

# **Gas Turbine Emission Standards**

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- Environmental Issues
- International Standards
- Emission Prevention Systems
- Combined Heat & Power

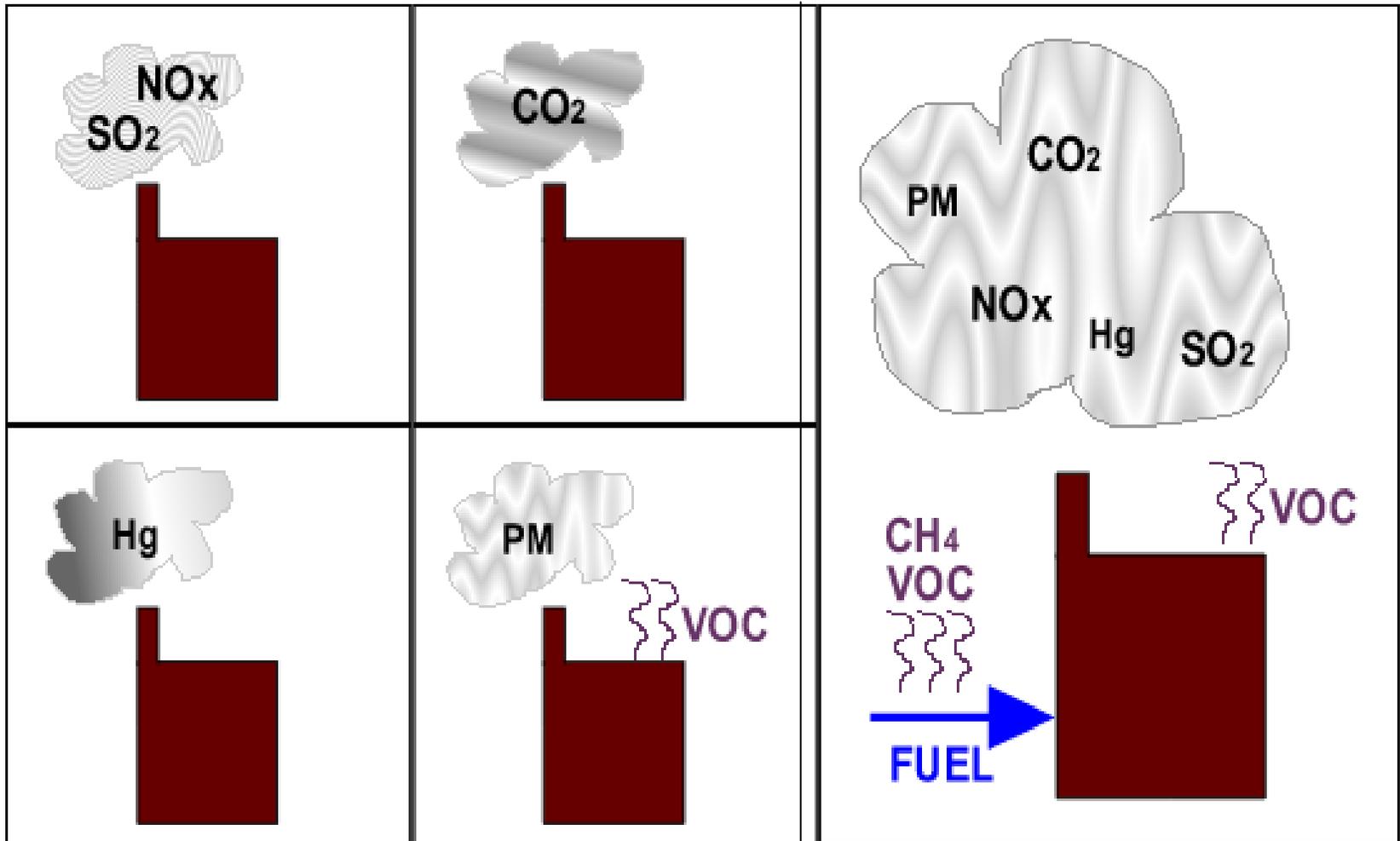
(June 2005, IGTI Conference, Reno USA)

# Environmental Objectives

- Low Air Pollution and Toxics
- Minimize Greenhouse Gases, CFCs
- Pollution Prevention
- Maximize Energy Conservation
- Overall System and Plant Design
- Low Water Impacts
- Energy Diversity and Reliability

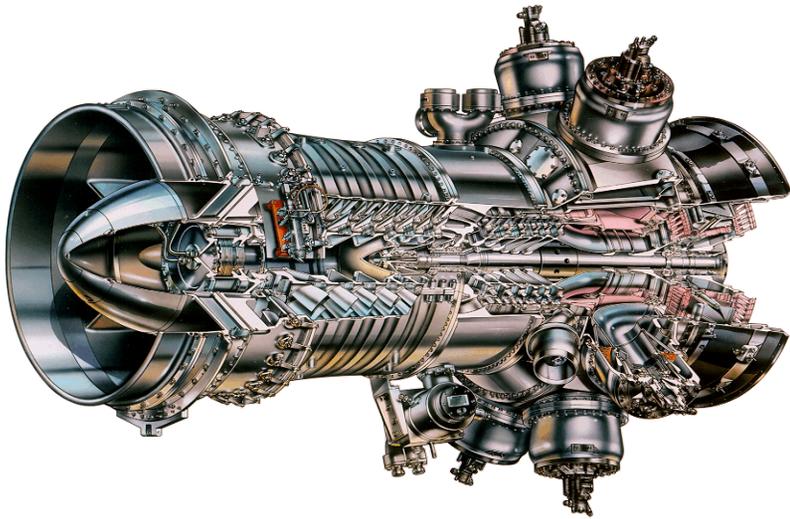
# Separate Emissions ??

# System

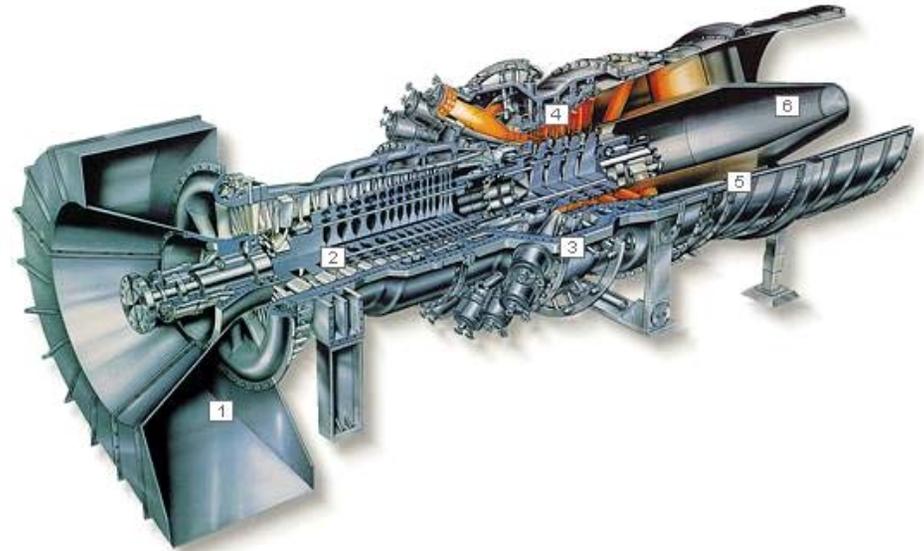


# What Are Major GT Design Issues Today?

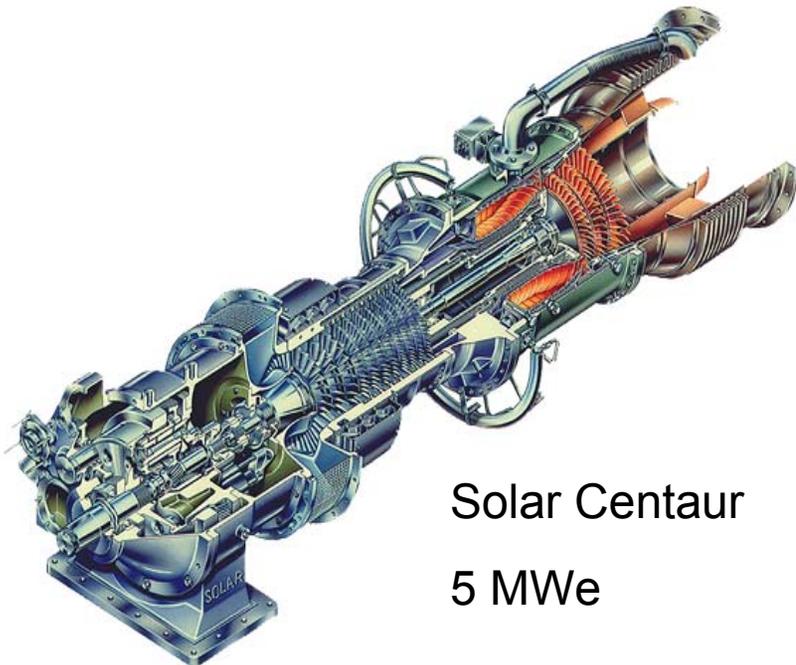
- Efficiency and Power
- Reliability and Maintenance
- Life Cycle Cost and Profitability
- *Combustor Design, Pressure Oscillations*
  
- ***Fuel Supply and Pricing***
  
- Greenhouse Gases
- *The Need for Ultra-Low NO<sub>x</sub> Levels ?*
- *Air Toxics and HAPS ?*



28 MWe Industrial RB211 DLE



Siemens Westinghouse W501F, 180 MWe



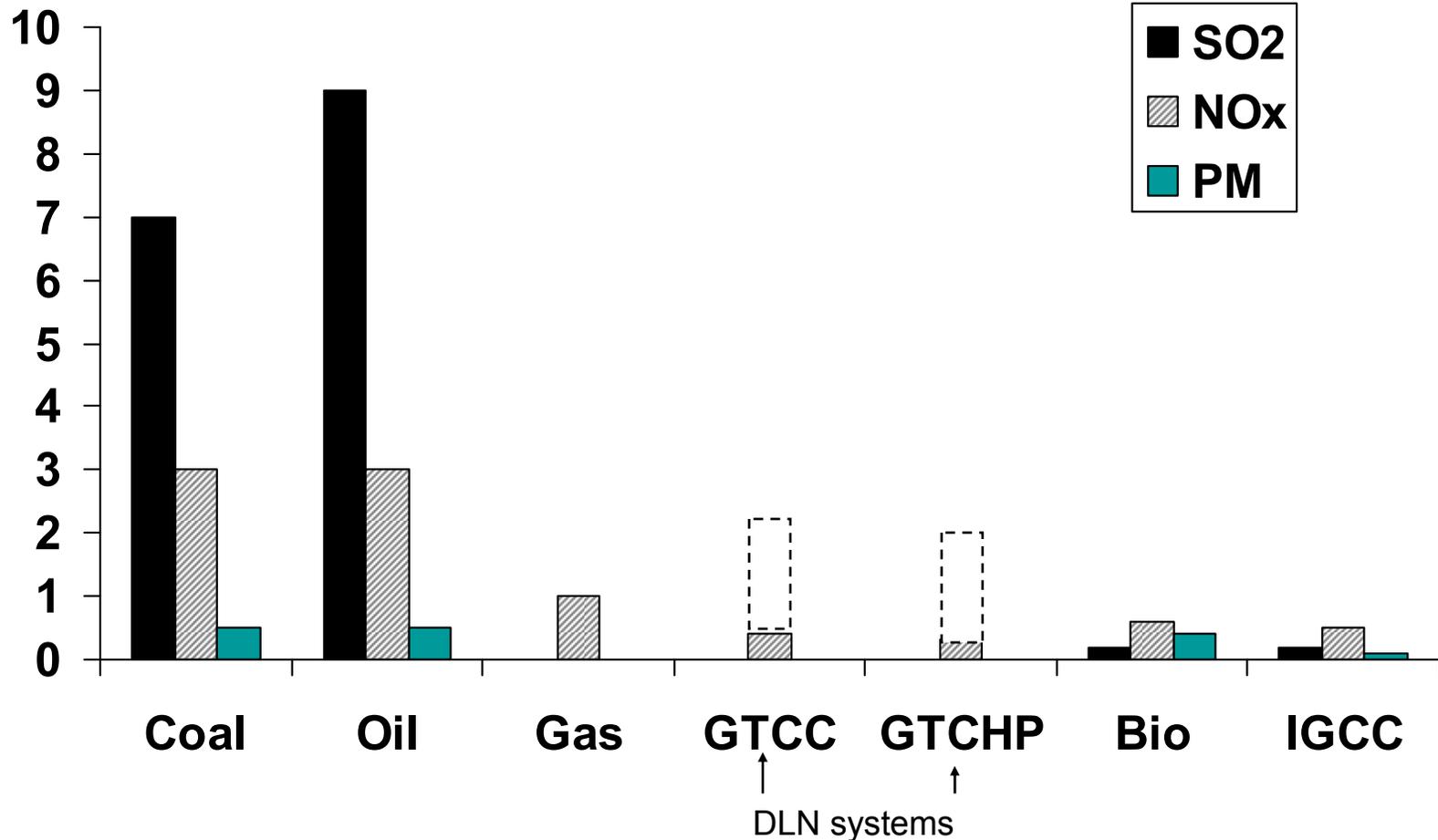
Solar Centaur  
5 MWe



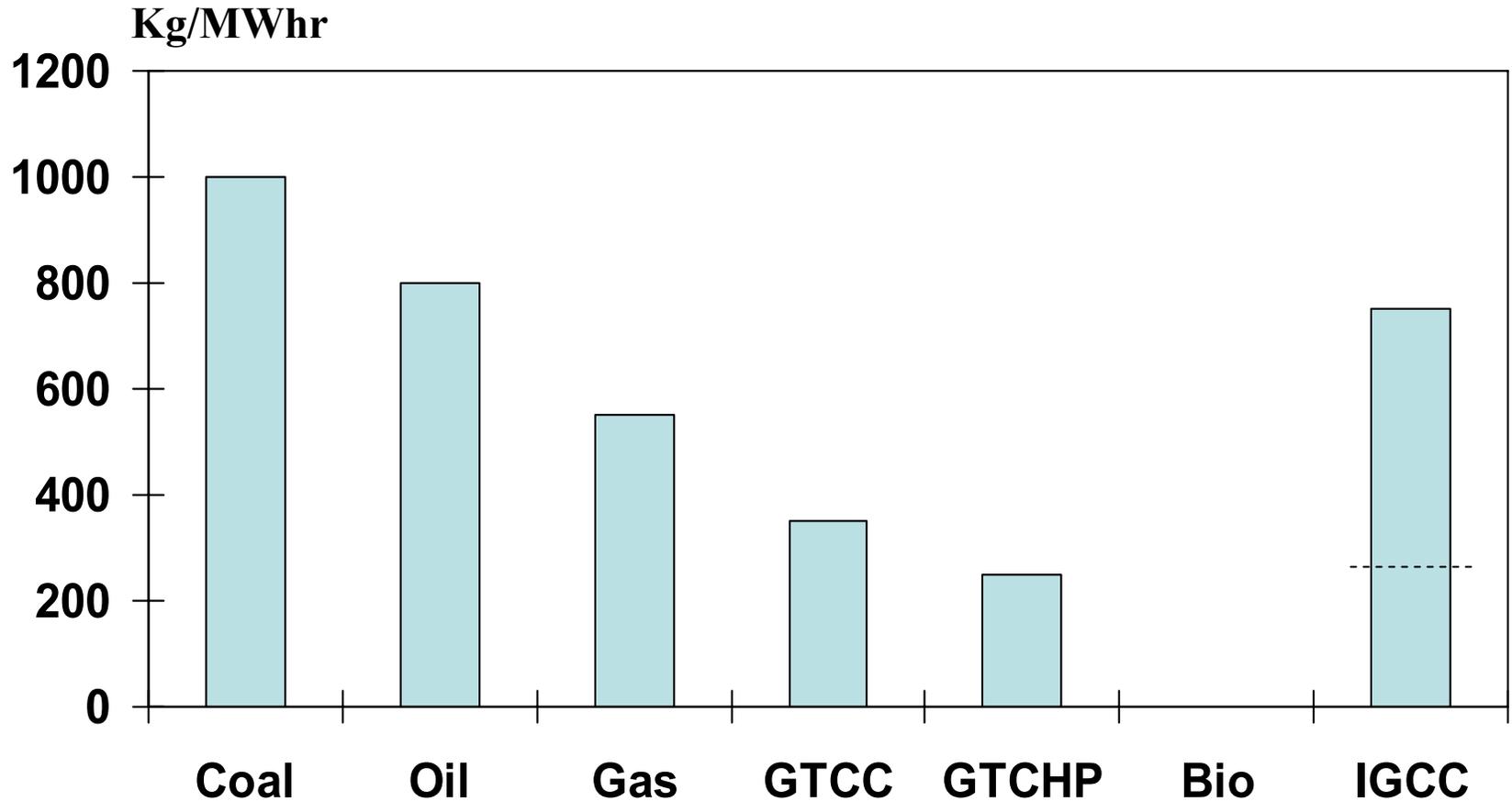
Capstone Microturbines

# Comparison of Air Pollution Emissions from Existing Power Generating Plants

Kg/MWhr

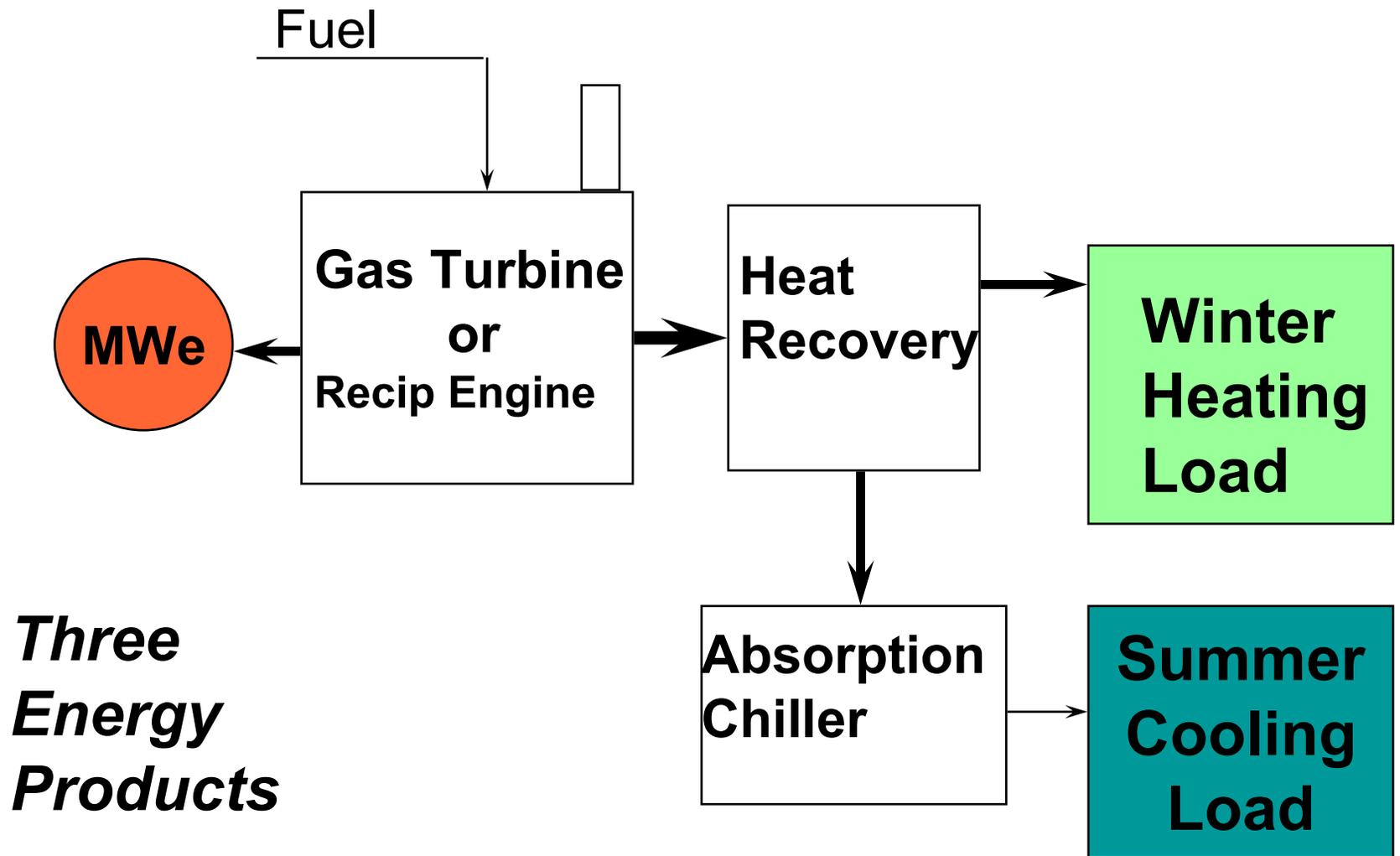


# Comparison of CO<sub>2</sub> Emissions from Various Power Generation Plants



# Cleaner Energy Choices

- Aggressive Energy Conservation
- Small Renewable Energies
- *Waste Heat Recovery, Biomass*
- *High Efficiency Gas Systems, CHP*
- Large Hydro & Nuclear Power
- Coal Gasification IGCC Systems
- Waste Fuels and Materials Recycling
- Coal & Oil Steam Plants (max controls)



*Three  
Energy  
Products*

**Combined Heat & Power Schematic**

# Emission Reduction Methods

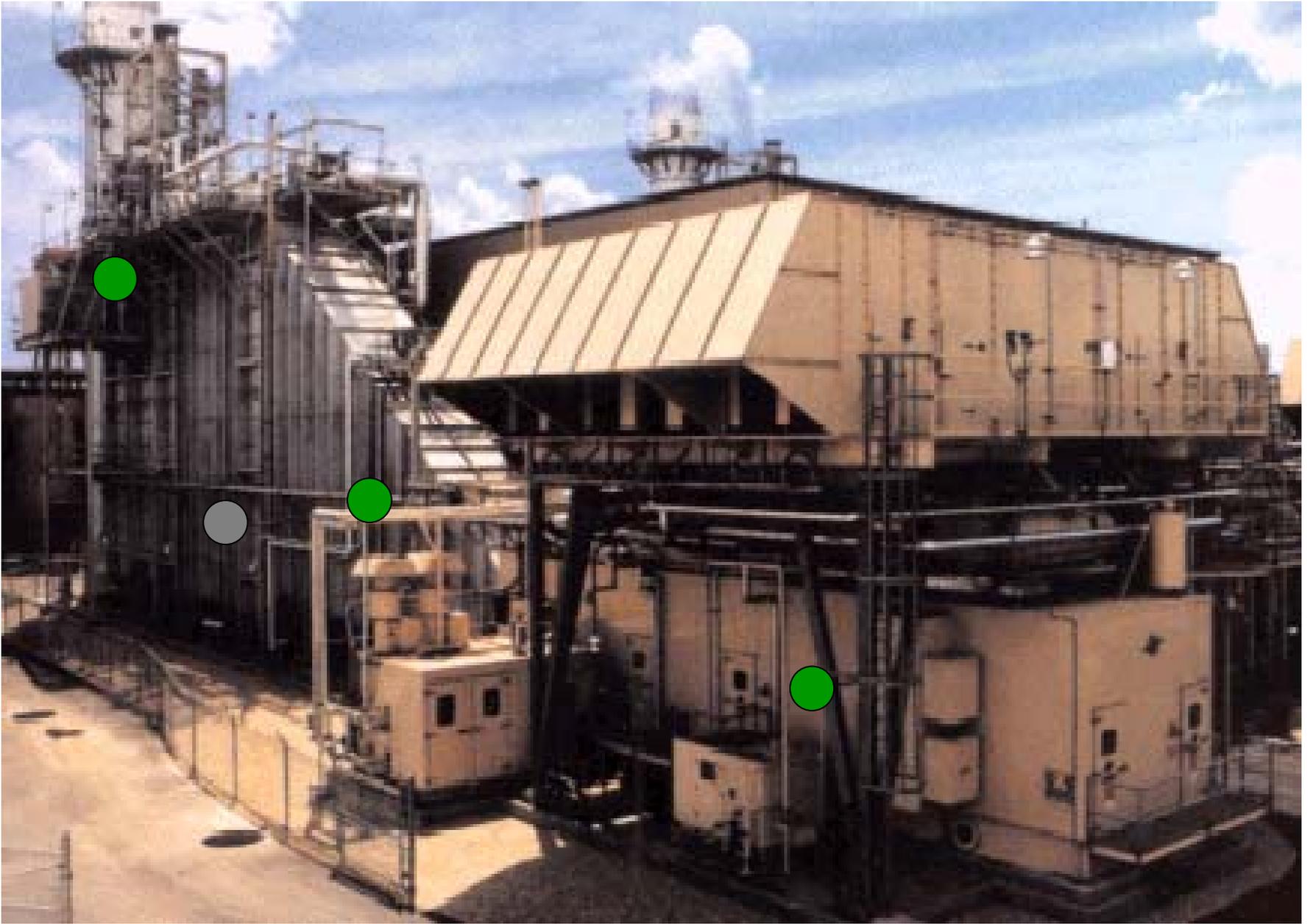
- Back End Controls
- **New Combustion Processes**
- **Cleaner Fuels & Efficiency**
- **Energy Conservation**

*Pollution Prevention is a combination of last 3 items*

# Examples of International Standards for GT Units Larger than ~ 10 MWe

- United States 2 - 42 ppm
- Australia 42 ppm
- UK 60 mg/m<sup>3</sup>
- Germany 150 mg/m<sup>3</sup>
- France 100 - 150 mg/m<sup>3</sup>
- Canada 0.5 kg/MW<sub>hr</sub> \*
- New EU LCPD 50 - 75 mg/m<sup>3</sup> \*
- World Bank 320 mg/m<sup>3</sup>

\* Facility Cogeneration Incentives  
(Above Values Subject to Change)

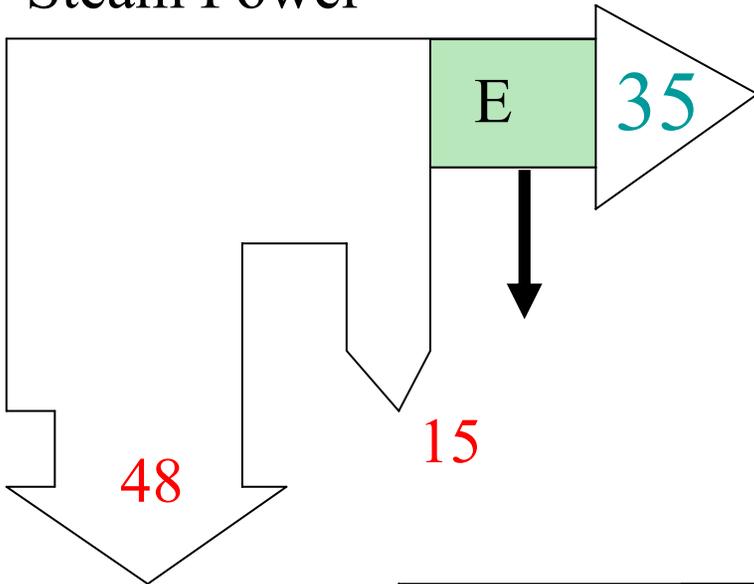


GE Power Systems

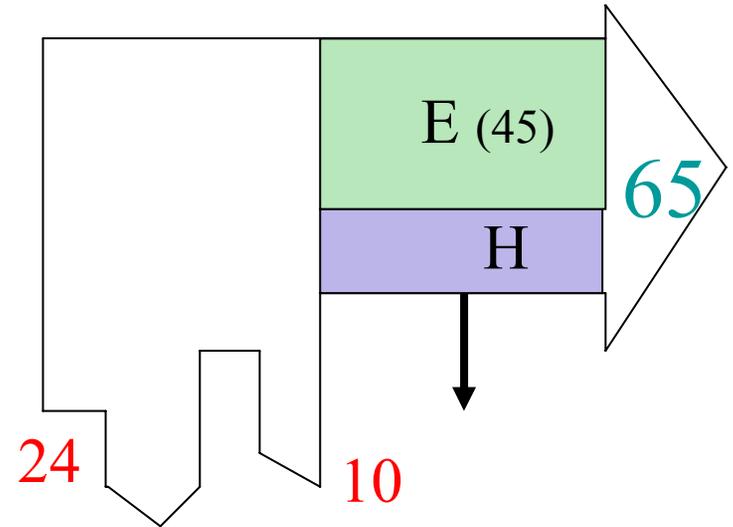
# Cycle Comparison, Heat to Power Ratio

(100 Energy Units Input)

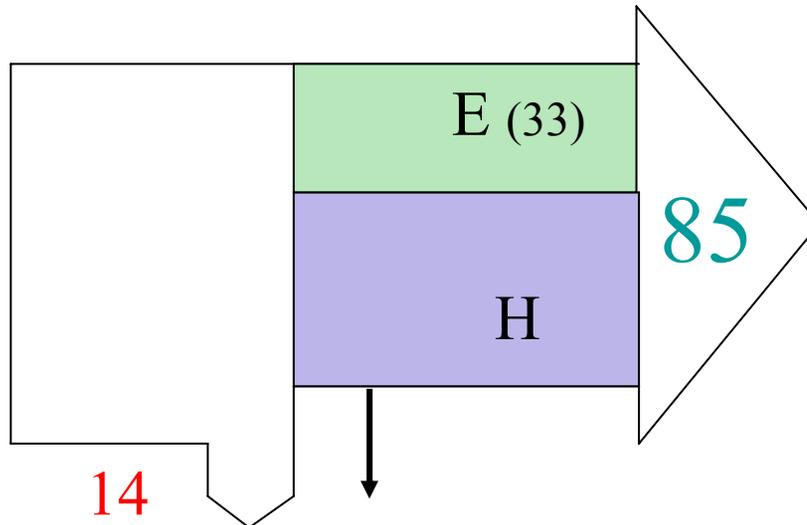
Steam Power



GT Combined Cycle Cogen



GT CHP



Energy Output (E,H)  
Condenser, Stack Loss  
Auxiliary losses

# Output Based Criteria

Traditional concentration (ppm, mg/m<sup>3</sup>) and fuel input (g/Gj<sub>in</sub>, lb/MMBTU) can be inadequate;

- difficult to interpret
- do not give appropriate design signal
- do not encourage system efficiency
- do not encourage Pollution Prevention
- Recip engines have kg/MWhr rules

Mass per Product Output (*kg/tonne, kg/MWhr*)

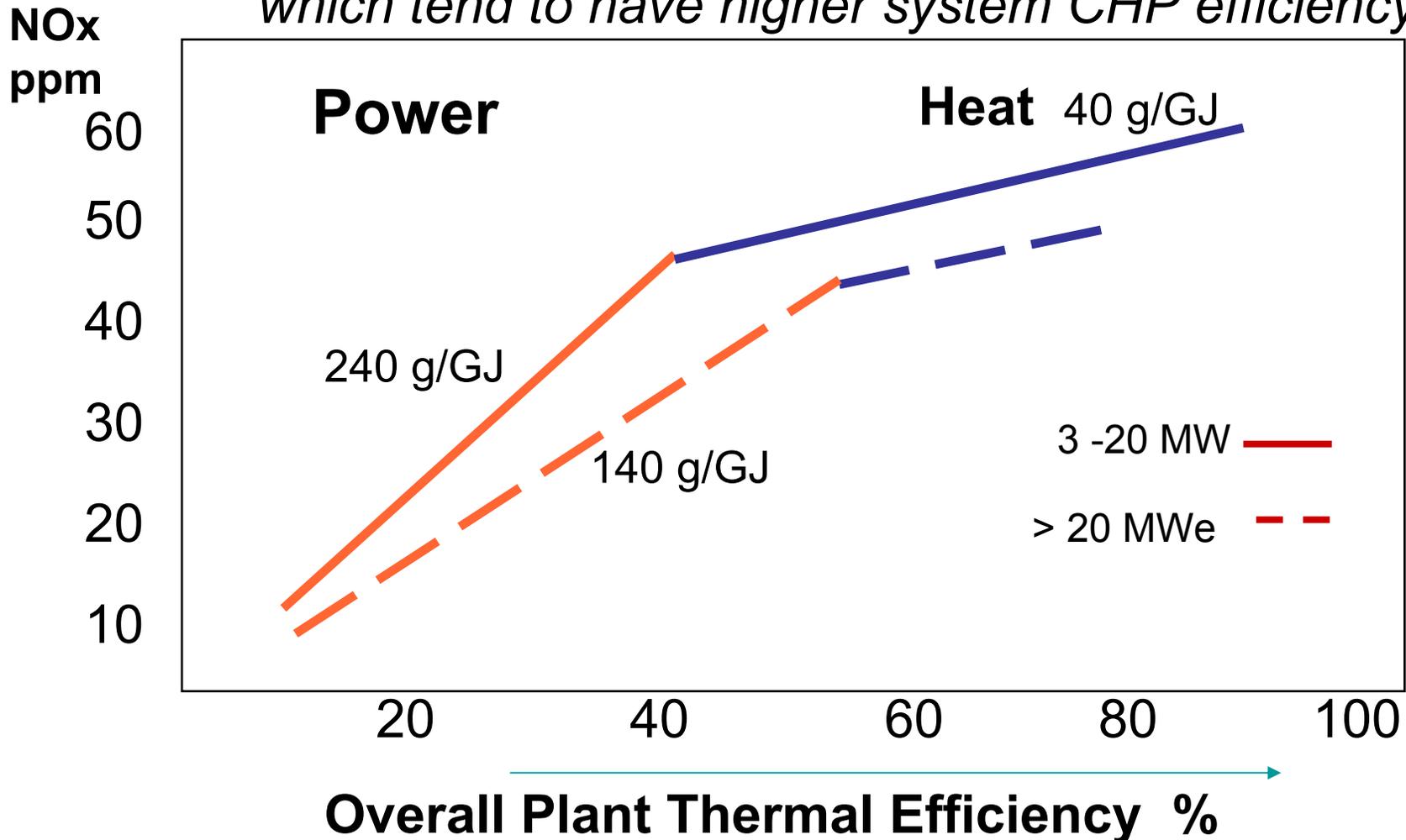
————→ tonnes/yr      —————→ \$/tonne      —————→ \$/MWhr

# **Canadian CCME GT Emission Guidelines (1992)**

- Guideline Reflects National Consensus
- Reflect Reasonable NO<sub>x</sub> Prevention Technology
- Output-Based Standard Rewards Efficiency
- Engine Sizing Considerations
- Promotes Cogeneration and low CO<sub>2</sub>
- Provincial and Local Authorities May Opt for More Stringent Requirements
- Flexible Emissions Monitoring

# CCME Gas Turbine Guideline

*CCME allows higher NO<sub>x</sub> for smaller units, which tend to have higher system CHP efficiency*



# Proposed New US EPA Emission Rules for Gas Turbines

- **Feb 2005 – New Proposal for Output-based Stds**

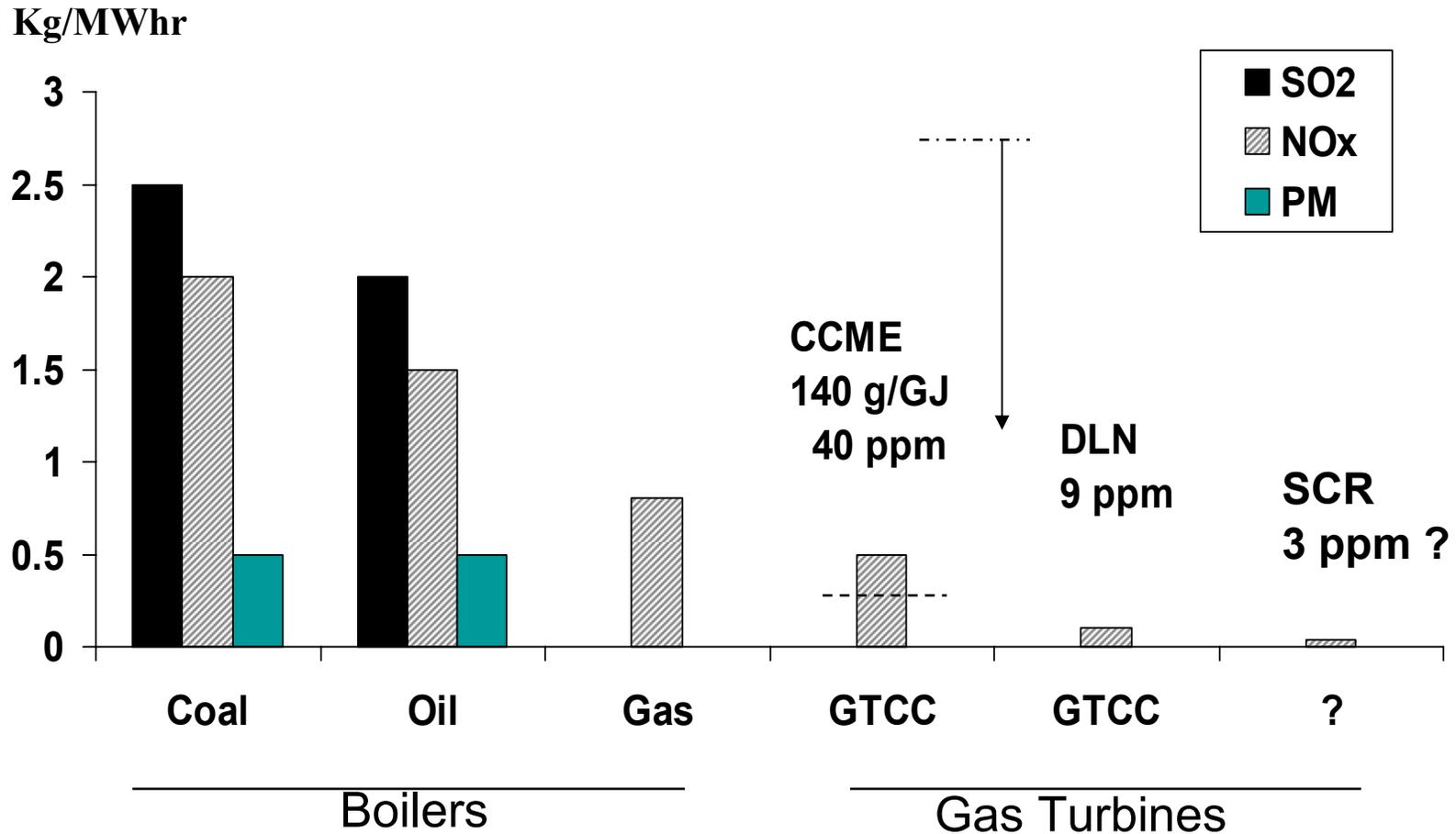
**1 lb/MWhr                      < 30 MWe**

**0.4 lb/MWhr                    > 30 MWe**

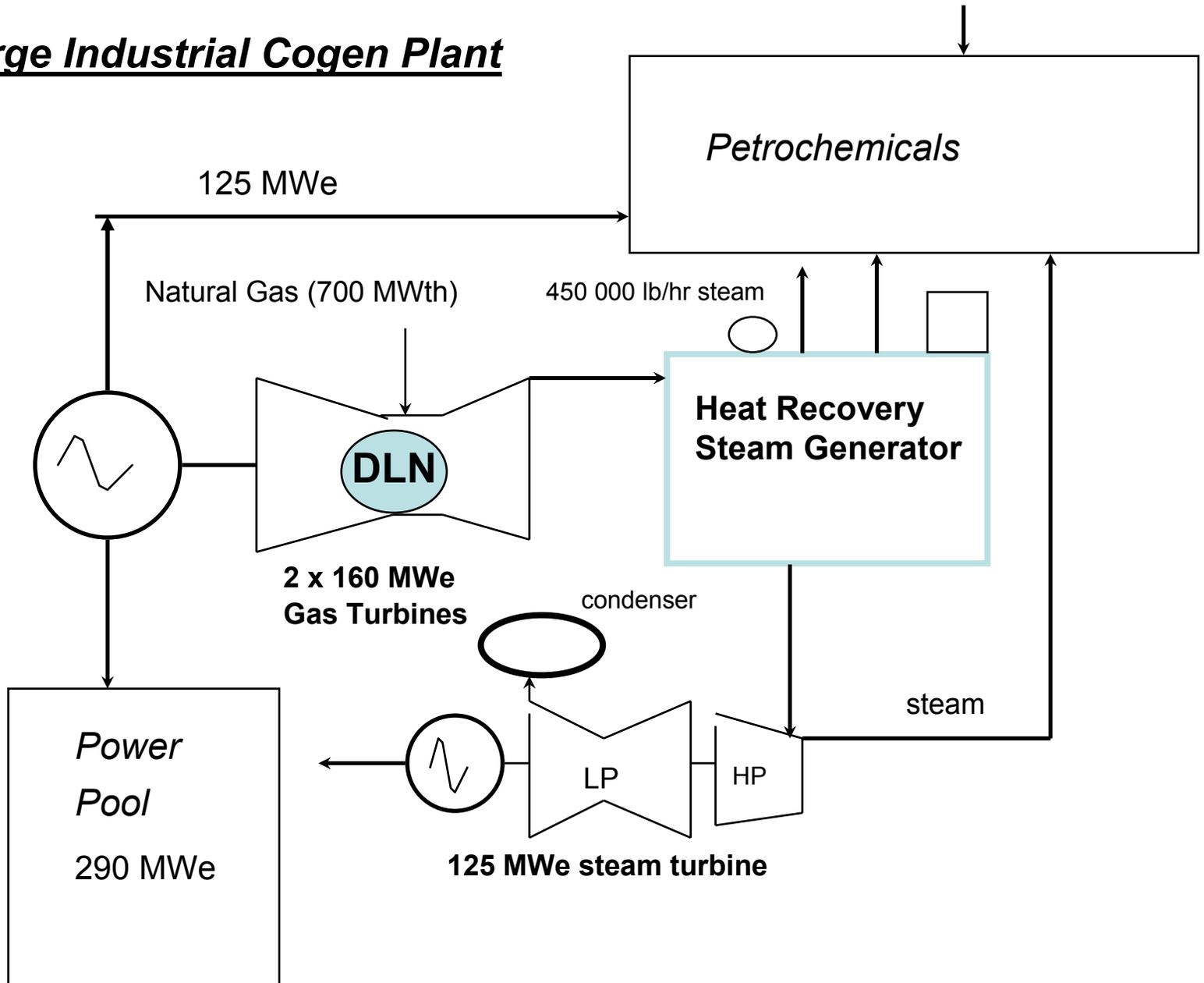
**(may include MWth for waste heat)**

- **Efficiency based, SCR likely not required**
- **Flexible Emissions Monitoring**

# Comparison of Air Pollution Emissions from New Energy Generating Plants



# Large Industrial Cogen Plant



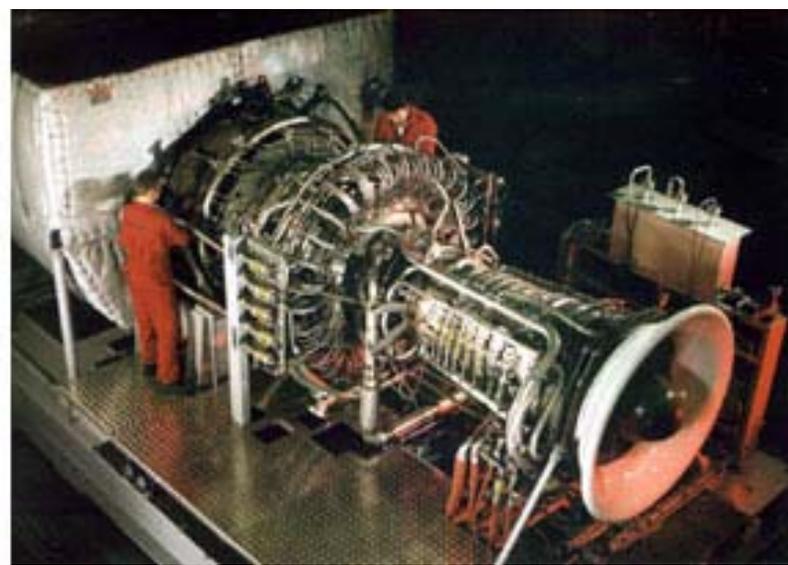
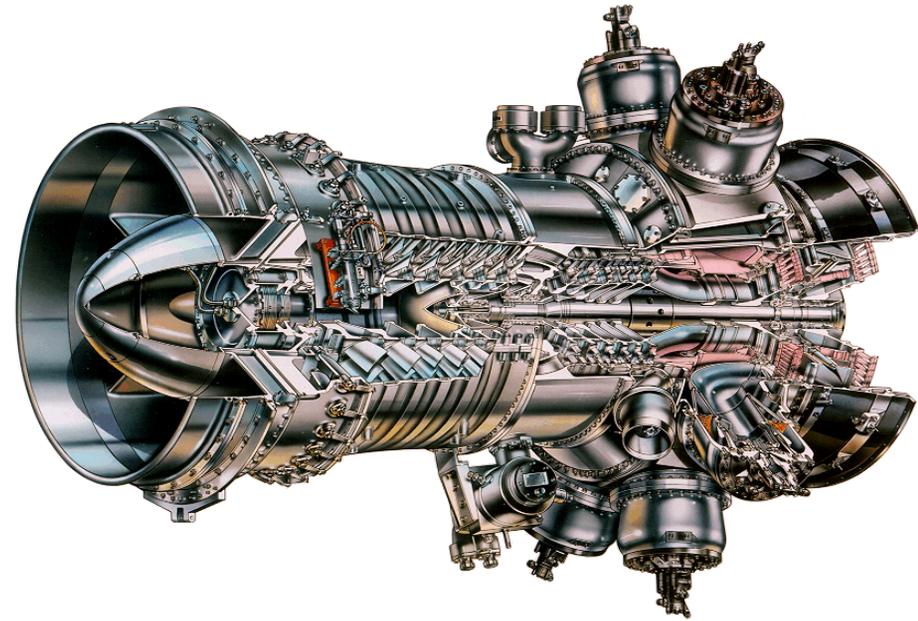
# **Environmental Assessments of Gas Turbine Energy Plants**

(T.McCann Study, for *TCPL and Env Can*)

- Companies may be required to install added ammonia-based SCR controls after DLN
- Ammonia transportation & handling is a serious local health and safety issue
- Given the capital and operating costs associated with SCR systems, the environmental benefits in Alberta do not justify the economic expense.

# Aero-Derived DLN Systems

## Rolls Royce RB211 DLE



**LM2500 (DR Vectra)**



**GE LM600 DLE**



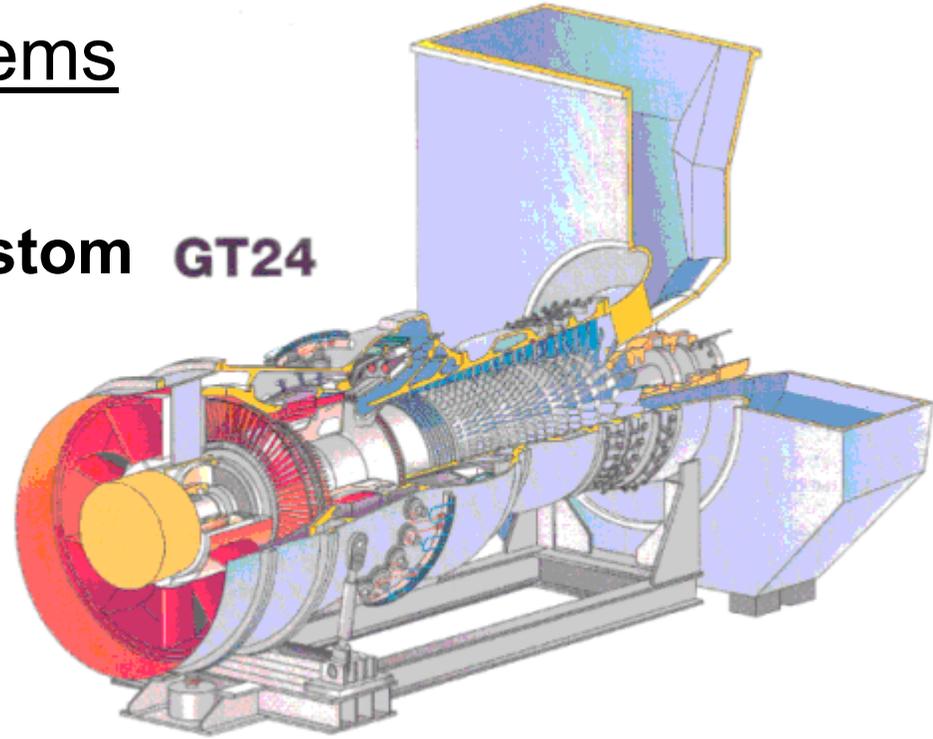
courtesy of the BFC Group

**RR Trent**

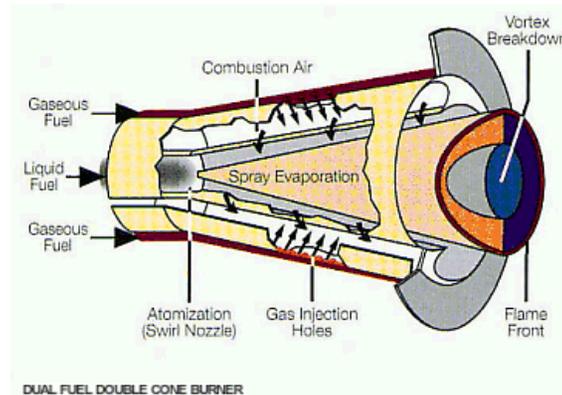
# Industrial Frame DLN Systems



## Alstom GT24



## GE Frame 7 DLN



## EV Burner



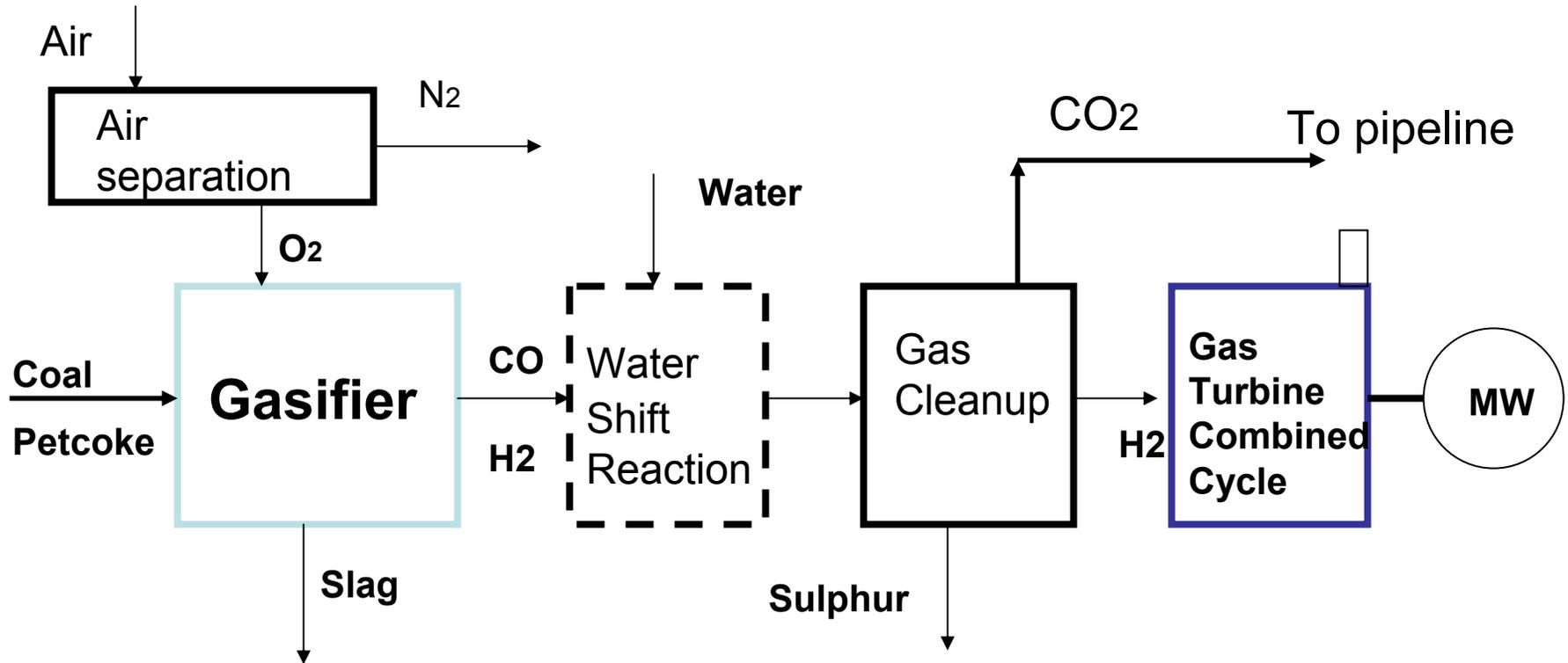
# Large GT Combined Cycles

- Produce only Electricity
- Large Condensers Reject 40% of Fuel Energy
- Cause Environmental Thermal Pollution Issue
- Too Large for Good CHP Heat Recovery



Built Quickly in Large Sizes, Consume Large Amounts of Natural Gas Over Short Time Frame ... (Gas Supply and Prices ?)

# Solid Fuel Gasification System



Essential elements :

**Gasifier, gas turbines, cogeneration, CO<sub>2</sub> capture, H<sub>2</sub> co-production**

# Concluding Remarks

- **Gas Turbine Plants have Very Low Air Emissions**
- **Energy deregulation, economic efficiency and environment will drive future GT & CHP growth**
- **All Plant Emissions Should be Addressed**
- **Need System Design, Long Term Planning**
- ***A gas turbine is an engine, part of a system***
- **Combustor Reliability & Fuel Supply are Problems**
- **Output-based Standards can be Superior**
- **Need Training and Awareness**