CHP Technologies and Waste Heat to Power

Environmental Friendly Drilling Systems
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HARC
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Agenda

• CHP Basics
• Who is using CHP?
• Waste Heat to Power
• The Bakken Experience
CHP Overview

What is CHP?

CHP, also known as cogeneration, is the concurrent production of electricity and useful thermal energy (heating and/or cooling) from a single source of energy.
Combined Heat and Power

CHP is ..

- An Integrated system
- Located at or near a building or facility,
- Satisfying at least a portion of facility’s electric and thermal demand
- Utilize the heat generated by electric power generating equipment to provide cooling, heating and de-humidification
CHP Benefits

- **EFFICIENCY**
  Total thermal efficiency is typically 25% greater in CHP than conventional power plant/on-site boiler. Total efficiency of system is around 75%

- **ENVIRONMENTAL**
  SOx and NOx reduction; approximately 50% less greenhouse gases; significant reduction in water usage

- **ECONOMIC**
  Provides stability in the face of uncertain electricity prices

- **ENERGY SECURITY**
  Improved asset resilience and less reliance on grid

Source: EPA
Topping and Bottoming Cycles

Two (2) Forms of CHP

Conventional CHP
(also referred to as Topping Cycle CHP or Direct Fired CHP)

Waste Heat Recovery CHP
(also referred to as Bottoming Cycle CHP or Indirect Fired CHP)

Conventional CHP System

Fuel → Electricity → Heat

Waste Heat Recovery CHP

Fuel → Steam Turbine → Electricity → Heat

Heat recovery steam boiler → Industrial Process → Fuel
Technologies

PRIME MOVERS | PRODUCE ELECTRICITY AND HEAT

- Gas Turbines
- Reciprocating Engines
- Micro turbines
- Fuel Cells
- Steam Turbines

Selection criteria
- Electricity needs
- Thermal needs
- Capital costs
- Permitting
Gas Turbines

- 5 MW - 250 MW
- Same technology as a jet engine
- Best suited for base-load (24/7) operations
- Typically fueled by natural gas
- Produce high quality heat from exhaust
Reciprocating Engines

• 5 kW – 10 MW
• Excellent part-load operation
• Waste heat recovered from engine exhaust, engine jacket and oil coolant
• Low set-up cost, fast start-up
• Emissions signature has improved significantly
  o Lean-burn engines
  o Selective catalytic reduction (SCR)
Micro Turbines

- 25 kW to 400 kW
- Essentially small gas turbines
- Compact and low maintenance
- Exhaust temperatures at 500 F to 600 F
- Manufacturers include Capstone, Ingersoll Rand
- Can operate on variety of fuels
- Single digit NOx ppm levels
- Low vibration and noise
Good Candidates for CHP

Include the following conditions:

- Continuous demand for both thermal and electric power;
  - Petro Chemical Refineries, oil and gas midstream, Hotels, Data Centers, University Campuses, Hospitals, Manufacturing
- Critical Infrastructure - Economic value of power reliability is high
- Favorable spark spread
  - Large cost differential between utility’s electricity prices and CHP fuel costs
- Long operating hours
- Central heating/cooling system
- Planning a renovation and/or expansion of existing facilities
Islanding from the Grid

• A recent study by KLJ estimates projected load demand in ND to double from 1.2 MW to 2.5 MW by 2032.

• Huge demand for additional power lines and transmission lines

• Power needed for pumps, lifting, separation, compression, transportation etc.

• 4 new 45 MW peaker units to be built.

• 200 miles of transmission lines to be added.

• What if load does not materialize? OR too much??
• On site gas if available to fuel micro-turbines
• Produce most of site’s needed power
• Electrical Load following
• Replace the need for utility power lines
• Offset boilers for frac fluid heating, steam assist etc.
Typical CHP Applications so far

• Typical examples include offshore oil and gas production platforms as well as remote gas pipeline stations where installation of grid power is not feasible.

• Fuel for these applications can be sourced from pipeline or production gas including fuels with H2S components or gas which is typically vented or flared.

• The high volume of exhaust can be combined with heat recovery and used in process that require hot water, glycol, or oil, as well as direct heat to processes such as heater treaters.
Midstream application

- Operates power packages to power compressor stations in Utica / Marcellus Shale
- Continuous duty cycles
- Comes with factory protection plan for 24/7 maintenance
- Water heating for buildings and facility fuel gas heating.
Other Micro Turbine applications

**White Oak Compression & Dehydration Site**
Ritchie County, WV

- (2) Capstone C200 MicroTurbines installed in parallel as standalone power

**Ardell Transmission and Compression Site**
Benezette, PA

- C800 standalone Capstone Power Package providing 800kW of onsite power for the facility

**Green County Water Pumping Facility**
Cameron, WV

- C800 dual mode Capstone Power Package operating (2) 500HP water pumps and auxiliary electrical equipment
Other Mid Stream Applications

**Crayne Compressor Station** – Waynesburg, PA

- (3) Capstone C65 ICHP MicroTurbines provide electricity & heating for buildings and fuel gas

**Blacksville Gas Gathering, Dehydration & Compression Station** – Blacksville, WV

- (6) C65 ICHP standalone MicroTurbines operate the station 24/7 and provides 100% electricity and fuel gas heating

**Silver Springs Transmission Station** – Silver Springs, NY

- (3) Capstone C65 MicroTurbines provide electricity & heating for buildings and fuel gas
Bottoming Cycle- WHP

• Is the waste heat source a gas or a liquid stream?
• What is the availability of the waste heat—is it continuous, cyclic, or intermittent?
• What is the load factor of the waste heat source?
• Does the temperature of the waste stream vary over time?
• What is the flow rate of the waste stream, and does it vary?
• What is the composition of the waste stream?
• Are there contaminants that may corrode or erode the heat recovery equipment?
Organic Rankine Cycle

- Organic fluids with low boiling points
- Single Stage expander
- Simplest WHP cycle - operates as low as at 300°F waste heat stream
- Used commercially in compressor applications
Kalina Cycle

- Water and Ammonia as working fluid
- Operating temperatures between 200 F to 1000F
- 15% to 25% more efficient than ORC
- Can use air cooled condenser
Flaring

- Controlled burning of natural gas
- The option to release gas to atmosphere is considered a necessary practice but difficult to accept waste
- GE report puts the wastage value at 400 million tons of GHG’s or 23% of all natural gas consumption in the US
- Flares happen when selling or re-injection is not feasible - geography, cost, availability of customers, transportation infrastructure etc.
Flaring Regulations in ND

- Under current regulations, drillers can flare a well’s gas for up to a year without penalty, after which controlling needs to occur.
- The North Dakota Industrial commission passed new flaring standards, with the goal of capturing more natural gas.
- Drillers need to capture 74% of all gas produced by October 2014 and 90% by 2020.
- Oil production limits will take effect if a producer fails to meet requirements to capture natural gas at the well site- 200 barrels per day at the well.
Low Temperature Waste Heat to Power

This is SMART POWER®
Organic Rankine Cycle = Waste Heat to Power

- Recover heat from hot water flow to boil working fluid
- Use pressure of expanded working fluid to spin a drive shaft connected to a generator
The Solution:
Gas Fired Low Emission Boiler + ORC
EFD TIP- Field Trial in Bakken

• Proven Power Plus technology to help convert flare to electricity – supplied by Gulf Coast Green Energy

• Flare gas will fire a low NOx and low VOC hot water boiler to provide fuel source for ORC

• Economically viable proven technology will create distributed electricity

• Offsets electricity requirements and minimizes environmental impact – no additional fuel needed
Project Goals

• Demonstrate ability of the equipment to produce electricity from flare
• Demonstrate that electricity production does not interfere with well operations
• Reduce operating costs
• Determine if kWh output would have practical applications
• Determine environmental impacts
What's different about Power Plus?

- Conventional ORC’s are not viable – require large hot water flow @ 1000 gpm
- Electratherm Green Machine uses patented robust twin screw expander @200 gpm flow and allows wet vapor
- Minimal footprint of 300 square foot –can be moved with a fork lift
- Uses non hazardous, non toxic refrigerant HFC -245a
- Simple design, low maintenance, no gear box, no oil pump
HA- ROLFSRUD field site
Ready to Go
Installation and Prep
Hooking Up Water Lines
Job Done
Post Installation Data

• 71 Days into the 90 Day Field Trial
  – Start date, August 3rd

• Cumulative run time: 1319 Hrs
  – 82% Up Time

• Total Cumulative kWh generated: 69,961

• Average Gross kWe: 58.4
Problems Encountered

Issue
- Power Surges causing Power+ to shut down due to safety concerns. Boiler is unaffected by shut downs.

Solution
- McKenzie Electric Coop recently installed recording equipment on their power line to monitor future phase imbalances. Currently waiting for results.
- Remote access allows for Power+ to be restarted easily
## Preliminary Data

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![Graph showing the relationship between Time (weeks), Hours, and kWh.](image.png)
Maintenance

• Power+ System is designed to be end user friendly.
  - Start up and shut down, for both boiler and generator, are very simple.
• Boiler inspections are performed once a week by a boiler tech, Mike Cleveland.
• Power+ is monitored daily though remote monitoring along with bi weekly inspections from Hess Field Personnel.
Lessons Learned

- Installation – No need for crane. Power+ and boiler can be kept on trailer.
- Find way to restart boiler though remote monitoring system.
- Investigate the option of a higher PSI boiler. Electratherm claims 60 psi provides much higher power output than the current 30 psi boiler.
- Use larger diaphragm regulators.
- Electratherm investigating altering Power+ tolerance to power surges.
• Locate the Power+ as far from flare as possible. Heat from flare has been found to raise ambient temperature around the ORC generator by as much as 20 degrees. Decrease in efficiency has been observed.
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