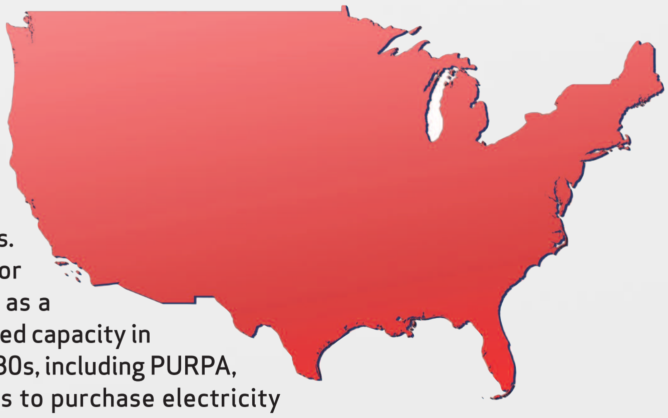
The International CHP/DHC Collaborative

Advancing Near-Term Low Carbon Technologies

CHP/DHC Country Scorecard: United States



The United States has a long history of using Combined Heat and Power (CHP), and 8% of US electricity generation is provided by 85 gigawatts (GWe) of installed CHP capacity at over 3 300 facilities. The large-scale district energy systems are located in many major cities, and 330 university campuses use district energy systems as a low-carbon, decentralised energy solution. The large base of installed capacity in the US is the result of supportive federal policies in the 1970s and 80s, including PURPA, the Public Utilities Regulatory Policy Act, which required utilities to purchase electricity from CHP plants at a set rate. A number of US States, including California, New York and other States in the Northeast, also provide incentives and recognition in environmental regulations for CHP, which has supported new development. However, the partial repeal of PURPA, as well as a wide diversity in state support, have resulted in a patchwork of CHP markets.

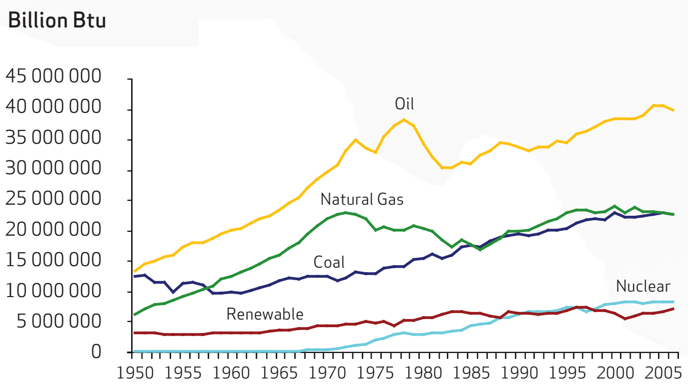
As a result, there are important barriers that must be addressed if the US is to realise the GHG and energy benefits associated with greater use of CHP and district energy in the future.

Energy Overview

The United States is the world's largest energy producer, consumer, and net importer. It ranks eleventh worldwide in reserves of oil, sixth in natural gas, and first in coal. Most energy currently consumed in the United States, as in the rest of the industrialized world, comes from – coal, natural gas, and oil. While the efficiency with which Americans use energy improved by 49% between 1950 and 2000, overall, a growing population and economy has driven total energy use up. As the US population expanded from 149 million people in 1950 to 281 million in 2000, total energy consumption grew from 32 quadrillion Btu to 98 quadrillion Btu (up 208%). Figure 1 demonstrates the growth in energy consumption by fuel type between 1950 and 2006.

Figure 1: US Energy Consumption in Billion Btu from 1950-2006

Source: US Energy Information Administration (EIA)[1]

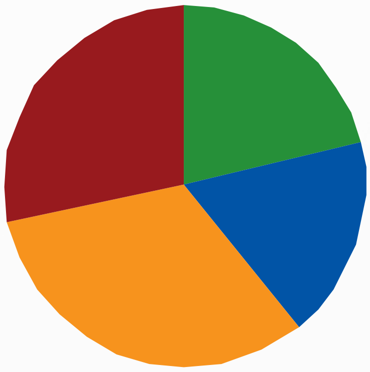


1. US Department of Energy, Energy Information Administration, www.eia.doe.gov.

Energy plays a central role in the operation of the industrialized U.S. economy, and energy spending is commensurately large. In recent years, American consumers have spent over half a trillion dollars a year on energy. That energy is consumed in four broad market sectors: residential, commercial, industrial, and transportation. Figure 2 shows the breakdown of energy consumption by consuming sector.

FIGURE 2: US ENERGY CONSUMPTION BY SECTOR IN BILLION BTU (2006)

SOURCE: EIA[2]



Industry is historically the largest consuming sector of the economy. About three-fifths of the energy consumed in the industrial sector is used for manufacturing. The remainder goes to mining, construction, agriculture, fisheries, and forestry. Within manufacturing, large consumers of energy are the petroleum and coal products, chemicals and allied products, paper and allied products, and primary metal industries. Natural gas is the most commonly used energy source in manufacturing. The predominant end-use activity is process heating (both steam and direct), followed by machine drive and then by facility heating, ventilation, and air conditioning combined.

The U.S. Energy Information Administration forecasts that electricity consumption will increase at an annual rate of 1.1% between now and 2030, a reduction from its previous forecasts. This reduction is caused by the current slowing of the US economy, rising electricity prices, and the passage of new energy efficiency standards in the Energy Independence and Security Act of 2007[3].

Climate Change Context

Federal action: Although the US is a signatory to the United Nations Framework Convention on Climate Change and was a main participant in the development of the Kyoto Protocol, the U.S. Senate never voted to ratify the treaty, primarily due to concerns about potential damage to the US economy. Although the United States did not ratify the Kyoto Protocol, the US Federal government has adopted a series of measures and is considering additional policies to begin to address climate change by[4]:

- slowing the growth of greenhouse gas emissions;
- increasing support for scientific research and technology development;
- enhancing international cooperation; and
- taking voluntary action to reduce GHG emissions.

In June 2008, the Senate suspended debate on the, "Climate Security Act," S.2191, introduced by Senators Lieberman (I-CT) and Warner (R-VA), which included an economy-wide cap-and-trade program. While the bill failed to advance through the legislative process in 2008, it appears that similar legislation will be reintroduced in 2009.

State and local action: In the absence of mandatory Federal action on climate change, states and regions across the country are implementing their own climate change policies. These include the development of regional GHG reduction programs and mandates to increase renewable energy generation (often in the form of a "Renewable Portfolio Standard", some which include support for increased use of CHP). As of mid-2008, half of the states had some form of mandatory GHG emission reduction requirement in place or under development[5]. These state and regional climate policies will likely provide models for future national efforts. Recent state initiatives include:

- **The Regional Greenhouse Gas Initiative (RGGI)** is a cooperative effort by nine Northeast and Mid-Atlantic states to develop a multi-state cap-and-trade program covering greenhouse gas (GHG) emissions[6].

- **California Global Warming Solutions Act of 2006 (AB 32)** – The state of California has committed to reduce its global warming emissions to 1990 levels by 2020. This will be accomplished through a statewide cap on global warming emissions that will be phased in starting in 2012.

2. *DOE EIA Annual Energy Outlook 2008*, www.eia.doe.gov.
3. *DOE EIA Annual Energy Outlook 2008.*
4. US Environmental Protection Agency (EPA), Climate Change Policy, http://www.epa.gov/climatechange/policy/index.html.
5. US EPA State and Local Programs Branch, http://epa.gov/climatechange/wycd/stateandlocalgov/state_actionslist.html.
6. Additional information on the RGGI program can be found at www.rggi.org.

AB 32 directs the California Air Resources Board to develop establish a reporting system to track and monitor GHG emissions levels.[7]

- **The Western Climate Initiative (WCI)** is a collaborative effort by the Governors of Arizona, California, New Mexico, Oregon, Utah, Montana, Washington, and several Canadian Provinces to develop a regional strategy to address climate change. The WCI partners established a regional goal to reduce GHG emissions 15% below 2005 levels by 2020. The strategy calls for a regional cap-and-trade program and other measures[8].
- The **Midwest Climate Change Accord** is a regional climate initiative by the states of Illinois, Iowa, Kansas, Michigan, Minnesota and Wisconsin and the Canadian Province of Manitoba. As well as recommending a cap-and-trade programme, the Accord will also focus on providing incentives for local "green" energy technologies and sustainable biofuels.[9]

These federal, state and local climate and energy policies form the backdrop against which more specific policy efforts to advance CHP and district energy must be considered. The next section discusses these CHP/DE policies in more detail.

History of CHP and District Energy Development in the United States

Decentralized CHP systems located at industrial and municipal sites were the foundation of the early electric power industry in the United States. However, as power generation technologies advanced, the power industry began to build larger central station facilities to take advantage of increasing economies of scale. CHP became a limited practice utilized by a handful of industries (paper, chemicals, refining and steel) which had high and relatively constant steam and electric demands and access to low-cost fuels.

By the 1970s, the US electricity market was dominated by mature, regulated electric utilities using large, power-only central station generating plants. As a result of this competitive position, utilities had little incentive to encourage customer-sited generation, including CHP. Further, a host of regulatory barriers at the state and federal level served to further discourage broad CHP development.

Partly in response to the oil crisis, in 1978, Congress passed the **Public Utilities Regulatory Policies Act (PURPA)** to encourage greater energy efficiency. PURPA provisions encouraged energy efficient CHP and small power production from renewables by requiring electric utilities to interconnect with "qualified facilities" (QFs). CHP facilities had to meet minimum fuel-specific efficiency standards[10] in order to become a QF. PURPA required utilities to provide QFs with reasonable standby and back-up charges, and to purchase excess electricity from these facilities at the utilities' avoided costs[11]. PURPA also exempted QFs from regulatory oversight under the Public Utilities Holding Company Act and from constraints on natural gas use imposed by the Fuel Use Act. Shortly after enacting PURPA, Congress also enacted a series of **CHP tax incentives**. The incentives included a limited term investment tax credit of 10% and a shortened depreciation schedule for CHP systems. The implementation of PURPA and the tax incentives were successful in expanding CHP development; installed capacity increased from about 12 000 MW in 1980 to over 66 000 MW in 2000[12].

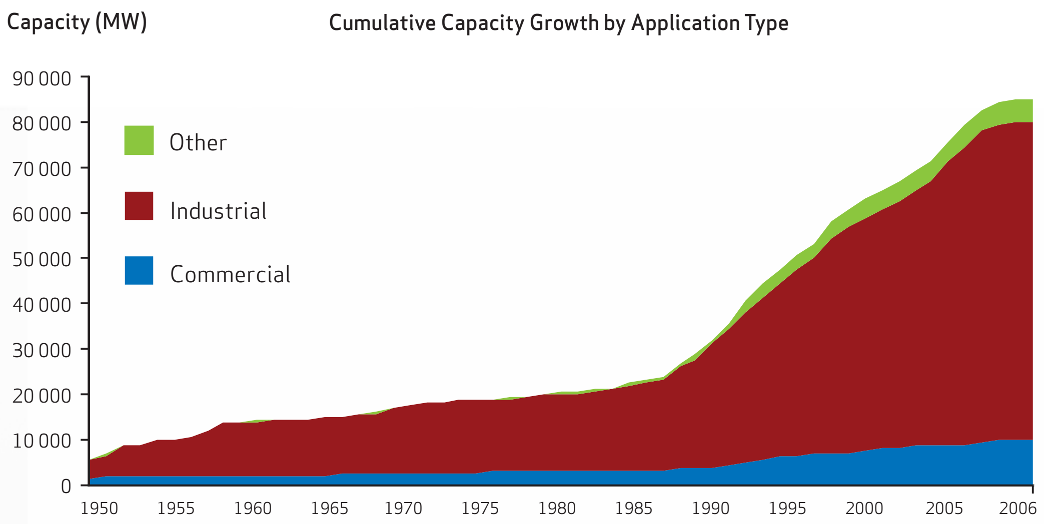
While PURPA promoted CHP development, it also had unforeseen consequences. PURPA was enacted at the same time that larger, more efficient, lower-cost combustion turbines and combined cycle systems became widely available. These technologies were capable of producing greater amounts of power in proportion to useful thermal output compared to traditional boiler/steam turbine CHP systems. Therefore, the power purchase provisions of PURPA, combined with the availability of these new technologies, resulted in the development of very large merchant CHP plants designed for high electricity production.

For the first time since the inception of the power industry, non-utility participation was allowed in the US power market, triggering the development of third-party CHP developers who had greater interest in electric markets than thermal markets. As a result, the development of large CHP facilities (greater than 100 MW) paired with industrial facilities increased dramatically; today almost 65% of existing US CHP capacity – 55 000 MW – is concentrated in plants over 100 MW in size[13]. Figure 3 shows the cumulative growth of CHP capacity in the U.S. since 1950, highlighting the rapid increase in growth starting in the late 1980s.

7. Union of Concerned Scientists. AB 32 Fact Sheet. http://www.ef.org/documents/AB-32-fact-sheet.pdf.
8. A draft of the WCI recommendations is available for review at www.westernclimateinitiative.org.
9. Information on the Midwest accord can be found at www.midwesterngovernors.org.
10. Efficiency hurdles were higher for natural gas CHP.
11. Avoided cost is the cost an electric utility would otherwise incur to generate power if it did not purchase electricity from another source.
12. CHP Installation Database developed by Energy and Environmental Analysis, Inc for Oak Ridge National Laboratory and the U.S. DOE; 2007. Available at http://www.eea-inc.com/chpdata/index.html.
13. Ibid.

Figure 3: CHP Cumulative Capacity Growth by Application Type in the US

Source: EEA/ICF CHP Installation Database, 2007



The environment changed again in the late 1990s with the advent of deregulated wholesale markets for electricity. Independent power producers could now sell directly to the market without the need for QF status. The movement toward restructuring (deregulation) of power markets in individual states also caused uncertainty, resulting in delayed investments. As a result, CHP development slowed. These changes also coincided with rising natural gas prices as the supply demand balance in the US tightened. This further dampened the market for CHP development.

At the end of the 1990s, policymakers began to explore the efficiency and emission reduction benefits of thermally based CHP. They realized that a new generation of locally deployed CHP systems could play a more important role in meeting future US energy needs in a less carbon-intensive manner. As a result, the federal government and several states began to take actions to promote further deployment of CHP. CHP has been specifically singled out for promotion by the US Department of Energy and U.S. Environmental Protection Agency, which committed to a **target of increasing CHP capacity** to 92 GW between 2000 and 2010[14].

In addition to supporting research, the Department of Energy in 2001 established the first of eight **regional CHP application centers** to provide local technical assistance and educational support for CHP development[15]. In 2001, the Environmental Protection Agency established the **CHP Partnership**[16] to encourage cost-effective CHP projects and expand CHP development in under-utilized markets and applications. Individual states also began to realize that a variety of policy measures were needed to remove the barriers to CHP development, and developed a series of policies and incentives, including streamlined grid interconnection requirements, simplified environmental permitting procedures, and establishing rate-payer financed incentive programs for CHP deployment.

CHP/DE Today: Applications and Markets

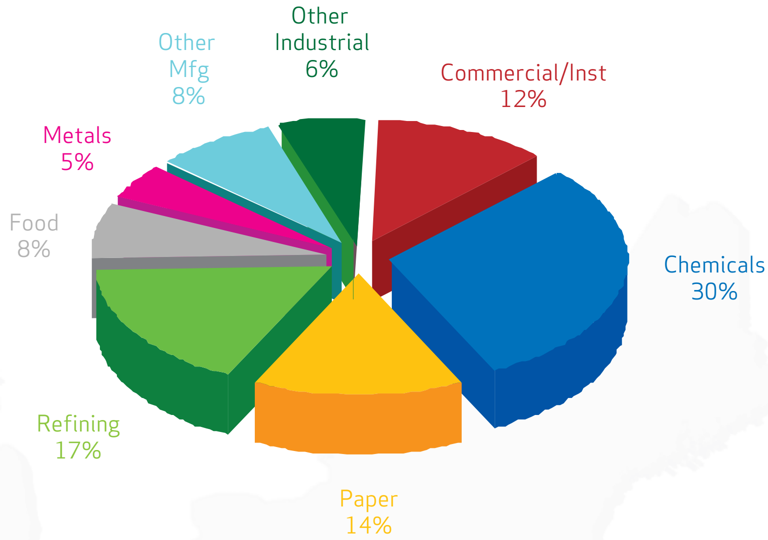
CHP and District Energy are important electric generating resource in the United States. The 85 gigawatts (GW) of existing CHP generation capacity at over 3 300 facilities represents over 8% of total US power generation capacity[17]. CHP represents over 12% of annual US power generation, reflecting the longer operating hours of CHP assets.

CHP is used in a broad range of applications. Figure 4 shows that 88% of CHP capacity in the United States is found in industrial applications, primarily providing power and steam to large industries such as chemicals, paper, refining, food processing and metals. CHP in commercial and institutional applications is currently limited (12% of existing capacity) but growing in use, providing power, heating, and, in many cases, cooling to hospitals, schools, university campuses and office and apartment complexes.

14. This target, known as the National CHP Roadmap, has nearly been achieved; see http://www.eere.energy.gov/de/pdfs/chp_national_roadmap.pdf.
15. CHP Regional Application Centers http://www.eere.energy.gov/de/chp/chp_applications/chp_application_centers.html.
16. EPA Combined Heat and Power Partnership www.epa.gov/chp.
17. CHP Installation Database developed by Energy and Environmental Analysis, Inc for Oak Ridge National Laboratory and the U.S. DOE; 2007. Available at <www.eea-inc.com>.

FIGURE 4:
EXISTING CHP CAPACITY IN THE UNITED STATES – 84 880 MW (2006)

SOURCE: EEA/ICF CHP INSTALLATION DATABASE, 2007



CHP installations in the US use a diverse mix of fuels, with natural gas being the most common fuel at 72% of CHP capacity. Coal and process wastes make up the remaining fuel mix (14 and 8% respectively), followed by biomass, wood, oil, and other waste fuels. There has been increased interest in biomass and waste fuels in recent years as policymakers and consumers seek to use more renewable fuel sources.

The prominent use of natural gas as a fuel for CHP in the United States is driven by the extensive use of gas turbine and combined cycle (gas turbine/steam turbine) systems. Figure 5 shows that combined cycles and gas turbines represent 52 and 14% of existing CHP capacity respectively. Boiler/steam turbine systems represent 33% of total CHP capacity and are fueled by solid fuels such as coal and wood waste. Reciprocating engines, primarily fueled by natural gas, represent 2% of CHP capacity in the United States. Together, microturbines (small, recuperated gas turbines in the 60 to 250 kW size range), fuel cells and other technologies such as organic Rankine cycles represent less than one percent of installed CHP capacity. Figure 6 shows the market share of CHP technologies based on the number of installations. Reciprocating engines are the primary technology of choice, used in 47% of existing CHP systems in the United States. Emerging technologies such as fuel cells and microturbines are used in 8% of existing CHP systems in the United States.

FIGURE 5:
US CHP CAPACITY BY TECHNOLOGY – 84 880 MW (2006)

SOURCE: EEA/ICF CHP INSTALLATION DATABASE, 2007

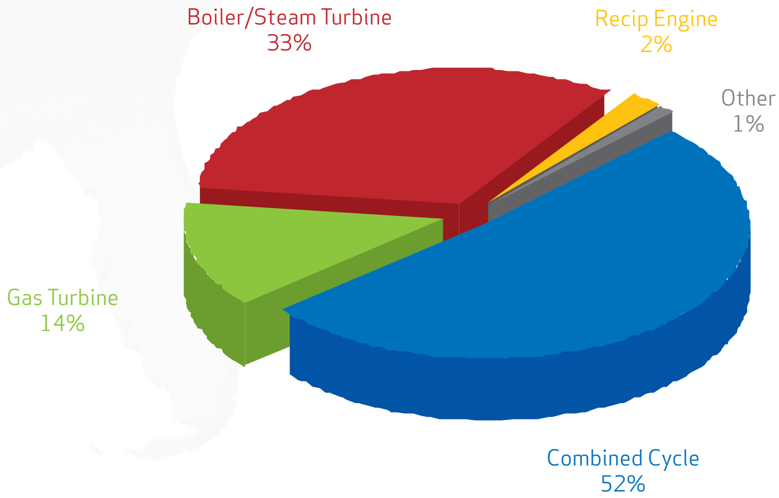
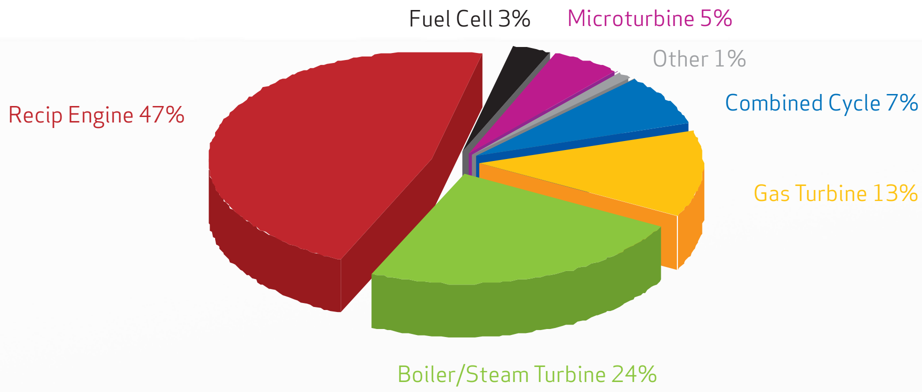
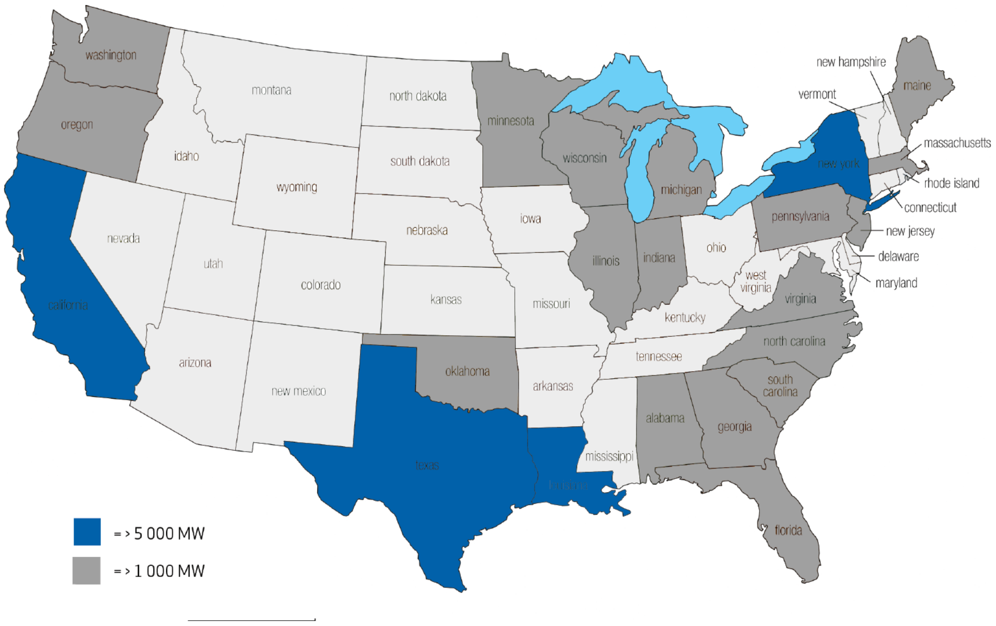


FIGURE 6:
US CHP SITES BY TECHNOLOGY – 3 316 SITES (2006)
SOURCE: EEA/ICF CHP INSTALLATION DATABASE, 2007



There are significant regional differences in the distribution of CHP sites and capacity. Some states are far ahead of others in terms of adopting policies that encourage CHP growth, most notably New York and Connecticut, which offer financial and other incentives to CHP. Other regional variations can be traced to industrial development. For example, chemicals and refining are common in the Gulf Coast states and paper production in the Southeast. The map in Figure 7 shows the states with the highest amount of CHP capacity, with dark blue states having more than 5 GW of capacity, light blue states having more than 1 GW, and white states with less than 1 GW.

FIGURE 7:
US STATES WITH LARGE AMOUNTS OF CHP CAPACITY
SOURCE: EEA/ICF CHP INSTALLATION DATABASE, 2007



Industrial and Commercial Applications

Industrial CHP installations in the US are typically large and represent 78% of total installed national capacity (Figure 4). Installation of large (greater than 20 MW) CHP systems in this sector has been limited in recent years because of higher natural gas prices and excess power capacity in many regions of the US, but market activity is increasing as utility electricity rates are rising and reserve margins are shrinking in many regions. There is also increasing interest in biomass and other alternative fuels.

CHP installations in commercial facilities make up 55% of CHP sites in the US but account for only 12% of capacity (see Figure 4). This is due to the relative size of commercial facilities which are typically much smaller than industrial facilities. Commercial and institutional applications (and light industrial) are seen as potential growth markets for CHP in the US. The Department of Energy and developers have both invested in technology improvements for these applications, focusing on increasing efficiency, incorporating new thermally activated technologies to provide both heating and cooling services, and integrating components and controls into cost effective packages. The box below illustrates a case study for a commercial CHP application of a DOE-funded integrated CHP system in a hospital.

Case Study: Dell Children's Hospital[18]

The Dell Children's Medical Center located in Austin, Texas, has installed a 4.5 MW natural gas-fired turbine CHP system that supplies 100% of the hospital's electricity needs.

Benefits:

- Fuel efficiency exceeds 70%
- Lower emissions of nitrogen oxides and a 40% reduction in carbon dioxide[19]
- Steam is utilized in absorption chillers to produce all the hospital's chilled water needs
- Chilled water storage tank allows for peak shaving
- Enhanced power quality
- Plant expandable for future growth of the hospital
- Utility company, Austin Energy, funded and operates the system, reducing $7 million in capital costs to the hospital from not owning its own central plant

18. Burns & McDonnell, "CHP Case Studies". Industrial Energy Technology Conference. May 2008.
19. The Daily Texan. http://www.dailytexanonline.com/home/index.cfm?event=displayArticlePrinterFriendly&uStory_id=2a01bd4d-71dc-4cf9-95c6-de1259a7861c.

District Energy

In the US, district energy systems are typically located in dense urban settings in the central business districts of larger cities, on university or college campuses; and on hospital or research campuses; military bases and airports. District energy systems in the United States typically serve "clusters" of buildings, which are sometimes commonly owned, as in the case of a private or public university campus or hospital. Frequently, however, in downtown systems, the customer buildings have distinct and separate owners; are generally located near each other in a central business district or segment of the city; and are interconnected individually to the distribution piping network.

There are several thousand district heating and cooling facilities in the US, ranging from two or more buildings sharing a common boiler or cooling plant, to large campus-type installations where dozens of buildings are served by district heating and cooling lines. The large scale district energy systems in the US are located in two key market segments: downtown district energy systems, and university campus district energy systems. There are currently 72 US downtown district energy systems serving 1 888 million square feet of building space, 36 of which incorporate CHP into their systems. The systems represent almost 50 000 MMBtu/hr of heating capacity, over 1 000 000 tons of cooling capacity and close to 2 300 MW of CHP generating capacity. There are 330 university campus district energy systems in the US, serving 2 487 million square feet of building space; nearly a third of these campuses incorporate CHP into their systems. These systems represent over 65 000 MMBtu/hr of heating capacity, almost 2 000 000 tons of cooling capacity and about 2 200 MW of CHP generating capacity[20]. The box below illustrates a case study showing CHP implementation in a downtown district energy system.

Case Study:

St Paul Downtown District Energy System[21]

In 2003, a 25 MW wood-fired CHP system was added to the twenty year old district heating and cooling system in St Paul, Minnesota. The combined system serves more than 185 commercial buildings (31.1 million square feet) and 300 single family town homes in the downtown Saint Paul area.

Benefits:

- Twice as efficient as previous steam-only system
- Powered by renewable wood waste
- Reduces coal and oil use by 80%
- Achieves system reliability of 99.99%
- Reduction in greenhouse gas emissions of more than 280 000 tons[22]
- Provides low, stable energy rates for those connected to the system

Environmental Benefits of CHP

CHP systems in the US offer significant environmental benefits when compared with purchased electricity and onsite-generated heat. Table 1 demonstrates the estimated CO_2 emissions impact of existing CHP capacity in the US compared to average fossil-based utility generation. The 242 million metric tonnes of CO_2 reduction from existing CHP represents a 4% reduction in the total 2006 US CO_2 emissions from all sources[23].

20. "District Energy Services Commercial Data Analysis for EIA's National Energy Modeling System". EEA/IDEA. August 2007.
21. http://www.districtenergy.com/.
22. City of St Paul website: http://www.stpaul.gov/index.asp?NID=501.
23. US DOE Energy Information Administration estimate for 2006, www.eia.doe.gov/oiaf/1605/ggrpt/.

TABLE 1:

ENERGY AND GREENHOUSE GAS REDUCTIONS FROM EXISTING CHP IN THE US

Reduced Fuel Consumption with CHP (Quadrillion Btus):	1.9
Total CO_2 reductions with CHP (Million Metric Tonnes):	242
Million Metrics Tonnes of carbon:	66
Equivalent acres of forest planted (millions of acres):	55
Equivalent number of cars removed from road (millions of cars):	44

SOURCE: US DOE[24]

Government CHP Promotion Policies

Beyond research and market transformation programs at the Department of Energy and Environmental Protection Agency, national CHP promotion policies are currently limited. The **Energy Policy Act of 2005** established limited-term tax incentives for two emerging CHP technologies (fuel cells and microturbines) and for renewable generation[25]. The **Energy Independence and Security Act of 2007** authorized a number of grant programs and regulatory incentives for CHP and District Energy, but Congress has yet to enact the necessary legislation to appropriate funds to implement the programs.

Many state governments, however, are developing policies and programs aimed at greater investment in energy efficiency, renewable energy, and CHP. Important CHP initiatives at the state level include:

- **Enacting output-based air pollution regulations**. Output-based regulations relate air emissions to the productive output of a process and encourage the use of fuel conversion efficiency as an air pollution control or prevention measure. Output-based regulations that include both the thermal and electric output of an energy technology recognize the higher efficiency and environmental benefits of CHP/DE. Several states have implemented output-based regulations with recognition of thermal output for CHP systems, especially for smaller systems. In recent years, regulators have increasingly adopted market-based regulatory structures, primarily emission cap and trade programs. In these programs, allocation of emission allowances is a critical component. Some states have adopted output-based allocation methodologies that include both electricity and thermal output of CHP systems, creating an important incentive for more efficient units such as CHP/DE[26].

- **Establishing interconnection standards**. Economic use of CHP for most customers requires integration with the electric utility grid for back-up and supplemental power needs, and, in some cases, selling excess power. Therefore, states are encouraging CHP by establishing uniform processes and technical requirements for interconnection[27].

- **Removing unintended utility tariff barriers to CHP**. When CHP units are interconnected, electric utilities typically charge special rates for electricity and for services associated with this service, including supplemental rates, standby rates, and buy-back rates. If not properly designed, these rates can create unnecessary barriers to the use of CHP. Appropriate rate design is critical to allowing utility cost recovery while also providing appropriate price signals for clean energy supply. States such as California, New York, New Jersey, Maine, Oregon and Wisconsin are exploring different types of rate structures that allow utilities to maintain profitability and also encourage the use of customer-sited CHP[28].

- **Leading by Example**. States are also establishing programs that achieve energy savings within their own state facilities. State governments work with state agencies, local governments and schools to identify and develop CHP opportunities at their facilities. For example, Massachusetts has developed an Executive Order[29] in which it plans to take a leading role in demonstrating CHP in state buildings.

24. Draft DOE White Paper, *CHP and Energy and Emissions Savings in the United States*, 2008.
25. This act also established a rebuttable presumption that if a qualifying facility (QF) is provided with nondiscriminatory access to markets, then the utility will not be required to enter new contracts with QFs of more than 20 MW net capacity. Under the provisions of the Energy Policy Act of 2005, the FERC has affirmed all of the utilities that have filed to have met all required obligations.
26. *Output-Based Regulations: A Handbook for Air Regulators*. US EPA, 2004.
27. US EPA Combined Heat and Power Partnership, http//www.epa.gov/chp/documents/survy_interconnection_rules.pdf.
28. *EPA Utility Rates Factsheet*. http://www.epa.gov/chp/state-policy/utility_fs.html.
29. http://www.mass.gov/envir/Sustainable/pdf/07_eo484.pdf.

Stakeholders

Federal government

U.S. Department of Energy (DOE) – DOE has led CHP technology development, demonstration, and deployment, partnering with consortia in the commercial building marketplace, and with many different industries. DOE provides technical and financial support, best practices information, education and training, resulting in greater market penetration of CHP and DE.

U.S. Environmental Protection Agency's **Combined Heat and Power Partnership** (CHPP) – The EPA established the CHP Partnership in 2000 to promote high-efficiency CHP technologies as a strategy to mitigate climate change. The Partnership works with energy users, the CHP industry, state and local governments and other clean energy stakeholders to facilitate the development of new projects and to promote their environmental and economic benefits.

State government

Elimination of economic, regulatory and institutional barriers to CHP has been primarily focused at the state government. As a result, a patchwork of state incentives and regulations exists, controlled by public utility commissions, state energy offices, governors and state legislative bodies responsible for interconnection rules, renewable portfolio standards, and environmental permitting issues.

Industry

Many companies are already involved in the US CHP market with more entering the market all the time, including equipment manufacturers and CHP project developers. Equipment manufacturers include, but are not limited to, Solar Turbines, General Electric, Caterpillar, Capstone Turbines, United Technologies, Ingersoll-Rand, Tecogen, Cummins, Siemens-Westinghouse, Elliot Turbines and Fairbanks Morse.

Non-governmental organizations

United Stated Clean Heat and Power Association (USCHPA) – The USCHPA brings together diverse market interests to promote the growth of clean, efficient local energy generation in the United States.

International District Energy Association (IDEA) – IDEA is an association devoted to advancing global environmental quality through efficient district energy. IDEA enhances educational experiences for DE professionals, assists members in marketing the benefits of DE, and secures favorable policies, legislation and regulations.

Regional CHP Application Centers – These entities are funded by DOE and offer CHP technical assistance, training, educational opportunities, and outreach support. In addition to providing educational and outreach activities, many of them conduct research on CHP in selected market segments, as well as provide substantive technical support for installation of CHP projects in their regions.

American Council for an Energy Efficiency Economy (ACEEE) – The American Council for an Energy-Efficient Economy conducts in-depth technical and policy assessments on energy efficiency topics including CHP and advises policymakers and program managers.

Key Barriers to CHP

Regulatory and market barriers to increased deployment of CHP/DE in the US include:

Relative energy prices and uncertainty: Similar to other countries, the relative price of fuel and electricity and the costs of alternatives have an important impact on the commercial viability of CHP and DE. For the economics of a CHP project to be favorable, the project needs a high "spark spread", defined as the difference in cost of electricity and fuel. CHP is most economic in areas where the electric prices are high and fuel prices are low. In addition in recent years, fuel prices have been very volatile, which has created an environment where potential CHP sites see the investment in CHP as too risky.

Grid interconnection: The key to the ultimate market success of CHP is the ability to safely, reliably, and economically interconnect with the utility grid system. The current lack of uniformity in interconnection standards makes it difficult for equipment manufacturers to produce modular packages, and reduces the economic incentives for on-site generation.

Utility tariff structures: Electricity rate structures can have significant impact on CHP economics and on utility attitudes toward CHP development. Rate structures that link utility revenues and returns to the volume of electricity sales provide a disincentive for utilities to encourage CHP and other forms of on-site generation. Rate structures that recover the majority of the cost of service in non-bypassable fixed charges and/or ratcheted demand charges reduce the economic savings potential of CHP.

Standby/back-up charges: Electric utilities often assess specific standby charges to cover the additional costs the utilities incur as they continue to provide generating, transmission, or distribution capacity (depending on the structure of the utility) to supply backup power when requested (sometimes on short notice). The level of these charges can create unintended barriers to CHP[30].

Lack of recognition of CHP in environmental regulations: Higher efficiency generally means lower fuel consumption and lower emissions of all pollutants. Nevertheless, most US environmental regulations have established emission limits based on heat input (lb/MMBtu) or exhaust concentration (parts per million [ppm]). These input-based limits do not recognize or encourage the higher efficiency offered by CHP. Moreover, since CHP generates electricity and thermal energy, it can potentially increase on-site emissions even while it reduces the total global emissions. Thus, output-based emissions approaches environmental permitting can be an important way to recognize the benefits of CHP.

Tax policies: Tax policies can significantly affect the economics of investing in new on-site power generation equipment such as CHP. CHP systems do not fall into a specific tax depreciation category. As a result, the resulting depreciation period can range from 5 to 39 years. These disparate depreciation policies may discourage CHP project ownership arrangements, increasing the difficulty of raising capital and discouraging development.

30. US EPA Combined Heat and Power Partnership, http//www.epa.gov/chp/state-policy/utility.html.

CHP Potential

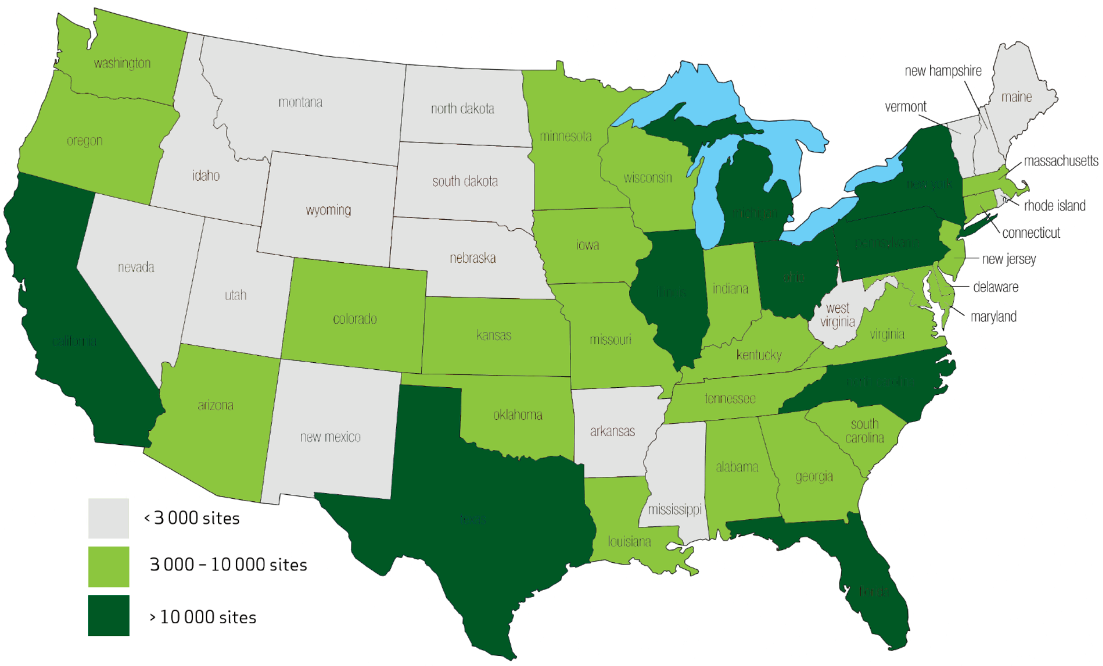
The US Department of Energy estimates that there is 70 – 90 GW of additional industrial CHP potential, and 40 – 60 GW of commercial/institutional CHP potential in the US, for a total of 110 to 150 GW of additional capacity. This would represent 4 to 5 Quads of total energy savings, and a reduction of 400 to 600 million metric tonnes of annual CO_2 emissions. Key additional features include:

- Almost one-half of the technical potential is in commercial/institutional applications
- Just over one-half of the technical potential is in systems below 5 MW in size
- Much of the technical potential is in applications with limited experience with CHP

Figures 10 and 11 show the regional breakdown of CHP technical potential in the US[31].

CHP TECHNICAL POTENTIAL BY NUMBER OF SITES

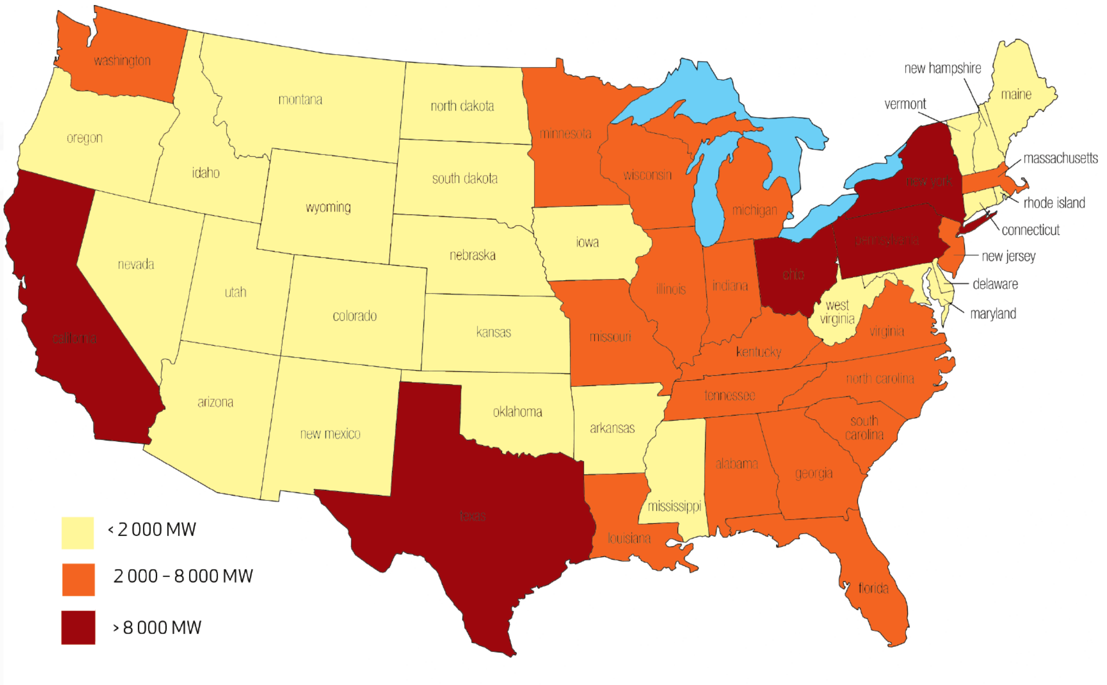
FIGURE 10: US CHP POTENTIAL



31. Draft DOE White Paper, *Combined Heat and Power: An Effective Energy Solution for A Sustainable Future*, 2008. The technical market potential does not consider screening for economic rate of return, or other factors such as ability to retrofit, owner interest in applying CHP, capital availability, natural gas availability, and variation of energy consumption within customer application/size class. However, the technical potential as outlined is useful in understanding the potential size and distribution of the target CHP markets among the states.

CHP TECHNICAL POTENTIAL BY MW CAPACITY

FIGURE 11: US CHP POTENTIAL



The IEA CHP / DHC Collaborative estimates that CHP can generate 250 TWh per year in 2030, if supported by a strong policy framework[33]. According to that report, which analysed the benefits of increased CHP use in the G8 and 5 other large economies, countries that invest in accelerated policies for CHP should realise the following benefits:

- a 3-7% decrease in energy investment costs between now and 2030;
- a slight decrease in consumer electricity costs; and
- up to 10%reductions in CO_2 emissions by 2030.

33. International Energy Agency, *Combined Heat and Power: Evaluating the Benefits of Greater Global Investment*, IEA/OECD, Paris (2008).

Achieving the Benefits of CHP/DC

The US saw a significant amount of CHP growth in the early 2000s, much of it in large industrial systems exporting excess power into the wholesale power market. This has slowed in recent years as natural gas prices have increased. The CHP market seems to have shifted to smaller commercial/industrial systems (at or below 20 MW) located in regions with high retail electricity prices and supportive state policies (e.g., the Northeast, California and Texas). Achieving the full potential for CHP/DE in the US will require continued technology advancements, explicit recognition of CHP's energy efficiency and CO_2 reduction benefits in GHG programs as they are implemented at the national and regional levels and continued progress in removing (and coordinating) regulatory and institutional barriers.

Summary Policy Recommendations

- **Recognize CHP, DE and waste heat recovery as important energy efficiency options in pending GHG legislation and programs. It is important for policymakers to understand the key role that CHP and DHC can play in reducing GHG emissions in the US; particular attention should be given to the treatment of CHP and DHC under proposed cap-and-trade programmes.**

- **Support expanded technology research, demonstration and deployment, particularly in emerging biomass and small-to-medium sized applications.**

- **Help level the playing field for CHP and DHC through regulatory and policy changes, including:**
  - **Implementing standardized interconnection rules; and**
  - **Developing transparent standby rate policies that recognize the benefits of CHP/DE while appropriately compensating the utility for its provided services; and**
  - **Encouraging uniform siting and environmental compliance policies; and**
  - **Establishing uniform tax policies.**

- **Provide incentives to overcome market barriers and promote societal benefits:**
  - **Include CHP in renewable and/or energy efficiency portfolio standards, or explore other tax incentives, where appropriate; and**
  - **Eliminate exit fees for new CHP installations; and**
  - **Promote sizing of CHP and DHC for maximum efficiency – provide a market solution for excess power produced by systems sized to meet thermal load; and**
  - **Appropriate funds for implementing the CHP/DE incentives contained in the 2007 Energy Independence and Security Act.**

CHP / DHC Scorecard

To aid in comparing amongst countries, the IEA has developed a scorecard of national CHP/DHC policy efforts that takes into account three criteria:

- The effectiveness of past policies in developing the CHP/DHC market over the last 5 years;
- Statements and commitments of intent in respect of future CHP/DHC policy, for example through the creation of national growth targets; and
- The existence today of meaningful policy incentives that are already causing significant market growth or that are likely to do so in the near future.

Each country is given a scorecard rating as follows:

No material policy effort or intent to promote CHP/DHC. The market is not expected to grow for the foreseeable future. ★☆☆☆☆

Some minor recognition of the role of CHP/DHC, but policies are not fully effective or are otherwise insufficient to influence market development. ★★☆☆☆

There is a clear recognition of the role of CHP/DHC, accompanied by the introduction of some measures to accelerate the market, but CHP/DHC are not high priorities compared to other energy solutions. In addition, the country lacks an integrated CHP/DHC strategy. As a result, market growth is likely to be modest. ★★★☆☆

CHP/DHC is at or close to the top of the list of energy policy priorities and a series of effective policies are being implemented as part of a coherent strategy. Important growth is expected in CHP / DHC markets. ★★★★☆

A world leader in prioritising CHP/DHC, with a clear and proven strategy for bringing about significant market development and the implementation of at least one global best-practice policy measure. ★★★★★

United States Rating: ★★★☆☆

The International CHP/DHC Collaborative

The **International CHP/DHC Collaborative** was launched in March 2007 to help evaluate global lessons learned and guide the G8 leaders and other policy makers as they attempt to assess the potential of CHP as an energy technology solution.

The Collaborative includes the following activities:
- collecting global data on current CHP installations;
- assessing growth potentials for key markets;
- developing country scorecards with data and relevant policies;
- documenting best practice policies for CHP and DHC; and
- convening an international CHP/DHC network, to share experiences and ideas.

Participants in the Collaborative include public and private Partner organisations and other government, industry and non-governmental organizations that provide expertise and support. The Collaborative Network, the larger group that is informed about meetings, publications and outreach, has over 350 participants.

If you are interested in participating in the Collaborative, please visit www.iea.org/G8/CHP/chp.asp.

The **IEA District Heating and Cooling Programme** (IEA DHC) is the major international research and development programme for district heating and cooling. It functions within the IEA's Framework for International Energy Technology Co-operation. The programme conducts highly effective Research and Development as well as policy analysis of District Heating and Cooling systems with low environmental impact through international collaboration. Established in 1983, IEA DHC currently has nine participant countries: Canada, Denmark, Finland, Korea, Netherlands, Norway, Sweden, UK and USA. For more information, visit www.iea-dhc.org.

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