INTERNATIONAL DISTRICT ENERGY ASSOCIATION

Combined Heat and Power (CHP): Essential for a Cost Effective Clean Energy Standard

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Executive Summary

In March 2011, both Congress and the Obama Administration have put forward the notion of a federal Clean Energy Standard (CES) as a central approach to advancing a new national energy policy. In past Congresses, a range of bills were introduced to establish renewable electricity standards, in which electric utilities would be required to obtain a growing percentage of their "portfolio" of supplies from prescribed renewable power generation technologies such as solar and wind.

This concept has now been broadened in legislative proposals, offered by both Republicans and Democrats, to encompass other sources including nuclear, clean coal with carbon capture and sequestration (CCS), and (in some proposals) energy efficiency measures. (It is important to note that CCS is not a proven, commercially available technology.) President Obama has called for a CES to provide 80 percent of electricity by 2035 from a range of sources including "efficient natural gas" as well as nuclear and coal with CCS.

The projected cost reductions for U.S. ratepayers from including CHP in a CES exceed $500 billion through 2035.

The CES concept has bipartisan support and could strengthen energy security, increase efficiency and reduce environmental impacts. Increasingly stringent regulation of coal air emissions and ash management is expected to push as much as 52,000 MegaWatts (MW) of coal-fired power plants into retirement – one sixth of total current coal power capacity. To maintain and strengthen energy security, we need to replace this capacity with a diverse set of clean, efficient resources.

The International District Energy Association (IDEA) advocates CES legislation that:

1. Includes combined heat and power as an eligible clean technology.
2. Takes a truly technology-neutral approach to calculating CES credits based on the avoided primary energy consumption or greenhouse gas (GHG) reductions compared with: generation of electricity using a reference plant generating only power (for example, a natural gas combined-cycle plant); and production of heat using a natural gas boiler.
3. Allows credits to be issued to entities other than electric utilities.

Ratepayers will win, emissions will be reduced, and our power infrastructure will be more reliable, diverse and efficient.

This approach will be far more cost-effective and flexible in increasing power-sector efficiency and reducing GHG emissions, as demonstrated in the analysis presented in this White Paper. The projected cost reductions for U.S. ratepayers from including CHP exceed $500 billion through 2035.

CHP can be implemented by a wide range of entities all across the country, including not only electric utilities but also thousands of existing district energy systems, industrial facilities, colleges, universities and hospitals. It is critically important that the full range of end-users be eligible for CES credit.

Including CHP in a CES provides a four-way win: it will reduce consumer and industrial costs, enhance energy security, increase energy efficiency and reduce emissions.

Background

Combined heat and power, as illustrated in Figure 1 below, is a proven technology that can dramatically increase the energy efficiency of the electricity sector with the simultaneous production of useful thermal energy and power from a single fuel source.

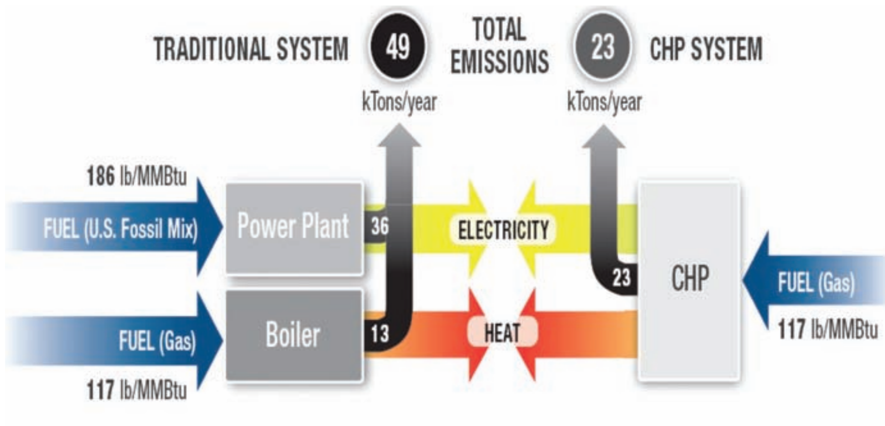


Figure 1. CHP Efficiency Conserves Fuel and Cuts Emissions (1)

Oak Ridge National Laboratory estimated in a 2008 report for the US Department of Energy that increasing the percentage of electricity generated by combined heat and power in the US from 85 GW of capacity (9%) to 241 GW (20%) by 2030 would attract $234 billion in private investment, produce 5.3 quads of annual fuel savings, create nearly 1 million new jobs and cut CO2 emissions equivalent to taking 154 million cars off the road. (1)

Increasing to 20% US electricity produced by CHP will:

- **attract $234 billion in private sector investment**
- **create nearly 1 million new jobs**
- **save 5.3 quads of fuel annually**
- **reduce emissions equivalent to taking 154 million cars off the road**

Oak Ridge National Laboratory, 2008

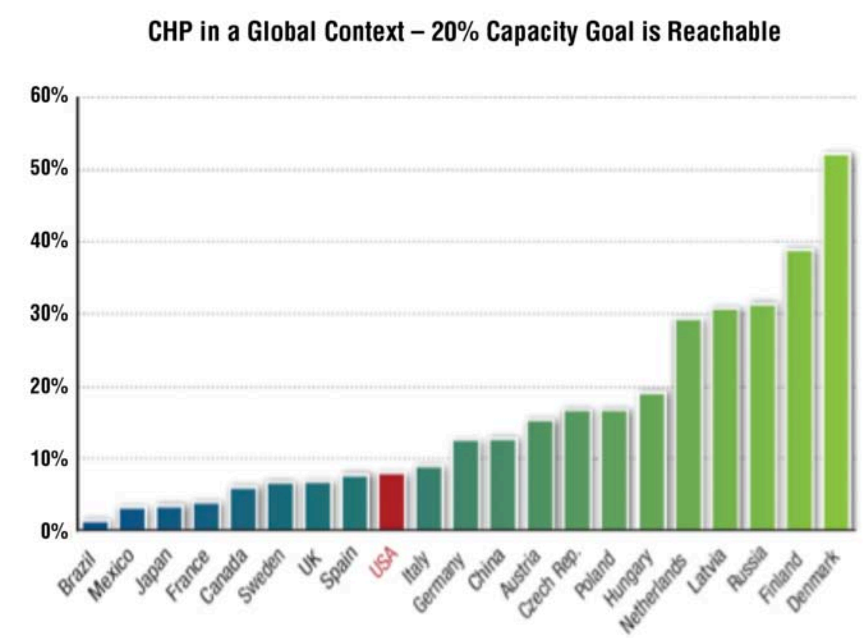


Figure 2. Country Percentage of Electricity Provided by Combined Heat & Power (1)

As a proven, commercially-available technology, CHP can be deployed in all 50 states in a variety of industries and market applications. With appropriate policy support and industry engagement, it is reasonable to expect that the US can reach 20% of national electricity production from CHP by 2030 from the current level of 9%. As shown in Figure 2, numerous countries produce between 15% and 50% of electricity from CHP, with the largest CHP penetration occurring in countries like Denmark where district energy systems are also widely used.

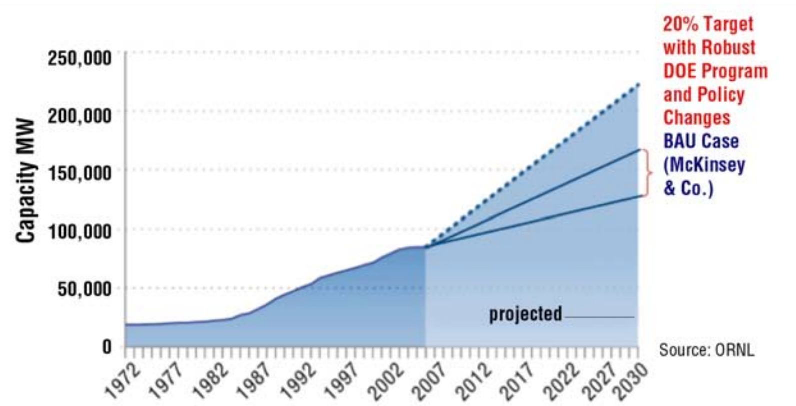
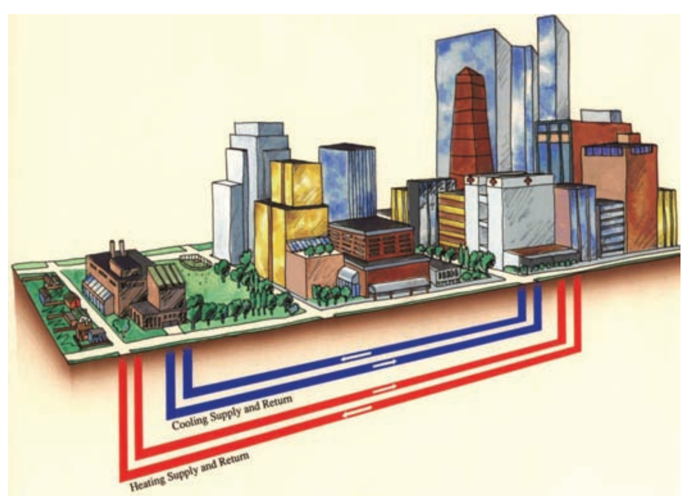


Figure 3. Potential Growth for US CHP Capacity (2)

	2006	2030
CHP Capacity	85 GW	241 GW
Annual Fuel Savings	1.9 quads	5.3 quads
Total Annual CO2 Reduction	248 MMT	848 MMT
Cars Taken Off Road (Equivalent)	45 million	154 million
Source: ORNL 2008		

Table 1. Energy and Environmental Savings from CHP (1)

District energy systems are critical for realization of the full potential of CHP. These systems supply thermal energy through underground piping networks for heating, cooling and process energy to multiple buildings in a city, community or campus. By aggregating the thermal needs of dozens or even hundreds of buildings, the district energy system optimizes the economical use of surplus heat from power plants, industry or CHP facilities.



Determining which broader categories or energy technologies warrant inclusion in a Clean Energy Standard will be subject to much discussion and debate. It is important that factors such as economics and availability are reasonably considered along with regional preferences or environmental efficacy.

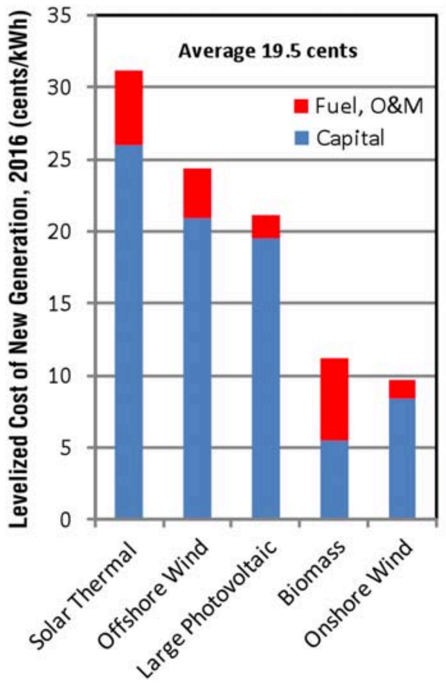


Figure 4. Levelized Cost of New Renewable Power-Only Generation Resources On Line in 2016. (3)

Renewable Power Generation

There appear to be two key concerns about a federal renewable energy standard. First, there is an uneven distribution of renewable resources across the country, so some states feel they will be put at a competitive disadvantage. Second, renewable energy tends to be costly.

Figure 4 shows the levelized cost per kilowatt-hour of power generated from a range of renewable technologies, according to the U.S. Energy Information Administration (EIA). For nondispatchable technologies such as solar or wind, the levelized cost per kilowatt-hour of capital costs is significantly higher than technologies that can be operated with much greater frequency and at a higher capacity factor. These renewable power-only technologies have an average levelized cost of 19.5 cents/kWh.

Nuclear and Fossil Plants

Concerns about the availability and costs of renewable power resources have led to proposals for a broader clean energy standard that incorporates nuclear and fossil-fueled plants with CCS. While the technical performance and costs of CCS are unproven, and commercially viable systems may not be available for many years, advocates have succeeded in having CCS incorporated into CES proposals.

President Obama has taken this one step further by including efficient natural gas in his CES initiative. The administration has not yet clarified how they would define "efficient natural gas." However, it appears that it would give credit to gas-fired power to the extent that it reduces GHG emissions compared with coal. This is consistent with administration statements that we are already half-way to the president's stated goal of 80 percent 'clean' electricity.

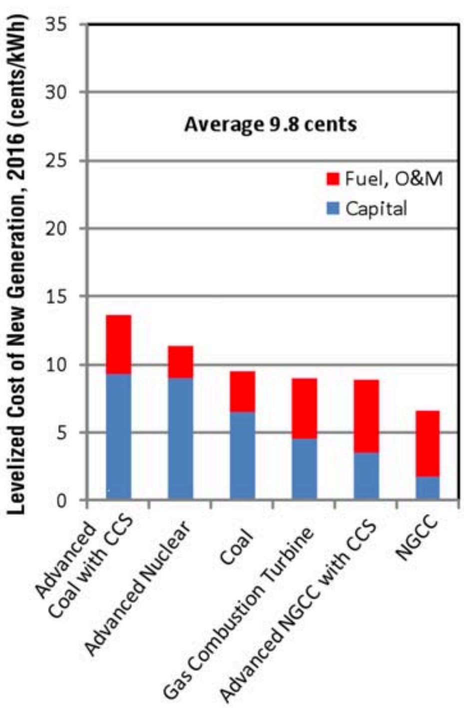


Figure 5. Levelized Cost of New Nonrenewable Power-Only Generation Resources On Line in 2016. (3)

Figure 5 shows the levelized costs[1] per kilowatt-hour of power generation for a range of nonrenewable power-only technologies, including fossil plants as well as nuclear. The EIA's assumptions for the fuel components of levelized costs are summarized in table 2.

	Levelized fuel cost ($/MMBtu)
Natural gas	$ 6.00
Coal	$ 2.30
Nuclear	$ 0.93
Biomass	$ 2.62

Table 2. Levelized Cost of Fuels for Generation Resources On Line in 2016. (3)

1 Per the U.S. Energy Information Administration, "Levelized cost represents the present value of the cost of building and operating a generating plant over an assumed life and duty cycle, converted to equal annual payments and expressed in terms of real dollars to remove the impact of inflation. Levelized cost reflects overnight capital costs, fuel costs, fixed and variable O&M cost, financing cost, and an assumed utilization rate for each plant type."

Natural gas combined-cycle (NGCC), which is considered highly efficient, still throws away 50% of the fuel input in the form of waste heat.

These nonrenewable power-only technologies have an average levelized cost of 9.8 cents/kWh, significantly lower than the renewable power-only technologies. However, nuclear plants will be extremely difficult to site and carry with them safety concerns and the unresolved problem of nuclear waste disposal. Carbon capture and sequestration is an unproven technology. What's left? Natural gas combined-cycle (NGCC), which is considered highly efficient, still throws away half of the fuel input through waste heat. Further, given the historic volatility of natural gas prices, the costs of gas-fired generation could be significantly higher than illustrated in figure 5.

Combined Heat and Power

Broadening the standard to credit nonrenewable resources to the extent that they deliver GHG reduction is a step toward providing flexibility and reducing costs. But what the president has proposed is not a technology-neutral approach and misses an important set of opportunities that can further reduce costs and are applicable in every state: combined heat and power (CHP).

The waste heat resulting from electricity generation accounts for a huge portion (27 percent) of total U.S. primary energy consumption, as illustrated in figure 6. There is a range of CHP technologies, including natural gas reciprocating engines, natural gas combustion turbines and steam turbine CHP using biomass. The common characteristic is that the heat that is normally exhausted from the power generation process is recovered.

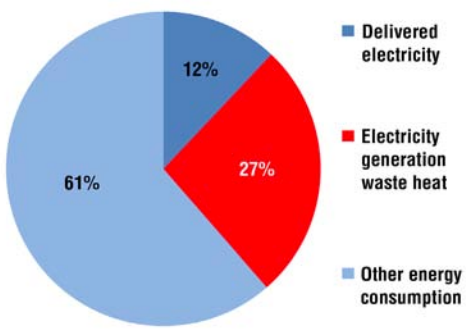


Figure 6. Electricity Generation Waste Heat as a Percentage of Total U.S. Primary Energy Consumption. (4)

Another technology, sometimes called Waste Heat to Power (WHP), can convert relatively low temperature waste heat, such as exhaust gases from industrial processes into electricity without burning additional fuel using a process called organic rankine cycle (ORC). Although different from the CHP technologies described above, WHP does combine heat and power production and for this analysis will be grouped within CHP.

Recovering power generation waste heat through CHP eliminates the fuel consumption that would otherwise be required to produce thermal energy. The U.S. Department of Energy (DOE) has estimated that increasing CHP from its current 9 percent share of U.S. electric power to 20 percent by 2030 would:

- avoid 60 percent of the projected increase in U.S. carbon dioxide emissions (equivalent to taking half of all U.S. passenger vehicles off the road);
- create more than 1 million new, highly skilled jobs here in the U.S.; and
- generate $234 billion in new investments. (1)

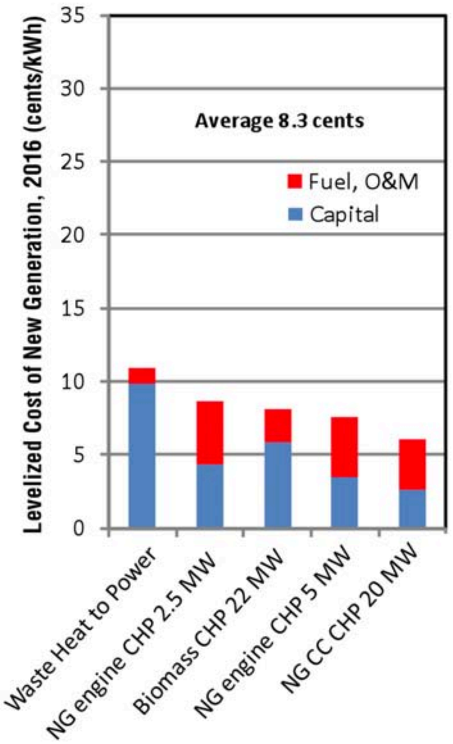


Figure 7. Levelized Cost of New Combined Heat and Power Generation Resources On Line in 2016. (5)

The levelized costs per kilowatt-hour of representative CHP power generation in a range of sizes and types is profiled in figure 7, using the same methodology used by the U.S. EIA for figures 4 and 5. These CHP technologies have an average levelized cost of 8.3 cents/kWh.

CHP provides more cost-effective power because the byproduct heat is put to use rather than just exhausted to waterways or to the atmopshere. However, CHP faces a range of barriers, including onerous electric utility interconnection requirements and costs, high backup power rates and air emission regulations that penalize the additional fuel consumption required to generate electricity and heat (compared to just heat production alone), despite the total emissions reductions achieved compared with separate heat and power.

Economies of scale make it more cost-effective to install CHP in sizes above 5 MW, which is why district energy systems are critical to more widespread implementation of CHP. These systems pool the thermal users to accommodate larger, more cost-effective CHP units.

Total Picture

The total picture for all generation resources is summarized in figure 8, contrasting the total levelized cost per kilowatt-hour for CHP, renewable power-only, and fossil fuel and nuclear power-only plants. CHP clearly can contribute to reducing power costs but needs policy support to help overcome the barriers to implementation.

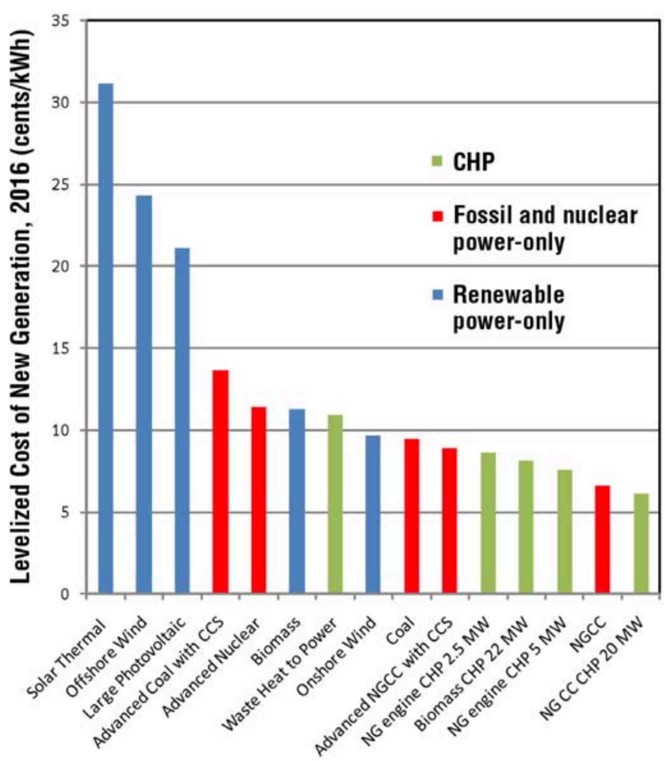


Figure 8. Summary of Levelized Cost of Generation Resources On Line in 2016. (6)

Fossil Fuel and GHG Reduction A Double Benefit

How effective are potential clean energy resources in reducing fossil fuel consumption and GHG emissions? Table 3 shows net fuel consumption and GHG emissions for each resource. Renewable, nuclear and WHP consume no net fossil fuel and have zero GHG emissions. Coal or natural gas generation with CCS have significant fuel consumption but will cut GHG emission by 90 percent if the technology proves as effective as presumed.

CHP shows significant reductions in net fossil fuel use due to displacement of fuel consumption (presumed to be natural gas) that would otherwise be required to produce thermal energy. Biomass CHP actually shows a net reduction in total fossil fuel use because a renewable fuel is displacing both electric generation and thermal production using natural gas.

It is instructive to consider the costs together with fossil fuel reduction and GHG data to determine relative cost-effectiveness in cutting fossil fuel consumption and reducing GHG emissions.

CHP increases power generation energy efficiency more cost-effectively than most renewable or fossil-fuel power-only technologies.

		Fossil fuel consumption (Btu/kWh)	GHG emissions (metric tons/MWH)
Fossil and Nuclea Power-only	Conventional Coal	8,784	0.82
	Conventional NGCC	6,967	0.37
	Nuclear	-	-
	Advanced Coal with CCS *	10,434	0.11
	Advanced NGCC with CCS *	7,521	0.04
Renewable power-only	Biomass	-	-
	Onshore Wind	-	-
	Offshore Wind	-	-
	Solar Thermal	-	-
	Large Photovoltaic	-	-
CHP	Waste heat to power	-	-
	Biomass CHP 22 MW	(767)	(0.43)
	NG engine CHP 2.5 MW	5,292	0.28
	NG engine CHP 5 MW	5,195	0.28
	NG CC CHP 20 MW	4,492	0.24

* Note: CCS is not a proven technology.

Table 3. Fossil Fuel Consumption and Greenhouse Gas Emissions From a Range of Generation Resources. (7)

Figure 9 shows the levelized cost of power generation fossil fuel reduction in dollars per million Btu of fossil fuel. Of the five lowest-cost options for GHG reduction, four are CHP, and one is available only in certain locations (onshore wind). Large gas-fired CHP actually shows a net savings. None of the fossil fuel options, including those with CCS, provide reductions in fossil fuel consumption compared with NGCC.

Figure 10 shows the levelized cost of GHG reductions in dollars per metric ton of carbon dioxide. Of the five lowest-cost options for GHG reduction, three are CHP, one is available only in certain locations (onshore wind) and one is unproven (NGCC with CCS).

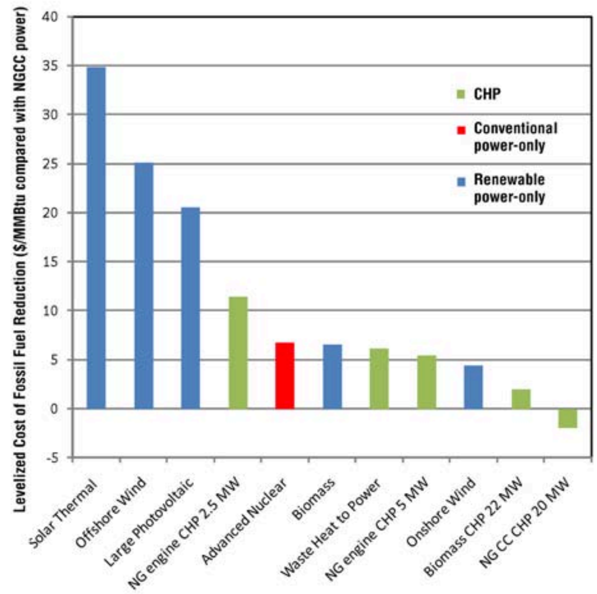


Figure 9. Levelized Cost of Power Generation Fossil Fuel Reduction Compared With Natural Gas Combined-Cycle On Line in 2016. (8)

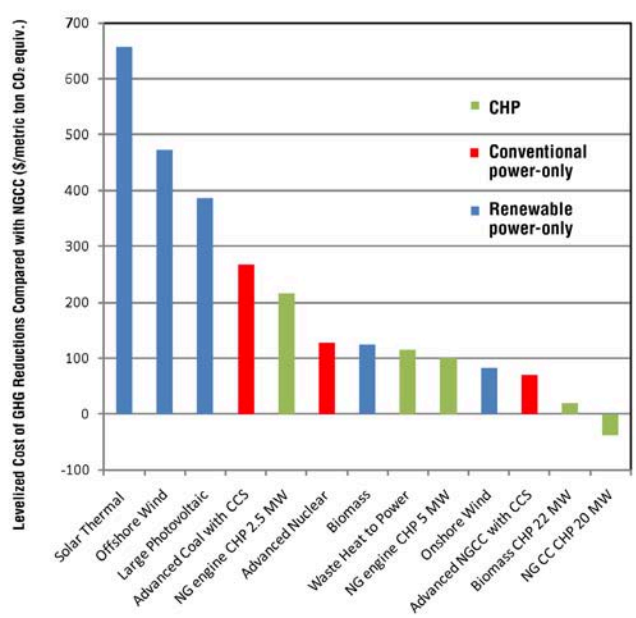


Figure 10. Levelized Cost of Greenhouse Gas Reduction for New Generation Resources Compared With Natural Gas Combined-Cycle On Line in 2016. (8)

Bottom Line

The goal established by the DOE – to generate 20 percent of our power from CHP by 2030 – is achievable with federal policy support. That support must include providing an incentive for electric utilities to embrace CHP as a reliable, local power resource, rather than lobby against its use. Inclusion of CHP in a clean energy standard is a very appropriate and critical step forward if CHP is to increase from its current 9 percent to 20 percent of US power generation by 2030. CHP would provide one third of the new clean energy sources targeted by the president's CES proposal, saving US ratepayers over $500 billion by 2035, based on a gradual ramp up of new CHP capacity and reflecting the difference between the average cost of CHP and the average cost of power only generation (both renewable and non-renewable technologies.)

Entities for CHP Implementation

CHP can be implemented by many entities, including industrial facilities, district energy utility companies, colleges, universities and hospitals and others. It is important that a range of entities, and not just electric utilities, be eligible for credits in a CES. Credits issued for CHP implemented by other than an electric utility should be issued to the entity responsible for installing or placing the CHP in operation.

We urge the administration and the Congress, as they consider CES legislation, to make it truly technology-neutral by including CHP. Ratepayers will win, emissions will be reduced, and our power infrastructure will be more reliable, diverse and efficient.

International District Energy Association (IDEA) is a non-profit trade association, founded in 1909 and currently has over 1400 members in 27 countries. IDEA promotes energy efficiency and environmental quality through the advancement of district heating, district cooling and cogeneration (also known as combined heat and power or CHP). Contact idea@districtenergy.org or visit www.districtenergy.org.

About the Author

Mark Spurr is legislative director of IDEA and president of FVB Energy Inc. (www.fvbenergy.com) He serves on the Executive Committee for the International Energy Agency Implementing Agreement on District Heating, Cooling and Combined Heat & Power. He may be reached at mspurr@fvbenergy.com.

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(2) US Dept of Energy, EERE, Industrial Technologies Program, Clean Energy Regional Application Centers, 2010.

(3) U.S. Energy Information Administration, *Levelized Cost of New Generation Resources in the Annual Energy Outlook 2011*, December 2010, DOE-IEA-0383 (2010).

(4) U.S. Energy Information Administration, *Annual Energy Outlook 2007*.

(5) FVB Energy Inc. analysis consistent with the methodology used in U.S. Energy Information Administration's *Levelized Cost of New Generation Resources in the Annual Energy Outlook 2011*, December 2010, DOE-IEA-0383 (2010). Data from project files of FVB Energy and JA Coleman LLC.

(6) From data in Figures 4, 5 and 7.

(7) U.S. Energy Information Administration, *Updated Capital Cost Estimates for Electricity Generation Plants*, November 2010, with additional analysis by FVB Energy Inc. consistent with the methodology used in the U.S. EIA study.

(8) FVB Energy Inc. analysis consistent with the methodology used in U.S. Energy Information Administration, *Levelized Cost of New Generation Resources in the Annual Energy Outlook 2011*, December 2010, DOE-IEA-0383 (2010).

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