Does Cogeneration Make Sense for Me?

The First Step in Examining the Cogeneration Opportunity

Doing a detailed economic analysis of cogeneration for a facility can take substantial time and resources. Facility owners want to understand whether there is a clear opportunity before embarking on a protracted evaluation. A few simple questions and calculations are justified. We will run through a series of forms and an example calculation to show how this is done.

The example is a large commercial building currently on the Commonwealth Edison 6L rate with a peak demand of 3,000 kw and an average on-peak electric usage of 2100 kW which amounts to 462,000 kwh per month. The current gas cost if $6.00/MMBtu delivered.

The calculation in

Figure 1 determines the true or total cost of electricity, including demand charges. In some areas, transition charges are currently being included in either the demand charge or energy charge and these should be included on either line 2 or 5. Note that these charges may be on a separate line on you electric bill.

True Electric Costs		Summer On Peak	Winter On Peak	Off-Peak	Units
Electric Energy Rate	*From Utility Bill*				$/kWh
Electric Demand Rate	*From Utility Bill*				$/kW
Electric Usage	*From Utility Bill*				kWh
Demand Usage	*From Utility Bill*				kW
Energy Charges	*Usage X Energy Rate*				
Demand Charges	*Demand X Demand Rate*				
Total Bill	*Energy + Demand*				
True Cost of Electric Power	*Total Bill/Electric Usage*				$/kWh

Figure 1: Calculate True Cost of Electricity

The Figure 1 calculation should be done for one summer and one winter month as the cost of electricity can vary widely between the two seasons. Perform the calculation for any off peak rates as well. Figure 2 shows this table for our example case.

True Electric Costs		Summer On Peak	Winter On Peak	Off-Peak	Units
Electric Energy Rate	*From Utility Bill*	$0.05022	$0.05022	$0.022	$/kWh
Electric Demand Rate	*From Utility Bill*	$16.41	$12.85	$0	$/kW
Electric Usage	*From Utility Bill*	462,000	462,000	142,000	kWh
Demand Usage	*From Utility Bill*	3,000	3,000	800	kW
Energy Charges	*Usage X Energy Rate*	$23,202	$23,202	$3,124	
Demand Charges	*Demand X Demand Rate*	$49,230	$38,550	$0	
Total Bill	*Energy + Demand*	$72,432	$61,752	$3,124	
Average Cost on Peak	*Total Bill/Electric Usage*	$0.157	$0.134	$0.022	$/kWh

Figure 2: Example Calculation on the True Cost of Electricity

The next step is to plot the true cost of electricity, summer on-peak, winter on-peak and off-peak, along with your current gas cost on the Graphs shown in Figure 3. This is done by drawing horizontal lines across the graph for each of the electric costs and a vertical line in for the natural gas cost. The results for our Example are as shown in Figure 4.

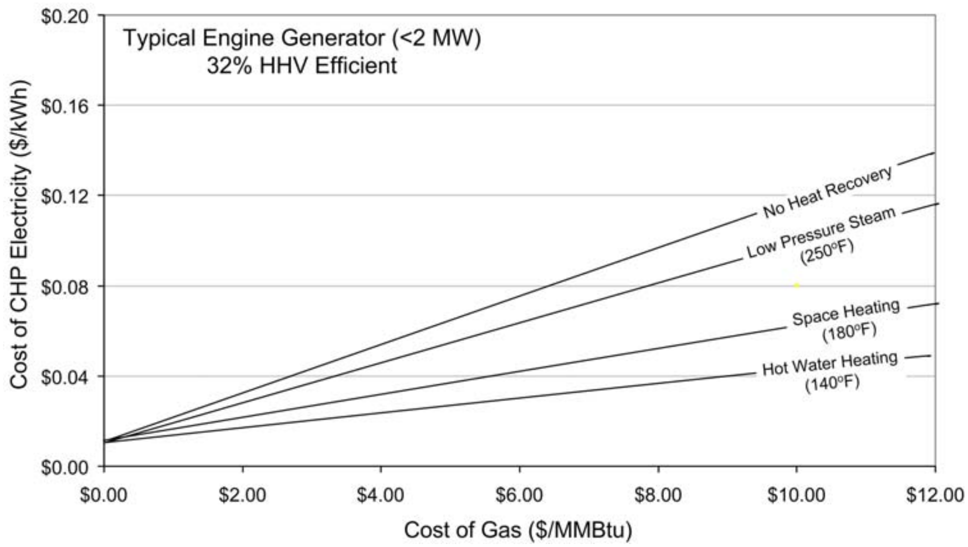


Figure 3: Cost of Electricity Graphs for Engines

Chart assumes an engine heat rate of 10,660 Btu./kWh and a maintenance allocation of $0.011/kWh for engines of under 2 MW. Larger engine often have lower maintenance allocations.Enginesd are not recommended for high pressure steam applicatiions (>15 psig). A separate chart is supplied at the back for gas turbines.

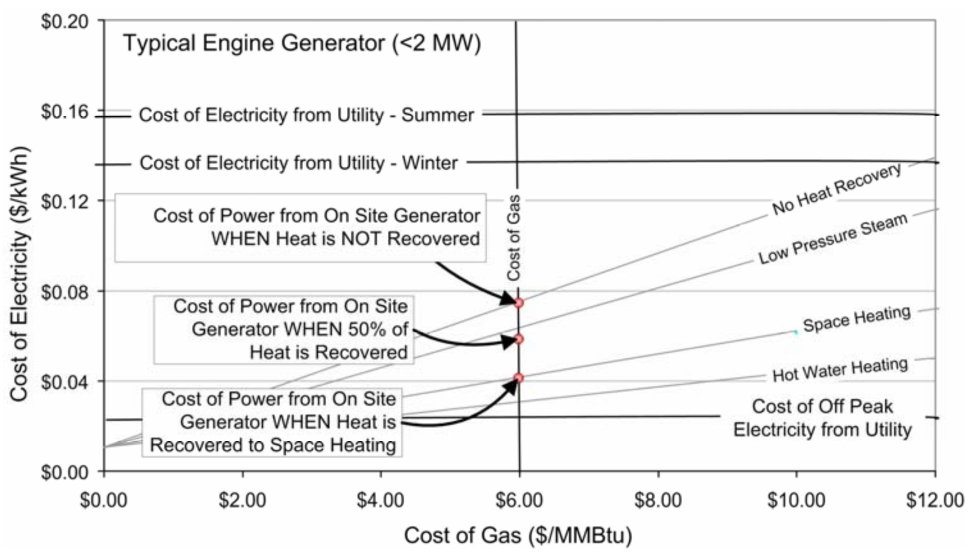


Figure 4: Cost of Electricity Graph for Our Example

Chart shows the True Off-Peak and On-Peak Summer and Winter Electric Price from the Utility as Well as the Cost of Electricity from the On-Site Generator IF the Recoverable Heat is Used for Space Heating. You Can See that On-Site Generation is Profitable During All On-Peak Hours but NOT During Off Peak Hours. Also, On-Site Generation Remains Profitable Even if Heat is NOT Recovered. Therefore, the On-Peak Operation of the CHP System Should be Controlled by the Need for Electricity (Not Heat).

Next compare your point against the "Cost of CHP Electricity" in Figure 4 . This is the cost of electricity generated by the system after crediting the economics for the value of the heat recovered and charging in a widely accepted engine maintenance allocation. The distance between your point and the net cost of electricity line is the amount that you would save for each kilowatt-hour generated.

In the example, there is no savings during off-peak periods. This is a common result. When this happens, cogeneration systems are run during on-peak hours only.

In the example, the savings during winter peak periods is $0.094 per kWh and during summer peak periods is $0.117 per kWh.

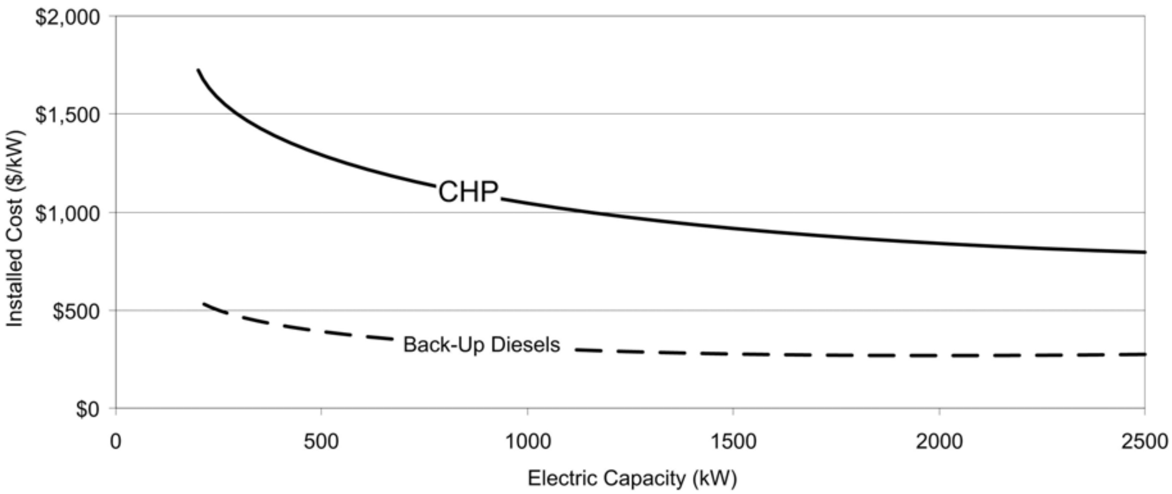


Figure 5: Typical Costs for Cogeneration Systems Based on the Size of the Systems

Chart Includes Typical Costs for Heat Recovery Equipment, Installation, and Housing

By making a few simplifications, some preliminary economics can be done. Cogeneration systems produce the best financial results when sized to between 40-60% of the peak electric load of a commercial facility. Larger systems will increase first cost for added capacity that is rarely used. Fill out the Table in Figure 6 to get a very rough estimate of what an engine driven cogeneration system could save your facility.

Line			On Peak Summer	On Peak Winter	Off Peak
1	On Peak Hours of Operation	From Rate Schedule or Utility Bill			
2	True Cost of Electricity	From Table in Figure 1			
3	Cost of Generating Electricity	From Figure 2			
4	Cost Savings per kWh	Line 2 - Line 3			
5	System Size	Use 50% of the Maximum Demand			
6	Cost Savings per Year	If Line 4 >0, Line 4 X Line 5 x Line 1			
7	Total Savings per Year	Add 3 Values in Line 6 Together			
8	First Cost of System ($/kW)	From Figure 3			
9	Total First Cost	Line 8 x Line 5			
	Payback	Divide Line 9 by Line 7			

Figure 6: Economics Calculating Table

Line			On Peak Summer	On Peak Winter	Off Peak
1	Hours of Operation	From Rate Schedule or Utility Bill	715	2145	5900
2	True Cost of Electricity	From Table in Figure 1	$0.157	$0.134	$0.022
3	Cost of Generating Electricity	From Figure 2	$0.04	$0.04	$0.04
4	Cost Savings per kWh	Line 2 - Line 3	$0.12	$0.09	-$0.02
5	System Size	Use 50% of the Maximum Demand	1,500		
6	Cost Savings per Year	If Line 4 >0, Line 4 X Line 5 x Line 1	$125,483	$302,445	NA
7	Total Savings per Year	Add 3 Values in Line 6 Together	$427,928		
8	First Cost of System ($/kW)	From Figure 3	$900.00		
9	Total First Cost	Line 8 x Line 5	$1,350,000		
	Payback	Divide Line 9 by Line 7	3.15		

Figure 7: Economic Calculating Table for the Example

Notice that the cost saving for off peak operation are negative. The CHP system should be shut down at night. Therefore, the off-peak column is not used after line 4 The 1,500 kW size of the CHP system was set at 50% of the peak demand for the facility.

Figure 7 indicates a good payback (3.15Years) IF all of the recoverable heat can be used, which may happen in applications where there is a very large heat load available. However, in many applications, particularly in commercial buildings where the recoverd heat is largely used only for space heating and cooling, actual useful recovery equal ~50% of the total recoverable heat – paybacks tend to increase (Figure 8).

Line			On Peak Summer	On Peak Winter	Off Peak
1	Hours of Operation	From Rate Schedule or Utility Bill	715	2145	5900
2	True Cost of Electricity	From Table in Figure 1	$0.157	$0.134	$0.022
3	Cost of Generating Electricity	From Figure 2	$0.06	$0.06	$0.06
4	Cost Savings per kWh	Line 2 - Line 3	$0.10	$0.07	-$0.04
5	System Size	Use 50% of the Maximum Demand	1,500		
6	Cost Savings per Year	If Line 4 >0, Line 4 X Line 5 x Line 1	$104,033	$238,095	NA
7	Total Savings per Year	Add 3 Values in Line 6 Together	$342,128		
8	First Cost of System ($/kW)	From Figure 3	$900.00		
9	Total First Cost	Line 8 x Line 5	$1,350,000		
	Payback	Divide Line 9 by Line 7	3.95		

Figure 8: Economic Calculating Table for the Example with 50% of Heat Recovered

To this point, there have been no credits given for other benefits of having the CHP system. If the facility is using the CHP systems as an alternative to putting in emergency generators or an alternative to replacing existing dilapidated generators, then the cost of "Back-Up Deisels", as shown in Figure 5, should be subtracted from the first costs of the CHP. For our example, the First Cost of the Cogeneration System is $900 per kW. However, at the 1500 kW size, an Emergency or Back-Up Generator would cost $350/kW. This means that the net cost of the cogeneration function to the facility is $550/kW. When this is used in the cogeneration analysis, the payback period becomes 2.4 years. This payback should be understood carefully – this is the payback for upgrading the back-up generators with cogeneration capability (adding heat exchangers, upgrading to continuous duty engines, adding electrical parallelling gear, and so on).

Facilities with greater than 6 MW of peak demand can productively use a generator of over 3 MW. A gas turbine may be more practical for such a facility. The same process as outlined previously can be used. However, the chart in Figure 9 should replace Figure 3. Gas turbines produce enough hot exhaust to generate high pressure steam (125 psig or greater) which may be of mor use for hospital or industrial facilities.

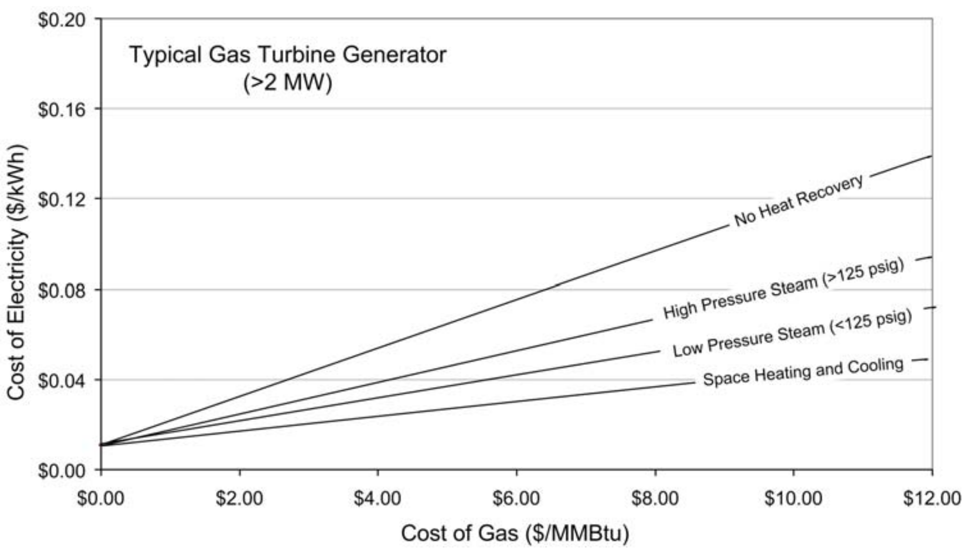


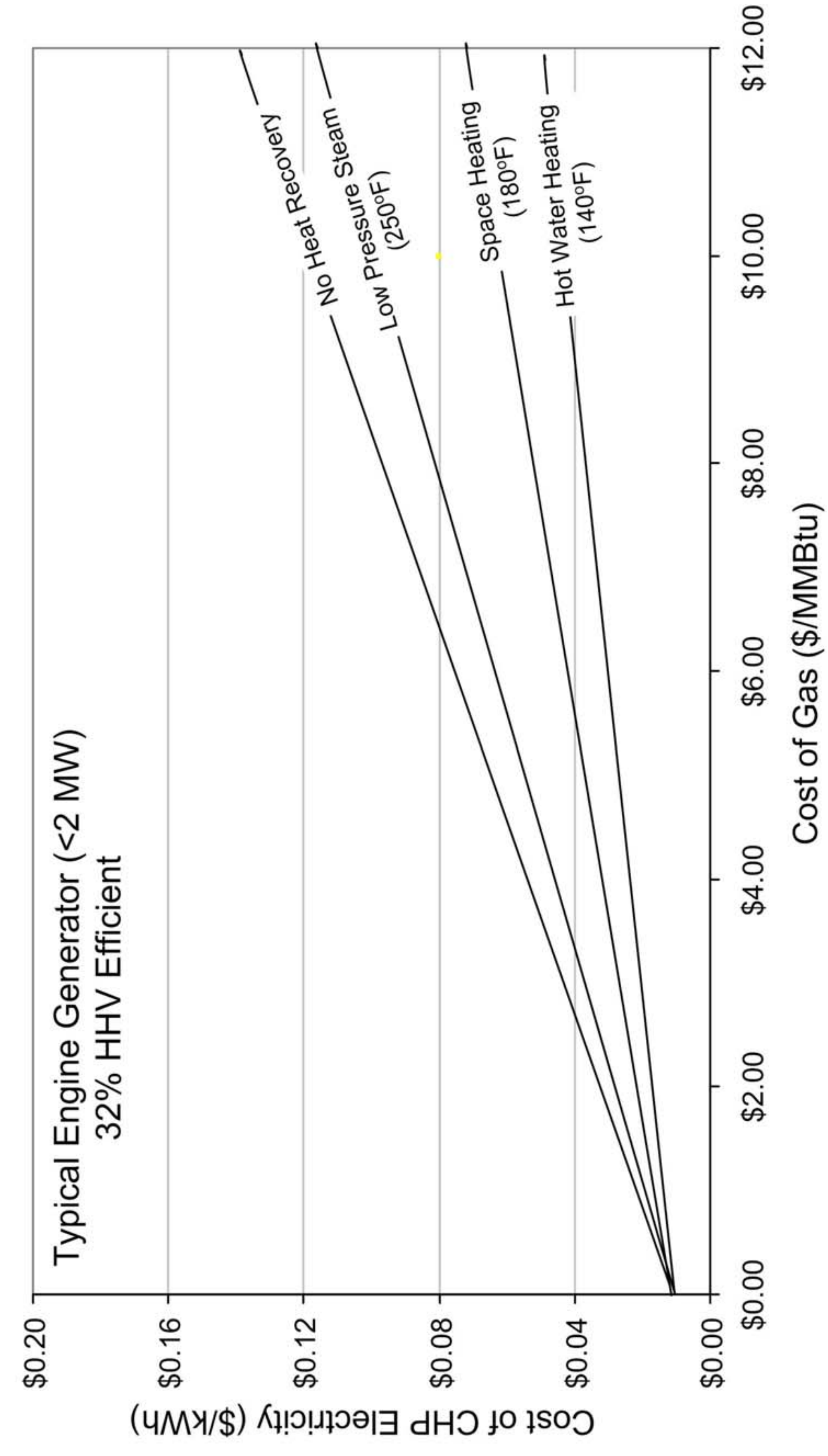
Figure 9: Cost of Electricity Graphs for Turbines

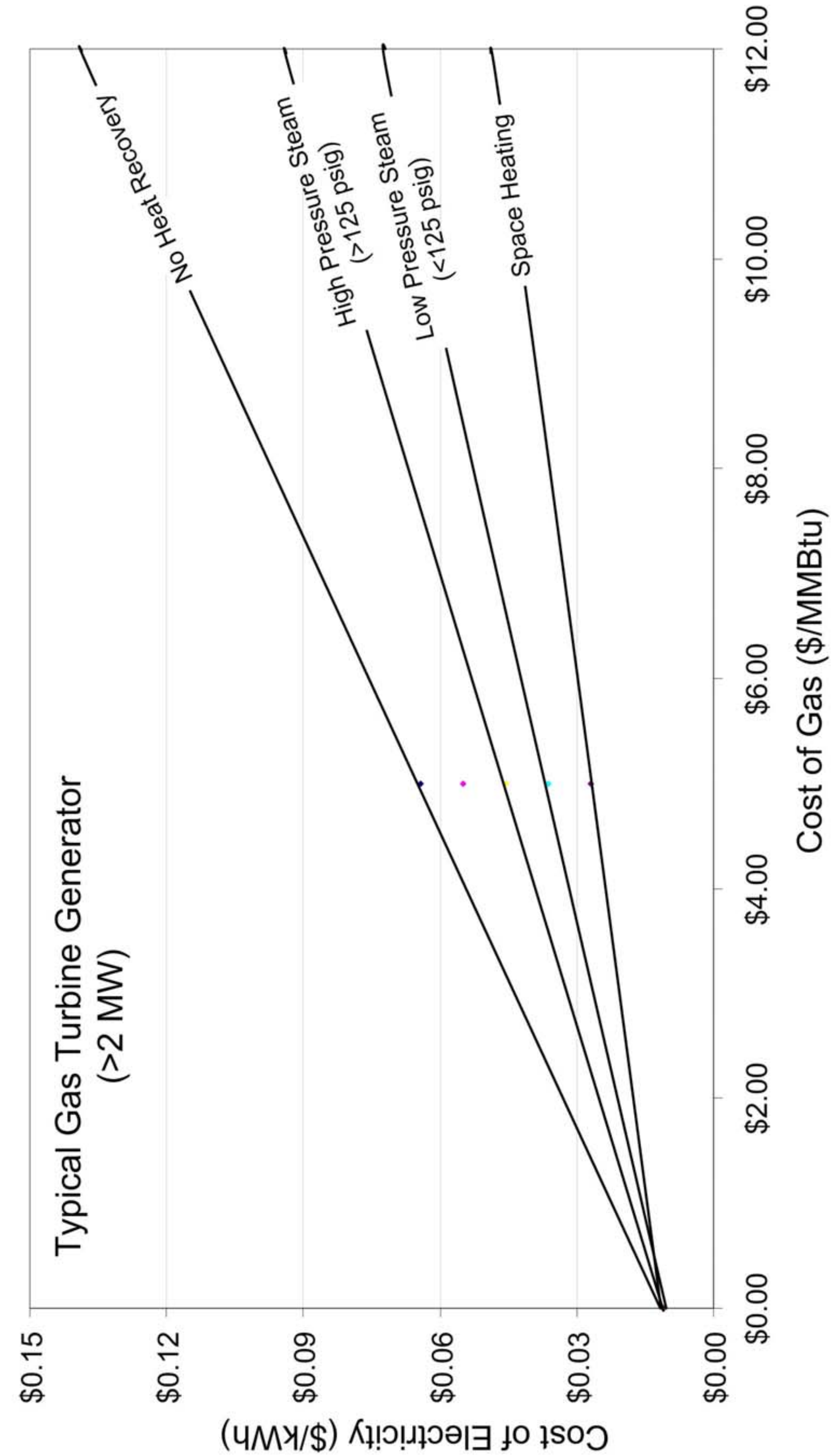
Chart assumes an turbine heat rate of 10,660 Btu./kWh and a maintenance allocation. Notice that gas turbines can produce low electric costs even when high pressure steam is required due to the large quantitiy of high temperature heat in turbine exhaust.

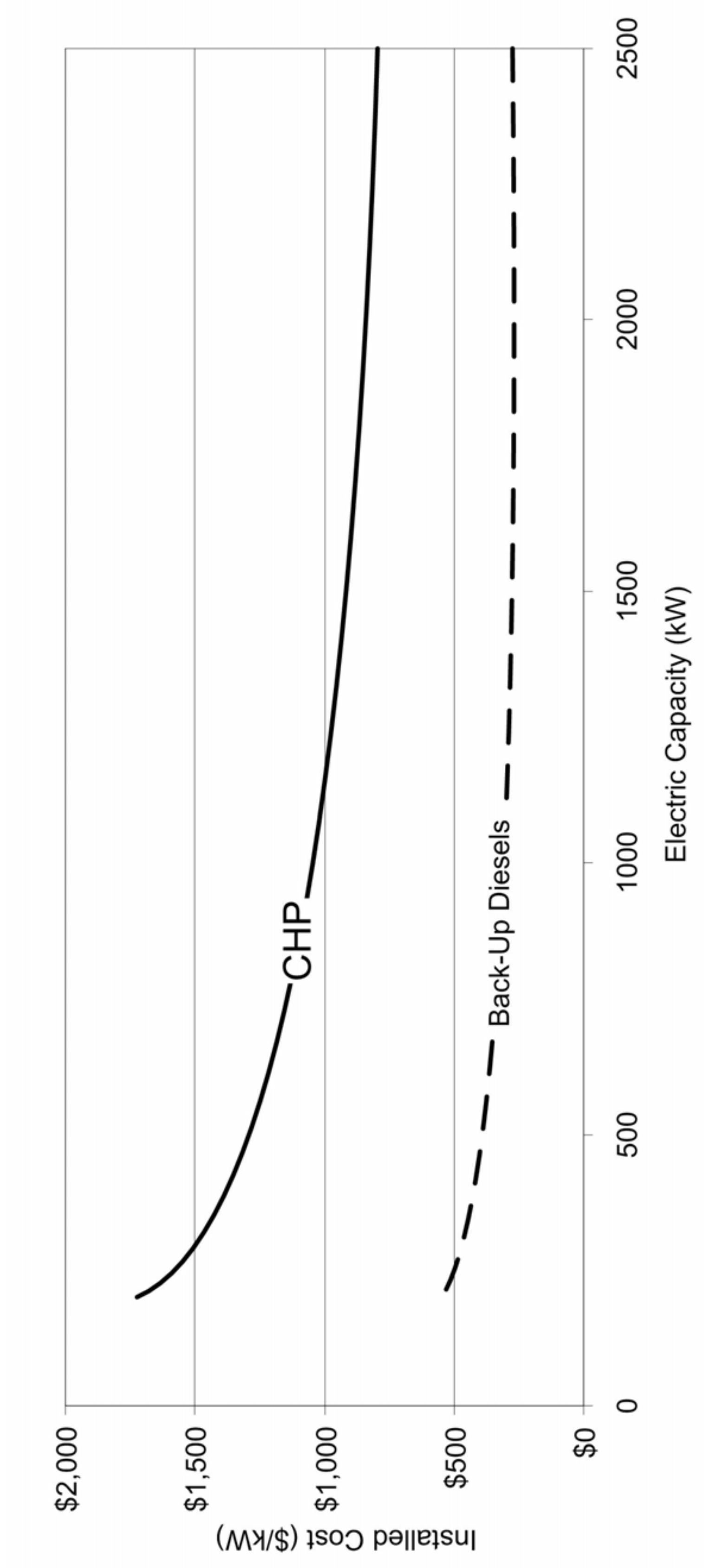
Appendix: Expanded Tables and Charts

True Electric Costs		Summer	Winter	Off-Peak	
Electric Energy Rate	*From Utility Bill*				$/kWh
Electric Demand Rate	*From Utility Bill*				$/kW
On Peak Electric Usage	*From Utility Bill*				kWh
Demand Usage	*From Utility Bill*				kW
Energy Charges	*Usage X Energy Rate*				
Demand Charges	*Demand X Demand Rate*				
Total Bill	*Energy + Demand*				
Average Cost on Peak	*Total Bill/Electric Usage*				$/kWh

			On Peak		Off Peak
			Summer	Winter	
Line					
1	On Peak Hours of Operation	From Rate Schedule or Utility Bill			
2	True Cost of Electricity	From Table in Figure 1			
3	Cost of Generating Electricity	From Figure 2			
4	Cost Savings per kWh	Line 2 - Line 3			
5	System Size	Use 50% of the Maximum Demand			
6	Cost Savings per Year	If Line 4 >0, Line 4 X Line 5 x Line 1			
7	Total Savings per Year	Add 3 Values in Line 6 Together			
8	First Cost of System ($/kW)	From Figure 3			
9	Total First Cost	Line 8 x Line 5			
	Payback	Divide Line 9 by Line 7			


Typical Engine Generator (<2 MW)
32% HHV Efficient
No Heat Recovery
Low Pressure Steam
(250°F)
Space Heating
(180°F)
Hot Water Heating
(140°F)
$0.20
$0.16
$0.12
$0.08
$0.04
$0.00
Cost of CHP Electricity ($/kWh)
$0.00
$2.00
$4.00
$6.00
$8.00
$10.00
$12.00
Cost of Gas ($/MMBtu)


Typical Gas Turbine Generator
(>2 MW)
No Heat Recovery
High Pressure Steam
(>125 psig)
Low Pressure Steam
(<125 psig)
Space Heating
Cost of Electricity ($/kWh)
$0.15
$0.12
$0.09
$0.06
$0.03
$0.00
$0.00
$2.00
$4.00
$6.00
$8.00
$10.00
$12.00
Cost of Gas ($/MMBtu)


CHP
Back-Up Diesels
Installed Cost ($/kW)
$2,000
$1,500
$1,000
$500
$0
Electric Capacity (kW)
0
500
1000
1500
2000
2500