High Natural Gas Prices and the Updated Market for CHP

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ABSTRACT

Combined heat and power (CHP) has long been the most frequent application for distributed generation (DG) units. Indeed, the chemical, paper, and petroleum refining industries have converted their excess fuel stocks into power since the 1920s. Today, emerging technologies such as microturbines and fuel cells are increasingly being used for CHP. This is likely to remain the most important DG application for the next decade, with the existing installed distributed generation CHP base doubling by 2014.

This article looks at both the United States historic DG installation record and suggests the likely size of the future distributed generation CHP market. Not only are market trends that influence the use of CHP identified, but by using a highly disaggregated and detailed model, their impacts on market potential are quantified. The article presents top-level insights into which CHP technologies and size ranges have been and will be the largest market segments for manufacturers, developers and fuel suppliers. The data has been calculated by region of the U.S. as well. These forecasts summarize the first DG CHP market assessment to consider the impact of higher gas prices. This information may assist policy making in the DG and CHP arenas, and could influence R&D efforts.

INTRODUCTION

Also referred to as combined heat and power or cogeneration, CHP is generally operated year round to allow a facility to generate some or all of its power. A portion of the generator's thermal output is used for water heating, space heating, steam generation or other thermal loads. In some instances this thermal energy can also be used to operate cooling equipment. While most CHP is operated continuously, there are situations where daytime only CHP can be operated economically. CHP has most commonly been used by industrial clients, with a small portion of overall installations in the commercial sector. In smaller sizes, because of their superior life-cycle economics, CHP applications are much more common than baseload DG applications. With declining prime mover capital cost, increased efficiency, and ever fewer regulatory barriers, CHP has a bright future.

HISTORIC AND FORECAST COMBINED HEAT AND POWER POTENTIAL

The Department of Energy's Energy Information Administration (EIA) provides a good accounting of the amount of CHP already installed by both electric utilities and industrial/commercial enterprises. Figure 1 notes the cumulative installed CHP capacity over time. EIA also forecasts anticipated CHP additions in both these sectors; these are added to the installed base in Figure 1 to show how capacity might

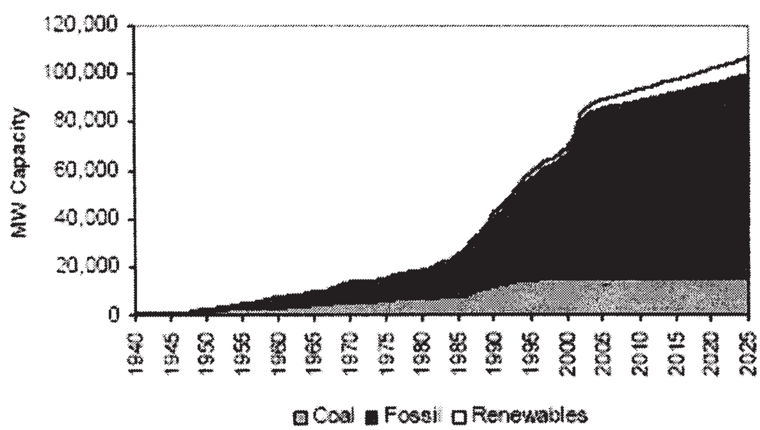

Figure 1. Installed and forecast CHP capacity.

Source: Energy Information Administration. Numbers for 1907-2002 are historical installations as contained in the Form 860 database for 2002, covering units greater than 1 MW in size. Forecasts from 2003-2025 indicate the amount of additional CHP capacity to be added by year, from the Annual Energy Outlook 2004.

expand. The 19 GW jump in capacity from 1999 to 2002 reflects what actually happened; much of this was added by independent power producers.

The forecast is for very little new coal-based CHP capacity to be installed, an increasing but still minority share of renewable based CHP to be added, and a large increase in fossil fuel based CHP capacity to be installed (oil, gas, diesel, and dual fueled technologies). EIA projects a 23 GW increase in CHP of all sizes between 2003 and 2025. Thus much of the increased fuel demand will be natural gas. Offsetting this, in many parts of the country each CHP unit installed results in a net decrease in total gas demand, principally the result of CHP's higher efficiency.

Figure 1 indicates that 83 GW of non-retired CHP greater than 1 MW in size existed in the U.S. at the beginning of 2003. When CHP units less than 1 MW in size are added, there is a total installed base of 88 GW of CHP today. In mid-1999 DOE examined the existing installed CHP base, determined it to be 46 GW, and established a "CHP Challenge Goal" of doubling this to 92 GW by 2010. Clearly the country is well on track to achieve this goal after the large number of recent installations, improvements in data collection "found" more existing units, and anticipated future additions.

For many observers, this point forecast does not provide adequate insight into either the installed base or the future market potential, especially of smaller DG-sized units. Details by technology, size, and region can add insights needed by policymakers, developers, manufacturers, and gas companies. Before presenting the market potential data this way, we explore the related historical DG market.

HISTORIC DISTRIBUTED GENERATION POTENTIAL

Distributed generation technologies are defined here to include generators up to 60 MW in size that use all or most of their generation locally. Three main differences exist between CHP and DG. First, CHP units can be larger than 60 MW. Second, CHP units sometimes primarily sell their power to electric utilities for non-local consumption, thus these units are not considered DG. Third, DG includes not only CHP, but also baseload, peaking, and spinning reserve applications. Additionally there are very significant levels of DG in emergency/standby and other non-interconnected uses (e.g. offshore oil platforms, mobile generators, Hollywood sets, circuses).

Table 1 reconciles these distinctions between CHP and DG. In short, DG is more narrowly defined than CHP, while CHP is just one of the applications of DG. The following market potential forecasts for CHP applications focus only on DG units; therefore, Table 1 provides the baseline against which additional future market potential should be compared.

Table 1. U.S. installed CHP and DG capacity 2003.

Category	*Capacity (GW)*
Total CHP	**88**
Greater than 60 MW units	60
Under 60 MW power sold to electric utility	6
DG, under 60 MW, power used locally	22
Total DG	**234**
CHP	22
Baseload	4
Peaking	6
Spinning	1
Emergency non-interconnected	188
Other non-interconnected	13

Sources: Energy Information Administration, Form 860 databases for 2002-2003 and The Installed Base of U.S. Distributed Generation, 2004 Edition, Resource Dynamics Corporation, Washington D.C.

Figure 2 provides the cumulative capacity of historically interconnected 1-60 MW sized units through the beginning of 2004. Figure 2 illustrates two important points. First, CHP is the single largest application of interconnected DG by far. Second, despite significant CHP having been installed decades ago, considerable new CHP capacity has been added since 1990 and it continues to grow. This perspective aids in understanding how CHP is likely to develop over the next decade.

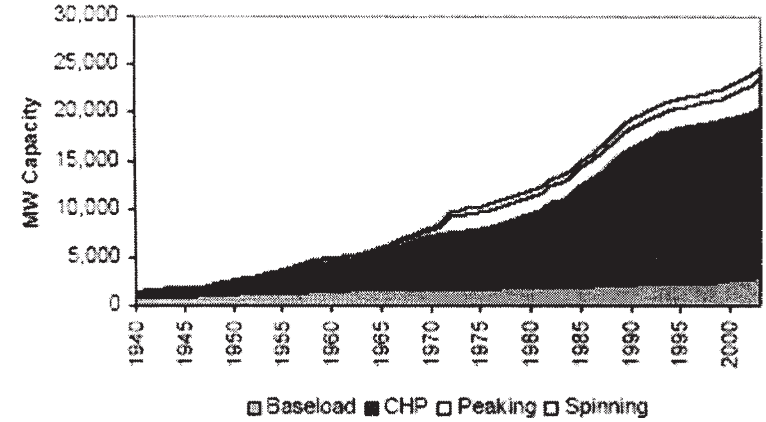

Figure 2. Installed DG capacity.—*Source: Energy Information Administration, Form 860 databases for 2002-2003.*

COMBINED HEAT AND POWER FUTURE MARKET POTENTIAL

Market potential is measured by how many DG units could be economically deployed as an alternative to traditional purchases of electric utility power. Deployment might be for any number of applications, such as CHP, baseload electricity, or peak shaving—provided it saves the customer money by doing so.

To measure how much additional CHP market potential exists, on top of that already installed, we utilized a proven detailed model entitled DISPERSE (an acronym for Distributed Power Economic Rationale Selection). This model estimates the economically rational potential of a defined CHP market by competing various CHP technology proposals against one another and with the traditional purchase of electricity from a retail supplier. For each commercial and industrial facility in the United States, the model determines which technology, unit size, and operating mode is the most economic. While the model forecasts the number of units, capacity, generation and thermal output, only the capacity is presented here, because it is the most commonly discussed metric.

Any forecast depends on underlying assumptions. For the Base Case forecast, we chose to examine the situation that included the most likely DG technology development over the next 10 years, \$8.10/MCF commercial and \$5.67/MCF industrial average starting gas prices which reflect recent market prices, and annual gas price increases of 2.4% to 11.2%. In the Base Case, there is an estimated 20 GW of new distributed generation CHP market potential that can economically be deployed today, nearly doubling the existing CHP installed base of 22 GW.

Natural gas prices are a critical input variable. Each market potential forecast can vary significantly by the price of natural gas used as a CHP fuel input. Thousands of different gas prices are used to model realistic rates that each enterprise faces throughout the year. In the Base Case, small commercial customers face prices ranging from $3.17 to $18.99 per thousand cubic feet, with an average price of $8.10 for an average month in the year, depending on the customer's location. Industrial customers face lower gas prices that are the minimum of the industrial city gate price or electric utility rates, and range from $1.70 to $11.20, with an overall average of $5.67. These prices are escalated each year over a 10-year generator life-cycle using an inflation rate.

To better understand the Base Case forecast, it is helpful to examine the results of alternative forecasts. Figure 3 summarizes the results of four sensitivity analyses to the Base Case results, providing the total U.S. potential capacity for each case, by sector. In the first alternative, the Future Case determines market potential assuming advances in DG technology price and performance forecast by the DOE as achievable by 2014. The Future Case projects a 103% increase in market potential over the Base Case, with significant growth in recuperated microturbines.

In the second alternative, we examine the sensitivity of the Base Case forecasts to natural gas prices by measuring the impact of doubling the assumed rate of inflation in gas prices. In this High Gas Prices Case, gas price escalation rates range from 4.9% to 22.4% per annum, depend-

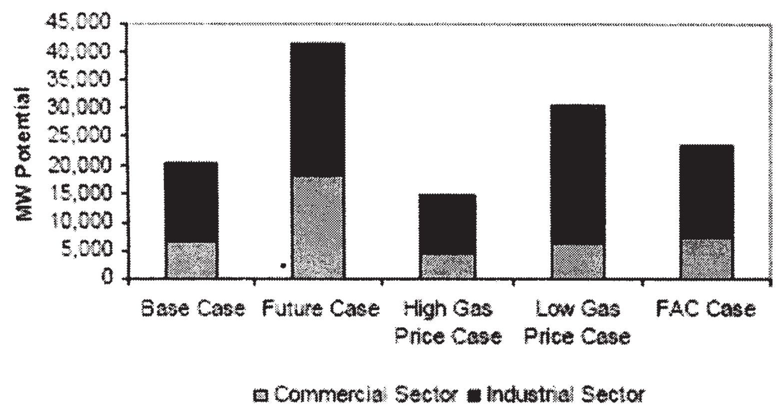

Figure 3. Market potential for additional CHP/DG capacity.
Source: The Potential U.S. Market For Distributed Generation, 2004, Resource Dynamics Corporation.

ing on the year in the generator's life-cycle, the region where the CHP is located, and whether a commercial, industrial or utility gas rate is being adjusted. The High Gas Prices Case forecasts a 28% decrease in CHP market potential.

In the third alternative, labeled the Low Gas Prices Case, gas prices are reduced to their historic 1990s level. Base Case natural gas price escalation rates are used. Gas prices still vary by month, state, and rate type. Commercial rates range from $1.48 to $8.84, with an average rate of $4.35 per thousand cubic feet. Industrial rates range from $1.48 to $5.95, with an average rate of $3.65 per thousand cubic feet. On average, the gas prices are lower than in the Base Case by 54% in the commercial sector and 64% in the industrial sector. The Low Gas Prices Case forecasts a 49% increase in CHP market potential, with large increases in reciprocating engines.

In the fourth and final alternative, the impact on market potential is examined of passing through the changes in gas prices over the last year into electric rates, via existing state-by-state electric utility fuel adjustment clauses. These raised the electric rates against which DG competes an average of 0.21 cents per kWh. Changes range from increasing prices in Maine by 1.62 cents per kWh to lowering the electric price in Connecticut by 0.11 cents per kWh. The Fuel Adjustment Clause Case increases CHP market potential capacity by 14%.

COMBINED HEAT AND POWER MARKET POTENTIAL BY TECHNOLOGY, SIZE AND REGION

For manufacturers, developers and fuel suppliers to better understand where the real CHP market potential lies, it is helpful to know the details. Because DISPERSE is a highly disaggregated bottom-up model, results are available for numerous breakouts. Key top-level breakouts for the CHP application of DG are now provided for the Base Case. Generally, it is fair to assume that these results are scaleable for alternative input assumptions (cases) using the data provided in Figure 3. The main point arising from these tabulations is an indication of the relative importance of different technologies, sizes and regions to CHP's development.

Figure 4 notes CHP market potential by technology and sector. Reciprocating engines and combustion turbines have nearly equal market potential, but the engines are much more likely to be deployed in the commercial sector.

Figure 5 provides the CHP market potential by size range and sector. Commercial applications are more economical in smaller size ranges. A broad range of sizes might economically be deployed in the industrial sector.

Figure 6 indicates where market potential is greatest, by providing sector breakouts for the 9 states with at least 1 GW of new CHP market potential. Most states have a relatively similar distribution of market potential across the commercial and industrial sectors. This list of states is not surprising as they have a) the largest populations, b) the most industrial and commercial enterprises, c) the largest existing installed

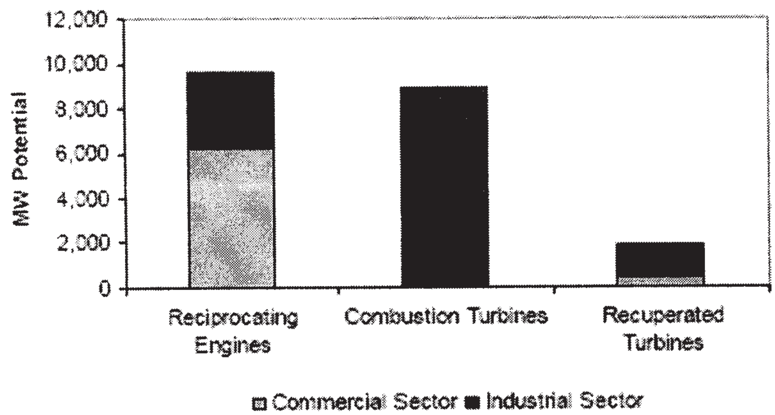

Figure 4. CHP/DG market potential by technology
Source: Ibid.

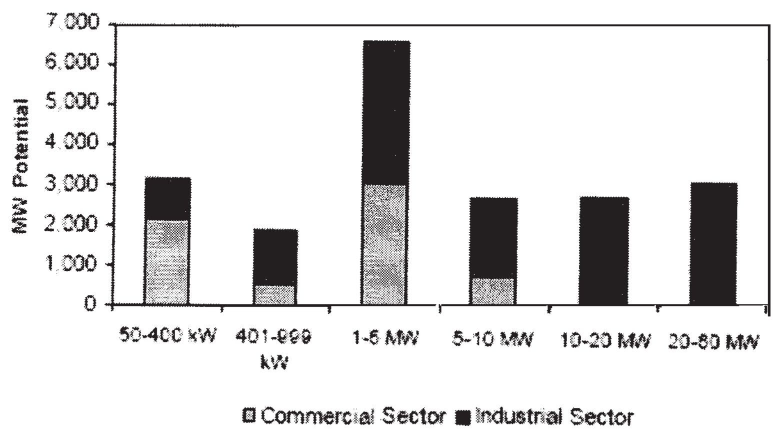

Figure 5. CHP/DG market potential by size.
Source: Ibid.

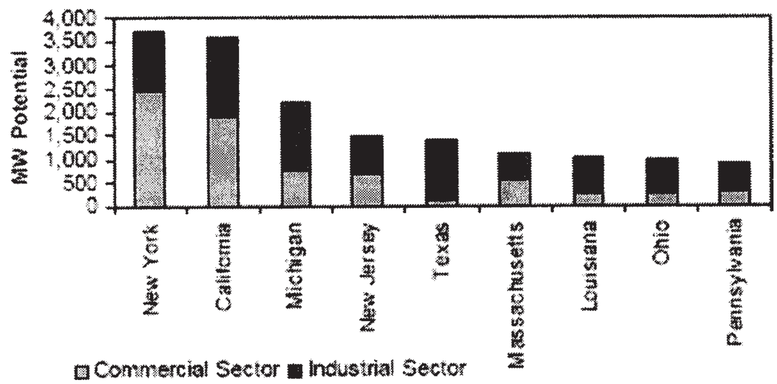

Figure 6. CHP/DG market potential by census region.*Source: Ibid.*

base of CHP, and d) in several cases, done the most to improve the regulatory environment to allow CHP to compete on a level playing field.

SUMMARY AND CONCLUSIONS

CHP applications dominate overall DG industrial and commercial market potential. They comprise over two-thirds of all DG Base Case market potential and over half of the Future Case market potential. Additionally, CHP is likely to be the best growth application for nearly all industrial sectors, with economics superior to those associated with either baseload or peaking applications.

Despite this dominance, CHP is a technology option that is clearly underutilized in the commercial buildings sector. While partly the result of insufficient economic returns related to seasonal heating and cooling loads, there are institutional reasons why CHP is not more widely used now. Many building owners make their decisions on the basis of first cost, and CHP options tend to cost more than conventional alternatives. Also the building design community tends to be risk adverse, favoring proven designs and not recommending options that they have not previously built.

The forecasts presented here summarize the first DG CHP national market assessment to consider the impact of higher natural gas prices. The results suggest the existing installed base of distributed generation CHP could double even under these high gas price conditions. And, as technology improves, the market's size could more than triple. The Base Case forecast of 20 GW of new CHP units can be compared with EIA's forecast of 23 GW of additional CHP to be added by 2025, the latter including both units greater than 60 MW in size and some that sell power to the electric industry for distribution to end users. Thus the forecasts presented here actually indicate a somewhat larger CHP market potential than does the Annual Energy Outlook.

Obviously there is a huge gap between the currently installed 22 GW and the 63 GW that would exist if all Future Case market potential were deployed. Why the gap? There are several reasons.

First, about 21 GW of the 41 GW of new market potential only becomes economically viable once DG performance improves over the coming decade or so. The introduction of combined heat and power with cooling systems is part of this trend.

Second, a knowledge barrier limits CHP adoption even when it can be the economically preferable solution. This includes low levels of knowledge about CHP, its siting, its operation, and the state and federal regulations that affect its use. Together this lack of information on the part of end users, architects, engineers, building inspectors, public utility commissions and policymakers has contributed to CHP not even being considered an option for a particular new or retrofit building, or for an industrial application.

Third, siting costs are relatively high compared with a small CHP unit's capital cost. This is a particular problem for commercial sector CHP. Sometimes older regulations or utility policies have prevented CHP from being considered on a level playing field with grid based power. For instance, non-standard utility interconnection policies are often cited as being a time and cost barrier when installing a CHP project; indeed this very issue is now being addressed both in some states and at the federal level. Although state approved pre-certification programs are helping, siting remains a unique process raising installation costs considerably.

Fourth, there are CHP use restrictions in some locations, especially for smaller reciprocating engines. Under the Clean Air Act stationary generators must meet strict air emission requirements in some non-attainment areas. Similarly, some jurisdictions limit the number of hours per year certain CHP technologies can be operated. Other building, safety and fire codes often restrict where or how fuel can be stored.

Thus, achieving full economic market potential is likely an improbable task. Actual market penetration will always lag market potential. This is one reason the market potential forecasts presented here exceed EIA's estimate of how much CHP will be installed by 2025. However, an estimate of which CHP technology makes economic sense in a particular utility service area remains very valuable information, even though it must be evaluated in light of business barriers and challenges to market adoption. Decisions are not based on economics alone. Nonetheless, knowing that the existing market could double during the next decade using existing technology strongly motivates many industry stakeholders.

To smooth the way forward toward more complete adoption of the economically viable CHP, policymakers might consider providing expedited or simplified low-cost processes for permitting and interconnecting very small CHP units. Several states now have such processes, which do save developers time and costs. Policymakers might also provide incentive programs that give an early push toward market adoption of certain technologies such as fuel cells, and promote the energy-efficiency of CHP. To do so, each state might note what incentive programs have already been adopted and are working well in other states. More standardization across such programs might assist developers operating nationally. Additionally, policymakers might consider including the value of CHP thermal output in state air emission requirements. Several states are doing so, thus putting CHP technologies on a more level playing field.

Finally, manufacturers and government agencies investing R&D in the CHP industry need to consider the tremendous importance of technology price and performance on economic viability. As noted in Figure 3, this can greatly expand the number of firms, especially commercial enterprises, willing to consider CHP.

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