Cogeneration: Energy Production maximising Efficiency and minimising Environmental Impact at all scales

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## Cogeneration

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What is Cogeneration?

Definition

‘The simultaneous production of both heat and power from a single source’

- Cogeneration can be:
  - Topping Cycle
    - Focused on electricity production with wasted energy used to provide heat
  - Bottoming Cycle
    - Focused on heat production, with surplus energy used to produce electricity
What is Cogeneration?

A properly designed Cogeneration plant is the most efficient way to meet site energy demands.

![Diagram showing energy efficiency comparison between remote power plant and on-site cogeneration plant.]

**Overall Energy Efficiency**

- **Remote Power Plant**
  - Fuel: 100%
  - Electricity: 25 - 55%
  - Steam: 75 - 85%
  - T&D losses: circa 5%
  - Overall Energy Efficiency: 50 – 70%

- **On-site Cogeneration Plant**
  - Fuel: 100%
  - Electricity: > 30%
  - Steam: > 45%
  - Steam distribution losses: > 45%
  - Overall Energy Efficiency: > 75%

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Utilizing Natural Gas

Why use Natural Gas?

- Widespread availability

- Reserves for > 150 years consumption

- Transportable
  - Pipeline
  - LNG
  - CNG

- Can be stored to provide strategic reserve
  - Underground Gas Storage (UGS)
  - LNG

- Competitively priced
Utilizing Natural Gas

Why use Natural Gas?

- ‘Clean’ fossil fuel
- Low carbon content = low CO$_2$ emissions
- Clean burning, low pollutants
  - No SO$_x$
  - No particulate
- Clean Combustion Technologies
  - Low NO$_x$
  - Low CO
  - Low Unburned Hydrocarbons
  - Caution: Methane Slip on Gas and Dual Fuel Engines
- Saves money and protects the Environment!
Cogeneration Applications

Cogeneration can be applied at any scale where there is both a power and heat (or cooling) demand

- From a few kW to 100’s of MW
- Domestic
- Commercial
- Municipal
  - District Heating/Cooling
  - Hospitals / Swimming Pools
  - Universities
- Industrial
  - Chemicals, Pharmaceuticals, Food & Drink, Automotive, Pulp & Paper, Textiles, Ceramics…
Cogeneration Technologies

A range of potential technologies exists

- Applicability often dependent on scale

![Cogeneration Technologies Diagram]

Increasing Power

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Choosing a Technology

Gas Turbines, Steam Turbines and Gas Engines dominate the Cogeneration market

- Gas Turbines have the vast majority of recoverable heat in the high temperature exhaust gases
  - 30kW – 300MW+

- Different Steam Turbine configurations based on heat demand
  - Back-pressure
  - Condensing with Steam Extraction
  - kW to hundreds of MW

- Gas Engines have 2 waste heat streams
  - High temperature exhaust gases
  - Low temperature cooling circuits
  - kW to ≈ 17MW
Choosing a Technology

Power Output, Heat to Power Ratio and the Type of Heat will all have an impact on the optimum technology choice

• Technical and economic limitations on power output may apply to some technologies
  • Both at higher and lower ends of scale

• Electrical efficiency impacts on amount of heat recoverable
  • Higher electrical efficiency, less waste heat

• Temperature of Waste Heat will affect type and amount of process heat recoverable
  • e.g. Steam requires high temperature waste heat

• High Electrical Efficiency does not necessarily mean high overall energy efficiency
Choosing a Technology

Heat to Power Ratio

Total Efficiency of Gas Turbine and Reciprocating Engine vs. Power / Heat Output

Steam Turbine
Gas Turbine
with supplementary fired WHRU
Gas Engine

Total Efficiency, Heat and Power
SGT-500 + WHRU
Reciprocating Engine + WHRU
Choosing a Technology

Using Supplementary Firing of GT exhaust gases to boost Heat to Power Ratio

- Supplementary Firing can double steam (heat) production

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Choosing a Technology

Type of Process Heat required

- **Low Temperature Hot Water (LTHW)**
  - Very high overall energy efficiencies as can recover waste heat from low temperature cooling circuits
- **High Temperature Hot Water (HTHW)**
  - Needs higher temperature waste heat, so in some cases not able to use all waste heat sources
- **Steam**
  - Needs high temperature heat source, the higher the steam pressure required, the higher the waste heat temperature needs to be
- **Hot Air**
  - Depends on application: Direct/Indirect Drying or Space Heating
Choosing a Technology

Selecting the correct technology for the specific application can lead to very high overall energy efficiencies

- LTHW Hot water > 90%
- Steam > 75%
  - > 85% with supplementary firing
- Hot Air > 90%
- High energy efficiency
  - lower fuel consumption
  - lower fuel bills
  - fewer emissions
  - environmental benefits
Choosing a Technology

Or the correct combination of technologies!

- Multiple gas turbines for extended load range and part load efficiency
- Supplementary HRSG firing from 545 to 740°C (All HRSG)
- Air-cooled DH auxiliary cooler allows independent Power generation
- Heat-only boiler for DH peaks

Customer:
Latvenergo Riga TPP1, Latvia
Business Concept: EPC / Power Plant
In operation: Oct 2005

Net power output: 140 MW
District heating duty: 140 MW
Fuel efficiency: 91%

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Alternative Fuel Options

If Natural Gas is unavailable, other fuels can be utilized in many technologies as the primary fuel or back-up fuel

- Diesel and high quality distillate fuels
- LPG, NGLs, Condensates and Naphtha
- Intermediate and Heavy Fuel Oils
- Crude Oil

- Biogases
  - Digester (sewage) gas
  - Landfill gas

- Process Off-Gases
  - Refinery Gases
  - Coke Oven Gas
  - Blast Furnace Gas
Conclusions

Cogeneration

• The most efficient way to meet local power and heat demand

• Offers Economic benefits

• Offers local and global Environmental benefits
  • Especially on Natural Gas Fuel

• Multiple technologies available to all optimum plant design
Thank you for your attention
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