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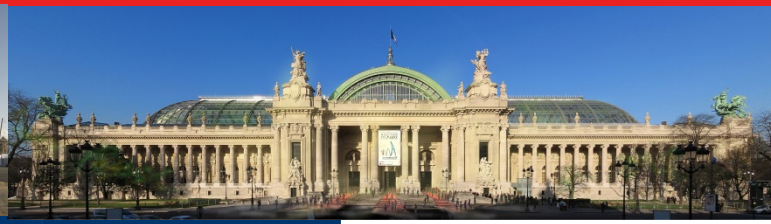

Action Plan for the Effects of Variation of Fuel Gas Composition and Heating Value on Gas Turbines in Korea

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WORLD GAS CONFERENCE

Background

- Long-term calorie views of LNG imported by KOGAS
  - Currently, rich LNG has been decreasing in the LNG trade market, LNG imported by KOGAS has been leaner continuously
  - After 2020, average HHV could converged to 10,152 kcal/Nm³ (42.5MJ/Nm³) the change of gas heat supply system was requited to supply lean LNG

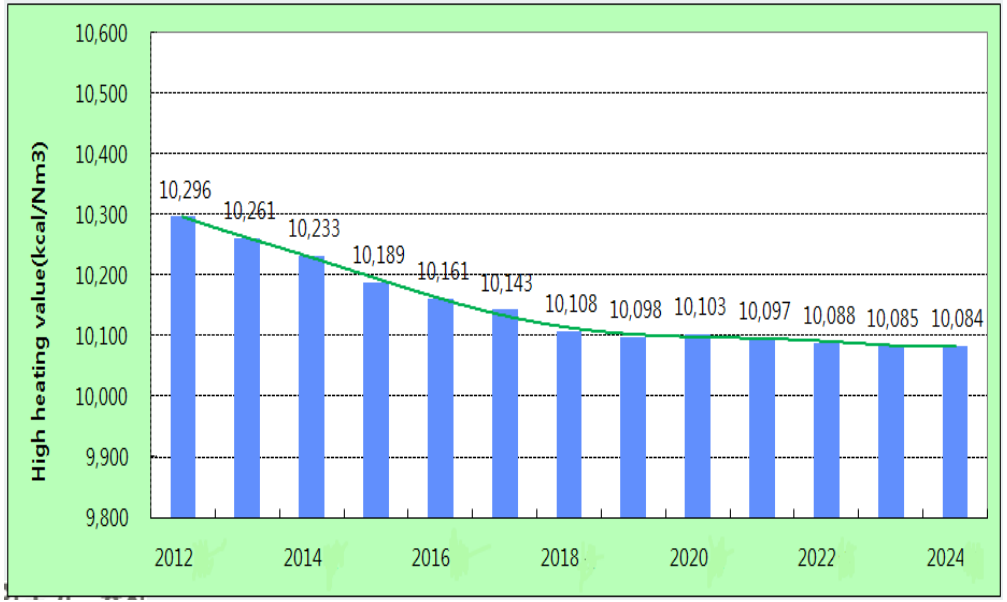


Fig. 1 Expected heating value of Korea domestic natural gas based on demand outlook

Objectives

- Gas heat supply system was improved in calorie range from standard heat supply system

Item	Before(Standard HV Sys.)	After(Since July 2012),HV range
Change of supplying calories	Standard calories : 43.54MJ/Nm³ (10,400 kcal/Nm³) Low limit calories : 42.28MJ/Nm³ (10,100 kcal/Nm³) Max Wobbe: 57.77MJ/Nm³ (13,800 kcal/Nm³) Min Wobbe : 52.75MJ/Nm³ (12,600 kcal/Nm³)	High limit calories: 44.4MJ/Nm³ (10,600 kcal/Nm³) Low limit calories : 41.0MJ/Nm³ (9,800 kcal/Nm³) Max Wobbe: 56.1MJ/Nm³ (13,400 kcal/Nm³) Min Wobbe : 54.0MJ/Nm³ (12,900 kcal/Nm³)

Objectives

After reviewing effects of heating variation on gas turbine, the countermeasures have been established and subsequently pre-adjusted the plan

- Reviewing effect on gas turbine
  - Performance, Combustion dynamics, Efficiency and Emission
- Countermeasures
  - Tune or adjust GT, install instruments, change H/W, S/W and Parts

Status of Gas Turbines

- The Gas Turbines installed in KOREA : 133 units made by 5 manufacturers

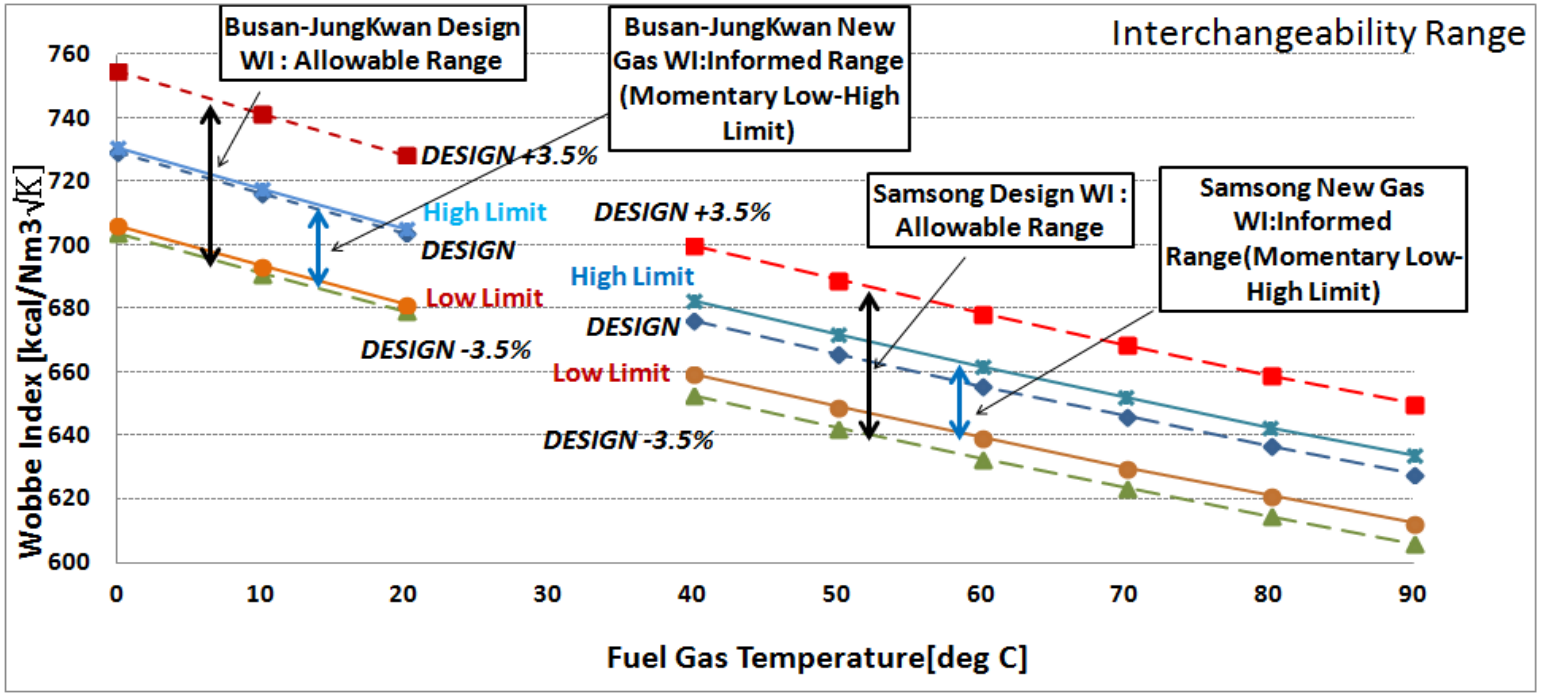
Manufacturer	Units	Installation year
Siemens	47	1992~2013
GE	34	1992.06~2011
Alstom	20	1991~1998
MHI	19	2007~2013
Hitachi	5	2007~2011
SUM	**133**	

Fuel Gas Design Factor and Definition

Manufacture	Design Factor & Range	Definition
MHI	$WI \pm 5\%$	$WI = \frac{LHV}{\sqrt{S_g}}$
Alstom	$WI_{net} \pm 10\%$	$WI_{net} = LHV_{mass} \times \frac{\rho_{gas(T)}}{\sqrt{\frac{\rho_{gas(T)}}{\rho_{air(0°C)}}}}$
Siemens	$WI_{\inf} \pm 5\%$	$WI\,\inf = \frac{LHV}{\sqrt{S_g}}(kJ/Nm^3),\ LHV\,(kJ/kg)$
GE	$MWI \pm 5\%$	$MWI = \frac{LHV}{\sqrt{(T_{fuel})(S_g)}}$
Hitachi	$MWI \pm 3.5\%$	$MWI = \frac{LHV}{\sqrt{(T_{fuel})(S_g)}}$

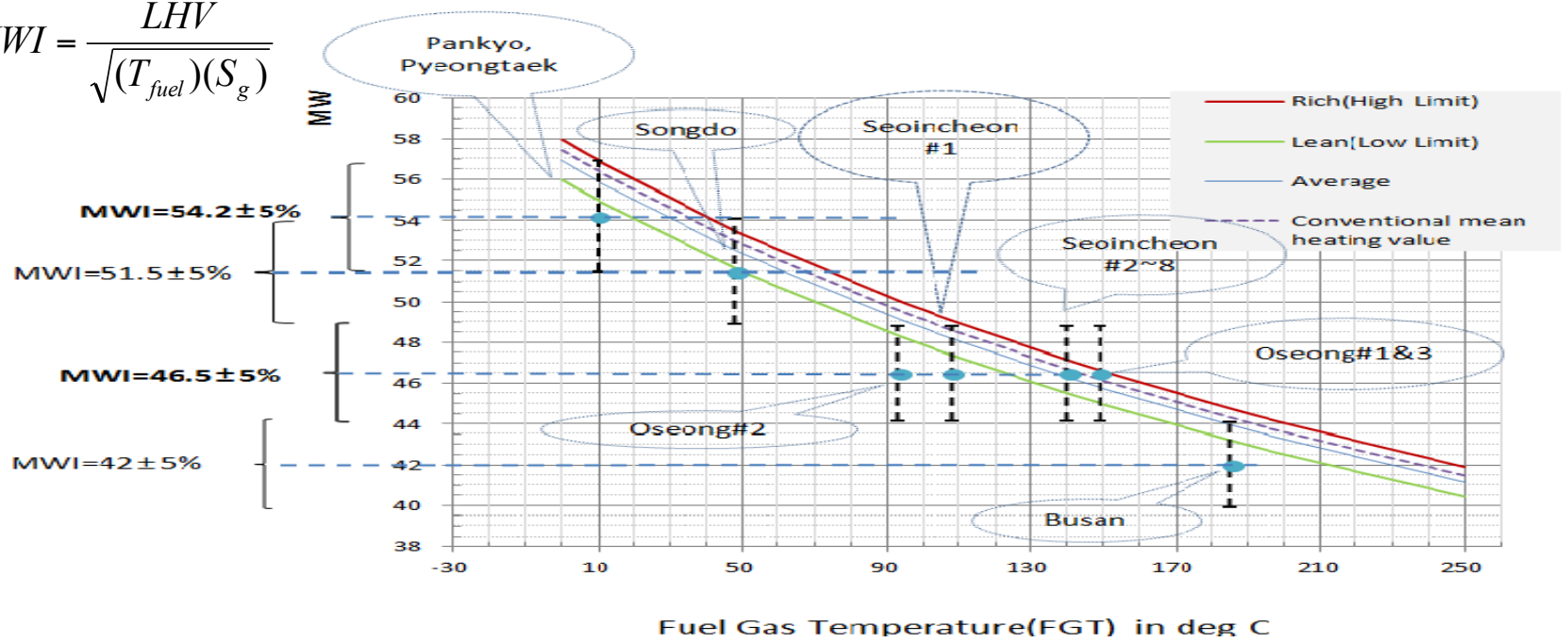
Interchangeability Range of T Gas Turbine

$$MWI = \frac{LHV}{\sqrt{(T_{fuel})(S_g)}}$$

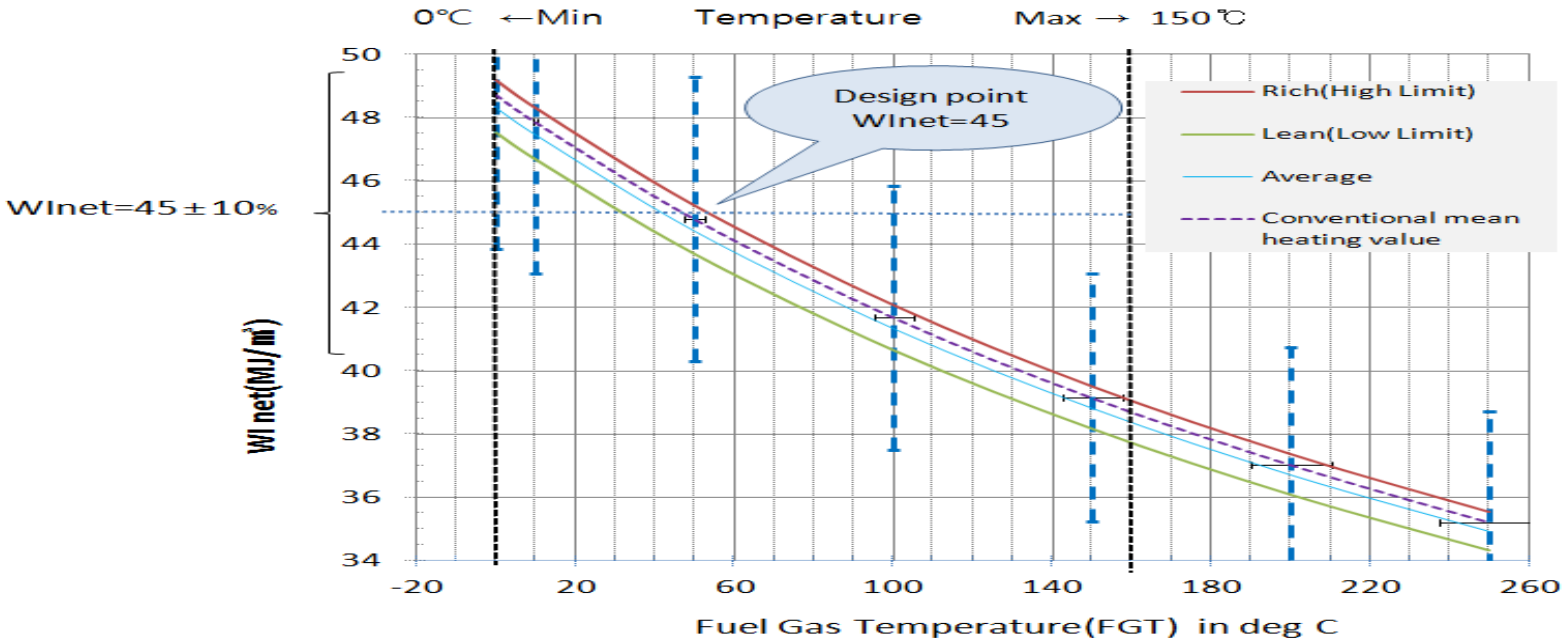


Fuel Study Results of E-Gas Turbine

$$MWI = \frac{LHV}{\sqrt{(T_{fuel})(S_g)}}$$



Fuel Study Results of S-Gas Turbine



Conclusion

- Gas turbines combustion system tuning is recommended to accommodate ignition, combustion dynamic and NOx emission for new gas
- Gas turbines installed after 2007 are not affected and do es not need tuning for new fuel gas
- New fuel gas is out of design range for the three sites Ga s Turbine Units of one brand, autotune is required for thr ee sites and recommended due to the expected fuel varia tions for other sites to GTs