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GAS TURBINE EMISSIONS REGULATORY DEVELOPMENTS

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GAS TURBINE EMISSIONS REGULATORY DEVELOPMENTS

- **REASONS for REGULATION**
- **AIR TOXICS & PRIMARY POLLUTANTS**
- **EVOLUTION OF REGULATORY LIMITS**

(CONVERGENCE of SOME STANDARDS TO RECOGNIZE PROCESS EFFICIENCY & EMISSION REDUCTION ON EXISTING UNITS)

- **ON-GOING ACTIVITY & OBSERVATIONS**

REASONS for REGULATION

- Human nature is to react when air quality reaches, or exceeds, a maximum tolerable level or critical level
- Typical examples would be the 1991 Acid Rain, Canada-US Air Quality Agreement to REDUCE both SO2 & NOx emissions
- Los Angeles SMOG in 1960's & subsequent vehicle emission standards
- NOx + Volatile Organic Compounds = photochemical SMOG = Ozone & other toxics
- Provide adequate protection against adverse effects on soil , water, vegetation materials, animals, visibility, personal comfort & well-being (public health)

AIR TOXICS & PRIMARY POLLUTANTS

- **Canadian National Air Quality Objectives 1989-1990**
  Max Acceptable avg. concentration over **1 h period**
  - Sulfur Dioxide **SO_2** **0.34 ppm**
  - **Nitric Oxides** **NOx** **0.21 ppm**
  - Carbon Monoxide **CO** **31 ppm**
  - **Ozone** **O_3** **0.08 ppm**

- The maximum acceptable level was intended to provide adequate protection against adverse effects
- **2012 Canadian Ambient Air Quality Standards (CAAQS) effective 2015.**

  Ozone action threshold for achieving air zone CAAQS is **63 ppb (0.063 ppm) 8 h average** based on the 3 year average of the annual 4th-highest daily maximum 8 hour average concentrations

EVOLUTION OF REGULATORY LIMITS

- **1979 U.S.** Environmental Protection Agency (EPA) established standards of Performance for new, modified, or reconstructed stationary gas turbines. (40 CFR Part 60). Generally, for units with a LHV heat **input** of greater than 107.2 GJ/h (approx.10,000 Hp output), gas fuel emission limits were:

- **Nitric Oxides** **NOx** **75 ppm** + allowance if fuel N >0.015%
- Sulfur Dioxide **SO_2** **150 ppm** or fuel < 0.8% Sulfur

Reference point was ISO standard day conditions, with turbine exhaust O_2 concentration at 15% on dry basis, and allowable emissions adjusted upward for units with thermal efficiencies > 25%.(Heat rate adjustment)

EVOLUTION OF REGULATORY LIMITS

- **1992 CCME** Canadian Council of Ministers of the Environment National Emission Guidelines for Stationary Combustion Turbines. This guideline set an allowable mass of NOx (grams) per unit output of shaft or electrical energy (Gigajoules) as well as an allowance for an additional quantity of NOx emitted if useful energy is demonstrated to be recovered from the facility's exhaust thermal energy during normal operation.

For non-peaking gas fueled combustion turbines > 20 MW

- **Nitric Oxides NOx 140 g/GJ Power + 40 g/GJ Heat recovery**
- Carbon Monoxide **CO** **50 ppm** at power rating
- Sulfur Dioxide **SO_2** **800 g/GJ Power**

- Reference conditions for measurement are ISO standard day with turbine exhaust O2 concentration at 15% on a dry basis.
- 3.6 GJ = 1 MWh

EVOLUTION OF REGULATORY LIMITS

- **2006 U.S. E.P.A** updates standards of performance for stationary combustion turbines. (40 CFR Part 60).

Some changes of interest were:

- adoption of the CCME concept of allowable NOx per useful energy output (more generous in some cases than CCME 92 for heat recovery!)
  For units with heat input (HHV) > 850 MMBtu/h & firing natural gas:

  NOx 15 ppm or 54 ng/J of useful output (0.43 lb/MWh)

- For units in the range > 50 & ≤ 850 MMBtu/h heat **input** (this can be up to a 110 MW unit at 44% efficiency) there is a less stringent standard for modified or reconstructed turbines. This is an incentive for older high emission units to be retrofitted to reduce air toxics. Firing natural gas :

  NOx 25 ppm or 150 ng/J of useful output (1.2 lb/MWh) for NEW units

  NOx 42 ppm or 250 ng/J of useful output (2.0 lb/MWh) for MODIFIED or RECONSTRUCTED units

- Reference conditions for measurement are ISO standard day with turbine exhaust O2 concentration at 15% on a dry basis.
- ng/J = g/GJ

EVOLUTION OF REGULATORY LIMITS

- **ALBERTA NOx & SO_2 Standards for New Thermal Generation Units.**

  from CASA (Clean Air Strategic Alliance) 2003 report
  Emissions Management Framework for Alberta Electricity Sector

- Effective **Jan 1, 2006 NOx** standards for new gas fired units:
  - **0.6 kg/MWh (**167 g/GJ**) for units less than 20 MW** power capacity
  - **0.4 kg/MWh** (111 g/GJ) **for units between 20 & 60 MW** capacity
  - **0.3 kg/MWh** (83 g/GJ) **for units greater than 60 MW capacity**

  For Co-generation units, MWh **includes combined steam heat** and electricity

- Effective **Jan 1, 2006,** standards for new coal fired units:
  - **0.69 kg/MWh** (192 g/GJ) **for NOx**
  - **0.80 kg/MWh** (222g/GJ) **for SO_2**

ON-GOING ACTIVITY & OBSERVATIONS

- **BLIERS : (extracts from Bliers Expert Group final report)**

In Canada, the **2011** Combustion Turbine (CT) base level industrial emission requirements (BLIERs) working group was formed under the Air Quality Management System (AQMS) to analyze, discuss, and develop BLIERs for **new** combustion turbines used in various industrial sectors in Canada.

For any outstanding work or issues that were not dealt with and agreed upon in this BLIER process, the Canadian Council of Environment Ministers (CCME) 1992 guideline will continue to be the national emissions reference (e.g. heat recovery allowance for cogeneration systems and emissions standards for liquid-fuelled combustion turbines).

The mandate of the working group is to develop BLIERs for new combustion turbines that should match the stringency of emission levels in leading jurisdictions – inside or outside Canada, that meet a good base level of environmental performance.

ON-GOING ACTIVITY & OBSERVATIONS

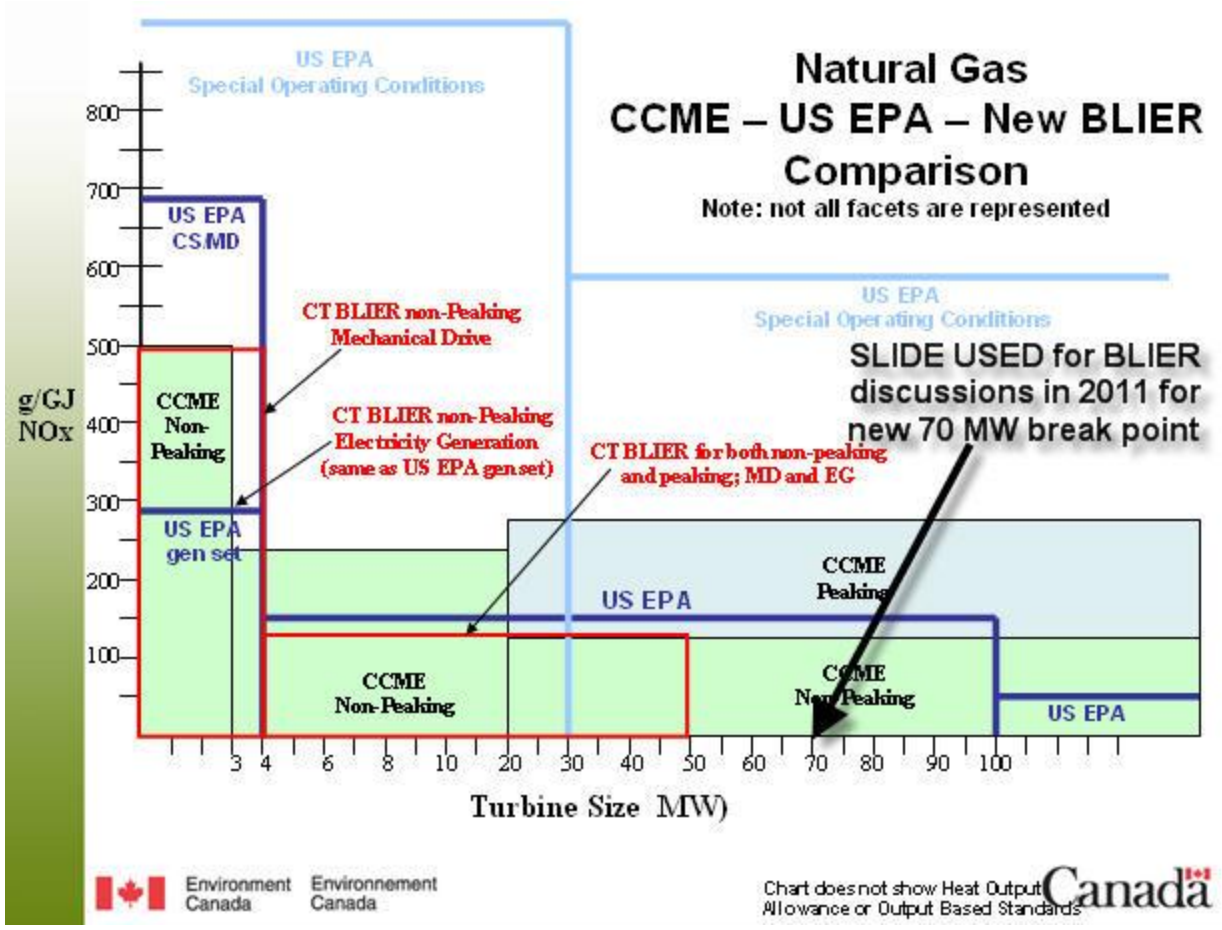
- **BLIERS** cont'd

The scope of this group was to develop BLIERs for:

- **NOx** from new 50+ MW natural gas-fuelled turbines
- **NOx** from new natural gas-fuelled combined cycle turbine system
- **NOx heat recovery allowances** from new natural gas-fuelled cogeneration turbine systems (containing gas turbine(s) and heat recovery steam generator operating with or without duct burners)
- **NOx, PM, VOCs and SOx** from new turbines/systems fuelled by liquid fuels such as; diesel, fuel oil, etc. and non-natural gas gaseous fuels such as syngas, refinery gas, landfill gas, etc.

ON-GOING ACTIVITY & OBSERVATIONS

An example of a discussion slide during the BLIER process



ON-GOING ACTIVITY & OBSERVATIONS

- 2011 Natural Gas Fuel emissions from BLIER final report

Table 1 –Consensus BLIERS for New Combustion Turbines

Source	Form/Scope		NOx BLIER emission standard		Degree of Consensus
	Type	Power Rating (MW)	g/GJ (power output)	ppmv (15% O_2 dry)	
Combustion Turbine	Non-peaking - Mechanical Drive	< 4	500	75	All (CAMS process)
Combustion Turbine System (simple and combined cycle)	Non-peaking- Electricity Generation	< 4	290	42	All (CAMS process)
Combustion Turbine	Peaking	< 4	exempt	exempt	All (CAMS process)
Combustion Turbine System (simple and combined cycle)	Non-peaking and Peaking, Mechanical Drive or Electricity Generation	4 - 70	140	25	All (Combination of CAMS and AQMS processes)
Combustion Turbine System (simple and combined cycle)	Non-peaking, Mechanical Drive or Electricity Generation	> 70	85	15	Partial (non-consensus by one company for the 70-100MW range only)
Combustion Turbine	Peaking	> 70	140	25	All

ON-GOING ACTIVITY & OBSERVATIONS

- **Positive directions noted in the evolution of some regulations.**
  - Recognition that mass of pollutant per unit of useful energy output (e.g. g/GJ , kg/MWh, etc) encourages energy efficiency and provides an easy comparison of the relative cleanliness of various thermal energy systems. (EPA also uses it for Diesel Engines)
  - Regulations that allow, and hence encourage, existing units to have emission reduction techniques applied when they are upgraded; but not force them to meet new unit requirements.
  - Lower the allowable differences in emissions levels permitted depending on fuel type or process chosen to convert energy.
  - Given that current air quality concerns are due to highly polluting "grandfathered" technologies compared to what is available today on new units, there is no intrinsic value in having 2 or 3 significant figures to a very clean standard.

    (e.g. 0.3 kg/MWh output, is a good number for NOx)