



Project Summary Report:

**Assessment of Large
Combined Heat and Power Market**

ORNL Subcontract 4000021456
Task 2

Submitted to:

Oak Ridge National Laboratory
P.O. Box 2008
1 Bethel Valley Road
Oak Ridge, TN 37831-6065

Submitted by:

Energy and Environmental Analysis, Inc.
1655 N. Fort Myer Drive, Suite 600
Arlington, Virginia 22209
(703) 528-1900

April 2004

Assessment of Large Combined Heat and Power Market

Background

This report summarizes an assessment of the 2-50 MW combined heat and power (CHP) market and near-term opportunities for a fixed set of CHP technologies. This size range has been the biggest contributor to the traditional inside-the-fence CHP market to date. Opportunities still exist and a current understanding of the remaining prospects will help focus efforts that can accelerate near-term markets.

The assessment utilized the IHS Energy Major Industrial Plant Database (MIPD) and Commercial Energy Profile Database (CEPD). The databases contain energy and operations data for over 160,000 large industrial and commercial facilities. The analysis characterized the market for five classes of CHP technology that are of interest to the Department of Energy (DOE) and Oak Ridge National Laboratory (ORNL):

- Conventional Reciprocating Engine System (1MW)
- Advanced Reciprocating Engine System (3 MW)
- Conventional Industrial Gas Turbine System (5 MW)
- Conventional Industrial Gas Turbine (10 MW)
- Advanced Recuperated Gas Turbine (4.2 MW)

The cost and performance assumptions used are based on the recently completed CHP technology characterizations.

Approach

This report documents how the entire database sample was sorted and screened based on criteria that included customer load and cost data from the MIPD and CEPD. This screen resulted in assessing the near-term (1-4 years) opportunity for each of the five CHP technologies.

The screening results were used to identify the most promising sectors for CHP. The sectors were then profiled and characterized with respect to the near term outlook of the three technology classes.

Screening Methodology

A methodology was developed to look at the attractiveness of each of the five CHP technologies in industrial and large commercial sectors. Given the near-term emphasis of this project, only existing facilities contained within the MIPD and CEPD databases were considered in assessing the size of the economically viable market. The methodology looked at each technology individually and does not assess the competitiveness vis-à-vis the other technologies considered, i.e., the results apply to each technology only and are not additive.

The screening was based on the facilities listed in the MIPD and CEPD databases and is only as accurate as the information contained therein. The screening criteria included electric demand, electricity usage, steam demand, hours of operation, and average cost of electricity of facility. EIA data was used to supplement incomplete data in the CEPD.

The screening criteria are summarized in Table 1. CEPD does not contain thermal load to the detail contained with MIPD. Consequently, a thermal screen could not be applied to commercial sites.

Table 1: Site Screening Criteria

Site Screening Criteria	Cutoff
Electric Demand	2-50 MW
Industrial Facility Steam Load	3.7-25 MMBtu/hr
Industrial Hours of Operation	>6000 hours

Sites were then further screened by applying an economic component to the criteria. The economic screen entailed developing cost of electricity estimates for each of the five technologies considered. The calculated cost of electricity for each technology was used to identify sites on two bases. First, those sites whose current cost of electricity was equal to or greater than the calculated CHP costs were identified. Secondly, sites were further screened by identifying those sites whose current electricity costs allowed for a five year or less simple payback on the CHP installed costs. Assumptions used in the cost of electricity calculation are summarized in Table 2.

Table 2: Screen Assumptions

Assumptions	
Gas Price	\$6.00/MMBtu
Commercial Hours of Operation	EIA CBECS data
Displaced Boiler Efficiency	80%
Capital Recovery Factor	16%
Project Life	10 years
Maximum Payback Period	5 years

The CEPD database does not contain hours of operation data. Therefore it was assumed that commercial facilities operate at the EIA CBECS median annual hours of operation. These assumptions are shown in Table 3.

Table 3: EIA CBECS Annual Operating Hours for Commercial Facilities

SIC	CBECS Category	Hrs/year
51	Other	2548
52	Retail other than Mall	3224
54	Food Sales	6136
70	Lodging	7800
72	Service	3276
78	Public Assembly	2808
80	Healthcare	3432
82	Education	2600
92	Public Order & Safety	4940

The cost and performance of each CHP technology system was based on the recently completed EEA CHP Technology Characterizations. These technology characterizations represent typical technology parameters for representative classes of CHP alternatives. The cost and performance assumptions used in this assessment are shown in Table 4.

Table 4: CHP Technology Cost and Performance Assumptions

	Recuperated Gas Turbine System	Conventional Gas Turbine System	Conventional Gas Turbine System	Conventional Reciprocating Engine System	Advanced Reciprocating Engine System
Output (kW)	4200	5000	10000	1000	3000
Heat Rate (Btu/kWh HHV)	8978	12590	11765	10035	9700
Recoverable Heat (MMBtu/hr)	11.00	25.00	46.50	3.70	9.84
Installed Costs (\$/kW)	950	1024	930	940	935
O & M Costs (\$/kWh)	0.006	0.0059	0.0055	0.009	0.0085

The net cost of electricity was calculated by applying a thermal credit for recovery of waste heat. Examples of typical CHP costs of electricity for each CHP technology considered are shown in Table 5.

Table 5: Typical Industrial CHP Costs of Electricity (based on 6000 annual hours of operation)

	Recuperated Gas Turbine System (4.2 MW)	Conventional Gas Turbine System (5 MW)	Conventional Gas Turbine System (10 MW)	Conventional Reciprocating Engine System (1 MW)	Advanced Reciprocating Engine System (3 MW)
COE (\$/kWh)	0.08563	0.10921	0.10131	0.09470	0.09206
Thermal Credit (\$/kWh)	0.01964	0.0375	0.03487	0.02775	0.0246
Net COE (\$/kWh)	0.06599	0.07171	0.06644	0.06695	0.06746

Once economic sites were identified for each of the technologies, sites were then further screen based on the facility electric demand and capacity (kW) of each technology. For example, only economic sites with electric demand greater than 5000 kW are suitable for the 5MW gas turbine system. Also, economic sites that were larger than the CHP technology were rounded down to the nearest whole number of units that could be utilized at the site. No export of power was assumed.

Results were then tabulated for each technology by SIC and state. The results section of this report shows the near-term opportunity using both economic thresholds – CHP cost less than or equal to current cost of electricity and five year or less simple payback on CHP installation costs.

Screening Results

The results of the screening are summarized in Tables 6 through 11. These tables illustrate the near term opportunity for each technology by sites, units, and capacity (MW) for both economic thresholds - CHP cost less than or equal to the current cost of electricity and five year or less simple payback on CHP installation costs. Note again that the methodology looks at each technology independently and totals are not additive across technology classes.

Table 6: Number of Potential CHP Sites Screened by Net Cost of Electricity

		4.2MW Recup GT	5MW GT	10MW GT	1MW Recip Engine	3MW ARES
SIC2		1	2	3	4	5
Industrial	20 Food & Kindred Products	23	16	5	42	30
	22 Textile Mill Products	4	1	0	7	4
	24 Lumber & Wood Products	4	0	2	7	4
	26 Paper & Allied Products	33	18	17	49	36
	27 Printing & Publishing	0	0	0	2	0
	28 Chemicals & Allied Products	37	28	17	61	39
	29 Petroleum & Coal Products	8	6	5	13	9
	30 Rubber & Misc. Plastic Prods.	6	4	3	12	6
	32 Stone, Clay & Glass Prods.	3	3	3	7	4
	33 Primary Metal Industries	8	5	5	15	11
	34 Fabricated Metal Products	4	2	2	7	6
	35 Machinery & Computer Equip	7	6	3	12	8
	36 Electric & Electronic Equip	5	3	2	9	7
37 Transportation Equip	9	7	5	12	10	
38 Instruments & Related Prods	4	0	1	5	4	
39 Misc. Manufacturing Industries	2	1	0	2	2	
Commercial	51 Wholesale Trade -Nondurable Goods	0	0	0	1	1
	52 Bldg Materials, Hardware, Garden Sup.	0	0	0	2	0
	54 Food Stores	31	15	0	345	82
	70 Hotels, Rooming Houses, Lodging	31	24	0	123	63
	78 Motion Pictures	0	0	0	1	0
	80 Health Services	259	153	53	541	369
	82 Educational Services	59	27	13	184	108
	92 Justice, Public Order, and Safety	8	6	1	34	16
Total Sites		545	325	137	1493	819

Table 7: Number of Potential CHP Sites Screened by Five Year or Less Simple Payback

		4.2MW Recup GT	5MW GT	10MW GT	1MW Recip Engine	3MW ARES
SIC2		1	2	3	4	5
Industrial	20 Food & Kindred Products	19	10	5	35	24
	22 Textile Mill Products	1	1	0	2	2
	24 Lumber & Wood Products	0	0	0	3	1
	26 Paper & Allied Products	20	11	11	29	21
	27 Printing & Publishing	0	0	0	2	0
	28 Chemicals & Allied Products	31	16	14	48	33
	29 Petroleum & Coal Products	6	5	3	8	7
	30 Rubber & Misc. Plastic Prods.	4	2	2	10	6
	32 Stone, Clay & Glass Prods.	3	1	3	5	3
	33 Primary Metal Industries	7	3	4	11	10
	34 Fabricated Metal Products	3	2	2	3	3
	35 Machinery & Computer Equip	6	5	3	11	6
	36 Electric & Electronic Equip	3	3	2	6	4
	37 Transportation Equip	8	4	4	10	8
38 Instruments & Related Prods	1	0	0	2	1	
39 Misc. Manufacturing Industries	1	1	0	2	2	
Commercial	51 Wholesale Trade -Nondurable Goods	0	0	0	1	1
	52 Bldg Materials, Hardware, Garden Sup.	0	0	0	2	0
	54 Food Stores	22	14	0	267	58
	70 Hotels, Rooming Houses, Lodging	29	12	0	108	57
	78 Motion Pictures	0	0	0	1	0
	80 Health Services	204	101	42	409	288
	82 Educational Services	18	12	7	57	33
	92 Justice, Public Order, and Safety	8	5	1	30	14
Total Sites		394	208	103	1062	582

Table 8: Number of Potential CHP Units Screened by Net Cost of Electricity

		Mercury 4.2MW Recup GT	5MW GT	10MW GT	1MW Recip Engine	3MW ARES
SIC2		1	2	3	4	5
Industrial	20 Food & Kindred Products	39	26	6	226	58
	22 Textile Mill Products	4	1	0	27	5
	24 Lumber & Wood Products	13	0	4	27	7
	26 Paper & Allied Products	95	48	30	479	138
	27 Printing & Publishing	0	0	0	4	0
	28 Chemicals & Allied Products	85	60	25	454	123
	29 Petroleum & Coal Products	26	16	8	129	37
	30 Rubber & Misc. Plastic Prods.	20	13	6	91	24
	32 Stone, Clay & Glass Prods.	9	8	3	52	14
	33 Primary Metal Industries	25	18	9	134	39
	34 Fabricated Metal Products	7	5	2	43	12
	35 Machinery & Computer Equip	19	16	5	108	31
	36 Electric & Electronic Equip	12	7	2	65	19
	37 Transportation Equip	21	14	6	108	31
38 Instruments & Related Prods	5	0	1	25	6	
39 Misc. Manufacturing Industries	8	1	0	8	2	
Commercial	51 Wholesale Trade -Nondurable Goods	0	0	0	3	1
	52 Bldg Materials, Hardware, Garden Sup.	0	0	0	4	0
	54 Food Stores	34	15	0	850	93
	70 Hotels, Rooming Houses, Lodging	38	24	0	406	85
	78 Motion Pictures	0	0	0	2	0
	80 Health Services	385	215	50	2569	637
	82 Educational Services	93	43	16	764	147
	92 Justice, Public Order, and Safety	9	7	1	110	20
Total Sites		947	537	174	6688	1529
Total GW		3.98	2.69	1.74	6.69	4.59

Table 9: Number of Potential CHP Units Screened by Five Year or Less Simple Payback

			Mercury 4.2MW Recup GT	5MW GT	10MW GT	1MW Recip Engine	3MW ARES
	SIC2		1	2	3	4	5
Industrial	20	Food & Kindred Products	34	13	6	203	53
	22	Textile Mill Products	1	1	0	12	3
	24	Lumber & Wood Products	0	0	0	7	1
	26	Paper & Allied Products	58	22	21	218	62
	27	Printing & Publishing	0	0	0	2	0
	28	Chemicals & Allied Products	73	34	22	372	103
	29	Petroleum & Coal Products	19	15	6	93	28
	30	Rubber & Misc. Plastic Prods.	16	2	5	85	24
	32	Stone, Clay & Glass Prods.	9	3	3	50	9
	33	Primary Metal Industries	22	12	8	114	35
	34	Fabricated Metal Products	6	5	2	31	9
	35	Machinery & Computer Equip	18	13	5	100	24
	36	Electric & Electronic Equip	9	9	2	50	13
	37	Transportation Equip	18	7	5	68	18
38	Instruments & Related Prods	1	0	0	6	1	
39	Misc. Manufacturing Industries	1	1	0	8	2	
Commercial	51	Wholesale Trade -Nondurable Goods	0	0	0	3	1
	52	Bldg Materials, Hardware, Garden Sup.	0	0	0	2	0
	54	Food Stores	25	14	0	658	69
	70	Hotels, Rooming Houses, Lodging	36	12	0	365	79
	78	Motion Pictures	0	0	0	0	0
	80	Health Services	306	139	44	1979	500
	82	Educational Services	37	25	9	275	68
	92	Justice, Public Order, and Safety	9	6	1	99	18
Total Sites			698	333	139	4800	1120
Total GW			2.93	1.67	1.39	4.80	3.36

Table 10: Potential CHP Capacity (MW) Screened by Net Cost of Electricity

		4.2MW Recup GT	5MW GT	10MW GT	1MW Recip Engine	3MW ARES
SIC2		1	2	3	4	5
Industrial	20 Food & Kindred Products	163.8	130	60	226	174
	22 Textile Mill Products	16.8	5	0	27	15
	24 Lumber & Wood Products	54.6	0	40	27	21
	26 Paper & Allied Products	399	240	300	479	414
	27 Printing & Publishing	0	0	0	4	0
	28 Chemicals & Allied Products	357	300	250	454	369
	29 Petroleum & Coal Products	109.2	80	80	129	111
	30 Rubber & Misc. Plastic Prods.	84	65	60	91	72
	32 Stone, Clay & Glass Prods.	37.8	40	30	52	42
	33 Primary Metal Industries	105	90	90	134	117
	34 Fabricated Metal Products	29.4	25	20	43	36
	35 Machinery & Computer Equip	79.8	80	50	108	93
	36 Electric & Electronic Equip	50.4	35	20	65	57
	37 Transportation Equip	88.2	70	60	108	93
38 Instruments & Related Prods	21	0	10	25	18	
39 Misc. Manufacturing Industries	33.6	5	0	8	6	
Commercial	51 Wholesale Trade -Nondurable Goods	0	0	0	3	3
	52 Bldg Materials, Hardware, Garden Sup.	0	0	0	4	0
	54 Food Stores	142.8	75	0	850	279
	70 Hotels, Rooming Houses, Lodging	159.6	120	0	406	255
	78 Motion Pictures	0	0	0	2	0
	80 Health Services	1617	1075	500	2569	1911
	82 Educational Services	390.6	215	160	764	441
	92 Justice, Public Order, and Safety	37.8	35	10	110	60
Total MW		3977.4	2685	1740	6688	4587

Table 11: Potential CHP Capacity (MW) Screened by Five Year or Less Simple Payback

			4.2MW Recup GT	5MW GT	10MW GT	1MW Recip Engine	3MW ARES
Industrial	SIC2		1	2	3	4	5
		20 Food & Kindred Products	142.8	65	60	203	159
		22 Textile Mill Products	4.2	5	0	12	9
		24 Lumber & Wood Products	0	0	0	7	3
		26 Paper & Allied Products	243.6	110	210	218	186
		27 Printing & Publishing	0	0	0	2	0
		28 Chemicals & Allied Products	306.6	170	220	372	309
		29 Petroleum & Coal Products	79.8	75	60	93	84
		30 Rubber & Misc. Plastic Prods.	67.2	10	50	85	72
		32 Stone, Clay & Glass Prods.	37.8	15	30	50	27
		33 Primary Metal Industries	92.4	60	80	114	105
		34 Fabricated Metal Products	25.2	25	20	31	27
	Commercial		51 Wholesale Trade -Nondurable Goods	0	0	0	3
		52 Bldg Materials, Hardware, Garden Sup.	0	0	0	2	0
		54 Food Stores	105	70	0	658	207
		70 Hotels, Rooming Houses, Lodging	151.2	60	0	365	237
		78 Motion Pictures	0	0	0	0	0
		80 Health Services	1285.2	695	440	1979	1500
		82 Educational Services	155.4	125	90	275	204
		92 Justice, Public Order, and Safety	37.8	30	10	99	54
		Total MW	2931.6	1665	1390	4800	3360

Appendix A contains a breakdown by state of the number of economically potential CHP sites for each CHP technology considered.

Screening Conclusions and Recommendations

One of the most interesting observations from the work to date is the notable reduction in CHP potential for all technologies when the economic screen is changed from Net Cost of Electricity below Current Cost to Five Year or Less Simple Payback. As shown in Table 12 this reduces potential by as much as 38% for some technologies.

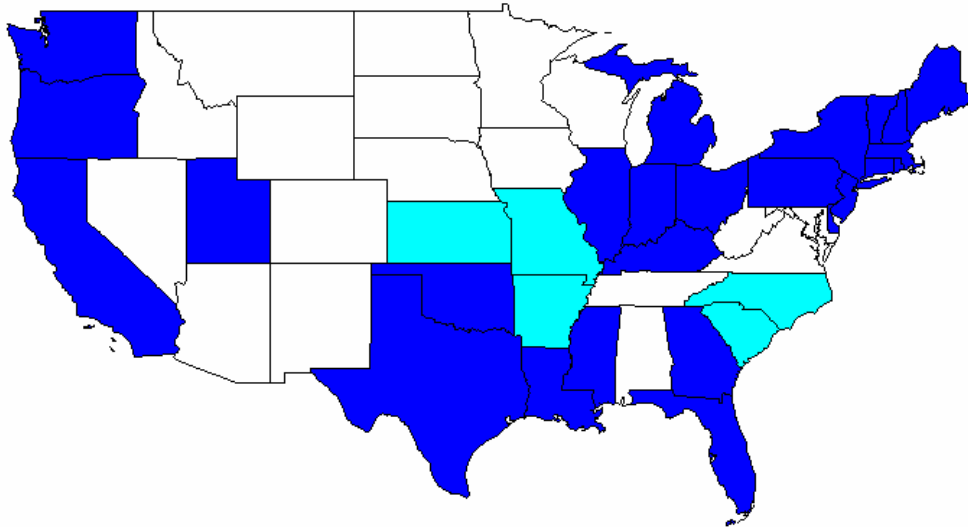
Table 12: Comparison of CHP Potential Using Different Economic Screens

Economic Screen	4.2MWRec GT			5MWGT			10MWGT			1MWRecip			3MWARES		
	Sites	Units	Capacity (MW)	Sites	Units	Capacity (MW)	Sites	Units	Capacity (MW)	Sites	Units	Capacity (MW)	Sites	Units	Capacity (MW)
Net CCE	546	947	3977	325	537	2685	137	174	1740	1493	6688	6688	819	1529	4587
5-Year Simple Payback	394	698	2932	208	333	1665	103	139	1390	1062	4800	4800	582	1120	3360
%Difference	27.7%	26.3%	26.3%	36.0%	38.0%	38.0%	24.8%	20.1%	20.1%	28.9%	28.2%	28.2%	28.9%	26.7%	26.7%

This dramatic decrease in economic potential is very noteworthy. The Net Cost of Electricity was based on an assumed 16% capital recovery factor. This corresponds

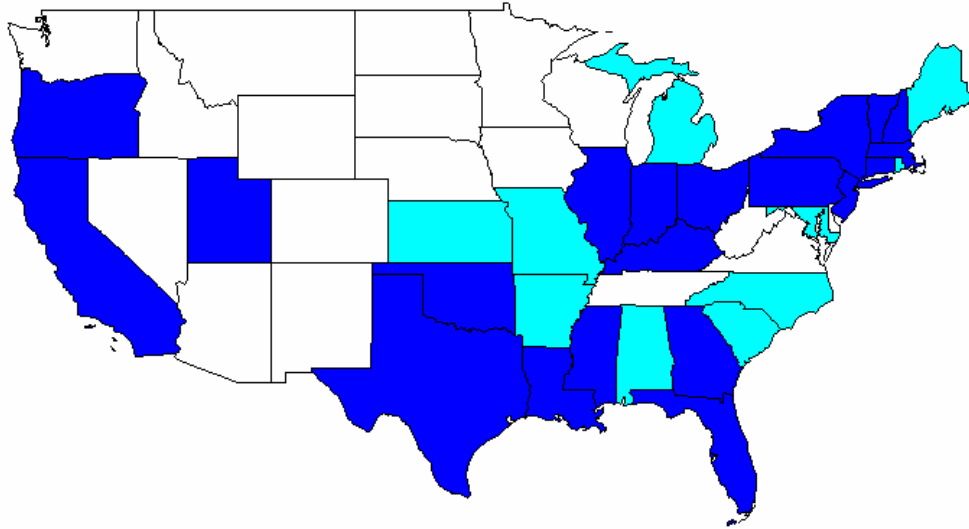
roughly to a slightly longer than six year payback on capital costs. The sizable difference that occurs when using small changes in economic screens underscores the fact that many potential projects are “on the bubble” with regard to economic viability and even marginal reductions in costs can open markets. This is illustrated graphically in Figures 1 and 2.

The two figures represent states containing suitable sites for the economic utilization of the 1 MW Reciprocating Engine and 4.2 MW Recuperated Gas Turbine respectively. Darker shades represent states that contain potential sites using the Five Year or Less Payback criterion. Lighter shades represent states that would open up if the slightly less stringent economic hurdle of Net Cost of Electricity Less than Current Costs was applied. In the case of the recuperated gas turbine the incremental market is sizable.



*Dark blue states contain sites that meet screen of Five Year or Less Simple Payback.
Light blue states are states that contain additional sites that meet screen of Net Cost of Electricity Less than Current cost.*

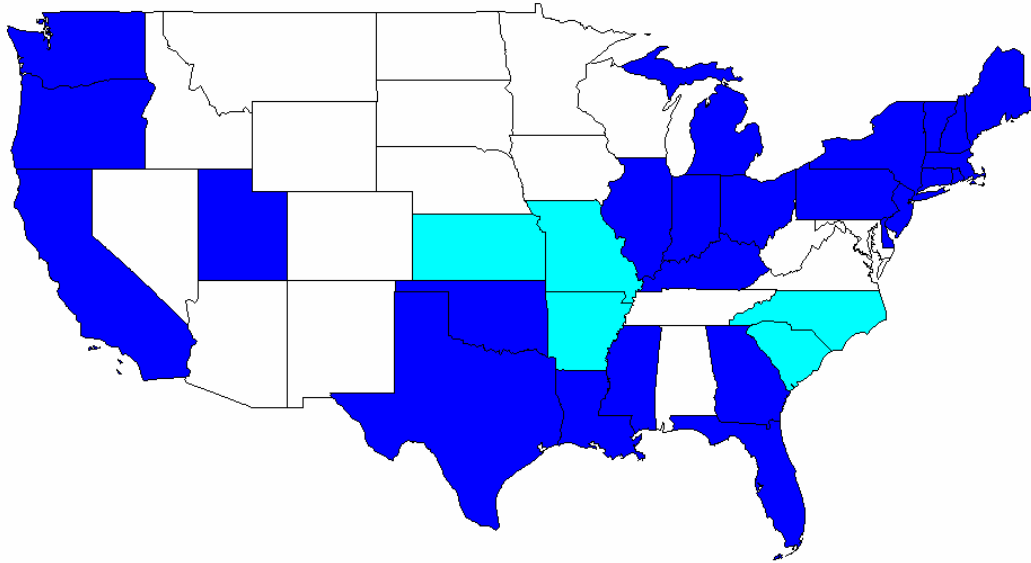
Figure 1: States with Economically Viable CHP Sites for 1 MW Reciprocating Engine



*Dark blue states contain sites that meet screen of Five Year or Less Simple Payback.
Light blue states are states that contain additional sites that meet screen of Net Cost of Electricity Less than Current cost.*

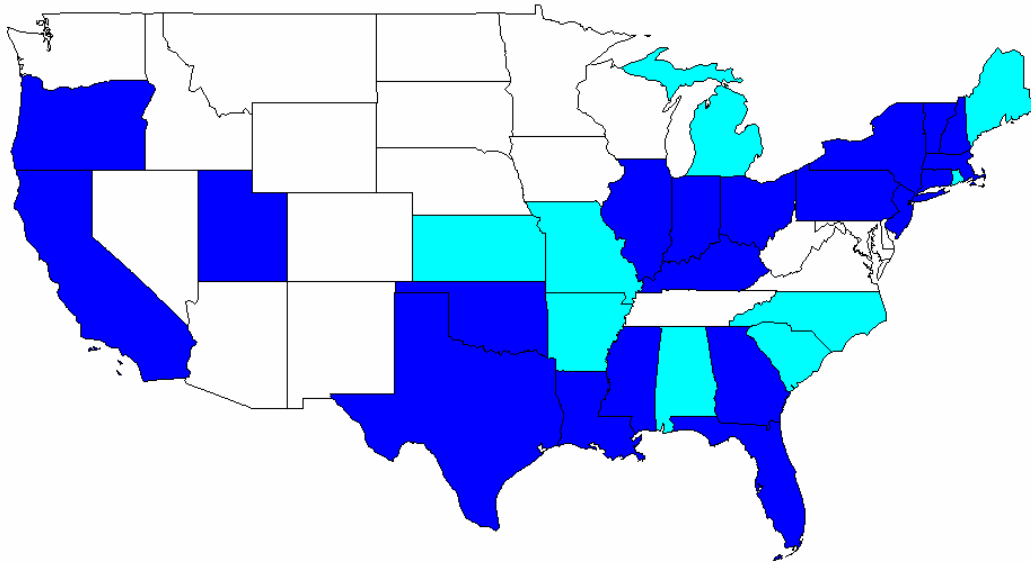
Figure 2: States with Economically Viable CHP Sites for 4.2 MW Recuperated Gas Turbine

One of the primary contributors to higher operating costs from CHP systems in the current market is natural gas price. To see if a reduction in natural gas prices would improve market viability a scenario was evaluated using a \$5.00/MMBtu price rather than \$6.00/MMBtu. Figures 3 and 4 illustrate that the one dollar reduction in price has almost the same effect as relaxing the economic viability screen. In those figures, the dark blue states represent states that meet the Five Year or Less Simple Payback with a \$6.00 natural gas price, and the light blue states represent states that meet the same criterion with a \$5.00 natural gas price.



Dark blue states contain sites that meet screen of Five Year or Less Simple Payback under \$6.00 Natural Gas Price Scenario.
Light blue states contain additional sites that meet screen of Five Year or Less Simple Payback under \$5.00 Natural Gas Price Scenario.

Figure 3: States with Economically Viable CHP Sites for 1 MW Reciprocating Engine based on Five Year or Less Simple Payback under Different Natural Gas Price Scenarios



Dark blue states contain sites that meet screen of Five Year or Less Simple Payback under \$6.00 Natural Gas Price Scenario.

Light blue states contain additional sites that meet screen of Five Year or Less Simple Payback under \$5.00 Natural Gas Price Scenario.

Figure 4: States with Economically Viable CHP Sites for 4.2 MW Recuperated Gas Turbine based on Five Year or Less Simple Payback under Different Natural Gas Price Scenarios

High Potential Market Sectors

Three of the four commercial sectors shown to have potential as a result of this effort – Food Stores, Lodging, and Health Services – have already been recently profiled by EEA for Oak Ridge National Laboratory in the reports *National Account Sector Energy Profiles* and *Market Potential for Advanced Thermally Activated BCHP in Five National Account Sectors*. Those reports highlighted the difficulty in matching CHP technologies to the existing thermal load profiles in some of these sectors and the need for cost-effective thermally activated technologies before that market can fully develop. That time period is likely beyond the near-term emphasis of this project.

The industrial sectors that look most promising for further evaluation are outline below.

SIC 20 – Food and Kindred Products

- 42 economic sites
- Up to 276 MW of economic potential
- Most sites less than 20 MW
- Annual hours of operation range from 6200-8700
- Good steam loads
- Natural gas prevalent
- Low penetration of CHP to date among economic candidates

SIC 26 – Paper and Allied Products

- 49 economic sites
- Most sites less than 20 MW
- 90% of facilities operated more than 8000 hours per year
- Good steam loads
- Most plants greater than 10 MW currently generate some electricity
- Untapped potential at plants less than 10MW
- Most plants have natural gas
- Trend to less than 10 MW finishing plants close to retail markets

SIC 28 – Chemicals and Allied Products

- 61 economic sites
- Most sites less than 20 MW
- Good steam load for CHP
- Traditionally a good CHP market
- 75% of sites have natural gas
- Self generation common at facilities greater than 20 MW

SIC's 34-39 – Manufacturing Sectors

- 47 economic sites
- Most sites less than 20 MW
- Very few self generate
- Adequate steam load at most sites
- Most sites use natural gas

Sector Profiles

Four promising sectors for growth in CHP installations were profiled to characterize attitudes toward and historical use of CHP, growth trends, purchasing criteria and process, geographic concentration, and opportunities for innovative non-steam based CHP. The sectors profiled include food and kindred products, pharmaceuticals, inorganic chemicals, and organic chemicals. These profiles are contained in a separate PowerPoint report file however a brief summary is included below.

- *Food and Kindred Products* - U.S. food processing accounts for 26% of food processing output of the world with over 10,000 food processing facilities in US. There is an industry trend toward the use of electricity instead of steam for many processes, including heating, cooling, drying, debacterisation, and pre-cooking. The primary regions where food processing sites have CHP are California, Florida, Illinois, and New York. There are over 200 food processing sites with CHP in the U.S. representing over 6 GW of capacity.
- *Pharmaceuticals* - The U.S. represents the largest worldwide market for pharmaceuticals, taking 50% of the world market in 2002 compared with 34% in

1992. Most pharmaceutical companies in the U.S. continued to increase capital spending over the last four years despite the decrease in the chemical industry as a whole. The primary regions where pharmaceutical sites have CHP are California, New York, New Jersey, North Carolina, and Pennsylvania. There are over 30 pharmaceutical sites with CHP in the U.S. representing over 740 MW of capacity.

- *Inorganic and Organic Chemicals* - Chemicals represent 10.3% of manufacturing activity in the U.S. and 1.9% of the gross domestic product. The main regions where organic chemical sites have CHP are Texas, Illinois, New Jersey, and Louisiana. Whereas inorganic chemical sites with CHP are primarily in California, Texas, Louisiana, and Ohio. The financial progress that is being made in the chemical industry is due primarily to cost-cutting techniques than to increased output or sales. Most companies are cutting research and development as well as capital spending to save money. There are over 200 chemical sites with CHP in the U.S. representing over 23 GW of capacity.

Conclusions

Based on the economic screening methodology used in this project, the 2-50 MW CHP market was shown to still possess notable attractive near-term project development opportunities. The sectors identified for profiling represent industrial customers who are for relatively sophisticated with regard to energy usage and supply options. It should also be noted that they possess some historic use of CHP.

Not surprisingly, market opportunities are concentrated in regions with favorable spark spreads or the prevailing source of power generation is natural gas fueled – California, Northeast, Midwest, and Texas. The second key observation from this analysis is that there are significant market opportunities that are economically “on the bubble”. The market opportunity for CHP in this size range can increase significantly with just marginal improvements in capital costs, heat rate, and fuel price.

Appendix A: Breakdown by State of Economically Potential CHP Sites for CHP Technologies

Table A-1: Potential Commercial CHP Sites for the 4.2MW Recup GT Screened by Net Cost of Electricity

STATE	54 Food Stores	70 Lodging	80 Healthcare	82 Education	92 Public Order	Grand Total
AZ	1		4			5
CA	5	2	83	29	6	125
CO	3					3
CT	1		10			11
FL		1				1
HI		1	2	1		4
IA	3	2				5
IL	2	2				4
IN	1	2				3
MA	2		15			17
ME	1		2			3
MN	1					1
MO	2					2
MS		1				1
NH			1			1
NJ	1		41	3	1	46
NV		15				15
NY	3	2	63	17		85
OH	3		19	1		23
PA	1	2	17	7	1	28
RI			2			2
TX	1	1				2
VT				1		1
Grand Total	31	31	259	59	8	388

Table A-2: Potential Commercial CHP Sites for the 5MW GT Screened by Net Cost of Electricity

STATE	54 Food Stores	70 Lodging	80 Healthcare	82 Education	92 Public Order	Grand Total
AZ	1		2			3
CA	4	2	62	14	4	86
CT	1		2			3
HI		1	2	1		4
IA		2				2
IL	2	1				3
IN		1				1
MA	2		11			13
ME	1		2			3
NJ	1		9	1	1	12
NV		15				15
NY	1	2	45	11		59
OH	1		9			10
PA	1		8		1	10
RI			1			1
Grand Total	15	24	153	27	6	225

Table A-3: Potential Commercial CHP Sites for the 10MW GT Screened by Net Cost of Electricity

STATE	80 Healthcare	82 Education	92 Public Order	Grand Total
CA	14	5	1	20
CT	2			2
HI	1	1		2
MA	4			4
NJ	5			5
NY	13	5		18
OH	8	1		9
PA	6	1		7
Grand Total	53	13	1	67

Table A-4: Potential Commercial CHP Sites for the 1MW Reciprocating Engine Screened by Net Cost of Electricity

STATE	52 Bldg Materials	54 Food Stores	70 Lodging	78 Motion Pictures	80 Healthcare	82 Education	92 Public Order	Grand Total
AK		2						2
AZ		5	1		5	3	2	16
CA		18	18	1	158	81	15	291
CO		26						26
CT		16			24	1		41
DC			2					2
FL		1	6					7
GA			3					3
HI		1	7		2	2		12
IA		20	2					22
IL		29	11				2	42
IN		8	3					11
KS		3			1			4
LA		2	2					4
MA		22	1		46	3		72
ME		1			7	2		10
MI		15	2				1	18
MN		2	1					3
MO		4						4
MS			2					2
ND		1						1
NH		1			6	1		8
NJ	1	39	1		71	9	5	126
NM		2						2
NV		2	35					37
NY	1	45	12		132	62	3	256
OH		38	3		40	3	1	85
PA		11	8		37	15	5	76
RI		3			9			12
SC		1						1
SD		3						3
TN			1					1
TX		9	1		3			13
UT		10						10
VA		2						2
VT						2		2
WA			1					1
WI		3						3
Grand Total	2	345	123	1	541	184	34	1231

Table A-5: Potential Commercial CHP Sites for the 3MW ARES Screened by Net Cost of Electricity

STATE	51 Wholesale Trade	54 Food Stores	70 Lodging	80 Healthcare	82 Education	92 Public Order	Grand Total
AZ		1		4	2	1	8
CA		7	11	110	52	10	190
CO		6					6
CT		3		14			17
FL		1	2				3
HI			3	2	2		7
IA		9	2				11
IL		4	5			1	10
IN		1	3				4
KS		1					1
LA			1				1
MA		7		25			32
ME		1		2	1		4
MI		1	1			1	3
MO		3					3
MS			1				1
NH				4	1		5
NJ		6		57	5	1	69
NV			23				23
NY	1	9	6	88	32	1	137
OH		9		28	2		39
PA		4	3	28	10	1	46
RI				4			4
SD		3					3
TN			1				1
TX		3	1	3			7
UT		1					1
VA		1					1
VT					1		1
WI		1					1
Grand Total	1	82	63	369	108	16	639

Table A-6: Potential Industrial CHP Sites for the 4.2MW Recup GT Screened by Net Cost of Electricity

State	20 Food	22 Textiles	24 Lumber	26 Paper	28 Chemicals	29 Petroleum & Coal	30 Rubber & Plastic	32 Stone, Clay, Glass	33 Primary Metals	34 Fabricated Metals	35 Machinery	36 Electronics	37 Transportation	38 Instruments	39 Misc. Manufacturing	Grand Total
AL				1			1									2
AR				2	1	1										6
CA	4		2	6	4	3	1	2	2			2	2			26
CT				3	1				1		1		3			9
FL				1												1
GA	1			5	3			1					1			11
HI						1										1
IL	1			1	1				3	1	1					8
IN												1				1
KS						1										1
KY					1											1
LA				2	12		1			1			1			17
MA		1		2						1					1	7
MI				2								1				2
MO	1															1
NC		2	2		1											5
NH					1		1									2
NJ	5			3	4	1	1		1		1	1	1	1	1	20
NY	2			2	3		1		1		4			2		15
OK					1											1
OR				1												1
PA	5			1	4					1						11
RI													1			1
SC	1	1														2
TX	2					1										3
UT	1															1
VT				1												1
Grand Total	23	4	4	33	37	8	6	3	8	4	7	5	9	4	2	157

Table A-7: Potential Industrial CHP Sites for the 5MW GT Screened by Net Cost of Electricity

State	20 Food	22 Textiles	26 Paper	28 Chemicals	29 Petroleum & Coal	30 Rubber & Plastic	32 Stone, Clay, Glass	33 Primary Metals	34 Fabricated Metals	35 Machinery	36 Electronics	37 Transportation	39 Misc. Manufacturing	Grand Total
CA	4		5	3	3	1	2	2			2	2		24
CT			1					1		1		3		6
GA	1		4	3			1					1		10
HI					1									1
IL			1	1				1		1				4
IN											1			1
KY				1										1
LA				11		1			1					13
MA		1	1						1					3
NH				1		1								2
NJ	4		3	3	1					1		1	1	14
NY	2		1	3		1		1		3				11
OK				1										1
OR			1											1
PA	3			1										4
TX	1				1									2
UT	1													1
VT			1											1
Grand Total	16	1	18	28	6	4	3	5	2	6	3	7	1	100

Table A-8: Potential Industrial CHP Sites for the 10MW GT Screened by Net Cost of Electricity

	20	24	26	28	29	30	32	33	34	35	36	37	38	
State	Food	Lumber	Paper	Chemicals	Petroleum & Coal	Rubber & Plastic	Stone, Clay, Glass	Primary Metals	Fabricated Metals	Machinery	Electronics	Transportation	Instruments	Grand Total
AL						1								1
AR			2		1									3
CA			3	1	2	1	2	2			1			12
CT			1					1				2		4
GA	1		4	3			1					1		10
IL			1					1						2
IN											1			1
KS					1									1
LA			1	8		1			1					11
MA									1					1
MI			1											1
NC		2		1										3
NJ	2		2	2						1		1		8
NY			1	1				1		2			1	6
OK				1										1
OR			1											1
RI												1		1
TX	1				1									2
UT	1													1
Grand Total	5	2	17	17	5	3	3	5	2	3	2	5	1	70

Table A-9: Potential Industrial CHP Sites for the IMW Reciprocating Engine Screened by Net Cost of Electricity

	20	22	24	26	27	28	29	30	32	33	34	35	36	37	38
State	Food	Textiles	Lumber	Paper	Printing	Chemicals	Petroleum & Coal	Rubber & Plastic	Stone, Clay, Glass	Primary Metals	Fabricated Metals	Machinery	Electronics	Transportation	Instruments
AR			3	2		2	2								
CA	10	1		7	1	10	5	3	3	2		1	3	4	1
CT	1			3		4				2	1	1		3	
FL	1			1											
GA	1	3		6		3			1				1	1	
HI							1								
IL	1			1		3				3	2	1			
IN				1									1		
KS							1								
KY						1									
LA			3	2		15		1			1			1	
MA	1	1		10	1	1		1		1	1	2	1		1
ME		1											1		
MI				3											
MO	1														
MS			1				1								
NC	1														
NH						1		1		1		1			
NJ	10			5		7	1	3	1	2	1	1	1	1	1
NY	4			3		6		2	1	2		5	1	1	2
OK						1									
OR				1											
PA	6			3		3				2	1				
RI						1		1	1					1	
SC		1				1									
TX	3					2	2								
UT	1														
VT				1											
WA	1														
Grand Total	42	7	7	49	2	61	13	12	7	15	7	12	9	12	5

Table A-10: Potential Industrial CHP Sites for the 3MW ARES Screened by Net Cost of Electricity

State	20 Food	22 Textiles	24 Lumber	26 Paper	28 Chemicals	29 Petroleum & Coal	30 Rubber & Plastic	32 Stone, Clay, Glass	33 Primary Metals	34 Fabricated Metals	35 Machinery	36 Electronics	37 Transportati on	38 Instruments	39 Misc. Manufacturing	Grand Total
AR			2	2	1	1										6
CA	6	1		7	4	4	1	2	2			2	3			32
CT				3	2				2	1	1		3			12
GA	1	1		6	3			1				1	1			14
HI						1										1
IL	1			1	2				3	1	1					9
IN												1				1
KS						1										1
KY					1											1
LA			2	2	12		1			1			1			19
MA		1		3	1					1		1		1		8
MI				2												2
MO	1															1
NH					1		1		1							3
NJ	7			4	6	1	1		1	1	1	1	1	1	1	26
NY	3			2	3		1		2		5	1		2	1	20
OK					1											1
OR				1												1
PA	5			2	2					1						10
RI							1	1					1			3
SC		1														1
TX	2					1										3
UT	1															1
VT				1												1
WA	1															1
Grand Total	28	4	4	36	39	9	6	4	11	6	8	7	10	4	2	178