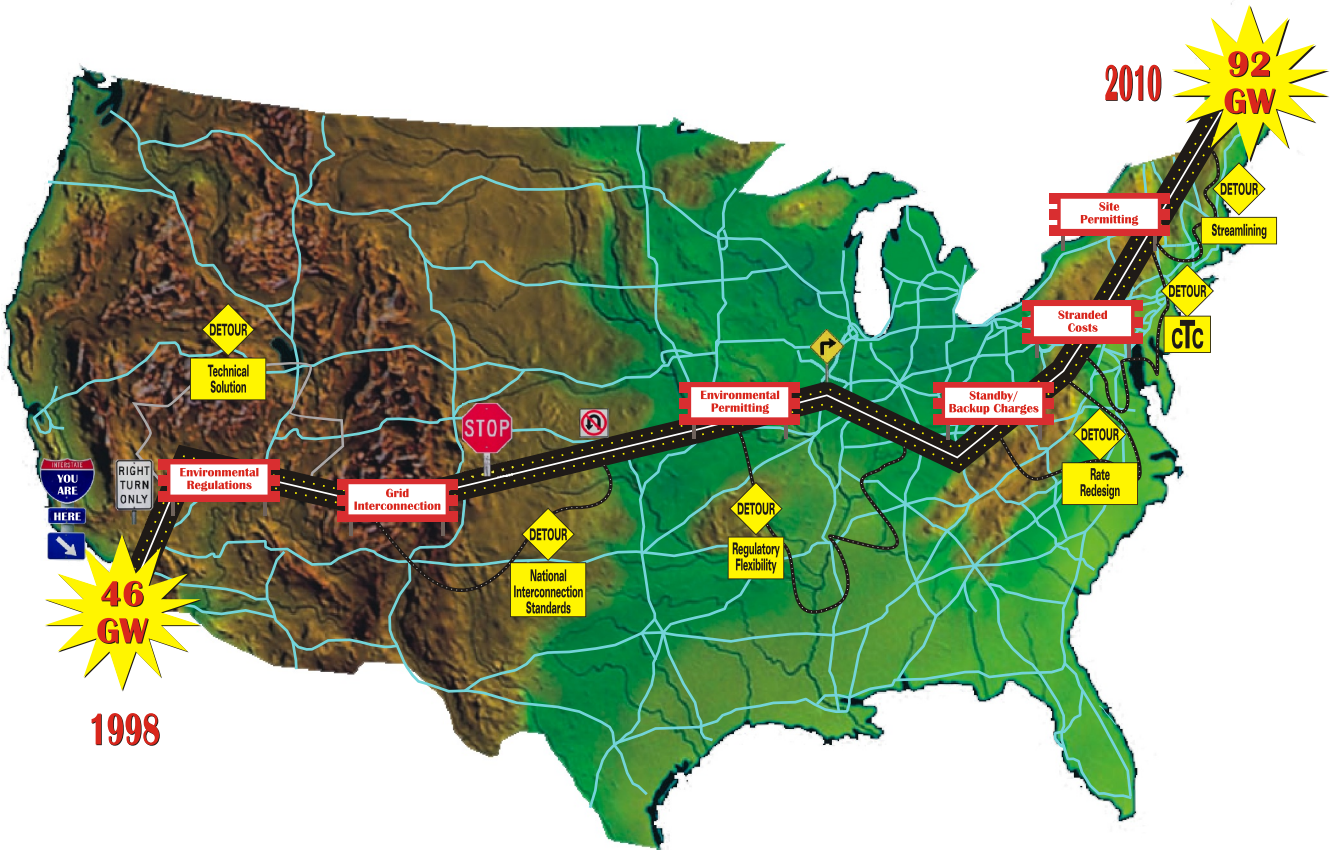
National CHP Roadmap

Doubling Combined Heat and Power Capacity in the United States by 2010



March 2001

United States Combined Heat & Power Association

In Cooperation with

U.S. Department of Energy
U.S. Environmental Protection Agency

A Call to Action

Energy price spikes, power outages, power quality problems, dirty air, global climate change. All of these problems are hitting us at once at the beginning of the 21st century. For example, electricity prices in areas of California have tripled since last year. Information technology industries require higher quality power than our infrastructure can support. And while significant progress has been made we are still far from conquering our environmental problems. Yet we have a solution to address all of these simultaneously. Combined heat and power (CHP) can allow us to make progress in solving ***all*** of these problems.

The following is the National CHP Roadmap, the culmination of more than eighteen state, regional, national, and international workshops, and numerous discussions, planning studies, and assessments over the past two years. Of the many critical issues that have been identified, one point stands out: Because of the problems in energy markets today, unless action is taken soon, the progress America has made over the last decade in the economy and the environment could stall, or possibly even reverse.

> *"America needs CHP now more than ever."*

Simply speaking, the recent surge in energy demand is outstripping America's energy supplies. In fact, several of the energy problems that were only on the horizon when this effort was begun are now reality. And most of the problems that were with us then are still with us today. CHP is a proven technology and is one of our most cost-effective sources of clean energy generation. As a result, *America needs CHP now more than ever.*

The development of this roadmap began at a national conference, the *CHP Summit,* held on December 1, 1998. There the CHP Challenge was issued before an audience of more than 100 executives from Federal and state government agencies, businesses and industries, and non-governmental organizations from across America. The CHP Challenge sets forth a goal to "double the amount of CHP capacity in the U.S. by 2010, as compared to 1998 levels." This means adding approximately 46 gigawatts of new CHP installations by the end of the decade.

The United States Combined Heat and Power Association (USCHPA) is dedicated to achieving this goal. For two years, the USCHPA led the *CHP Vision and Roadmap Process,* which consisted of a series of workshops involving hundreds of individuals from across the country and around the world in high-level discussions to raise awareness about CHP and identify the steps needed to achieve the CHP Challenge goal. The primary aim has been a "call to action" to CHP practitioners, policy makers, and others to identify and eliminate the barriers to and expand the use of CHP in factories, commercial buildings, schools, hospitals, government facilities, urban areas, and power parks.

Now is the time to implement this roadmap and achieve the *CHP Challenge*. Please join us in our quest to double the amount of CHP by the end of the decade. This roadmap outlines a robust course of action to develop CHP across many fronts, with many players. What is needed now is a commitment to accomplishing the goal. Towards this end, the USCHPA is eager to work with all interested parties. The potential national benefits are enormous. Please contact us so we may work with you to advance CHP and build a cleaner, more energy-efficient economy.

John Jimison
Executive Director
U.S. Combined Heat and Power Association

Executive Summary

This National CHP Roadmap[1] is the culmination of a wide array of industry-led activities over the past two years. The origin of these activities was a conference held in Alexandria, Virginia, on December 1, 1998, where the "CHP Challenge" was initiated by the U.S. Department of Energy (DOE) and the U. S. Environmental Protection Agency (EPA) with the goal of doubling the amount of CHP capacity in the U.S. from 46 GW to 92 GW by 2010. The newly formed U.S. Combined Heat and Power Association (USCHPA) accepted the CHP Challenge and agreed to launch a vision and roadmap process to identify how to achieve this goal.

The purpose of this Roadmap is to organize all of the ideas that have been developed over the past two years into a plan for action. Eighteen CHP workshops have been held in locations across the country to convene stakeholders and discuss problems and solutions. These workshops involved almost one thousand individuals, representing equipment manufacturers, electric and gas utilities, energy services companies, architect and engineering firms, project developers, Federal and state agencies, universities, national laboratories, and public interest groups.

This Roadmap charts a course for doubling the amount of CHP capacity in the United States by 2010.

The DOE and EPA have been major supporters of the National CHP Vision and Roadmap process. In addition, the DOE conducts a wide array of research, development, and demonstration (RD&D) programs in technology areas related to CHP such as advanced turbines, microturbines, reciprocating engines, fuel cells, thermally activated and humidity control equipment. In conducting this RD&D, technology plans, technology transfer, and market assessments have been completed. EPA's support has included a re-evaluation of its methods to set emission standards. These efforts have provided useful inputs to the CHP Vision and Roadmap process.

The culminating event was the National CHP Roadmap Workshop held October 12-13, 2000, in Baltimore, Maryland. This workshop brought together representatives from the previous workshops to discuss the progress made and to chart the next steps. As a result, this Roadmap consists of a series of specific actions for raising CHP awareness, eliminating regulatory and institutional barriers, and developing markets and technologies, all aimed at achieving the *CHP Challenge* goal of doubling CHP by 2010.

Major Findings

The major findings of the National CHP Vision and Roadmap process include the following:

- CHP is a win-win-win solution for energy users, energy and equipment suppliers, and society-at-large and produces measurable national benefits for energy efficiency, environmental protection, and economic growth.
- The potential for expanding the use of CHP in the U.S. is enormous. While CHP plays an important role today, expansion possibilities exist in virtually every sector of the economy, particularly industrial plants, commercial buildings, federal facilities, and district energy systems.

[1] A companion document – *Combined Heat and Power (CHP): A Vision for the Future of CHP in the U.S* – was published in June 1999 and discusses the major drivers that are shaping the future of CHP, the barriers that are interfering with CHP development, and the strategic goals that need to be achieved. This document is available from www.nemw.org/uschpa or DOE's web site www.eren.doe.gov/der/chp.

- The possibility of achieving the *CHP Challenge* goal is doable, but certain regulatory and institutional issues need to be resolved, fast. These include grid interconnection, environmental siting and permitting, utility policies and practices, local building codes and standards, and tax treatment.

- Because of the magnitude of the potential national benefits, and that many of the most difficult barriers to CHP development involve regulatory and/or policy solutions, an industry-government partnership of the type represented by this National CHP Roadmap is the best framework to use for achieving the *CHP Challenge* goal.

- Implementation involves a high degree of coordination, partnerships, and leveraging of resources among a wide variety of organizations across the country. Clear identification of roles and responsibilities between the various participants is paramount.

Proposed actions to eliminate regulatory and insitutional barriers interfering with CHP are the centerpiece of this Roadmap.

Action Agenda

This roadmap consists of actions in three primary areas: (1) awareness; (2) regulatory and institutional barriers; and (3) technology and market development. This action agenda is summarized on page vii.

Raise CHP Awareness. There is a tremendous need to educate citizens, business executives, and public policy makers on the merits of clean energy generation the CHP way. Because of the wide variety of audiences that need to be addressed, the strategy is multifaceted. The key elements of this strategy include the following:

- Strengthen existing efforts to build a more effective **industry coalition** dedicated to CHP by joining forces among like-minded trade groups and companies to leverage resources and sponsor targeted education and outreach campaigns

- Support the expansion of existing CHP education and awareness efforts involving **Federal coordination**, particularly those operated by DOE and EPA

- Create new and support existing CHP awareness efforts by **regional and state groups**

Eliminate Regulatory and Institutional Barriers. This set of actions is the centerpiece of this Roadmap. There are CHP systems that are commercially viable today but that developers have trouble getting installed because of roadblocks in siting, permitting, and interconnecting. The key elements of the strategy are to:

- Implement ***uniform interconnection standards*** across utility service territories and states by supporting the standards development process of the Institute of Electrical and Electronic Engineers (IEEE) and working to enable quick implementation of that standard across the country once it is final.

- Develop ***effective and competitively fair utility policies and practices*** including standard commercial practices and business terms and conditions for utility-CHP interconnections; development of "model" rate and tariff provisions for standby charges, exit fees, and competitive transition charges; development of analysis tools and case studies; and the quick and effective establishment of dispute resolution processes.

- Develop ***output-based emissions standards*** by working with the EPA in the analysis of alternative technical approaches, development of guidance to state and local air quality officials, and in the offering of technical assistance.

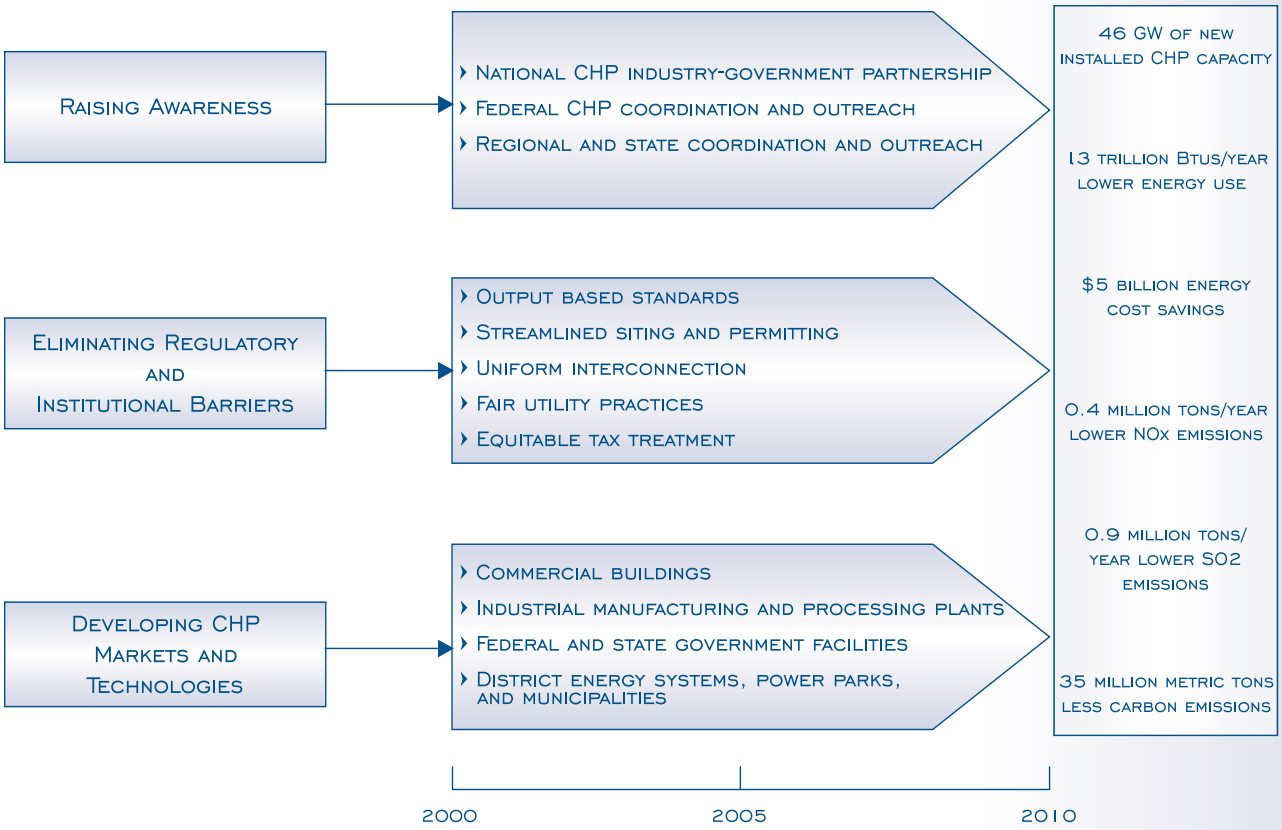
- Develop ***streamlined siting and permitting processes*** for CHP installations including pre-certification of small, packaged CHP systems; development of permitting guidance for local zoning, building, fire, and safety code officials; develop of "model" codes for policy makers; and development of tool kits for developers.

- Develop ***equitable tax provisions*** for CHP equipment so that depreciation schedules and other tax treatments are comparable and consistent for CHP vis a vis other power generation equipment.

Developing CHP Markets and Technologies. CHP currently accounts for approximately 40 percent of the nation's non-utility generation capacity and 7 percent of total generation capacity. Doubling CHP capacity by 2010 involves raising awareness and eliminating barriers as mentioned above. It also involves concerted actions in each of the four primary target market sectors to develop better technologies, integrated CHP system packages, and strategies for selling those systems to potential end users. The key elements of the strategy are to:

- Install ***27 GW of additional industrial CHP*** capacity by replicating "best practices," supporting the use of output-based emissions standards in more states and by EPA, and in participating in cost-shared RD&D projects with Federal and state government agencies in the areas of advanced industrial power generation, black liquor and biomass gasification, advanced materials and combustion processes, and advanced power electronics, communications, and controls.

National CHP Roadmap



- Install ***8 GW of additional buildings cooling, heating, and power*** capacity by implementing the BCHP Roadmap; conducting a coordinated outreach campaign to educate architects, building designers, and local building and other code officials about BCHP; providing "SWAT" team technical assistance to those interested in installing BCHP systems, and participating in cost-shared RD&D projects with Federal and state government agencies in the areas of packaged system integration, power electronics, communications and controls, fuel cells, microturbines, reciprocating engines, and thermally activated cooling and humidity control equipment.

- Install ***8 GW of additional district energy*** capacity by expanding education and outreach efforts to municipal and community governments, college campuses, and military bases; providing "how-to" guidebooks to those interested in installed district energy systems; and advocating more demonstration projects of innovative applications in power parks, communities, "brownfield redevelopment", and public housing projects.

- Install ***5 GW of additional CHP capacity in federal facilities*** by working with the Federal Energy Management Program (FEMP) and federal sites to identify new sources of funding for the installation and operation of CHP systems; conducting assessments of CHP opportunities in federal facilities nationwide; working with FEMP to provide technical assistance to facility managers interested in installing CHP systems; and conducting case studies to demonstrate all forms of CHP in Federal facilities across a wide range of building types, agencies, and regions of the country.

Acknowledgements

The USCHPA would like to thank the many organizations and individuals who have contributed to the development of this National CHP Roadmap:

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Introduction

The Situation Today

The nation has been experiencing one of the longest periods of sustained economic growth in U.S. history. During this period, significant progress has been made in addressing some of the nation's most pressing environmental challenges. For example, the U.S. EPA reports that emissions of certain air pollutants have measurably declined since the late 1980s.[2] As a result, the once strongly held belief that it is not possible to improve the environment without slowing the economy has been proven false.

Unfortunately, even with the progress that has been made, problems with energy and the environment are back on the front pages and rapidly rising to the top of the public's policy agenda. Perhaps it can be said that the robust economy has become a victim of its own success, for the expanding economy has led to a surge in energy demand, particularly in the demand for electricity to power the burgeoning e-commerce sector. This in turn has put the energy supply sector under stress to respond. So far, the response has not been smooth. This past summer, for example, California experienced unprecedented electricity price spikes and severe power supply constraints. Natural gas prices are also on the rise, and supplies of home heating oil are expected to be tight this winter as well.

In addition, while it is evident that progress has been made in cleaning up the environment, most of the country's urban centers remain classified as "non-attainment areas." To improve air quality and come into compliance with the Clean Air Act, many states and local jurisdictions are searching for clean power generation solutions to lower environmental emissions.

The bottom line is simple: Without immediate action to address the problems, the recent record of economic and environmental success will stall, or possibly even reverse.

CHP — What's in a Name?

Combined heat and power. Cooling, heating, and power. District heating and cooling. District energy systems. Cogeneration. Buildings cooling, heating, and power. These are similar terms for a single concept known for more than a century. In converting fuel to electricity, approximately two-thirds of the energy input is released to the environment during the conversion process and not used for productive purposes. Technologies that use this "wasted energy" for making steam, heating water, or refreshing a desiccant humidity control device are known as CHP systems. CHP makes greater use of the fuel inputs by producing multiple products – electricity and usable thermal energy. The average efficiency of the typical power plant in the U.S. is approximately 33 percent; however, CHP systems can reach efficiency levels of 70 percent or greater. CHP is considered by many as the best pollution prevention practice in the energy generation industry.

National Problems – National Needs

Our country faces many energy problems that *must* be overcome in order to continue our economic and environmental successes of the past decade.

Reliability of the Electric Grid. Approximately 15,000 power plants deliver more than 3 trillion kilowatt-hours (kWh) of electricity annually with approximately 99.7 percent (almost "three nines") reliability. Three nines means about 8 hours of outages per year for the typical customer. Hospitals, telecommunications centers, airports, and critical fire and safety facilities have

[2] U.S. Environmental Protection Agency, *National Air Pollutant Emission Trends, 1900-1998*, August 2000.

required more than three nines for years. The burgeoning e-commerce sector operates equipment that is said to require "six nines" of reliability, or 30 seconds of outages a year. Our current power grid simply can not keep pace with these demands. Onsite generation is the only way to ensure this level of reliability.

Quality of Power from the Grid. Even with high reliability, voltage surges and sags can damage sensitive electronic components. Even minor power anomalies can permanently affect digital equipment and appliances. Facilities located on the outskirts of the grid are particularly vulnerable to power quality disruptions. Needs for better power quality have been increasing across the country while at the same time certain regions have been experiencing power supply constraints.

Aging Energy Infrastructure. The nation's stock of heavy-duty, capital-intensive energy equipment – e.g., power plants, boilers, natural gas pipelines, and electricity transmission and distribution systems – has yet to be upgraded for the digital age. Much of this stock dates from the 1950s and 1960s and is due for replacement. The capital requirements over the next 10-20 years will be substantial. It is expected that at least $180 billion will be needed by 2010 for electric capacity additions alone.

Rising Energy Prices. Constraints in power supplies, fuels, refining capacity, and pipeline capacity have put upward pressure on energy prices. In San Diego last summer, for example, electricity bills for some customers were fully three times higher than the previous year. Natural gas prices are also on the rise at the point of consumption.

Air Quality. Air quality is a major public health concern. While cars and trucks are a major source of the problem, energy generation systems are also major contributors. Common solutions involve capital expenditures in costly pollution abatement equipment, which is a rising component of electricity costs. "Pollution prevention" techniques can be a cheaper and more effective alternative.

E-Commerce

An important source of new electricity growth is e-commerce. The increase in the use of computers exceeds levels predicted by most energy forecasters, and the commercial centers that house the computing facilities needed to handle the rise in internet traffic each require a new power supply equivalent to the addition of a major new industrial plant. These centers are sprouting up across the country and are demanding levels of reliability that far exceed what the existing system was designed to deliver.

Why CHP Now?

Fortunately, there is an energy solution available right now that can help address these problems today. CHP uses less energy, produces less emissions, and accomplishes more work than equivalently sized conventional energy generation facilities. CHP offers win-win-win solutions by attacking energy, economic, and environmental problems.

CHP is not a new technology, especially in large industrial applications, hospitals and university campuses, and district energy systems in urban areas. In fact, the nation's first commercial power plant, Thomas Edison's Pearl Street Station, which began operations in New York City in 1882, served lower Manhattan with *both* electricity for lighting and steam for local manufacturing. The Public Utilities Regulatory Policy Act of 1978 (PURPA) stimulated CHP capacity growth from approximately 12 GW in 1980 to 45 GW by 1995. By 1995 the pace of CHP installations had stalled due to uncertainties of the changing electricity marketplace.

Recent developments in the availability of new generation equipment — such as advanced reciprocating engines, combustion turbines and fuel cells — present an opportunity to deploy CHP in manufacturing plants, buildings, and in district energy systems. The technology development that has enabled CHP has been made possible by coordinated research efforts within the academic, industry and government sectors over the last quarter century. While there are opportunities to further develop these important technologies, CHP systems are now both available and cost-effective.

CHP Size Range Categories

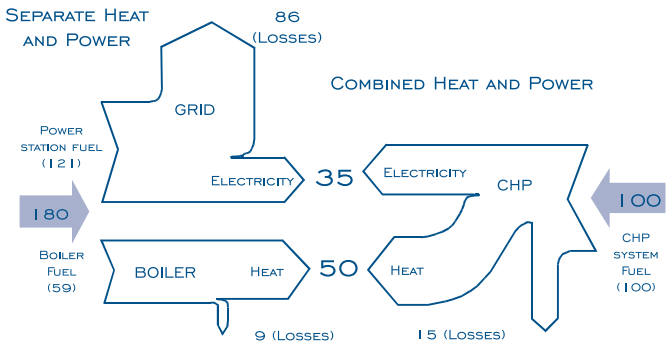
Micro	Less than 500 kW
Mini	500 kW to 2 MW
Small	2 MW to 15 MW
Medium	15 MW to 40 MW
Large	Greater than 40 MW

Source: ACEEE

The potential benefits from increasing the use of CHP and accomplishing the CHP Challenge goal by 2010 are enormous. Doubling the amount of CHP capacity in the U.S. could annually produce:

- 46 GW of new, clean electric capacity
- $5 billion in energy cost savings
- 1.3 trillion Btus per year in reduced energy consumption
- 0.4 million tons reduction in NO_x emissions
- 0.9 million tons reduction in SO_2 emissions
- 35 million metric tons reduction in carbon equivalent emissions

CHP Uses Less Energy



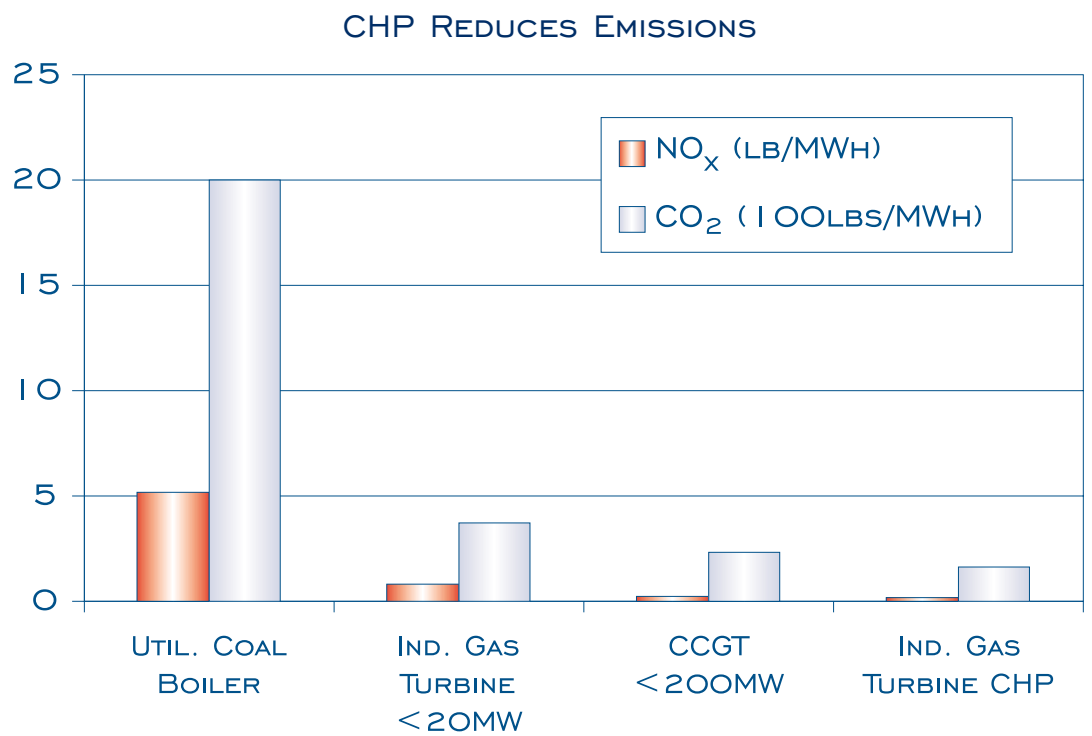
Source: Kaarsberg 1998

History of the CHP Vision and Roadmap Process

The origin of the process was the *CHP Summit*, a national CHP conference that was held on December 1, 1998, in Alexandria, Virginia. At the Summit, the U.S. Department of Energy (DOE) joined with the U.S. Environmental Protection Agency (EPA) and the newly-formed U.S. Combined Heat and Power Association (USCHPA) in launching the *CHP Challenge* initiative.

Following the Summit, in February 1999 at the 3rd Industrial Energy Efficiency Symposium and Exhibition, the USCHPA announced it was launching a *CHP Vision and Roadmap* process to outline specific goals, barriers, strategies, and actions with respect to the CHP Challenge goal of doubling U.S. CHP capacity by 2010. In June 2000, the first major step in the vision and roadmap process occurred when the *CHP Challenge Vision Workshop* was held in Washington, D.C. The result of this workshop was the USCHPA document entitled "*Combined Heat and Power (CHP) - A Vision for the Future Of CHP in the U.S. in 2020*."[3] This document outlines, in broad terms, a national vision of the future for CHP in the U.S. and the major barriers and strategic goals that need to be addressed in achieving it.

[3] The CHP Vision is available by contacting the USCHPA at 202-955-6067, or it can be downloaded in pdf format from the USCHPA's web site www.nemw.org/uschpa or from DOE's web site, www.eren.gov/der/chp.



Source: EEA, Inc. 2000

The fairest way to compare emissions is to use an output-basis in which total emissions are divided by total usable output from the system. For a CHP system, this is the sum of the usable power and thermal energy converted into common units, usually MWh. The high efficiency of CHP systems produces very low emissions, especially when compared to electricity-only generation systems. Emission rates are frequently even lower than the cleanest, most efficient electric-only generation technology, large combined-cycle gas turbines (CCGTs).

During this same time period, a second group of CHP practitioners met to discuss the potential for expanding CHP in the buildings sector. Because of the special complexities of accomplishing CHP in buildings, this group formed the *Buildings Cooling, Heating and Power (BCHP)* Initiative, with the aim of identifying and overcoming specific policy, market, and technology barriers. This effort has resulted in a draft roadmap document outlining a course of action and a wide range of activities for developing and deploying CHP systems for heating, cooling, power, and humidity control in commercial buildings.[4]

On February 1, 2000, at the 1st International CHP Symposium in Washington, D.C., leaders of the CHP Challenge and BCHP Initiative joined forces with the International District Energy Association and DOE to sign the *Combined Heat and Power Compact - Clean Energy for the 21st Century*. This event underscored the commitment of participants to accomplish the CHP Challenge goal.

As a result of these activities, the CHP Challenge and the BCHP Initiative have succeeded in raising the general level of awareness in CHP and have sparked on-going dialogues about CHP in virtually every region of the country. In fact, over the past eighteen months, a series of CHP workshops have been held at locations across the country with the intent of "spinning off" local efforts to increase the use of CHP. The following is a list of the key events that have taken place since the CHP Challenge began.

[4] The BCHP Roadmap can be downloaded in pdf format from the BCHP web site, www.bchp.org.

List of CHP Workshops

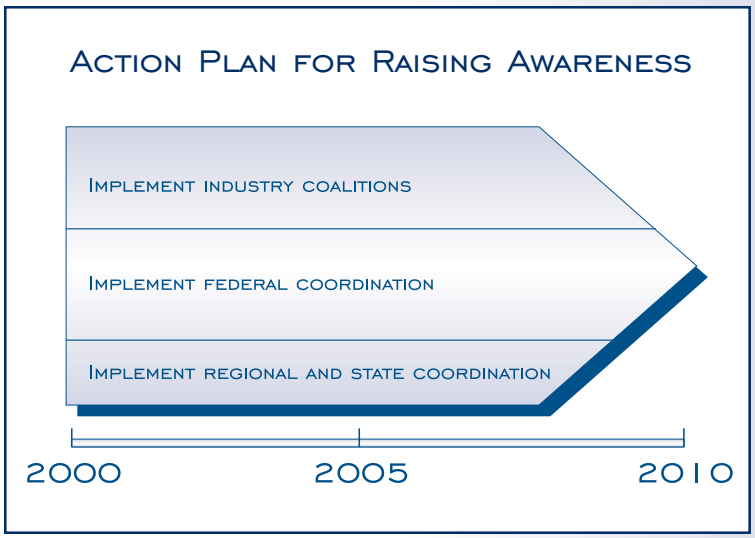
Date	Event	Location
December 1, 1998	CHP Summit	Alexandria, Virginia
March 1, 1999	CHP Data Workshop	Washington, DC
March 11, 1999	BCHP "Founders" Meeting	Chicago, Illinois
April 25, 1999	Maine CHP Workshop	Portland, Maine
June 1-3, 1999	BCHP Roadmap Workshop	Chantilly, Virginia
June 8 – 9, 1999	National CHP Vision Meeting	Washington, DC
June 28, 1999	CHP Analysis Workshop	Washington, DC
October 6, 1999	New York CHP Workshop	Albany, New York
November 8-9, 1999	BCHP Technology Workshop	Chicago, Illinois
November 10 – 11, 1999	Lake Michigan Regional CHP Roadmap Workshop	Chicago, Illinois
January 12-13, 1999	BCHP Process Workshop	Washington, DC
January 19 – 20, 2000	Northeast Regional CHP Roadmap Workshop	Piscataway, New Jersey
February 1-2, 2000	International CHP Symposium	Washington, DC
March 7 – 8, 2000	Pacific Northwest Regional CHP Challenge Workshop and Expo.	Seattle, Washington
March 20-21, 2000	BCHP Policy Workshop	College Park, Maryland
April 6, 2000	Upper Northeast CHP Workshop	Orono, Maine
May 16, 2000	New Mexico Summit on Combined Heat and Power	Albuquerque, New Mexico
August 14-15, 2000	Texas CHP Workshop	Houston, Texas
October 11-12, 2000	National CHP Roadmap Workshop	Baltimore, Maryland

Structure of the National CHP Roadmap

This roadmap consists of three main actions: raising awareness, eliminating regulatory and institutional barriers, and developing markets and technologies. The remainder of the roadmap consists of chapters devoted to each of the three actions, a concluding chapter on implementation of this roadmap, and several appendices with lists of participating organizations, CHP resources, and key contact information.

2. Raising CHP Awareness

One of the most significant barriers facing CHP is the lack of understanding about it. CHP, by its very nature, can be technically complex and does not fit easily into the existing energy paradigm in the U.S. The difficulties are compounded by misunderstandings about the relationship between CHP and related concepts such as distributed generation and distributed energy resources.



The existing energy paradigm uses a business model with large, central-station power generation facilities located far from their end users. Yet the system did not start out that way. Thomas Edison's original vision, as exemplified by his Pearl Street Station, involved building local energy facilities that distributed electricity and thermal energy short distances to nearby factories. But in 1896 George Westinghouse and Nikola Tesla invented a method to transmit electricity cost-effectively over long distances using alternating current. This allowed electricity to be produced at a remote location, such as Niagara Falls, and used in an urban area, such as Buffalo.

Many early electricity generation facilities were industrial plants that added generators to their existing steam systems. As the electric power business matured, the relative costs and benefits of on-site versus centrally generated energy shifted. Sprawling economic development patterns coupled with increasing economies of scale in power generation led to today's energy system. While electricity can be transmitted economically over long distances, thermal energy cannot. One of the unfortunate results of this pattern of development is that both power generation and thermal energy applications turned down separate and less efficient paths.

The challenge before us today is to educate citizens, business executives, and public policy makers on the merits of clean and efficient energy generation the CHP way. Locating facilities on-site or near where energy is used offers tremendous benefits in terms of lower energy use, lower emissions, and better local control over power quality and reliability.

Because of the wide variety of audiences that need to be addressed, the strategy for raising awareness is multi-faceted. The key elements of this strategy are:

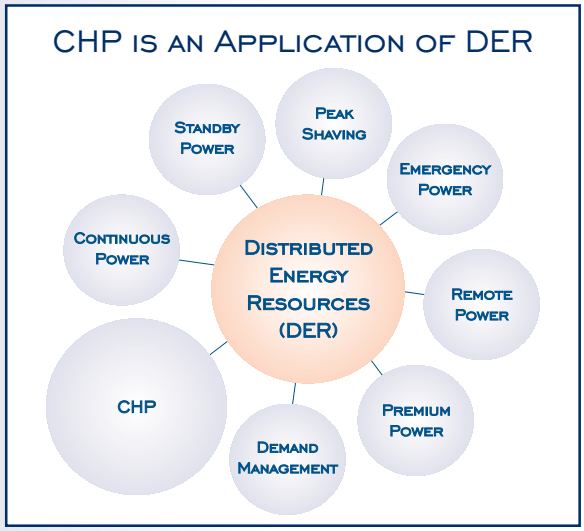
Taxonomy of Terms

Distributed Generation: Involves any technology that produces power outside of the utility grid. Includes prime movers such as combustion turbines, engines, fuels cells, wind turbines, and solar energy systems. This equipment may be operated either in parallel with or independent of the grid.

Distributed Power: Includes all distributed generation technologies plus energy storage.

Distributed Energy: Includes all distributed generation and power technologies plus demand-side measures such as energy management, energy-efficient equipment such as lighting, heating cooling and refrigeration systems, as well as load management and peak shaving devices.

Emergency Power: Onsite power generation equipment, usually diesel engines, and storage device such as batteries intended to be operated for limited periods when service is interrupted due to utility outages.



- To strengthen existing efforts to build a more effective **industry coalition** dedicated to CHP by joining forces with like-minded associations and trade groups to leverage resources and sponsor targeted information dissemination efforts and outreach campaigns
- To support the expansion of existing CHP education and awareness efforts involving **Federal coordination**, particularly those being operated by DOE and the EPA
- To call for the creation of new and support existing CHP awareness efforts by **regional groups and the states**

Industry Coalition

The USCHPA has joined several other industry trade organizations in the implementation of this **National CHP Roadmap**. In addition, other industry organizations, private businesses, national laboratories, and non-governmental organizations have been active participants. Many challenges for this group lie ahead.

National CHP Coalition. The key organizations who have been involved include: American Gas Cooling Center (AGCC), Buildings Cooling, Heating, and Power (BCHP) Initiative, Distributed Power Coalition of America (DPCA), and the International District Energy Association (IDEA). Other national-level industry organizations have been active in the Vision and Roadmap Process, including the Gas Technology Institute (GTI), American Gas Association (AGA), Council of Industrial Boiler Owners (CIBO), National Association of Energy Services Companies (NAESCO), International Federation of Industrial Energy Consumers - North America (IFIEC), and the American Forest and Paper Association (AF&PA). Participating companies include: Solar Turbines, Trigen, Onsite-Sycom, Dow, Duke Solutions, Energetics, Exergy Partners, Honeywell, Keyspan, Mississippi Valley Gas Company, NiSource, Northwind Boston, Southern California Gas Company, Tecogen, and Weyerhauser. Participating non-governmental organizations and national laboratories include: the American Council for an Energy Efficient Economy (ACEEE), the Alliance to Save Energy (ASE), the Northeast-Midwest Institute (NEMW), Oak Ridge National Laboratory (ORNL), the National Renewable Energy Laboratory (NREL), and Pacific Northwest National Laboratory (PNNL).

BCHP Initiative

This initiative is an industry-government RD&D partnership to promote the development and deployment of CHP systems in commercial, institutional, and multi-family buildings to meet a full spectrum of energy needs. More than 200 individuals have participated in the BCHP Initiative since its inception in 1999 and in the development of the BCHP Technology Roadmap (www.bchp.org). The aims of the initiative are to improve the energy efficiency of buildings, reduce air pollution and greenhouse gas emissions, and improve indoor air quality through the integration of small scale power generation equipment (e.g., microturbines, fuel cells, reciprocating engines) and thermally activated heating, cooling, and humidity control equipment (e.g., absorption chillers and desiccants).

Critical actions needed within the next year to strengthen the national industry CHP coalition include the following:

- Formation of a formal **"multi-trade group" CHP coalition** to enable joint education and outreach initiatives, seminars, and conferences
- Expansion of the USCHPA **product and service offerings** to include more education and outreach materials targeted to state and local energy, environmental, and economic development officials
- Development of **unified points of view** on issues of common interest related to expanding the prospects for the development and deployment of CHP systems
- Continued active participation in and support for **industry-government RD&D partnerships** for the development of "next generation" CHP systems, subsystems, and components

Federal Coordination

DOE and the EPA are valuable partners in the development and implementation of this National CHP Roadmap. Their participation will secure the national public benefits from the expanded use of CHP systems by the industrial and buildings sectors, Federal facilities, and district energy systems. The Department of Treasury is also working with USCHPA by considering revisions to the tax code so that CHP systems will be subject to the same tax treatment as similar types of equipment used for other purposes.

Critical actions needed by DOE include the following:

- **Expand RD&D programs** in the Office of Energy Efficiency and Renewable Energy, Office of Power Technologies in the area of Distributed Energy Resources that affect CHP, including on-going efforts in advanced turbines, microturbines, reciprocating engines, fuel cells, thermally activated equipment, grid interconnection systems, power electronics, advanced materials, and communications and controls systems
- Continue **CHP education and outreach activities** including maintenance of the CHP website and the CHP Registry, support to the CHP EnergyStar® Awards (with the EPA), and CHP assessments
- Through the **Federal Energy Management Program**, expand efforts to identify candidates for CHP installations in Federal facilities and obtain funding for accomplishing appropriate projects

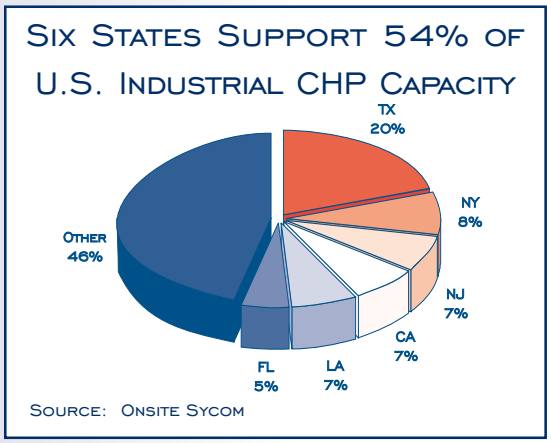
Critical actions identified by EPA include the following:

- Continue efforts to promote the use of **output-based "Best Available Control Technology" (BACT) standards** through the development of guidance for the states

EnergyStar® CHP Awards

The *Combined Heat and Power (Cogeneration) EnergyStar® Award and CHP Certificate of Recognition* is a new joint EPA-DOE program to recognize cost-effective, high-efficiency CHP projects. Awards are given to qualifying projects that use at least 10% less fuel than separate heat and power generation. To be eligible for an Award, projects must have twelve months and 5,000 hours of operating data, and thermal energy must comprise between 10 and 90 percent of the total net system output. The CHP facility must be operating within existing emission permit levels to apply. A Certificate of Recognition is available to projects with less than one year of operation for showing leadership in environmental performance without achieving the strict award criteria. For applications for the 2nd Annual CHP EnergyStar® awards, contact Christian Fellner at (202)564-2664 or fellner.christian@epamail.epa.gov.

- Implement a stronger **outreach program to facilitate CHP project development** in a few key states by offering technical assistance, policy/permitting guidance, and public recognition
- Prepare, and disseminate widely, a white paper that provides objective information on the **environmental benefits of CHP systems** in relation to other energy supply alternatives
- Coordinate the 2nd Annual **CHP EnergyStar®** Awards



Regional and State Coordination

The government officials on the "front lines" in the siting, permitting, and interconnecting of CHP facilities are state and local energy and environmental regulators and local zoning and building, fire, and safety code officials. The scope of the education and awareness effort to reach these individuals is enormous. There are 50 states and more than 10,000 counties, towns, and local jurisdictions. The Vision and Roadmap Process has included a series of regional and state workshops. The aim of these events has been to catalyze local actions and spur regional and/or state CHP roadmap efforts. The following states have had representatives participating in the various CHP events over the last two years:

- Connecticut
- Idaho
- Illinois
- Indiana
- Maine
- Massachusetts
- Michigan
- Montana
- New Hampshire
- New Jersey
- New Mexico
- New York
- Oregon
- Pennsylvania
- Texas
- Vermont
- Washington
- Wisconsin

The regional workshops resulted in a series of suggestions about the steps needed to expand the installation of CHP systems. Participants in the workshops expressed their views about the relative priority of the actions that need to be done.

Critical actions needed by the regions and the states include the following:

- Build state and regional **information exchange networks** to expand communications on CHP and related energy environmental, and economic development-related policy issues.

- Obtain **financial assistance** from state (e.g., public benefits funds) and federal sources (e.g., U.S. DOE and EPA grants) for local CHP education and awareness activities
- Address top priority **regulatory and institutional barriers** to the expanded deployment of CHP systems

CHP Action Priorities Identified at the Regional Workshops

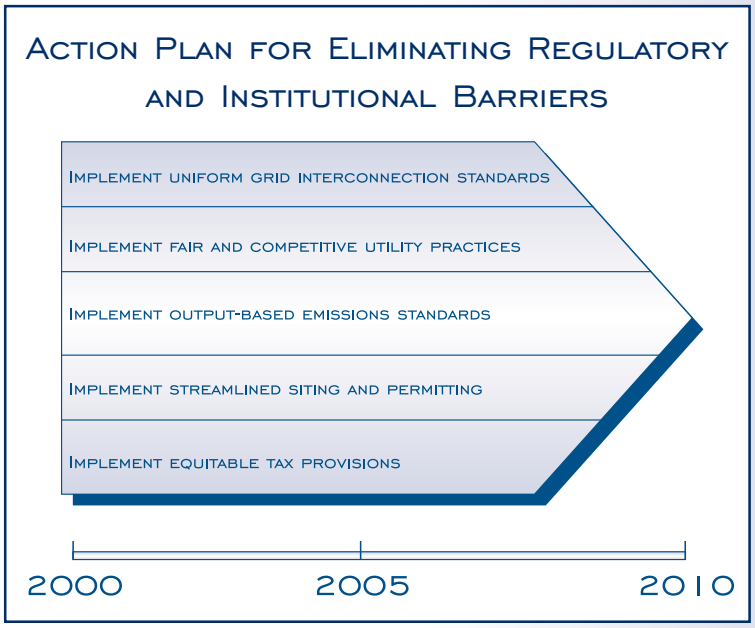
Lake Michigan Region (IL, IN, MI, WI)	Pacific Northwest Region (ID, MT, OR, WA)	Northeast Region (CT, NJ, NY, PA)	New England Region (MA, ME, NH, VT)
• Create uniform and streamlined interconnection standard • Create uniform and streamlined environmental siting and permitting • Write regional CHP website and handbook	• Create uniform and streamlined interconnection standards • Showcase demonstrations of successful CHP projects • Provide technical assistance to expand district energy CHP projects	• Implement a legislative strategy for CHP-friendly restructuring and environmental rules • Conduct detailed grid studies quantifying the costs and benefits of CHP installations • Create uniform and streamlined environmental siting and permitting	• Address unfair utility practices and embedded disincentives • Mandate CHP installations in state facilities • Petition PUC to "rethink" utility business practices vis a vis CHP • Implement environmental credits for CHP Install regional CHP website

3. Eliminating Regulatory and Institutional Barriers

The CHP Vision outlines a number of regulatory and institutional barriers that interfere with the expanded use of CHP systems in the U.S. The presence of these barriers was confirmed at each and every one of the regional and state CHP workshops. The elimination of these barriers is the centerpiece of the National CHP Roadmap.

The most pressing regulatory and institutional barriers facing CHP include the following:

- Irregular interconnection requirements
- Unjustified and costly standby and backup power charges
- Prohibitive stranded cost-recovery charges and exit fees
- Air regulations that do not recognize the environmental superiority of CHP
- Irregular environmental permitting procedures
- Time consuming and confusing site permitting (e.g., zoning, building, fire, and safety codes)
- Inconsistent tax treatment and depreciation policies



Uniform Grid Interconnection Standards

The problems that many project developers have experienced interconnecting with the utility grid are not limited to CHP installations. Many on-site and distributed energy generation projects – e.g., rooftop photovoltaic installations, wind turbine projects, industrial self-generation systems, and backup power supplies – encounter similar interconnection difficulties. In a number of cases, particularly for smaller-sized projects, utility interconnection costs can be "deal breakers." Utility interconnection requirements often go beyond the minimum standards needed to ensure safe and reliable grid operations. Requirements vary across service territories and states and have been known to vary on a project-by-project basis. The market for CHP will not develop on a large scale until there is a national solution to the interconnection issue.

IEEE Interconnection Standard - P1547

The P1547 working group of the IEEE SCC 21 committee is developing a voluntary standard for interconnecting distributed resources with electric power systems, including CHP systems. The working group has more than 300 participants, representing every facet of the power community. Current plans call for an IEEE Standard to be published by the end of 2001.

In general, the technical interconnection requirements of the utilities for engineering, reviews, technical inspections, operating limits, feasibility studies, and design criteria stem from concerns about worker safety and grid stability. The electric distribution system has not been designed to handle two-way power flows, and utilities are reluctant to rely on customer-supplied protective relays. Integrated "interconnection packages" are not generally known or accepted by the industry.

Interconnection issues are being addressed. Vendors have developed equipment packages that integrate protective relaying and power conditioning systems. The Edison Electric Institute and the U.S. Department of Energy have recently published reports documenting interconnection problems.[5] Several states are attempting to address interconnection as part of their utility restructuring programs (e.g., New York, California, Vermont, Texas, and Delaware.) The Clinton Administration's proposed electricity restructuring legislative package, the *Comprehensive Electricity Competition Plan*, contains a provision for encouraging standardization of grid interconnection. And the Institute of Electrical and Electronic Engineers (IEEE) Standards Coordinating Committee (SCC) 21 is developing voluntary interconnection standards for fuel cells, photovoltaics, dispersed generation, and energy storage. CHP interconnection is also being addressed in the IEEE process.

Recent State Actions on Interconnection

In December 1999, Texas and New York adopted rules aimed at reducing the interconnection to small power systems. New York forbids "interconnection studies" for systems under 10 kW. Texas forbids the utility from charging customers for the costs of such studies for certain types of distributed energy systems. In addition, the Texas rule sets a time limit for such studies to 4 weeks or less, requires utilities to file written reports of the findings, requires that customers know in advance the costs of such studies, and requires that the studies consider costs and benefits.

Continuation of these efforts is a vital part of this National CHP Roadmap to achieve the CHP Challenge goal. Critical actions needed over the next several years to strengthen ongoing interconnection efforts include the following:

- Support efforts by the states to include streamlined **interconnection procedures** in their utility restructuring implementation plans
- Propose **Federal legislation** for interconnection of distributed energy facilities and CHP for the next administration and the 107th Congress.
- Support efforts by the IEEE to develop **uniform interconnection standards** that cover CHP systems and their implementation by the states and utilities

Utility Policies and Practices

There are a variety of utility policies and practices whose effect is to place severe limits on the viability and cost effectiveness of CHP installations. CHP developers can document examples of promising installations being abandoned, delayed, or made more costly than necessary because of various actions by utilities. These actions include, for example:

- Direct prohibition by the local utility from operating and interconnecting an on-site CHP system in parallel with the grid

[5] Instances of unnecessary utility interconnection requirements are documented in the U.S. Department of Energy report, *Making Connections – Case Studies of Interconnection Barriers and Their Impact on Distributed Power Projects*, May 2000, NREL/SR-200-28053 and the *Edison Electric Institute Distributed Resources Task Force Interconnection Study*, an unpublished draft report.

- Utility tariff provisions that are seen to discourage CHP, such as demand charges and backup rates, buy-back rates, exit fees, "uplift" charges, and competitive transition or stranded cost recovery charges
- Transmission access procedures, rules, and costs
- Selective discounting of utility services to large customers to prevent the use of on-site generation

The lack of standard utility procedures and business practices for dealing with distributed energy projects has led to numerous delays and expenses and is one of the most frequently voiced complaints from CHP and distributed energy developers. Problems range from a lack of a single contact person to open-ended initial price quotes for back-up services. Utilities lack data and analysis tools for assessing the impacts and costs of adding distributed energy and CHP projects. The existing utility regulatory framework is not generally compatible with the distributed energy business model and the need for additional on-site power generators, including CHP. Distributed energy issues were not at the forefront of policy deliberations at the outset of the utility restructuring process. As a result, utility restructuring legislation and regulations being adopted by the states are only now beginning to include provisions for distributed energy systems.

Coordinated efforts need to be undertaken on a national basis to address and eliminate utility policies and practices that unnecessarily discourage distributed energy and CHP projects. Implementation of this portion of the National CHP Roadmap needs to include coordination with other members of the distributed energy community such as the Distributed Power Coalition of America and the California Alliance on Distributed Energy Resources. Organizations such as the National Association of Regulatory Utility Commissioners and the National Conference of State Legislators are critical partners in accomplishing the following actions:

- Develop and promulgate **standard commercial practices** and business terms for utilities in their dealings with distributed energy and CHP developers
- Develop and disseminate **"model" utility regulatory principles**, tariffs, and legislative provisions for distributed energy generation and CHP projects
- **Develop analysis tools, data, and case studies** for assessing the value and impacts of distributed energy systems and CHP on local electricity and natural gas distribution systems
- **Establish dispute resolution processes and capabilities** for expediting distributed energy and CHP project proposals

Output-Based Emissions Standards

As a part of its overall pollution prevention strategy, the Federal government is actively working to increase the efficiency of electricity generation in the U.S. Historically, emissions regulations have been based on the amount of fuel required as an input to the generation of electricity. Nitrogen oxide emissions, for example, are measured as pounds of NO_x per million Btu of heat *input*. To illustrate how this standard weakens incentives for increasing energy efficiency of power generation, consider two plants with equal capacity and operating conditions. The

less-efficient plant will be allowed higher emissions under current regulations because it uses more fuel to generate the same amount of electricity.

Implementation of output-based emissions standards is a critical part of this National CHP Roadmap

Therefore, one technique for encouraging power plant owners to reduce emissions by increasing efficiency is through the use of output-based emissions standards. Such standards determine emissions levels based on the amount of electricity (and useful thermal energy) *generated*. In effect, output-based standards require the less efficient plant to account for those emissions that result from the added fuel needed to produce the same amount of electricity. Output-based standards support improved efficiency without regard to the type of fuel or technology used.

The Federal government has expressed its commitment to output-based standards and has taken a number of steps to encourage their implementation. The Clean Air Act requires that each state develop a State Implementation Plan (SIP) detailing the steps it will take to achieve national ambient air quality goals. The EPA, in a recent rulemaking known as the "SIP Call," required 22 states and the District of Columbia to address ozone transport issues by submitting revised SIPs that meet established state budgets for NO_x emissions, which represent substantial reductions from current levels. Proposed was a NO_x budget-trading program that would establish a multi-state trading system for NO_x allowances. Guidance for the states as to how they can use output-based standards to allocate NO_x allowances is under development.

Output-Based Emission Standards

$$\text{EMISSIONS RATE} = \frac{\text{EMISSIONS}}{E_{THERMAL} + E_{ELECTRIC}}$$

Benefits:

- credits efficiency
- technology neutral
- fuel neutral
- provides compliance flexibility
- minimizes emissions

Implementation of output-based emissions standards is a critical part of this National CHP Roadmap. Critical actions needed over the next several years include the following:

- Conduct and disseminate analysis of the relative merits of **alternative technical approaches** to output-based standards and their potential impacts on the use of CHP
- Provide **technical assistance** and information to support continued efforts by the EPA to encourage the use of output-based standards for compliance with the Clean Air Act
- Provide **technical assistance** and information to support efforts by the states to develop and use output-based standards in SIPs

Streamlined Siting and Permitting Procedures

There are thousands of CHP sites in the U.S. today. Doubling CHP capacity means at least doubling the number of sites. If the use of smaller scale CHP systems in buildings increases as expected, the growth in CHP sites could explode. These additions, coupled with growth in other forms of distributed energy generation, could easily overwhelm the ability of siting, permitting, and zoning

officials to respond. Unless changes are made to streamline siting and permitting procedures nationwide, CHP developers can expect even more lengthy delays and unnecessary costs than they face today.

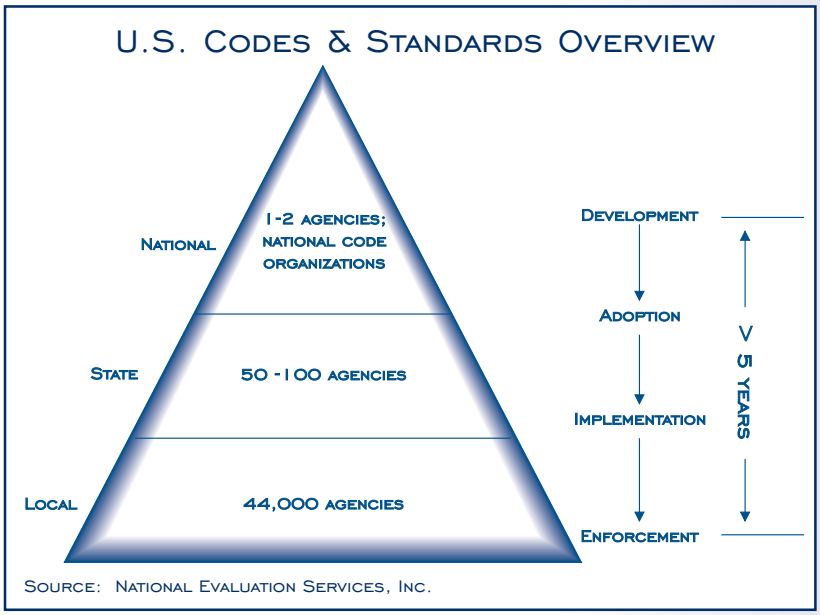
A key facet in siting and permitting CHP facilities is size. The state or local agencies that have approval jurisdiction depend on the size of the project, as do the regulations that apply. For example, the Clean Air Act requires that larger industrial facilities obtain a permit before beginning construction of a new facility or significantly increasing emissions at existing ones. This process is known as New Source Review (NSR). The permitting process differs, depending upon whether the facility is located in an area in which pollution levels exceed national ambient air quality standards (non-attainment areas). Prevention of Significant Deterioration (PSD) procedures apply in non-attainment areas. PSD requirements include the application of "best available control technology" (BACT) on a case-by-case basis.

A recent "triggering" analysis of 62,000 stand-alone boilers in the U.S. by the EPA indicated that CHP conversions would not trigger NSR permits in the vast majority of cases. Nevertheless, NSR permits are an issue for larger size CHP installations.

The expanded use of smaller CHP systems in buildings will be greatly affected by manufacturing, performance, installation, and operational codes and standards. There are more than 44,000 state and local jurisdictions in the U.S. Manufacturing codes and standards affect the materials, design, and construction of individual units and are published by organizations such as Underwriters Laboratories (UL). Installation and operations codes and standards address electrical, fire, and worker safety issues and are developed and published by organizations such as UL, the American National Standards Institute (ANSI), the National Fire Protection Association (NFPA), the Electrical Generating Systems Association (EGSA), the American Society for Testing and Materials (ASTM), the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE), and IEEE. Land use, zoning, and building construction codes and standards will be increasingly affected by the expanded use of smaller scale CHP in buildings.

A number of important national actions are needed to streamline the siting and permitting process for CHP developers including:

- Develop **CHP permitting guidance** and protocols for state environmental officials including pre-certification of certain CHP equipment
- Conduct national campaign to engage manufacturers, utilities, and others in developing **code changes** for adoption by the model code agencies



- Develop **siting and permitting guidelines and tool kits** for CHP designers, developers, and installers on a state-by-state basis
- Develop **pre-certification standards and permits-by-rule provisions** for certain types of small scale facilities

Equitable Tax Treatment

Equipment used in CHP systems may qualify for one of several tax treatment categories depending on configuration of the system and ownership, so that the resulting depreciation schedule ranges from 5 to 39 years. According to current federal tax laws, systems larger than 500 kW have a tax life of 15-20 years. In contrast, a similar engine used to power airplanes or industrial equipment has a 5 to 7 year tax life. Accelerating the depreciation of CHP equipment from 15 to 20 years to 5 to 10 years will improve the economics of investing in CHP systems and reduce the cost of project financing. The U.S. Treasury Department is currently considering ways to standardize depreciation tax life and provide a depreciation schedule for CHP that better reflects the 7-10 year operating life of the equipment:

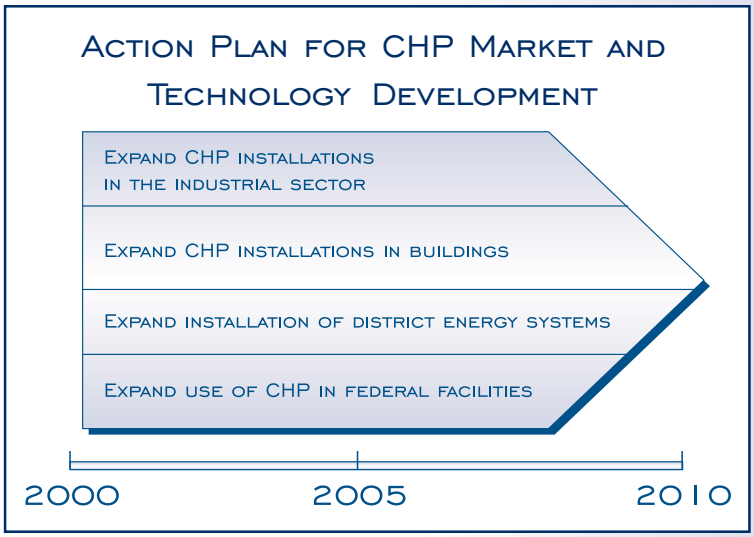
Action is needed to make the tax treatment of CHP systems more equitable.

- Support efforts to **revise the U.S. tax code** and define an accelerated depreciation schedule for CHP systems that is closer in line with the expected 7-10 year engineering life of CHP equipment

4. Developing CHP Markets and Technologies

Overview

In 1999 the electric power capacity of the U.S. totaled approximately 780 GW. Of this amount, non-utility generation totaled approximately 140 GW, a figure that has doubled since 1997, because several major utilities have recently decided to "spin-off" power generation assets and form non-utility subsidiaries.

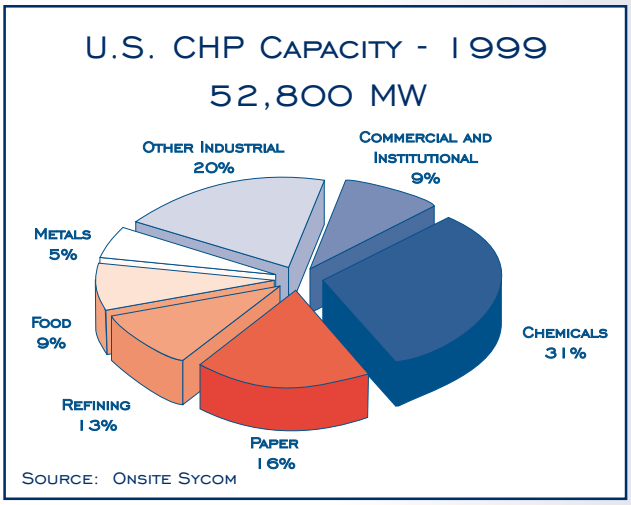


CHP capacity in the U.S. in 1999 totaled almost 53 GW, which amounts to about 40 percent of non-utility and 7 percent of U.S. electric capacity.[6] There are currently more than 2100 CHP sites in the U.S.

Primary CHP technologies are gas turbines (over 60 percent of the market); steam cycle boilers (over 30 percent of the market); and natural gas engines (under 5 percent of the market). Natural gas is the primary fuel for more than 60 percent of CHP systems today. Other CHP fuels include coal, oil, wood, and wastes.

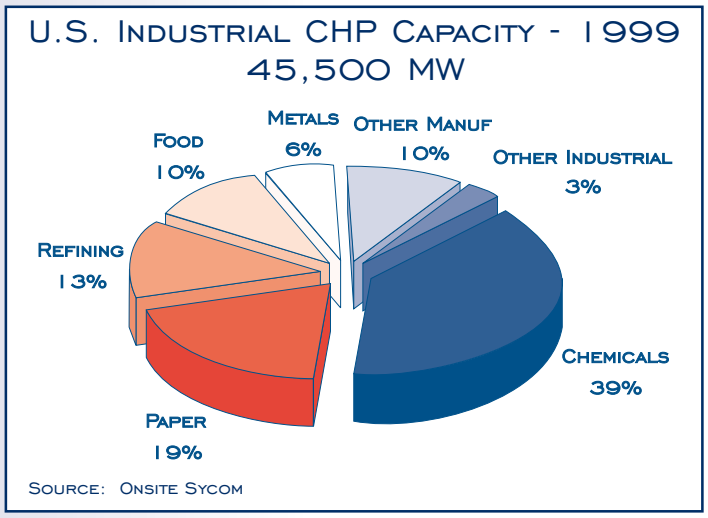
The actions discussed in Chapters 2 and 3 that address awareness and regulatory and institutional barriers crosscut the entire market for CHP. There are, however, specific actions in the area of market and technology development that apply only to particular sectors. The four markets targeted in this roadmap for expanding CHP installations are:

- Industrial plants (manufacturing and processing)
- Buildings (commercial, individual schools and hospitals, and multi-family)
- District energy systems (college campuses, hospital complexes, power parks, and communities/municipalities systems)
- Federal facilities (buildings and manufacturing plants)



While clean, efficient, and cost-competitive CHP systems are on the market and available today,

[6] National statistics for tracking CHP installations are incomplete. The best source of information is DOE's Energy Information Administration, but their surveys only cover facilities greater than 1 MW and are believed to undercount district energy applications of CHP. Obtaining more accurate national statistics on CHP installations is key to the successful implementation of this National CHP Roadmap.



technology improvements are needed to lower costs, boost performance, and increase the range of potential market applications. Further research, development, and demonstration (RD&D) is particularly crucial for smaller-sized systems that use new technologies such as microturbines, fuel cells, and thermally-activated cooling and humidity control equipment. New technologies, tools, and techniques are needed to enhance systems integration, remote monitoring and dispatch, communications, and control systems.

Industry

The industrial sector is the largest of the four market targets for CHP. This sector accounts for approximately 90 percent of installed CHP capacity in the U.S. today and more than 50 percent of the potential additions. The chemicals, pulp and paper, and petroleum refining industries are the dominant CHP users in the market today. Industrial systems span the size range, and over 60 percent use natural gas.

The actions discussed in Chapters 2 and 3 to raise awareness and eliminate regulatory and institutional barriers are critical for expanding the use of CHP by U.S. industries. In addition, RD&D to lower costs and improve performance is another critical element of the industrial CHP strategy.

Black Liquor and Biomass Gasification

This is an important RD&D target for industrial CHP. The pulp and paper industry currently generates more than half of its own power from existing boilers. It is estimated that within 20 years about 80 percent of these boilers will need to be replaced. Gasification is an alternative means of generating heat and power from biomass feedstocks. Black liquor is a lignin-rich byproduct from pulp and paper making. RD&D is needed to lower the costs and improve the performance of black liquor and biomass gasification technologies, particularly in the scale-up from bench models to commercial facilities. Successful demonstration of advanced gasification technologies could more than double the amount of CHP in the pulp and paper industry. Developing such systems is a critical element of the technology roadmap of the Forest Products' *Industry of the Future* initiative.

Attractive CHP technologies exist today for industrial applications. New technologies are nearing commercialization that could improve the attractiveness of CHP to industrial customers even more. For example, DOE's Advanced Turbine Systems program is field testing a cleaner and more fuel efficient product, an advanced distributed generation turbine, called the *Mercury 50*. *RD&D* in advanced ceramic materials and alloys is resulting in new designs for components that enable successful operations at higher temperatures, which boosts energy efficiency and lowers emissions. Further RD&D is needed to lower costs, enhance durability and reliability, reduce emissions, and boost efficiency even more.

The potential for additional CHP installations in the U.S. industrial sector is enormous. **The goal of this National CHP Roadmap is to add 27 GW of new industrial CHP capacity by 2010**. This goal is less than one-third of the estimated industrial CHP potential in the U.S. (88 GW). Promising target markets for industrial CHP additions include paper (approximately 26 GW), chemicals (approximately 9 GW), food (approximately 8 GW), metals (approximately 7 GW), and machinery (approximately 6 GW).[7]

Untapped CHP Potential for Selected Industries

Industry	CHP Potential (GW)	Existing CHP (GW)	Untapped Potential
Food and Kindred Products	12.7	4.6	74%
Paper and Allied Products	34.8	8.6	75%
Chemicals and Allied Products	27.1	17.7	35%
Petroleum and Coal Products	12.4	5.6	55%
Primary Metals Industries	9.8	2.9	71%
Fabricated Metal Products	5.7	0.08	99%
Industrial and Transportation Equipment	11.8	0.95	92%

Source: Onsite Sycom

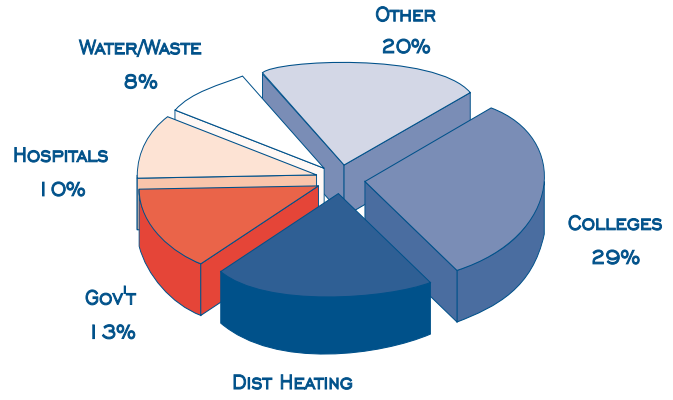
To achieve the CHP Challenge goal for the industrial sector, the following actions need to be taken:

- In raising CHP awareness, focus initially on demonstrating "**best practices**" with regard to industrial energy efficiency and CHP systems in the most promising industrial sub-sectors and "roll-out" to others to achieve broader acceptance
- In eliminating regulatory and institutional barriers, focus on developing "model" **output-based standards** for environmental siting and permitting in several of key states and "roll-out" to achieve broader acceptance
- Focus on developing "model" **utility access and exit fees**
- Conduct cost-shared **RD&D projects** with Federal and state governments in the areas of advanced industrial power generation, black liquor and biomass gasification, advanced materials and combustion processes, and advanced power electronics, sensors, and controls

Buildings

Commercial buildings account for approximately one-sixth of the energy consumption in the U.S. and encompass more than 60 billion square feet of floor space. Energy efficiency improvements for lighting, heating, cooling, and ventilation systems are forecasted to radically reduce energy demand growth in this sector radically. The growing use of computers and telecommunications systems, however, is forecasted to substantially increase, and the amount of highly reliable power needed to meet the growing needs of the e-commerce sector is straining the grid in many regions of the country.

U.S. Commercial CHP Capacity - 1999
4,930 MW



Source: Onsite Sycom

Commercial buildings are a critical and emerging market for CHP systems. Primary market segments include office and retail buildings, water and waste management facilities, and individual schools and hospitals.[8] Natural gas is used in more than 70 percent of the existing CHP installations in the commercial sector.

[7] Onsite-Sycom Corporation, *CHP Market Assessment for the U.S. DOE's Energy Information Administration*, September 2000.

[8] Multiple buildings that share a common thermal energy distribution loop, such as hospital complexes and university campuses, are considered district energy systems.

Four states – New York, California, Texas, and Pennsylvania – account for more than half of the known installations of CHP in buildings.

Recent improvements in smaller-scale power generation and thermal energy systems have increased the attractiveness of CHP for a variety of building types and functions. Small-scale CHP installations in buildings are difficult to track since one of the primary sources of CHP data, DOE's Energy Information Administration, does not currently collect data on CHP systems less than 1 MW.

However, there are a number of technical challenges that need to be addressed. These are discussed in the *Buildings CHP Roadmap*, along with policy and other actions aimed at increasing the use of CHP systems in buildings. As outlined in the *Buildings CHP Roadmap*, high priority research and development needs include:

- **BCHP Package Integration**
  - Thermal recovery equipment
  - Small to medium-sized air-cooled BCHP commercial chillers
  - Communications protocol system controls and "plug&play" equipment
- **Next Generation BCHP Systems**
  - Monitoring software
  - "Plug&play" equipment
  - Improved prime movers (e.g., fuel cells, microturbines, reciprocating engines)
  - Advanced cooling systems
- **Analysis and Design Tools**
  - Computerized screening tools
  - Model and software libraries
  - Design tools for architects and building designers

BCHP Test Facility

DOE is co-sponsoring a systems integration test facility at the University of Maryland, College Park. At this facility, an administrative building is being converted by the University's Center for Environmental Energy Engineering from an all-electric building to a building where most of the energy needed to satisfy the occupants is generated on-site. This is being accomplished with two natural gas engine-driven air conditioners that have been integrated with an enthalpy/desiccant ventilation unit for humidity control and heat recovery. Waste heat from an installed microturbine used to drive an absorption chiller. Engineering analysis will be conducted to test various operating modes to optimize performance and to develop controls and fault analysis software.

The potential for additional CHP installations in commercial and institutional buildings in the U.S. is enormous. **The goal of this National CHP Roadmap is to add 8 GW of new CHP capacity in buildings by 2010**. This goal is slightly less than 10 percent of the estimated buildings CHP potential in the U.S. (77 GW). Promising targets include office buildings (approximately 18 GW) , schools (approximately 15 GW), hospitals (approximately 9 GW), nursing homes (approximately 8 GW), and hotels/motels (approximately 7 GW).

To achieve the CHP Challenge goal for the buildings sector, the following actions need to be taken:

- In raising CHP awareness, conduct an **outreach campaign** to educate architects, building designers, and engineering firms on the relative merits of buildings CHP systems in buildings and to provide "SWAT" team technical assistance to answer questions and reduce uncertainties

- In eliminating regulatory and institutional barriers, address the information needs of state and local code officials to develop **standards for buildings CHP** that address zoning, fire, safety, and construction concerns

- Conduct **cost-shared RD&D** with Federal and state governments in the areas of packaged systems integration; interoperability, communications, and controls protocols; and cleaner, more efficient, and more affordable "prime movers," including fuel cells, microturbines, natural gas engines, and thermally activated cooling and humidity control equipment

District Energy

District energy is a large and growing market for CHP. District systems distribute steam, hot water, and/or chilled water from a central plant to individual buildings through a network of pipes. District energy systems can provide customers with space heating, air conditioning, domestic hot water, and/or industrial process energy. The strength of district energy is its ability to aggregate thermal loads. What makes district energy such an attractive CHP technique is the ability to combine multiple low-temperature loads into a large enough block for the most cost-effective CHP technologies. Recovered heat can be directly used for district heating or can be used to produce chilled water for air-conditioning.

Gray's Ferry

In 1997, an aging district system serving downtown Philadelphia was upgraded to include a 118 MW combined cycle gas turbine to provide electricity to the grid and steam to 70 percent of downtown businesses. The entire system has a fuel conversion efficiency of approximately 70 percent. The system is capable of burning natural gas or fuel oil. With natural gas, the system generates energy with 50 percent lower CO_2 emissions and 90 percent lower NO_x emissions.

The most recent statistics on district energy systems in the U.S. were compiled in 1993. At that time it was estimated that there were:

- about 5,800 district energy systems in operation in the U.S.

- about 800 billion Btus per hour of installed thermal energy production

- more than 20,000 miles of pipe for delivery

District energy systems crosscut the other CHP market sectors because they involve commercial and institutional buildings, industrial, and Federal facilities. For example, about 24 percent of all district energy systems in the U.S. are college campuses, 17 percent are hospital complexes, 16 percent are military bases, and 8 percent involve industrial plants.

The potential for additional CHP installations in district energy systems is significant, particularly in existing energy systems at universities, Federal facilities, or downtown areas. District heating plays a much larger role in the energy sectors of northern Europe, Russia, and Canada than it does in the U.S. For example, district energy comprises 70 percent of the space heating market in Russia, 50 percent in Denmark, and 44 percent in Sweden, compared to 3 percent in the U.S.[9]

CANMET — Community Energy Systems

Natural Resources Canada operates a community energy system program for assisting local and municipal governments across Canada with installation of district heating and cooling systems. The program provides hands-on technical assistance for local government officials in the development of feasibility studies, project management, system designs, and trouble-shooting. A particularly valuable service has been to sponsor on-site visits to district energy facilities in Denmark and Sweden for Canadian municipal government managers so that actual facilities, operations, and benefits can be verified by actual decision makers. This effort has raised the level of interest and led to the installation of new systems.

[9] Natural Resources Canada, *The District Energy Option in Canada*, ISBN M27-117/1996E, 1996.

It is estimated that there is up to 19 GW of additional CHP potential in district energy applications by the year 2010.[10] **The goal of this National CHP roadmap is to add 8 GW of new district energy CHP by 2010**. This goal is almost one-half of the estimated potential for district energy CHP.

To achieve the CHP Challenge goal for district energy, the following actions need to be taken:

- Launch an **outreach campaign** to educate municipal and community governments, colleges, universities, and military bases about district energy and CHP systems by providing a series of "how-to" guidebooks that aid in conceptualizing, designing, financing, installing, owning, and operating these systems
- Expand **technical assistance** through on-site training, "SWAT" teams, and other means for potential users of district energy systems to overcome technical, legal, financial, and institutional barriers to development of district energy systems and to implement CHP in existing district systems
- Conduct more **demonstration projects** of innovative CHP applications in communities and power parks, particularly for "brownfield" redevelopment and public housing applications

CHP/St. Paul Minnesota

District Energy St. Paul, Inc., in partnership with Trigen-Cinergy Solutions, is constructing a CHP plant fueled with wood waste. The CHP system will supply 25 MW of power to the grid, and over 75 percent of the thermal energy required by the district heating and district cooling system. The district heating system serves over 75 percent of downtown building space. By turning regional wood waste into a useful product, the system will keep energy dollars in the local economy. A substantial portion of the wood waste will come from downed trees, trimmings and branches. Making use of this wood waste will also solve what is an ongoing community environmental challenge, since much of it currently goes to landfills or is burned in open fires.

Federal Facilities

The Federal government provides energy to approximately 500,000 buildings and facilities, comprising approximately 3 billion square feet of floor space. Some of the facilities house energy intensive operations such as laboratory, testing, warehousing, and manufacturing/assembly. In 1997, these activities used more than 400 billion Btu of energy, cost taxpayers more than $4 billion, and contributed to the nation's inventory of environmental emissions.[11] From a CHP perspective, the Federal government is a microcosm of the entire economy in that there are many opportunities to use CHP in office buildings, manufacturing facilities, and district energy systems.

Executive Order 13123, *Greening of the Government Through Efficient Energy Management*, establishes goals for reducing energy use, emissions, and costs of government federal operations. The Order encourages Federal agency managers to use CHP in all of its forms whenever it proves to be cost effective from a life-cycle perspective.

CHP — Marine Corps Base

In 2001, the United States Marine Corps Air Ground Combat Center (MAGC) at 29 Palms, California, is scheduled to install a high-tech 7.1 MW CHP facility based on equipment manufactured by Solar Turbines, Inc. This CHP system will provide a large portion of heat and power required by the 21,000 people living at MAGC, the largest Marine Corps base in the world (about ¾ the size of Rhode Island) and is projected to have an annual savings of over $1.8 million.

[10] American Council for an Energy Efficient Economy, *Combining Heat and Power: Capturing Wasted Energy,* R. Neal Elliott and Mark Spurr, May 1999.
[11] U.S. Department of Energy, *Annual Report to Congress on Federal Government Energy Management and Conservation Programs Fiscal Year 1997,* August 1999, DOE/EE-0222.

The potential for additional CHP installations at Federal facilities is significant. The Federal sector presents its own set of issues including funding limitations, Federal procurement regulations, and certain unique "mission critical" functions such as multi-purpose military bases, one-of-a-kind laboratory complexes, health and public safety facilities, and recreation centers. **The goal of this National CHP roadmap is to add 5 GW of new CHP installations in Federal facilities by 2010.**

To achieve this CHP Challenge goal for the federal sector, the following actions need to be taken:

- Develop **new sources of funding** for the installation and operation of CHP in Federal facilities through the federal appropriations process, state public benefits funds, third parties such as energy services companies, utility companies, and foundations
- Compile a national **inventory of potential Federal CHP sites** that characterizes opportunities for expansion of existing systems and development of new CHP systems
- Require detailed **assessments of CHP opportunities** before significant changes are made in Federal facilities that may eliminate the potential for CHP
- Engage DOE's **Federal Energy Management Program** in providing technical assistance, information, and analysis tools to decision makers at federal facilities across the country
- Develop more **case studies** to demonstrate all forms of CHP in Federal facilities across a range of building types, agencies, and regions of the country

CHP — Fort Bragg Army Base

Fort Bragg, one of the largest military installations in the world, is proposing to install a state-of-the art 12 MW CHP facility. The CHP system will be based on three 3.5 MW gas turbines developed by Honeywell. Fort Bragg has a base load of less than 40 MW, a peak load of approximately 100MW, and a load factor of 56% that is weather driven. Its goal is to reduce its energy costs by as much as 30% per year with a combination of rate negotiations, internal generation, load management and energy reduction. The CHP system will provide thermal energy for the central heating and cooling district that needs 120 MMBtu per hour to service over 150 buildings on the circuit.

CHP Market Segmentation

Market Segment	Typical Size (MW)	Dominant Form of Ownership	Typical Heat-to-Power Ratio	Design Strategy	Power Utilization
Traditional	3-40	Owner Operated	0.2-1.5	Match existing process; thermal base load	On-site
Regulatory Driven	50-1,000	3rd Party	>2.0 (CCCT) >0.5 (Steam)	Maximize power generation	Sales to grid
Market Driven	1-20	3rd Party	0.5-2.0	Balance power and thermal loads	On-site and sales to grid
District Energy	1-40	3rd Party	0.2-2.0	Match existing thermal load	On-site and sales to grid
Buildings	0.1-10	3rd Party	0.4-2.0	Match space conditioning load	On-site
Direct Drive	0.1-4	3rd party and owner operated	0.5-1.5	Size to driven load with heat recovery	On-site

Source: ACEEE

5. Implementation

Implementation of this Roadmap, and accelerated development and deployment of CHP systems in America, depends on the coordinated efforts of a number of individuals and organizations across the country. The Roadmap points the way, illustrating how various individuals and organizations can contribute to the overall effort. Success will require new and revised strategies that achieve the specific actions and goals outlined in the National CHP Vision and Roadmap.

This implementation effort is a partnership in which participating organizations will be counted upon to apply their own resources, and if necessary, seek support from appropriate Federal, state, and local government agencies. With the concerted collective action of all participating individuals and organizations, the significant resources of each can be leveraged for maximum impact.

The USCHPA has assumed the responsibility for coordinating the implementation of this National CHP Roadmap. By doing so, the USCHPA commits to expand its coordination and outreach efforts and involve more individuals and organizations in the enterprize. Effective leveraging of resources is paramount. The USCHPA is a new and relatively small organization. Development of partnerships and cooperative working relationships with other participants is critical if the National CHP Roadmap is to be implemented properly. This partnership approach is illustrated in the table below.

Responsibility	Lead Organization	Supporting Organization(s)
National Coordination	USCHPA	U.S. DOE, U.S. EPA
Industrial Sector	USCHPA	Chemicals Manufacturers Association, American Forest and Paper Association, Council of Industrial Boilers Operators
Buildings Sector	BCHP Initiative	American Gas Cooling Center Gas Technology Institute Oak Ridge National Laboratory National Renewable Energy Laboratory Pacific Northwest National Laboratory
District Energy Systems	International District Energy Association	U.S. HUD, NYSERDA
Federal Facilities	Federal Energy Management Program (DOE)	Oak Ridge National Laboratory Pacific Northwest National Laboratory National Renewable Energy Laboratory

A. Participating Organizations

Air Technology Systems	Frederick	MD
Alliance to Save Energy	Washington	DC
Allison Engine Company	Indianapolis	IN
American Chemistry Council	Arlington	VA
American Council for an Energy Efficient Economy	Washington	DC
American Forestry and Paper Association	Washington	DC
American Gas Association	Washington	DC
American Gas Cooling Center	Washington	DC
Arthur D. Little	Cambridge	MA
Ballard Engineering	Rockford	IL
Bowman Power Systems	Woodland Hills	CA
Bristol-Myers Squibb Company	New York	NY
Broad USA	New York	NY
Capstone Turbine Corporation	Tarzana	CA
Cascade Associates	Washington	DC
Caterpillar International Power System	Lafayette	IN
Comfort Link	Baltimore	MD
Council of Industrial Boiler Owners	Burke	VA
Delta Institute	Chicago	IL
Dow Chemical	Washington	DC
Duke Solutions	Lincolnshire	IL
ELPC	Chicago	IL
Encorp	Chicago	IL
Energetics, Incorporated	Columbia	MD
Energy and Environment Analysis, Inc.	Arlington	VA
Energy and Environment Center	Portland	ME
Energy Recovery International	Lincoln	NE
EXERGY Partners Corp.	Herndon	VA
Gas Technology Institute	Des Plaines	IL
General Electric Power Systems	Schenectedy	NY
General Motors	Detroit	MI
Good Company	Austin	TX
Honeywell Power Systems Inc.	Torrance	CA
International District Energy Assoc.	Minneapolis	MN
Johnson Controls, Inc.	Milwaukee	WI
Keyspan	Brooklyn	NY
Kohler Power Systems	Kohler	WI
Michigan Consolidated Gas Company	Detroit	MI
Mississippi Valley Gas	Jackson	MS
Munters Corporation	Amesbury	MA
National Park Service	Staten Island	NY
National Renewable Energy Laboratory	Golden	CO
NiSource Inc	Merrillville	IN
Northeast Midwest Institute	Washington	DC
Northwind Boston	Hopkinton	MA
Natural Resources Defense Council	New York	NY
New York State Department of Public Service	Albany	NY

New York State Energy Research & Development Authority	Albany	NY
Oak Ridge National Laboratory	Oak Ridge	TN
ONSI	Hartford	CT
Onsite Sycom	Carlsbad	CA
Oregon Office of Energy	Salem	OR
Pace University Energy Project	White Plains	NY
Pacific Northwest National Laboratory	Richland	WA
Rutgers University	Piscataway	NJ
Seattle City Light	Seattle	WA
Solar Turbines, Inc.	Washington	DC
Southern California Gas Co.	Los Angeles	CA
Tecogen	Waltham	MA
The Dow Chemical Company	Houston	TX
The Energy Network, Inc.	Hartford	CT
The Trane Company	LaCrosse	WI
Trigen Energy Corporation	Trenton	NJ
U.S. Department of Energy	Washington	DC
U.S. Environmental Protection Agency	Washington	DC
University of Illinois Chicago Energy Resources Center	Chicago	IL
University of Maryland	College Park	MD
Waukesha Engine	Waukesha	WI
Weyerhaeuser	Federal Way	WA

B. For More Information

Websites

www.nemw.org/uschpa
www.bchp.org
www.eren.doe.gov/der/chp
www.epa.gov/globalwarming/actions/cleanenergy

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