Cogeneration for Increased Profit & Reduced Emissions

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Presentation Outline

- Emissions Reduction
- Cogeneration Technologies
- Reliability Improvement
- Cogeneration Summarized: 7c/kWh = $19.44/GJ
- Grid Interconnection
- Conclusion

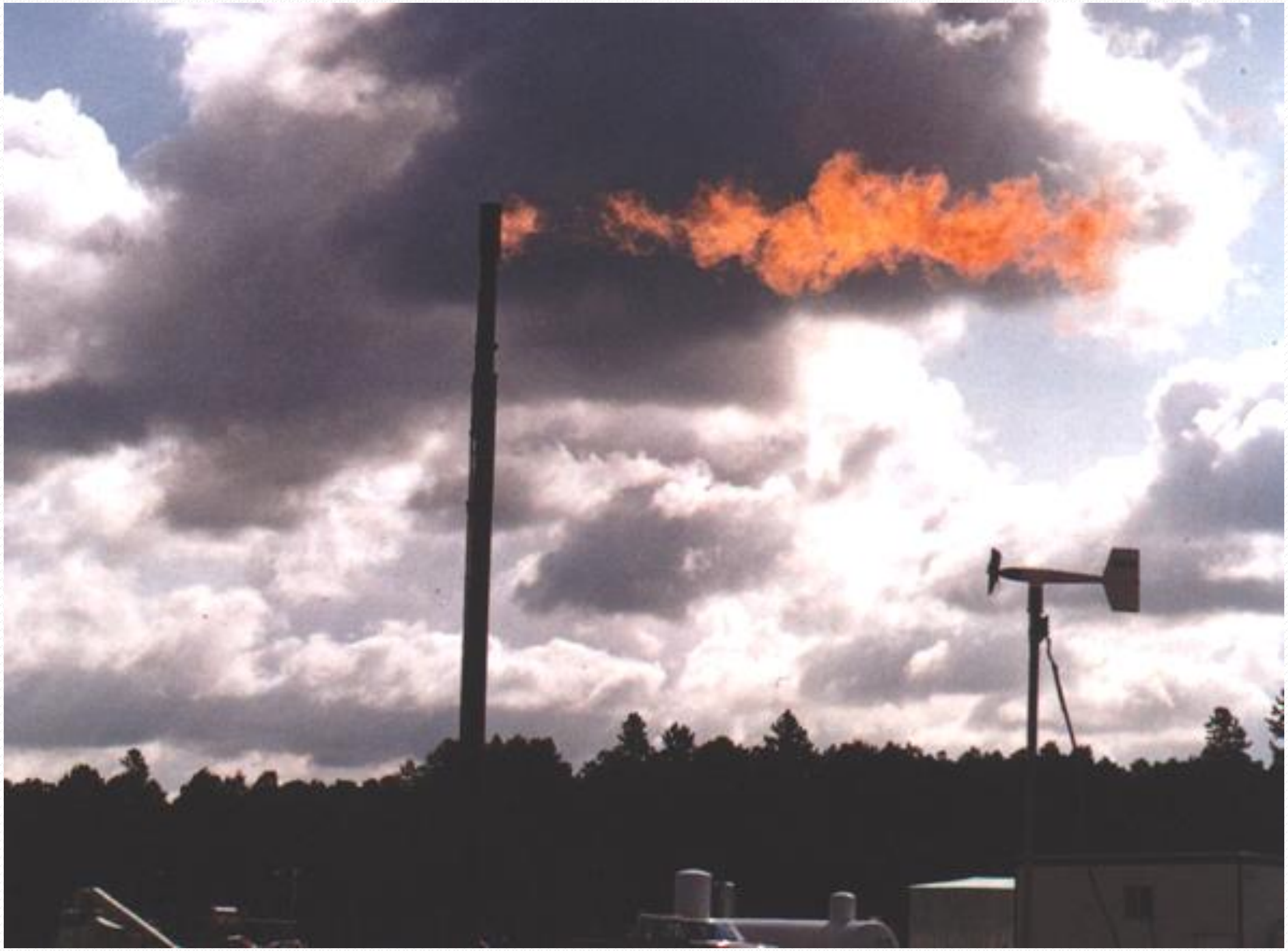
Gas flaring - A Challenging Energy and Environmental Problem

- “Gas flaring is one of the most challenging energy and environmental problems facing the world today. ….

- Gas flaring reduction has the potential to be a great energy and environmental success story. By creating value from a wasted resource, flare gas reduction enables wider access to energy, improves environmental conditions, and provides economic development for local, provincial, and national governments.”

- Peter C. Evans, Ph.D
Director, Global Strategy and Planning
General Electric

OIL FIELD FLARE



Flare Gas

- **Flaring** operates at as **low as 66% combustion efficiency**, emitting **black smoke** and **numerous toxic pollutants**
- These are not benign or innocuous flares:
  - **300 toxic compounds** in flare emissions
  - **Significant health problems** caused by the compounds emitted
- **100% of energy** in flaring **is wasted**, when it could generate electricity
- US Researchers have shown **winds carry oil field emissions over 300km**

Some Pollutants from Flare Stacks

- **Polycyclic aromatic hydrocarbons**, a likely cancer risk
- **Benzene**, for example**,** a known carcinogen
- **Benzo(a)pyrene**, potent carcinogen, reproductive harm/birth defects
- **Carbon disulfide**, reproductive harm/birth defects
- **Carbon monoxide**, < 1% impairs neurological functions
- **Sulfur dioxide**, asthma at 0.25 ppm, bronchitis, vegetation necrosis
- **Methane**, 24 times the global warming effect of CO_2 by weight
- **Black smoke**, causes heart, lung disease, cancer
- **Hydrogen sulfide,** a highly toxic, corrosive gas, neurotoxin
- **Toluene**, reproductive harm/birth defects, health hazard, skin irritant
- **Naphthalene**, reproductive harm/birth defects, insecticide, used in mothballs
- **Ethylene,** injures vegetation
- **Many other complex harmful hydrocarbon compounds**

Benzo(a)pyrene

- Shown at the University of Texas that **Benzo(a)pyrene, causes lung cancer** at the molecular level :
  - "**most potent mutagen and carcinogen known**" - Science, Oct., 1996 M.F. Denissenko, et al
  - **product of incomplete combustion in flarestacks**
  - **causes cancer at concentrations of 300 to 400 nanograms per cubic meter**
  - **specific site on gene has been identified where damage is done**
- **Benzo(a)pyrene concentration in flare gas is at least 1000 times that in inhaled cigarette smoke, based on:**
  - 460 000 nanograms/cubic meter in flare gas
  - 333 nanogram/cubic meter in inhaled cigarette smoke

California's PROPOSITION 65

- **CALIFORNIA PROPOSITION 65** … **"natural gas contains chemicals** ….**known to the State to cause cancer, birth defects and reproductive harm"**

- **The Safe Drinking Water and Toxic Enforcement Act of 1986** (**better known as "Proposition 65")** prohibits any person from exposing another unwitting individual to a chemical known to the State of California to cause birth defects or cancer

- Essentially California has recognized the hazard of natural gas emissions and has acted to eliminate them.

Cogeneration Improves Environment

- **99.5%+ incineration of toxic compounds with turbogenerators**
- Significantly **reduced levels of environmental emissions**:

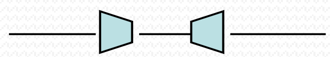
	% Emissions Reductions*
Carbon dioxide (CO_2)	60%+
Nitrogen oxides (NO_X)	95%
Particulates	100%

*Emissions reductions from using gas fired cogeneration vs. conventional coal fired generation

ENERGY Efficiency of Cogeneration vs. Conventional Power Generation

- **<u>Conventional Power Station ENERGY Efficiency</u>:**

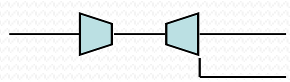
Fuel/Gas Energy Stream



Electrical Energy **(30%)**

- **<u>Cogeneration ENERGY Efficiency</u>:**

Fuel/Gas Energy Stream



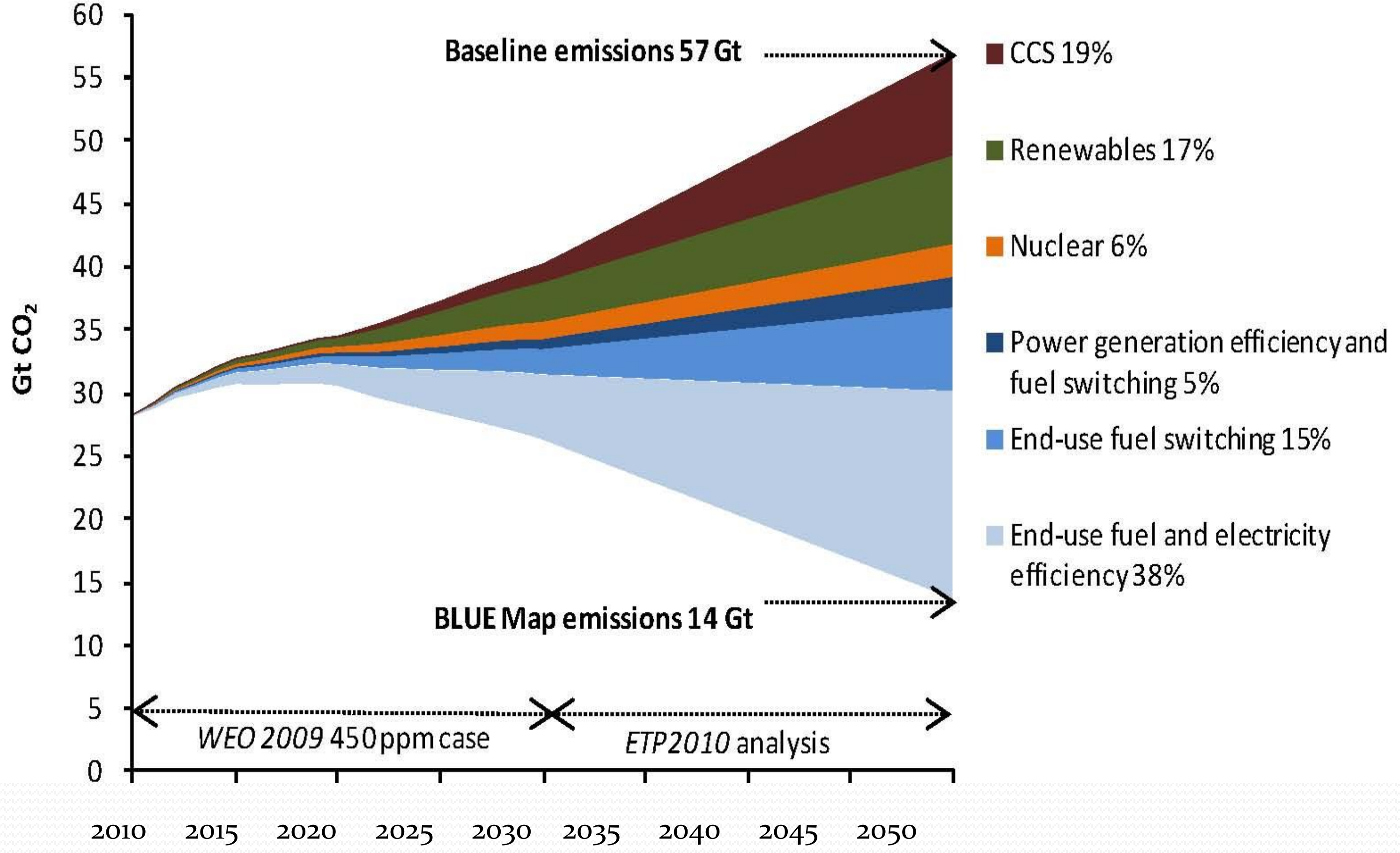
Electrical Energy **(30%)**

Useable Heat Energy **(50% +)**

<u>Total = 80 + %</u>

<u>Cogeneration</u> (also called Combined Heat and Power, CHP) is the joint production of electricity and useful heat.

Key Technologies for Reducing C02 Emissions
International Energy Agency - June 2011



Microturbine Generation, Saskatchewan

•Installation of 2 x 30 KW microturbines

•Units are designed to operate continuously in a grid connect application

•***<u>Eliminates Continuous Flare</u>***

(Supplied by Cummins/Capstone)

Cogen System, Manley Oil Company, Downtown, Los Angeles

Containerized CHP Modules (up to 1.4 MW)

CHP system will be delivered to site, off-loaded and fully assembled with only 3 customer connection points:

- Gas inlet
- Hot water supply and return
- Electrical connections at synchronizing breaker

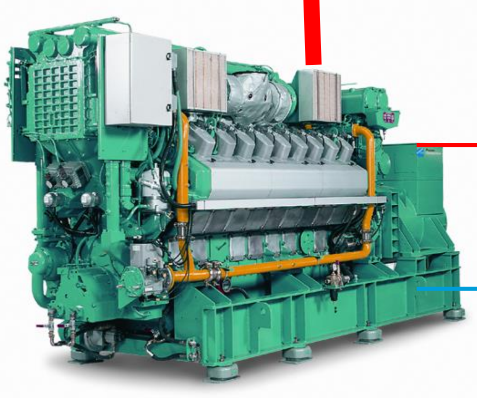
Benefits

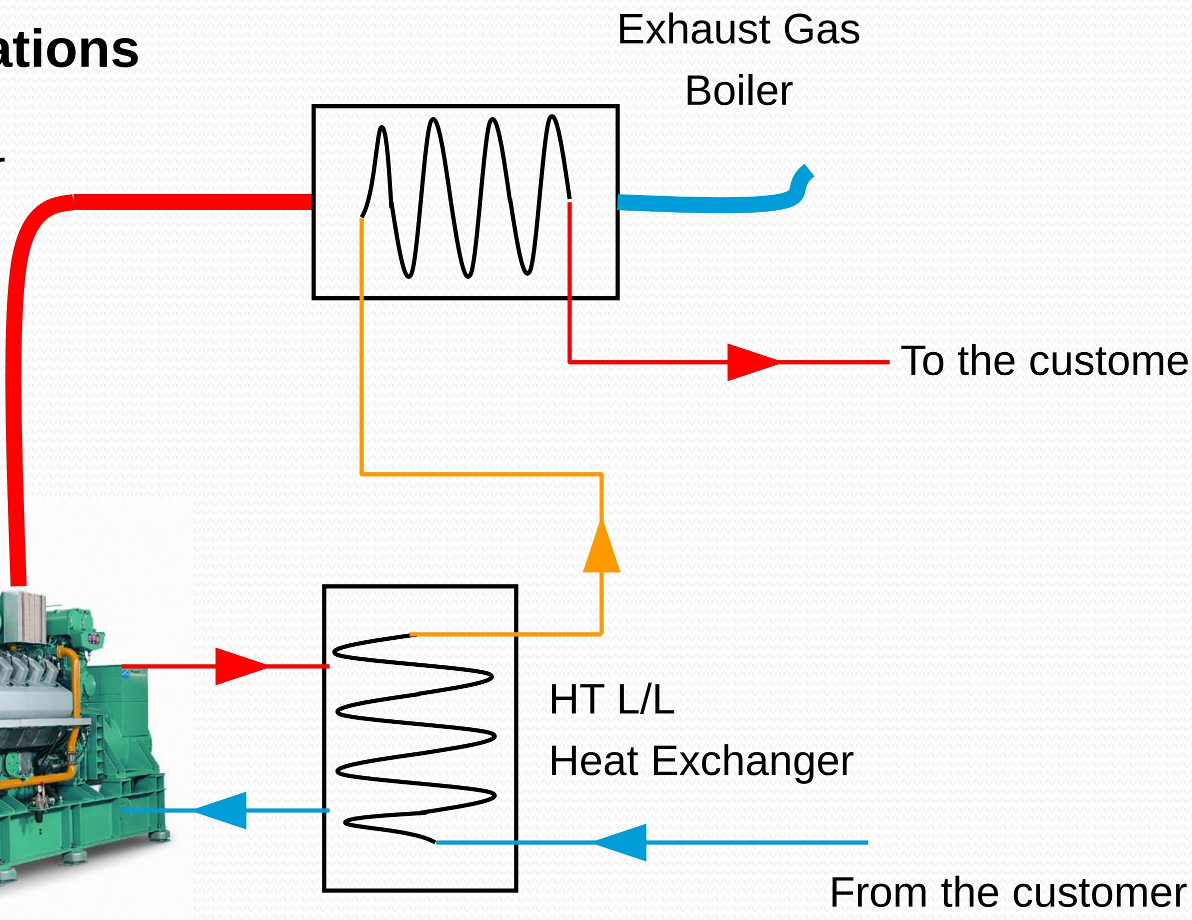
- Lower engineering and installation costs
- Increased system reliability
- Shorter project timelines

Cogeneration with Reciprocating Engines

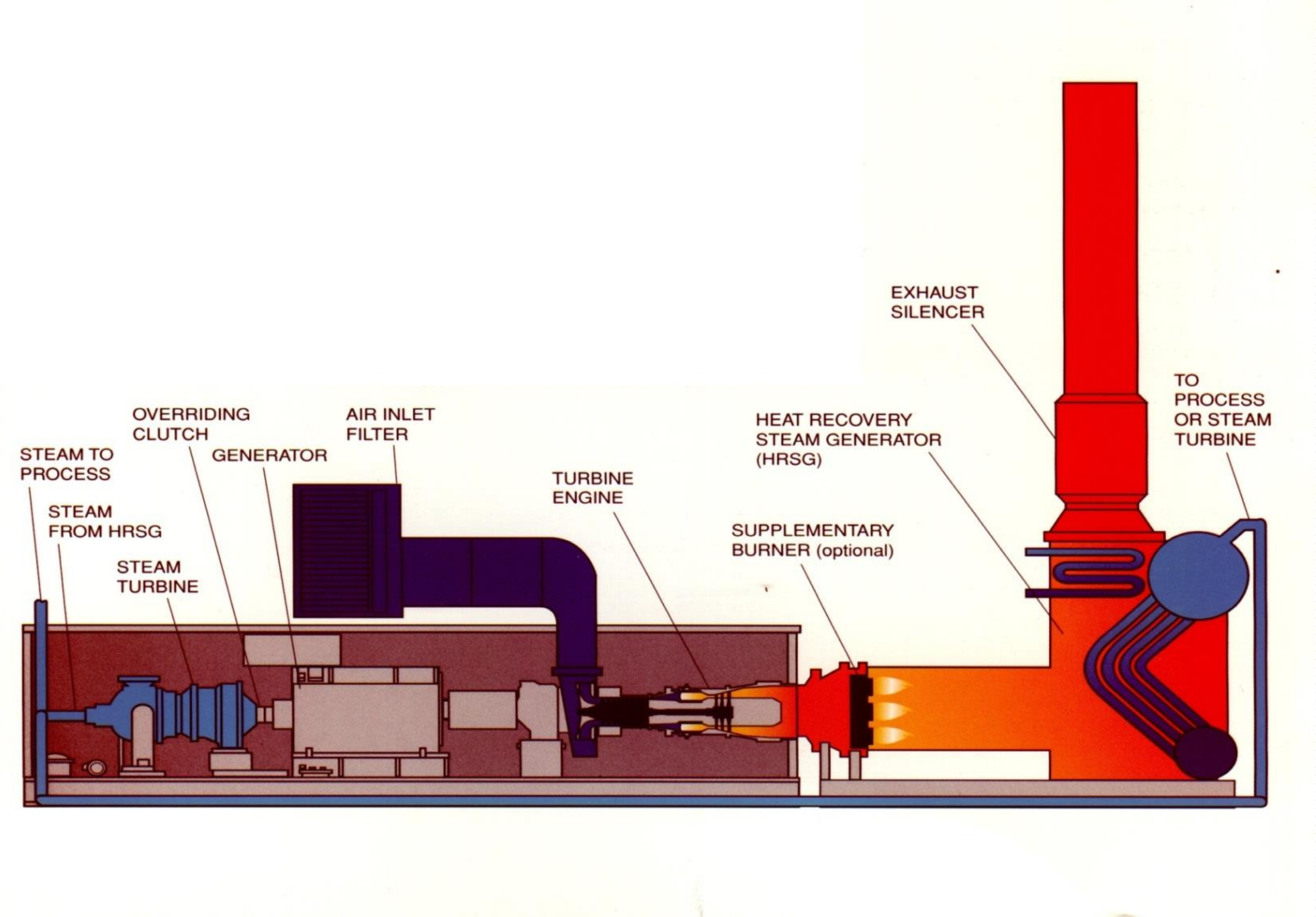
Cogeneration Applications

- Heat Oil Field Treater
- Process/Bldg Heat
- Hot water or Steam
- Absorption Chilling

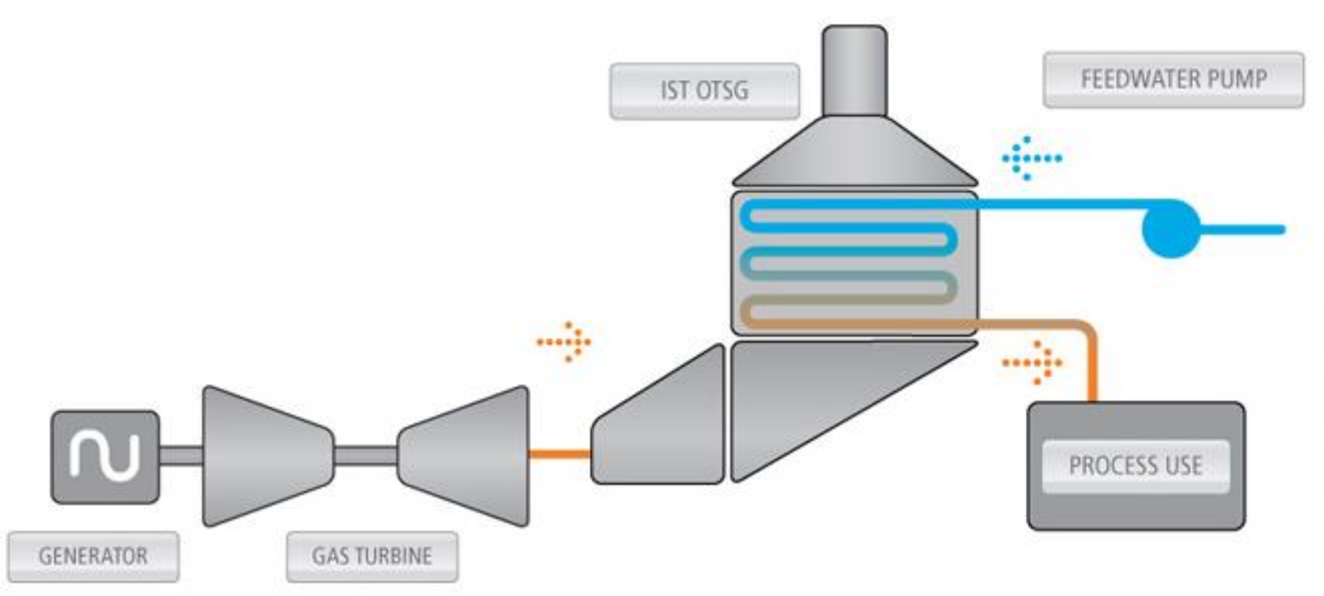




STAC (Steam Turbine Assisted Cogeneration) (Combined Cycle)



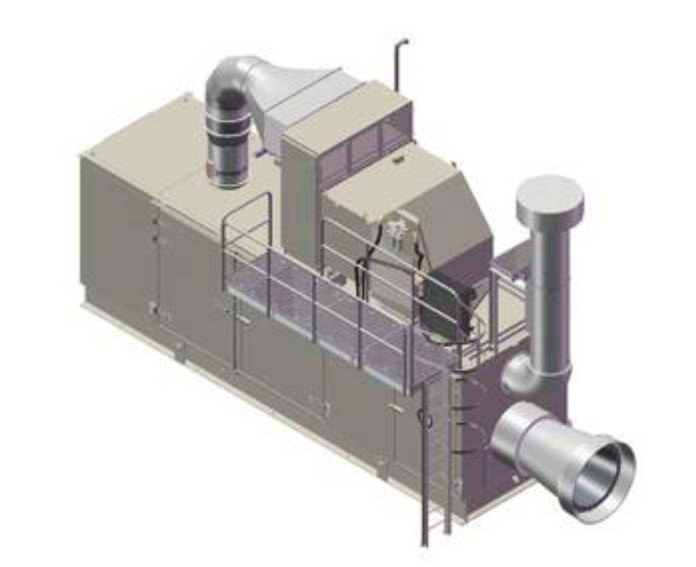
Cogen with HRSG[1] or OTSG[2]

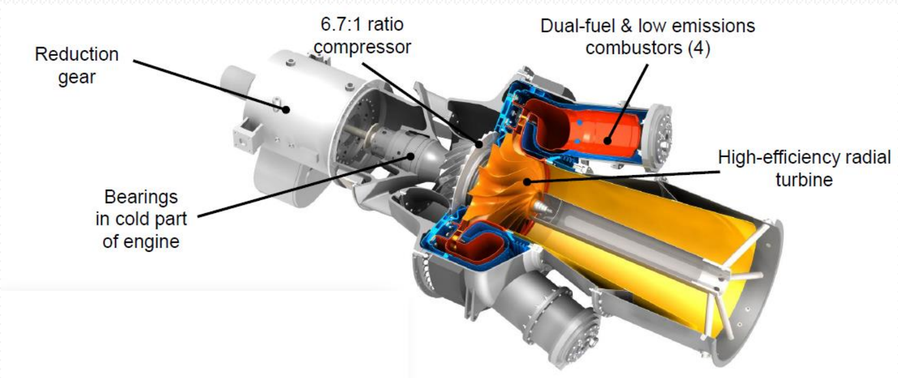


[1] **HRSG** (Heat Recovery Steam Generator)

[2] **OTSG** (**Once Through** Heat Recovery **Steam Generator**)

1.9 MW OP-16 Gas Turbine





- OP-16 gas turbine fleet has successfully operated more than 700,000 hours on untreated well-head gas
- The well-head gas is sour, contains 4% H2S and heavier hydrocarbons
- Composition and availability varies over time

Why Generate Electricity from Flare Gas?

- Power generation from flare gas presents an opportunity for:
  - Reduction in emissions of **hazardous chemicals**
  - Reduction in Kyoto or other environmental commitments
  - **Reduction of greenhouse gas emissions**
  - **Improvement in health** through reduction of respiratory disease
  - Reduced **political pressure** on the government
  - Reduced potential for total **"brown outs"** by contributing distributed electrical energy sources
  - Revenue generating use of a **"free" resource** that otherwise causes problems
  - **Just 7c/kWh = $19.44/GJ**

How much power does 1 MMCFD of gas generate?

Daily energy value is

$= 1 \text{ X } 10^6 \text{ ft}^3 \text{ X } 1000 \text{ BTU/ft}^3$ BTU

$= 1 \text{ X } 10^9 \text{ BTU X } 1054.35\text{J/BTU}$ Joules

$= 1054.35 \text{ X } 10^9$ Joules

Therm.Power = $1054.35 \text{ X}10^9$ /(1dayx24hrsx60minx60sec) J/s

= $12.2 \text{ X } 10^6$ watts, (1 J/s = 1 watt, by definition)

= **12.2 MW (Thermal)**

Elec. power = 12.2 X 30% MW (electric), @ 30% efficiency

= 3.7 MW (Electric) →

Onsite Generation Increases Reliability Over Tenfold

2000 Reliabilty Statistics:

			Annual Downtime
ENMAX =		0.999931507	36 minutes downtime
	=	99.99315068 %	
UPS		0.9999990	30 seconds downtime
	=	99.99990487 %	
Utility Industry Average		0.999693683	161 minutes downtime
	=	99.96936834 %	
Combined ENMAX and UPS =		0.99999999993	0.002 seconds of downtime
		99.99999999 %	
Turbine		0.95	438 Hours downtime
		95 %	
Combined ENMAX and Turbine		0.99999657534	108 seconds of downtime
		99.99965753 %	
Combined Industry Average and Turbine		0.99998468417	8 minutes
		99.99846842 %	

Conversion of Energy Revenue from cents/kWhr to $/GigaJoule (i.e.$/GJ)

If Power Pool price of energy is 7c/kWhr i.e. Revenue for 1kWhr = $0.07

1 kilowatt hour (kWhr) = 1000 watt-hour X 60 minutes/hour X 60 seconds/minute
= 3.6 X 10^6 Watt-seconds
= 3.6 X 10^6 Joules (1 Watt-second = 1Joule, by definition)

Therefore, Revenue for 3.6 X 10^6 Joules = $0.07

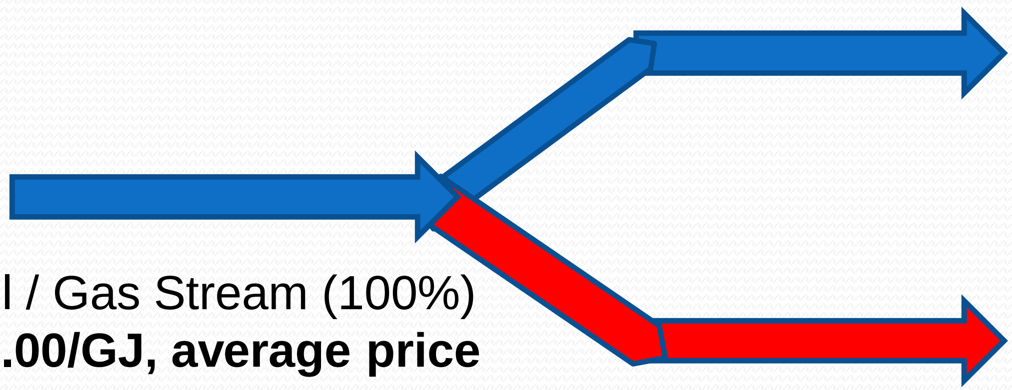
Revenue for 1 Joule = $0.07/(3.6 X 10^6 Joules)

Revenue for 1 GigaJoule (GJ) = ($0.07 X 10^9 Joules)/3.6 X 10^6 Joules)
(Giga = 10^9)
= $19.44

Therefore, unit energy Revenue of 7c/kWh = $19.44/GJ →
(Note 1 MCF = ~1 GJ of energy for 1000 BTU/ft^3 gas)

Cogeneration Summarized

- Cogeneration is the simultaneous production of useful heat energy and electricity



Electrical Energy (~30%)*
7c/kWh = <u>$19.44/GJ</u>

Fuel / Gas Stream (100%)
~$3.00/GJ, average price

Heat Energy (~70%)

<u>Note</u>:
*If all the heat energy and all the electrical energy is effectively used, and assuming both product streams are equally profitable, the relative heat and electrical conversion efficiencies would be <u>irrelevant</u> to the profitability of the cogenerator.
(** 1kWh = 3.6 X 10^6 Joules)

Interconnection Approval Process

Documentation would include:

- Completed application form
- Overall description of how the interconnection protection will function
- Detailed Single Line Diagram
- Identification details of the protection components
- Protection function settings
- Details of the disconnect switch

EMF Technical Services Inc.

- An engineering consulting firm whose principals and associates are experienced in:
  - Electrical and control systems design, including PLC programming
  - Electrical power generation and distribution
  - Cogeneration facility proposal development and economic analysis.
  - All phases of engineering design, construction, commissioning, trouble shooting and optimization
  - Design and construction of oil and gas pipelines, compressor stations, pump stations, processing facilities
  - Existing facility upgrades/retrofits

Herbert G. Dreyer P. Eng.

- Experienced in generator interconnection guide and standards development for tying new generation facilities into power systems.

- Experienced as member of Alberta Distributed Generation Technical Committee, MicroPower Connect Technical Committee, Alberta Safety Codes Council Task Force on Micropower Generation, and both CSA and IEEE standards committees for Interconnecting Distributed Resources with Electric Power Systems.

- Played key role in important development of guides and standards for safe interconnection of Distributed Energy technologies to improve energy efficiency and reduce emissions.

Conclusion

- **Can resolve environmental issues:**
  - Can improve profitability by using a wasted resource
  - Can reduce greenhouse gas emissions
  - Can reduce environmental health issues
  - Cogeneration and Distributed Generation is key to efficient resource production
  - New, efficient environmentally friendly, Distributed Generation technologies have been developed
  - Can gain more public and landowner support
  - Can improve power reliability
  - Can be used to access shut in oil/gas to further increase profitability

EMF Technical Services Inc.

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