Combined Heat and Power (CHP)

A Vision for the Future of CHP in the U.S. in 2020

Based on Discussions at the CHP Vision Workshop
Washington, D.C.
June 8-9, 1999

September 1999

U.S. CHPA
United States Combined Heat & Power Association

Table of Contents

Preface

The U.S. Combined Heat and Power Association (U.S.CHPA) was formed in December 1998 with the purpose of promoting the use of clean and efficient industrial combined heat and power and buildings cooling, heating and power (CHP) technologies in the U.S. The organization's mission is to "*Create a regulatory, institutional, and market environment that fosters the use of clean, efficient CHP as a major source of electric power and thermal energy in the U.S.*"

This mission is urgent. There will be a historic opportunity over the next five to ten years to amend the rules of the marketplace for energy services to make it more open and competitive. During this time period many companies will be facing decisions to replace, retire, or refurbish aging power plants, industrial boilers and heating, ventilation and air conditioning (HVAC) systems. If constructed fairly and consistently, the new rules could eliminate barriers that currently interfere with the deployment of CHP systems in the marketplace.

In addition, because CHP systems are so highly energy efficient, they are gaining greater recognition from policy makers around the world who are searching for tools to address energy and environmental problems. The United Kingdom, for example, recently enacted policies to expand the use of CHP as a part of a larger effort to reduce energy-related carbon emissions.

Now is the time for business and government leaders in the U.S. to join together to ensure that CHP's full potential is realized. Towards this end, on December 1, 1998, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy sponsored *The CHP Summit — A National Dialogue on Combined Heat and Power.* At the Summit, Assistant Secretary Dan Reicher announced the CHP Challenge goal to double the amount of CHP capacity in the U.S. by 2010. Shortly thereafter, Robert Percisepe, Assistant Administrator of the U.S. Environmental Protection Agency agreed to work with the Department of Energy to achieve this goal.

On February 9, 1999, at the 3rd Industrial Energy Efficiency Symposium and Exposition, the U.S.CHPA announced that it would launch a vision and roadmap process to identify the most productive pathways for all sectors, in collaboration with the federal government and others, to achieve the CHP Challenge goal. On June 8-9 1999, the U.S. CHPA held a CHP "visioning" workshop in Washington D.C. with more than 30 business executives representing the industries that develop, install, and use CHP systems. A list of participants can be found in the Appendix. The workshop consisted of a series of facilitated discussions exploring the future of CHP in the U.S., including drivers, barriers, visions, and goals. This document is the result of the discussions that took place at the workshop.

1. Introduction

On average, two-thirds of the fuel used to make electricity in the U.S. is wasted. While there have been impressive energy efficiency gains in other sectors of the economy since the oil price shocks of the 1970s, the average efficiency of power generation in the U.S. has remained around 33 percent since 1960.

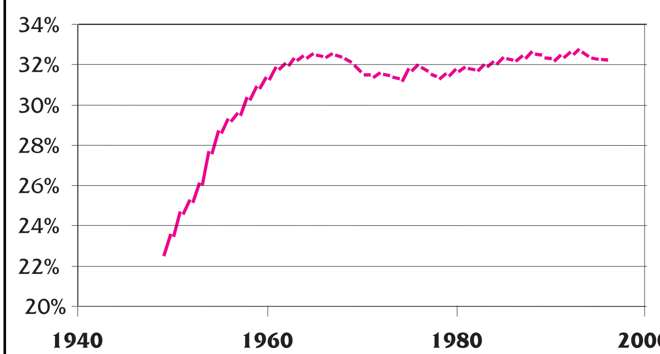
Industrial combined heat and power and buildings cooling, heating and power (CHP) systems use the waste heat that is normally vented in conventional power plants for productive purposes. These purposes include heating and cooling buildings or providing heat, mechanical power, dehumidifying systems, or compressed air for industrial and commercial applications. CHP systems can operate on-site at an industrial plant, commercial or institutional building, or government facility as well as in district energy systems that distribute thermal energy to buildings in a college campus, hospital complex, industrial park, or municipality. By making productive use of the wasted energy, CHP systems can achieve overall energy efficiency levels of 70%, or greater.

The nation — indeed the world — can no longer afford to waste as much energy as it currently does in making electricity. In the U.S., the thermal losses in power plants totaled almost 23 quadrillion BTUs of energy in 1997, representing over 24 percent of total U.S. energy consumption. This amount of wasted energy is nearly equal to the amount of energy used to fuel the entire U.S. transportation sector in 1997.

Clearly, if economical means could be found to tap this wasted energy resource, U.S. citizens and businesses could expand their level of economic activity without increasing energy consumption, environmental emissions, or imports of fossil fuels.

The economic stakes are high. Electric capacity requirements are projected to increase by over two percent annually. As a result, almost $180 billion in new power generation assets may be needed by 2010 to meet growing consumer needs for electricity. Utility restructuring means that many of these investments will be made in the midst of a transition from tightly regulated power markets to a new era of more openly competitive markets for electricity and natural gas.

Stagnant Efficiency of U.S. Electric System



Fossil Electric Generation Efficiency (at plant, W/O T&D)
Sources: EIA, Annual Energy Review, 1996

As technology advances lead to a greater reliance on industrial automation and precision manufacturing, the need for better quality and more reliable energy services will continue to grow. In fact, there is mounting concern about the potential negative effects of competitive markets on the reliability of the power grid. As a result, many companies have renewed their interest in on-site power generation as a method of ensuring that power quality and reliability needs are met no matter what happens in the utility regulatory arena or the power grid.

CHP is not a new technology, especially for large industrial applications, university campus HVAC systems, and district energy plants. With the passage of the Public Utilities Regulatory Act of 1978 (PURPA), new rules were put into effect designed to increase the efficiency of fuel use by removing regulatory and institutional barriers to the development of CHP. PURPA required utilities to interconnect with qualified CHP facilities, provide back up power at reasonable rates, and purchase any excess electricity at the same rate the utilities would have had to pay to generate it themselves. The result was a dramatic increase in CHP use at large industrial plants.

PURPA successfully stimulated the CHP market, for large systems – industrial CHP capacity increased from about 12,000 MW in 1980 to more than 45,000 MW in 1995. PURPA also encouraged capacity sales in some regions that exceeded incremental requirements. PURPA related CHP installations have stagnated since 1995.

Today, electric power industry restructuring, coupled with the unbundling of various components of electric service, is ushering a new era in which customers will have greater opportunities to optimize their energy services than ever before. Customers are becoming far more conscious of their electricity and energy use and are increasingly seeking out new options to cost-effectively meet their energy needs. Restructuring is also introducing new players into the power market that can facilitate the marketing and sales of distributed generation and CHP systems. Simultaneously, technological improvements that allow smaller power systems to be built with high efficiency, low cost, and relatively low environmental impacts are allowing distributed generation and CHP technologies to compete with central station power.

Despite these prospects, there are a variety of regulatory and institutional factors that threaten to constrain the development of cost-effective, beneficial CHP systems. Unless steps are taken to address these regulatory and institutional barriers, future growth in the use of CHP systems will be limited. CHP facilities must be treated fairly and equitably with existing power generators regarding interconnection to the grid, distribution of power produced, ability to buy and sell power, environmental permitting, and tax depreciation.

2. The U.S. Combined Heat and Power Industry

The very first commercial power plant in the U.S. — Thomas Edison's Pearl Street station built in Manhattan in 1881 — was a CHP facility. Many of the early electricity generation facilities were industrial facilities that added generators to their existing steam systems. As electric generating technology and the electric utility industry specialized and matured, the costs of centrally-produced power and the value of on-site generation declined in most applications. Sprawling economic development patterns coupled with increasing economies of scale in power generation led to the creation of the modern power grid. Large power plants needed to be sited remotely from customers and their needs for thermal energy. While electricity can be transmitted economically over long distances, thermal energy cannot. Opportunities for combined heat and power generation became less feasible. One of the unfortunate results of these trends is that both power generation and thermal energy applications went down a less efficient path.

The total electric power capacity in the U.S. today, from both utility and non-utility generators, exceeds 770 GW. About 10 percent of this capacity is from non-utility sources such as industrial on-site generators, small power producers, exempt wholesale generators, and PURPA qualifying facilities. About three-quarters of this non-utility capacity, or about 54 GW, is from CHP facilities, making CHP capacity responsible for approximately 7 percent of America's total electric resource portfolio.

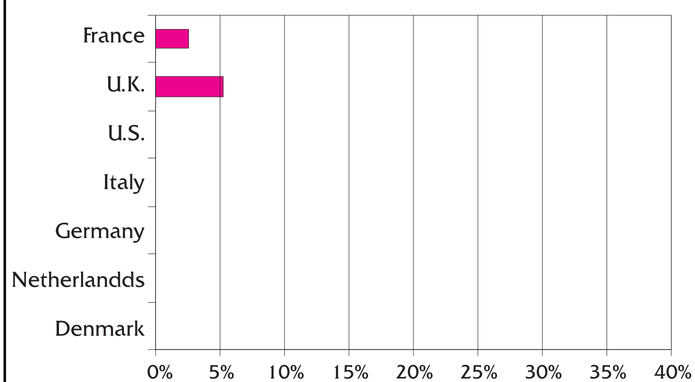
Recent energy projections made by the Department of Energy's Energy Information Administration show CHP capacity growing very slowly over the next twenty years. The average annual growth rate is 0.5 percent. At this pace, it would take approximately 144 years for the CHP capacity of the U.S. to double. Most experts believe these projections underestimate the expected pace of CHP development over the next decade.

CHP Technologies

Recent improvements to power generation technologies have been a major factor driving renewed interest in CHP. This interest has been heightened by the commercialization of new CHP technologies that have greatly expanded the suite of reliable, cost-effective options for systems in a wide range of sizes and applications. These include new prime movers, such as advanced combustion turbines, fuel cells, and reciprocating engines, as well as enabling technologies such as advanced system control equipment and improved materials that withstand high temperatures and corrosion. The following examples highlight recent technology developments in CHP equipment.

International CHP Power Production

Other nations use CHP to a much greater extent. In recognition of its valuable role, the European Union has declared a goal of doubling CHP's share of the nation's energy portfolio from 9 percent to 18 percent by 2010. The United Kingdom has declared a goal of increasing CHP capacity by 35 percent by 2000.



Sources: European Cogeneration Review, 1997; Cogen Europe, 1997; Annual Energy Outlook, 1997

- Recent developments in **boilers** include new tubing materials that have increased durability, and more modular designs that require less operating expertise.

- New **steam turbine designs** have resulted in smaller sized units that are lower in cost and higher in efficiency and reliability.

- Advances in ceramic components and power electronics have led to a new generation of simple cycle **combustion turbines** that are cleaner, more efficient and reliable, lower in cost, and able to operate in much smaller size ranges, including a new suite of so-called microturbines that are under 300 kW.

- **Spark ignition engines**, the fastest selling of the existing suite of CHP systems, can now operate on a wider range of fuels, with greater reliability and lower emissions than previous models.

- Recent advances in computerized design techniques and the use of advanced materials have improved the reliability and efficiency of **diesel engines** while reducing emissions.

Advancing Technology Through Industry-Government Partnerships

In 1998, Malden Mills Industries, a textile manufacturer employing 2,300 workers, installed a state-of-the art CHP system at its facility in Lawrence, Massachusetts. The system is based on two 4.3 MW turbines developed by Solar Turbines. The turbines feature innovative ceramic liners, involving a retrofit to the combustion system, that were developed in a partnership with the Department of Energy's Advanced Turbine Systems program. The result is a state-of-the-art CHP system with ultra-high total efficiency and extremely low nitrogen oxide emissions. One of the turbine retrofits took place in the summer of 1999, the second is scheduled for the fall.

- Advances in **black liquor gasification** technologies could revolutionize the pulp and paper manufacturing process and increase the opportunity for CHP applications. Gasification technologies could transform the pulp and paper industry from net consumers to net producers of electricity.

- Recent commercialization efforts with respect to **fuel cells** continue to demonstrate improvements in efficiencies and hybrid cycles that will lead to cost reductions and performance improvements for use in power generation and CHP applications.

- **Absorption chillers** have improved in terms of efficiency, reliability and costs making absorption chillers a high value-added use of recovered heat.

- **Engine driven chillers** have proven to be the most efficient direct drive machines on the market and have improved in reliability and operating ease through use of microprocessor controls. Similar advances have been made in **engine-driven air compressors**.

- **Desiccant dehumidification** ventilation air conditioning technology is becoming recognized as a key solution to indoor air quality problems and can effectively be incorporated into a building CHP system.

CHP Markets

The market for CHP systems is evolving, driven by changing technologies and the rapid pace of developments in markets for electricity and natural gas. Untapped potential remains in the traditional industrial applications in the chemicals, pulp and paper, steel, and petroleum refining industries. New applications in other industries and commercial and institutional buildings are also extensive. For example:

- The greatest current use of and near-term potential for large CHP installations lies in the so-called "process industries" of **petroleum refining and chemicals** where there is estimated to be 70 GW of untapped CHP opportunity.

- The **pulp and paper industry** accounts for 40 percent of all cogenerated electricity used in the U.S. today. With the commercialization of new black liquor gasification technologies, an additional 30 GW of capacity could be realized.

- There are an estimated 5,800 **district energy systems** and building CHP systems operating in the U.S. today; most serving university campuses, hospital complexes, and military bases. There is significant potential to implement CHP in these systems, primarily in sizes ranging from 5 to 50 MW.

- The nation's stock of boilers providing process steam to **small manufacturing plants** is aging and could be replaced with packaged CHP systems in sizes ranging from 50 kW to 5 MW.

- Boilers providing steam heat or hot water to **commercial and institutional buildings and multi-family dwellings**, as well as chillers providing cooling and dehumidification could be replaced with the newer smaller models of packaged CHP using microturbines, fuel cells or advanced engine designs.

- Still under development, fuel cells or Stirling engines could provide CHP services to the **single family residential** market in the future.

- Fuel cells have been demonstrated for CHP applications supplying hot water to buildings and electricity for on-site needs and excess to the grid.

CHP Industries

There does not yet exist a well-defined single "industry" for CHP. The industry today consists of four subsectors that make up the "core" CHP industry. Over time, as CHP gains increasing market share, these subsectors will evolve into a more coherent whole. The four subsectors are:

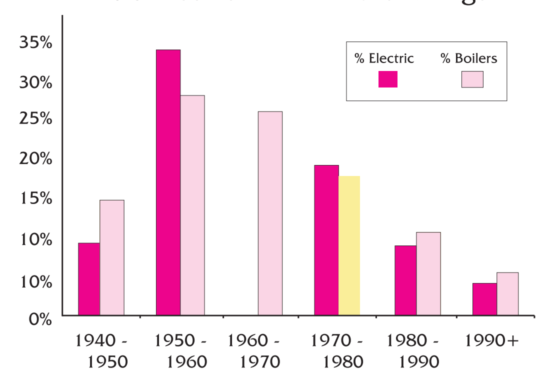
- **Equipment vendors** consist of firms that manufacture turbines, engines, heat recovery equipment, boilers, steam turbines, fuel cells, heating and cooling equipment, and thermal distribution systems.

- **Energy services providers**, including independent power producers and district energy system operators, conduct audits and make recommendations, install systems and engage in performance contracts, act as third party providers by maintaining ownership of the equipment they install, and produce power and/or thermal energy on a contract basis for specific customers or the power grid. This group includes utility company affiliates, unaffiliated energy service providers, as well as the growing fleet of "merchant" power plant operators.

Market Potential

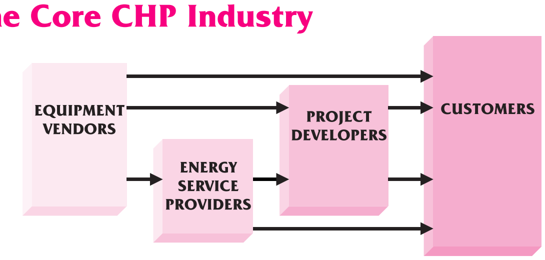
The aging infrastructure of power generation equipment in the U.S. is opening up new opportunities to implement highly efficient, environmentally sound technologies.

U.S. Electric Plan and Boiler Vintage



Sources: Energy Information Administration, Gas Research Institute

The Core CHP Industry



- **Project developers** consist of engineering and design companies that get tasked with sizing and permitting facilities and often play a key role in obtaining financing.

- **Customers** are the industrial, commercial, and institutional facilities that use CHP systems, particularly those divisions with responsibility for energy procurement and management.

3. Combined Heat & Power — Vision for 2020

The Vision...

Industry and government have worked together to create conditions that allow CHP use in the U.S. to flourish and contribute 200 GW to the nation's energy portfolio.

Industrial, commercial, institutional, and residential customers can select from an array of ultra-high efficiency, ultra-low emission, fuel-flexible, and cost competitive CHP products and services. These products come in a range of sizes and technologies and can be easily interconnected into a competitive "plug&play" market. Customers often choose CHP because they understand and value the economic, environmental, and energy benefits. The regulatory framework — covering the federal, state, and local levels — has been designed to deliver economic value and environmental stewardship to the public.

This *Vision for 2020* is based on the development of an energy infrastructure that is more conducive to the installation and operation of CHP systems than the one that is in place today. The foundation of this energy infrastructure will be an updated regulatory framework that supports both public and private goals. Such a foundation will ensure that new capital investments reflect the needs and desires of the nation's energy producers and consumers while sustaining economic growth in an environmentally acceptable manner.

Predicting Energy Demand. . . *Not an Exact Science*

The Project Independence Report issued by the Federal Energy Administration in 1975 predicted that U.S. energy consumption would reach 98 quadrillion BTUs by 1985. In fact, the U.S. has yet to use this much energy even though the economy has grown by 75% since 1975.

By 2020, America's demand for increasingly clean, efficient, reliable and affordable heat and power will be reflected in a new fleet of energy generation technologies. No longer restricted to remote locations, a large percentage of these new technologies will be located in urban and suburban facilities, will produce power, heat, steam, compressed air, and hot and chilled water, and will distribute these products to on-site or nearby customers. By necessity, the nation's energy distribution network will provide open access to energy providers and consumers, allowing for the open trade of energy and ancillary services for centralized, distributed and on-site applications.

As a result, in 2020 CHP facilities will be commonly used throughout the economy in factories; manufacturing and processing plants; commercial and government buildings; district energy systems serving schools, hospitals, health care complexes and downtown areas; and residential communities. Benefits to U.S. citizens and industries from CHP will include lower energy costs, higher energy system efficiency and reliability, and lower emissions of carbon and criteria pollutants.

Drivers

In establishing this *Vision for 2020*, the CHP industry has painted a picture of the future it plans to create for CHP in this country. This picture is designed to serve as an endpoint, guiding and motivating all members of the CHP industry as they take actions to battle barriers and expand markets for CHP technologies.

This vision was established in the face of great uncertainty about the energy generation situation that the nation will face over the next twenty years. There are any number of factors, issues, trends and opportunities that will determine the future of CHP in the U.S. These drivers include changes in government policies, market forces, technology breakthroughs, and geopolitical developments. The drivers also include evolving consumer energy preferences motivated by changes in demographics, incomes, and lifestyles.

One of the key drivers that will affect the future of CHP is consumer demand for energy. While energy efficiency will continue to improve, the need for electricity and thermal energy is likely to grow. The extent of future consumer energy demand will heavily influence investment choices with respect to the nation's generation and transmission infrastructure. Related factors such as the price and availability of natural gas, decisions about licencing nuclear plants, and upgrades to aging boilers will also play a role. In addition, the growth of energy-dependent information and telecommunications technologies will increase the need for premium quality power. The modern economy will be reliant upon reliable and affordable energy supplies that will satisfy a myriad of growing consumer needs.

Another driver is the future of the regulatory framework within which the market for CHP technologies must operate. A critical factor is the degree to which energy regulations move from the existing central station paradigm towards a framework more conducive to distributed generation technologies. Transition to an open transmission and distribution system that allows for the seamless interconnection of on-site and local generation technologies will have a large impact on the growth of CHP. This tansistion will allow an open, competitive — the so called plug&play market — to evolve. In addition, decisions about environmental permitting requirements will have serious consequences for the future cost and availability of CHP. Factors such as the emissions limits for new versus existing generation facilities, streamlined permitting policies, the use of output based standards, and emissions trading mechanisms will be very important.

The trend toward more open and competitive power markets will be an important driver over the next twenty years. In the U.S., the railroad, airline, banking, telecommunication, natural gas, and now electricity industries have undergone a process to restructure traditional government regulations in favor of an approach that relies more heavily on competition and market forces to achieve public aims. Future electricity markets will need to be more hotly contested and less mired in government regulations than they are today.

Another driver is technological innovation. Trends towards computerization, miniaturization, and customization will continue to shape the nation's capital stock of technologies and equipment. Costs for electronic devices, information and telecommunications systems of all kinds have plummeted in the last decade and these trends will continue. Advances in materials, engineering designs, sensors and controls, and computer software will continue to enable more efficient, more reliable, more durable, and less costly equipment to be manufactured and deployed. In energy, these trends will be manifested in lower cost and more efficient prime movers such as fuel cells, advanced turbines, engines and microturbines. Another factor will be the emergence of advanced fuels derived from fossil energy and increasingly from biological sources. Growth in the use of advanced fuels could maximize synergies with CHP using industries such as chemicals and pulp and paper.

Public concern about the environment will raise interest, acceptance, and use of CHP systems. As incomes and education levels continue to rise across the country and around the world, concern about potential health and climatic effects of environmental emissions from power generation will get stronger. Pressure will continue to grow for industry to produce goods and services with increasingly smaller impacts on the environment, public health, and safety.

Driving Industry Growth

Recent regulatory initiatives are bringing about the growth of retail customer choice in the electric power industry as well as the opening of markets in the telecommunications industry. These factors are driving the development of entire new industries based on business opportunities that did not even exist ten years ago. For instance, in the U.S., a thriving market is emerging focused on providing services related to electricity metering, information collection and billing.

4. Barriers to Achieving the Vision

In order to achieve an expanded role for CHP, several market and regulatory barriers will have to be overcome. These barriers include utility practices and electricity rate designs that discourage on-site generation, lengthy and costly environmental permitting and siting processes, uneven tax treatment of CHP assets, and high customer hurdle rates for energy related investments.

Grid Interconnection. Non-standardized interconnect requirements have been a barrier to widespread deployment of CHP technologies. Interconnect requirements vary by state and/or utility and are often not based on state-of-the-art technology or data. Compliance often requires custom engineering and lengthy negotiations that add cost and time to system installation. These requirements can be especially burdensome to smaller systems. Non-standardized requirements also make it difficult for equipment manufacturers to design and produce modular packages, hampering their ability to realize economies of scale.

Standby/Backup Charges. Typically, customer-sited generation requires a backup source of power to meet load requirements during generation outages or routine maintenance periods. Utility charges for this standby/backup power are not always cost-justified. In a restructured market, the generation backup charge will be negotiated between the user and the generation supplier and the distribution charge will be negotiated with the utility. A competitive means for supplying these services is essential to ensure the economic use of CHP. However, state regulators struggling with the more contentious issues of restructuring legislation, are often unaware of the importance of standby fees and back up charges on the economic viability of on-site generation and CHP.

Stranded Costs. Under many state restructuring plans, utilities are permitted to recover some or all of the costs of stranded assets. Although utilities need to recover charges incurred on behalf of their customers under previous regulatory arrangements, inappropriate application of these charges to CHP facilities can significantly affect the economics of projects and delay widespread implementation. Some states have already authorized non-bypassable tariffs for stranded cost recovery, and customers installing on-site generation pay a fee on the kilowatt hours they generate as well as those they purchase, or are charged a one time exit fee equal to the expected stranded cost if they elect to leave the grid. Other states have decided to charge on-site generators exit fees for potentially unused distribution assets even after stranded generation and transmission assets are completely recovered through the restructuring transition period. Other states, such as Illinois, Massachusetts and New Jersey, have recognized the potential benefits of CHP and have either waived or partially exempted various forms of on-site generation from competitive transition charges or fees.

Environmental Regulations. CHP has the potential to reduce overall air emissions of both criteria pollutants and greenhouse gases. The use of CHP by customers to supply some or all of their electricity will displace the need for power purchases thus offsetting emissions at the central station plant. CHP also displaces emissions from existing boilers and burners. Unfortunately, current regulations of air emissions in the U.S. are based on limiting the emission of criteria pollutants per unit of fuel input or their concentration in exhaust streams from specific sources. This approach does not credit CHP with the emissions reductions associated with reduced consumption of electricity from the grid or for displaced emissions from existing sources. In addition, regulatory emphasis has focused on new sources, which theoretically can more easily meet stringent regulations. This emphasis imparts favorable treatment on the nearly 70 percent of existing facilities allowed to continue emitting at current levels under the Clean Air Act. Such an approach effectively penalizes the installation of new power generation facilities, including CHP systems.

Environmental Permitting. Treatment of CHP projects by air quality and air permitting agencies varies widely among jurisdictions, ranging from straightforward and low cost to expensive and difficult. Making the challenge even greater is the process itself. Local environmental permitting of power facilities has been structured to handle a few large plants per year, not for hundreds of small installations. For CHP, a rapid, predictable and inexpensive permitting process is a prerequisite for the project to be economically viable

Site Permitting. One of the most significant impediments to deployment of on-site generation is the inconsistent and location-specific rules, regulations, and procedures affecting general siting and permitting. In order to obtain a permit, a variety of additional criteria must be addressed including water impacts, noise, land use, visual impacts, fire, safety, fuels, and hazardous materials. Present permitting requirements have been developed either for backup generators or large baseload projects and are often inappropriate for CHP applications. Lack of familiarity with CHP technologies and applications, and lack of a pre-certification option result in site-specific negotiations that can be needlessly time consuming and costly, particularly for smaller CHP systems.

Tax Policy. Inconsistent tax treatment of on-site generation investments is an additional hurdle to widespread market development. On-site generation systems do not fall into a specific tax depreciation category. CHP systems can qualify for one of several categories depending on configuration and ownership, so that the resulting depreciation period can range from 5 to 39 years. Existing depreciation policies may foreclose certain ownership arrangements for on-site generation, increasing the difficulty of raising capital and discouraging development.

Technology Needs. Although CHP technologies for large industrial applications have long been established and tested, there remains a need for improvement in smaller industrial, commercial and institutional and ultimately residential systems. Specifically, further developments in systems integration could reduce costs and expand market applications. Similar benefits would result from additional research to improve manufacturability and reliability of existing technologies. Advances in sensors, controls, software and communications could enhance the distribution system benefits of CHP. Improvements in efficiency and emission profiles of CHP technologies such as reciprocating engines and microturbines would increase economic benefits and expand the range of applications. Space heating, cooling, and dehumidification technologies, can be used in CHP application to improve building operations and inner air quality. Advanced technologies such as fuel cells and Stirling engines could provide additional benefits to both users and the nation. Gasification combined cycle technologies must be commercially demonstrated in the pulp and paper industry and the knowledge gained from this experience transferred to other industries.

Depreciation Barriers

Six Mars 90 combustion turbines, manufactured by Solar Turbines, with auxiliary-fired heat recovery steam generators have been operating in a Pennsylvania facility since June 1989. After 7.5 years in operation, this 60MW system incurred capital improvements, maintenance, and overhaul costs that totalled 85% of the original cost of the system. During this time period, no technologies to improve the overall efficiency or performance of the facility were introduced. This case study, as well as others indicates that the depreciation life of CHP systems falls within a seven to ten year time period.

5. Strategic Goals

To overcome the barriers and achieve the *Vision for 2020*, a number of goals related to the development and deployment of CHP systems will need to be accomplished. These goals have been categorized by time frame and topic. Unless noted, the goals listed cover all types of technologies and sizes of systems. The time frames are 2005 (nearer-term), 2010 (mid-term), and 2020 (longer-term). Specific pathways for achieving these goals will be developed as part of the subsequent Roadmap process. The topics are:

- **Technical performance.** Reductions in the capital, operating, and life-cycle costs of CHP systems; increases in the overall system efficiency with respect to converting fuel to useful work in the form of power, heating, cooling, mechanical energy; and improvements to CHP systems that increase durability or expand fuel flexibility.

- **Environmental performance.** Improvements to CHP systems that result in lower emissions of criteria pollutants and carbon dioxide and lower "neighborhood" impacts in terms of noise, aesthetics, and land use.

- **Interconnection standards and systems.** Actions taken to standardize interconnection protocols among states and service territories or the application of technologies that make it easier to achieve a "plug&play" market for CHP systems.

- **Regulatory framework.** Changes in methods of accounting for emissions reductions from the use of CHP systems both on-site and from the power system and; actions taken at the federal, state, or local levels to streamline the process and reduce the costs associated with permitting CHP facilities.

- **Market deployment.** Increases in the contribution of CHP facilities to the nation's power portfolio for industrial, commercial, institutional, municipal, and residential applications.

- **Application development.** Advances in bringing CHP systems for new applications to the marketplace.

- **Education and awareness.** Actions taken to increase the level of understanding among customers and policy makers (federal, state, and local) about the costs and benefits of CHP systems and related technologies such as district energy systems that aggregate thermal loads to facilitate CHP.

Nearer-term Goals — By 2005

Topic	Goal
Technical Performance	• The average design efficiency of new installations exceeds 65%. • Installation costs are 10% lower then they are today. • O&M costs are 10% lower then they are today. • Packaged units are available in smaller size ranges (< 1MW) that have maintenance intervals exceeding 1000 operating hours.
Environmental Performance	• The average new installation produces less than 0.5 lb/$MW_{(t+e)}$ of all NOx emissions.* • CHP systems are available that are less noisy and "friendlier" for local applications.
Interconnection Standards and Systems	• Uniform interconnection standards accepted by all fifty states and supported by professional groups (e.g., IEEE and ASHRAE). • Bi-lateral transactions (e.g. standby charges, ancillary services, power sales) between the CHP facility and the electric grid are determined by competitive market forces.
Regulatory Framework	• Output-based standards cover all emissions and are being used by the states, federal government, and other permitting agencies. • National policies for carbon emissions have been determined. • Streamlined permitting process in place in all relevant jurisdictions. • New Source Review reform measures in place. • Consistent tax depreciation based on useful life.
Market Deployment	• All new and 25% of existing federal facilities that can use CHP have it.
Application Development	• Program begun to develop CHP "appliances" for plug&play market. • Demonstrate biomass and "black liquor" gasification for use in CHP systems by the forest products industry. • Fully commercialized fuel cells for residential, commercial, and industrial stationary power applications.
Education & Awareness	• All federal, state, and local agencies have been informed about the costs and benefits of CHP systems. • Standardized energy accounting rules in place for all types of CHP facilities. • Studies published documenting the costs and benefits of CHP in all size ranges and potential applications.

* Equivalent to less than 25 parts per million NOx emissions.

Mid-term Goals — By 2010

Topic	Goal
Technical Performance	• The average design efficiency of new installations exceeds 75%. • Installation costs are 20% lower then they are today. • O&M costs are 20% lower then they are today. • CHP systems < 1MW have system lifetimes that exceed 60,000 hours.
Environmental Performance	• The average of all new installation produces less 0.1 $lb/MW_{(t+e)}$ NOx emissions.*
Interconnection Standards and Systems	• Short-term electricity storage integrated with CHP systems. • Standardized, “smart”, low-cost switchgear commercially available.
Regulatory Framework	• Output-based emissions standards fully accepted and used in all jurisdictions. • One-stop permitting available for all types of potential CHP users.
Market Deployment	• Total U.S. CHP capacity doubled compared to 1997 levels. • All new and 50% of existing federal facilities that can use CHP have it. • 50% of urban area district energy systems have CHP.
Application Development	• Standard packages for plug and play operations available for all types and sizes of CHP. • Multi-fuel CHP systems commercially available. • Lower cost thermal distribution systems commercially available. • New CHP technologies commercially available.
Education & Awareness	• All relevant policy makers and potential CHP users have information on the costs and benefits of CHP systems.

Longer-term Goals — By 2020

Topic	Goal
Technical Performance	• The average design efficiency of new installations exceeds 80%. • Installation costs are 40% lower than they are today. • O&M costs are 40% lower than they are today. • The average new installation uses multiple fuels, including bio-derived solids, liquids, and gases.
Environmental Performance	• The average of all new installation produces near zero parts per million of criteria pollutant.
Interconnection Standards and Systems	• N/A
Regulatory Framework	• Export market barriers eliminated.
Market Deployment	• U.S. CHP installed capacity doubled compared to 2010 levels.
Application Development	• District energy load aggregation systems can be installed for $800/foot in urban centers.
Education & Awareness	• N/A

* Equivalent to less than 5 parts per million NOx emissions.

6. Conclusions and Next Steps

The *Vision for 2020* offered in this document paints a bright future for CHP in the United States. There is tremendous opportunity to greatly increase the use of CHP over the next twenty years, bringing about substantial economic, energy, and environmental benefits for the nation as a whole.

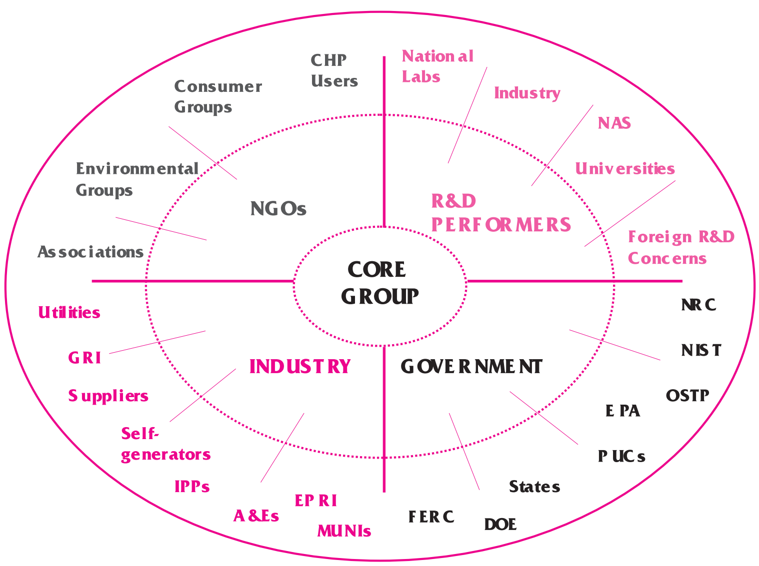
We must act now in order to achieve this vision and fully realize the potential of CHP. All members of the CHP industry need to come together in partnership with federal, state, and local government, using the vision as a guide and focus, to define and implement the steps that will move the nation towards success.

Education is a top priority for the various industries, commercial and ultimately residential building owners and operators, state and local governments, federal agencies, energy services providers, and others to raise awareness about the benefits of CHP and potential strategies for implementing new projects. This will be a difficult undertaking and the CHP industry must continue to work together with partners in the government, other industries, and other countries to leverage resources.

This document is expected to provide the foundation for an extensive roadmap process that will draw upon the expertise of a wide range of industry leaders to lay out a specific course for the CHP industries to move forward to accomplish its goals and realize its *Vision for 2020.*

Strategy for Inclusive Participation

A model for action in achieving broader participation.



List of CHP Vision Workshop Participants

Dan Adamson
Deputy Assistant Secretary
Office of Power Technologies
U. S. Department of Energy
Washington, DC

Craig Bennett
Director, Office of CEO
Trigen Energy Corporation
Princeton, NJ

Robert Bessette
President
Council of Industrial Boiler Owners
Burke, VA

Frank Bevc
Manager, Emerging Technologies
Westinghouse Electric
Orlando, FL

Richard Brent
Director, Government Affairs
Solar Turbines Incorporated
Washington, DC

Joe Bryson
Program Manager
U. S. Environmental Protection Agency
Washington, DC

Michael Burke
Chairman
NEV Technologies
Los Angeles, CA

Peter Carroll
VP Government Affairs
Solar Turbines, Incorporated
Washington, DC

Allan Casanova
Director, Strategic Marketing & Business
Siemens Westinghouse Science and Technology Center
Pittsburgh, PA

Tom Casten
President & CEO
Trigen Energy Corporation
White Plains, NY

Daniel Dessanti
General Manager, Marketing
Keyspan Energy
Brooklyn, NY

Neal Elliott
Senior Associate
American Council for an Energy Efficient Economy
Washington, DC 20036

Ronald Fiskum
Program Manager
Office of Building Technologies, State and Community Programs
U. S. Department of Energy
Washington, DC

Al Forte
Director, Energy Procurement
American Home Products
Madison, NJ

David Friedman
Director, Energy & Technology
American Forest & Paper Association
Washington, DC

Mark Gaines
Director, Commercial & Industrial Marketing
Southern California Gas Co.
Los Angeles, CA

Mark Ginsberg
Deputy Assistant Secretary
Office of Building Technologies, State and Community Programs
U. S. Department of Energy
Washington, DC

Fred Hart
Program Manager
Office of Industrial Technologies
U. S. Department of Energy
Washington, DC

Bruce Hedman
Vice President
ONSITE SYCOM Energy Corp.
Washington, DC

Al Hildreth
Staff Engineer
General Motors
Detroit, MI

Patricia Hoffman
Program Manager
Office of Industrial Technologies
U. S. Department of Energy
Washington, DC

Crawford Honeycutt
Industry Economist
Energy Information Administration
U. S. Department of Energy
Washington, DC

Kim Johnson
Vice President, Market Development
Coral Energy, L.P.
A Wholly Owned Subsidiary of The Royal Dutch Shell Group
Houston, TX

Fred Jones
President
Cogen Designs, Inc.
Canton, MI

Tina Kaarsberg
Senior Scientist
Northeast-Midwest Institute
Washington, DC

Allen Koleff
Vice President,
Environmental Affairs
Smurfit-Stone Container
Tucker, GA

Tom Kruziki
Vice President, Marketing
Waukesha Engine Division
Waukesha, WI

Harry Kumpula
Vice President, Marketing & Sales
National Dynamics
Lincoln, NE

Martin Kurtovich
Special Assistant
Office of Power Technologies
U. S. Department of Energy
Washington, DC

Skip Laitner
Senior Economist for Technology Policy
Office of Atmospheric Programs
U. S. Environmental Protection Agency
Washington, DC

Deborah Miller
Senior Policy Advisor
Office of Energy Efficiency and Renewable Energy
U. S. Department of Energy
Washington, DC

John Oleson
Director, Manufacturing Technology
Dow Corning Corporation
Midland, MI

Robert Panora
General Manager
Tecogen
Waltham, MA

Steven Parker
Senior Research Engineer
FEMP
U. S. Department of Energy
Richland, WA

Bill Parks
Director
Office of Industrial Technologies
U. S. Department of Energy
Washington, DC 20585

Delmar Raymond
Director, Strategic Energy
Weyerhaeuser
Tacoma, WA

Dan Reicher
Assistant Secretary
Office of Energy Efficiency and Renewable Energy
U. S. Department of Energy
Washington, DC

Valri Robinson
General Engineer
Office of Industrial Technologies
U. S. Department of Energy
Washington, DC

Richard Scheer
Assistant Vice President
Energetics, Incorporated
Washington, DC

Jennifer Schilling
Energetics, Incorporated
Washington, DC

Barbara Sisson
Associate Deputy Assistant Secretary
Office of Building Technologies, State and Community Programs
U. S. Department of Energy
Washington, DC

Mark Skowronski
Marketing Manager
AlliedSignal
Torrance, CA

Arthur Smith
Environmental Officer & Counsel
NiSource
Merrillville, IN

S. Lynn Sutcliffe
President
ONSITE SYCOM Energy Corp.
Somerset, NJ

Denise Swink
Deputy Assistant Secretary
Office of Industrial Technologies
U. S. Department of Energy
Washington, DC

Thomas Szabo
General Manager, Atlantic Region
Black & Veatch Corporation
Washington, DC

Dionne Thompson
Attorney
U.S. Combined Heat & Power Association
Washington, DC

Robert Thornton
President
Northwind Boston
Boston, MA

Gideon Varga
Office of Industrial Technologies
U. S. Department of Energy
Washington, DC

James Watts
Marketing Manager
NREC
Woburn, MA

Steven Weiner
Chair, Laboratory Coordinating Council
Pacific Northwest National Laboratory
Washington, DC

Thomas White
Vice President, Industrial Services
Duke Solutions
Bannockburn, IL

John Wimberly
President
I.C. Thomasson Associates, Inc.
Nashville, TN