WWTP CHP

**Combined Heat & Power (CHP)
for Wastewater Treatment Plants
WEF 2012, Atlantic City, NJ**

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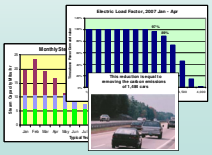


What is CHP?

Combined Heat and Power (CHP) describes any system that simultaneously generates power and useful, recovered thermal energy. It is the oldest commercially demonstrated form of power generation, as Thomas Edison's Pearl Street Station in Manhattan was a CHP facility.

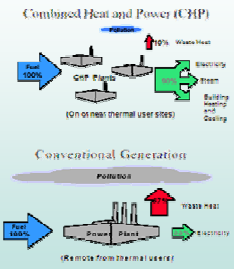
CHP is also known as CCHP or Cogeneration

ASHRAE Handbook: "Combined heat and power (CHP). Simultaneous production of electrical or mechanical energy and useful thermal energy from a single energy stream."

What is CHP?

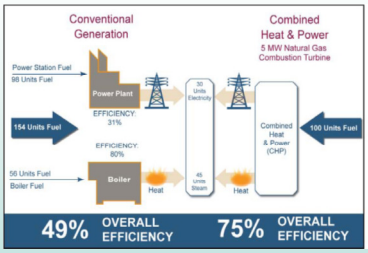
'Conventional' grid based generators are located remote from thermal applications while CHP plants are located close to thermal applications

While thermal energy is recovered directly from CHP systems as heat, it may be used for cooling, heating, refrigeration or dehumidification applications



What is CHP?

When considering both thermal and electrical processes together, CHP typically requires only 2/3 of the primary energy input that separate heat and power systems require.



Source: EPA's Handbook of CHP Technologies

Policy Background

High energy costs favor Energy Efficiency while the positive Emissions Impact and Infrastructure Support offered by CHP is gaining regulatory recognition

CHP has a high private-to-public investment ratio and provides a very cost effect means of reducing carbon emissions

CHP is Supply Side Energy Efficiency

The Federal Government, States as well as other entities have developed CHP support programs towards meeting the goals of reducing Energy Cost and Emissions , while increasing Grid Reliability and Energy Security through implementation of CHP

Policy Background

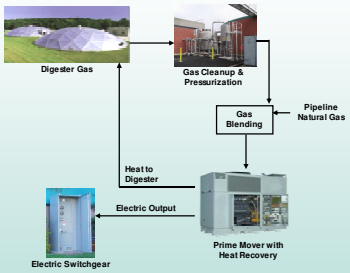
The economic, reliability, and environmental consequences of the "business as usual" scenario are unacceptable. Actions must be implemented to ensure that the state's future energy environment provides energy that is competitively priced, reliable and consistent with greenhouse gas targets ….. NJ BPU EMP

1st Call

CHP
- Maximize energy conservation and energy efficiency.
- Reduce peak electricity demand. DG CHP
- Meet XX% of the State's electricity needs from renewable sources. CHP
- Develop new low carbon emitting, efficient power plants to help close the gap between the supply and demand of electricity. CHP
- Invest in innovative clean energy technologies and businesses to stimulate the industry's growth and job creation.

CHP System Components

- Fuel Supply
- Fuel Treatment
- Prime Mover
- Heat Recovery
- Thermal Technology
- Accessory Devices
- Switchgear
- Controls/M&V



WWTP CHP System

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Fuel Treatment

WWTP Digester Gas contains many contaminants including moisture, particulates, sulfur and siloxanes to varying degrees which can cause significant damage to CHP system components if not removed. The DG pressure also needs to boosted to meet prime mover requirements.

Fuel Treatment Methods:
- Gas Compressors
- Chillers for Moisture Removal
- Iron Sponge for Sulfur removal
- Filter for Particulate & Moisture removal
- Carbon Filters or Membranes for Siloxanes removal

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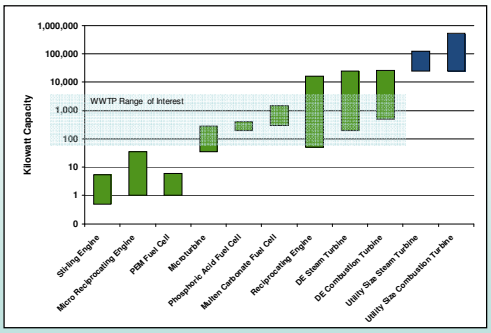
Prime Movers



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Prime Movers

Gas Combustion Turbines > 1 MW
Microturbines 35 kW – 250 kW
IC Engines 30 kW – 6 MW
Fuel Cells 250 kW

75% - 60% HEAT
25% - 40% Electricity

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Thermal Technology

Technologies:
- Hot Water HEX
- Boilers/Steam Generators
- Organic Rankin Cycle
- Backpressure Turbines
- Absorbers
- Steam Turbines
- Desiccants
- Adsorbers

COGENERATION TECHNOLOGIES

Applications:
- Process Heat
- Space Heat
- Domestic Hot Water
- Cooling
- Freezing
- Dehumidification
- Power Generation

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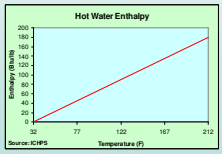
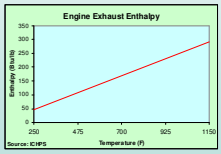
Thermal Technology

Heat Recovered = Flow x Sp Gravity x Sp Heat x Δ-T
Δ-T = Inlet Temp – Outlet Temp

Heat Recovery Inlet Temp is determined by the type and specific configuration of the prime mover

Outlet Temp is defined by the HR equipment which is defined by the thermal product quality required





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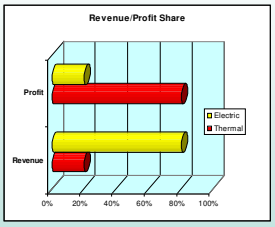
Thermal Technology

Economics

- **Essentially the electric output covers the cost of operation and the thermal revenue represents the annual cost savings.**
- **Capital cost recovery is from cost savings.**



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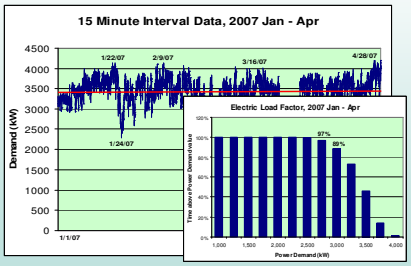
CHP Evaluation

To optimize the economic advantage provided by CHP, the plant must have a high electric and thermal load factor.

Natural Gas can be blended with DG to increase plant capacity



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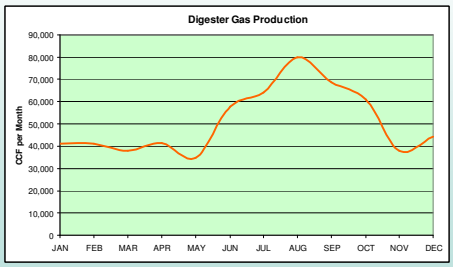
CHP Evaluation

Digester Gas volume is a primary consideration in evaluating CHP for a WWTP. It should be noted that DG Production can vary considerably by month



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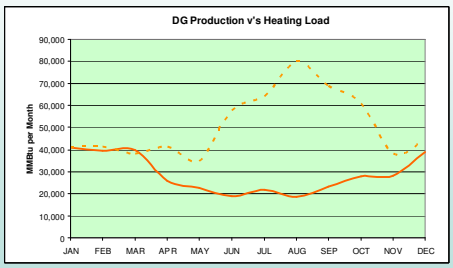
CHP Evaluation

Year round thermal load availability is also a major consideration. Digester heating generally provides the main thermal load for WWTP's



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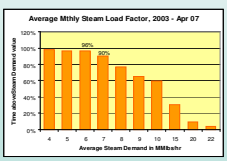
CHP Evaluation

Physical Location & Space Availability

- Fit equipment including gas clean-up with service access
- Generation and Heat Recovery should be close
- Easier transmit steam or water than exhaust
- Proximity to Switchgear & Thermal Loads Cost issue

Thermal Distribution System

- Type and Quality
- Tie-in point at return line
- Maximize load for all 12 months



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CHP Evaluation

Electric Distribution System

- Tie-in prior to distribution
- Only 1 Meter – Cannot back feed
- CHP output at 480 – 13,000 V
- Grid Interconnection – Parallel or Island Mode
- Parallel ⇒ No Power Export/Simpler Interconnection

Fuel Availability, Pressure & Quality

- Combustion Turbines require high pressure
- Fuel quality can have significant impact

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CHP Evaluation

Electric Issues
- Facility Grid Reliability
- 'Black Start' Capability – Emergency Circuits
- Generator Block Loading Capability
- CHP System Parasitics

Emissions
- EPA Title 5 or Local Authority

Noise
- Mitigated with Enclosures & Silencers

CHP System Control & Metering
- Integrate with component controls, utility meters & BAS

Generator Emissions

Emissions		Rate g/bhp-hr	Annual Total	Monthly Average
NO_x	Tons	0.15	5.7	0.5
NH_3	Tons	0.04	1.5	0.1
CO	Tons	0.5	19.0	1.6
O_2	%	9.4		

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WWTP CHP Economics

WWTP Digester Gas holds significant potential to provide electric power generation

1,000 CF of DG at 600 Btu/CF = 600,000 Btu

Typical Engine Generator Electric Efficiency = 30%

Typical Engine Generator Thermal Efficiency = 40%

With CHP = 52.7 kW Electricity + 240 MBH Heating

With an 80% Efficient Boiler = 480 MBH

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WWTP CHP Economics

Grid Electric = 11 ¢/kWh Nat Gas = 70 ¢/Therm
CHP System O&M = 3 ¢/kWh

50% Higher Value

Nom Value per 1,000 CF	CHP Plant	Boiler
Electric Offset	$5.80	-
Thermal Offset	$2.10	$4.20
O&M Cost	$1.58	-
Net Output Value	$6.32	$4.20

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WWTP CHP Economics

Load Factors (LF) are critical to evaluation of the economics when using Digester Gas
(Boiler's higher thermal output has lower LF than CHP)
CHP Electric LF = 90%, CHP Thermal LF = 80%
Boiler Load Factor = 60%

Adj Value per 1,000 CF	CHP Plant	Boiler
Electric Offset	$5.22	-
Thermal Offset	$1.68	$2.52
O&M Cost	$1.42	-
Net Output Value	$5.48	$2.52

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WWTP CHP Economics

The operating advantage for a digester gas CHP system over a boiler = $2.96 per 1,000 CF

Typical 10 MGD WWTP Plant:
Digester Gas production = 150,000 CF per day
Can support 330 kW CHP Plant

Average Daily DG production	=	150,000 CF
Value of CHP Output versus Boiler	=	$444/day
Annual CHP Operating Advantage	=	$162,060

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WWTP CHP Economics

The operating advantage for a digester gas CHP system if flaring DG = $5.48 per 1,000 CF

Typical 10 MGD WWTP Plant:
Digester Gas production = 150,000 CF per day
Can support 330 kW CHP Plant

Average Daily DG production	=	150,000 CF
Value of CHP Output versus Flaring	=	$822/day
Annual CHP Operating Advantage	=	$300,030

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WWTP CHP Economics

CHP System CapX at $4,000 per kW = $1,320,000

Net CHP Benefit against existing DG Boiler = $162,060
Simple Payback = 8.1 years without Rebates
Rebate Cap = 40% of project ⇒ 4.9 year Simple Payback

Net CHP Benefit against Flaring = $300,030
Simple Payback = 4.4 years without Rebates
Rebate Cap = 40% of project ⇒ 2.6 year Simple Payback

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Incentives

NJ BPU Clean Energy Program REIP

REIP = Renewable Energy Incentive Program

NJ BPU CEP REIP:

Capacity	(Biopower only)	(Biopower CHP)
First 500,000 watts	$2.00/ watt	$3.00/ watt
Next 500,000 watts	$1.00/ watt	$2.00/ watt

330 kW Project = 330,000 x $3/watt = $990,000

★ **CHP Project Cap = 40% = $528,000**

(Biopower only cap = 30%)

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Incentives

Federal 10% Investment Tax Credit for CHP:

The credit is equal to 10% of expenditures, with no maximum limit stated. Eligible CHP property generally includes systems up to 50 MW in capacity that exceed 60% energy efficiency, subject to certain limitations and reductions for large systems. The efficiency requirement does not apply to CHP systems that use biomass for at least 90% of the system's energy source, but the credit may be reduced for less-efficient systems. This credit applies to eligible property placed in service after October 3, 2008.

The American Recovery and Reinvestment Act of 2009, which allows Production Tax Credit-eligible facilities to use the 30% ITC, has implications for some technologies that were already potentially eligible for either incentive in some form. Certain geothermal and open- or closed- loop biomass systems (which may include certain types of biomass CHP projects) now qualify for a 30% tax credit through December 31, 2013, the in-service deadline for these technologies under the PTC.

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Incentives

Biopower CHP Feasibility Study Incentives. Eligibility for feasibility studies is only for behind-the-meter non-residential projects. This category includes all commercial, public, and non-profit organizations.

Expected Project Size (kW)	Incentive Award Range
100 kW - 500 kW	50% of the cost of the feasibility study or $25,000, whichever is less
501 kW - 1,000 kW	50% of the cost of the feasibility study or $50,000, whichever is less

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Incentives

NJ BPU Clean Energy Program REIP:

When you submit a complete biopower application packet, you will receive a rebate approval letter within 4 - 6 weeks of receipt, assuming that all eligibility requirements are met. All projects must be approved by the Market Manager; projects requesting a rebate of $300,000 or greater also require BPU approval, which may delay receipt of the approval letter by a few additional weeks. Once approved, REIP applicants will have 18 months from the date of the approval letter to satisfy all program requirements and submit the Final As-Built Packet to request a state inspection.

Incentives will be processed by the Market Manager and paid in full upon project completion and inspection.

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Incentives

10 MGD Plant with 150,000 CFD of Digester Gas
330 kW CHP Plant

Gross CapX	$1,320,000
NJ REIP Grant	$528,000
Fed 10% ITC	$132,000
Net CapX	$660,000
Simple Payback versus Boiler	4 Years
10-Year Net	$960,600
Annual Simplified ROI	14.5%

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Q&A

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New Jersey Director,
DOE's Mid-Atlantic Clean Energy Application Center

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