On-Site Power Generation Opportunities For U.S. Industry

ABSTRACT

The potential for on-site power generation in the nine most energy-intensive U.S. industries, which DOE's Office of Industrial Technologies call "Industries of the Future," (IOFs) is the subject of a recent report prepared for OIT. On-site generation can reduce energy costs, help a facility comply with environmental regulations, and ensure a reliable power supply. Electric market restructuring and its effect on pricing and reliability are creating strong interest in this subject.

The report covers existing and potential on-site generation; combined heat and power (CHP) and its potential, its economics, and its environmental benefits; barriers to on-site generation; and policy and technology recommendations.

This article abstracts information from the OIT report. To view the complete report, see ordering information at the close.

EXISTING ON-SITE GENERATION IN THE INDUSTRIAL SECTOR

On-site power generation is not a new concept for the U.S. industrial sector. Historically, the on-site power market was driven by the availability of waste fuels, locally high retail electricity prices, and attractive wholesale power purchase agreements. Existing on-site generation capacity in the industrial sector, exclusive of emergency generator sets, is in excess of 45,000 MW with a vast majority (42,000 MW) being combined heat and power (CHP) plants. The IOFs account for 93 percent of this installed capacity as shown in Figure 1.

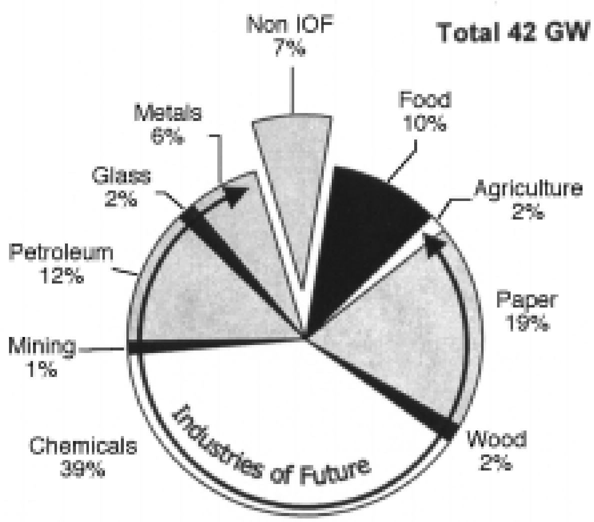

Figure 1. Existing CHP in the Industrial Sector

A high percentage of applications employing large on-site power plants have already been implemented as CHP and dominate the installed capacity shown in Figure 1. Much of the remaining potential can be characterized as smaller discrete loads, mechanical drive applications providing chilled water, compressed air, refrigeration, and liquids pumping and facilities with smaller electric and/or thermal loads.

REMAINING POTENTIAL FOR ON-SITE GENERATION IN THE INDUSTRIAL SECTOR

The total remaining potential for in-fence on-site generation in the industrial sector is estimated at 140,000 MW. This potential represents the total site (in-fence) electric demand for power-only and CHP. The IOFs represent approximately 113,000 MW or 79% of the total opportunity as shown in Figure 2.

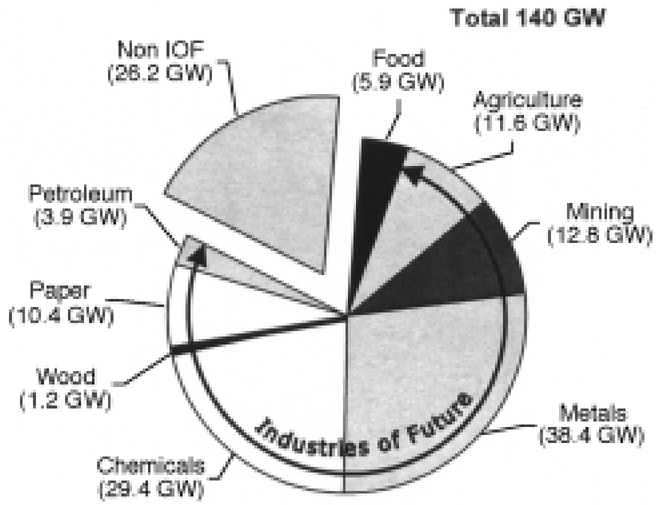

Figure 2. In-Fence On-Site Generation Potential for Industry

REMAINING CHP POTENTIAL IN THE INDUSTRIAL SECTOR

The remaining CBP potential in the industrial sector is estimated at 88,000 MW. Remaining potential for the IOF industry groups is estimated at 61,000 MW or 69% of the total CUP opportunity as shown in Figure 3. The CHP potential includes systems that export power to the grid meaning that the estimated potentials are in excess of site (in-fence) demand requirements.

CHP ECONOMICS

The economics of CHP can be compelling when compared to industrial electric rates. Figure 4 indicates the price points for several CHP technologies as compared to the U.S. industrial electricity price distribution. The figure shows that a 5 MW CHP system is competitive with delivered electricity prices for 37 percent of industrial customers. For a 30 MW system the comparison shows that CHP is competitive for 68 percent of industrial customers. A 1 MW reciprocating engine system is competitive in 20 percent of the industrial sector. The comparison is based on $3.50/MMBtu natural gas cost for the CHP system and the avoided boiler fuel.

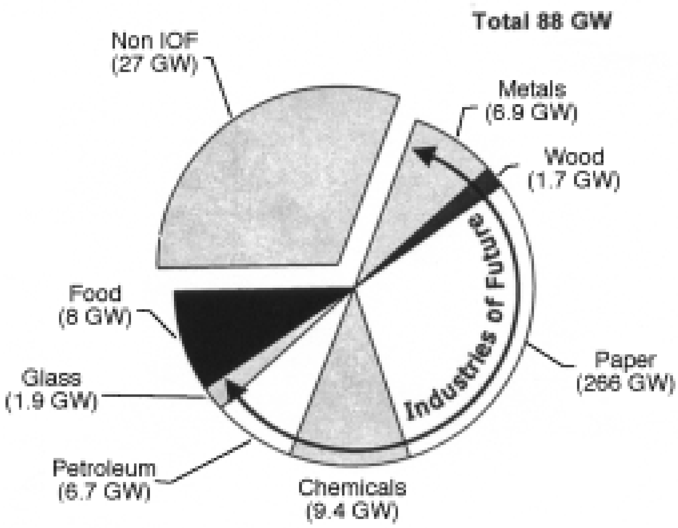

Figure 3. Remaining CHP Potential for the Industrial Sector.

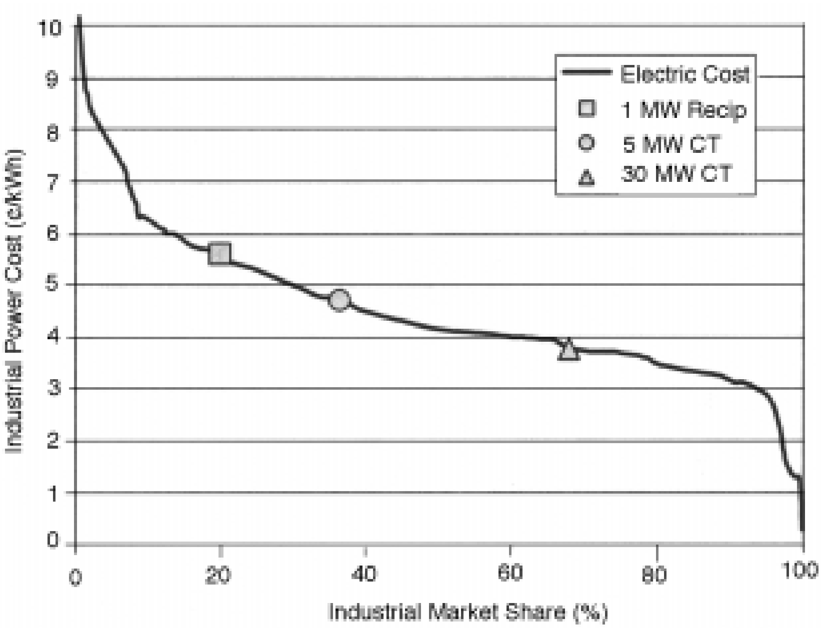

Figure 4. Comparison of CHP Net Power Costs to U.S. Industrial Electricity Prices

The competitive market shares are sensitive to the CHP fuel price. Figure 5 shows declining industrial market share as natural gas prices increase for each CHP system. For example, with natural gas at $2.50/MMBtu, a 30 MW CHP system is competitive in 90 percent of the industrial market, however, at $4.75/MMBtu, the competitive share drops to 43 percent of industrial customers, assuming that electric prices remain constant.

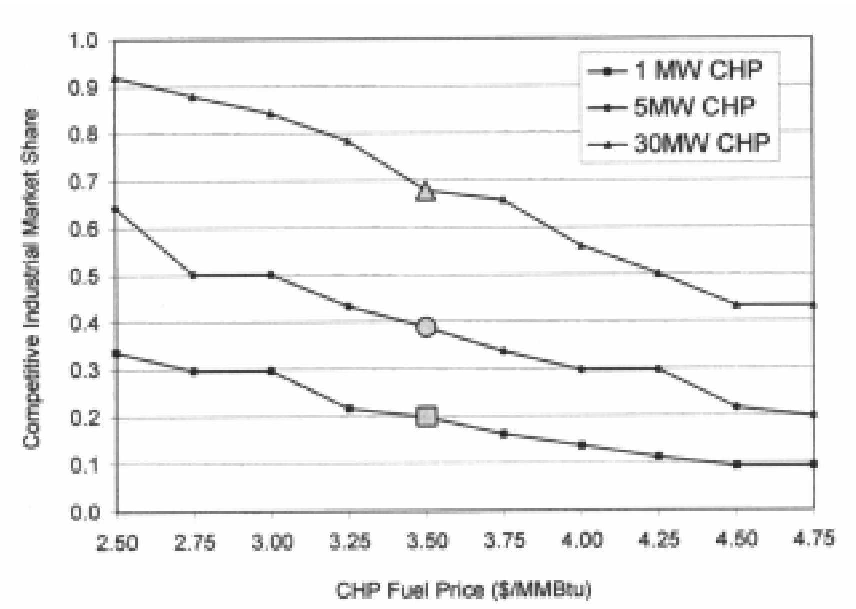

Figure 5. Effect of CHP Fuel Price on Industrial Market Share

ENVIRONMENTAL BENEFITS OF CHP

The environmental value of CHP is most noteworthy for its potential to reduce global climate change emissions as illustrated in Figure 6. If the full potential for CHP were realized (about 130 GW), a 70 million metric ton reduction in carbon equivalent emissions would result. This is equivalent to approximately 285 million tons of CO_2 emissions.

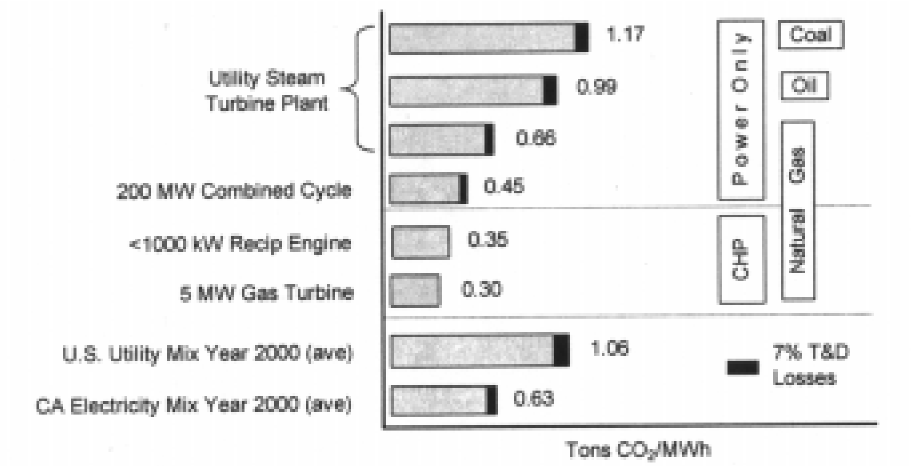

Figure 6. Global Warming Implications of CHP

BARRIERS TO ON-SITE GENERATION

Barriers to on-site generation in the industrial sector have included institutional, market and technical issues:

- High electric utility backup power costs, onerous grid interconnection requirements, and deferral rates
- Local environmental regulations that do not recognize the offsetting plant boiler and central station generation emissions
- Unfavorable depreciation tax treatment for on-site generation (non-core investment, requiring quick pay-back)
- High costs for equipment, installation, environmental compliance, and maintenance for smaller on-site generation systems

CHP/ COGENERATION

On-site power generation, when coupled with waste heat recovery, is referred to "Combined Heat and Power" (CHP), also known as *cogeneration.**

*The term cogeneration has become strongly associated with a particular regulatory process and contracting approach that was imposed on utilities in 1978 by Federal and state regulation. The term CHP is now used to distinguish the underlying technology from a regulatory configuration of that technology.

On-site power generation allows industry to utilize the waste heat that central power stations typically must discharge to the environment. CHP can reduce energy costs and increase productivity. From a national perspective, CHP reduces U.S. consumption of energy and decreases regional air emissions and greenhouse gases that contribute to global warming.

"Power Only" on-site generation (without heat recovery) also provides benefits by reducing the facility's peak power costs, deferring the need for power system expansion, increasing reliability for the facility and the grid, and improving power quality. On-site generation systems, whether CHP or power-only, are further referred to as distributed generation (DG) to distinguish them from traditional central station power plants.

POWER-ONLY AND CHP TECHNICAL POTENTIAL

Table 1 shows remaining power-only (in-fence) and CHP technical potential for the industrial sector. The number of sites screened includes 8,900 IOF facilities from the Major Industrial Plant Base (MIPD)*, 18,000 mining establishments and 1.91 million farms from the census data and over 25,000 IOF sites less than 1 MW from the MarketPlace database.

The estimated remaining CHP technical potential for the industrial sector is approximately 88,000 MW. Based on the Hagler-Bailly Independent Power Database, approximately 45,000 MW is already installed that represents about 33 percent of the total CHP market.

The paper, chemical, food, primary metals and refining sectors account for approximately 61,000 MW or 61 percent of the remaining CHP potential. Paper has the largest remaining CHP potential of any one sector, accounting for 26,000 MW. However, significant remaining potential exists in other industries such as textiles, rubber and plastics, metals fabrication and equipment, industries that have not aggressively implemented CHP. The CHP potential includes larger systems that export excess power to the grid. Often, the thermal load of an industrial site can support a CHP system with greater electrical capacity than just the site requirements. In these cases, the power-only (in-fence) potential is estimated at approximately 140,000 MW for the industrial sector. The

*Petroleum Information/Dwights LLC *Major Industrial Plant Database*, 1998.

Table 1. Remaining Power-Only and CHP Potential

SIC	SIC Description	*Power Only Market (MW)*	*CHP Market*			*Existing CHP (MW)*	*Remaining CHP Potential* (MW)*
			Plant Size		*Total (MW)*		
			100-1,000kW	*>1,000kW*			
IOF							
1-7	Agriculture	11,462	N/A	N/A	N/A	751	N/A
11,12,14	Mining	12,844	N/A	N/A	N/A	492	N/A
20	Food and Kindred Products	5,896	2,683	9,997	12,680	4,594	8,086
24	Lumber and Wood Products	1,171	595	1,946	2,542	806	1,736
26	Paper and Allied Products	10,459	1,168	33,584	34,751	8,553	26,198
28	Chemicals, Allied Products	29,364	1,780	25,352	27,132	17,692	9,440
29	Petroleum, Coal Products	3,949	154	12,253	12,407	5,618	6,789
32	Stone, Clay, Glass, Concrete*	0	N/A	2,699	2,698	774	1,924
33	Primary Metals Industries*	38,389	294	9,520	9,814	2,873	6,941
	IOF Total	113,5341	6,674	95,350	102,0251	42,1531	61,115

(Continued)

Table 1. Remaining Power-Only and CHP Potential (*Continued*)

Non-IOF

21	Tobacco and Allied Products	77	16	87	103	131	—
22	Textile Mill Products	2,576	766	3,011	3,777	651	3,126
23	Apparel Manufacturing	335	N/A	163	163	0	163
25	Furniture	583	N/A	402	401	68	333
27	Printing and Publishing	685	N/A	404	404	19	385
30	Rubber and Misc. Plastics	2,546	2,772	1,641	4,413	787	3,626
31	Leather and Tanning	92	N/A	98	98	0	98
34	Fabricated Metal Products	2,558	4,050	1,676	5,726	78	5,648
35	Industrial Machinery and Equip.	4,095	4,787	1,598	6,385	149	6,236
36	Electrical and Electron. Equip.	4,958	N/A	987	987	180	807
37	Transportation Equipment	4,884	1,169	4,243	5,412	808	4,604
38	Instruments and Related Prod.	2,483	972	590	1,562	59	1,503
39	Miscellaneous Manufacturing	374	784	343	1,128	402	726
	Non IOF Total	26,246	15,316	15,243	30,558	3,332	27,226
20-39	Total Manufacturing	139,779	21,990	110,593	132,583	45,485	88,369

N/A = Not available

power-only market potential represents the in-fence opportunity.

Figure 7 shows CHP technical potential sorted by site capacity requirements. Nearly half of the remaining potential is for installations greater than 50 MW. There is also a significant technical potential for sites less than 1 MW where there has been little activity due to the high cost of packaging and siting small CBP systems.

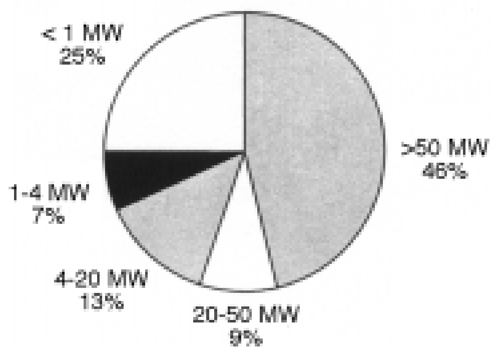

Figure 7. Remaining CHP Potential Sorted by Capacity

Figure 8 indicates the capacity of existing and remaining CHP potential for key IOFs. The forest products industry has the largest remaining CHP potential followed by chemicals and food. The chemical industry has demonstrated the highest capacity saturation having implemented approximately 65 percent of its total CHP market. Refining has achieved 45 percent saturation. Non-IOFs have installed only 10 percent of its market.

Figure 9 shows the remaining potential in key industries as a function of site capacity requirements. Applications between 0-4 MW will be dominated by reciprocating engines and small industrial gas turbines. Most of the potential for small CHP exists in the food and non-IOF industries. The food, chemical and non-IOFs contain the largest number of applicable sites in the 4-50 MW size range that is suitable for combustion turbines. For sites having a potential greater than 50 MW, suitable for combustion turbines or combined cycle plants, the paper industry has the largest share of applicable sites followed by the refining and steel industries. There is less potential for large CHP in the food and non-IOF sectors. The glass industry has a very low potential for CHP.

Figures 10 through 12 show the remaining CHP potential for se-

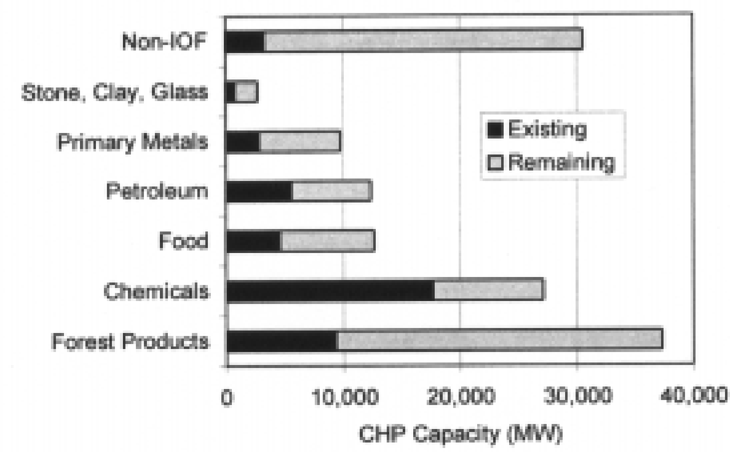

Figure 8. Existing and Remaining CHP Potential Sorted by Industry

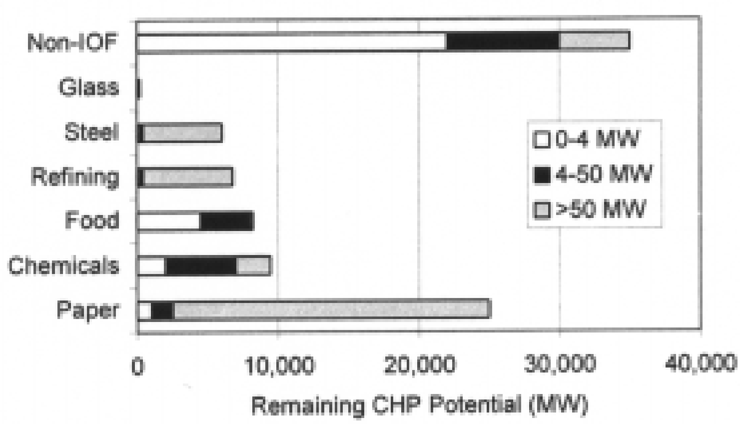

Figure 9. Remaining CHP Potential Sorted by Capacity

lected industries. In the food industry (Figure 10), the highest CHP potentials are in meat and poultry processing, canned fruits and vegetables, and malt beverages. The industries shown do not comprise the entire food industry, and there are opportunities in other sectors. In the paper industry, shown in Figure 11, the highest potentials are in the paper and paperboard sectors. In the chemical industry, shown in Figure

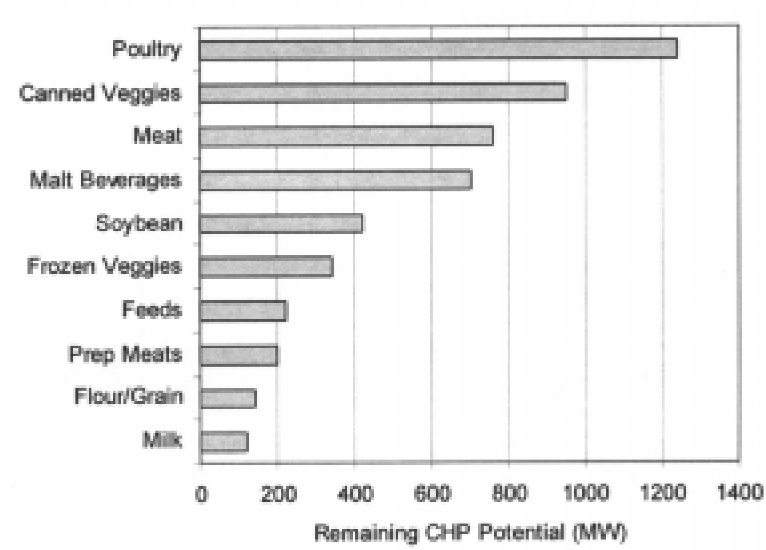

Figure 10. Remaining CHP Potential in the Food Industry

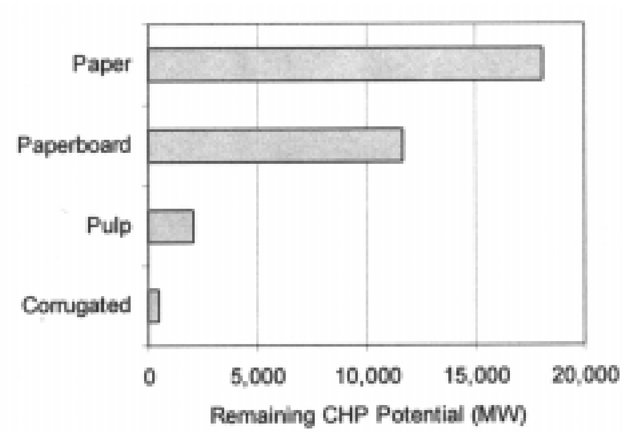

Figure 11. Remaining CHP Potential in the Paper Industry

12, the highest CHP potentials are in the basic organic and inorganic chemicals sectors. Chlor-alkali production and nitrogenous fertilizers also represent important sectors within the chemical industry.

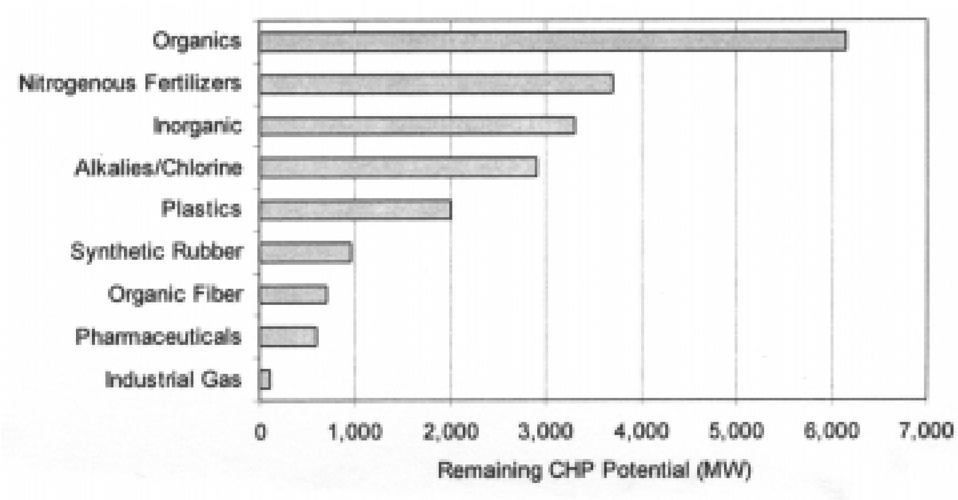

Figure 12. Remaining CHP Potential in the Chemical Industry

BENEFITS OF CHP

CHP provides many benefits compared to separate heat and power production. These benefits include increased energy efficiency, operating cost savings, and reduced air pollution and global warming. There are additional benefits for industry including increased reliability, power quality, and higher productivity. The electric power industry and its customers can also benefit when industrial CHP capacity is used to support and optimize the overall power grid.

ENERGY BENEFITS

Power generation systems create large amounts of heat in the process of converting fuel into electricity. For the average central utility power plant, over two thirds of the energy content of the input fuel is converted to heat and wasted. As an alternative, an end-user with significant thermal and power needs can simultaneously generate both its thermal and electrical energy in a CHP system located at or near its facility. CHP can significantly increase the efficiency of energy utilization as shown in Figure 13.

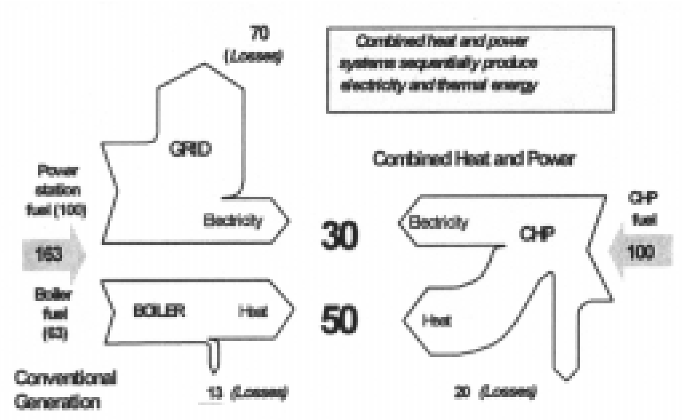

Figure 13. Example of CHP Energy Savings

The figure show that a typical CHP system can reduce energy requirements by close to 40 percent compared to separate production of heat and power. For 100 units of input fuel, CHP converts 80 units to useful energy of which 30 units is electricity and 50 units is for steam or hot water. Traditional separate heat and power components require 163 units of energy to accomplish the same end use tasks.

ENVIRONMENTAL BENEFITS AND EMISSIONS REDUCTION

By increasing energy efficiency, CHP significantly reduces emissions of criteria pollutants such as NO_x, and SO_2, and non-criteria greenhouse gases such as CO_2. The IOFs have a stated mission of reducing their emissions and CHP is an option that can provide environmental benefits as part of an economically attractive investment. Figures 14 and 15 show NO_x and CO_2 emission comparisons respectively by power generation technology and fuel type. While reductions in both NO_x and CO_2 result by switching from solid and liquid fuels to natural gas, the figures show the added reductions due to efficiency. CHP technologies can significantly reduce emissions and compare favorably to advanced low emission central station technologies such as the gas-fired combined cycle.

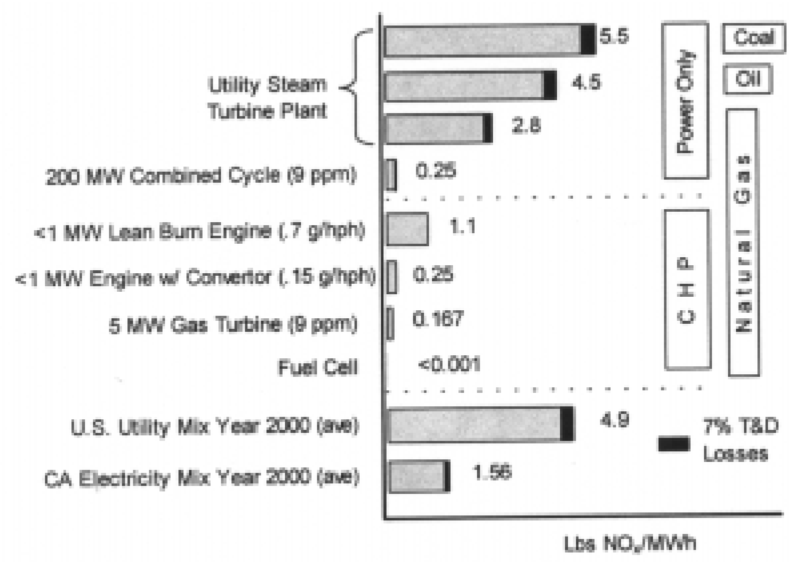

Figure 14. NO_x Implications of CHP

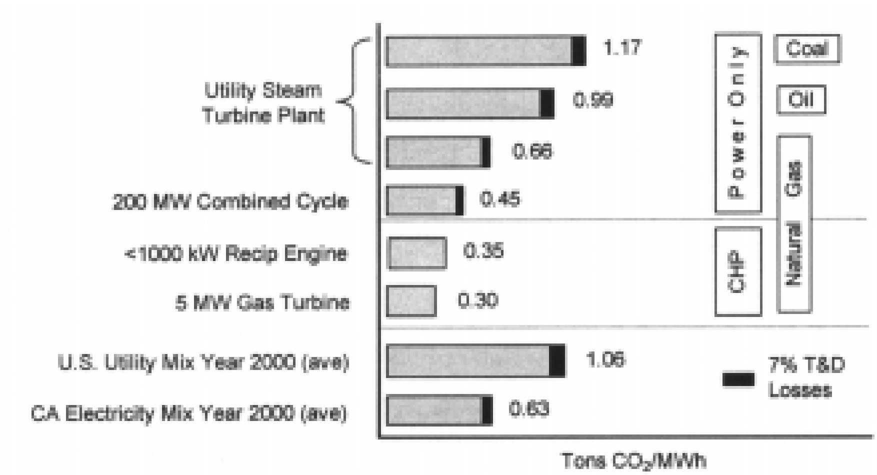

Figure 15. Global Warming Implications of CHP

ECONOMIC BENEFITS

The primary economic driver for CHP is production of power at rates that are lower than the utility's delivered price. Figure 16 demonstrates how CHP compares with traditional central station generation combined with the cost of transmission and distribution (T&D).

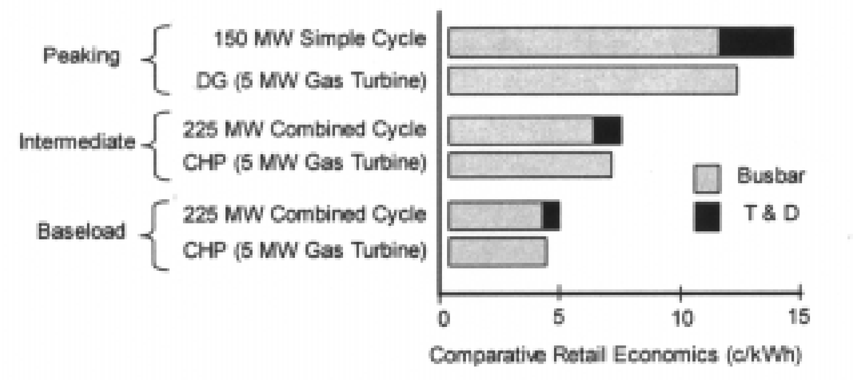

Figure 16. Comparative Retail Economics of CHP

By comparison, the cost to produce electricity from a CHP system using an industrial-sized gas turbine, including fuel, capital and operation and maintenance (O&M) expenses, is less than $0.04/kWh for baseload operation. This cost compares favorably to a baseload central-station combined-cycle plant at the busbar even before adding T&D costs. As shown in Figure 16, CHP can compete against large simple cycle gas turbine plants for intermediate duty and peaking power after adding T&D costs. The cost of CHP varies by application, technology, and grid circumstances, but as this example illustrates, the economic fundamentals will frequently favor CHP. In a restructured power market, end-users may place significant economic value on the stand-by capability and increased reliability that CHP can provide, further enhancing the potential economic benefits of CHP.

The economics of CHP are compelling when compared against retail power prices. Figure 17 illustrates the cost of power from typical industrial CHP technologies in comparison to the electricity price distribution in the industrial sector in the U.S. Figure 19 shows that a 5 MW combustion turbine CHP system is competitive with delivered electricity prices for 37 percent of industrial customers paying higher rates. For a 30 MW combustion turbine system, CHP is competitive for 68 percent of industrial customers. A smaller, 1 MW reciprocating engine system is competitive for 20 percent of the market. Figure 17 is based on a $3.50/ MMBtu gas cost for the CHP system and avoided boiler fuel.

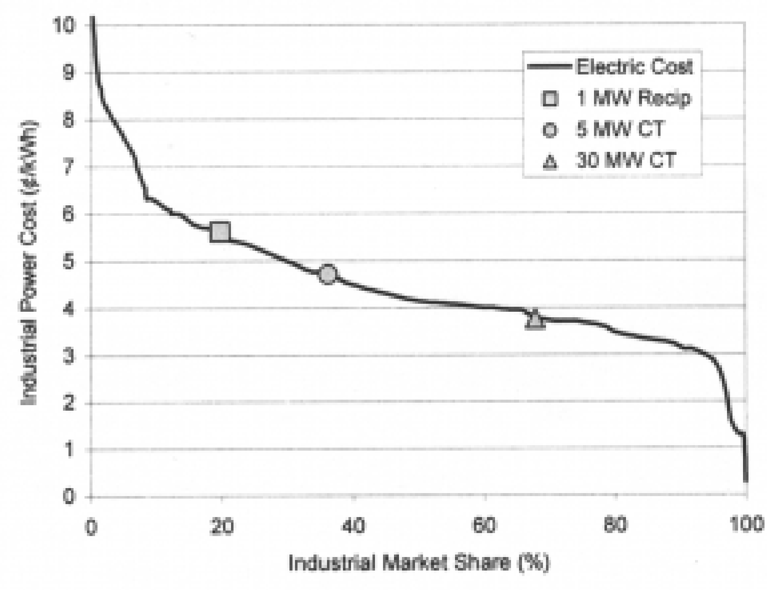

Figure 17. CHP Competitive Industrial Market Shares

The competitive market shares for each CHP system are sensitive to the cost of natural gas. Figure 18 shows how the competitive industrial market share changes for gas prices between $2.50 to $4.75/MMBtu. At $2.50/MMBtu gas price, a 30 MW CHP system is competitive in 90 percent of the industrial market; at $4.75/MMBtu gas price, the competitive share drops to 43 percent. For a 1 MW and 5 MW CHP systems, the corresponding competitive market shares range from 9-33 percent and 20-64 percent, respectively.

ANCILLARY BENEFITS

In a restructured power market, CHP and other on-site generation options can offer grid support to the local distribution utility. On-site

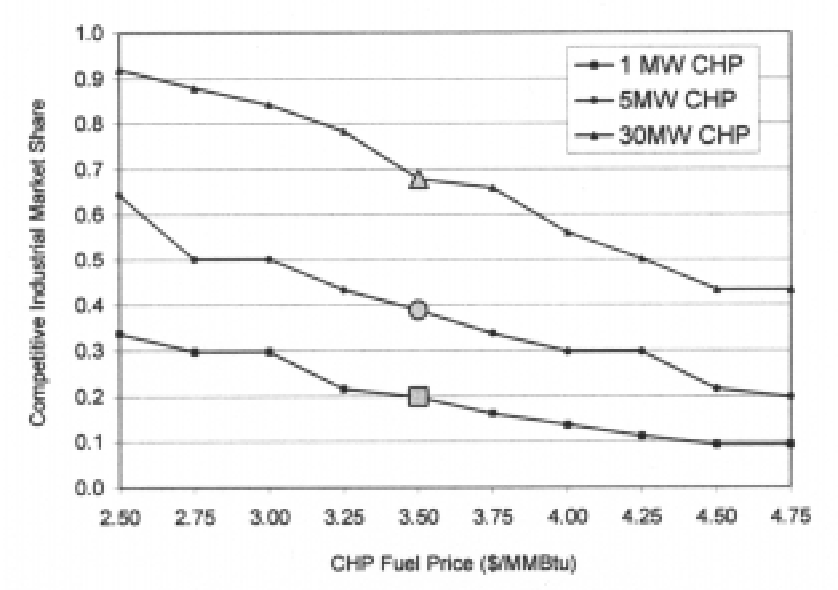

Figure 18. Effect of CHP Fuel Price on **Competitive Industrial Market Share**

generation can offer ancillary benefits to the grid including:

- Voltage and frequency support to enhance reliability and power quality
- Avoidance or deferral of high cost, long lead time T&D upgrades
- Bulk power risk management
- Reduced line losses, reactive power control
- Outage cost savings
- Reduced central station generating reserve requirements
- Transmission capacity release

CHP offers a customer enhanced reliability, operational and load management flexibility, ability to arbitrage electric and gas prices, and energy management techniques including peak shaving and thermal energy storage. The value of these benefits depends on the characteristics of the facility, energy use and prices, load profiles, and electric rate tariffs, etc. A CHP investment should consider the possible ancillary benefits including the revenue stream from sale of T&D benefits to the independent system operator (or equivalent) and reduced operating costs, along with the other costs and benefits of the project.

BENEFITS CALCULATION FOR EXISTING AND POTENTIAL INDUSTRIAL CHP

The estimated energy, economic and emissions benefits were developed for the existing and remaining CHP market potential. Table 2 shows representative CHP technologies and their cost and performance characteristics for four size bins between 0.1 MW to greater than 20 MW.*

Table 2. Representative CHP Cost and Performance

Size Range (MW)	*Representative Technology*	*Electric Effic %*	*Recovered Heat (Btu/kWh)*	*Heat Used %*	*Capital Cost ($/kW)*	*O&M Cost ($/kWh)*
0.1-1	Recip. Engine	31.3%	4,100	80%	$980	$0.0132
1-4	Gas Turbine	27.6%	5,600	80%	$1,150	$0.0059
4-20	Gas Turbine	29.0%	5,300	90%	$980	$0.0055
>20	Gas Turbine	37.0%	3,800	90%	$700	$0.0042

Energy Savings

The total annual energy savings attributable to existing and remaining industrial CHP are shown in Table 3 using the stated assumptions for annual load factor, average utility heat rate, T&D losses, and typical boiler efficiency. Results indicate that the existing 44 GW of industrial CHP saves 1.5 quads of energy per year, and the remaining potential of 88 GW could save an additional 2.7 quads of energy per year.

*Analytic and Data Support for NEMS Industrial Cogeneration Modeling (Draft), Onsite Energy Corporation, Energy Information Administration, January 27, 2000.

Table 4 shows the net overall cost savings that are calculated by subtracting total cost of CHP fuel, O&M, and capital from the annual savings. CHP cost savings are estimated for avoided electric power purchases and avoided boiler fuel using the cost and performance estimates for the representative technologies shown in Table 2. These calculations show that existing CHP saves U.S. industry nearly $2.5 billion annually and the remaining CHP potential could save an additional $5.4 billion annually. If all of the remaining industrial CHP potential were implemented, the current $69 billion annual energy bill could be reduced by about 8 percent.

Table 3. Net Energy Savings for Industrial CHP

Size Range (MW)	*CHP Capacity (MW)*	*CHP Output (GWh)*	*CHP Energy Used*	*Avoided Utility Electric*	*Avoided Thermal*	*Net Energy Saved*
Existing CHP		(Quads)				
0.1-1	60	360	0.004	0.004	0.001	0.001
1-4	369	2,214	0.027	0.024	0.012	0.009
4-20	2,442	14,652	0.172	0.158	0.087	0.073
>20	41,372	248,232	2.290	2.685	1.055	1.450
Total	44,243	265,458	2.493	2.871	1.156	1.534
Remaining CHP Potential						
0.1-1	21,930	131,580	1.437	1.423	0.539	0.525
1-4	6,070	36,420	0.450	0.394	0.204	0.148
4-20	11,337	68,022	0.799	0.736	0.404	0.341
>20	48,983	293,898	2.711	3.179	1.249	1.717
Total	88,320	529,920	5.397	5.731	2.397	2.7301

Assumptions:
Average Utility Heat Rate (Btu/kWh): 10,300
Average T&D Losses: 5%
Average CHP Hours of Operation: 6,000
Existing Boiler Efficiency: 80%

Table 4. Economic Savings from Industrial CHP

	- Savings -		- Costs -		
Size Range (MW)	*Avoided utility Power ($/kWh)*	*Avoided Boiler Fuel ($/kWh)*	*CHP Cost to Generate Power ($/kWh)*	*Net Savings ($/kWh)*	*Net Savings (million $)*
Existing CHP					
0.1-1	$0.070	$0,012	($0.067)	$0.015	$5.4
1-4	$0.060	$0.017	($0.068)	$0.009	$20
4-20	$0.050	$0.018	($0.062)	$0.006	$80
>20	$0.044	$0.013	($0.047)	$0.009	$2,350
Total					$2,460
Remaining CHP Potential					
0.1-1	$0.070	$0.012	($0.067)	$0.015	$1,970
1-4	$0.060	$0.017	($0.068)	$0.009	$310
4-20	$0.050	$0.018	($0.062)	$0.006	$390
>20	$0.044	$0.013	($0.047)	$0.009	$2,790
Total					$5,450

Assumptions:
Natural Gas Cost $/MMBtu: $3.00
Capital Recovery Factor (15-year life, 10% return on investment): 13.15%

ENVIRONMENTAL BENEFITS

CHP technologies also provide environmental benefits. Table 5 shows the reduction in NO_x emissions and Table 6 shows the reduction in CO_2 emissions, a primary contributor to global warming. Assuming that gas-fired CHP technologies would off-set coal-fired power generation, there would also be substantial reductions in SO_2 emissions.

EIA estimated that the electric utility industry produced 7.2 million tons of NO_x in 1998. Based on electricity sales of 3.2 trillion kWh/year, this represents an average emissions factor of 4.49 lbs/MWh for the power industry. This average emissions rate is well above new performance standards for the industry of about 0.15 lbs/MWh.

For this analysis, the average industry emissions was used to measure the benefits of existing CHP and the new performance standards to measure the benefits of penetrating the remaining CHP potential. The latter assumption is probably over-conservative and yields a minimum savings. The CHP emissions factors were estimated to reflect typical performance of existing CHP systems and also the performance of state-of-the-art units that could be installed for future penetration. There is an 85-90 percent reduction in emissions achievable by new installations with extensive controls compared to existing units.

The table shows that existing industrial CHP units save over 500 thousand tons/year of NO_x emissions compared to average utility and boiler NO_x, emissions. The remaining CHP potential will most likely compete against much cleaner utility power technology. Therefore, even though new CHP is much cleaner, the benefits are comparatively smaller about 34 thousand tons of NO_x/year can be avoided.

Table 5. Reduction in NO_x Emissions with Industrial CHP

Size Range (MW)	*CHP Capacity (MW)*	*CHP Output (GWh)*	*CHP Emissions (lbs/MWh)*	*Ave. Utility Emissions (lbs/MWh)*	*Boiler Emissions (lb/MMBtu)*	*Avoided NO_x Emissions (tons/yr)*
Existing CHP						
0.1-1	60	360	2.957	4.485	0.035	300
1-4	370	2,200	1.113	4.485	0.035	3,900
4-20	2,400	14,600	1.113	4.485	0.035	26,200
>20	41,400	248,000	0.764	4.485	0.035	480,300
Total	44,200	265,000				510,700
Remaining CHP Potential						
0.1-1	21,930	131,580	0.440	0.150	0.035	9,700
1-4	6,070	36,420	0.124	0.150	0.035	4,100
4-20	11,337	68,022	0.124	0.150	0.035	8,000
>20	48,983	293,898	0.085	0.150	0.035	31,400
Total	88,320	529,920				33,800

Assumptions:
Existing reciprocating engine emissions are 1 gram/bhp-hr
Existing gas turbine emissions are assumed to be 0.09 lbs/MMBtu
Emissions for new technology is assumed to represent 85-90% reduction

Table 6. Reduction in CO_2 Emissions with Industrial CHP

Size Range (MW)	*CHP Capacity (MW)*	*CHP Output (GWh)*	*CHP Emissions (lbs/MWh)*	*Ave. Utility Emissions (lbs/MWh)*	*Boiler Emissions (lb/MMBtu)*	*Avoided CO_2 Emissions (1000 tons/yr)*
Existing CHP						
0.1-1	60	360	1,310	1,372	120	100
1-4	370	2,200	1,352	1,372	120	770
4-20	2,400	14,700	1,410	1,372	120	4,900
>20	41,400	248,200	1,107	1,372	120	96,200
Total	44,200	265,500				102,000
Remaining CHP Potential						
0.1-1	21,900	131,600	1,310	1,372	120	36,400
1-4	610	36,400	1,352	1,372	120	12,600
4-20	11,300	68,000	1,410	1,372	120	23,000
>20	49,000	293,900	1,107	1,372	120	114,000
Total	88,300	529,900				186,000

CHP technologies reduce CO_2 emissions because of their high efficiency and their reliance on natural gas. Natural gas contributes less CO_2 per unit of energy than either coal or oil. The power industry's heavy reliance on coal for power production creates a high level of greenhouse gas emissions. The utility industry as a whole emits 1,372 lbs/MWh of CO_2. This average includes all of the hydroelectric and nuclear output that do not directly contribute to CO_2 emissions.

The estimates for each CHP size range reflect the changes due to the electrical efficiency of the technology. Existing CHP in the industrial sector saves 102 million tons/year of CO_2. Penetration of the remaining CHP potential would save an additional 185 million tons/year. Considering the total CHP potential as a whole, the CO_2 emissions reduction could reflect 15 percent of the total power industry emissions.

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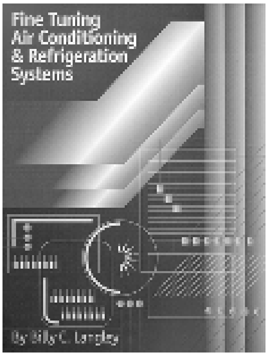

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