

Benefits of High Efficiency Cogeneration and CHP Facilities

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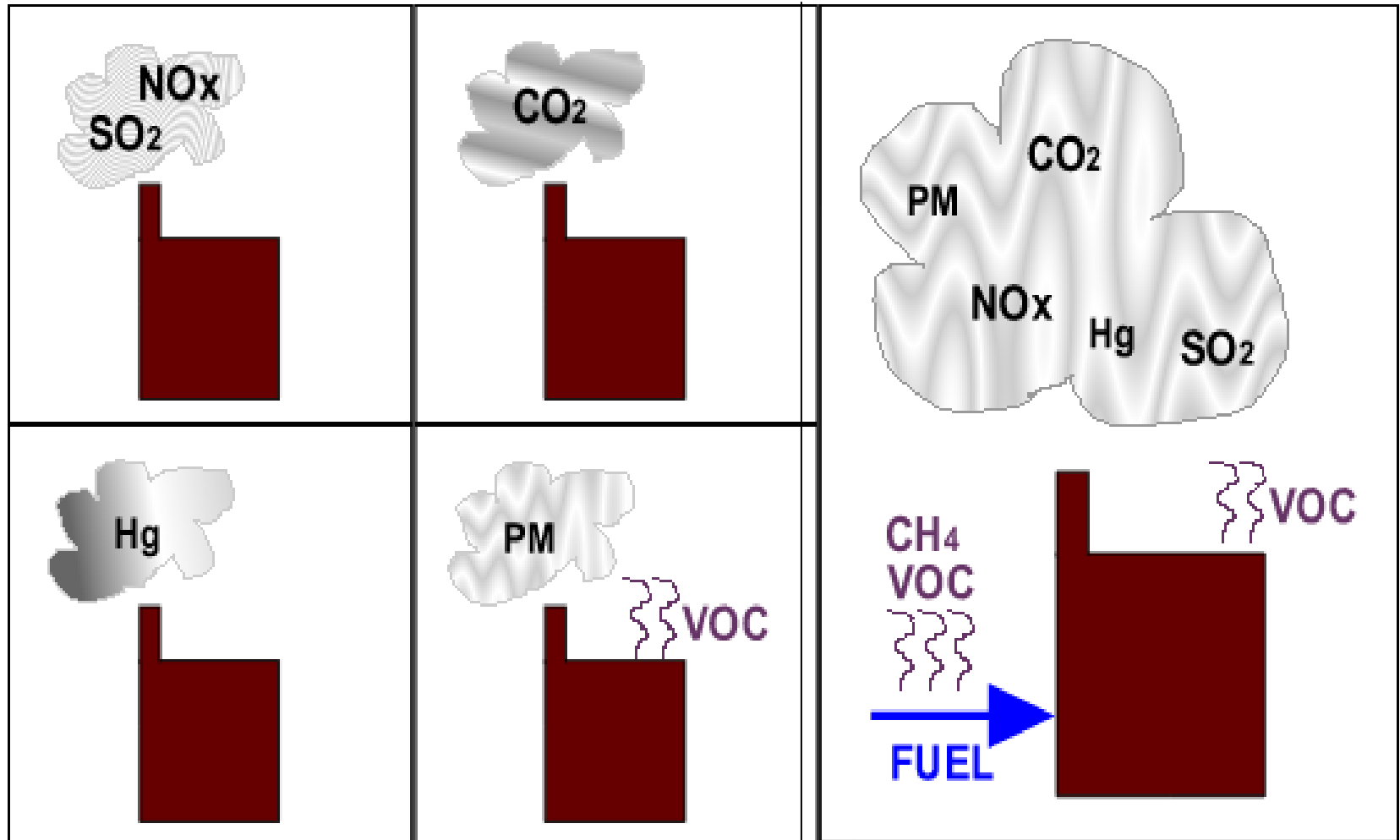
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- **Air Pollution and GHGs**
- **Benefits of Combined Heat & Power (CHP)**
- **Canadian Examples, CHP Potential**
- **Solutions to Barriers**

Air Pollution and Greenhouse Gases

Separate Emissions ??

System



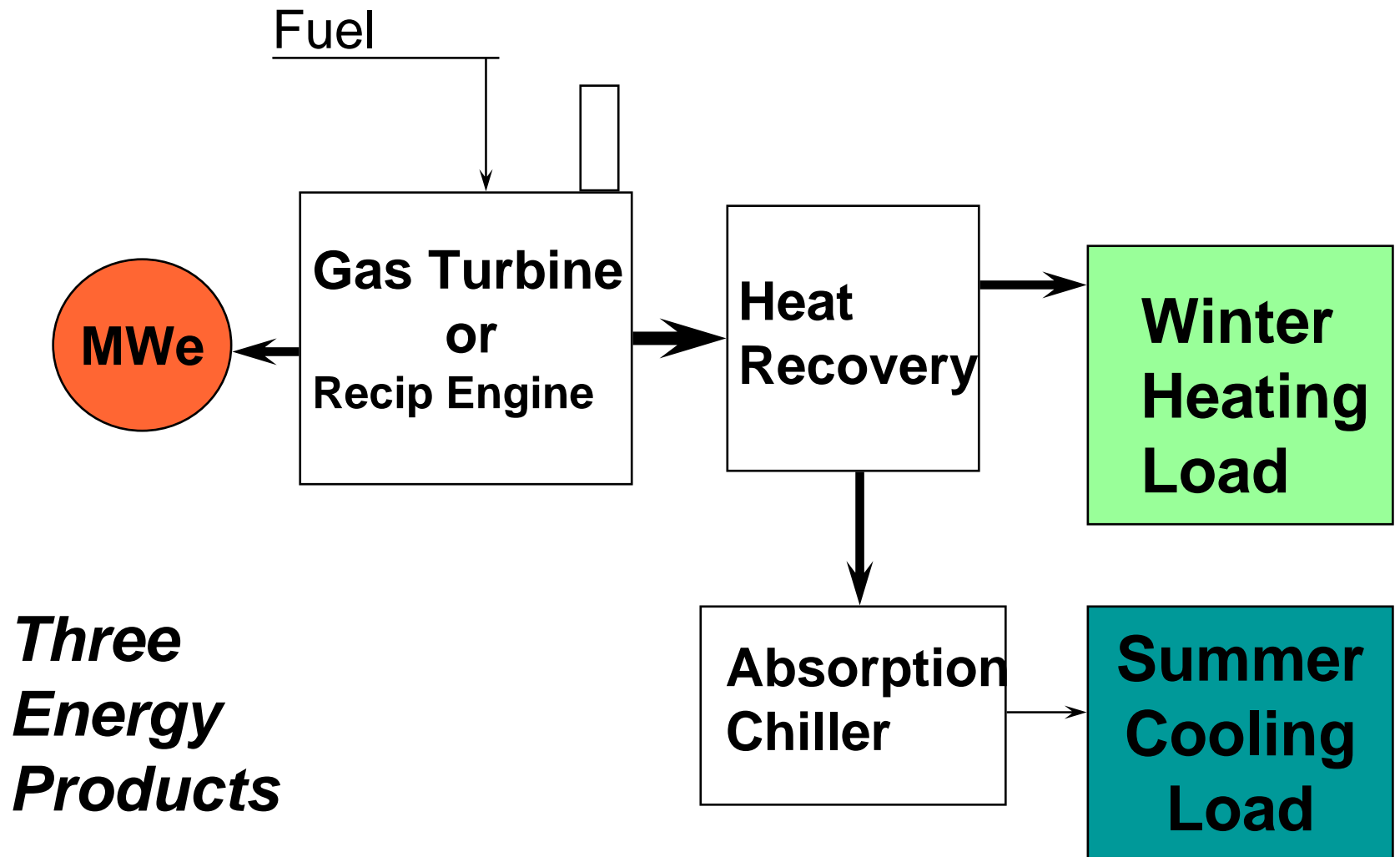
Emission Reduction Methods

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

Pollution Prevention is a
combination of last 3 items

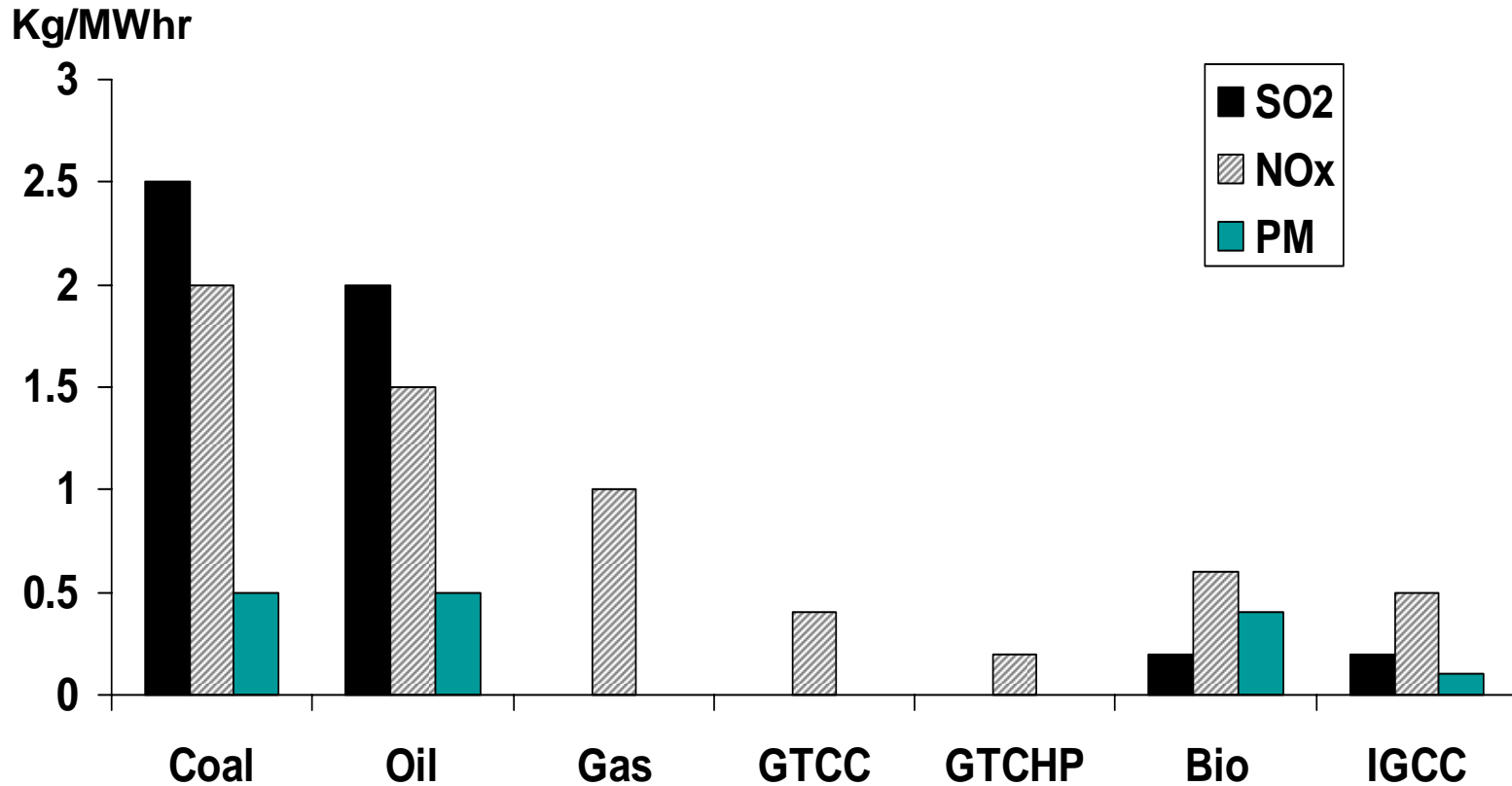
Cleaner Energy Choices

- Aggressive Energy Conservation
- Small Renewable Energies, Biomass
- High Efficiency Natural Gas CHP Systems
- Large Hydro & Nuclear
- Coal and Petcoke Gasification Systems
- Waste Material Recycling and Use
- Coal/Oil Combustion (with max controls)



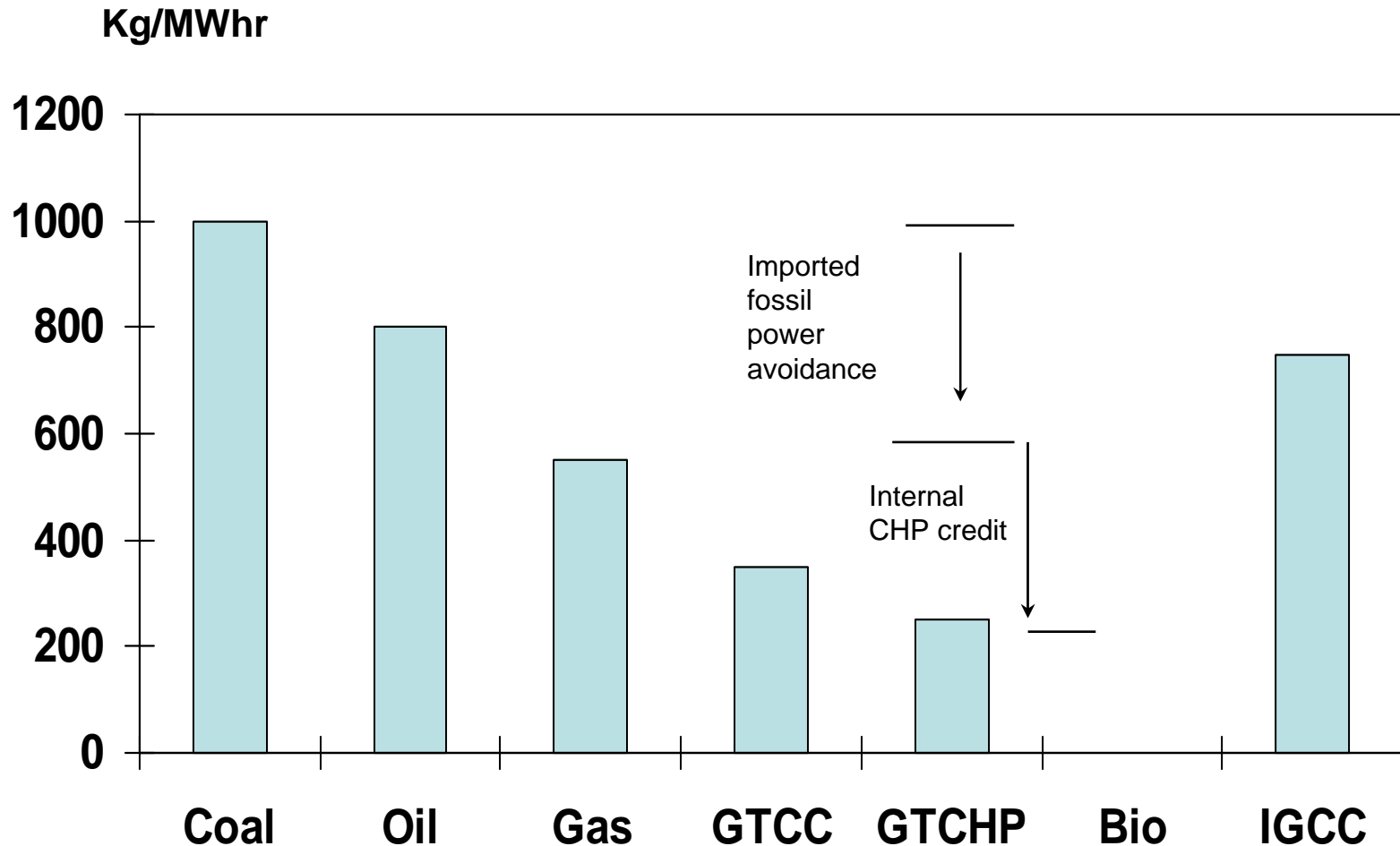
Combined Heat & Power Schematic

Comparison of Air Pollution Emissions from Various New Energy Generating Plants

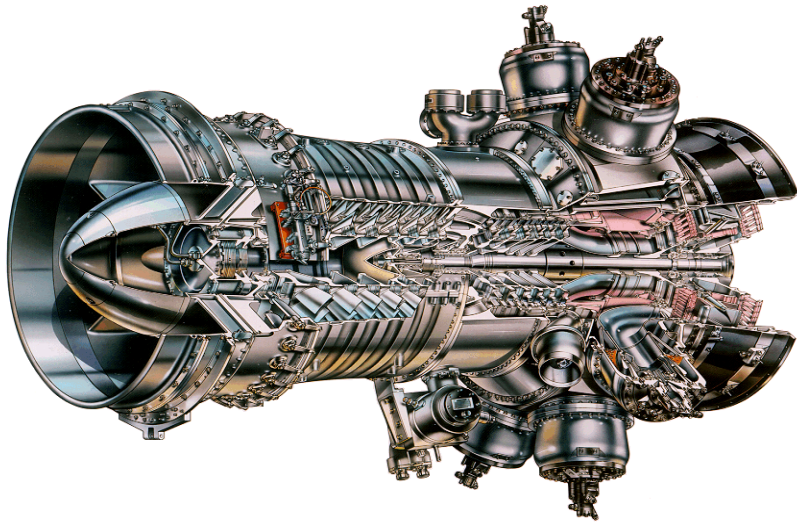


Comparison of CO₂ Emissions from Various Power Generation Plants

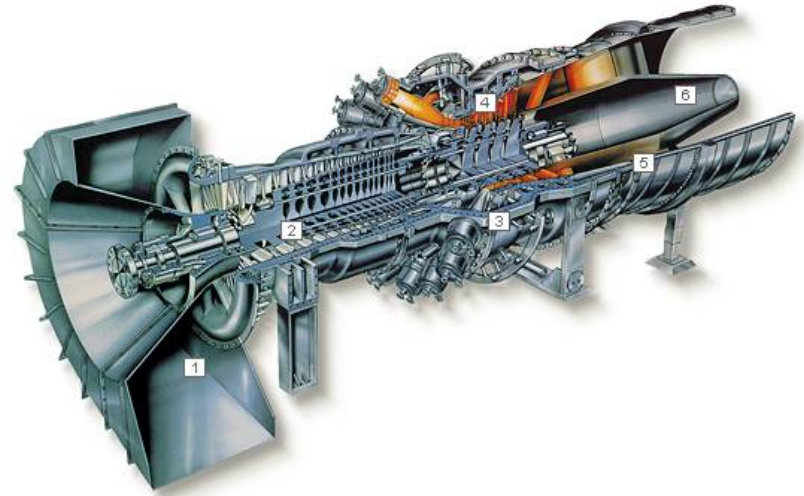
(Heat Rate x Fuel CO₂ = kg/MW hr)



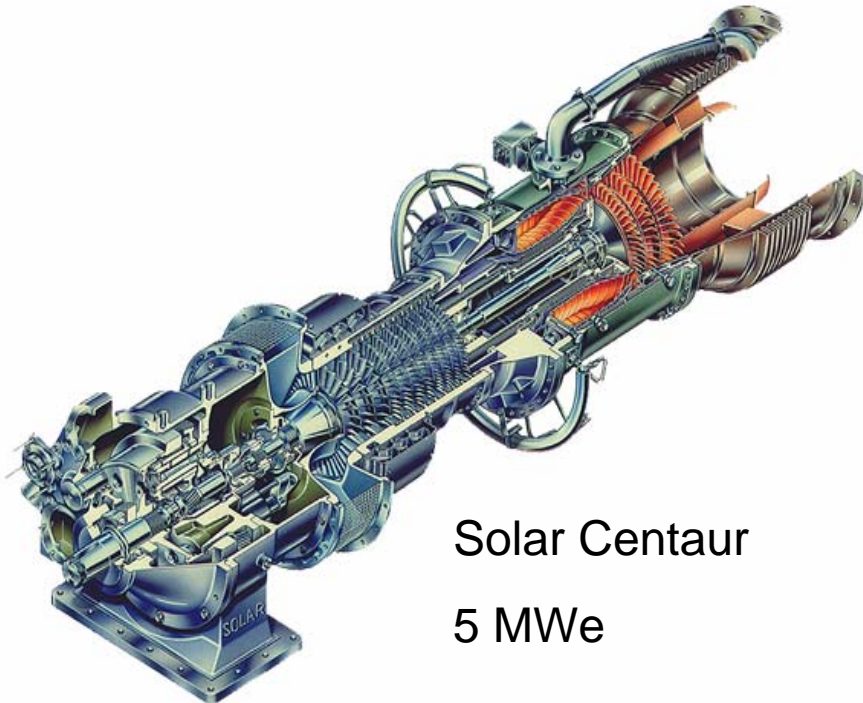
Gas Turbines



28 MWe Industrial RB211 DLE



Siemens Westinghouse W501F, 180 MWe



Solar Centaur
5 MWe

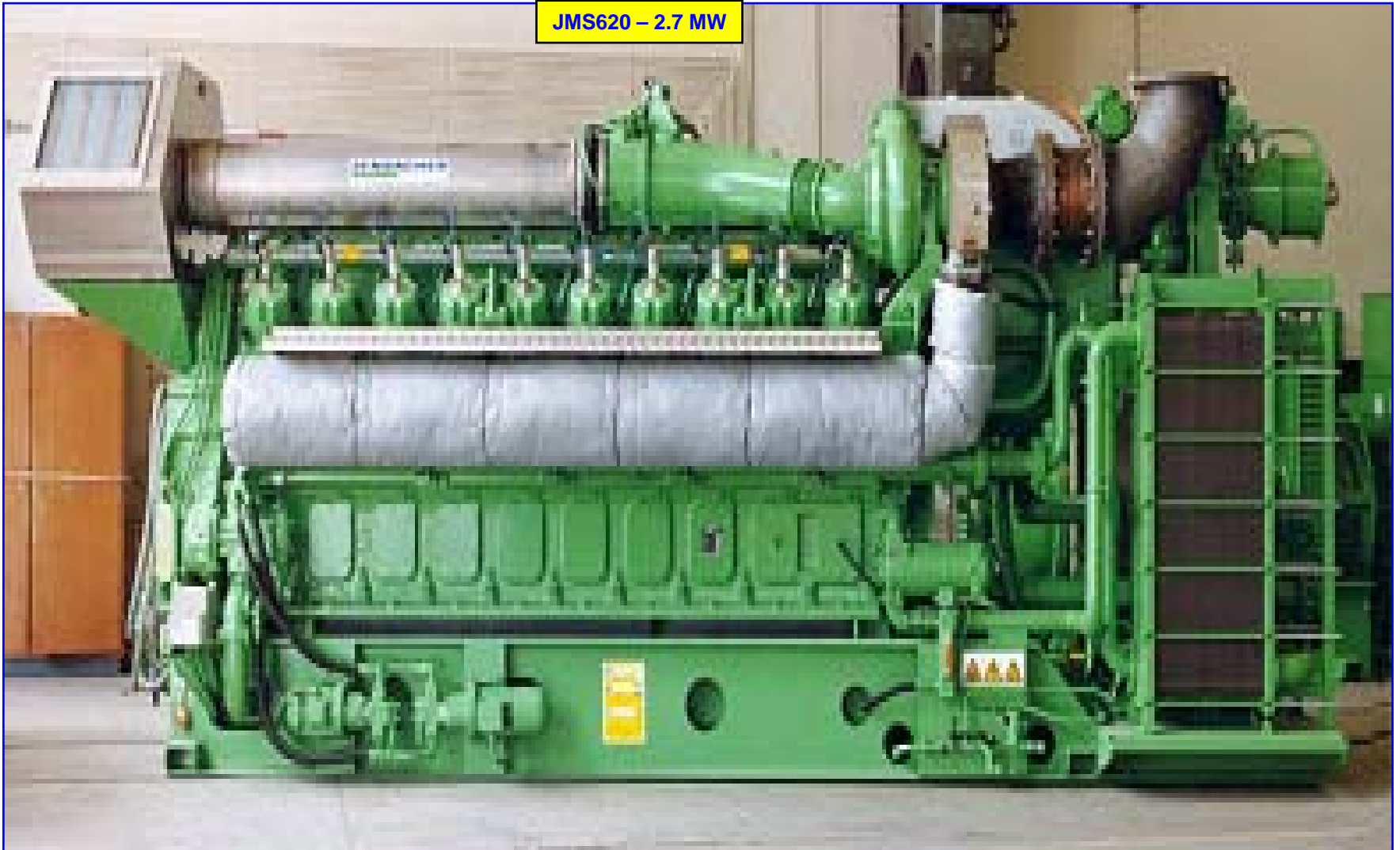


42 MWe GE LM6000



Gas Turbine & Heat Recovery Steam Generator (GE Power Systems)

JMS620 – 2.7 MW



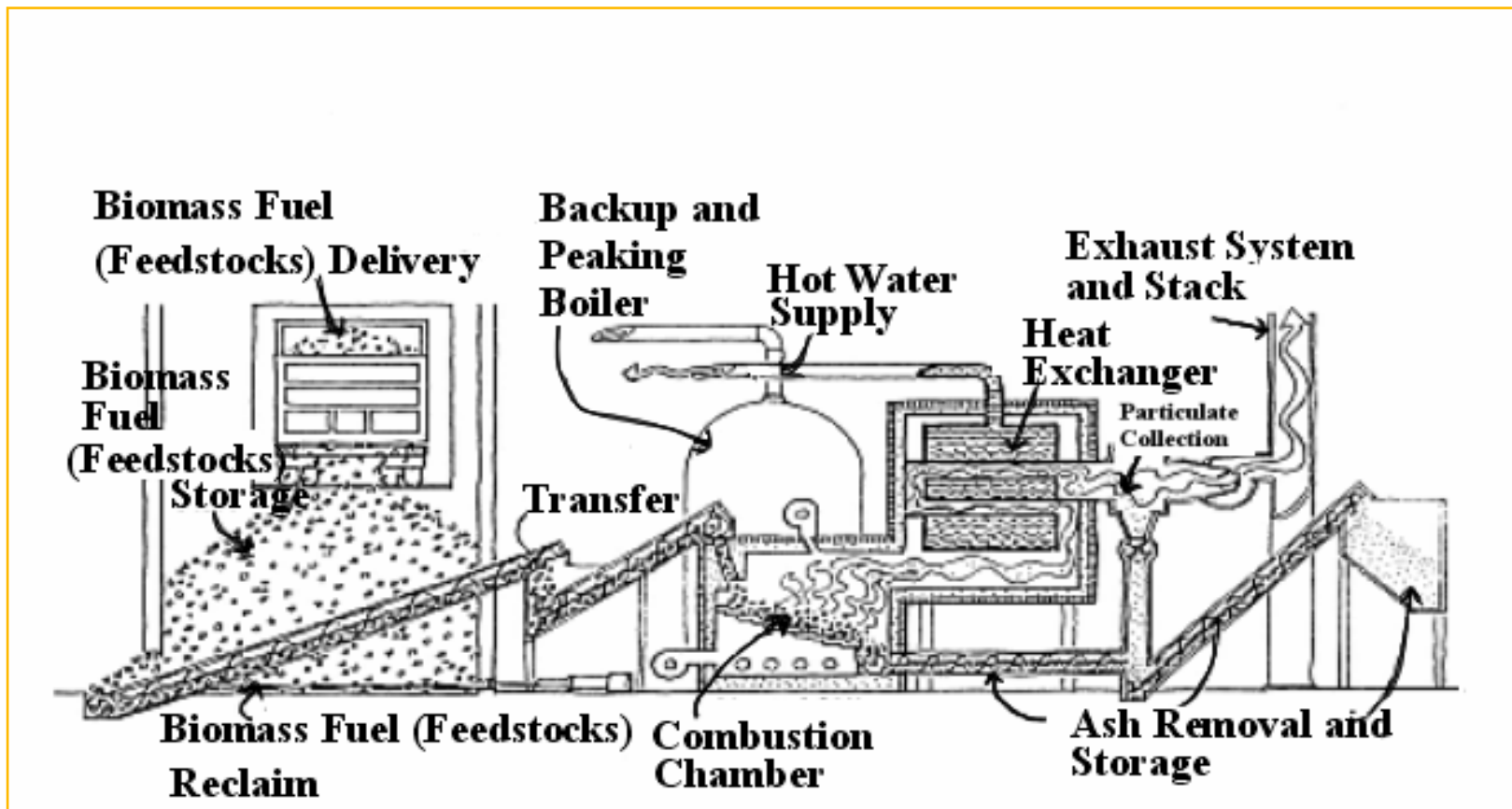
(GE Jenbacher)

Biomass Heating System Description



RETScreen® INTERNATIONAL

www.retscreen.net



(NRCan)

STATIONARY ENERGY USE

(8 000 PJ/yr)

- Most energy applications make only one form of energy (power, heat or cooling)
- About half of today's stationary energy is produced in form of waste heat
- The combined production of both Electrical and Heat/Cooling energy in “distributed” systems can save ~ 1/3 of fuel usage

Quality of Energy

- Electricity & Shaft Power
- Industrial Process Heat
- Cooling
- High Pressure Steam
- Hot Water
- Space Heating

High



Low

- **All of these can be made with same fuel**
- **Need to Use Energy at Best Level**
- **Env. Standards could Encourage this**

Objectives of Industrial Ecology

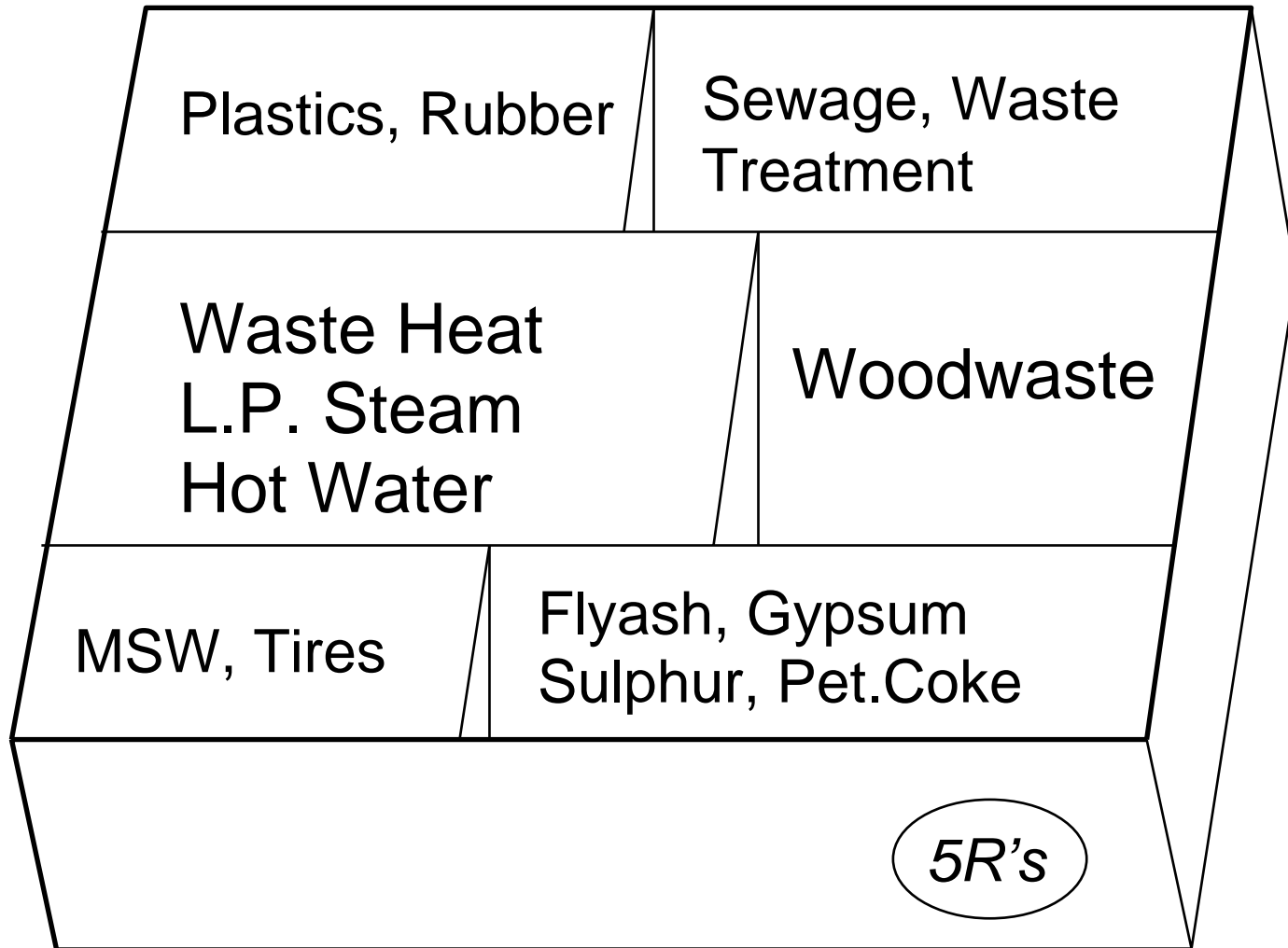
(Process Integration, Intensification)

- To reduce Waste and Increase Profits by Turning **OUTPUTS** of One Process into **INPUTS** to Another Process

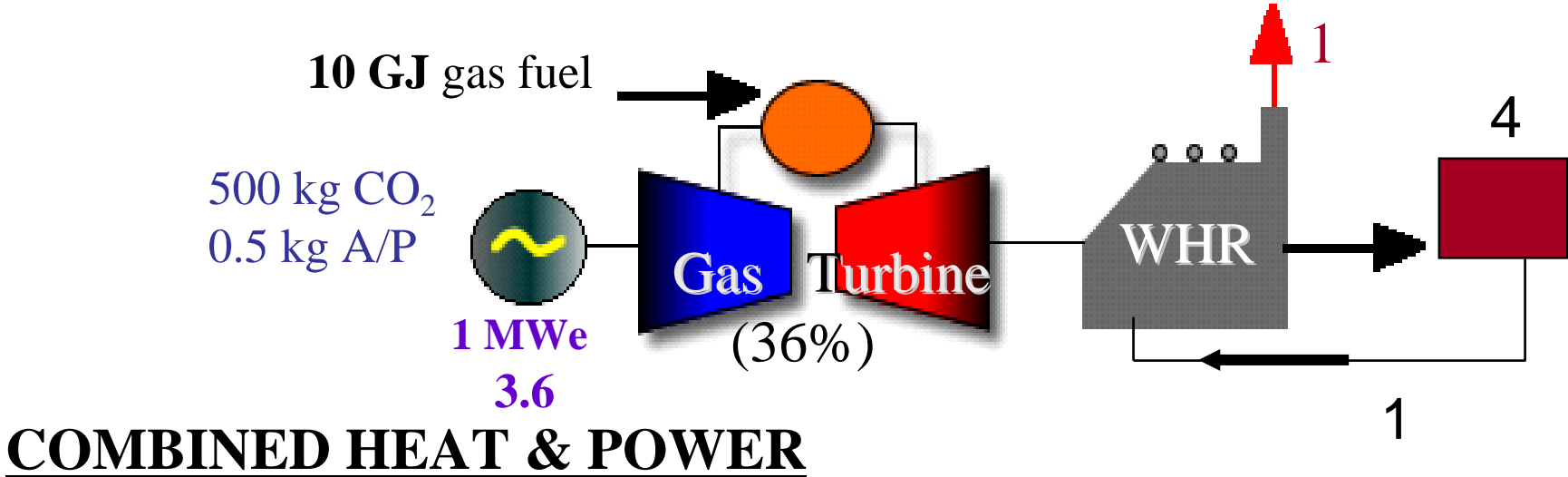
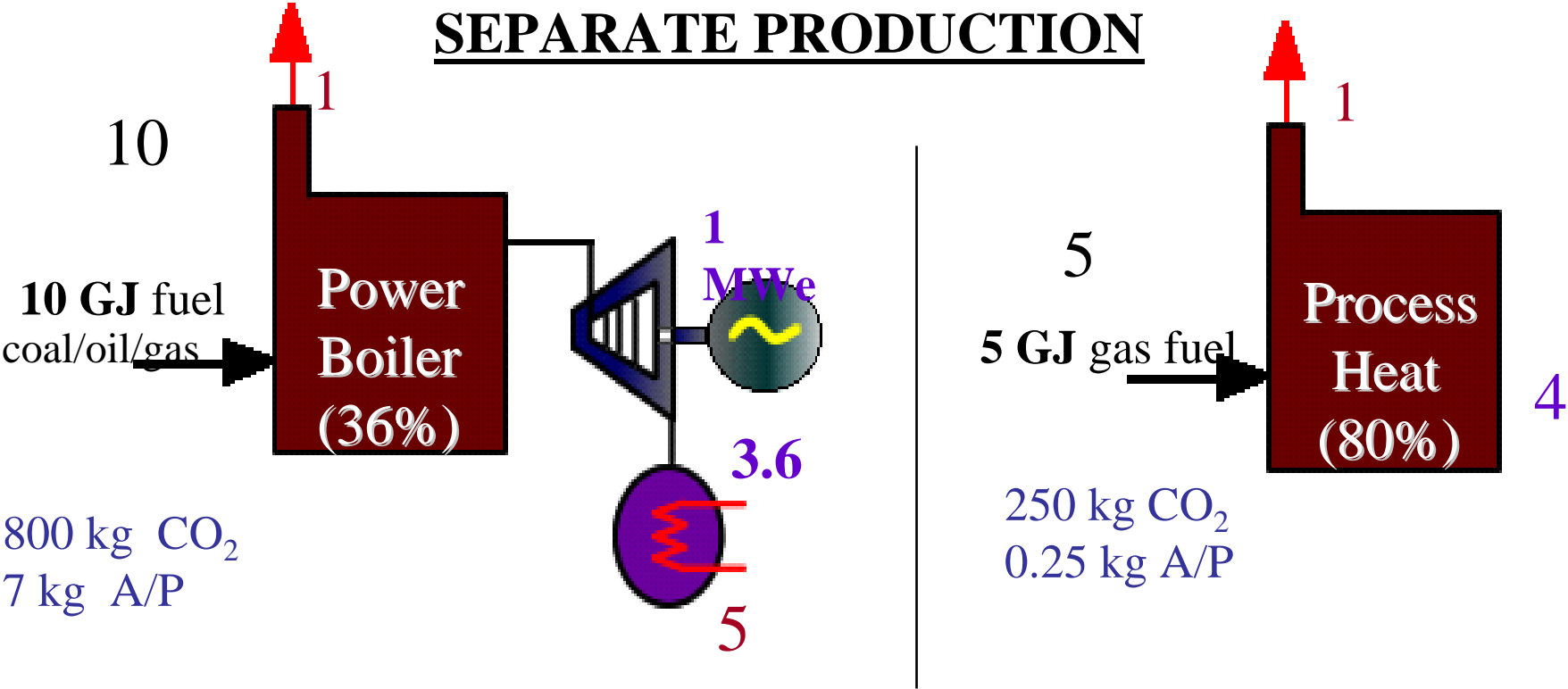
Eco-Industrial Park Features;

- Energy Conservation in Industrial Processes (waste heat recovery)
- Waste Material Recycling
- Synergistic Siting of New Industries

"Industrial Blue Box"



SEPARATE PRODUCTION



COMBINED HEAT & POWER

Comparing *Separate Heat and Power* Production with *Combined Heat & Power CHP System*

(System Needs; 1 MW electricity and 4 MW thermal energy)

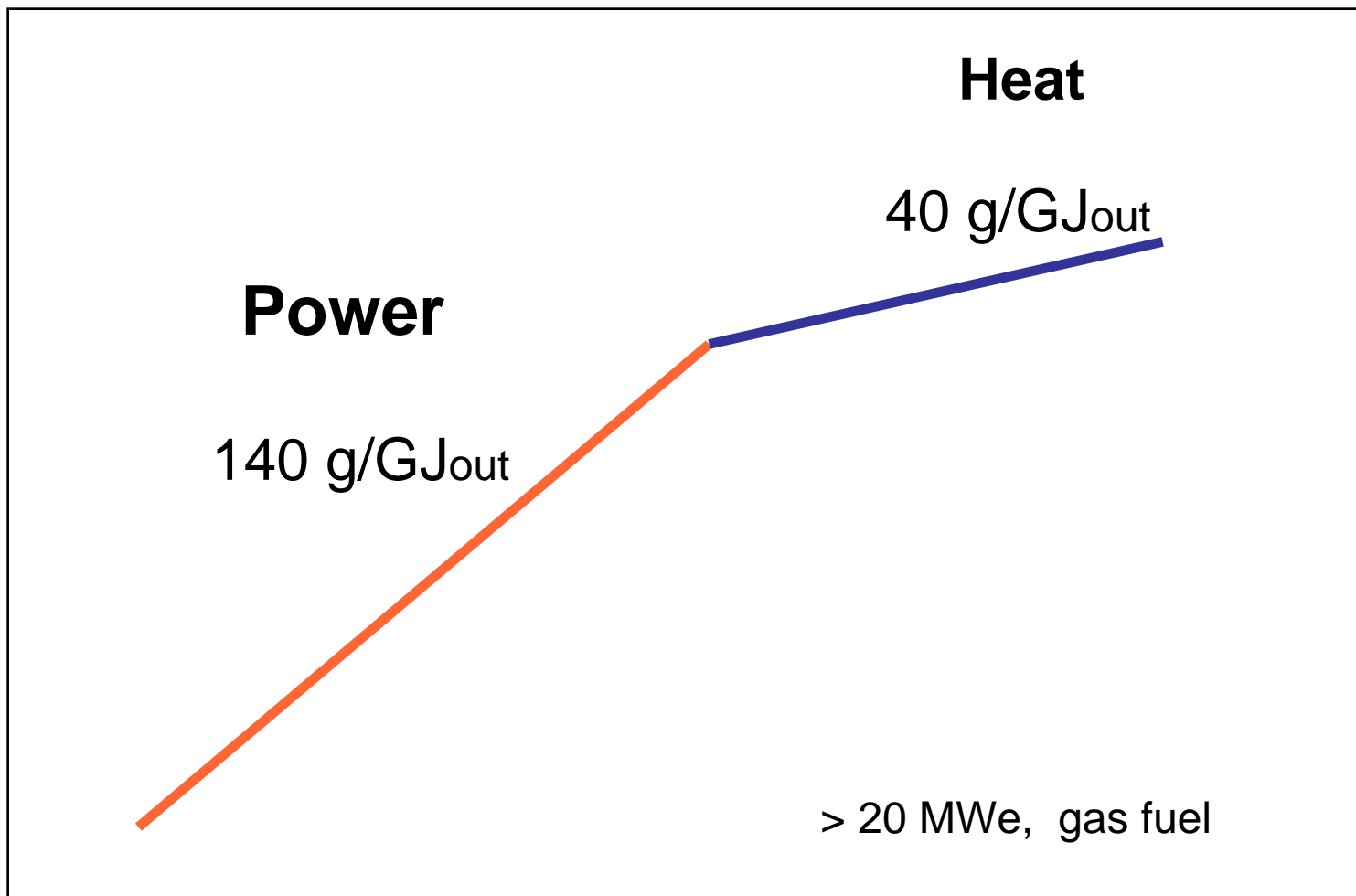
- Separate Prod'n uses 10 GJ of mixed Fuel in Boiler making 3.6 GJ of electricity, and 5 GJ gas fuel for 4 GJ of steam (loss = 7 GJ)
 - Fuel: 15 GJ Air Pollution: 7.25 kg CO₂ 1250 kg
-
- CHP uses 10 GJ of Fuel in Engine to make 3.6 GJ of electricity, and from Waste Heat Boiler makes 4 GJ of steam (loss = 2 GJ)
 - Fuel: 10 GJ Air Pollution: 0.5 kg CO₂ 500 kg
-
- *Comparison suggests a reduction of 30 % in fuel , 90% in A/P , and a 60% GHG reduction*

Critical Elements for CHP Systems

- Awareness of Opportunities
- Nearby Site
- Proper Plant Sizing to Match Thermal Load
- Design for Seasonal Heating/Cooling
- Electrical Interconnection, Utility Interface
- Availability of Gas, Biomass, H₂ fuels
- Low Air Pollution, Local Impacts

CCME 1992 Gas Turbine Emission Guideline

NO_x
ppm



20

40

60

80

100

Overall Plant Thermal Efficiency %

Benefits of CHP Systems

- Energy Conservation and Security
- Maintaining Energy \$\$ in Communities
- Energy Diversity and Reliability
- Reduces Thermal Pollution
- Reduces Transmission Losses
- More Building Space Available
- Lower GHGs, Air Pollution, CFCs

Energy Security

- Power Outages (...rare ?)
- Heat & Cooling services affected
- Importance to;
 - Public, Commerce, Industrial Processes
- CHP plants can function through Outages
- “Islanding” Design & Operation
- Interconnection and Safety

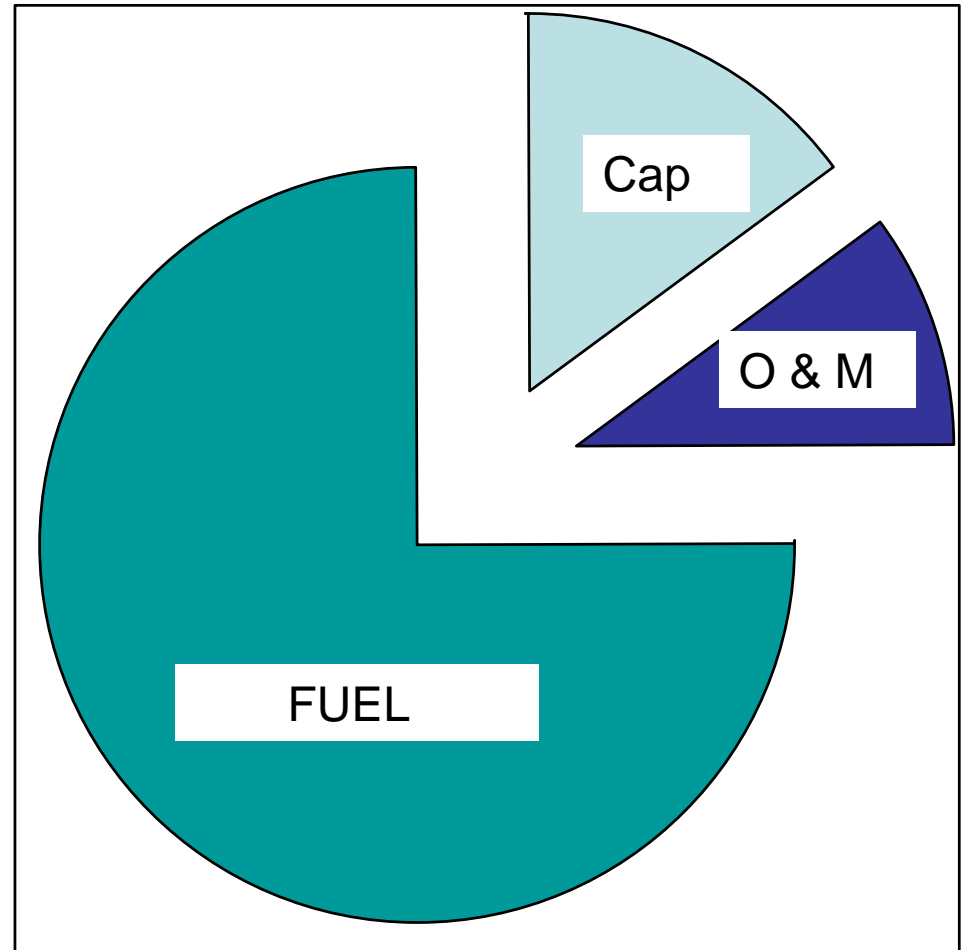
Barriers to CHP Systems

Inadequacies in...

- Awareness of Opportunities
- Cooperation (all levels and sectors)
- Business Case (Multiple Benefits)
- Long Term Planning
- Financial Incentives (incl. Taxation)
- Utility Restructuring
- Infrastructure Capital Cost ↔ O&M Budgets
- Output-Based Emission Standards
- Balanced Environmental Assessment

Typical CHP Plant Annual Costs

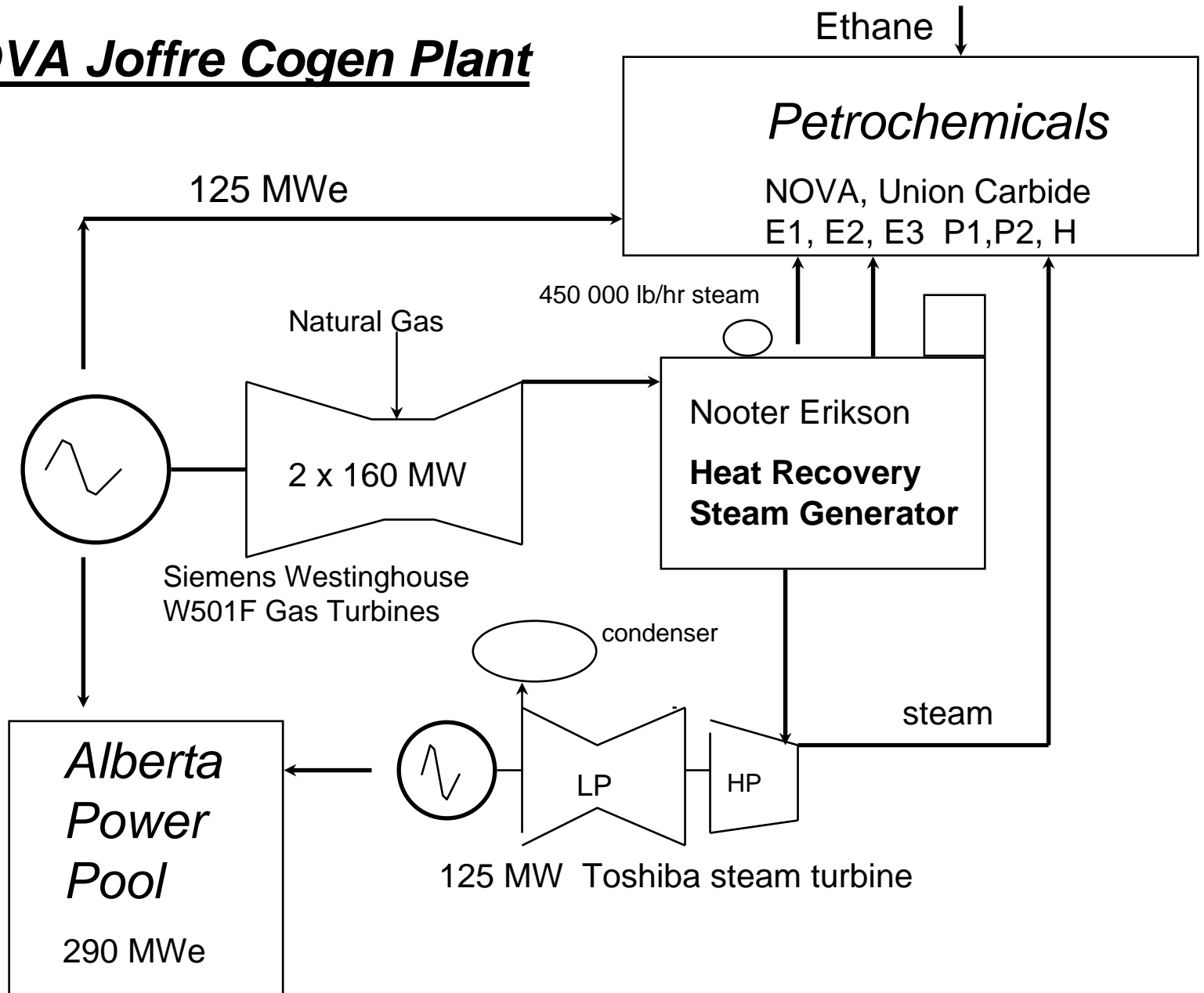
- System Fuel
Efficiency is the most important long term planning parameter
- Most Affected by plant Size, Location, and Application



GT Combined Cycles

- Produce only Electricity
- Large Condensers Reject 40% of Fuel Energy
- Cause Enviro. 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 Prices ?)

NOVA Joffre Cogen Plant





TCPL Nipigon 40 MWe Enhanced Combined Cycle



SaskPower Meridien 215 MWe, Lloydminster

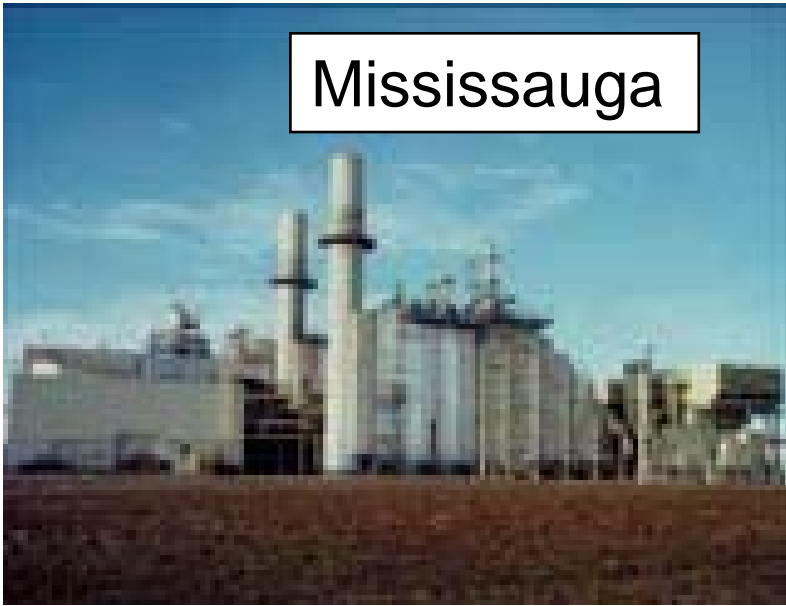


Whitby Cogeneration, 50 MWe



Calpine 250 MWe Island Cogen, Van. Is.

Mississauga



Joffre



Ottawa



Sarnia



Descriptions of Institutional Gas Turbine Cogeneration Plants

- TransAlta Ottawa 68 MWe 1992
- Trigen London 3 MWe 1997
- University of Windsor 4 MWe 1993
- University of Toronto 6 MWe 1993
- York U. Toronto 5 MWe 1997
- NRCC Ottawa 4 MWe 1994
- SAIT Calgary 3 MWe 1999
- York U Toronto 6 MWe 2003



**Capstone
Microturbines
SAIT, Calgary**



Capstone



Suntec Greenhouses , Med Hat



SONOCO Trenton 6 MWe CHP Plant



Microturbine, Tufts Cove NS

Institutional Recip Engine CHP Plants

	<u>MWe</u>	
• University of Ottawa	0.5	1988
• Olympium, Etobicoke	0.25	1991
• Brock University	6.3	1994
• Cornwall District Energy	5	1995
• EC WWTC, Burlington	0.8	1995
• Ft MacPherson	2	1997
• Ottawa Water Treatment	2.4	1999
• St. Catherines Hospital	2.5	1999
• City of Sudbury	5	2000
• Markham	3.3	2002

Community-Scale Cogen & District Heating

Cornwall, Ontario

- Two natural gas fired reciprocating engines
 - power 5.5 MWe, heat 7 MW_{th}
- District heating system total load 11 MW_{th},
 - pipes 4.5 km, 14 customers



(CANMET)



Markham District Energy (3.3 MWe, Power, Heat, Cooling) FVB Energy



Hamilton District Energy (3 MWe) (FVB Energy)



Ouge Bougoumou District Energy, Quebec

(CANMET)

Concluding Remarks

- CHP Plants have Low Air Emissions
- Air Pollution and GHGs can be prevented at the same time in a *system*
- Need to increase *energy conservation, large and small renewables, very efficient Gas & Hydrogen, Biomass & alternative fuels*
- Multiple Benefits of CHP must be recognized
- Some Barriers Remain to be Addressed
- NRCan, EC working on national CHP policies