Appendix 6:
Method of Calculating Results from DOE's Combined Heat and Power Activities

Method of Calculating Results from DOE's Combined Heat and Power Activities

Industrial Distributed Energy, a cross-cutting activity within the Industrial Technologies Program (ITP), builds on activities conducted by DOE's Office of Industrial Technologies during the 1980s and 1990s and the DOE Distributed Energy Resources program since 2000. Since 1990, the use of distributed energy within the United States, primarily combined heat and power (CHP), has increased significantly. CHP capacity additions between 1990 and 2009 totaled 56.4 GW, according to the CHP Installation Database maintained by ICF International for DOE through a contract with Oak Ridge National Laboratory.

According to a report prepared by ORNL, if CHP capacity were to reach 20% of U.S. electricity production by 2030, more than 5.3 quad of energy would be saved, and CO_2 emissions would be reduced by 848 million metric tons. This represents 60% of the projected greenhouse gas emissions production from 2006 to 2030.

DOE distributed energy activities since 1990 include R&D, market transformation, and deployment activities. R&D activities have focused on developing advanced reciprocating engine systems, advanced industrial gas turbines, microturbines, thermally activated technologies, fuel cells, and integrated energy systems. As a result, many commercial products have been successfully developed. Market transformation activities have focused on project support, education, and outreach and have recently been led by eight Regional Clean Energy Application Centers that offer individualized solutions to end users and promote the adoption of CHP to state policymakers and regulators. DOE also has continually supported public-private partnerships with various CHP stakeholders through collaborations with other federal agencies, state governments and agencies, trade associations and private industry, and non-government organizations in order to increase market deployment of CHP technology.

Before 2007, attribution of energy from DOE distributed energy activities was not well documented. ICF International recently developed a preliminary methodology for calculating and attributing energy savings from DOE distributed energy activities. This methodology will be refined and reviewed by external peers.

The energy savings' benefit of a CHP system is from the aggregate reduction in overall fuel consumption. A CHP system replaces both a separate on-site thermal system (furnace or boiler) and purchased power (typically electricity from a central station power plant) with a single, integrated system that produces thermal energy and power concurrently. To calculate the fuel use avoided by a CHP system, both outputs of the CHP system must be accounted for. The CHP system's thermal output displaces the fuel normally consumed in on-site thermal generation in a boiler or other equipment, and the power output displaces the fuel consumed from grid-connected power plants. Quantifying a CHP system's fuel savings involves subtracting the fuel use released from the CHP system from the fuel use that normally would occur without the system (i.e., using conventional separate heat and power).

The CHP energy savings' estimates are based on CHP operating characteristics contained in the CHP Installation Database, which is recognized as the leading source for current and comprehensive data on U.S. CHP installations and market trends. As of June 1, 2009, the database contained 3,518 operating CHP installations representing 84,923 MW of electric capacity. The database includes detailed data for each site including location, application, CHP technology, fuel type, electric generating capacity, ownership, servicing utility, and system start-up date. The database contains partial information on thermal application and capacity, sales to the grid, thermal sales, annual fuel use, annual generation, and annual thermal utilization. Annual CHP capacity additions were generated from the database starting in 1990 by system size (<20 MW, 20 to 50 MW, > 50MW) and fuel type.

CHP energy savings' estimates are derived from operating information (i.e., fuel consumption, electricity, and thermal energy generated) for the CHP fleet contained in or derived from the CHP database. A key operating parameter is the CHP system's power-to-heat ratio. This parameter was calculated directly for sites with data on both electric generation and thermal output. For sites missing information on the thermal output, a typical power-to-heat ratio was assumed based on the prime-mover technology and the electric capacity of the CHP system. Performance characteristics, including the power, thermal, and overall efficiencies of the operating CHP capacity, are estimated for 13 different fuel types; and summary data are derived for each fuel type, including annual electric generation, thermal output, and fuel consumption.

In the absence of data to track the DOE program impact for every CHP installation, a portion of energy savings from all CHP systems installed since 1990 were linked to DOE's efforts. Attribution of benefits for DOE activities are based on DOE program activities to advance CHP technology in each market segment and are estimated to be 50% of the capacity additions <20 MW, 25% of the capacity additions from 20 to 50 MW, and 10% of the capacity additions >50 MW. DOE's most extensive efforts have supported CHP <20 MW, which uses engine, microturbine, and fuel cell technologies. DOE also supported turbine technology focused on CHP units from 20 to 50 MW; manufacturers have also transferred these technologies to CHP units >50 MW.

Method of Calculating Results from DOE's Combined Heat and Power Activities

IMPACTS

Total CHP capacity additions from 1990 to 2009 and the resulting energy savings attributed to DOE activities based on the methodology described above are depicted in the table. The annual and cumulative energy savings from CHP systems are shown in the table for each year. In 2009, the annual energy savings are 210 TBtu and the cumulative energy savings through 2009 are 2,748 TBtu. Energy cost savings, carbon reduction, and other benefits are related to energy savings by projected fuel prices and emission coefficients. The cumulative CHP energy cost savings and the cumulative carbon reduction are shown through 2009 in the last two rows of the table.

Through current and expanded funding from the *American Reinvestment and Recovery Act*, ITP is advancing CHP as one of the more promising efficient energy solutions that can help to revitalize the American economy, enhance the nation's energy security, and reduce carbon pollution. CHP can achieve efficiencies of as much as 80% compared with roughly 45% for conventional heat and power production.

Total CHP Capacity Additions with Energy, Cost, and Carbon Savings Attributed to DOE Activities

Item	1990	1991	1992	1993	1994	1995	1996	1997	1998
Capacity Additions (MW)									
<20 MW	385.7	243.0	234.1	179.4	200.1	201.1	206.9	164.8	154.8
20 -50 MW	903.1	687.8	342.3	435.7	398.0	372.2	229.1	93.6	221.9
>50 MW	3,462.3	2,453.8	2,693.0	2,651.9	5,131.4	2,162.5	2,123.4	2,311.3	1,123.5
Total Capacity Additions	4,751	3,385	3,269	3,267	5,730	2,736	2,559	2,570	1,500
Annual Energy Savngs (*TBtu*)	23.2	39.8	52.7	66.6	85.6	96.2	107.1	116.7	124.6
Cumulative Energy Savings (*TBtu*)	23.2	63	115.7	182.3	267.9	364.1	471.2	587.9	712.5
Cumulative Energy Cost Savings (*B$*)	0.027	0.072	0.130	0.199	0.283	0.371	0.469	0.575	0.684
Cumulative Carbon Reduction (*MMTCE*)	0.6	1.6	2.9	4.6	6.7	9.1	11.8	14.8	17.9
Item	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Capacity Additions (MW)									
<20 MW	252.6	317.2	299.3	238.2	222.9	182.8	214.2	187.4	171.7
20 - 50 MW	177.7	386.8	379.8	361.0	132.0	124.5	28.0	149.2	99.0
>50 MW	1,825.9	2,425.4	5,528.9	4,436.0	3,395.0	3,192.0	1,391.0	0.0	224.0
Total Capacity Additions	2,256	3,129	6,208	5,035	3,750	3,499	1,633	337	495
Annual Energy Savngs (*TBtu*)	134.5	149.6	170.3	180.3	190.6	194.0	199.6	199.8	201.3
Cumulative Energy Savings (*TBtu*)	847.0	996.6	1,167	1,347	1,538	1,732	1,931	2,131	2,332
Cumulative Energy Cost Savings (*B$*)	0.802	0.935	1.095	1.256	1.438	1.655	1.922	2.166	2.418
Cumulative Carbon Reduction (*MMTCE*)	21.3	25.1	29.3	33.9	38.7	43.6	48.6	53.7	58.7
Item	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Capacity Additions (MW									
<20 MW	189.8	201.9	–	–	–	–	–	–	–
20 - 50 MW	81.2	169.0	–	–	–	–	–	–	–
>50 MW	141.0	235.0	–	–	–	–	–	–	–
Total Capacity Additions	412	606	–	–	–	–	–	–	–
Annual Energy Savngs (*TBtu*)	205.5	210.2	–	–	–	–	–	–	–
Cumulative Energy Savings (*TBtu*)	2,538	2,748	–	–	–	–	–	–	–
Cumulative Energy Cost Savings (*B$*)	2.729	3.059	–	–	–	–	–	–	–
Cumulative Carbon Reduction (*MMTCE*)	64.0	69.3	–	–	–	–	–	–	–