Combined Heat and Power

A Clean Energy Solution

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Executive Summary

Combined heat and power (CHP) is an efficient and clean approach to generating electric power and useful thermal energy from a single fuel source. Instead of purchasing electricity from the distribution grid and burning fuel in an on-site furnace or boiler to produce thermal energy, an industrial or commercial facility can use CHP to provide both energy services in one energy-efficient step. The average efficiency of power generation in the United States has remained at 34 percent since the 1960s — the energy lost in wasted heat from power generation in the U.S. is greater than the total energy use of Japan. CHP captures this waste energy and uses it to provide heating and cooling to factories and businesses, saving them money and improving the environment. CHP is a commercially available clean energy solution that directly addresses a number of national priorities including improving the competitiveness of U.S. manufacturing, increasing energy efficiency, reducing emissions, enhancing our energy infrastructure, improving energy security and growing our economy.

While CHP has been in use in the United States in some form or another for more than 100 years, it remains an underutilized resource today. CHP currently represents approximately 8 percent of U.S. generating capacity compared to over 30 percent in countries such as Denmark, Finland and the Netherlands. Its use in the U.S. has been limited, particularly in recent years, by a host of market and non-market barriers. Nevertheless, the outlook for increased use of CHP is bright — policymakers at the federal and state level are beginning to recognize the potential benefits of CHP and the role it could play in providing clean, reliable, cost-effective energy services to industry and businesses. A number of states have developed innovative approaches to increase the deployment of CHP to the benefit of users, utilities and ratepayers. CHP is being looked at as a productive investment by some companies facing significant costs to upgrade outdated coal and oil-fired boilers. In addition, CHP can provide a cost-effective source of highly-efficient new generating capacity. Finally, the economics of CHP are improving as a result of the changing outlook in the long-term supply and price of North American natural gas — a preferred fuel for many CHP applications.

Recognizing the benefits of CHP and its current underutilization as an energy resource in the United States, the Obama Administration is supporting a new challenge to achieve 40 gigawatts (GW) of new, cost-effective CHP by 2020. Achieving this goal would:

- Increase total CHP capacity in the U.S. by 50 percent in less than a decade
- Save energy users $10 billion a year compared to current energy use
- Save one quadrillion Btus (Quad) of energy — the equivalent of 1 percent of all energy use in the U.S.
- Reduce emissions by 150 million metric tons of CO_2 annually — equivalent to the emissions from over 25 million cars

- Result in $40-$80 billion in new capital investment in manufacturing and other U.S. facilities over the next decade

This goal can be achieved through the promotion of utility partnerships with the CHP industry to reduce risk to potential users, the encouragement of effective and innovative CHP policies and financing, as well as encouraging highly efficient CHP to be used in areas where new generation capacity is needed. The U.S. Department of Energy (DOE) will be convening a series of workshops to foster a national dialogue on developing and implementing state best practice policies and investment models that address the multiple barriers to greater investment in industrial energy efficiency and CHP.

This paper provides a foundation for national discussions on effective ways to reach the 40 GW target, and includes an overview of the key issues currently impacting CHP deployment and the factors that need to be considered by stakeholders participating in the dialogue.

Introduction

Combined Heat and Power (CHP) represents a proven, effective, and underutilized near-term energy solution to help the United States enhance energy efficiency, improve environmental quality, promote economic growth, and maintain a robust energy infrastructure. The U.S. currently has an installed capacity of 82 GW of CHP, with 87 percent in manufacturing plants around the country[1]. CHP, or cogeneration, has been around in one form or another for more than 100 years — it is a proven commercial technology. Despite this track record, CHP remains underutilized in the U.S., even though it is one of the most compelling sources of efficient generation that could, with even modest investments, move the nation quickly toward greater energy security and a cleaner environment.

As an efficiency technology, CHP helps makes businesses more competitive by lowering their energy costs, reducing demand on the electricity delivery system, reducing strain on the electric grid, and reducing greenhouse gas (GHG) and other harmful emissions. Already used by many industrial facilities and a growing number of commercial and institutional entities, CHP is a commercially available clean energy resource that is immediately deployable, and that can help address current and future U.S. energy needs.

Cost-effective, clean CHP can provide a suite of benefits to both the user and to the nation:

- Benefits of CHP for U.S. businesses
  - Reduces energy costs for the user
  - Reduces risk of electric grid disruptions and enhances energy reliability
  - Provides stability in the face of uncertain electricity prices

- Benefits of CHP for the Nation
  - Improves U.S. manufacturing competitiveness
  - Offers a low-cost approach to new electricity generation capacity
  - Provides an immediate path to lower GHG emissions through increased energy efficiency
  - Lessens the need for new transmission and distribution (T&D) infrastructure and enhances power grid security
  - Uses abundant clean domestic energy sources
  - Uses highly skilled American labor and American technology

Installing an additional 40 GW of CHP (about 50 percent more than the current levels of U.S. CHP capacity) would save approximately one Quadrillion Btus (Quad) of energy annually[2] and eliminate over 150 million metric tons of CO_2 emissions each year (equivalent to the emissions of over 25 million cars). The additional CHP capacity would save energy users $10 billion a year relative to their existing energy sources[3]. Achieving this goal would also result in $40-80 billion in new capital investment in manufacturing and other U.S. facilities over the next decade.

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[1] CHP Installation Database developed by ICF International for Oak Ridge National Laboratory and the U.S. DOE; 2012. Available at http://www.eea-inc.com/chpdata/index.html.

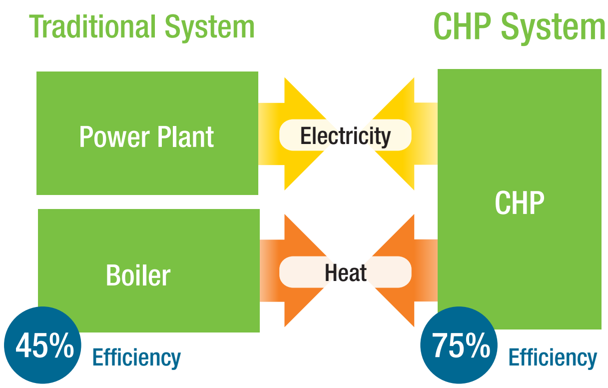
[2] One Quad equals 10^{15} Btus and is equivalent to 1 percent of total annual energy consumption in the U.S.

[3] $40-80 billion is the investment amount required to deliver the 40 GW based on a range of costs from $1,000 to $2,000/kW.

Combined Heat and Power as a Clean Energy Solution

Combined heat and power is an efficient and clean approach to generating power and thermal energy from a single fuel source. CHP is used either to replace or supplement conventional separate heat and power (SHP). Instead of purchasing electricity from the local utility and burning fuel in an on-site furnace or boiler to produce needed steam or hot water, an industrial or commercial user can use CHP to provide both energy services in one energy-efficient step **(Figure 1)**. Every CHP application involves the recovery of thermal energy that would otherwise be wasted to produce additional power or useful thermal energy; as such, CHP can provide significant energy efficiency and environmental advantages over separate heat and power. It is reasonable to expect CHP applications to operate at 65–75 percent efficiency, a large improvement over the national average of 45 percent for these services when separately provided.

FIGURE 1 | Efficiency Benefits of CHP



CHP can be configured either as a topping or bottoming cycle. In a topping cycle, fuel is combusted in a prime mover such as a gas turbine or reciprocating engine, generating electricity or mechanical power. Energy normally lost in the prime mover's hot exhaust and/or cooling systems is recovered to provide process heat, hot water, or space heating/cooling for the site[4]. In a bottoming cycle, also referred to as waste heat to power, fuel is combusted to provide thermal input to a furnace or other industrial process and some of the heat rejected from the process is then used for power production. For optimal efficiency, CHP systems are typically designed and sized to meet a facility's baseload thermal demand.

CHP is a distributed energy resource that is, by definition, strategically located at or near the point of energy use **(Figure 2)**[5]. While 87 percent of existing U.S. CHP capacity is located at industrial facilities, CHP can also be an attractive resource for commercial or institutional facilities such as schools and hospitals, in district energy systems, and in military installations. Such on-site generation avoids the transmission and distribution (T&D) losses associated with electricity purchased via the grid from central stations and defers or eliminates the need for new T&D investment. CHP's inherent higher efficiency and elimination of transmission and distribution losses from the central station generator results in reduced primary energy use and lower GHG emissions.

FIGURE 2 | Location of Existing CHP Capacity

Source: CHP Installation Database, ICF International

The increase in fuel use efficiency of CHP combined with the use of lower carbon fuels such as natural gas generally translates into reductions in GHG and criteria emissions compared to separate heat and power. **Table 1** compares the annual energy and CO_2 savings of a 10 MW natural gas-fired CHP system over separate heat and power with the energy and CO_2 savings from utility-scale renewable

TABLE 1 | CHP Energy and CO_2 Savings Potential

Category	10 MW CHP	10 MW PV	10 MW Wind	Combined Cycle (10 MV Portion)
Annual Capacity Factor	85%	22%	34%	70%
Annual Electricity	74,446 MWh	19,272 MWh	29,784 MWh	61,320 MWh
Annual Useful Heat	103,417 MWh_t	None	None	None
Footprint Required	6,000 sq ft	1,740,000 sq ft	76,000 sq ft	N/A
Capital Cost	$20 million	$60.5 million	$24.4 million	$10 million
Annual Energy Savings	308,100 MMBtu	196,462 MMBtu	303,623 MMBtu	154,649 MMBtu
Annual CO_2 Savings	42,751 Tons	17,887 Tons	27,644 Tons	28,172 Tons
Annual NOx Savings	59.4 Tons	16.2 Tons	24.9 Tons	39.3 Tons

The values in TABLE 1 are based on:

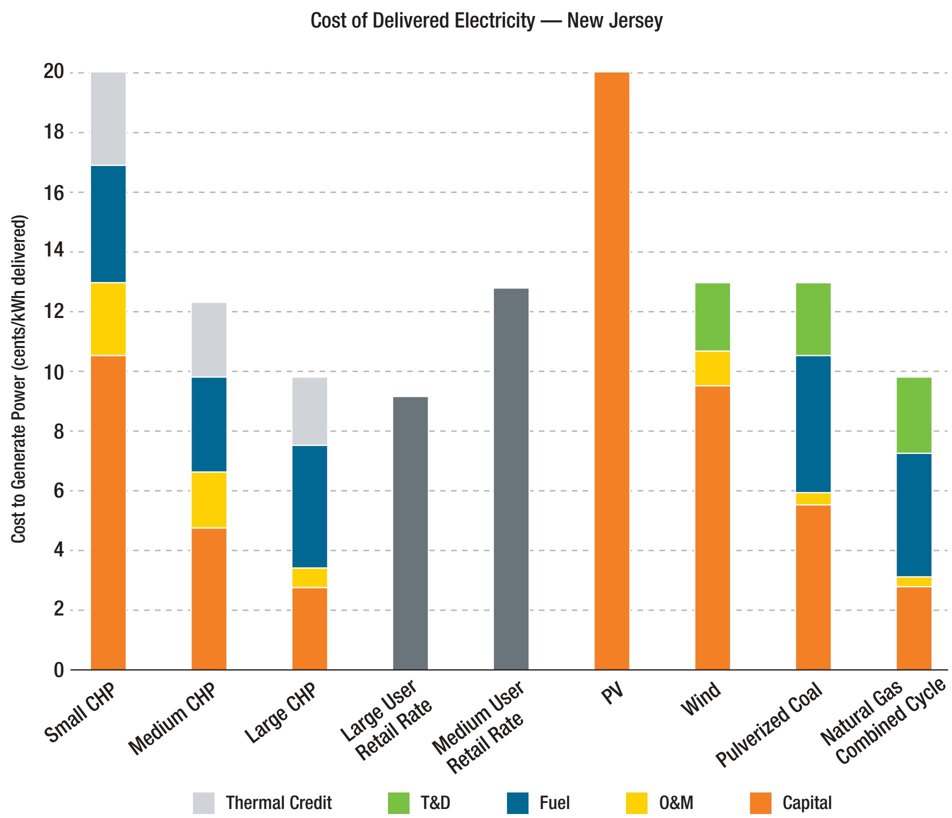
- 10 MW Gas Turbine CHP — 28% electric efficiency, 68% total CHP efficiency, 15 ppm NOx emissions
- Capacity factors and capital costs for PV and Wind based on utility systems in DOE's Advanced Energy Outlook 2011
- Capital cost and efficiency for natural gas combined cycle system based on Advanced Energy Outlook 2011 (540 MW system proportioned to 10 MW of output), NGCC 48% electric efficiency, NOx emissions 9 ppm
- CHP, PV, Wind and NGCC electricity displaces National All Fossil Average Generation resources (eGRID 2012) — 9,572 Btu/kWh, 1,743 lbs CO_2/MWh, 1.5708 lbs NOx/MWh, 6.5% T&D losses; CHP thermal output displaces 80% efficient on-site natural gas boiler with 0.1 lb/MMBtu NOx emissions

technologies and natural gas combined cycle (NGCC) systems producing power only. This shows that CHP can provide overall energy and CO_2 savings on par with comparably sized solar photovoltaics (PV), wind, NGCC, and at a capital cost that is lower than solar and wind and on par with NGCC.

CHP can provide lower energy costs for the user by displacing higher priced purchased electricity and boiler fuel with lower cost self-generated power and recovered thermal energy. The amount of savings that CHP represents depends on the difference in costs between displaced electricity purchases and fuel used by the CHP system. To be cost-effective, the savings in power and fuel costs need to be compared to the added capital, fuel and other operating and maintenance costs associated with operating a combined heat and power system.

In many parts of the country, CHP provides not only operating savings for the user, but also represents a cost-effective supply of new power generation capacity. As an example, **Figure 3** compares the cost of electricity generated from small, medium, and large sized CHP projects with delivered electricity costs in New Jersey and the cost of electricity from new central power generation[6]. The light shaded area at the top of the CHP bars shows the savings in the costs of displaced on-site boiler fuel from capturing and using the waste heat from CHP at the site. The net cost of power from large and medium CHP systems are below the large and medium electric customer delivered retail electricity rates respectively indicating that CHP can generate savings for the end-user. The net costs of large and medium CHP power

FIGURE 3 | CHP can be a Cost-Effective Source of New Generation Capacity



are also at or below the delivered costs of new coal and natural gas central station generation as well as utility-based renewable options, indicating that CHP represents a cost-effective source of new generation capacity for the state as a whole. The New Jersey results are indicative of current conditions in most Northeast and Mid-Atlantic states and also in California and Texas. This type of comparison can be done throughout the country using state and utility-specific information.

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[4] In another version of a topping cycle, fuel is burned in a boiler to produce high pressure steam. That steam is fed to a steam turbine, generating mechanical power or electricity, before exiting the turbine at lower pressure and temperature and used for process or heating applications at the site.

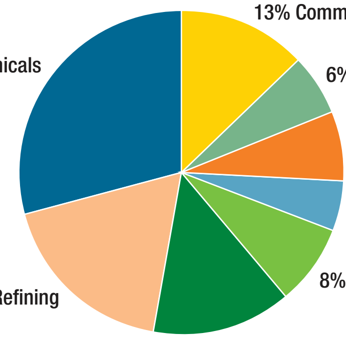
[5] CHP Installation Database developed by ICF International for Oak Ridge National Laboratory and the U.S. DOE; 2012. Available at http://www.eea-inc.com/chpdata/index.html.

[6] Capital and O&M costs for coal, NGCC, wind and PV and annual capacity factors for wind and PV based on EIA AEO 2011; annual capacity factors for coal and NGCC based on 2009 national averages (64 and 42%); Utility coal and natural gas prices $4.40/MMBtu and $5.50/MMBtu respectively, CHP based on 100 kW engine system and $7.50/MMBtu natural gas (small CHP), 1 MW engine system and $6.25 natural gas (medium CHP), 25 MW gas turbine and $6.25 natural gas (large CHP); cost of capital 12% for CHP and 8% for central station systems.

The Current Status of CHP and Its Potential Future Role in the United States

CHP is already an important resource for the U.S. — the existing 82 GW of CHP capacity at over 3,700 industrial and commercial facilities represents approximately 8 percent of current U.S. generating capacity and over 12 percent of total MWh generated annually[7]. CHP can be utilized in a variety of applications that have significant and coincident, power and thermal loads. **Figure 4** shows the sectors currently using CHP — 87 percent of existing CHP capacity is found in industrial applications, providing power and steam to energy intensive industries such as chemicals, paper, refining, food processing, and metals manufacturing. CHP in commercial and institutional applications is currently 13 percent of existing capacity, providing power, heating and cooling to hospitals, schools, university campuses, hotels, nursing homes, office buildings and apartment complexes; district energy CHP systems in cities and university campuses represent approximately 5 GW of installed CHP[8].

FIGURE 4 | Existing CHP Capacity

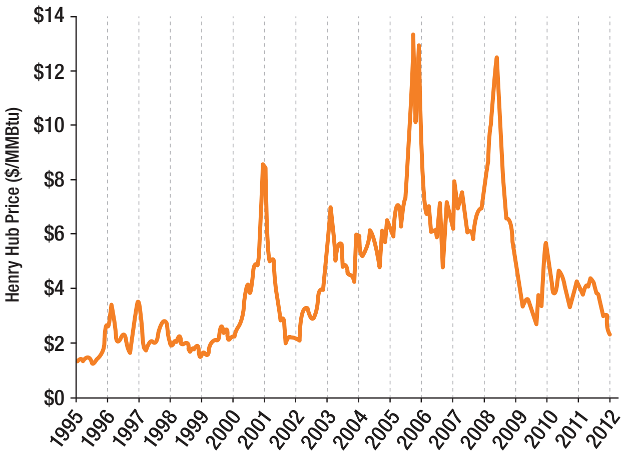


Current CHP installations in the United States use a diverse set of fuels, although natural gas is by far the most common fuel at 72 percent of installed CHP capacity. Biomass, process wastes and coal make up the remaining CHP fuel mix. Compared to the average fossil-based electricity generation, the entire existing base of CHP saves 1.8 Quads of energy annually and eliminates 240 million metric tons of CO_2 emissions each year (equivalent to the emissions of over 40 million cars).

There is a long history of using CHP in the U.S. Decentralized CHP systems located at industrial and municipal sites were the foundation of the early electric power industry in the United States. However, as power generation technologies advanced, the power industry began to build larger central station facilities to take advantage of increasing economies of scale. CHP became a limited practice primarily utilized by a handful of industries (paper, chemicals, refining and steel) which had high and relatively constant steam and electric demands and access to low-cost fuels. Utilities had little incentive to encourage customer-sited generation, including CHP. Various market and non-market barriers at the state and federal level served to further discourage broad CHP development[9].

Spurred by the oil crisis, in 1978, Congress passed the Public Utilities Regulatory Policies Act (PURPA) to encourage greater energy efficiency. PURPA provisions encouraged energy efficient CHP and small power production from renewables by requiring electric utilities to interconnect with "qualified facilities" (QFs). CHP facilities had to meet minimum fuel-specific efficiency standards[10] in order to become a QF. PURPA required utilities to provide QFs with reasonable standby and

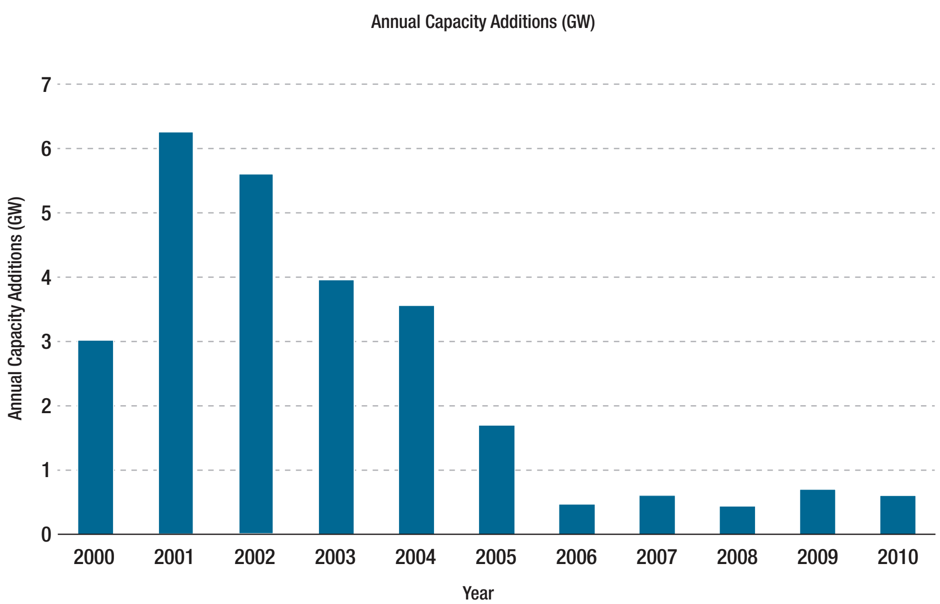
FIGURE 5 | Henry Hub Natural Gas Prices



back-up charges, and to purchase excess electricity from these facilities at the utilities' avoided costs[11]. PURPA also exempted QFs from regulatory oversight under the Public Utilities Holding Company Act and from constraints on natural gas use imposed by the Fuel Use Act. Shortly after enacting PURPA, Congress also provided tax credits for investments in cogeneration equipment under the Energy Tax Act of 1978 (P.L. 95-618; 96-223) and the Crude Oil Windfall Profits Tax Act of 1980 (P.L. 96-223; 96-471). The Energy Tax Act included a 10 percent tax credit on waste-heat boilers and related equipment, and the Windfall Profits Tax Act extended the 10 percent credit to remaining CHP equipment for qualified projects[12]. The Windfall Profits Act limited the amount of oil or natural gas that a qualifying facility could use[13]. The implementation of PURPA and the tax incentives were successful in dramatically expanding CHP development; installed capacity increased from about 12,000 MW in 1980 to over 66,000 MW in 2000[14].

The environment for CHP changed again in the early 2000s with the advent of restructured wholesale markets for electricity in several regions of the country. Independent power producers could now sell directly to the market without the need for QF status. The movement toward restructuring (deregulation) of power markets in individual states also caused market uncertainty, resulting in delayed energy investments. As a result, CHP development slowed. As shown in **Figure 5**[15], these changes also coincided with rising and increasingly volatile natural gas

FIGURE 6 | CHP Capacity Additions Since 2000

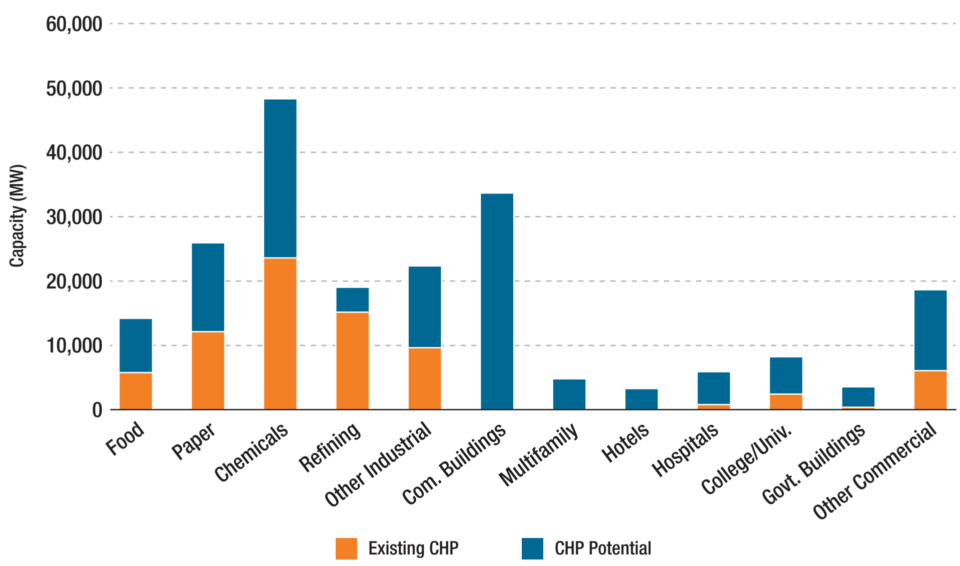


prices as the supply demand balance in the U.S. tightened. This further dampened the market for CHP development.

As **Figure 6** shows, investment in new CHP capacity slowed precipitously in the 2004/2005 timeframe[16]. At that point, a combination of highly volatile natural gas prices, continuing market barriers and an uncertain economic outlook led to a steep decline in CHP installations that persists through today.

While recent investment in CHP has declined, CHP's potential role as a clean energy source for the future is much greater than recent market trends would indicate. Like other forms of energy efficiency, efficient on-site CHP represents a largely untapped resource that exists in a variety of energy-intensive industries and businesses (**Figure 7**). Recent estimates indicate the technical potential[17] for additional CHP at existing industrial facilities is just under 65 GW, with the corresponding technical potential for CHP at commercial and institutional facilities at just over 65 GW[18], for a total of about 130 GW. A 2009 study by McKinsey and Company estimated that 50 GW of CHP in industrial and large commercial/institutional applications could be deployable at reasonable returns with then current equipment and energy prices[19]. The economic potential is likely greater today given the improving outlook in natural gas supply and prices.

FIGURE 7 | Technical Potential for Additional CHP at Existing Industrial and Commercial Facilities[20]



The 65 GW of industrial technical potential outlined above represents efficient CHP systems sized to the baseload thermal demand of the site and does not include the potential for producing electricity for export to the grid beyond the facility's on-site demand. This export capacity from many industrials represents another

significant resource base of clean, efficient CHP. The technical potential in industrial applications more than doubles to 130 GW if systems are sized to the thermal demand without a cap in power output, and excess electricity generated but not used on site could be easily exported to the grid or sold to adjacent users[21].

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[7] CHP Installation Database developed by ICF International for Oak Ridge National Laboratory and the U.S. DOE; 2012. Available at http://www.eea-inc.com/chpdata/index.html.

[8] International District Energy Association.

[9] "Combined Heat and Power: Effective Energy Solutions for a Sustainable Future", Oak Ridge National Laboratory, ORNL/TM-2008/224, December 2008.

[10] Efficiency hurdles were higher for natural gas CHP.

[11] Avoided cost is the cost an electric utility would otherwise incur to generate power if it did not purchase electricity from another source.

[12] "Energy Tax Policy: Historical Perspectives on the Current Status of Energy Tax Expenditures", Congressional Research Service, May 2011.

[13] Gary Fowler, Albert Baugher and Steven Jansen, "Cogeneration", Illinois Issues, Northern Illinois University, December 1981.

[14] CHP Installation Database developed by ICF International for Oak Ridge National Laboratory and the U.S. DOE; 2012. Available at http://www.eea-inc.com/chpdata/index.html.

[15] Platts Gas Daily historical data.

[16] CHP Installation Database developed by ICF International for Oak Ridge National Laboratory and the U.S. DOE; 2012. Available at http://www.eea-inc.com/chpdata/index.html.

[17] The technical market potential is an estimation of market size constrained only by technological limits — the ability of CHP technologies to fit existing customer energy needs. The technical potential includes sites that have the energy consumption characteristics that could apply CHP. The technical market potential does not consider screening for other factors such as ability to retrofit, owner interest in applying CHP, capital availability, fuel availability, and variation of energy consumption within customer application/size classes. All of these factors affect the feasibility, cost and ultimate acceptance of CHP at a site and are critical in the actual economic implementation of CHP.

[18] Based on ICF International internal estimates as detailed in "Effect of a 30 Percent Investment Tax Credit on the Economic Market Potential for Combined Heat and Power", report prepared for WADE and USCHPA, October 2010. These estimates are on the same order as recent estimates developed by McKinsey and Company in "Unlocking Energy Efficiency in the U.S. Economy", July 2009.

[19] McKinsey and Company, "Unlocking Energy Efficiency in the U.S. Economy", July 2009.

[20] Internal estimates by ICF International and CHP Installation Database developed by ICF International for Oak Ridge National Laboratory and the U.S. DOE; 2012. Available at http://www.eea-inc.com/chpdata/index.html.

[21] Internal estimates from ICF International.

Emerging Drivers for CHP

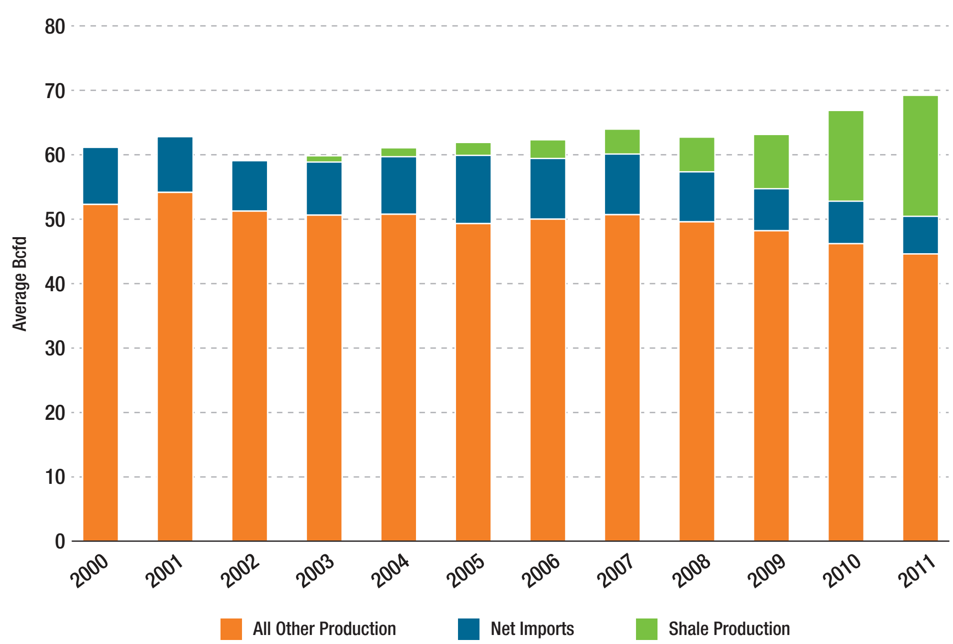
While investment in CHP has remained low since 2005, recent market activity suggests the time is right for a rebound in CHP development powered by four critical drivers:

Changing Outlook for Natural Gas Supply and Price

The United States is in the midst of a shale gas revolution that has been described as a "game changer" in terms of the near- and long-term supply outlook for natural gas. The revolution in recovering natural gas from shale formations is the result of large-scale application of horizontal drilling and hydraulic fracturing techniques in the shale development that began in the early 2000s.

The Barnett shale formation in Texas was one of the first to be tapped. Other large shale formations include the Haynesville shale in Louisiana, the Fayetteville shale in Arkansas, and (perhaps the largest) the Marcellus shale that extends southward from New York State, through Pennsylvania and into the Appalachian Mountains. As shown in **Figure 8**, the amount of shale gas supplied to the U.S. market has grown by a factor of 14 since 2005, displacing imports and more than offsetting declines in other North American production resources[22].

FIGURE 8 | U.S. Natural Gas Supply



The development of shale gas has had a significant moderating effect on natural gas prices. Prices in the five years prior to the recession averaged about $7.50/MMBtu; since 2008, gas prices have averaged about $4/MMBtu[23]. Continuing advancements in technology are driving reassessments of long term gas outlook as analysts project more and more shale gas is economically recoverable at prices below $5 per MMBtu. Estimates of the natural gas resource base in North America that can be technically recovered using current exploration and production technologies now range from 2,000 to over 4,000 trillion cubic feet (Tcf) — enough natural gas to supply the United States and Canada for 100 to 150 years at current levels of consumption[24]. Henry Hub gas prices remain in the $4 to $7 range through 2030 in current EIA projections[25]; sufficient to support the levels of supply development in the projection, but not high enough to discourage market growth. Continuing moderate, and less volatile, gas prices will be a strong incentive for CHP market development. As detailed above, 72 percent of existing CHP capacity is fueled by natural gas, and the clean burning and low carbon aspects of natural gas will make it a preferred fuel for future CHP growth.

Growing State Policymaker Support

Policymakers at the state level are increasingly recognizing the benefits that CHP offers in terms of energy efficiency, reduced emissions, and economic growth, and are adopting supportive policies. These policies include recognizing CHP in state energy portfolio standards (renewable, clean energy, and energy efficiency) and addressing utility regulatory policies that unduly discourage new CHP project development.

Twenty-three states recognize CHP in one form or another as part of their Renewable Portfolio Standards or Energy Efficiency Resource Standards. A number of states, including California, New York, Massachusetts, New Jersey, and North Carolina, have initiated specific incentive programs for CHP. Examples include:

- Massachusetts Green Communities Act — The Green Communities Act includes a rebate incentive for efficient CHP systems ($750/kW up to 50 percent of total installed costs). The incentive value is determined on a case-by-case basis considering the value of CHP in the participating utility's overall energy efficiency portfolio, the project's benefit to cost ratio, the project's contribution to energy efficiency, project risk, and customer investment threshold. All of the kilowatt-hours from CHP installed under the program are credited to the servicing utility's energy efficiency goals.
- California Feed-in Tariff for CHP below 20 MW — California has targeted up to 6,500 MW of new CHP capacity by 2030 as a critical element in meeting its GHG reduction goals; this goal was established under Governor Brown's Clean Energy Jobs Plan released in 2010. To help stimulate CHP deployment, the state has initiated a feed-in-tariff (FIT) for CHP systems less than 20 MW and with excess power (per AB 1613). The CHP system must be sized to thermal load and operate at greater than 62% efficiency. The FIT price is tied to natural gas prices adjusted by the time of day and season (Market Price Referent (MPR)). California's FIT is not preempted by FERC as long as

the CHP generators are qualified facilities and the rate does not exceed the avoided cost. FERC approved California's FIT design that included multi-tiered rates (higher rates for greater efficiency) and adders for transmission constraints and environmental externalities.

Changing Market Conditions For Power And Industrial Sectors

There are a number of factors that are affecting the market for producing electricity. These changing factors include significantly reduced prices for natural gas and expectations that prices will remain low for several years, moderately climbing prices for coal, reduced projections for electricity demand growth, an aging fleet of coal-fired power plants, and the U.S. Environmental Protection Agency's (EPA) recently finalized power sector air regulations which will require investments in pollution control technology at fossil-fired plants that currently lack modern controls. A variety of power plant owners in the U.S. have announced a number of plant retirements over the past two years[26].

While there is a fair amount of excess power generating capacity currently, in some regions the increase in announced power plant retirements is resulting in the need for new generation capacity sooner than would otherwise be required in order to maintain targeted reserve margins within regional electricity planning authorities. In addition, the retirement of individual units can require the need to assess more localized impacts on the grid in order to ensure continued maintenance of established reliability standards. These factors create the need for new generation within regions most impacted by retirements, as well as to provide localized resources to ensure reliability over the coming years. This creates a significant opportunity for the development of new CHP to meet these needs.

Similarly, industrial facilities may need to invest to improve or replace aging boilers, whether to comply with pollution standards or to address aging capital equipment. Investments in industrial facilities provide an opportunity for CHP deployment, which is often a better investment, cleaner, and more energy efficient than alternatives. DOE and EPA have partnered to ensure that industrial facilities have information on alternative cost-effective clean energy strategies such as CHP when making investment decisions[27].

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[22] ICF Internal estimates based on historical production data.

[23] See Figure 5.

[24] The lower limit is based on DOE's natural gas resource estimate for the United States in EIA's Annual Energy Outlook 2012; the upper limit is based on ICF International's estimates of recoverable North American resources as of spring 2012.

[25] DOE Energy Information Administration, Annual Energy Outlook 2012.

[26] Energy Information Agency, Projected retirements of coal-fired power plants. http://www.eia.gov/todayinenergy/detail.cfm?id=7330.

[27] http://www1.eere.energy.gov/manufacturing/distributedenergy/boilermact.html.

Barriers to Increased CHP Deployment

Although much progress has been made in the last decade to remove technical and regulatory barriers to wider adoption of CHP, and while significant new market drivers support an increase in CHP development, several major hurdles remain:

Unclear Utility Value Proposition

Many investor-owned electric utilities still experience customer-sited CHP as revenue erosion due to traditional business models linking sales to cost recovery and revenues. Since most facilities that install CHP remain connected to the grid and need to rely on their servicing utility for supplemental power needs beyond their self-generation capacity and/or for standby and back-up service during outages or planned maintenance, utility policies, attitudes, and actions can make or break a CHP project's economics. Utility tariff structures and standby rates impact the economics of on-site generation[28]. Similarly, interconnection processes can delay the project development process and add expenses by requiring costly studies, onerous technical requirements, or significant delays in the process.

Limited CHP Supply Infrastructure

The downturn in CHP investment since 2005 has reduced the size and focus of the industry sales and service infrastructure. CHP is not currently a major emphasis for most energy developers and equipment suppliers. Increased use of CHP will help bring system costs down and develop service infrastructure for CHP.

Market and Non-Market Uncertainties

CHP requires a significant capital investment and the equipment has a long life – 20+ years. It can be challenging to make investment decisions in a rapidly changing policy and economic environment. Uncertain factors affecting project economics include: fuel and electricity prices, regional/national economic conditions, market sector growth, utility and power market regulation, and environmental policy. Sizing the CHP system to maximize efficiency in many industrial facilities (i.e., thermal match) often produces power in excess of the host site's needs, introducing the added market risk of power pricing to a consumer usually in a different core business. In addition, CHP may increase emissions on-site while reducing emissions regionally; CHP projects benefit from policies that recognize and account for these savings[29].

End-User Awareness and Economic Decision-Making

CHP is not regarded as part of most end-users' core business focus and, as such, is sometimes subject to higher investment hurdle rates than competing internal options. In addition, many potential industrial project hosts are not fully aware of the full array of benefits provided by CHP, or are overly sensitive to perceived CHP investment risks.

Local Permitting and Siting Issues

CHP installations must comply with a host of local zoning, environmental, health and safety requirements at the site. These include rules on air and water quality, fire prevention, fuel storage, hazardous waste disposal, worker safety and building construction standards. This requires interaction with various local agencies including fire districts, air districts, and water districts and planning commissions, many of which may have no previous experience with a CHP project and are unfamiliar with the technologies and systems.

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[28] Rate structures that recover the majority of the cost of service in non-bypassable fixed charges and/or ratcheted demand charges reduce the economic savings potential of CHP.

[29] International Energy Agency, Combined Heat & Power: and Emissions Trading: Options for Policy Makers, July 2008, http://www.iea.org/papers/2008/chp_ets.pdf.

Innovative Solutions for Increased CHP Deployment

Given the barriers outlined above, policymakers are beginning to craft solutions that benefit all stakeholders (users, utilities, ratepayers). These include:

Utility Partnerships to Advance CHP

Utilities currently own just 3% (~2.4 GW) of existing CHP capacity. Given the central role that they play in the development of new CHP — through policies that directly impact project economics — and this modest level of ownership, greater partnership between utilities, their industrial customers, project developers, and other stakeholders offers a significant opportunity for addressing several obstacles that currently limit project development. Utility recognition of CHP as an investment opportunity to retain large industrial customers, as well as a solution to needed investments in new generation and T&D infrastructure, is critical. Utilities can serve as important partners in the development of CHP projects in areas of the grid that are currently congested and in need of support. Financing difficulties can also be relieved by utilities that typically have a lower cost of capital and longer investment time horizons than many of their industrial customers. Overall, greater utility partnerships on CHP are a win-win for the utility, the end-user/project developer, and other ratepayers. The utilities can get the generation and T&D infrastructure support they need, while providing the user with stable financing and risk management. Project benefits will need to be appropriately apportioned to stakeholders through well-crafted, fair policies and strategies to ensure broad support.

State Policies to Capture Benefits of CHP

Many states, cognizant of the energy, environmental, and economic benefits of CHP, are crafting strategies to increase the use of CHP. These strategies include: state goals for new CHP development, energy efficiency or renewable energy portfolio standards that recognize CHP, utility regulatory policies, clean energy allowance set-asides under emissions trading programs, recognition of CHP's emissions reductions in state air planning, and tax policies or other mechanisms to provide incentives for CHP. Through their leadership, state policy makers are laying the groundwork for expanding CHP development and, in so doing, realizing the associated energy, environmental, and economic benefits for their state[30]. For example, the California Air Resources Board's (CARB's) Scoping Plan envisions enough CHP to reduce GHG emissions by 6.7 million metric tons (MMT) annually and the recent California Public Utilities' (CPUC) decision sets a target of 3,000 MW of new contracts by 2020, which has a target of 4.8 MMT of GHG reductions from new CHP projects[31].

Ensuring state permitting and siting officials share information about CHP and best practices, including standardized procedures for permitting and siting, encourages greater use of CHP. Some states, such as New York, have issued guidebooks on distributed generation siting, permitting and codes[32]. States have also moved towards developing standardized interconnection application forms, specifying that project developers comply with national technical and safety standards (IEEE, UL, fire safety guidelines, etc.), and have standardized application processes, timelines, and fees as a way of streamlining the process for CHP projects.

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[30] A number of states have begun to recognize CHP as an option under their clean energy goals. States have included CHP as an eligible resource in their renewable portfolio standards, typically under a separate tier devoted to efficiency measures. CHP has also been incorporated as part of a stand-alone state energy efficiency portfolio standard. For example, Massachusetts' Alternative Energy Portfolio Standard (AEPS) that requires 5 percent of the state's electric load be met with "alternative energy" by 2020. CHP qualifies under the AEPS and as of 2009 represented 99 percent installed capacity under the program. Additionally, some states have enacted broader legislation and/or issued executive orders establishing CHP targets such as California's goal of 6,500 MW of new CHP called for as part of an executive order or New Jersey's Energy Master Plan which calls for 1,500 MW of new CHP capacity within the state.

[31] Docket 11-IEP-1A. California Energy Commission. Comments on the Cogeneration Association of California and the Energy Producers and Users Coalition on the California Clean Energy Future Overview. June 20, 2011. http://www.energy.ca.gov/2011_energypolicy/documents/2011-07-06_workshop/comments/Cogeneration_Association_of_California_Comments_2011-07-20_TN-61457.pdf.

[32] Bourgeois, Tom, and Bruce Hedman. "Clean Distributed Generation in New York State: State and Local Siting, Permitting and Code Issues." Prepared for the New York State Energy Research and Development Authority. May 2003. http://www.pace.edu/lawschool/files/energy/docs/Pace_CHP_Siting_Guidebook.pdf.

Conclusion

CHP is a proven solution for meeting growing energy demand efficiently, cleanly and economically. CHP is a clean energy solution that immediately addresses a number of national priorities including improving the competitiveness of U.S. manufacturing, increasing energy efficiency, reducing emissions, enhancing our energy infrastructure, improving energy security and growing our economy.

The Obama Administration is supporting a national goal of achieving 40 GW of new, cost-effective CHP in the United States by the end of 2020. This challenge falls in line with the goals set by the Industrial Energy Efficiency and Combined Heat and Power Working Group of the State and Local Energy Efficiency Action Network (SEE Action), which is focused on promoting industrial energy efficiency and CHP[33].

Achieving this goal would require a significant increase in the level of CHP development over recent years, but the pace of development would be comparable with periods in the late 1980 through mid-1990s and again in the early 2000s when the market and policy landscapes were more favorable towards CHP. To meet this goal by 2020, barriers to CHP development need to be removed, and effective policies, programs and financing opportunities promoted.

An additional 40 GW of CHP (approximately 50 percent more than the current levels of U.S. CHP capacity) would save 1 Quad of energy (equivalent to 1 percent of total annual energy consumption in the U.S.), reduce CO_2 by 150 million metric tons annually (equivalent to the emissions of over 25 million cars), and save energy users $10 billion a year relative to their existing energy sources. Achieving this goal would also result in $40 – 80 billion in new capital investment in manufacturing and other U.S. facilities over the next decade.

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[33] Industrial Energy Efficiency and Combined Heat and Power Working Group, SEE Action Network. http://www1.eere.energy.gov/seeaction/combined_heat_power.html.

For More Information:

Visit the U.S. DOE Advanced Manufacturing Office Website at **www.eere.energy.gov/manufacturing.**

Visit the U.S. EPA Office of Air & Radiation Website at **www.epa.gov/air.**

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