Hazen and Sawyer
Environmental Engineers & Scientists

Increasing the Benefit of CHP Systems through Coordination with Utility Billing

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Outline

- Quick look at on-site energy production
- Review of utility rate structures
- Case study example
- Summary and questions

On-Site Electrical Energy Production by Combined Heat and Power (CHP) Systems

Reducing Energy Usage and Controlling Energy Cost

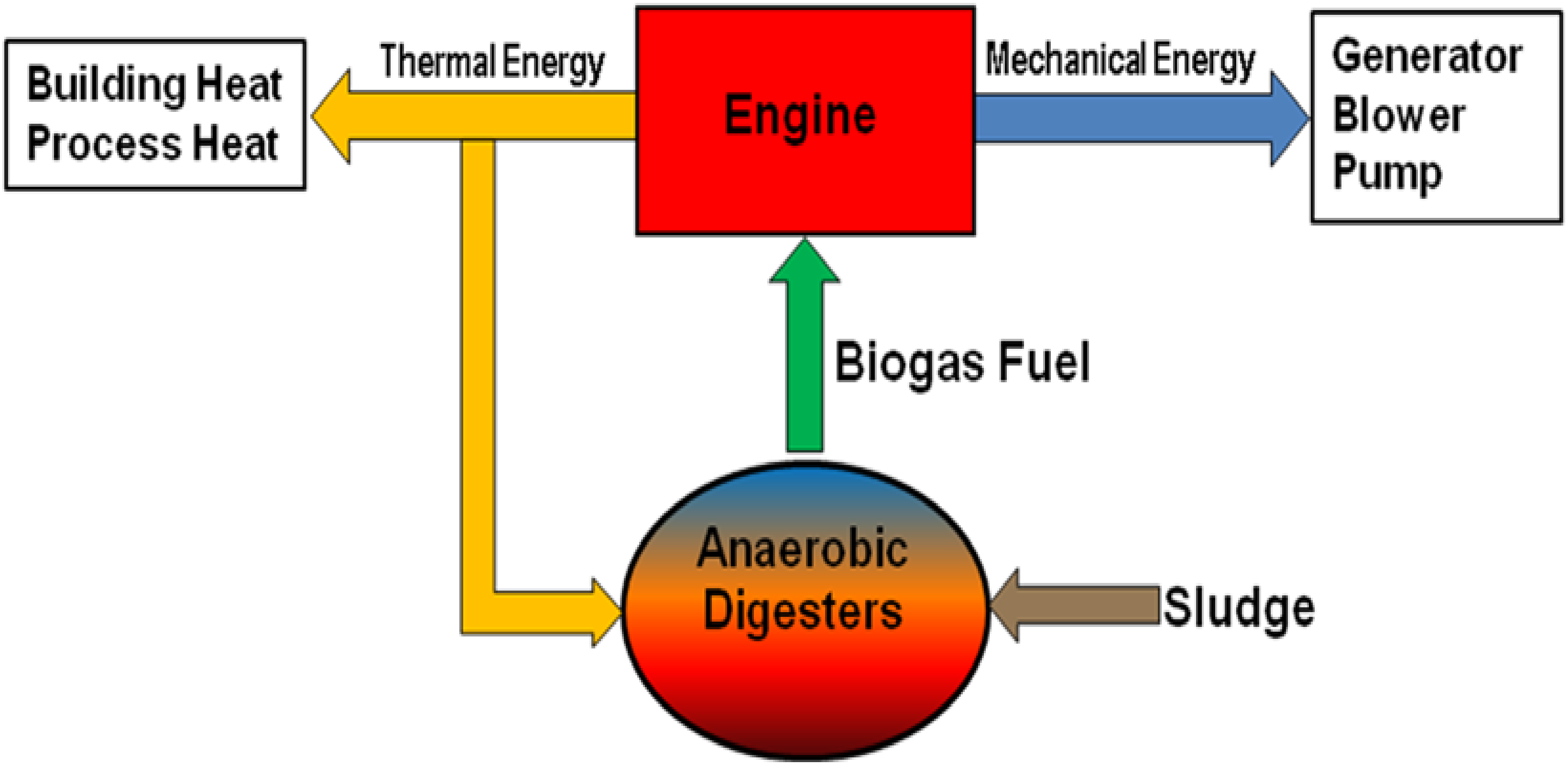
- **Increasing energy costs are consuming scarce resources in facility operating budgets even at current levels of energy consumption.**
- **Increasing flows to treatment plants drive energy consumption up even if we maintain the "status quo".**
- **Increasingly stringent effluent requirements are increasing the amount of energy usage per Mgal treated.**

Digester Gas Represents an Energy Resource

- **~16,000 Centralized Wastewater Treatment Plants in the USA**
- **~3.4% of plants with flow rate of > 5 MGD use anaerobic digestion for stabilization**
- **~21% of those plants with anaerobic digesters generate electrical and/or thermal energy from digester gas in a CHP system**

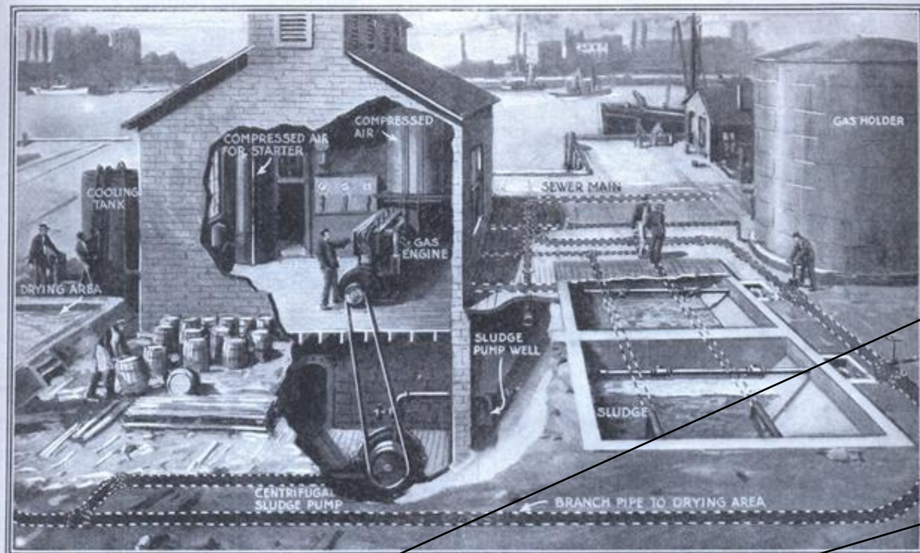
Reference: USEPA, Opportunities for and Benefits of Combined Heat and Power at Wastewater Treatment Facilities, April 2007

Relief from Onsite CHP Energy Production



Using “Sewage Gas” for Power Isn’t New

Gas from Sewage Waste Runs City Power Plant



How the sewage disposal plant at Birmingham, England, supplies its own power is described in the illustration. Gas from the sewage drives an engine of 20 brake horsepower, which operates a centrifugal sludge pump

SEWAGE that costs large cities tremendous sums each year can be turned into a source of power equivalent to thousands of tons of coal! The waste now dumped into rivers or shipped to sea may be used to run factories or to light buildings!

That conversion of sewage into power is possible has been proved conclusively by the city of Birmingham, England. There a suction gas engine of 20 brake horsepower has been successfully driven by the gases given off by sewage sludge.

On the basis of the Birmingham experiments, an American city that must now pay for the disposal of 400,000 tons of sewage sludge a year might produce 320,000,000 cubic feet of gas suitable for heat and power, or, in terms of energy, 16,000,000 horsepower hours at 20 cubic feet per brake horsepower.

The apparatus for producing gas from sewage consists of two sludge digestion tanks in which the sewage is allowed to ferment. The gases given off are composed of from 25 to 75 per cent of methane, or marsh gas.

A gas engine of the usual type will run on sewage gas without adjustment of the valves. Sewage gas has a higher calorific value than some illuminating gas, averaging about 650 thermal units to the cubic foot, as against 550.

The Birmingham engine runs about six hours a day and is used to operate a centrifugal sludge pump that moves the wet sludge from the gas-generating tank to the drying grounds. In this process a small proportion of the waste material produces enough power to run the pumps of the sewage disposal plant. If all the material were used, there would probably be enough gas available to light the city.

Popular Science, 1922

SEWAGE that costs large cities tremendous sums each year can be turned into a source of power equivalent to thousands of tons of coal! The waste now dumped into rivers or shipped to sea may be used to run factories or to light buildings!

Boy haven’t we come a long way in the last 90 years…

Using Digester Gas for Power Production Still Makes Sense

- Digester gas is a "free" fuel source
- Typical gas production rates can meet between 20% to 40% of a plant's power demand
- As a renewable fuel, it reduces GHG emissions

Reciprocating Internal Combustion Engines

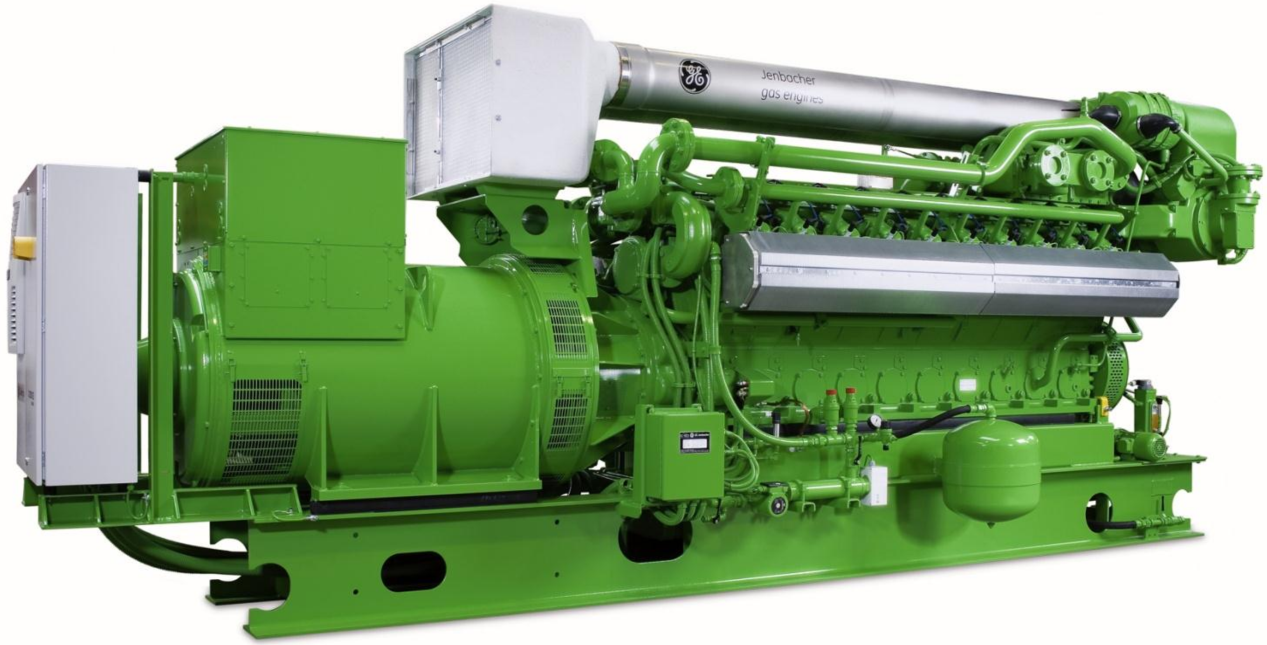
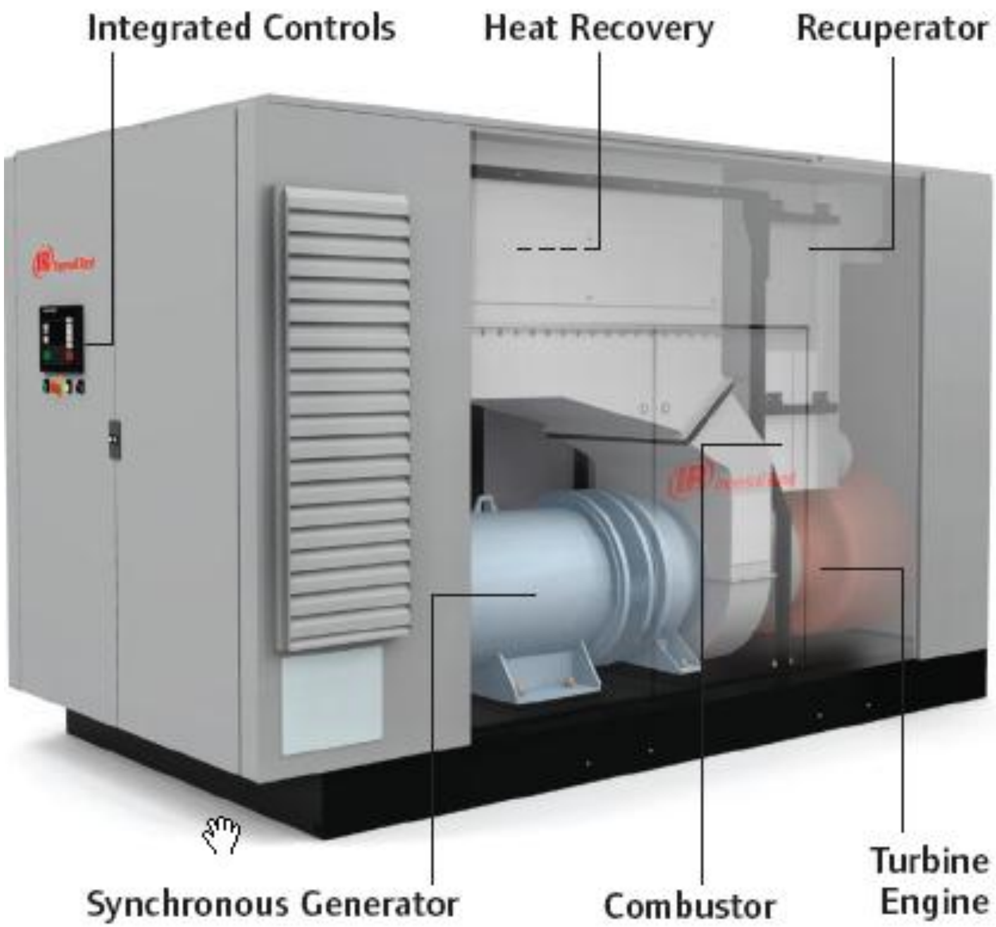
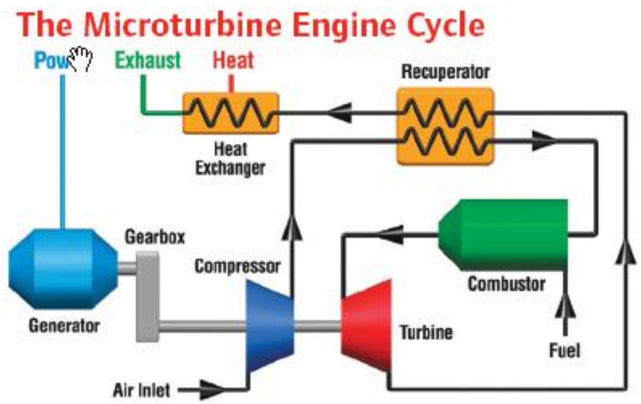


Image Courtesy GE/Jenbacher Engines

Microturbines





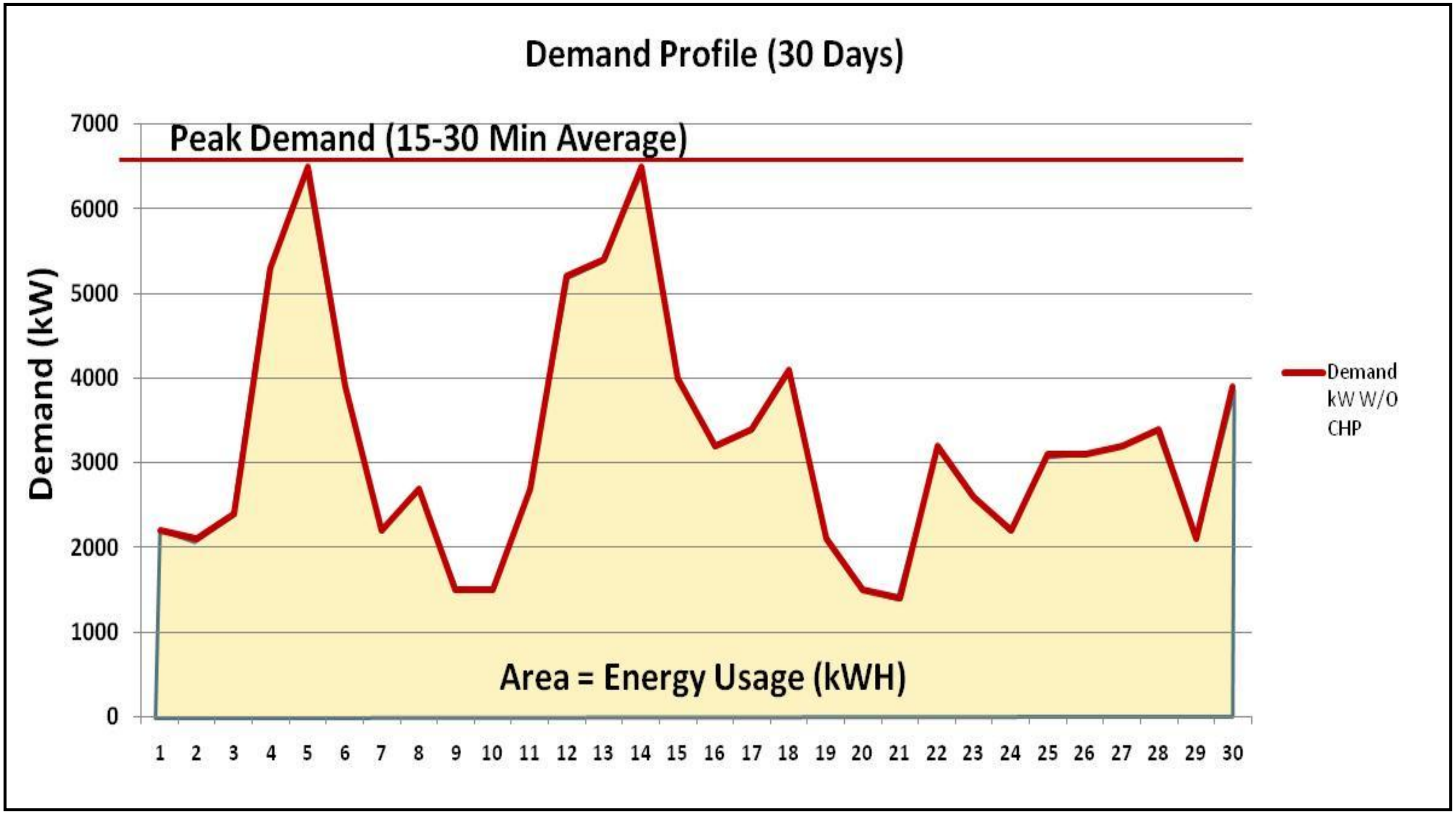
Images Courtesy Ingersoll-Rand

Electrical Utility Billing Rate Structures

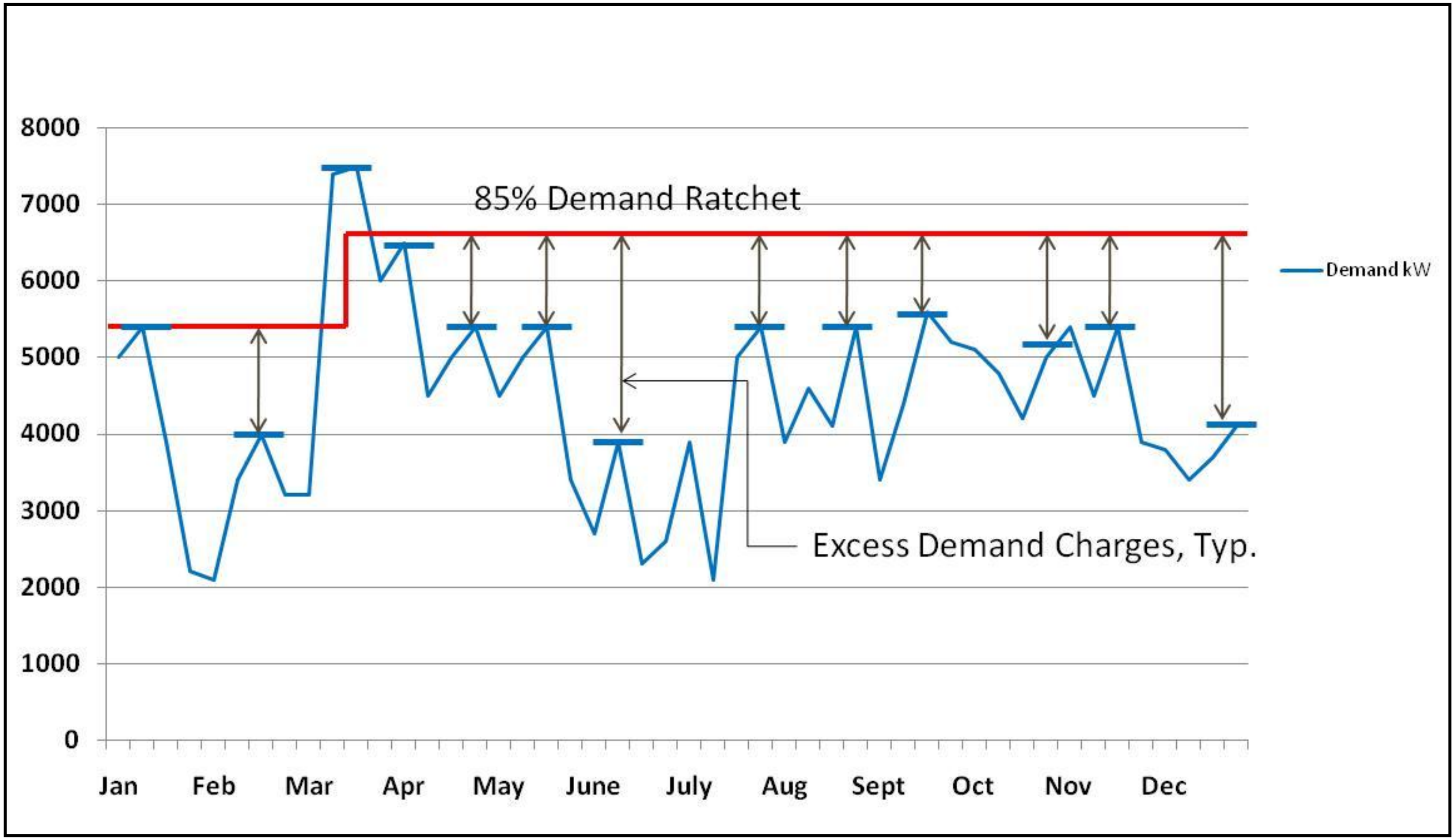
Electrical Utility Bills Typically Comprised of Several Aggregated Charges

- **Facility Charge**
  - Typ. “fixed” charge independent of demand or usage
  - Utility cost recovery for utility owned equipment
- **Demand Charge (kW)**
  - Used to recover capital cost of power generation and transmission facilities
  - Typically average demand across short period during certain hours (“on-peak”)
- **Energy Usage Charge (kWh)**
  - Actual energy consumed during the billing period
  - Typically “Flat Rate” or “Time of Use”

Understanding Demand and Energy Usage



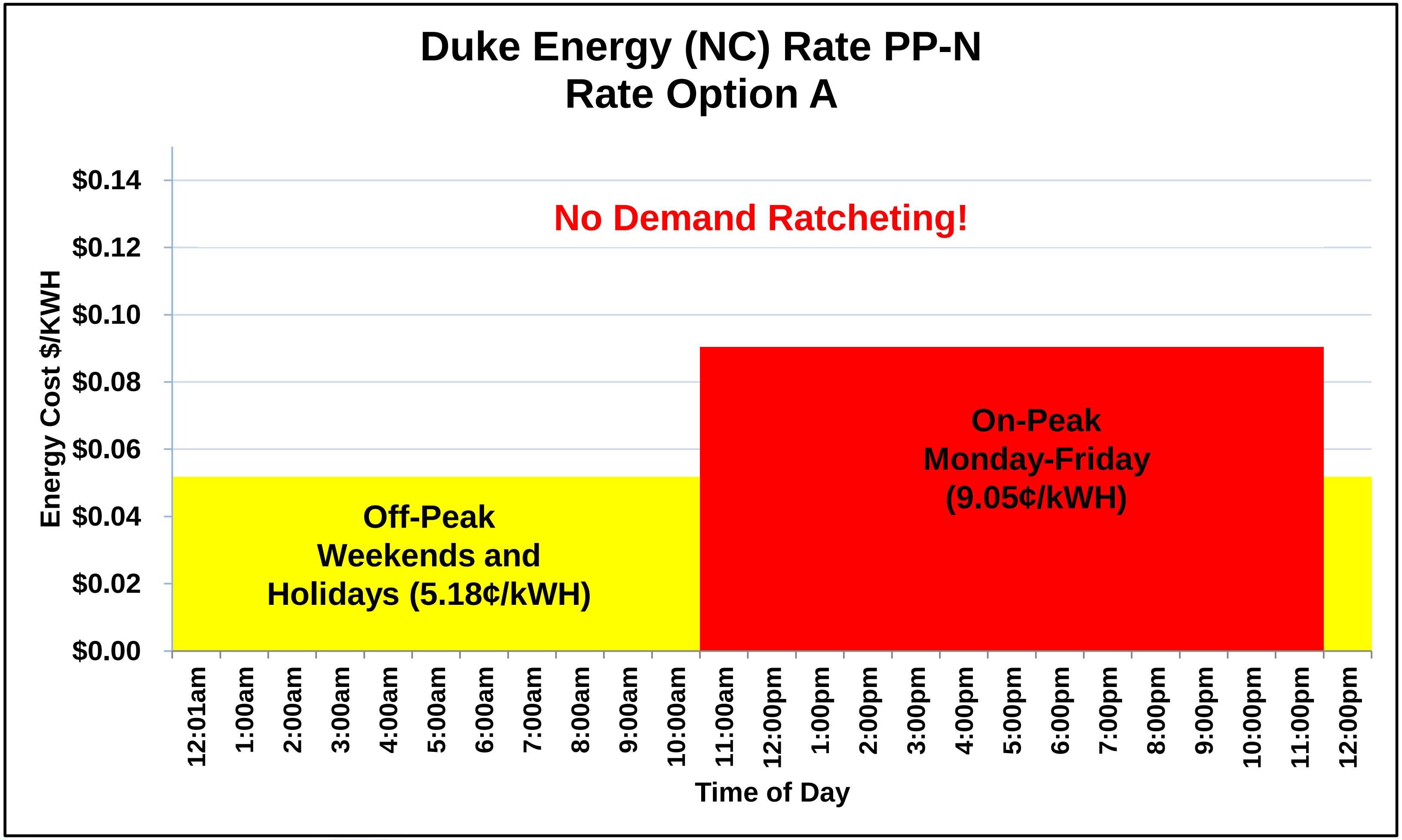
Demand Ratcheting Can Impact Billing Rates



Two Options To Benefit from Onsite Power Generation

- **Offset purchased power source**
  - Connection <u>downstream</u> of utility meter to the plant
  - Generate electricity or direct drive equipment
  - Power offset at the plant's utility rate
- **Sell energy directly to the utility**
  - Connection <u>upstream</u> of utility meter to the plant
  - PURPA laws require electric utilities to purchase energy generated from renewable sources at wholesale prices as a minimum
  - Alternate rates may provide more benefit
  - May be able to get an additional premium as a renewable source

Purchase of Power from Renewable Sources Based on Energy Only Rate



Use Caution When Evaluating Energy Costs

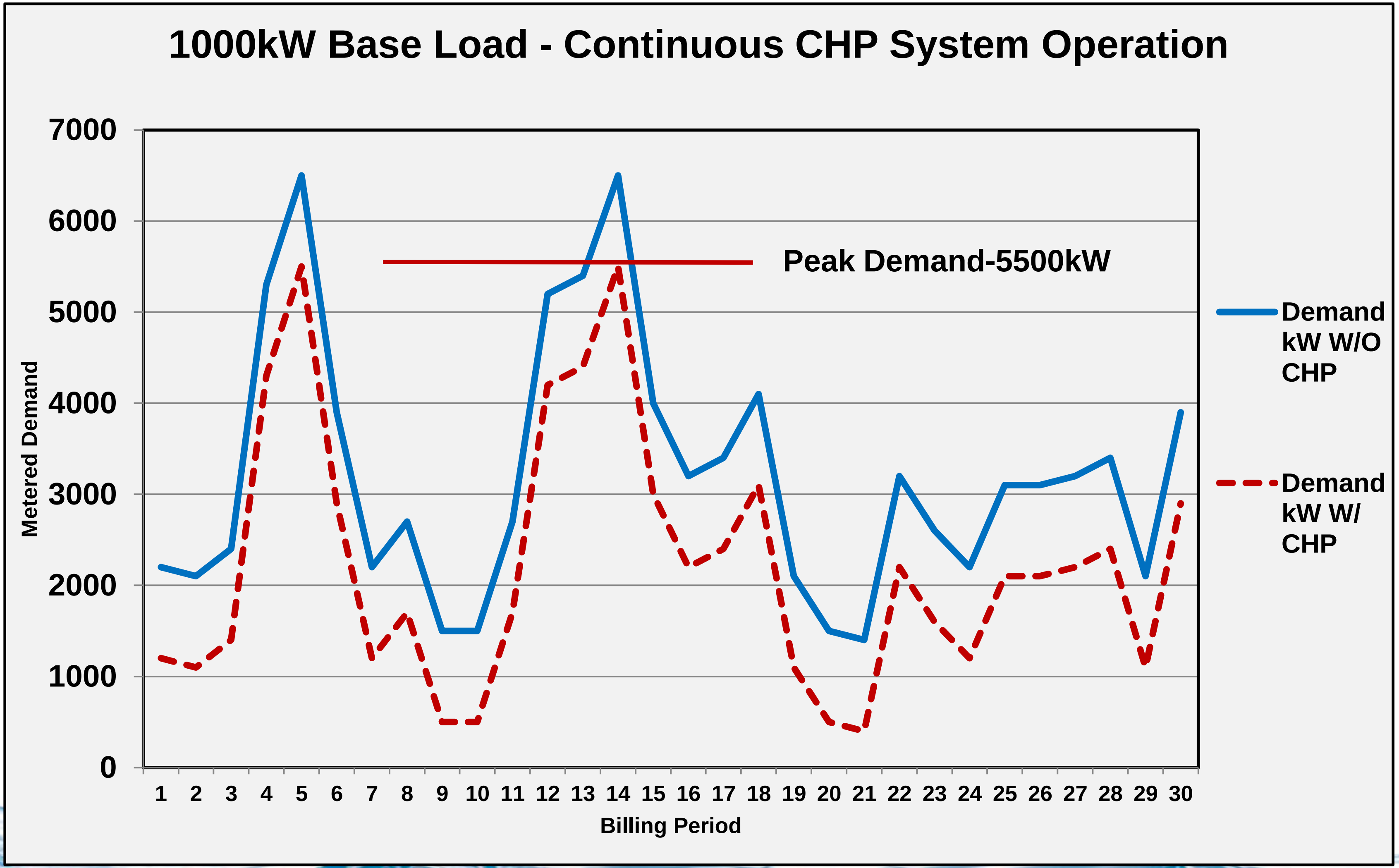
- A common practice is to use average energy cost to evaluate benefit from a CHP system – may not be realistic
  - Step 1 – Look at Power Bill ($)
  - Step 2 – Look at Power Consumption (kWh)
  - Step 3 – Calculate average energy cost ($/kWh)

A Case Study
On Understanding
System Operation
and
Rate Structure Impacts

Evaluating Benefits from 1,000 kW Output CHP System

- **Important Information on Utility Billing**
  - **Energy Charge – $0.03 / kWH**
  - **Monthly Demand Charge – $10.00 / kW**
- **Operating Scenarios to Consider**
  - **Base – CHP system operated continuously**
  - **Impacts of CHP system down time**
  - **Impact of selection of a demand management approach**
- **Examine differential costs associated with different operating scenarios**

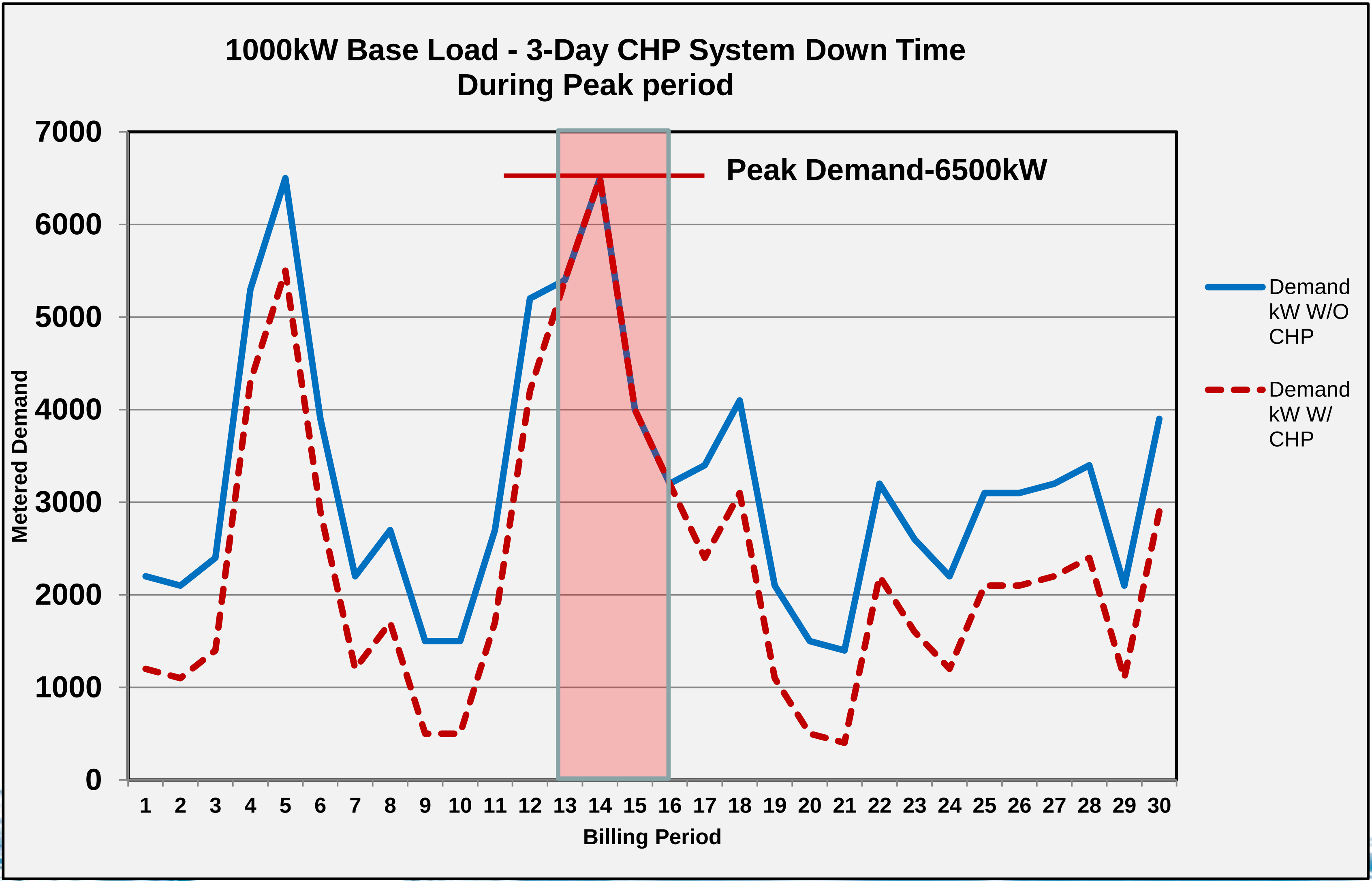
Continuous Operation Reduces Total and Peak Demands



Continuous Operation Results in Operational Savings

	Baseline With No CHP System	Base Load Continuous Operation (1,000 kW)
CHP Demand Charge Offset Amount	N/A	$10,000
CHP Energy Usage Offset Amount	N/A	$21,600
Total CHP Savings	N/A	$31,600
Billing Period Total Electrical Energy Cost	$134,912	$103,312
CHP System Operation Savings (% Change)		-23%

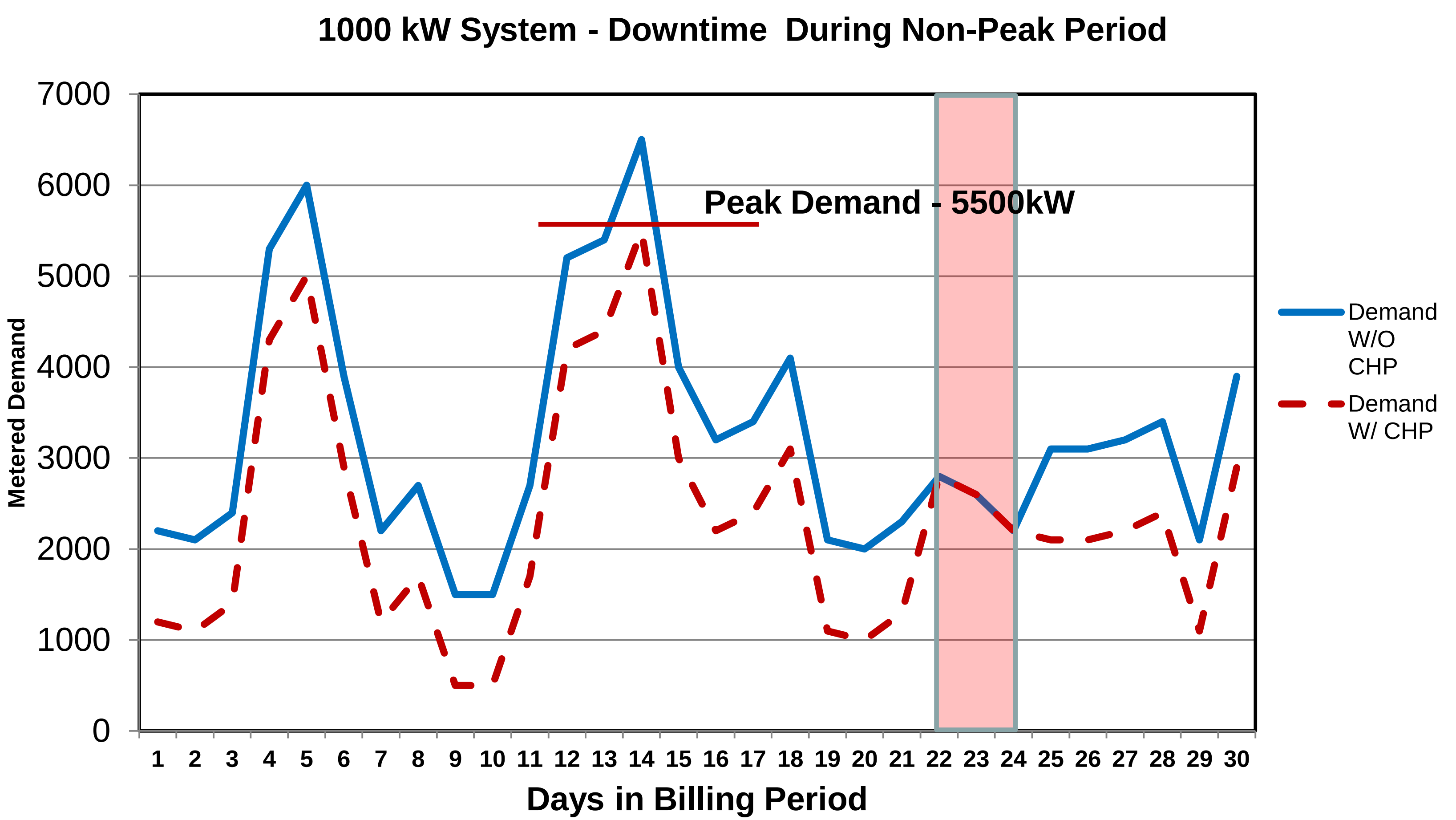
Timing of CHP Downtime Is Critical



CHP Downtime During Peak Demand Can Have Significant Impact

	Baseline With No CHP System	Loss of System Operation During Peak Demand Period
CHP Demand Charge Offset Amount	N/A	N/A
CHP Energy Usage Offset Amount	N/A	$19,440
Total CHP Savings	N/A	$19,440
Billing Period Total Electrical Energy Cost	$134,912	$115,472
CHP System Operation Savings (% Change)		-14%

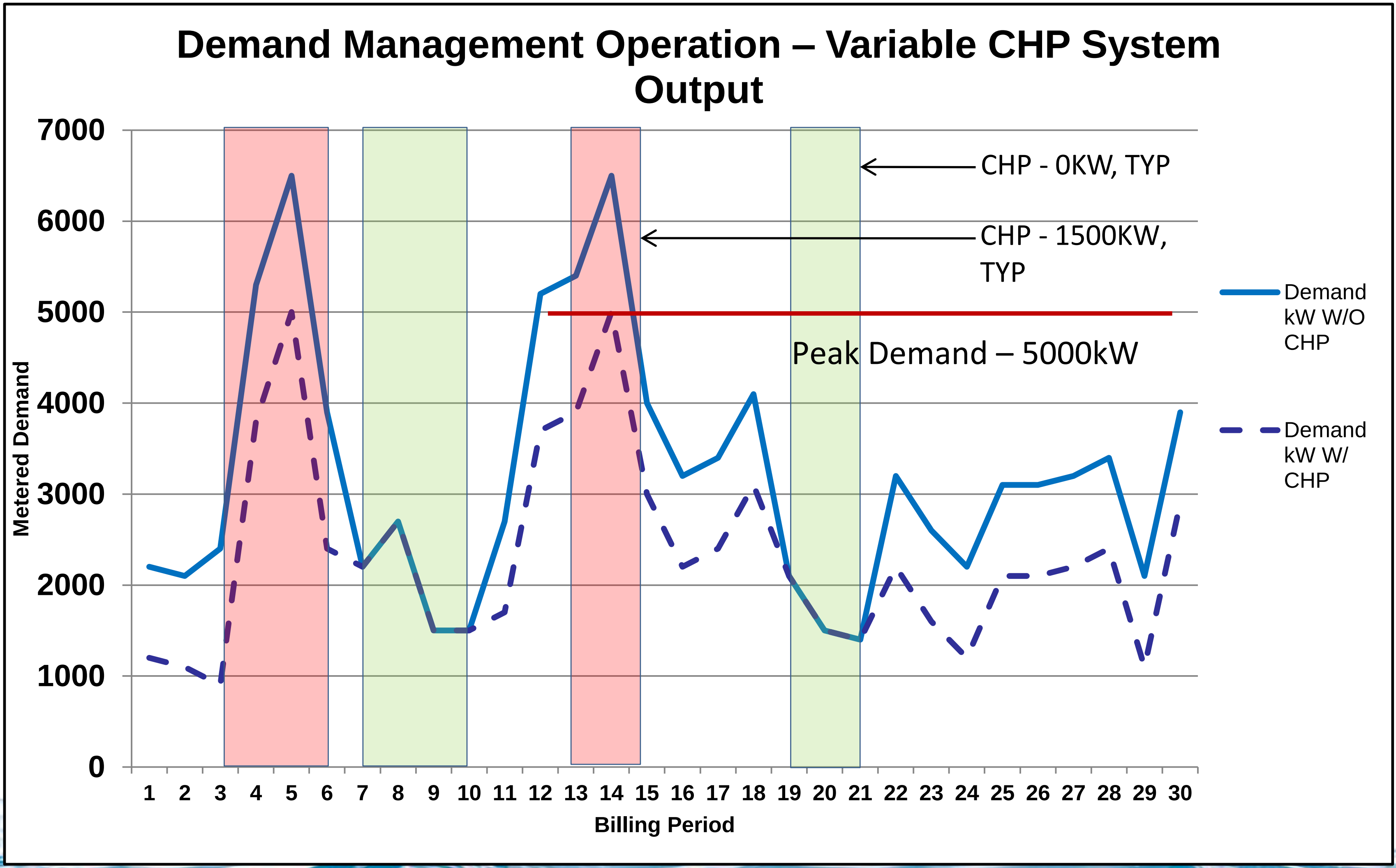
CHP Downtime During Low Demand Is Less Critical



CHP Downtime During Low Demand Has Less Impact

	Baseline With No CHP System	Loss of System Operation During Peak Demand Period
CHP Demand Charge Offset Amount	N/A	$10,000
CHP Energy Usage Offset Amount	N/A	$19,440
Total CHP Savings	N/A	$29,440
Billing Period Total Electrical Energy Cost	$134,912	$105,742
CHP System Operation Savings (% Change)		-22%

Opportunity To Further Increase Savings?



Demand Management Strategy Can Increase Offset of Demand Charges

	Baseline With No CHP System	Demand Management Strategy
CHP Demand Charge Offset Amount	N/A	$15,000
CHP Energy Usage Offset Amount	N/A	$21,240
Total CHP Savings	N/A	$36,240
Billing Period Total Electrical Energy Cost	$134,912	$98,672
CHP System Operation Savings (% Change)		-27%

Summary

CHP System Operation Impacts Potential Cost Savings

	Billing Period Savings	Percent Change from Baseline w/o CHP
Baseline Condition	$0	0%
Continuous Operation	$31,600	23%
Downtime During Peak	$19,440	14%
Downtime During Off-Peak	$29,440	22%
Demand Management	$36,240	27%

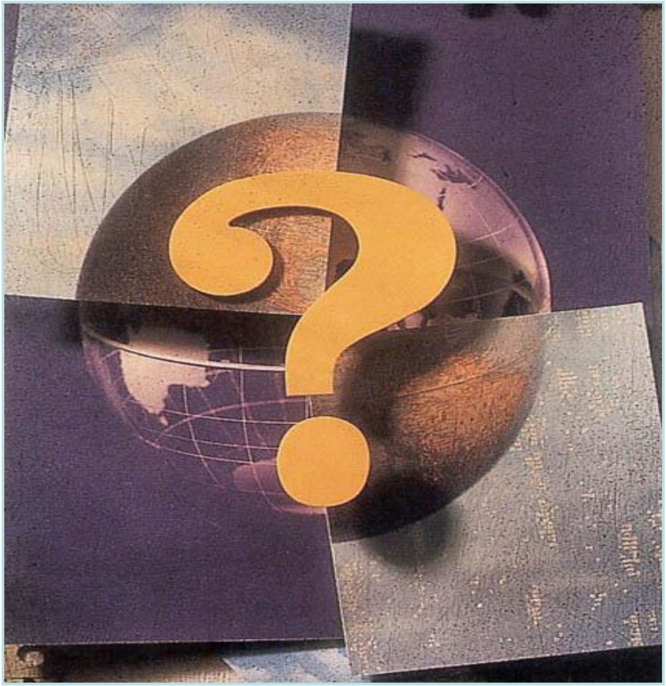
3-day CHP downtime period during peak demand resulted in a 40% loss of the CHP system benefit for the billing period

Demand ratchets can extend this type of loss for up to 12 months! – a 90% 12-month ratchet in this case could result in a loss of ~$130,000

Key Points

- **Understand the details of your specific utility rate structure**
- **Be aware of demand ratchets (if applicable)**
- **If possible, manage demand during CHP system downtime to recognize demand savings**
- **Evaluate alternate utility rates for a better deal**
- **Appropriately evaluate the costs and benefits of selling power generated by the CHP system directly to the electric utility**

Questions?



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