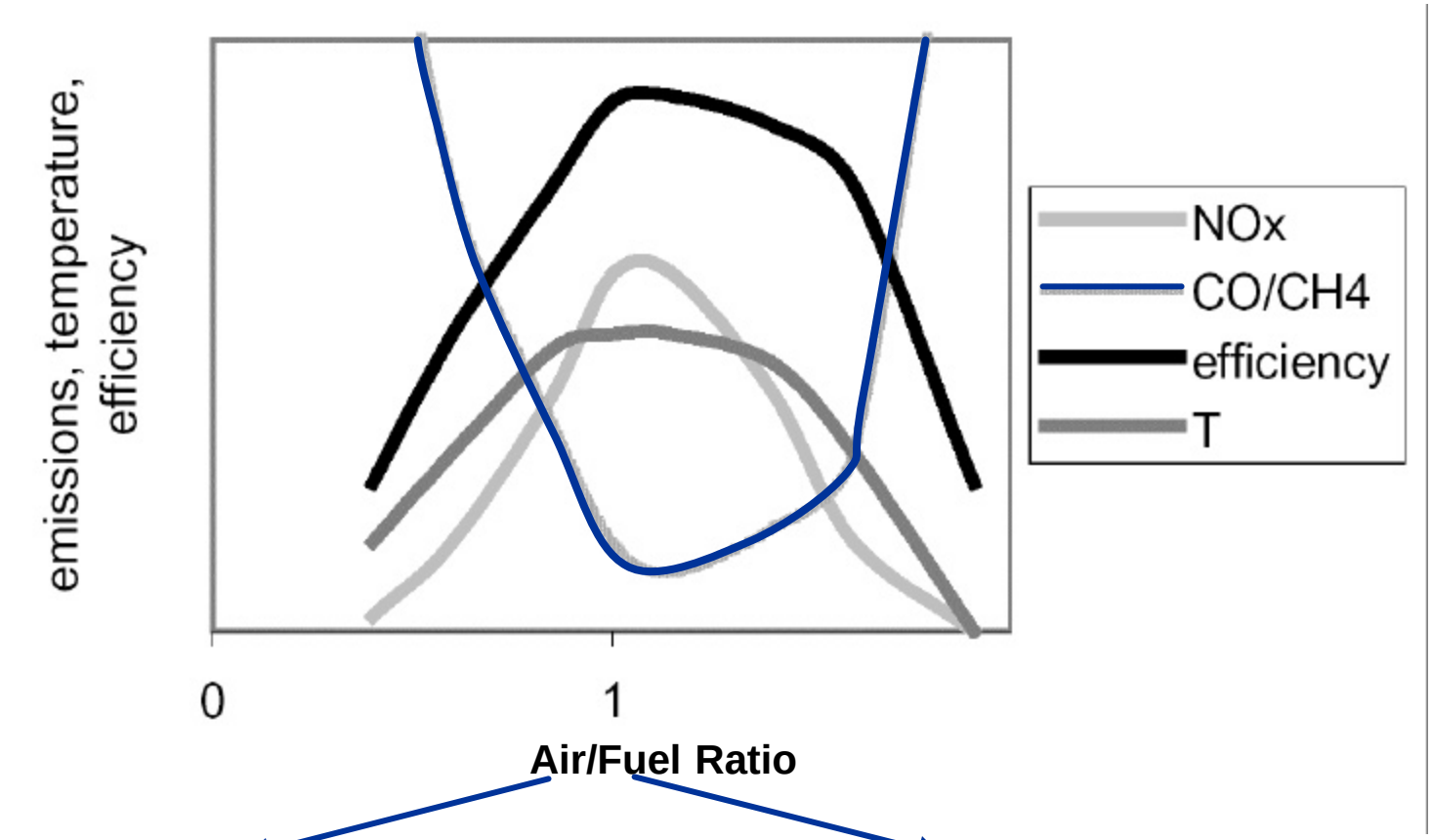
- NOx emissions
- CO emissions
- Yellow Tipping
- Lifting
- Flash-back
- Flame speed
- Knocking
- Efficiency
- Flame Temperature
- Flue gas dew point
- Auto-ignition
- ….

Interchangeability Specifications

- **Performance based quality specifications are superior to composition based specifications:**
  - Performance based interchangeability specifications provide a meaningful guarantee to end-users
  - Performance based interchangeability specifications will not unnecessarily close out supply options.

- **The Wobbe index is the single most important interchangeability parameter.**

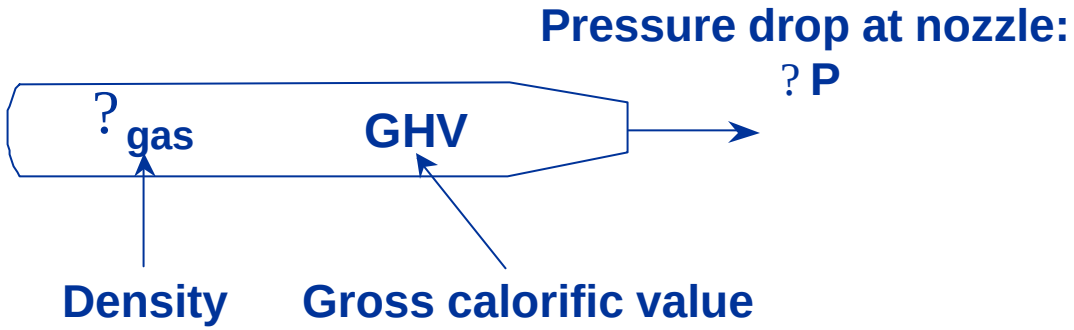
Combustion



‘In-dependent’ of gas quality

Dependent on gas quality

Wobbe Index



Energy supply rate of gas is proportional to heating value * flowrate

$$= HV * \sqrt{??_{air}/?_{gas}} * \sqrt{?P}$$

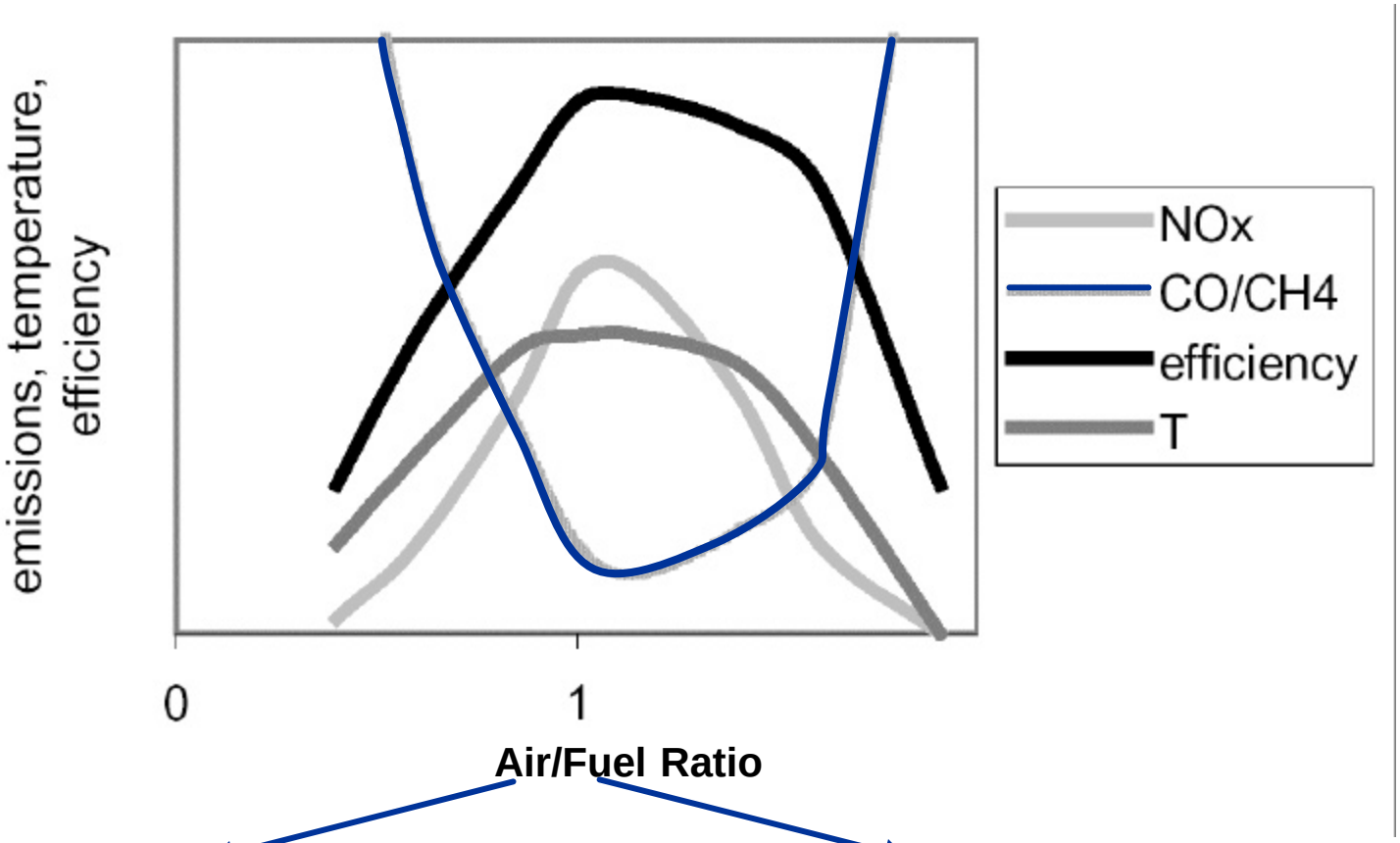
Defined as the Wobbe index, $W = \frac{GHV}{\sqrt{d}}$

d = relative density

($?_{air} = 1$**)**

- **Energy supply at constant grid pressure is proportional to the Wobbe index**

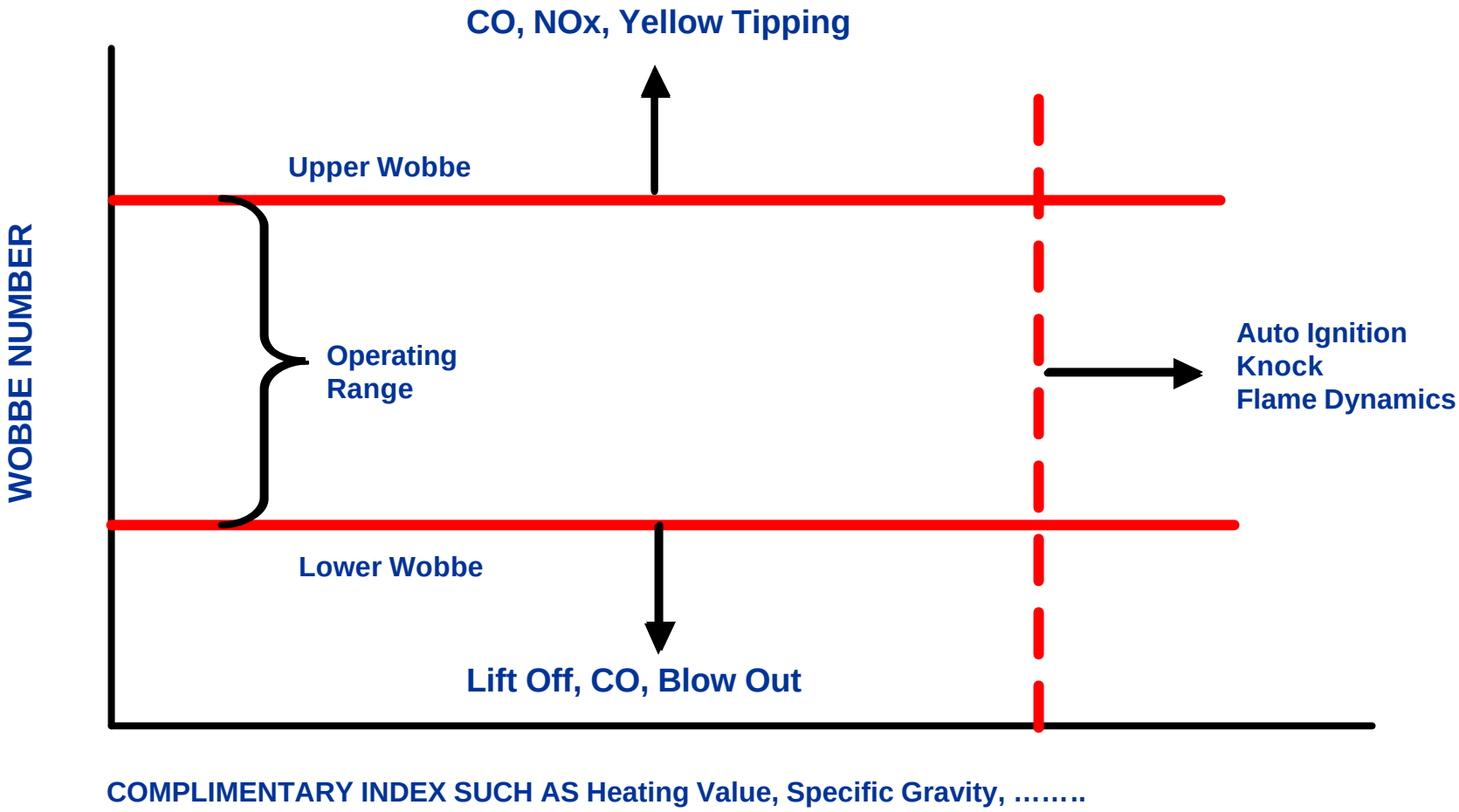
Combustion



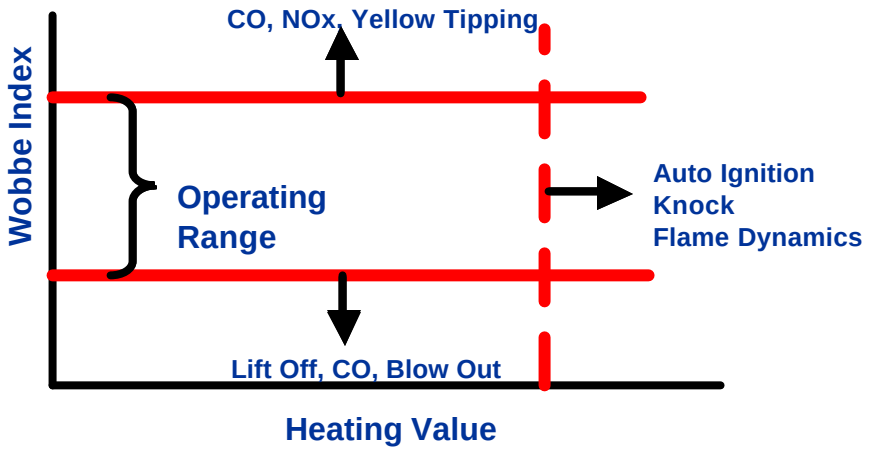
‘In-dependent’ of gas quality

Dependent on ~~gas quality~~ Wobbe Index

Interchangeability box



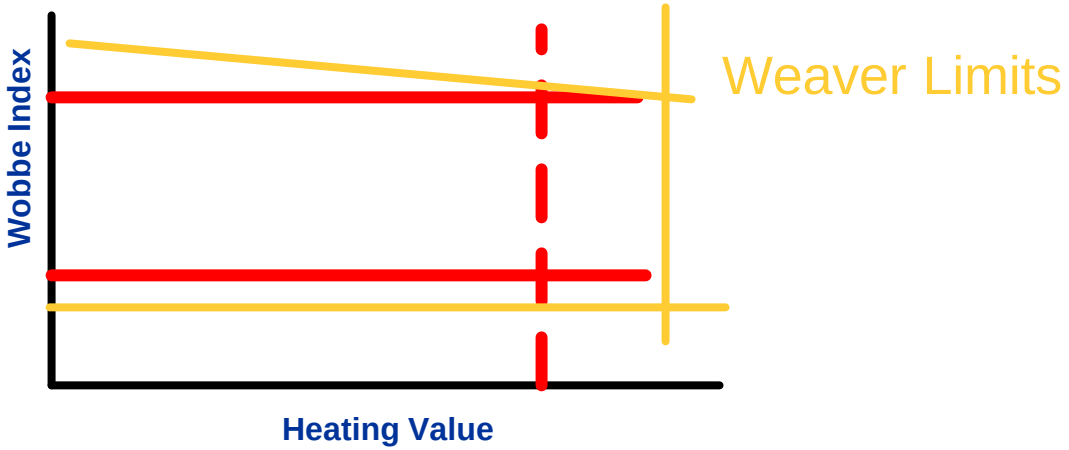
Interchangeability box



- Relative Operating range point wrt Burner Adjustment is relevant
- Most burners can handle a broad operating range w/o material impact
- However, some burners and processes are more critical e.g.
  - Gas turbines
  - Glass Manufacturing
- Critical equipment requires regular/continuous readjustment for optimum performance to cope with e.g. load variation, ambient changes, gas quality…
- Automatic tuning can be used for frequent/continuous readjustment.
- *Gas Quality fluctuations over the complete range are extremely unlikely*

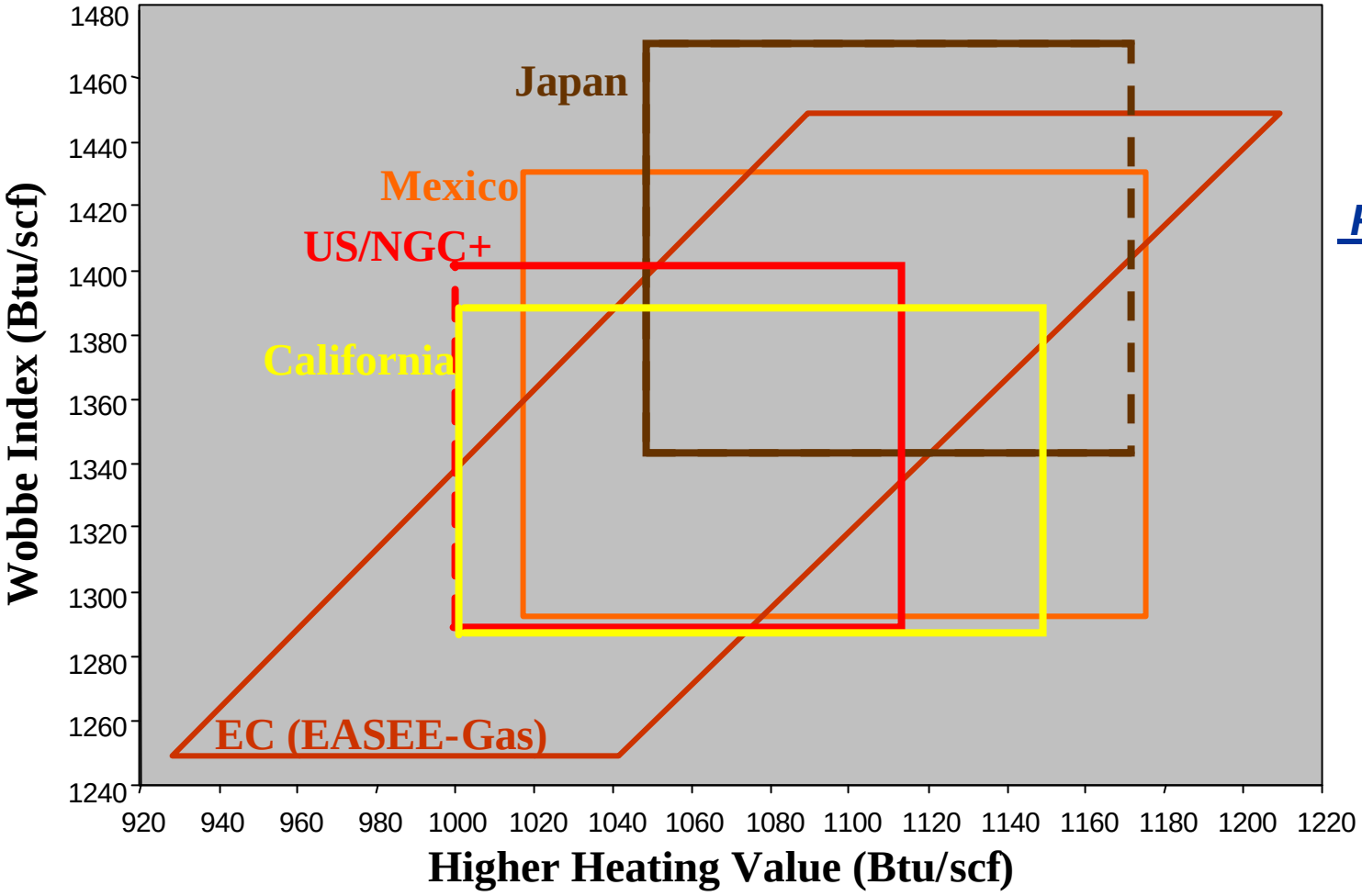
Weaver Indices

- Weaver Indices are empirical parameters developed some 60 years ago in US to address flash-back, incomplete combustion, yellow tipping, lifting.
- Conversion from manufactured gas (CO,H2) to Natural Gas (CH4)
- Developed for domestic Appliances.
- Complex calculations.
- Weaver parameters are strongly linked to Wobbe Index & HHV in case of Natural Gas supplies.



No need for additional Weaver limits in NOM001

Market Specifications



Relative **Wobbe range:**

- **EC +/- 7.5%**
- **Brazil +/-6%**
- **Japan +/-5%**
- **Mexico +/-5%**
- **US +/- 4%**

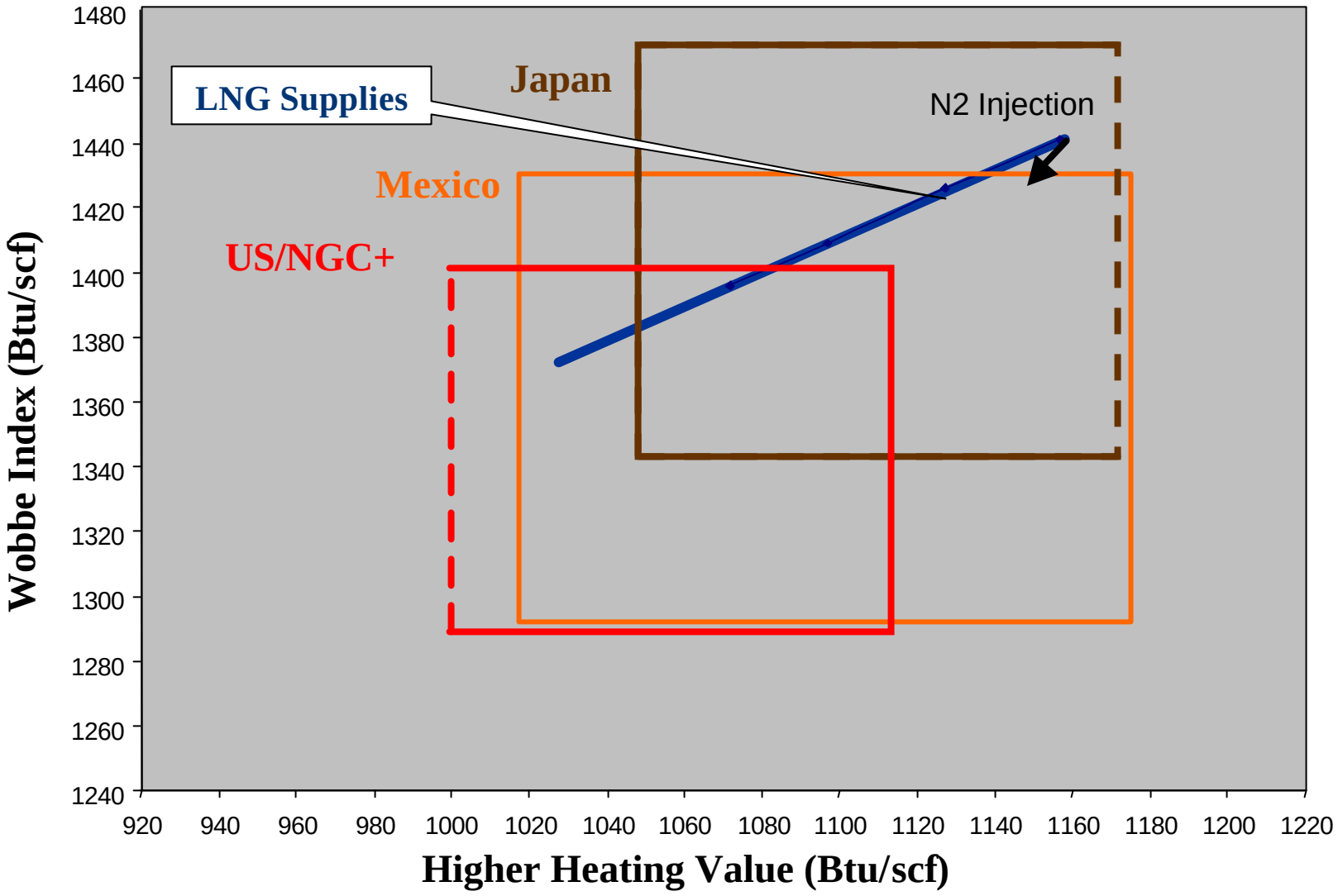
EC Gas Quality

- Existing National Specifications based on Wobbe Index.
- However, misalignment of National Specification seen as a hurdle to cross-border trade and supply competition.
- 2002 creation of EASEE Gas *"To develop and promote common practices to simplify and streamline business processes between the stakeholders that will lead to an efficient and effective European Gas Market"*
- 2005 EC Cross Border Quality Specifications (+/-7.5% Wobbe)
- Implementation

US Gas Quality

- Gas Quality Specifications set at individual pipeline level, regulated by FERC or State Regulators
- Existing gas quality specifications often lack clarity, e.g. no interchangeability or liquid drop out specs.
- Increased Natural Gas prices trigger a surge in gas quality related concerns.
- US gas industry has made significant progress over the last few years to address those concerns and provide more regulatory clarity:
  - 2004 start of industry task force; NGC+
  - 2005 NGC+ White Papers (+/-4% Wobbe)
  - 2006 FERC Policy
  - Pipeline Specific Decisions

LNG quality ranges vs Market Specifications



Summary

- **Performance based quality specifications are superior to composition based specifications**
- **The Wobbe index is the single most important interchangeability parameter. In combination with a secondary parameter (HHV or SG) it assures interchangeability.**
- **The NOM 001 Wobbe range provides a meaningful and conservative guarantee to end-users while at the same time allowing a broad range of supply options.**
- **One nation-wide specification allows a fully integrated network**