# Making the move to cogeneration

**> Decision factors for facility managers**

Cummins Power Generation

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In theory, almost any facility with a simultaneous need for both electric and thermal energy is a potential candidate for the energy-saving benefits of cogeneration — that is, on-site systems that produce both electric power and thermal energy from a single source of fuel. While the money and energy saving potential available applies to a wide variety of applications, it really depends on the details contained in three key factors: 1) the application's specific needs for heat and power; 2) a favorable ratio between the local cost of natural gas and electricity; and 3) the availability of governmental incentives or rebates.

This document is intended to help facility and energy managers quickly determine whether their facility is a viable candidate for cogeneration. It should be used as a screening tool only, because the actual analysis of an application is dependent on many complex factors. For a facility with the right application and low natural gas costs relative to electric rates, a simple payback can be calculated for a cogeneration system. This initial screening may encourage facility managers to proceed to a formal cogeneration economic analysis.

## Why a facility manager should consider cogeneration

Cogeneration, also known as combined heat and power (CHP), is an on-site generating technology with the following attributes:

- **Fuel efficiency:** Cogeneration systems can derive nearly three times the usable energy from a given amount of fuel compared to centralized power plants that burn coal. Centralized power plants only manage to convert about 27 percent of the energy in the fuel to usable electricity, with more than 60 percent rejected as heat or transportation losses. On-site cogeneration systems burning natural gas in a reciprocating engine with associated heat-recovery equipment can approach 90 percent overall efficiency. Cogeneration systems generate electricity and capture and make use of the "waste" thermal energy produced by the engine's exhaust and coolant circuits.
- **Smaller environmental footprint:** When fuel is consumed in an on-site cogeneration system, it produces almost 80% less carbon dioxide per unit of energy consumed compared to a central coal-fired power plant.

In addition, because the cogeneration system burns clean natural gas, much of the NOx and virtually all particulate emissions associated with centralized power plants are also eliminated.

> **Financial savings:** The efficiency of cogeneration can also produce big savings in utility bills — just how much can be saved depends on the particular characteristics of the application, the local cost of natural gas and the local cost of electricity. Special governmental financial incentives and "carbon credits," where available, can also play an important part in helping to make a cogeneration system financially viable.

There are three key factors that contribute to cogeneration systems delivering energy cost savings, reliability and a sufficiently attractive return on investment (ROI). The key economic factors include:

1. A favorable ratio between the local cost of natural gas and the cost of electricity.
2. A simultaneous base-load need with at least 300 kw of electricity and about 1 MMBtu/hour (342 kWh) of thermal energy.
3. Eligibility for government incentives and rebates.

| Some types of facilities are ideally suited to exploit the energy and money saving potential in cogeneration. Industrial facilities include: | |
|---|---|
| Animal feed processing | Paper mills |
| Chemical processing | Petroleum and coal products |
| Food processing | Pharmaceuticals |
| Manufacturing | Wood products |

| These commercial facilities are also good candidates for cogeneration: | |
|---|---|
| Commercial bakeries | Hotels and resorts |
| Data centers | Ice rinks |
| Greenhouses | Large office complexes |
| Health clubs and spas | Refrigerated warehouses |
| Hospitals and nursing homes | Swimming pools |

| Large governmental infrastructure projects include: |
|---|
| Airports |
| Government facilities |
| Landfills and solid waste digesters |
| Prisons |
| Schools and universities |
| Water and wastewater treatment |

1.

**Gas-electricity cost ratio**

This ratio, also known as the "spark spread," is equal to the local cost of electricity minus the local cost of natural gas on an equivalent kWh or MMBtu basis. Spark spread describes the financial leverage that occurs when one energy source is more economical than another. When the cost of electricity is high and the cost of natural gas is low in relative terms, facility managers can lower overall energy costs by displacing high electric utility costs with electricity generated on-site using natural gas. The larger this price differential, the more economically viable the cogeneration system is likely to be and to provide an ROI that is sufficient to justify installation.

2.

**Need for electric and thermal power**

To reap the economic benefits from a cogeneration system, there must be an on-site need for both electric and thermal energy. The thermal loads can be for hot air, hot water, steam, chilled water or ice. The thermal energy can be either used directly or if the thermal loads are not simultaneous to the electric loads a thermal storage system can be included such as a hot water tank or ice storage. An example may be heating a water tank during the day and using the hot water at night for building heat.

# Key factors affecting economic viability

Geography can play a significant role in spark spread. In some parts of the world, the cost of electricity is nearly equivalent to the cost of natural gas, and on-site cogeneration systems provide little or no economic advantage. (They almost always produce an environmental advantage by conserving energy resources and reducing both air pollutants and greenhouse gases.) However, many regions do exhibit a large enough spark spread to make cogeneration attractive and practical. Also included are key areas in the United States where the serving utilities generation portfolio has increased costs due to fuel conversion limitations, transmission congestion, aging infrastructure, or a combination of factors which influence a customer's total energy costs.

3.

**Government incentives and rebates**

Where available, government incentives and rebates can play a significant role in making cogeneration economically viable. These incentives can take the form of cash rebates or of environmental carbon credits that may be traded on the open market — where one ton of CO2 reduction equals one carbon credit. These incentives vary widely in availability and amount. It is best to check with local regulatory and governmental authorities regarding cogeneration system incentives and rebates.

# Figuring a simple payback

If an end-user has a sufficient base-load need for both electric and thermal energy, the following information can be useful for determining a simple payback. The first step is to determine the total cost of electricity at the point of use. This total cost can be determined by the following formula:

$$\text{Total electric cost} = \frac{[DC \times MD \times 12] + [EC \times AE]}{AE}$$

**DC = Monthly demand charges in $/kW**
**MD = Monthly demand in kW**
**EC = Average annual cost of energy in $/kWh**
**AE = Annual electric use in kWh**

Second, determine the end-user's average cost for natural gas at the facility site. Gas prices are usually quoted in $/therm, $/MMBtu or $/kWh. One MMBtu is equal to 10 therms.

Use these costs for electricity and natural gas with the following payback chart. By cross-referencing the cost of natural gas and the price of electricity, the chart will indicate the number of years it will take to pay back the cost of the cogeneration system. Thereafter, the cogeneration system will provide significant energy savings and environmental benefits. Many other factors can affect the payback period. Therefore, this chart should only be used as a screening device. A favorable result may indicate a reason to do a more thorough feasibility study.

**CHP Payback Calculator**

| $/MMBtu | Electricity ($/kWh) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.10 | 0.11 | 0.12 | 0.13 | 0.14 | 0.15 | 0.16 | 0.17 | 0.18 | 0.19 | 0.20 | 0.21 | 0.22 |
| 17.00 | | | | 40.58 | 17.30 | 11.00 | 8.06 | 6.36 | 5.25 | 4.47 | 3.90 | 3.45 | 3.10 |
| 16.60 | | | 517.80 | 31.96 | 15.52 | 10.25 | 7.65 | 6.10 | 5.08 | 4.34 | 3.80 | 3.37 | 3.03 |
| 16.20 | | | 105.24 | 25.73 | 13.89 | 9.51 | 7.23 | 5.83 | 4.89 | 4.21 | 3.69 | 3.29 | 2.96 |
| 15.80 | | | 58.57 | 21.54 | 12.57 | 8.87 | 6.86 | 5.59 | 4.71 | 4.06 | 3.59 | 3.21 | 2.89 |
| 15.40 | | | 40.58 | 18.52 | 11.47 | 8.31 | 6.52 | 5.36 | 4.56 | 3.95 | 3.50 | 3.13 | 2.83 |
| 15.00 | | | 31.96 | 16.24 | 10.56 | 7.82 | 6.21 | 5.15 | 4.40 | 3.84 | 3.41 | 3.06 | 2.77 |
| 14.60 | | 517.80 | 25.73 | 14.66 | 9.86 | 7.43 | 5.96 | 4.98 | 4.27 | 3.74 | 3.33 | 2.99 | 2.71 |
| 14.20 | | 105.24 | 21.54 | 13.19 | 9.18 | 7.04 | 5.71 | 4.80 | 4.14 | 3.64 | 3.25 | 2.92 | 2.66 |
| 13.80 | | 28.57 | 18.52 | 12.00 | 8.58 | 6.68 | 5.47 | 4.63 | 4.04 | 3.54 | 3.17 | 2.86 | 2.61 |
| 13.40 | | 40.58 | 16.24 | 11.00 | 8.06 | 6.36 | 5.25 | 4.47 | 3.90 | 3.45 | 3.10 | 2.80 | 2.56 |
| 13.00 | -539.27 | 31.96 | 15.52 | 10.25 | 7.65 | 6.10 | 5.08 | 4.34 | 3.80 | 3.37 | 3.03 | 2.74 | 2.51 |
| 12.60 | 174.92 | 25.73 | 13.89 | 9.51 | 7.23 | 5.83 | 4.89 | 4.21 | 3.69 | 3.29 | 2.96 | 2.69 | 2.45 |
| 12.20 | 75.26 | 21.54 | 12.57 | 8.87 | 6.86 | 5.59 | 4.71 | 4.06 | 3.59 | 3.21 | 2.89 | 2.63 | |
| 11.80 | 47.94 | 18.52 | 11.47 | 8.31 | 6.52 | 5.36 | 4.56 | 3.95 | 3.50 | 3.13 | 2.83 | 2.58 | |
| 11.40 | 35.17 | 16.24 | 10.56 | 7.82 | 6.21 | 5.15 | 4.40 | 3.84 | 3.41 | 3.06 | 2.77 | 2.53 | |
| 11.00 | 27.78 | 14.46 | 9.78 | 7.38 | 5.93 | 4.96 | 4.26 | 3.73 | 3.32 | 2.99 | 2.71 | 2.48 | |
| 10.60 | 22.95 | 13.03 | 9.10 | 6.99 | 5.68 | 4.78 | 4.12 | 3.63 | 3.24 | 2.92 | 2.66 | 2.42 | |
| 10.20 | 19.55 | 11.86 | 8.52 | 6.64 | 5.44 | 4.61 | 4.00 | 3.53 | 3.16 | 2.86 | 2.61 | | |
| 9.80 | 17.03 | 10.89 | 8.00 | 6.32 | 5.23 | 4.46 | 3.88 | 3.44 | 3.09 | 2.80 | | | |
| 9.40 | 15.09 | 10.06 | 7.54 | 6.03 | 5.03 | 4.31 | 3.77 | 3.35 | 3.02 | 2.74 | | | |
| 9.00 | 13.54 | 9.35 | 7.14 | 8.77 | 4.84 | 4.17 | 3.67 | 3.27 | 2.95 | 2.69 | | | |
| 8.60 | 12.28 | 8.73 | 6.77 | 5.53 | 4.67 | 4.05 | 3.57 | 3.19 | 2.89 | 2.63 | | | |
| 8.20 | 11.24 | 8.19 | 6.44 | 5.31 | 4.51 | 3.93 | 3.47 | 3.12 | 2.82 | 2.58 | | | |
| 7.80 | 10.36 | 7.71 | 6.14 | 5.10 | 4.36 | 3.81 | 3.38 | 3.04 | 2.76 | 2.53 | | | |
| 7.40 | 9.60 | 7.28 | 8.87 | 4.91 | 4.22 | 3.71 | 3.30 | 2.97 | 2.71 | 2.48 | | | |
| 7.00 | 8.88 | 6.86 | 8.61 | 4.75 | 4.08 | 3.61 | 3.22 | 2.91 | 2.65 | 2.42 | | | |

Negative payback

Payback period of 10 years or more

Payback from 5 to 10 years—application could be viable with incentives, carbon credits or rebates

Payback in less than 5 years—an ideal candidate for cogeneration

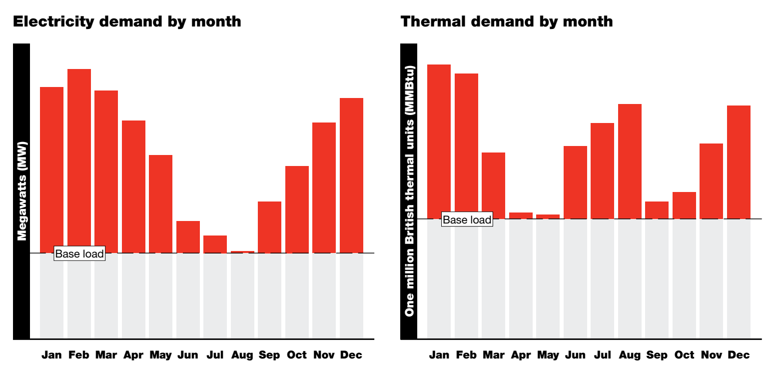
**NOTE:** This chart should only be used for initial screening. Each application should be analyzed on an individual basis.

1. Installed 1250 kW cogeneration unit
2. Installation costs based on $1,700/kW for engine, generator set and heat recovery equipment
3. Payback is listed in years
4. Operation and maintenance are included
5. No local, state or federal incentives or rebates are included
6. No financing costs are included

### Sizing cogeneration to electric and thermal base loads

In most facilities, the demand for electricity and thermal power varies by time of day and season. A factory or commercial facility will have a particular load profile that will reflect the facility's use of electricity over time. Likewise, thermal energy needs will vary during the day and also with the seasons. Air conditioning loads peak in the summer months, and heating needs peak in the winter. Thermal energy used for industrial processing will also vary by time of day. By tracking your electricity and thermal energy demands over time, an end-user will be able to determine the base loads.

Cogeneration systems are typically designed to provide only a portion of total electric and thermal needs. This portion is usually equal to the base-load energy needs for your facility. The peak energy needs will still need to be supplied by your electric utility and on-site boilers or furnaces.




# Cost calculations

| | |
|---|---|
| Total installed CHP system cost at $1,700/kW | $2,125,000 |
| Projected annual electric savings | $450,000 |
| Generator set operating costs (including fuel and maintenance) | $1,050,000 |
| Payback period | 4.72 years |
| Internal rate of return (IRR) | 22% |

### Environmental savings

By displacing power generated by coal-burning utilities, this cogeneration system delivers significant reductions in greenhouse gas emissions in addition to energy savings.

| | |
|---|---|
| Nitrogen oxide (NOx) reduction | 11.03 tons/year* |
| Sulfur dioxide (SO2) reduction | 31.46 tons/year |
| Carbon dioxide (CO2) reduction | 3,355 tons/year |

*Equal to planting 691 acres of new forest or removing 554 automobiles.

You can see from the figures that an on-site generator set that produces both electricity and thermal energy can cut total energy expenditures and greenhouse gas emissions by a significant amount. In this example, the CHP system will pay for itself in less than five years, and will provide annual positive cash flow for the facility.

### Taking the next step

By using the preceding information, tables, examples and guides, facility managers should now have a good idea if cogeneration has the potential to deliver energy cost savings and operational and environmental benefits.

Cogeneration systems from Cummins Power Generation can help:

- Reduce a facility's energy and operating costs
- Gain a competitive advantage over the competition
- Improve power quality and reliability
- Reduce a facility's carbon footprint and demonstrate corporate responsibility by operating in an environmentally friendly manner
- Provide standby generation

**The next step is to contact a Cummins Power Generation energy advisor for a detailed concept outline and budgetary proposal.**

## Ten reasons to choose cogeneration from Cummins Power Generation

1. Significant energy savings and greater customer control of energy costs
2. Increased power reliability and business continuity for critical operations
3. Measurable results
4. Single source manufacturer of engines, alternators and switchgear
5. Hands-off operations and maintenance with service agreements
6. Performance warranties
7. Proven technology using Cummins lean-burn gas engines
8. High heat quality, high fuel efficiency and low emissions
9. A hedge against rising energy costs
10. Improve your company's financial, environmental and competitive performance

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