U.S. Department of Energy
Clean Energy Application Center
MID-ATLANTIC

Promoting CHP, District Energy, and Waste Energy Recovery

FINAL REPORT

Award Number:
DE-EE0001109

Award Recipient:
Pennsylvania State University

Principal Investigator:
Jim Freihaut, (814)863-0083, jdf11@psu.edu

Reporting Period:
October 1, 2009 through September 30, 2013

Submission Date:
December 31, 2013

Submitted to:
U.S. DOE / NETL
Joseph Renk, (412) 386-6406, Joseph.Renk@NETL.DOE.GOV

U.S. Department of Energy
Clean Energy Application Center
MID-ATLANTIC

Mr. Joe Renk
Project Manager
Power and Vehicle Technology Division
NETL
PO Box 10940
Pittsburgh, PA 15236-0940

Dear Mr. Renk,

Please find the attached Final Technical Report for Award Number DE-EE0001109 – "Mid-Atlantic Region Clean Energy Application Center."
Below you will find a synopsis of our activities (deliverables and tasks) for the program.
If you have any questions, please do not hesitate to contact Jim Freihaut (814-863-0083, jdf11@psu.edu), Richard Sweetser (703-707-0293, rsweester@exergypartners.com), Gearoid Foley, (609-799-2340, gearoid@ichps.com) or Bill Valentine (215-353-3319, wjv3@psu.edu)

Thank you,

Jim Freihaut
Gearoid Foley
Rich Sweetser
Bill Valentine

FINAL TECHNICAL REPORT

Award Number: DE-EE0001109

Award Recipient: The Pennsylvania State University

Project Title: Mid Atlantic Clean Energy Application Center

Principal Investigator: Jim Freihaut, (814)863-0083, jdf11@psu.edu

Submission Date: December 31, 2013

Reporting Period: October 1, 2009 through September 30, 2013

Table of Contents

Executive Summary

The Mid Atlantic Clean Energy Application Center (MACEAC), managed by The Penn State College of Engineering, serves the six states in the Mid-Atlantic region (Pennsylvania, New Jersey, Delaware, Maryland, Virginia and West Virginia) plus the District of Columbia. The goals of the Mid-Atlantic CEAC are to promote the adoption of Combined Heat and Power (CHP), Waste Heat Recovery (WHR) and District Energy Systems (DES) in the Mid Atlantic area through education and technical support to more than 1,200 regional industry and government representatives in the region. The successful promotion of these technologies by the MACEAC was accomplished through the following efforts; (1)The MACEAC developed a series of technology transfer networks with State energy and environmental offices, Association of Energy Engineers local chapters, local community development organizations, utilities and, Penn State Department of Architectural Engineering alumni and their firms to effectively educate local practitioners about the energy utilization, environmental and economic advantages of CHP, WHR and DES; (2) Completed assessments of the regional technical and market potential for CHP, WHR and DE technologies application in the context of state specific energy prices, state energy and efficiency portfolio development. The studies were completed for Pennsylvania, New Jersey and Maryland and included a set of incentive adoption probability models used as a to guide during implementation discussions with State energy policy makers; (3) Using the technical and market assessments and adoption incentive models, the Mid Atlantic CEAC developed regional strategic action plans for the promotion of CHP Application technology for Pennsylvania, New Jersey and Maryland; (4) The CHP market assessment and incentive adoption model information was discussed, on a continuing basis, with relevant state agencies, policy makers and Public Utility Commission organizations resulting in CHP favorable incentive programs in New Jersey, Pennsylvania, Maryland and Delaware; (5) Developed and maintained a MACEAC website to provide technical information and regional CHP, WHR and DE case studies and site profiles for use by interested stakeholders in information transfer and policy discussions; (6) Provided Technical Assistance through feasibility studies and on site evaluations. The MACEAC completed 28 technical evaluations and 9 Level 1 CHP analyses ; and (7) the MACEAC provided Technical Education to the region through a series of 29 workshops and webinars, 37 technical presentations, 14 seminars and participation in 13 CHP conferences.

Background

The Mid Atlantic CEAC is based at the Philadelphia Navy Yard, a central location in the region with excellent transportation access. The Philadelphia Navy Yard is an ideal location for the Mid Atlantic CEAC. The Navy Yard was closed in 1996 by the federal government, and was acquired by the Philadelphia Industrial Development Corporation (PIDC) for redevelopment in 2000. Currently more than 130 companies are located on the 1,200 acre site, employing more than 10,000 people. One of the key activities on the site is the NAVSEA Warfare Center, Carderock Division (NSWCCD), a $1 billion per year, 1,700 employee Navy laboratory focusing on marine propulsion, power generation, energy efficiency, acoustics, communications, and materials engineering.

A key aim of the Navy Yard redevelopment effort is to make the site and the region a national headquarters for technology and workforce development in clean energy production and management, leveraging the combined education, research and commercialization strengths of government, industry, and universities in the region. The Mid Atlantic CEAC at the Navy Yard is part of this strategy serving as a locus of education and technical assistance for industry, government agencies, and others on clean energy applications technology.

Penn State College of Engineering joined together with strategic industry and association partners to leverage knowledge, experience and contacts within the six-state region plus the District of Columbia and the federal government end-users. The CEAC team included individuals and companies that are recognized leaders in the world of clean district generation and combined heat and power, including: Dr. Joseph A. Orlando, Previous Director Mid Atlantic CEAC; Gearoid Foley, President, ICHPS; Richard S. Sweetser, President, EXERGY Partners Corp and Bill Lauer, Delaware Valley Industrial Resource Center. These individuals advised the CEAC and act as on-site outreach and information representatives to the states and to federal agencies. University faculty members, staff, and students also provided management and administration and technical expertise in combined heat and power (CHP), clean district generation, waste heat recovery, compact gasification and combustion; biomass conversion, energy economics and policy, and other clean energy topics.

Accomplishments

The program accomplishments for the contract period are reported under four major task areas, Program Management, Policy Education, Technical Support and Technical Education & Outreach activities.

Program Management

Program Management activities included all tasking required to successfully execute the program. Tasks in support of DOE HQ program requirements included the following: maintaining a constant communication link with DOE program HQ; attending bi weekly program review teleconference meetings, supporting all HQ CHP conference requirements, supporting various HQ level task teams and attending annual CEAC team meetings; on time submission of all program report requirements including, but not limited to quarterly status reports, monthly program status reports, continual updates of CHP installation data bases, annual input of Key Performance Metrics, submission of Continuing Applications, etc. , A key document in the management of the program was the Program Management Plan which addresses program deliverables, task schedule and milestones and risk mitigation efforts. The plan was updated on a bi-annual basis.

Additional program management task s completed included the following: coordination of program level efforts including successfully establishing the CEAC structure and communication links with state and local government energy contacts, AEE and Penn State Alumni Networks, MEP Center, Industrial Resource Centers, utilities, and others to effectively accomplish program goals; conducting strategic planning sessions within the program, coordinating technical support visits, webinars, workshops and technical presentations, developing relationships with professional trade organizations etc.

One very effective tool in identifying and promoting CHP opportunities in the Mid-Atlantic Region has been the MACEAC website located at www.maceac.psu.edu. The website was developed at the initiation of the contract period and reworked as part of a CEAC Website standardization effort. In FY-13 the Mid Atlantic CEAC website site had 118, 242 unique visitors with 33, 865 page views.

A significant strategic effort for the Mid Atlantic CEAC was to conduct studies to determine the potential for CHP in the Mid-Atlantic region, broken down at the state level. This was accomplished by the development of state specific Combined Heat and Power Market Assessments. On a state-by-state basis, the effort quantitatively reassessed the regional technical and market potential for CHP, WHR and

DE technologies application in the context of state specific energy prices, state energy and efficiency portfolio development. The assessments included a set of incentive adoption probability models to guide implementation discussions with State energy policy makers. Assessments were completed for Pennsylvania, New Jersey and Maryland. Each state-specific study documents the economic, environmental and societal benefits derived from instituting certain policies that will stimulate use of combined heat and power (CHP) systems in the respective state. These reports quantify the long-term market penetration potential for combined heat and power (CHP), its economic impact and the degree to which CHP can reduce potential greenhouse gas emissions. The reports also examine how implementing various CHP financial and non-financial incentives would affect future CHP market penetration. The analysis covered the following five task areas: (1)Characteristics of existing CHP in each state; (2) Estimate of technical potential for CHP ; (3) Base case market analysis (4) Market potential analysis under alternative scenarios; and (5) Recommendations for implementation . A copy of the Pennsylvania Combined Heat and Power Market Assessment is included as appendix (A).

Industry Alliances:

Two key partners provided support to the MACEAC in identifying potential market sectors and individual companies that had the potential for adoption of CHP, as well as helping coordinate workshops, presentations and webinars and providing contacts in selected industry sectors, geographical areas and local Economic Development Councils. The Delaware Valley Industrial Resource Center is an economic development organization that focuses exclusively on the region's manufacturing community to grow business value through consulting services, talent development, training and education and networking. DVIRC offers "best practice" consulting services for small to mid-sized manufacturing enterprises and is part of a state wide IRC network that has unique business relationships with companies across the Commonwealth. The Pennsylvania Technical Assistance program, an Outreach program of The Pennsylvania State University PennTAP is a federal-state-university partnership for economic development. PennTAP helps Pennsylvania companies improve their competitiveness by providing technical assistance and information to help resolve specific technical questions or needs. The program focuses on helping smaller firms that normally do not have the in-house expertise or resources to resolve specific technology questions or needs. PennTAP technical specialists assist small companies by providing technical advice, technical information, and connections to other expertise, resources, or programs. In support of team development, the MACEAC conducted six CHP training sessions for PennTAP, DVIRC and related state wide Industrial Resource Centers.

The MACEAC also developed working relationships with Association of Energy Engineers local chapters, local community development organizations, regional gas and electric utilities and, Penn State Department of Architectural Engineering alumni and their firms to effectively educate regional practitioners about the energy utilization, environmental and economic advantages of CHP, WHR and DES. These working relationships are an effective way to reach various market segments and execute the mission of the MACEAC, however, having various industry groups collaborate on common goals to promote CHP would improve that effectiveness significantly. A as part of the MACEAC cosponsored Penn State Natural Gas Utilization Workshop on June 29-30, 2011, The MACEAC facilitated a working group session of 45 industry leaders, academics and policy makers interested in increasing CHP systems in Pennsylvania. The results of the workshop included an agreement to form an industry support group to help promote CHP, with a focus on and related shale gas development, within Pennsylvania. The industry initiative is called the Commonwealth Recycled Energy Economic Development Alliance (CREEDA). The group developed a mission for CREEDA to provide leadership in the development of programs and policies, to remove barriers and to champion combined heat and power projects as the most effective and environmentally-responsible energy solution for Pennsylvania. CREEDA's objective is to educate Pennsylvania businesses, legislators and policy-makers on the benefits of combined heat and power. It has done so by working closely with the Mid-Atlantic Clean Energy Application Center, the Department of Environmental Protection, Department of Community and Economic Development, the Public Utility Commission and various other resource providers across the Commonwealth.

During this reporting period, the U.S. Environmental Protection Agency (EPA) finalized the reconsideration process for its Clean Air Act pollution standards **National Emissions Standards for Hazardous Air Pollutants for Major Sources: Industrial, Commercial, and Institutional Boilers and Process Heaters** (known as Boiler Maximum Achievable Control Technology (MACT)), which applies to large and small boilers in a wide range of industrial facilities and institutions. The MACEAC was tasked to offer technical assistance in the Mid-Atlantic region to ensure that major sources burning coal or oil have information on cost-effective clean energy strategies for compliance, including combined heat and power, and to promote cleaner, more efficient boilers to cut harmful pollution and reduce operational costs.

The database of affected facilities in the Mid Atlantic area, provided by ICF International, included 128 facilities in a wide array of industries, from heavy manufacturing, to metals and plastics processing, to correctional facilities. Pennsylvania had the predominant number of facilities in the Mid-Atlantic region

(67), so the MACEAC developed a team including Pennsylvania Technical Assistance Program (PennTAP), current MACEAC team member Delaware Valley Industrial Resource Center (DVIRC) and their related statewide resource centers, and the Penn State Facilities Engineering Institute (PSFEI). PennTAP is one of the nation's first technical assistance programs and a valuable resource for helping Pennsylvania companies. PennTAP focuses on helping smaller firms that normally do not have the in-house expertise or resources to resolve specific technology issues. Through a network of technical specialists, they assist small companies by providing technical advice, technical information, and connections to other expertise, resources, or programs. The DVIRC is an economic development and technical support organization that focuses exclusively on the region's manufacturing community to grow business value through consulting services, talent development, training and education and networking. The Penn State Facilities Engineering Institute provides facility engineering services to 10 agencies of the Commonwealth. PSFEI's mission includes engineering support services relating to facility steam generation issues, training facility operators and managers, preparation of needs assessments, and the development of solutions and strategies for facility owners faced with ever-changing economic and environmental conditions. PSFEI has Boiler Plant expertise in the areas of Air Quality Permitting Assistance, Annual Emissions Reporting Assistance, Capital Project Design Specifications, GESA Project Technical Support, Boiler Controls Assessments, Operations and System Efficiency Assessments and Boiler System Troubleshooting. Additional perspectives on existing Boiler Combustion and emissions upgrade support were provided by the Penn State Department of Engineering, and personnel from the College of Earth and Mineral Sciences Energy Institute. The PennTAP, DVIRC and PSFI team addressed the Pennsylvania facilities and the MACEAC team, while assisting with Pennsylvania, completed the efforts with Virginia (36 sites), Delaware (3 sites) Maryland (4 sites) and West Virginia (12 sites). The process included initial contact with each company, through phone calls and emails to verify compliance/noncompliance status, discussions of plant data, compliance plans if applicable, and offers of technical support to assist in getting the plant into compliance. Of the 128 sites in the data base, 37 were in compliance, 16 were closed, 28 indicated that no support was required, and 35 failed to respond to repeated emails or phone calls. Technical discussions/ site analysis was conducted on the 12 remaining sites. Due to the restricted timeframe, no corporate decisions on technology implementation was made by the end of this reporting period, however all 12 sites are considered potential future candidates for CHP implementation.

Policy Education

Individual State Energy policies vary significantly in how they address energy efficiency measures and the impact they have on the implementation of those measures. A key effort of the MACEAC was to provide information, education and technical support on the benefits and potential application of Combined Heat and Power (CHP), Waste Heat Recovery (WHR) and District Energy Systems (DES). Using the state specific Combined Heat and Power Market Assessments discussed above, the Mid Atlantic CEAC developed regional strategic action plans for the promotion of CHP Application technology for Pennsylvania, New Jersey and Maryland and was involved, on a continuing basis, in discussions with relevant state agencies, policy makers and Public Utility Commission organizations in the Mid-Atlantic region. Since states continue to deal with severe budget constraints on a yearly basis, most incentive plans that were established had a one to two budget cycle, consequently the MACEAC engaged state authorities on a continuing basis to reinforce their understanding and appreciation of the benefits of these technologies. Below is a summary, by state, of the state policy related activities completed by the Mid-Atlantic CEAC.

New Jersey:

Continual engagement with New Jersey regulatory agencies including the Bureau of Public Utilities, Department of Environmental Protection (DEP) and the Economic Development Authority. MACEAC efforts resulted in CHP incentives for both small and large CHP installations being incentivized by dedicated appropriations. MACEAC provided technical support during a review of the state energy policies related to Energy Efficiency, Demand Management, CHP and Renewable Energy. Previous policies provide for a variety of programs funded mainly by Societal Benefits Charges, Commercial and Industrial Retail Margin Fund, RGGI Proceeds and Utility based special Rate Tariffs. As a result of the CEAC's inputs, New Jersey has recognized CHP as potentially providing a considerably better benefit per public dollar invested than renewables and views CHP as 'Supply Side Energy Efficiency' and a cost effective tool to reduce energy costs while also providing significant carbon removal. As a result, the state has established a CHP incentive program that has provide over $20M in annual incentives for developing CHP installations. The program has been fully subscribed in each of the last two years.

In support of the efforts summarized above the following is a list of individual meetings/events held during the program reporting period that contributed to the state policies now in effect:

Met with Joe Sullivan, N.J. Public Utilities Commissioner, in March 2010 to discuss the advantages of CHP in meeting energy efficiency and carbon reduction goals in N.J. Inhibiting aspects of current regulatory policies and lack of incentives were noted.

Met with New Jersey Board of Public Utilities, (Ombudsman and Chief of Staff), NJ Economic Development Authority, Governor Christie's Washington Office and EERE's Dr. Kathleen Hogan and Katrina Pielli on May 25, 2010. The 2011 NJ Budget (beginning July 1, 2010) was balanced, in part, by applying all discretionary funds that were not spent by Governor Christie's inauguration. This included $60 million in soon to be awarded, competitively bid CHP projects. The NJ BPU and Governor's office wanted to shift about $18-20 million in AARA funds from several other NJ energy programs as CHP was a higher priority. Since DOE is the cognizant Federal Agency administering this ARRA money, the NJ delegation sought Dr. Hogan's approval and support before they completed all the work necessary to submit such a request. The result of the meeting was that Dr. Hogan indicated strong support for NJ's CHP efforts and would look forward to their submission to DOE. Follow-on- NJ is expected to submit the formal request in mid-July. Subsequently Mid Atlantic CEAC representatives conducted several meetings with New Jersey Board of Public Utilities and NJ Economic Development Authority to support a request to DOE to reallocate the existing ARRA funding. The request was approved in Q3 for distribution of $18M through a one-time CHP rebate. A solicitation was issued by the NY EDA on September 7, 2010 for NJ projects. All project funds have been awarded.

Participated in NJ Board of Public Utility (BPU) hearings on the transition of the Clean Energy Program under which most CHP programs reside. Provided an updated NJ CHP Market Report, which included a section on a CHP Portfolio Standard with associated Alternative Compliance Payments. Supplied the report, together with written testimony, to the BPU. The report was also supplied to Assemblyman Chivukula who is the chairman of the Telecommunications & Utilities Committee.

Met with the NJ Department of Environmental Protection to discuss the benefits of applying CHP in NJ.

The New Jersey Energy Master Plan transitioned to Governor Christie's focus on the state of New Jersey becoming a green but business friendly state. Governor Christie has charged the New Jersey Board of Public Utilities (BPU) with making the Energy Master Plan realistic and business friendly. The footnote on page 81 of the NJ Energy Master Plan uses the MACEAC as a reference in development of the EMP's stated CHP goal of 1,500 MW over 10 years. The footnote reads "This goal is consistent with the conclusions presented in the August 2010 BPU/U.S. DOE study, performed by the Mid Atlantic Clean Energy Application Center, which indicated 6,000 MW of CHP market potential in New Jersey. Scaling this estimate towards actual projects and locations results in a more conservative and realistic estimate of 1,481 MW of new generation market potential." We will be providing testimony supporting the goals and seeking clarification on program implementation at the upcoming hearings on the EMP.

Attended the NJ BPU's 100th Anniversary Meeting on April 21, 2011 to support the current BPU staff pursue their stated goal of implementing 1,500 MW of CHP within 10 years.

Presented on the benefits of CHP in NJ on May 19, 2011 at a special hearing on CHP set up by the State Assembly Utilities and Energy Committee.

Met with New Jersey Economic Development Authority and NJ Board of Public Utility (BPU) personnel on June 24, 2011. Discussed CHP and set up future meetings with the EDA and BPU.

Met with Steven Goldenberg, lead counsel for the NJ Large Energy Users Group, to discuss CHP and policy issues on May 27, 2011.

Met with the New Jersey Board of Public Utilities Director of Economic Development & Energy Policy to discuss CHP future in New Jersey and begin industry coalition building to support future CHP initiatives by the state legislature.

Attended a NJ Spotlight Roundtable on 'NJ's Thirst for Power' on July 8, 2011 with NJ Bureau of Public Utilities President, Rate Council and Representatives from Independent Power Producers.

Met with NJ Natural Gas on July 11, 2011 to discuss NJ CHP policy strategy.

Attended the NJ BPU Energy Master Plan hearing on August 3, 2011.

Participated in a NJ EDA discussion on the CHP Loan/Grant Program on August 17, 2011.

Participated in the NJ BPU Clean Energy Program discussion on new CHP Program design for 2012 on August 19, 2011.

Submitted written comments to the NJ BPU on the New jersey Energy Master Plan on August 25, 2011.

Participated in a discussion with NJ Natural Gas on CHP policy strategy on September 2, 2011.

Attended the NJ Board of Public Utility's Clean Energy Funding work group at the Rutgers EcoComplex, Bordentown, NJ, on October 21, 2011 where they presented their recommendations on how to implement clean energy programs in NJ including support for CHP.

Met with Steven Goldenberg, Council for the NJ Large Energy Users Group, on November 3, in Trenton, NJ to discuss NJ energy legislation and support for CHP.

Attended NJ Board of Public Utility's Biomass work group presentation on their findings relating to biomass potential in NJ and opportunities for the BPU to support biomass to energy development including CHP. The meeting was held at the Rutgers EcoComplex in Bordentown, NJ on November 10, 2011.

Attended NJ BPU Renewable Incentive Program Manager discussion on programs and support for biomass to power in NJ by teleconference on November 17, 2011.

Attended NJ Senate hearing on Senate Bill S-2971/A-2872 regarding regulation of standby charges on December 1, 2011, in Trenton, NJ.

Met with NJ Natural Gas policy personnel on December 15, 2011, in Wall Township, NJ, to discuss CHP in NJ and pending legislative and regulatory action.

Attended the “NJ Spotlight” roundtable discussion on the future of natural gas in NJ's economy including discussion on CHP on December 16, 2011 in Lawrenceville, NJ.

Attended 1st work group meeting on January 5, 2012, in Iselin, NJ, on NJ BPU large CHP program design. Provided oral comments on CHP program design.

Attended 2nd work group meeting on Jan 19, Iselin, NJ: on NJ BPU large CHP program design. Provided oral comments on CHP program design.

Attend NJ Assembly Telecommunications & Utilities Committee hearing on January 30, 2012 in Trenton, NJ on Alternative Energy Portfolio Standard. Provided oral comments.

Met with NJ BPU's Christie Miller January 30, 2012 in Trenton, NJ to discuss standby charges review.

Met with NJ DEP Department of Sustainability on February 21, 2012 in Trenton, NJ regarding CHP and Biomass CHP.

Attended NJ BPU Biopower Working Group meeting on February 29, 2012 in Trenton, NJ.

Met with NJ BPU Policy Director Marybeth Brenner and State Energy Office Manager Ed Mercer on March 13, 2012 in Trenton, NJ to discuss CHP.

Attended the New Jersey Board of Public Utilities (NJ BPU) CHP Standby Rate Tariff Development budget hearings and participating in the NJ BPU CHP program hearings.

Met with the New Jersey Assembly Energy Committee Chair staff to discuss CHP Portfolio Standards. The BPU has established a working group

Participated in the BPU established working group to support execution of the Large CHP program.

Met with Mike Winka & Ed Mercer, NJ BPU to discuss CHP programs and issues, Trenton, NJ on December 3, 2012.

Met with NJ Natural Gas to discuss NJ CHP policy issues, Wall, NJ on December 5, 2012.

Attend NJ BPU EE Committee meeting, Trenton, NJ on December 11, 2012.

Participated in NJ BPU CHP Work Group meeting, Trenton, NJ on December 18, 2012.

Met with NJ Natural Gas to discuss CHP policy strategy, Wall, NJ on December 19, 2012.

An MACEAC representative met individually with NJ Natural Gas, Rick Morz & & Rhea Brekke of Veolia Energy, Mona Mosser, Bureau Chief, Energy Efficiency, NJ BPU and Steven Goldenberg, Director NJ Large Energy Users Group to discuss NJ CHP Policy and the development of an independent New Jersey CHP advocacy group.

The BPU has established a working group to support execution of the Large CHP program. MACEAC participated in working group meetings in Trenton NJ on January 30, 2013 and February 26, 2013.

Met with Joseph Sullivan of Concord Engineering (formerly of the BPU) to discuss CHP legislative issues on January 30, 2013.

Attend NJ Assembly Telecommunications & Energy Committee hearing on new CHP PS in Trenton, NJ on February 7, 2013.

Presented at National Governors Association Legislative Academy in Philadelphia, PA on March 6, 2013.

Met with Frank Felder, Director of Rutgers CEEEP to discuss CHP, New Brunswick, NJ on January 18, 2013.

Met with Rutgers CEEEP to discuss CHP, New Brunswick, NJ on 4/2/13 and 4/24/13.

Attend NJ BPU Clean Energy Program budget hearing in Trenton, NJ on 4/23/13.

Participated in a NJ BPU Hearing on Standby Charges in Trenton, NJ on 5/17/13.

Met with the NJ League of Municipalities to discuss CHP, Trenton, NJ on 5/21/13.

Attended a NJ Senate Hearing on CHP Portfolio Standards in Trenton, NJ on 6/3/13.

Met with the NJ BPU and Rutgers CEEEP on CHP cost/benefit analysis in Trenton, NJ on 6/11/13.
Attended a NJ BPU CHP program and budget hearing in Trenton, NJ on 6/12/13.
Participated in the NJ BPU CHP Working Group in Trenton, NJ on 6/19/13.

Met with lobbyist Steven Goldenberg to discuss pending legislation on public private partnerships on July 15, 2013, in Lawrenceville, NJ.

Participated in NJ BPU Biopower Working Group on July 23, 2013 in Trenton, NJ at the NJ DEP Offices. Discussions included renewable energy fuelled CHP.

Met with Jeanie Fox, NJ BPU at Princeton University on August 9, 2013 to discuss NJ CHP Program. Ms. Fox asked the Princeton Facility Manager to develop a case study about their system. The MACEAC will participate in the study.

Met with NJ League of Municipalities in Trenton on August 16, 2013 to discuss grid resiliency and CHP policy in NJ.

Met with NJ BPU contractors McKinesy on August 29, 2013 to discuss design of loan programs for support of grid resilient CHP.

Participated in the inaugural meeting on September 10 , 2013 of industry based NJ CHP/DG Coalition which is focused on developing policy and programs in support of CHP and GD.

Participated in NJ BPU Interconnection Work Group meeting in Trenton on September 11, 2013.

Participated in NJ BPU Standby Rate Work Group meeting in Trenton on September 17, 2013.

Pennsylvania:

MACEAC efforts in Pennsylvania were focused on establishing state agency awareness of the benefits of Combined Heat and Power (CHP), Waste Heat Recovery (WHR) and District Energy Systems (DES) CHP, particularly with the Department of Environmental Protection, the Public Utilities Commission and the Economic Development Authority. Pennsylvania does not have any direct CHP incentive programs at the state level, but rather established energy conservation goals at the utility level through the state's Energy program, PA Act 129, Energy Efficiency and Conservation Program. Each utility is responsible to attain set goals and can individually use CHP incentives at their discretion. Throughout the program period, the MACEAC met continuously with the state DEP, PUC, EDA and utilities to emphasize the advantages of CHP, WHR and DES and a means to achieve energy goals. The resultant reissued PA Act 129 has a significant increase in the amount of incentives for CHP through their prescriptive measures, although the types and amounts of incentives vary widely from utility to utility. The proposed incentive measures are still being evaluated by the PUC and will be published shortly. The MACEAC also continued focusing on the administrations overall energy goals, and the impact of the newly developed PA Marcellus shale gas play, which provides for an opportunity for CHP implementation in future state energy policy. Technical support to the Marcellus Shale Advisory Commission" resulted in the commission recommending the promotion of CHP as part of the study. Specific efforts in support of policy efforts in Pennsylvania are listed below:

Mid Atlantic personnel met with the Pennsylvania Department of Environmental Protection on June 30, 2010 to discuss state related CHP incentives as well as strategies and background for Mid Atlantic CEAC development of a CHP Action Plan for the State of Pennsylvania.

Held discussions with the Pennsylvania DEP Northeast concerning PA based incentives for CHP and PA Green Energy Program.

Held discussions with the Pennsylvania Department of Environmental Protection concerning PA based incentives for CHP and the need to involve Pennsylvania Utility companies in Incentivizing CHP installations as part of their energy plans.

Held discussions with the Pennsylvania Public Utilities Commission concerning PA based incentives for CHP and the need to involve Pennsylvania Utility companies in Incentivizing CHP installations as part of their energy plans. Also discussed the potential impact of Marcellus Shale Gas and Biomass on future CHP incentive programs.

Met with Pennsylvania State Representative Eugene DePasquale to discuss benefits of CHP for his future potential development of CHP related legislation.

Held discussions with PPL Electric Utilities and PECO regarding potential inclusion of CHP incentives as part of their ACT 129 plans. PECO has revised their ACT 129 compliance plan to include incentives for CHP.

Held a meeting PA Department of Environmental Protection in Evansville, PA to discuss CHP applications with Waste Water Treatment Systems.

Met with DVIRC legislative liaison representatives to discuss Pennsylvania Policy/Legislative approaches for CHP incentives.

The State of Pennsylvania is developing a Marcellus Shale Gas Utilization Policy Plan by the "Marcellus Shale Advisory Commission" to identify how best to utilize this vast new in-state natural resource. The 30 member commission was led by Lt. Governor Jim Cawley. The MACEAC was asked to testify before the commission June 9, 2011 in support of a natural gas utility (UGI). The commission issued its report to the Governor on July 22, 2011. The report specifically addresses the use of CHP in the following paragraph:

> *9.4.8 The Commonwealth should promote the use of cogeneration technology (Combined Heat & Power (CHP)) through the use of Permit-by-Rule, standardized utility power grid interconnection rules and direct financial incentives.*

Subsequently, Jim Freihaut and Rich Sweetser met with C. Alan Walker, Secretary of Community and Economic Development (a Commission member), his staff and PUC Chair Robert Powelson to discuss the benefits of CHP.

On June 29-30, 2011, Penn State held a Marcellus Shale Gas Utilization Workshop focusing on three areas where expanded gas use opportunities exist:

1. Industrial Uses
2. Distributed Power Generation
3. Transportation and Fuels

The Mid Atlantic CEAC facilitated a group of 45 industry leaders; academia and policy makers interested in increasing CHP systems in Pennsylvania in the areas of distributed power generation. Also discussed was the need to establish an industry initiative called the Commonwealth Recycled Energy Economic Development Alliance (CREEDA). Follow on discussions were held with the MACEAC providing technical, economic and policy support as requested within the appropriate DOE constraints.

Provided a presentation to the gas utility UGI in Harrisburg, PA as part of a coalition building effort to develop industry support for policy efforts in Pennsylvania.

A CHP focused industry consortium, the Commonwealth Recycled Energy and Economic Development Alliance (CREEDA), formed during the Natural Gas Utilization Conference at Penn State in June 2011 formalized its membership and held a workshop on November 15, 2011 in Harrisburg, Pa. Secretary Alan Walker, PA Department of Community & Economic Development, spoke about PA Government perspectives for CHP. CREEDA will focus on Pennsylvania policy issues related to CHP.

Met with PA PUC Vice Chairman John F. Coleman Jr. in Harrisburg, on December 14, 2011 to discuss CHP in PA.

Held a meeting on CHP with Pennsylvania Department of Environmental Protection Secretary Michael Krancer on December 14, 2011 at the Navy Yard, Philadelphia, PA.

MACEAC representatives and members of CREEDA attended the PA Act 129, Energy Efficiency and Conservation Program stakeholder meeting held by The PA Public Utilities Commission on March 16, 2012, in an effort to plan for a potential ACT 129 Phase 2 program. The current program expires on May 31, 2013. A CREEDA representative testified at the meeting in support of more focused CHP incentives in the follow-on Act 129 language.

MACEAC and CREEDA representatives met with the hearing chairman, Mr. Wayne Williams, PUC Director of the Bureau of Conservation, Economics and Energy Planning, following the stakeholder meeting on March 16, 2012, to discuss participation in a future PUC working group focused on CHP.

As a follow on to the meeting with PUC Wayne Williams, MACEAC representatives met with PUC Executive Director Jan Freeman on March 22, 2012, and discussed the proposed working group discussed above. He will be responsible for coordinating the working group.

Held a meeting with Tom Bell, Executive Director, PA Energy Development Authority, on April 3, 2012 concerning addressing CHP applications in PA Correctional facilities. Follow on discussions are planned.

Met with PA Environmental Resource Council and Pew Charitable Trust to discuss a joint CHP workshop focusing on PA Higher Education Institutions. The workshop will be held at the Navy Yard, Philadelphia, PA on June 6, 2012.

MACEAC and CREEDA representatives met with members of Pennsylvania's Commonwealth Financing Authority. The CFA was established as an independent agency of the Commonwealth to administer Pennsylvania's economic stimulus packages, including grants and low cost loans for energy projects. The CFA representatives are very aware of the benefits of CHP; however the program currently has no specific carve out for CHP funding. The CFA representatives agreed to utilize the MACEAC as technical resource on future proposed CHP projects

MACEAC and CREEDA reps met with, with PA PUC Vice Chairman Coleman and staff in August, 2012 to promote support of CHP.

MACEAC also provided information requested by John Memmi, PA senate staff for Policy development and Research. Regarding potential incentive programs for CHP in Pennsylvania.

Met with PA Representative Fattah staff to discuss CHP in Philadelphia on 6/21/13.
Met with representatives of UGI utilities to discuss PA CHP Policy in Philadelphia on 6/26/13.

Met with Patrick Henderson, the Governor's Energy Executive on April 24, 2013 to discuss establishing a CHP related meeting with the MACEAC, Patrick Henderson and C. Alan Walker, the Department of Community and Economic Development Secretary in August 2013.

Met with Patrick Henderson, the Governor's Energy Executive and C. Alan Walker, the Department of Community and Economic Development Secretary, on August 15, 2013. We discussed the potential for CHP related incentives through the state energy policy. Secretary Walker would like to see any CHP activities tied to natural gas utilization expansion, particularly focused on Marcellus Shale Gas.

Maryland**:**

The MACEAC has developed very good working relationships with both key Maryland state agencies, the Maryland Energy Administration and the Public Service Commission. As a result of numerous meetings and participation in conferences, both agencies are firm supporters of the benefits of CHP, WHR and DES. Utilizing the Combined Heat and Power Market Assessment for Maryland to firmly establish the technical potential for CHP in Maryland, discussions with the PSC and MEA indicated that the only potentially effective method of getting policy support for CHP would be through the individual utilities' Empower Maryland plans. EmPOWER Maryland was established in 2008, and targeted for renewal in 2011 and 2014. It established energy efficiency goal - to reduce power consumption in Maryland by 15% by the year 2015. As part of the EmPOWER Maryland legislation, Maryland's five utilities, including Baltimore Gas and Electric Company, Potomac Edison Company, Potomac Electric Power Company, Delmarva Power and Light Company and Southern Maryland Electric Cooperative, Inc., were required to develop programs to attain the consumption reduction goals. The Maryland Public Service Commission conducted legislative-style hearings in October 2011 to review the first three-year phase of EmPOWER and the proposed 2012–2014 plans to determine adequacy, cost effectiveness, and whether they will achieve the EmPOWER Act's underlying goals of energy savings and demand reduction. An excerpt of the report on the hearings states "Although installation and participant levels have increased in recent quarters, "the programs to date have not met the Commission's expectations, and we are deeply concerned that the Companies will not meet their 2015 statutory goals." This provided an opportunity for the PSC and MEA, through the Empower Maryland plan to encourage utilities to include CHP into their plans to meet required program goals. Through continued liaison and consultation with the Maryland Energy Administration and the Public Service Commission representatives, utility resistance to the incentives was overcome and significant CHP incentives were included in all five utilities' action plans for 2012-13. Specifics of the incentives are:

BGE incentives for all qualified projects include the following: Design incentive ($75/kW), subsequent to signed commitment letter and acceptance of minimum requirements document; Installation incentive ($175/kW), subsequent to commissioning of the CHP system and BGE inspection; and Production incentive ($0.07/kWh for 18 months), three payments subsequent to review of metering data at the end of the 6th, 12th and 18th months.

Delmarva incentives include an upfront payment of $250 per kilowatt (kW) to offset installation and engineering costs with additional production incentives set at $.07 per kilowatt-hour (kWh) for an 18-month period following the startup of the CHP system.

PEPCO Incentives include a payment of $250 per kilowatt (kW) of net system capacity payment. This payment will be made in two steps: 30% when the Customer signs contract obligation(s) corresponding to at least 75% of the total estimated cost of the CHP installation, and 70% when the CHP system has been commissioned, becomes fully operational and a final statement of actual costs (with supporting invoices) has been submitted. An upfront payment of $250 per kilowatt (kW) to offset installation and engineering costs with additional production incentive of $0.07/kWh for net electricity (kWh) produced during a period of 78 weeks commencing the day following system commissioning.

Due to their relatively small service area and potential customer base for CHP, both Potomac Edison and SMECO have requested, and were granted permission to include CHP as part of their existing Energy Efficiency custom measures rather than develop a separate program for CHP.

The incentive program was fully subscribed and the utilities indicated they will ask for approval of increased incentives in 2014. Specific efforts in support of policy efforts in Maryland are listed below:

> Mid Atlantic personnel met with the Maryland Public Service Commission staff on June 2, 2010 to discuss state related issues and how they impact CHP. Discussed strategy to re-propose a standby rate structure by rule to open up a key IOU's distribution system to CHP. Began fact finding and assessment of industrial, commercial and institutional CHP potential.
>
> At the request of the Maryland Public Service Commission, the MACEAC, along with the Maryland Energy Administration, participated in May and June 2011 in the public hearings for each utility's plan presentations for the revised Empower Maryland Energy Plan. During the hearings, discussions specific to CHP focused on the potential of adding CHP incentives to the individual utilities' prescriptive measures, however after significant discussion, the utilities were reluctant to add the incentives. The utilities did agree that they would support submission of individual projects to the Public Service Commission for incentive consideration.
>
> At the request of the MEA, the MACEAC has been reviewing portions of the proposed EmPOWER Maryland updates during Oct and Nov 2011 and participated in a series of workshops hosted by the Maryland PSC and Maryland Energy administration to craft the CHP section to the empower Maryland Plan in early 2012.
>
> Met with the Maryland Public Service Commission on April 15 and May 6, 2011 to discuss a strategy for potential inclusion of CHP as part of Maryland's energy Policy, EmPOWER Maryland.
>
> Met with the Fairfax County, VA Board of Supervisors Energy Task Force to discuss potential CHP installations.
>
> Met with Baltimore Gas and Electric and the Maryland Public Service Commission concerning support for BGE potential CHP demonstration proposal to be submitted as a special project under the Empower Maryland Energy Plan.

Coordinated a meeting with the Maryland Energy Administration and Chesapeake Utilities to discuss Chesapeake Utilities' strategic plan for promoting CHP installations in their service territory. Potential MEA incentive programs were also discussed.

Met with Maryland PSC Commissioner Kelly Speakes Backman on Feb 24, 2012 in Baltimore, MD to discuss CHP.

The MACEAC worked with the Maryland Energy Administration (MEA), PEPCO Holdings (Pepco and Delmarva Power) and BG&E designated as a working group to help develop commercial and industrial CHP pilot programs under EMPower Maryland.

The MACEAC supported the Maryland Energy Administration (MEA), the Public Service Commission and the utilities PEPCO Holdings (Pepco and Delmarva Power) and BG&E working group at the first review session for proposals received from the fourth quarter, 2012 Empower Maryland CHP solicitation on Feb 22, 2013.

Attended the semi-annual EmPOWER Maryland hearing at the request of the Maryland Public Service Commission on August 22, 2013 in Baltimore, MD. Several of the utilities' CHP programs, initiated as a result of recent incentives provided through the revised EmPOWER Maryland plan, were discussed. The program is fully subscribed and two utilities, initially reluctant to have any incentive program, requested that the incentive levels be increased during the next budget year. The MACEAC will work with the utilities to provide technical consult on the various CHP projects.

Virginia:

With the heavy focus on Pennsylvania, New Jersey and Maryland, policy activity in the Commonwealth of Virginia was very limited. Currently Virginia has no CHP incentive programs and discussions with state agencies indicated no desire to consider incentives at this time. Several discussions were held with the City of Arlington concerning the development of an Energy Master Plan that will consider district energy and municipal CHP-based systems. The MA CEAC will provide a third party review of the plan.

Delaware:

As with Virginia, up until 2013, Delaware had no CHP incentives in place. Following discussions with local Delaware natural gas utilities, MACEAC reps held several meetings and teleconferences with members of the Delaware Department of Environmental Resources during 2012 and 2013. Following those discussions, the Delaware Department of Environmental Resources initiated a pilot CHP incentive program in 2012-3 utilizing input from existing programs in Maryland and New Jersey as a model. At the request of the Delaware Department of Environmental Resources, MACEAC provided a review of the proposed program as well as a review of four proposed CHP installations requesting incentives through the program.

West Virginia:
Again, as with Virginia, West Virginia has no CHP incentive program and discussions with the West Virginia Department of Energy indicated no desire to consider incentives at this time. However, the West Virginia Department of Energy was interested in cosponsoring a workshop to address CHP, woody biomass and Boiler MACT efforts for the state. As a result the WVA Department of Energy participated in an MACEAC biomass workshop in West Virginia at the end of June, 2013. Follow-on meetings were held with reps from the West Virginia Department of Energy in Morgantown, WVA to discuss future potential CHP applications.

District of Columbia:
As with Virginia, there is no CHP incentive program in the District of Columbia. There was no policy related activity in the district by the MACEAC during this reporting period.

Technical support

Technical support provided by the MACEAC included meetings, site visits and teleconferences with utilities, government and development agencies, company owners, facility managers , designers, etc. The products of these interactions were usually recommendations, technical analyses/project screening or a Level 1 Analysis. During the reporting period, 28 technical analysis/project screenings and 9 Level 1 Analyses were completed. Specific details of visits related to technical support are listed below:

MACEAC personnel engaged facilities managers and site development personnel at the Philadelphia Navy Yard, a 1200 acre site being developed as an Energy Innovation Park for the city of Philadelphia by the Philadelphia Industrial Development Corporation (PIDC). CHP for building clusters and district energy for the campus are both under consideration.

The MACEAC worked with EPA's CHP Partnership to deliver a Report assessing the energy and environmental benefit of the proposed project. We have been told by the Capitol Plant staff that this report assisted in the ultimate funding and award of a Utility Energy Services this year to PEPCO Energy Services to develop the plant.

The MACEAC met with the NJ Economic Development Authority who own and operate numerous buildings in the state. The EDA is interested in the potential to have the CEAC provide Level I studies. The EDA is also very influential in NJ clean energy policy so integrating the CEAC with their efforts is recognized as having potential positive benefits in other areas.

As a result of meetings at the NJ Clean Energy Conference further dialogue will proceed on working with the NJ Department of Corrections to evaluate the potential for CHP at their various sites.

The MACEAC has engaged site development planners at the Pittsburgh Gateway Development Area, a site in which the first Vocational Technical School in the U.S. is to be renovated to educate for Green Collar jobs of the future. The site may be expanded to include the new Pittsburgh Penguins' Ice Facility and the surrounding acreage for residential and commercial building clustering. The Pittsburgh Gateway Corporation and the Pittsburgh Board of Education are the principals involved in the development project. CHP for building clusters and district energy for the campus are both under consideration.

The MACEAC met with NJ Natural Gas representatives to discuss potential sites for a Level I study requested as a result of meetings at the NJ Clean Energy Conference.

MACEAC personnel met with Dr. Pepper/Snapple Bottling Company, Aspers, PA. Representatives to identify potential application of CHP at their facilities in Aspers, PA. MACEAC reps met with the Engineering Director and Asset Care Manager, reviewed electrical systems, discussed plant electrical load profiles, heating, steam sanitization requirements, potential CHP site locations and future expansion plans.

A site visit to two facilities within Schuylkill Economic Development Corporation (SEDCO) SEDCO, Pottsville, PA territory was conducted by the MACEAC on June 10, 2010 to evaluate the potential for CHP at the Wal-Mart and Wegmans distribution centers. The site visits were conducted with SEDCO personnel to provide preliminary assessments on the specific sites as well as educate SEDCO personnel on how to identify suitable locations for CHP within their territory.

MACEAC personnel met with representatives from Devault Foods, Devault PA in July 2010 to identify potential applications of CHP. Devault Foods processes meat products for the retail industry. Discussions held with the Plant Manager and Facilities Manager. Discussed plant operating profiles power requirements, electrical distribution system, cooling and hot water washdown requirements and potential site location of CHP Plant. Mid Atlantic CEAC personnel held a follow-on meeting in November 2010 with representatives from Devault Foods, Devault PA to identify potential applications of CHP. A report was provided in Q3.10

MACEAC personnel met with facilities personnel at the LM Moorestown, NJ facility in September 2010 to evaluate the site for CHP. A report demonstrating the economic advantage and significant greenhouse gas reduction potential for CHP was developed and presented to LM.

The MACEAC conducted a site visit of Lockheed Martin Corporation, Valley Forge, PA Building 100 on April 26th 2011 to evaluate CHP potential for the building.

MACEAC personnel have engaged Capitol Hill Utilities Facilities management in December, 2010 and February of 2011 to assist in assessing the feasibility of installing a 7.5 MW natural gas turbine, duct-fired HRSG, 1.05 MW BP steam turbine that also produces 80,000 PPH steam at 205 psig. The plant will replace a 200 psig to 100 psig PRV with a 2.1 MW steam turbine generator as part of the project. The MA CEAC has worked with the Architect of the Capitol and EPA's CHP Partnership on the project. A suggested CHP design for the site has been established and is to be presented to appropriate D.C. authorities. Based, in part, on this report the Architect of the Capitol is proceeding to secure the funding which requires Congressional approval.

MACEAC personnel visited Barry Callebaut Company, Eddystone, Pa, in September 2010, to identify potential application of CHP. Barry Callebaut is a major worldwide processor of bulk chocolate. Met with the Plant Manager, reviewed electrical systems, discussed plant electrical load profiles, heating, steam requirements, potential CHP site locations and future expansion plans. Following the initial meeting and site review in September 2010, MACEAC and DCVIRC representatives met with Barry Callebaut Company facilities manager on April 25, 2011 to conduct a Level 1 feasibility study. . Existing wide distribution of multiple refrigeration systems makes application of CHP not feasible at this time. There is potential for plant expansion in the future and MACEAC will provide support for potential application of CHP at that time.

MACEAC personnel conducted a CHP technical evaluation of Blommer Chocolates, East Greenville, PA during an on-site visit on February 10, 2011.

MACEAC personnel met with Hatfield Quality Meats, Hatfield, PA representatives to identify potential application of CHP at their facilities in Hatfield PA. Hatfield is a major processor of pork products. Met with the Plant Manager, reviewed electrical systems and discussed plant electrical load profiles, heating, steam and refrigeration requirements, potential CHP site locations and future expansion plans. Conducted a follow-on visit and presentation of the report of the preliminary Level 1 Analysis conducted at the previous meeting discussed above.

The MACEAC conducted a Level 1 Analysis at the Princeton Plasma Physics Lab, Princeton Junction, and NJ on September 21, 2011.

MACEAC met with representatives from GENTEC, Carbondale, PA, a manufacturer of military and law enforcement protective equipment. Held discussions with the plant manager who indicated that they are planning on replacing several small chillers to upgrade the 100 year old facility. There is a 24/7 thermal load at the plant and significant electrical load. A feasibility analysis was presented to the company.

An MACEAC representative, along with a representative from the Pennsylvania Technical Assistance Program (Penn TAP) visited the Elkay Manufacturing Co., Mifflinburg, PA, a major manufacturer of cabinetry, to tour the facilities and conduct a Level 1 CHP feasibility study. Held discussions with the plant facilities manager and gathered data on electrical and thermal requirements

The MACEAC, in conjunction with DVIRC, visited Lambert Spawn, Coatsville, PA. and conducted a plant visit and held discussions with the facilities manager to gather data to perform a Level 1 analysis of the facility. Lambert Spawn manufactures spawn material for the mushroom industry and is the oldest independent spawn manufacturer in North America.

MACEAC representatives, along with a representative from DVIRC, visited, John C. Leo & Sons, Oxford, PA, owner of Country Fresh Mushrooms, a mushroom growers' cooperative, to tour the facilities and obtain electrical and thermal data to conduct a Level 1 CHP feasibility study.

MACEAC met with Princeton University facilities manager to discuss CHP and district energy systems operating experience.

MACEAC supported Pittsburgh gateways Project preliminary planning meeting during CHP and district energy discussions on February 10, 2012

MACEAC met with Caterpillar Inc., representative to discuss potential CHP applications in Delaware.

In collaboration with Philadelphia Industrial Development Corporation, MACEAC representatives met with Liberty Property Trust, Philadelphia Navy Yard developer, to discuss potential CHP and district energy applications for future Navy Yard development. Their current business model is to utilize stand alone systems in their buildings. As a result of the meeting, they will consider the application of a district energy and CHP system in their next Navy Yard complex.

MACEAC conducted a project screening with the facilities team at American Tinning and Galvanizing Co, Erie, PA in January 2102 to discuss potential CHP application. Thermal applications included process heating of numerous chemical baths. No commitment was made. AT & G needs to review investment requirements to upgrade heating coils in the chemical baths.

MACEAC conducted a project screening with Geris Inc., in March, 2012 to discuss potential CHP applications for development of a wood pellet production facility.

MACEAC conducted a CHP technical evaluation with Bangor PA School District for potential CHP applications. Unlikely candidate due to lack of consistent thermal load

MACEAC conducted a technical evaluation in June 2012 with Philadelphia Industrial Development Corporation of Philadelphia Technology Park's plan for potential CHP application for possible data center expansion at the Navy Yard, Philadelphia.

In collaboration with Philadelphia Industrial Development Corporation, MACEAC representatives held a follow on meeting with Liberty Property Trust, Philadelphia Navy Yard developer, to continue discussions on potential CHP and district energy applications for future Navy Yard development. This meeting focused on impact of CHP decisions on the PIDC Energy Master Plan under development.

The MACEAC held follow-on discussions with the Philadelphia Eagles on their initial plans in CY 11 to install a 10MW CHP system at Lincoln Financial Field along with Solar PV and wind turbines. The final decision and ongoing project is to install 3 MW of Solar PV and several wind turbines. The Eagles and their new contractor decided that CHP was not an ideal fit for the project.

MACEAC personnel provided technical assistance/project screening for the St Joseph's Villa Senior Care Facility in Philadelphia, PA on October 22, 2012.

P MACEAC personnel provided technical assistance/project screening for the   Thaddeus Stevens College of Technology in Lancaster PA on October 24, 2012.

MACEAC personnel met with Prince George County, Maryland Department of Corrections to discuss potential CHP applications utilizing landfill gas in Upper Marlboro, MD on 6/19/13. Preliminary technical evaluation was provided.

MACEAC personnel conducted a Level 1 analysis during an on-site visit with United Refining in Warren, PA on August 27, 2013.

P MACEAC personnel provided technical support to the Radford Army Ammunition Plant, Radford, VA. During August 2013. The CEAC will provide technical and economic advice to RFAAP and BAE as requested prior to their selection of a third party design firm to develop the preliminary design of CHPP, and as requested during the design phase.   Project is waiting funding for the third party design firm.

MACEAC personnel conducted a technical evaluation, by teleconference, of the Cherry Lane Nursing Center, Laurel, MD on September 5, 2013.

MACEAC personnel conducted a technical evaluation, by teleconference on September 17, 2013, of a proposed CHP installation at the Dover Downs Raceway, Dover, DE. The plan is being developed by Chesapeake Utilities through a Delaware Department of Natural Resources and Environmental Control CHP Incentive Program. A future on-site visit is planned. During a follow-on conference call, technical evaluations were completed for three additional CHP proposals submitted under the program.

A technical evaluation, by teleconference, on September 12 and 20, 2013, was conducted on the Guthrie Health Center, Sayre, PA. by the MACEAC. Information exchange will continue with a possible future site visit.

A technical evaluation, through an on-site visit, was conducted on a potential CHP installation by the MACEAC l at the Kirkbride Center, Philadelphia, PA. on September 26, 2013. Additional technical information will be provided by the property manager.

MACEAC personnel conducted a site visit to Fort Belvoir, Ft Belvoir, VA on September 30, 2013 to perform a preliminary evaluation of a potential 1 Mw CHP installation.

Project Profiles:

The MACEAC visited the United Correstack/Evergreen Community Power site in Reading, PA to gather data for a potential Project Profile of the 33 MW/CHP/Biomass power plant in Q.4.10. MACEAC has held follow on discussions with United Correstack technical representatives to refine the data and finalize the project profile. The project profile has been completed and was published in November 2011.

A case study of the Evergreen Community Power Plant was also completed and issued on November 16, 2011.

A project profile of the City of Allentown Water Resources Waste Water Treatment Plant CHP system, a 360kW Micro-turbine using digester gas, was completed and published in October 2011.

A case study of the Allentown Waste Water Treatment Plant was also completed and issued on October 10, 2011.

Technical Education and Outreach

In support of Education and Outreach responsibilities, the MACEAC conducted CHP, DES and WHR seminars, workshops and webinars in selected vertical markets, to state agencies, county development commissions, professional organizations, utilities and various other entities.

Workshops/Webinars:

The MACEAC conducted a webinar with Lockheed Martin Corporate Facilities Strategic Team on March 25, 2010 to discuss potential applications of CHP.

In collaboration with the Penn State Agricultural Extension organization of Penn State University, the MACEAC conducted a Biomass Based CHP Systems Short Course on March 18 and March 19, 2010. The seminar was attended by 35 personnel from throughout the U.S. and Canada.

MACEAC personnel held a one day CHP workshop with DVIRC personnel in support of the food service industry at the Philadelphia Navy Yard Innovation Center on August 18, 2010.

MACEAC personnel conducted a CHP Workshop on 4/8/10 2010 at the Innovation Center at the Navy Yard in Philadelphia. The workshop was attended by over 30 people from a cross-section of small, medium and large businesses, including energy firms and local utilities.

MACEAC personnel participated in a CHP Workshop sponsored by PWI, in Philadelphia, targeted for facility owners, operators and architects on 4/20/10.

MACEAC personnel participated in a CHP Workshop sponsored by Greater Philadelphia Association of Energy Engineers on 5/21/2010 at the site of the Four Seasons CHP Installation in Philadelphia, PA.

MACEAC personnel conducted a CHP Workshop at the Blair County Convention Center, Altoona, PA, on 7/8/2010. The workshop was attended by 75 people from small and mid-size companies in central Pennsylvania.

The MACEAC conducted a CHP workshop on August 18, 2010 at the Innovation Center at the Navy Yard in Philadelphia. The workshop was attended by over 25 people from the food processing industry.

MACEAC personnel conducted a CHP Workshop on July 8, 2010 in Altoona, PA co-sponsored by the Southern Alleghenies Planning and Development Commission. The workshop had over 100 participants.

MACEAC personnel conducted a one day CHP workshop on August 10, 2010 with the Pennsylvania Technical Assistance Program Energy Team at University Park, PA.

The MACEAC conducted a CHP workshop on October 20, 2010 in Scranton, PA. The workshop, "Reducing Facility Energy Costs and Operating Emissions: Implementation of Combined Heat and Power" was attended by over 40 people from a cross-section of government, education and industry professionals.

The MACEAC, in conjunction with the Penn State Biomass Energy Center and the Catalyst Connection, sponsored a two day short course on Biomass-Combined Heat and Power in Greensburg, PA on November 17 & 18, 2010. The event drew 35 attendees from industry, government and academia.

The MACEAC conducted a CHP workshop on March 24, 2011 in Woodbridge, New Jersey. The workshop, "The role of CHP & Waste Heat Recovery in New Jersey Manufacturing Competitiveness", was attended by 40 people and was co-sponsored by the Industrial Energy Consumers of America.

The MACEAC conducted a CHP workshop on April 28, 2011 in Bethlehem, PA at the Northampton community College. The workshop, "Combined Heat & Power with Emphasis on the Use of Natural Gas and Opportunity Fuels" was sponsored by the Mid Atlantic CEAC, the Emerging Technology Applications Center of Northampton Community College, and corporate sponsors UGI and PPL. This technical workshop was targeted for design engineers, facilities managers, and project developers with emphasis on utilization of natural gas and other opportunity fuels. The workshop had 48 attendees, an estimated 12-15 representing potential end-users.

The MACEAC conducted a CHP workshop on May 12, 2011 in West Homestead, PA. The workshop, "Combined Heat & Power with Discussion on Applications with Wastewater Treatment Facilities" was sponsored by the Mid Atlantic CEAC and the Southwestern Pennsylvania Commission. The workshop covered basic CHP characteristics as well as a profile of a CHP/Wastewater treatment facility. The workshop was attended by 26 regional Wastewater Treatment Facility engineers and operators.

The MACEAC conducted a CHP seminar as part of the Penn State Natural Gas Utilization Workshop on June 29-30, 2011. The workshop focusing on three areas where expanded gas use opportunities exist: Industrial Uses, Distributed Power Generation and Transportation and Fuels. The MACEAC facilitated a group of 45 industry leaders, academics and policy makers interested in increasing CHP systems in Pennsylvania. The results of the workshop included an agreement to form an industry support group to help promote CHP, with a focus on and related shale gas development, within Pennsylvania. The industry initiative is called the Commonwealth Recycled Energy Economic Development Alliance (CREEDA).

The MACEAC conducted a CHP workshop on September 27, 2011 in Strattanville, PA. The workshop, "Combined Heat & Power with Emphasis on Natural Gas and Biomass Fuels" was sponsored by the US DOE Mid Atlantic Clean Energy Application Center and the Northwestern Pennsylvania Commission. The workshop covered basic CHP characteristics as well as a profile of a CHP/biomass facility.

The MACEAC conducted a webinar with PECO on CHP and the impact of PA Act 129 and net metering on potential CHP installations, October, 2011.

MACEAC conducted a workshop entitled "The Susquehanna Valley Workshop on Combined Heat and Power" in Lewisburg, PA on November 8, 2011. The workshop included a tour of the Bucknell University CHP facility.

A Commonwealth Recycled Energy Economic Development Alliance (CREEDA) Conference was held on November 15, 2011 in Harrisburg, PA. The topic for the conference was the way ahead for CHP in PA. The keynote speaker was C. Alan Walker, Secretary, PA Department of Community & Economic Development. The conference included a CHP workshop hosted by the MACEAC.

MACEAC conducted a workshop on CHP for hospitals at Abington Hospital; Abington, PA entitled "Combined Heat & Power at Hospitals" on November 17, 2011. The workshop included a tour of a 5Mw CHP facility under construction at the hospital. The workshop was attended by 80 hospital facilities managers and administrators.

The MACEAC held a CHP workshop and panel discussion at Globalcon 2012 in Atlantic City, NY on March 7, 2012.

MACEAC Representative conducted a technical presentation in support of a CHP workshop sponsored by PPL to discuss their custom measures incentives as part of their Act 129 program on 7/12/12.

MACEAC Representatives conducted a CHP workshop at the request of the Maryland Energy Administration, to support the release of the Maryland CHP program on October 1, 2012.

The MACEAC conducted a CHP Workshop in conjunction with the National Association of Electrical Contractors (NECA) and PGW on November 11, 2012 at the Navy Yard.

The MACEAC provided a presentation and panel review at the Northeast/Mid Atlantic Industrial Energy Efficiency and CHP regional Dialog Meeting in Baltimore, MD on March 13, 2013.

The MACEAC Participated in an Empower Maryland CHP Planning webinar on March 15, 2013.

The MACEAC Co-hosted a Woody Biomass CHP Workshop with the Penn state Biomass Energy Center and West Virginia University on June 25, 2013 in Morgantown, WVA.

The MACEAC conducted a Boiler MACT/CHP Webinar in Richmond VA on 6/18/13.

Seminars:

The MACEAC provided a presentation to 15 Philadelphia Industrial Development Corporation personnel on the applicability of CHP to redevelopment of the Philadelphia Navy Yard into an Energy Innovation Park on October 1, 2009.

The MACEAC provided a presentation to the Capital District Region ASHRAE Society "Combined Heat and Power – a Key Component of Sustainable Building Design", in Washington, D.C. on October 13, 2009. The seminar was attended by 75 people.

The MACEAC conducted a Professional Accredited Seminar to Northeast Region Society of Professional Engineers "Grid Independence via CHP – a Critical Element of Green Design", in Muncie, PA. The seminar, held on October 15, 2009, was attended by 50 people.

The MACEAC provided a presentation on "Identifying CHP, Waste Heat Recovery and District Heating Technology Susceptible Industrial Application Sites" to the Pennsylvania Technical Assistance Program (PENNTAP) field engineering staff, in State College, PA. The seminar, held on October 27, 2009, was attended by 40 people.

The MACEAC participated in development of NJ Chapter of IEEE workshop and presented a segment on CHP System Design & Considerations to 40 members of the Electric Engineering group on October 30, 2009.

The MACEAC presented a lunch seminar to the New Jersey Construction Roundtable on CHP Definition, Qualifiers, Considerations and Economics for NJ. Approx. 30 attendees on November 13, 2009.

The MACEAC conducted a seminar in Pittsburgh, PA, on November 17, 2009, on Site CHP Feasibility Analysis to the Pittsburgh Gateway Project Team seeking to renovate Connelly Vocation Technical School for a Green Jobs Technical Training Center.

The MACEAC conducted a CHP seminar at Indiana University of Pennsylvania and had discussions concerning a potential Project Profile of their Co-gen Plant.

The MACEAC hosted a Clean Energy display booth at Urban Outfitters sponsored Green Energy Event at the Philadelphia Navy Yard on January 18, 2012.

The MACEAC conducted a CHP Seminar at the Electro Technology Application Center at North Hampton Community College, Bethlehem, PA.

The MACEAC conducted a CHP Seminar at the Susquehanna Economic Development Association Council of Governments in Lewisburg, PA.

The MACEAC conducted a CHP seminar at AFS Energy Systems, Inc., Lemoyne, PA with discussions on CHP applications for Biomass Boiler Systems.

The MACEAC conducted a CHP seminar at the EUCI conference entitled Utilizing Clean Power Development On-site on January 19, 2012 in Philadelphia, PA.

The MACEAC provided a MACEAC and CHP overview to a UGI Utilities management team strategic planning meeting on January 26, 2012, in Reading, PA

The MACEAC conducted a luncheon seminar on 'Energy Policy and CHP' for the New Jersey and Greater Philadelphia chapters of the Association of Energy Engineers on March 8, 2012.

Conferences:

The MACEAC provided a Technical Information Display and Information Booth at the New Jersey Clean Energy Technology Conference, Atlantic City, New Jersey in November 2009.

The MACEAC hosted a CHP technical session at GLOBALCON 2010 at the PA Convention Center in March 2010.

The MACEAC participated In Clean Cities Forum, Philadelphia, PA

The MACEAC participated in the Maryland Clean Energy Summit in Baltimore on October 4, 2010

The MACEAC participated in the Pennsylvania Economic Development Association conference in Erie, PA on October 20, 2010.

The MACEAC participated in the IDEA Campus Energy Conference Miami, FL in February 2011.

The MACEAC director chaired a CHP panel discussion at the Globalcon 2011 Energy Conference in March 2011, sponsored by the Association of Energy Engineers. Two additional members of the MACEAC participated on the panel.

The MACEAC, partnering with the DVIRC, sponsored a booth at the 53rd Annual Mushroom Industry Conference at Kennett Square, PA on June 19-21, 2011.

The MACEAC coordinated and chaired a CHP technical session at Globalcon 2013, in Phila. PA on March 7, 2013.

The MACEAC participated in MACRUC technical panel on Micro-grids in Hershey, PA on 6/26/13.

The MACEAC participated in a technical Panel at The Mid-Atlantic Distributed Resources Initiative (MADRI) Working Group Meeting # 29 on August 20, 2013 in Washington, DC. The focus of the panel was currently available CHP technologies and how they can impact cost and reliability for Distributed Generation owners and the utility system. A panel also discussed how rate making and tariff issues affect the economic viability of CHP systems and discussed non-tariff incentives at the federal and state level, and their effectiveness.

The MACEAC participated on a technical panel at the Natural Gas Utilization Conference in Pittsburgh, PA on September 11, 2013. The topic of the technical session was CHP and its impact on the utilization of Marcellus Shale gas.

MACEAC representatives participated in a MADRI Working Group meeting on PJM programs on September 30, 2013.

Technical Presentations:

The MACEAC provided the following presentations to various interested groups in support of our CHP education efforts:

The MACEAC provided a CHP Presentation to the MANTECH Headquarters group in York, PA on May 17, 2010.

The MACEAC provided a CHP Presentation to Bedford County Business Development Association in Bedford PA on May 6, 2010.

The MACEAC provided a CHP Presentation to Altoona Blair County Development Commission in Altoona, PA on May 12, 2010.

The MACEAC provided a CHP Presentation to Southern Alleghenies Planning & Development Commission on May 20, 2010 in preparation for CHP workshop scheduled for Q.3.10.

The MACEAC provided a CHP Presentation to Regional Economic Development Initiatives, in Harrisburg, PA on June 10, 2010.

The MACEAC provided a CHP Presentation to Johnstown Area Regional Industries in Johnstown, PA on June 17, 2010.

The MACEAC presented a CHP brief to the US Navy Facilities Engineering Command North East in Philadelphia on August 20, 2010.

The MACEAC presented a CHP brief to United Correstack/Evergreen Community Power at their site in Reading, PA in July 2010. Discussed potential Project Profile of the 33 MW/CHP/Biomass power plants.

The MACEAC presented a CHP brief to the Pittsburgh Gateways Energy Innovation Center in Philadelphia, PA on September 20, 2010.

The MACEAC presented a CHP brief to the Penn State Facilities Engineering Institute staff on October 21, 2010.

The MACEAC presented a CHP brief to the Northwest Pennsylvania Regional Planning and Development Commission in Erie, PA on October 26, 2010.

The MACEAC presented a CHP brief to the “Regional Community and Economic Development Forum” at the Philadelphia Navy Yard on November 18, 2010.

The MACEAC presented a CHP brief to the Philadelphia Gas Works Quarterly Customer Meeting in Philadelphia, PA on January 10, 2011.

The MACEAC presented a CHP brief to representatives from Philadelphia Gas Works, in Philadelphia, PA on March 10, 2011.

The MACEAC presented a CHP brief to Jacobs Engineering, Inc., Mount Laurel, NJ. October 26, 2010 with a follow up meeting held on April 20, 2011.

The MACEAC presented a CHP brief to representatives from PPL Electric utilities in Frackville, PA on December 14, 2010.

The MACEAC presented a CHP brief to the Springfield School District, Montgomery County, PA on January 13, 2011.

The MACEAC provided a CHP brief and held follow-on discussions with the Philadelphia Eagles and Solar Blue concerning planned Solar, Wind and CHP installation at Lincoln Financial Field, Philadelphia, PA on January 24, 2011.

The MACEAC presented a CHP brief at the ‘Combined Heat and Power for Maryland Industry’ one day workshop in Baltimore, MD on March 24, 2011, sponsored by SENTECH and requested by the Maryland Energy Administration.

The MACEAC presented a CHP brief to representatives from the gas utility Chesapeake Energy, in Dover DE on May 18, 2011. This presentation resulted in a follow up meeting with the Maryland Energy Administration on July 22, 2011, coordinated by the MACEAC, to discuss potential CHP installations in the State of Maryland.

The MACEAC presented a CHP brief to PWI Engineering in Philadelphia on June 21, 2011, in preparation for a future CHP workshop focused on the regional healthcare industry.

An MACEAC representative met with Arlington County, Virginia, officials to discuss specification development for district energy ready buildings on July 13, 2011.

The MACEAC presented a CHP brief at a one day energy seminar at World Kitchens, a major manufacturer of kitchen glassware, in Charleroi, PA. On September 13, 2011

The MACEAC presented a CHP brief to the American Gas Association Executive Board at a meeting at the Navy Yard, Philadelphia, Pa on September 22, 2011.

The MACEAC provided a CHP presentation at the Pennsylvania Facilities Managers Assoc. (PFMA) fall meeting at Ft. Indiantown Gap (near Harrisburg) on Sept. 28, 2011.

The MACEAC provided a CHP presentation to representatives from Alloy Surfaces on December 15, 2011 to discuss potential application of CHP to a hydrogen generator program they have under development.

The MACEAC supported the Maryland Energy Administration and Public Service Commission by conducting a CHP brief at the BG&E CHP Workshop, Baltimore, MD on October 1, 2012 in support of the launch of the Empower Maryland CHP solicitation.

The MACEAC provided a presentation on CHP at the PA Energy Management Conference, Harrisburg, PA on October 11, 2012.

MACEAC hosted a CHP technical session at the Electric EXPO 2011 at the Valley Forge Convention Center, Valley Forge, PA on Oct 13, 2011. The MACEAC also co-sponsored a booth at the Expo with the Delaware Valley Industrial Resource Center.

The MACEAC participated on a technical panel and provided a CHP presentation at the Federal Utilities Working Group annual meeting in Philadelphia on October 25, 2011.

The MACEAC provided a CHP presentation at the Pennsylvania Environmental Resource Consortium conference on Climate change & sustainable Energy at Susquehanna University, Selinsgrove, PA, on November 2, 2012.

The MACEAC conducted a joint CHP Workshop with the International Brotherhood of Electrical Workers and Philadelphia Gas works at PGW Headquarters in Philadelphia on November 12, 2012.

The MACEAC provided a presentation on CHP at the NJ AEE monthly meeting, Edison, NJ on November 14, 2012

The MACEAC provided a presentation at the Inter-Mountain CEAC Webinar on Absorption Cooling for CHP on December 12, 2012.

The MACEAC provided a presentation and panel review at the Northeast/Mid Atlantic Industrial Energy Efficiency and CHP regional Dialog Meeting in Baltimore, MD on March 13, 2013.

The MACEAC participated in MACRUC technical panel on Micro-grids in Hershey, PA on 6/26/13.

Program Summary

The Mid Atlantic Clean Energy Application Center (MACEAC) efforts during the contract period, met all the requirements of the program. The MACEAC's efforts in promoting the adoption of Combined Heat and Power (CHP), Waste Heat Recovery (WHR) and District Energy Systems (DES) in the Mid Atlantic are summarized as follows: (1)The MACEAC developed a series of technology transfer networks with State energy and environmental offices, Association of Energy Engineers local chapters, local community development organizations, utilities and, Penn State Department of Architectural Engineering alumni and their firms to effectively educate local practitioners about the energy utilization, environmental and economic advantages of CHP, WHR and DES; (2) Completed assessments of the regional technical and market potential for CHP, WHR and DE technologies application in the context of state specific energy prices, state energy and efficiency portfolio development. The studies were completed for Pennsylvania, New Jersey and Maryland and included a set of incentive adoption probability models used as a to guide during implementation discussions with State energy policy makers; (3) Using the technical and market assessments and adoption incentive models, the Mid Atlantic CEAC developed regional strategic action plans for the promotion of CHP Application technology for Pennsylvania, New Jersey and Maryland; (4) The CHP market assessment and incentive adoption model information was discussed, on a continuing basis, with relevant state agencies, policy makers and Public Utility Commission organizations resulting in CHP favorable incentive programs in New Jersey, Pennsylvania, Maryland and Delaware; (5) Developed and maintained a MACEAC website to provide technical information and regional CHP, WHR and DE case studies and site profiles for use by interested stakeholders in information transfer and policy discussions; (6) Provided Technical Assistance through feasibility studies and on site evaluations. The MACEAC completed 28 technical evaluations and 9 Level 1 CHP analyses, and; (7) the MACEAC provided Technical Education to the region through a series of 29 workshops and webinars, 37 technical presentations, 14 seminars and participation in 13 CHP conferences.

PENNSYLVANIA COMBINED HEAT AND POWER MARKET ASSESSMENT

Prepared for:

The State of Pennsylvania

Prepared by:

US DOE Mid-Atlantic Clean Energy Application Center

April 2011

Policy Report

U.S. Department of Energy
Mid-Atlantic Clean Energy Application Center
Promoting CHP, District Energy, and Waste Heat Recovery

NOTICES AND ACKNOWLEDGEMENTS

Acknowledgment: This material is based upon work supported by the Department of Energy's National Energy Technology Laboratory under Award Number DE-EE0001109. We would like to specifically acknowledge the work of Dr. Bruce Hedman, Ken Darrow and Anne Hampson, all from ICF International, who provided the technical and market potential modeling for this report, as well as assistance in ongoing CHP analysis.

Report preparation: This report was prepared by Richard Sweetser, an MA-CEAC Senior Advisor and President of *EXERGY* Partners Corp. 12020 Meadowville Court, Herndon, VA 20170, Phone: (703) 707-0293 email: rsweetser@exergypartners.com and Gearoid Foley, an MA-CEAC Senior Advisor and President of Integrated CHP Systems Corp., 50 Washington Road, Princeton Junction, NJ 08550, Phone: (609) 799-2340, email: gearoid@ichps.com.

Purpose: The purpose of this report is to provide economic, market, jobs and carbon reduction information regarding applying combined heat and power (CHP) and combined cooling, heating and power (CCHP) systems in Pennsylvania. It also assesses the impact of state incentives and rules changes on CHP and CCHP adoption rates, economic, environmental and employment impacts.

Jim Freihaut
Director, Mid-Atlantic Clean Energy Application Center
Pennsylvania State University
104 Engineering Unit A
University Park, PA 16802
Tel: 814-863-0083
Fax: 814-863-4789
jdf11@psu.edu

CONTENTS

EXECUTIVE SUMMARY

The purpose of this report is to document the economic, environmental and societal benefits derived from instituting certain policies that will stimulate use of combined heat and power (CHP) systems in Pennsylvania.

Combined heat and power (CHP) is the sequential production of heat and electricity or electricity and heat from a single fuel source. CHP systems save energy by recovering heat during the power generation process and using it, on site, for heating, drying, cooling, refrigeration and/or humidity control and thus improving the efficiency of the fuel used to power the plant. CHP systems are located at a host site (such as an industrial plant, university or hospital) to which they provide thermal energy (heat and/or cooling) and electricity to the host customer. Meeting the host's electricity requirements often requires additional purchases of electricity from or sales to the utility grid, while additional thermal needs can be resolved by augmenting with a conventional technology. In many applications, CHP results in a significant improvement in efficiency of energy use, which translates into lower operating costs.

Delivered fuel use efficiency of the electric grid has been about 31%[1] for several decades. CHP can achieve fuel use efficiency[2] over 65% and as high as 85% in some cases. This high fuel use efficiency provides significant energy cost savings, primary energy savings and CO_2 emissions reduction. In addition, development of in-state CHP systems reduces the cost of otherwise required transmission infrastructure, creates jobs and improves Pennsylvania's competitiveness.

The Commonwealth's Electric Future

The combined electric utility forecast of the Commonwealth's electric utilities peak load shows it is increasing from 27,597 MW in 2009 to 29,550 MW in 2014 at an average annual growth rate of 1.4 percent[3].

The PUC concluded in its 2010 report[4] *"[t]he fuel mix of generating units in the RFC region is 15.0 percent nuclear, 3.0 percent conventional and pumped storage hydro, 47.0 percent coal, 6.0 percent oil, 28.0 percent gas, and 1.0 percent wind and other. Since there currently are no adverse conditions affecting the resources within the RFC region, the RFC assessment assumes that any future adverse weather or fuel supply issues would be temporary in duration and limited in impact on resource availability, and will not affect the long-term assessment.*

Within the PJM footprint, the capacity mix is likely to shift to more natural gas-fired combined cycle and combustion turbine capacity. Continued reliance on steam (mainly coal) appears likely, although potential changes in environmental regulations may have an impact on coal units throughout the footprint."

Since the Report's[5] publication:

- Eastern coal prices have been on the rise, making coal fuel costs higher[6],
- EPA emission standards for electric utility steam generating units are projected to take 11 GW of old coal generators off PJM and add to the capital cost of new pulverized coal power plants,

---

[1] Includes all extraction, conversion and delivery losses and is measure in Higher Heating Value.
[2] Fuel use efficiency (aka overall CHP efficiency) is defined by ASHRAE as the delivered power in Btu / (fuel used by the CHP system less the fuel that would have been required to produce the thermal energy provided by the CHP system)
[3] ELECTRIC POWER OUTLOOK FOR PENNSYLVANIA 2009–2014, Pennsylvania Public Utility Commission, July 2010
[4] Ibid
[5] Ibid
[6] APPENDIX C: Coal Pricing

- the Fukushima Daiichi nuclear plant incident makes the nuclear power additions serving PJM unlikely for a decade or more,
- Henry Hub natural gas price fell from $6/MMBtu to $4/MMBtu and
- PA's Marcellus Shale gas recoverable resource estimates have increased.

The Pennsylvania PUC rightly concluded above "…the capacity mix is likely to shift to more natural gas-fired combined cycle and combustion turbine capacity." This report will provide evidence that CHP is an important Marcellus gas utilization strategy to generate new local jobs, retain existing jobs, reduce energy costs, improve the economy and enhance the environment.

Pennsylvania's Existing CHP Fleet

Pennsylvania's history with CHP dates back to 1929 serving a paper mill that opened in 1880 in Tyrone, PA. This CHP plant was designed to use Pennsylvania's rich natural resource of the day (coal) to deliver electricity and heat at high efficiency. Over the years four CHP systems were installed at the facility. Today, the largest and most recent unit still operates, providing 7.5 MW of power plus thermal energy to MeadWestvaco's American Eagle Paper Recycled Paper Mill.

According to a market evaluation carried out by ICF International in conjunction with the M-A CEAC on behalf of the federal Department of Energy, Pennsylvania's entire CHP fleet consists of 125 sites totaling 3,301 MW. The study further indicates that of the 3,301 MW installed, 3,218 MW was installed prior to 1999. This leaves only 83 MW of CHP installed in the ensuing decade. 65 MW of this is due to three projects consisting of one woody biomass CHP system (~ 30 MW), a municipal solid waste project (~ 23 MW) and a landfill gas project (~12 MW). This leaves 16 MW of CHP accounting for less than 1.6 MW per year for all other projects. In fact, only 2.8 MW of natural gas based CHP was brought on line between1999 and 2009.

Figure 1 shows that 560 MW was installed prior to 1980, located at several industrial and chemical sites and one university. During the key years for which CHP was a Commonwealth focus (1985 – 1995), Pennsylvania saw 2,208 MW of CHP installed and commissioned. From 1996 to the present only 211 MW were installed. During the past decade, CHP adoption has virtually stopped except for the biomass/biogas projects described above, because of financial instability, volatile natural gas prices, and regulatory uncertainty.

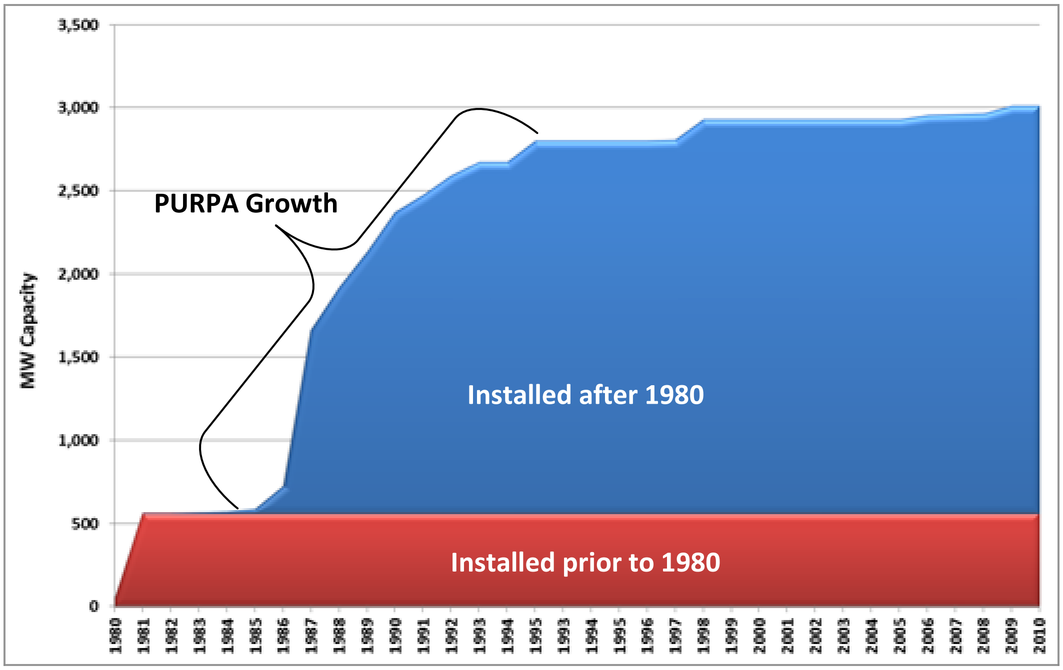


FIGURE 1 INSTALLED CHP CAPACITY IN PENNSYLVANIA

The state of Pennsylvania is currently viewed as a state that is disinterested in implementing CHP as an electricity supply option. Existing energy policy does not recognize the societal benefits provided by CHP and has not provided the atmosphere necessary to encourage development of CHP. This has lead to dissolution of the infrastructure necessary to develop CHP within the state and will significantly impede Pennsylvania from availing of the benefits offered by CHP moving forward.

Game Changing Event

The North American shale gas revolution is entering a new phase of activity with gas production in the "Big 7" US shale gas plays: Antrim, Barnett, Devonian, Fayetteville, Woodford, Haynesville and Marcellus are now estimated to be on track to rise to between 27 and 39 Bcf/d[7] over the next decade. The Marcellus field is now the world's second largest natural gas field – Marcellus gas production will be a major driving economic force in the Commonwealth, helping to create jobs for tens of thousands of Pennsylvanians, revitalizing rural economies, generating millions in tax revenue, bolstering small business and manufacturing growth and creating opportunities for a host of other industries across the region.

Certainly there are exploration and production issues that remain regarding exploitation of this important natural resource. It is assumed that these matters will be resolved, allowing this whitepaper to focus on the next important question, which is how best to use the Commonwealth's Marcellus resource? The following three pathways are among the top contenders for Marcellus gas utilization:

- New large central station combined-cycle combustion turbines to convert the gas to electricity and deliver it through transmission and distribution wires. Central station combined-cycle plants are cleaner than coal and perhaps safer than nuclear power, but may not be the most energy efficient or

[7] Billion cubic feet per day

economical electric power solution. In fact, delivered power is more expensive using grid based combined-cycle plants than new central coal power plants or natural gas CHP[8].

- Natural gas fleet vehicles are a choice to replace gasoline and diesel fuel. Indeed, NGVs are clean at the tailpipe and more cost competitive than liquid fuels at current prices, but there remains a question of infrastructure that needs to be evaluated for widespread use of NGV's.
- Combined Heat and Power (CHP) systems offer probably the best in-state use of Marcellus gas as it provides the lowest cost source of new power generation, increases Pennsylvania's business competitiveness and creates jobs. It can be deployed today without large capital infrastructure investment and substantially reduces emissions. However, CHP needs consistent state policy showing appropriate support for CHP to provide a business climate where a vibrant industry CHP can develop.

The best answer for Marcellus gas utilization for the Commonwealth will likely include a portfolio of energy policies including stimulating all of the above, as well as other energy solutions including energy efficiency and renewable resources[9].

Electric Energy Cost

The principle reason to consider providing policies and incentives supporting CHP in Pennsylvania is that it is the lowest supply cost means of providing additional power generation, as demonstrated in Figure 2. Medium and large scale CHP[10], including the thermal credit[11], provides power at close to the wholesale power price from the grid, lower than new coal or natural gas central station power plants and lower than onshore wind and solar photovoltaic (PV) systems[12]. The conclusion from Figure 2 is that large CHP is the least cost new electricity supply option for retail ratepayers in Pennsylvania today, and medium sized CHP shows an equivalent cost to new pulverized coal plants and less than new natural gas combined cycle power plants.

[8] See Figure 2
[9] The authors note that energy efficiency is the overall lowest cost and best form of energy intervention, but seeking to find the best use of Marcellus gas looks beyond energy efficiency.
[10] CHP in large and medium sizes ≥ 1MW in capacity with HHV efficiency of 36% and 37% respectively and using natural gas priced at $5.29 per million Btu's.
[11] Thermal credit applies the cost of generating the recovered (free) thermal energy from the CHP plant to reducing the power generation production cost. The credit is shown as a white column with dashed outline.
[12] Onshore wind has a production cost of 10.87¢/kWh, offshore wind is expected to be higher but the calculation unknowns are quite large at this point. Utility based solar PV is about 22 ¢/kWh and non-utility scale plants are about 32¢/kWh (however 18¢/kWh per ACEEE.)

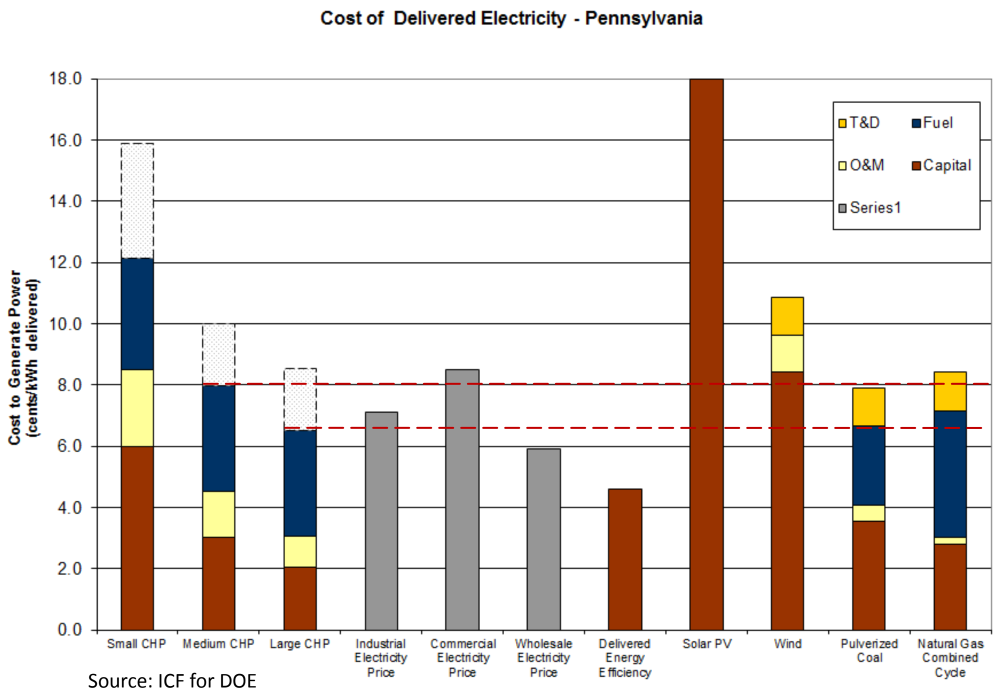


FIGURE 2: COST FOR ELECTRIC POWER PRODUCTION

Existing wholesale electricity prices in Pennsylvania are currently competitive with surrounding states and include a wide variety of existing generation sources. As described above, Pennsylvania's power demand is growing and many of the older coal plants are due to retire because of age and recently enacted environmental regulations. The new load growth and replacement of retiring plants will require development of new generation sources which will be a mix of 'base' load plants which operate under multi-year contracts and 'marginal' plants which operate under short-term contracts. The "Wholesale Electricity Price" in Figure 2 represents the grid cost of power and does not include distribution costs.

Figure 2 shows that the optimum cost-based grid loading order for new electricity production in Pennsylvania, based on economic dispatch and without accounting for societal benefits, should be:

1. Energy efficiency first and foremost
2. Large CHP
3. New pulverized coal
4. Medium CHP[13]
5. New combined cycle combustions turbines.

From the above energy cost data, CHP would appear to be an important economic means of delivering cost effective electricity in Pennsylvania. The additional societal benefits of lower emissions, increased grid stability and reduced transmission requirements offered by CHP provide further reasons to more fully exploit CHP as an in-state power supply resource.

Environmental Impact

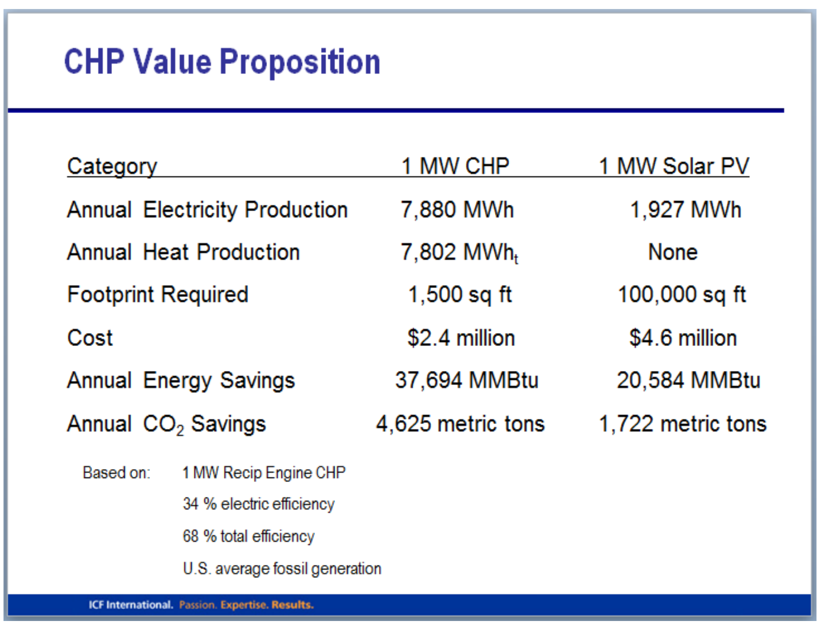
[13] 3 MW was modeled

The environment impact of energy supply is critical when constructing public policy options. CHP will clearly reduce hazardous pollutants when compared the fossil-based grid power it displaces. (Using EPA's all fossil grid average in Pennsylvania). It is important to note that existing nuclear generated power will not be offset by CHP as CHP does not operate as a first-call base load plant. It is also unlikely that power production from nuclear plants will be increased as market conditions dictate that nuclear is not a cost effective solution in an open power market. When comparing CHP to renewables related to carbon emissions, it is interesting to compare CHP to Photovoltaic (PV) panel power systems. PV has long been considered a policy tool to specifically reduce carbon emissions. The energy consultancy firm ICF International recently developed Figure 3.

In this example a 1 MW CHP system is compared to a 1 MW PV system. The natural gas based CHP system:

- produces over 400% more kWh (due to longer operating hours) than PV,
- uses 1.5% of the physical space required by PV,
- costs 52% of the of installed cost of PV,
- results in 183% greater primary energy savings than PV, and
- <u>reduces carbon emissions by 269% more than PV because of longer operating hours</u>

Therefore, natural gas based CHP should be considered an effective tool to reduce carbon emissions within the Commonwealth. In fact, CHP is not only an effective carbon reduction mechanism, but, according to McKinsey and Company[14] (Figure 4) CHP is projected to provide carbon abatement at a negative cost as it provides cheaper power than the higher carbon emitting plants it replaces.



CHP Value Proposition

Category	1 MW CHP	1 MW Solar PV
Annual Electricity Production	7,880 MWh	1,927 MWh
Annual Heat Production	7,802 MWh_t	None
Footprint Required	1,500 sq ft	100,000 sq ft
Cost	\$2.4 million	\$4.6 million
Annual Energy Savings	37,694 MMBtu	20,584 MMBtu
Annual CO_2 Savings	4,625 metric tons	1,722 metric tons

Based on: 1 MW Recip Engine CHP
34 % electric efficiency
68 % total efficiency
U.S. average fossil generation

ICF International. Passion. Expertise. Results.

FIGURE 3 CHP VS PV IMPACT

[14] December 2007 report titled "Reducing U.S. greenhouse gas emissions: How much at what cost?",

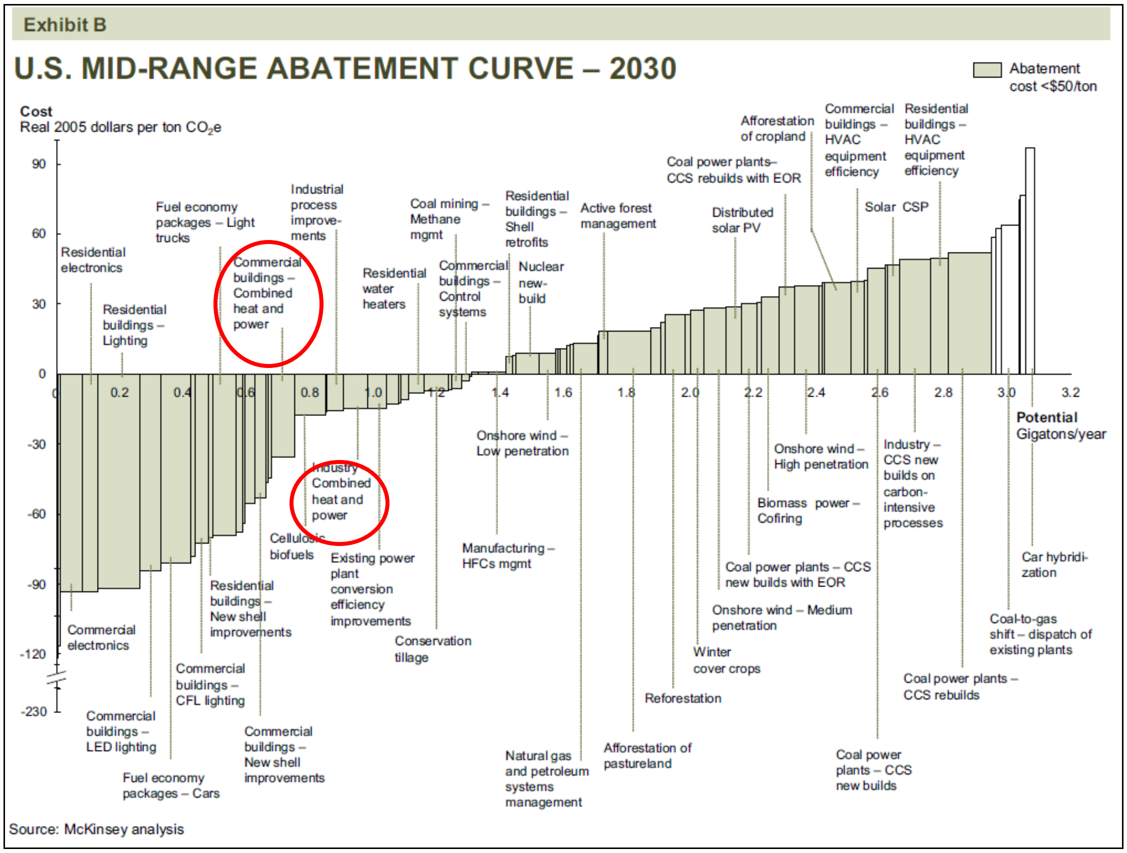


FIGURE 4 MCKINSEY AND COMPANY CARBON ABATEMENT CURVE

Benefits to the State of Pennsylvania for Supporting CHP

Figure 2 provides a strong macroeconomic reason to support CHP as a means to lower the marginal cost[15] of power to the direct user and also the grid at large by reducing the need to add new electric generation capacity or the purchase of high cost peak power. Successfully encouraging the in-state development of CHP can permanently forego the need to build new power plants and transmission and distribution infrastructure. This will lead to a more business friendly atmosphere while also reducing emissions and creating or retaining jobs. Table 1 shows between 839 and 1,836 MW of new natural gas CHP capacity can be added within the next 10 years resulting from implementation of a series of supportive measures described in this report, with the cost to the state and the private funds leveraged. Adding 1,836 MW of new natural gas CHP capacity also provides the consequential primary energy savings between 40 Trillion Btu/year, CO_2 reductions of 34.3 million short tons and the direct creation of 669 permanent construction and operations jobs. This does not take into account the potential retention of thousands of jobs by lowering energy prices.

TABLE 1: PROGRAM IMPACT

	Cumulative Market Penetration (MW)	Annual Primary Electric Energy Reduction (Trillion Btu/year)	Private sector investment ($ millions)	State investment ($ millions)	Total Cumulative CO_2 Reduced (million short tons)	Direct Sustained CHP Construction / Operating Jobs
Scenario #1 $450/kW Capital incentive						
10 Year Summary no Export	839	15	$611	$370	14.6	316
10 Year Summary with Export	1,617	32	$1,096	$721	30.3	586
20 Year Summary no Export	1,133	19	$874	$493	49.5	441
20 Year Summary with Export	2,009	38	$1,413	$887	97.9	742
Scenario #2 $10/MW/hr AEC						
10 Year Summary no Export	845	16	$984	$302	15.0	317
10 Year Summary with Export	1,671	35	$1,869	$633	31.7	603
20 Year Summary no Export	1,122	20	$1,342	$741	50.4	433
20 Year Summary with Export	2,050	41	$2,329	$1,446	101.7	751
Scenario #3 Multiple Measures 1: consisting of a $10/MW/hr AEC, state loan guarantee, and permit by rule regulation						
10 Year Summary no Export	960	19	$1,123	$335	16.6	364
10 Year Summary with Export	1,836	40	$2,063	$686	34.3	669
20 Year Summary no Export	1,296	24	$1,566	$839	56.4	508
20 Year Summary with Export	2,281	47	$2,615	$1,587	110.9	848

Conclusion

Poor CHP market penetration over the last decade and few CHP installations in the past two years despite relatively low natural gas prices makes it is clear that there are not sufficient market signals to develop a CHP market and as a result, there are few CHP project developers in the Commonwealth.

It should be noted that nine Pennsylvania CHP projects were awarded in 2009 using American Recovery and Reinvestment Act through Pennsylvania's "Green Energy Works!" grant program. These projects are due to go online in 2011. This small one time bit of stimulus quickly moved the market at an average incentive of slightly over $700/kW. Table 1 shows sustained consistent policy and support, at a much lower State investment level than the "Green Energy Works!" CHP grant, will spur the installation of a significant amount of CHP systems. This in turn will increase jobs in the Commonwealth to produce CHP equipment.

[15] In economics and finance, marginal cost is the change in total cost that arises when the quantity produced changes by one unit. That is, it is the cost of producing one more unit of a good. In general terms, marginal cost at each level of production includes any additional costs required to produce the next unit. In electrical terms, this means the cost of producing the next electron, which is highly time dependent. However, in the case of additional capacity referenced above, marginal cost merely means the cost of adding the next optimally designed power plant to meet the next electron's peak power needs above the current available grid capacity.

Examples are: Elliott turbine generators[16] and JCI York[17] absorption chillers; Caterpillar, Cummins, Waukesha, GE dealers manufacturing natural gas engine generators throughout the state; local engineering firms designing the systems; in state energy service companies like UGI Energy and Veolia Energy providing design/build/own CHP systems.

In order to fully exploit the advantages offered by CHP, a more proactive approach needs to be taken that recognizes the societal benefits provided by CHP. In addition, continued electric power demand growth (expected to continue as we pull out of the recession) and impending coal plant retirements will force Pennsylvania to rely on more expensive methods of power generation and delivery or curtail usage if it cannot stimulate significant CHP development.

Positive and sustained signals from the Pennsylvania government are required to move the industry forward and overcome a decade of poor market performance by removing remaining regulatory barriers, properly incentivizing CHP and stabilizing the policy environment. The government needs to account for the economic, environmental and job benefits offered by CHP and share these with CHP developers.

CHP addresses energy issues important to Pennsylvania by effectively using Marcellus gas, lowering consumer power costs, increasing power reliability, creating jobs and stimulating private investment while also providing a low cost means of reducing greenhouse gas (GHG) emissions. Whereas building or 'load side' energy efficiency is recognized as the lowest cost method of reducing energy demand and GHG emissions, CHP is the lowest cost method on the 'supply side' to attain energy efficiency and GHG reductions. This report identifies that implementation of state level programs and policies to incentivize CHP and removal of existing barriers to the implementation of CHP will result in a significant increase in the development of CHP plants within the state. This report suggests specific policies and demonstrates the result of these policies in terms of MW's installed. Implementation of the suggested or similar policies is necessary in order for Pennsylvania to benefit from the many advantages offered by CHP as the lowest cost supply-side energy efficiency option available today. Inaction will force the state to invest in more expensive supply-side solutions resulting ultimately in higher energy costs for consumers.

Table 1 provides three possible scenarios supporting CHP in Pennsylvania to create a more robust market that would allow the state obtain the energy, GHG and other societal benefits delineated in the table. The first scenario is centered on a capital cost reduction incentive policy designed to jump start the industry. The latter two scenarios focus on the creation of a CHP Alternative Energy Credit (AEC) patterned after the Solar Renewable Energy Credit (SREC) concept at a substantially reduced floor price of $10/MWh. Note that Table 1 also shows the AEC cost to the state for a 20 year AEC is between 1.7 and 1.9 times higher than a 10 year AEC for a 1.35 – 1.37 greater CHP capacity increase. This indicates that a 10 to 12 year AEC payout cap is optimal.

As with the capital grant approach, the AEC cost would ultimately be borne by the rate payer. The burden of the AEC to the rate payer is considerably lower per year but is paid over a longer period. However, the cost of the AEC would potentially be offset by the impact CHP would have on lowering the grid based rate for all rate payers served by the grid due to a reduction in demand.

[16] Jeannette, PA
[17] York, PA

1. INTRODUCTION

This report quantifies the long-term market penetration potential for combined heat and power (CHP), its economic impact and the degree to which CHP can reduce potential greenhouse gas (GHG[18]) emissions in support of Pennsylvania's Marcellus Shale Gas Utilization Plan. The report also examines how implementing various CHP financial and non-financial incentives would affect future CHP market penetration. The analysis covered the following five task areas:

- Characteristics of existing CHP in Pennsylvania
- Estimate of technical potential for CHP in Pennsylvania
- Base case market analysis
- Market potential analysis under alternative scenarios
- Recommendations

1.1 Traditional CHP

Traditional CHP generates electric power and recovers the waste heat for useful purposes where the electrical output is produced to meet all or a portion of the electric load for a facility and the heat output is used to provide all or a portion of the facility's thermal load. Depending on the type of facility, the appropriate sizing could be either electric or thermal limited. Industrial facilities often have "excess" thermal load compared to their on-site electric load. Commercial facilities almost always have excess electric load compared to their thermal load. Two sub-categories were considered:

High load factor applications: This market provides for continuous or nearly continuous operation. It includes all industrial applications and round-the-clock commercial/institutional operations such as colleges, hospitals, hotels, and prisons.

Low load factor applications: Some commercial and institutional markets provide an opportunity for coincident electric/thermal loads for a period of 3,500 to 5,000 hours per year. This sector includes applications such as office buildings, schools, and laundries.

1.2 Combined Cooling Heating and Power (CCHP)

All or a portion of the thermal output of a CHP system can be converted to air conditioning or refrigeration with the addition of a thermally activated cooling system. This type of system can potentially open up the benefits of CHP to facilities that do not have the year-round heating load to support a traditional CHP system. A typical system would provide the annual hot water load, a portion of the space heating load in the winter months and a portion of the cooling load during the summer months.

1.3 How CHP Saves Energy and Reduces CO_2 Emissions

Energy is one of the most significant driving forces of our economy. All buildings need electric power for lighting and operating equipment and appliances. One of the major consumers of energy in buildings is the equipment for space conditioning. Most commercial and institutional buildings for businesses, education, and healthcare require space conditioning for cooling, heating, and/or humidity control.

Two-thirds of all the fuel used to make electricity in the U.S. generally is wasted by venting unused thermal energy, from power generation equipment, into the air or discharging into water streams. While there have been impressive energy efficiency gains in other sectors of the economy since the oil price shocks of the 1970's, the average efficiency of power generation within the U.S. has remained around 31% since 1960.

[18] There are a number of gases classified as "greenhouse gases" including carbon dioxide, methane, and nitrous oxide. This analysis only considers the impact on carbon dioxide, the principal GHG produced from the deployment of combined heat and power.

The average overall primary energy efficiency of generating electricity and heat by conventional systems is around 49%.

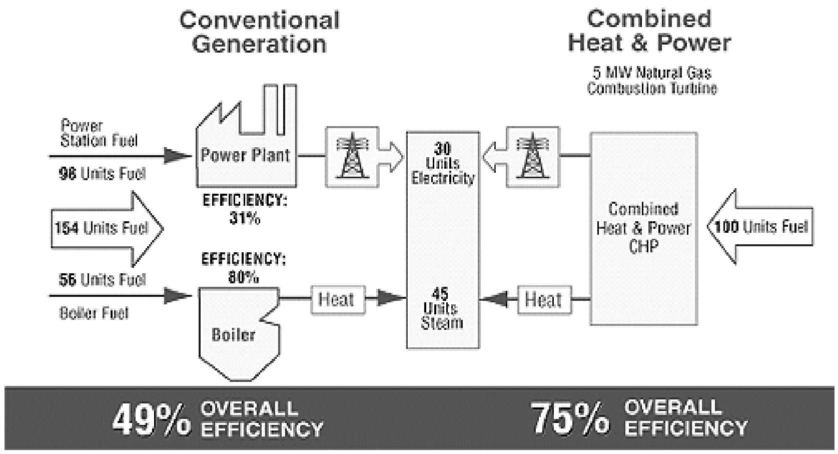


FIGURE 5: SEPARATE HEAT AND POWER VERSUS CHP – PRIMARY ENERGY [19]

CHP can increase primary energy efficiency to typically 75% and as high as 85%. This increase is accomplished by using thermal energy from power generation equipment, that otherwise would be wasted, for cooling, heating and humidity control. These plants are located at or near the facility's power and thermal distribution systems, and can save about 35% of the input energy required by conventional systems. In other words, conventional systems require 54% more energy than the integrated CHP systems, as shown in Figure 5 which demonstrates the efficiency gains of a 5 megawatt (MW) natural gas-fired combustion turbine CHP system compared to separate heat and power generation.

Industrial facilities, commercial buildings, college campuses, hospital complexes, correctional facilities and government facilities are good candidates for CHP.

Combined heat and power (CHP) systems also offer considerable environmental benefits when compared with conventionally generated electricity and onsite-generated heat. By capturing and utilizing heat that would otherwise be wasted from the production of electricity by remote large power plants, CHP systems require **less fuel** than equivalent separate heat and power systems to produce the same amount of energy.

Because less fuel is combusted, greenhouse gas emissions, such as carbon dioxide (CO_2), as well as criteria air pollutants like nitrogen oxides (NO_x) and sulfur dioxide (SO_2), are reduced. Figure 6 shows the magnitude of reduced CO_2 emissions of a 5 megawatt (MW) natural gas-fired CHP system compared with separate heat and power used to produce the same energy output. Figure 6 illustrates the CO_2 emissions output from power and thermal energy generation for two systems: (1) a separate heat and power system with a fossil fuel-fired power plant (emissions based on the U.S. fossil mix) and a natural gas-fired boiler; and (2) a 5 megawatt combustion-turbine CHP system powered by natural gas. The separate heat and power system emits a total of 49 kilotons of CO_2 per year (13 kilotons from the boiler and 36 kilotons from the power plant), while the CHP system, with its higher efficiency, emits 23 kilotons of CO_2 per year.

[19] Figure and efficiency calculations courtesy of EPA Combined Heat and Power Partnership http://www.epa.gov/chp/basic/environmental.html

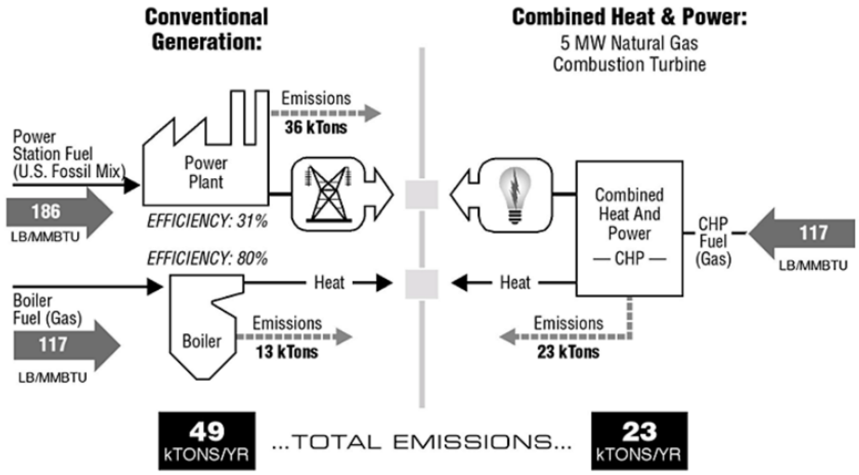
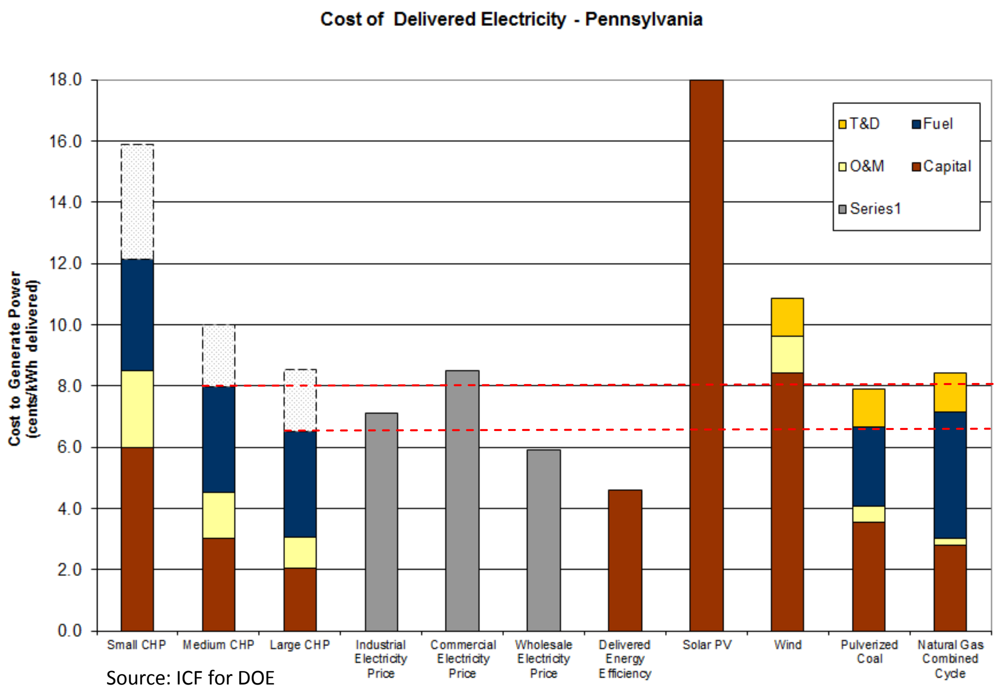


FIGURE 6: SEPARATE HEAT AND POWER VERSUS CHP – CO_2 EMISSIONS [20]

[20] Figure and emissions calculations courtesy of EPA Combined Heat and Power Partnership http://www.epa.gov/chp/basic/environmental.html

2. WHY CHP

The fundamental underpinning of this report is that there is indeed reason to consider removing barriers consumers face in applying CHP systems. Furthermore, this report provides support for the notion that CHP[21] is a low cost method of increasing primary energy efficiency, reducing carbon emissions and affecting local marginal electricity price reduction.



Source: ICF for DOE

FIGURE 7: COST FOR ELECTRIC POWER PRODUCTION

Figure 7[22] presents the "all-in" electricity production cost in ¢/kWh for various sources that demonstrates providing delivered energy efficiency is the lowest cost means of providing electricity at the margin[6]. Large and medium size (1 to 40 MW range) CHP systems produce electricity at 6.5¢ and 7.96¢ respectively, which is slightly higher than the current wholesale grid price of electricity (5.9¢) and significantly less than the current retail price. Offshore wind is expected to be higher but the installation cost and capacity factor variables are very large at this stage, as there is little supportive data. Utility based solar PV is estimated to produce electricity at about 20 ¢/kWh and non-utility commercial scale plants at about 32¢/kWh.[23]

Figure 7 provides a compelling direct financial reason to promote CHP in Pennsylvania as the most economically efficiency supply-side electricity provider. In addition, CHP's low cost of electricity supply combined with its high fuel use efficiency yields low cost primary energy savings and carbon reduction. Furthermore, permanently reducing peak electric demand leads to reduced regional marginal electricity pricing by lowering the demand for expensive wholesale peak electric power and reducing transmission and distribution costs.

[21] Reference to CHP throughout the remainder of the report means CHP and CCHP systems

[22] The central station data was derived from EIA AEO 2010, wind data is from internal DOE information and CHP data is from the DOE's MACEAC and DOE.. Data used can be found in Appendix A. Note high load factor markets represent commercial facilities such as hospitals and universities that operate around the clock, providing energy loads for CHP systems to operate nearly continuously. Low load factor markets represent commercial and institutional market opportunities such as office buildings, schools, and laundries.

[23] Solar PV data from ICF calculations for Office of Energy Efficiency and Renewable Energy, DOE

Efficiently lowering the cost of electricity for all Pennsylvania consumers yields strong potential for economic growth, jobs creation and attracting new businesses to the state. According to an assessment by the American Council for an Energy-Efficient Economy, CHP projects provide one construction and/or operation job for every $155,000[24] of capital investment. Investing in CHP could yield between 316 and 848 new construction/operations jobs that would last over the course of the program. This does not include the significant in-state supply chain job creation related to CHP equipment fabrication and packaging. Furthermore, Pennsylvania's industrial base is at risk due to high energy prices and global competition. CHP's power to reduce energy cost and future risk could literally save thousands of important manufacture jobs in the state.

In summary, promoting CHP in Pennsylvania is business friendly and consumer friendly while also being environmentally friendly.

[24] Developed by John A. Laitner, Director of Economic Analysis, American Council for an Energy-Efficient Economy, email: jslaitner@aceee.org, phone: (847) 865-5106

3. INSTALLED CHP BASE AND SITUATION

Dr. Carl Sagan reminds us that "You have to know the past to understand the present." To understand the current situation with CHP in Pennsylvania, it is important to understand the history of CHP in Pennsylvania. The historical installed base for CHP systems in Pennsylvania[25] is presented in Table 1 above and Figure 8. The installed base details (Table 2) consists of only 125 sites totaling 3,301 MW.[26] In fact, Sweetheart Cup's production in Pennsylvania has closed removing 15 MW of capacity from current production.

TABLE 2 PENNSYLVANIA INSTALLED CHP DATABASE

Facility Name	Prime Mover	Prim Fuel	Capacity	OpYear
Westvaco Corporation	Boiler/Steam Turbine	COAL	7	1929
East Lake Road Facility, Building 4	Boiler/Steam Turbine	COAL	28	1929
Coke Plant Facility	Boiler/Steam Turbine	W-FL	5	1930
Philadelphia Navy Yard	Boiler/Steam Turbine	NG	17.5	1941
U.S. Steel	Boiler/Steam Turbine	Blast Furnace Gas	52.5	1943
Sunoco Products	Boiler/Steam Turbine	COAL	2.5	1948
P. H. Glatfelter Company	Boiler/Steam Turbine	COAL	109.5	1948
Pennsylvania State University	Boiler/Steam Turbine	COAL	6	1950
Stone Container Corporation	Boiler/Steam Turbine	NG	2.98	1950
Philadelphia Refinery	Boiler/Steam Turbine	OG	30	1950
USX Fairless Works	Boiler/Steam Turbine	NG	60	1952
Erie Coke Corp	Boiler/Steam Turbine	OG	2.5	1953
Merck Chemical Riverside Project	Boiler/Steam Turbine	COAL	2.5	1954
U.S. Steel / Clairton Works	Boiler/Steam Turbine	OG	35	1955
G.F. Walton Station	Boiler/Steam Turbine	COAL	110	1958
Newman & Company	Boiler/Steam Turbine	OIL	1.8	1964
Merck, Sharp & Dohme, Unit II	Boiler/Steam Turbine	NG	91.3	1972
Mason Dixon Farms	Recip Engine	Biogas	0.6	1979
Penreco	Boiler/Steam Turbine	COAL	0.21	1980
Lord Corporation	Recip Engine	COAL	0.15	1980
Lord Corporation	Recip Engine	NG	0.9	1981
Advanced Casting Products	Recip Engine	OIL	0.1	1982
Oregon Dairy Farm	Recip Engine	Biogas	0.045	1983
Railroad Center	Recip Engine	OIL	8.2	1983
General Electric Co	Recip Engine	Residual Fuel Oil	4.476	1984
Rocky Knoll Swine Farm	Recip Engine	Biogas	0.13	1985
Knause Foods Corporation, Inc.	Gas Turbine	NG	0.8	1985
Susquehanna Plant	Boiler/Steam Turbine	Wood Waste	15	1985
Equitable Gas Company	Recip Engine	NG	0.7	1986
York Hospital	Recip Engine	NG	2.5	1986
Mehoopany Plant Cogen Project	Gas Turbine	NG	53	1986
NRG Energy Center Paxton Inc	Recip Engine	NG	12.6	1986
Packaged Products Division	Boiler/Steam Turbine	PC	67	1986
McIlvain	Boiler/Steam Turbine	Wood Waste	0.19	1986
Arco Chemical Beaver Valley Plant	Boiler/Steam Turbine	COAL	125	1987
Juniata Locomotive Shop	Boiler/Steam Turbine	COAL	10	1987
Holy Spirit Hospital	Gas Turbine	NG	0.665	1987
Sun-Marcus Hook Refinery	Combined Cycle	NG	798.8	1987
Polk Center	Boiler/Steam Turbine	COAL	0.3	1988
PEI Power Park	Boiler/Steam Turbine	Landfill Gas	25	1988
Philadelphian Condominium	Recip Engine	NG	1.48	1988
Crozer-Chester Medical Center	Recip Engine	NG	3.1	1988
Indiana University Of Pennsylvania	Recip Engine	NG	24.3	1988
Tastykake, Inc.	Gas Turbine	NG	3.75	1988
Caterpillar, Inc. / York Cogen Facility	Combined Cycle	NG	68.8	1988
Frackville Correctional Institute	Boiler/Steam Turbine	Waste Coal	44.5	1988
RI-Corp Coal	Boiler/Steam Turbine	W-FL	82	1988
Philadelphia	Recip Engine	NG	1.5	1989
Sani-Dairy/Penn Traffic Company	Recip Engine	NG	0.8	1989
Connelly Paper Mill	Recip Engine	NG	0.7	1989
Rohm & Haas	Boiler/Steam Turbine	OIL	1.5	1989

[25] DOE Combined Heat and Power Installation Database
[26] GW or gigawatt is equal to 1,000 megawats (MW) or 1,000,000 kilowatts (kW) or 1,000,000,000 watts.

Rohm & Haas	Boiler/Steam Turbine	OIL	1.5	1989
Kline Township Cogen Facility / Reading	Boiler/Steam Turbine	Waste Coal	55	1989
Scrubgrass Generating Company / St.	Boiler/Steam Turbine	Waste Coal	95	1989
Susquehanna Coal Company	Boiler/Steam Turbine	W-FL	41	1989
Smith-Kline	Recip Engine	W-FL	2	1989
Furman Foods, Inc.	Boiler/Steam Turbine	Wood Waste	18	1989
Sellinsgrove Center	Boiler/Steam Turbine	COAL	0.35	1990
Merck & Company, Inc	Boiler/Steam Turbine	COAL	2.5	1990
Double R Enterprises	Recip Engine	NG	1.6	1990
Digiam Battista	Recip Engine	O-ES	0.01	1990
Ebensburg Power Co	Boiler/Steam Turbine	Waste Coal	57.6	1990
St Nicholas Cogeneration Project	Boiler/Steam Turbine	Waste Coal	117	1990
Marcus Hook Project	Boiler/Steam Turbine	W-EN	4.5	1990
Ebensburg Center/State Hospital	Boiler/Steam Turbine	W-FL	55	1990
Bucknell University	Combined Cycle	NG	6.2	1991
Cambria Cogen	Boiler/Steam Turbine	Waste Coal	98	1991
1025 N. Church Street	Recip Engine	W-FL	0.03	1991
Einstein Hospital	Recip Engine	NG	1	1992
Welch Food, Inc.	Combined Cycle	NG	81	1992
Shannon & Piney Coal Prep Plant	Boiler/Steam Turbine	Waste Coal	33	1992
Greenhouse Project	Boiler/Steam Turbine	W-FL	94	1992
Penntech Papers, Inc.	Boiler/Steam Turbine	Black Liquor	60	1993
City Of Philadelphia Water Dept	Recip Engine	Digester Gas	22	1993
Pittsburgh International Airport Project	Fuel Cell	NG	0.18	1993
Riverview Seniors Center	Fuel Cell	NG	0.2	1993
Fizzano Bros Concrete Products	Recip Engine	NG	0.25	1993
Presbyterian Medical Center Of Oakmont	Fuel Cell	NG	0.2	1994
Hot Water Well Injection Project	Recip Engine	NG	0.1	1994
Westfield Tanning	Boiler/Steam Turbine	Fuel Oil	0.633	1995
Philadelphia International Airport	Gas Turbine	NG	14	1995
Residential System	Recip Engine	OIL	0.005	1995
Ponderosa Fiber De-Inking Facility	Boiler/Steam Turbine	Waste Coal	112	1995
Children's Hospital	Recip Engine	NG	3.04	1996
Grays Ferry - Schuylkill Station-I	Combined Cycle	NG	192.6	1997
Cogeneration Facility	Gas Turbine	NG	5	1997
Philadelphia Mint	Other/Unknown	Steam	0.231	1997
Buehler Lumber	Boiler/Steam Turbine	WOOD	0.462	1997
Sun Coal Corporation	Boiler/Steam Turbine	COAL	120	1998
Easton YMCA Cogeneration Facility	Recip Engine	NG	0.063	1998
E.I. Du Pont De Nemours & Co.	Boiler/Steam Turbine	Steam	0.15	1998
Carnegie Mellon	Boiler/Steam Turbine	waste heat	0.125	1999
Allegheny Energy Solutions	Microturbine	Digester Gas	0.03	2002
1845 Walnut Street	Gas Turbine	NG	0	2003
Masonic Homes	Microturbine	NG	0.36	2003
Hiram G. Andrews	Recip Engine	NG	0.45	2003
Wastewater Treatment Plant	Microturbine	Digester Gas	0.36	2004
County of Delaware Fair Acres Center	Recip Engine	NG	0.45	2004
Craine Station Gas Transmission	Microturbine	NG	0.18	2004
Brookside Dairy	Recip Engine	Digester Gas	0.085	2006
Doven Farms	Recip Engine	Digester Gas	0.1	2006
Four Winds Farm	Recip Engine	Digester Gas	0.13	2006
Mains Farm	Recip Engine	Digester Gas	0.09	2006
Penn England Farm	Recip Engine	Digester Gas	0.13	2006
Schrack Farm	Recip Engine	Digester Gas	0.2	2006
Creswell Landfill	Recip Engine	Landfill Gas	0.7	2006
Frey Farm Landfill	Recip Engine	Landfill Gas	2.5	2006
Harrisburg Resource Recovery Facility	Boiler/Steam Turbine	Waste	23	2006
Brubaker Farms	Recip Engine	Biogas	0.16	2007
Reinford Farms	Recip Engine	Biogas	0.13	2007
Hillcrest Saylors Farm	Recip Engine	Digester Gas	0.1	2007
Wanner's Pride and Joy Farm	Recip Engine	Digester Gas	0.16	2007
Polk County Waste Incinerator	Boiler/Steam Turbine	MSW	0.389	2007
Textile Manufacturer	Recip Engine	Biogenic biomass	6	2008
UGI Middletown	Microturbine	NG	0.13	2008
Micro CHP 11	Recip Engine	NG	0.0036	2008
Rock Tenn Company	Boiler/Steam Turbine	Waste Heat	0.626	2008
United Corrstack Paper Mill	Boiler/Steam Turbine	BIOMASS	30	2009
UGI Corporation / Broad Mountain	Gas Turbine	Landfill Gas	12	2009

Clarion University	Microturbine	NG	0.065	2009
Four Seasons Hotel	Microturbine	NG	0.195	2009
Sabinsville Compressor Station	Microturbine	NG	0.39	2009
Industrial Park	Microturbine	NG	0.325	2009
Bridge Business Center	Microturbine	NG	0.26	2009
Graymont Pleasant Gap	Boiler/Steam Turbine	Waste Heat	3	2009

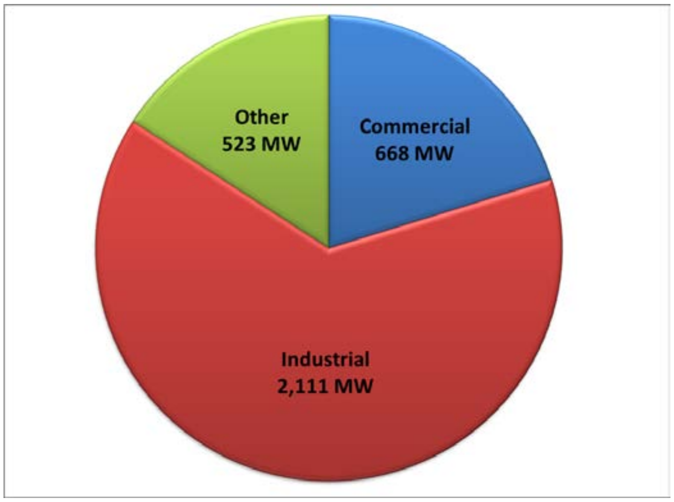


FIGURE 8: CURRENT PENNSYLVANIA INSTALLED CHP BASE IN MW BY APPLICATION

While the total number of 3,301 MW, which represents between 11 and 12%[27] of Pennsylvania's peak demand in 2008 - 2009, is a significant contribution, it is important to understand that most of this capacity was developed in the ten years from 1985 through 1995. There has been very little CHP development over the past fifteen years and if trends continue, the installed base will begin to decline rather than increase. Figure 9 and Figure 10 show the CHP installations on an annual basis.

[27] 27,597 MW peak in 2009, 30,050 MW Peak in 2008 ELECTRIC POWER OUTLOOK FOR PENNSYLVANIA 2009–2014, July 2010

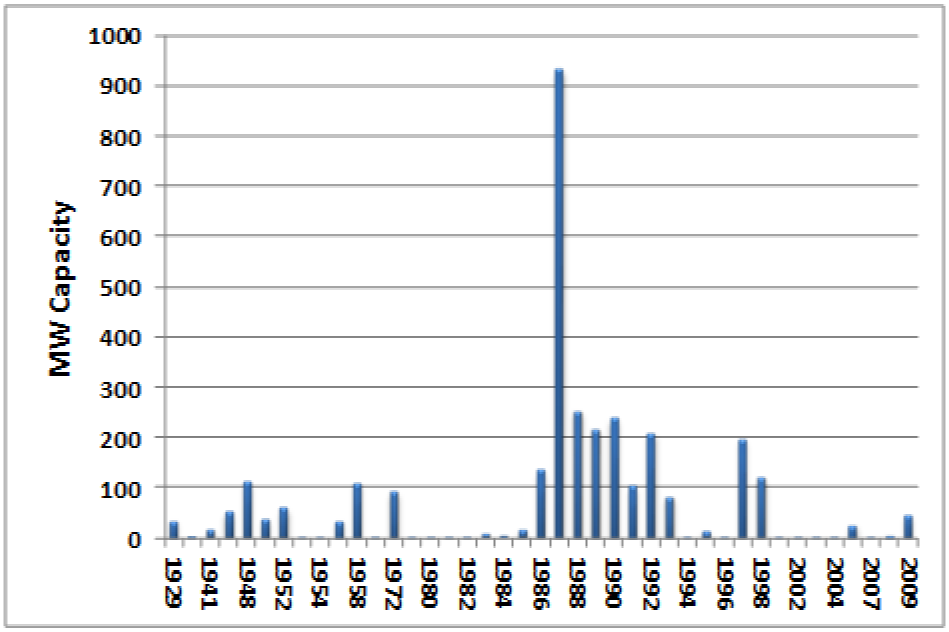


FIGURE 9 CURRENT PENNSYLVANIA INSTALLED CHP BASE IN MW BY YEAR

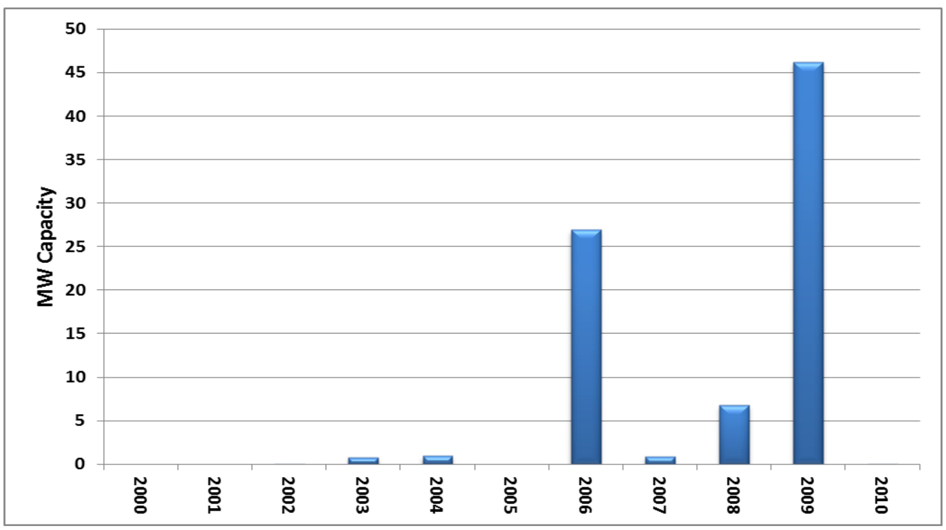


FIGURE 10 CURRENT PENNSYLVANIA INSTALLED CHP BASE IN MW BY YEAR 2000 AND LATER

Reviewing the above information in combination with the rest of the installation information, shows there are several significant conclusions that can be reached:

1. Prior to 2000, 3,106 MW of CHP was installed
2. PURPA[28] had dominant influence on CHP in Pennsylvania, accounting for 2,540 MW going online between 1983 and 1998.

[28] The Public Utility Regulatory Policies Act (PURPA) was passed in 1978 by the United States Congress as part of the National Energy Act. This law created a market for non-utility electric power producers forcing electric utilities to buy power from these producers at the "avoided cost" rate, which was the cost the electric utility would incur were it to generate or purchase from another source. Generally, this is considered to be the fuel costs incurred in the operation of a traditional power plant, associated variable operations and maintenance cost and new capital cost. Although a Federal law, the implementation was left to the States and a variety of regulatory regimes developed. The biggest result of PURPA is the prevalence

3. Since 2000, 83 MW of CHP was installed
4. Since 2000, 36 MW of this capacity was for a 30 MW woody biomass plant and a 6 MW biogenic biomass plant.
5. Since 2000, 15 MW was installed in three landfill gas applications
6. Since 2000, 3.6 MW was installed in two waste heat-to-power applications
7. Since 2000, 2.8 MW was installed using natural gas as a fuel
8. Since 2000, 1.4 MW was installed in 10 digester gas facilities
9. CHP installations in Pennsylvania in the past decade were influenced by energy price (spark spread) as the State enjoys relatively low electricity prices.

The current market situation is that the Pennsylvania Public Service Commission (PSC) provides no financial incentives for CHP. No utility programs are offered for CHP. As shown in Figure 11 and Figure 12, except for two hurricane related spikes, natural gas prices remain low and there exists a generally competitive spark spread. Project capital remains tight, environmental permitting remains a relatively long process, and utility attitude toward CHP remains unclear.

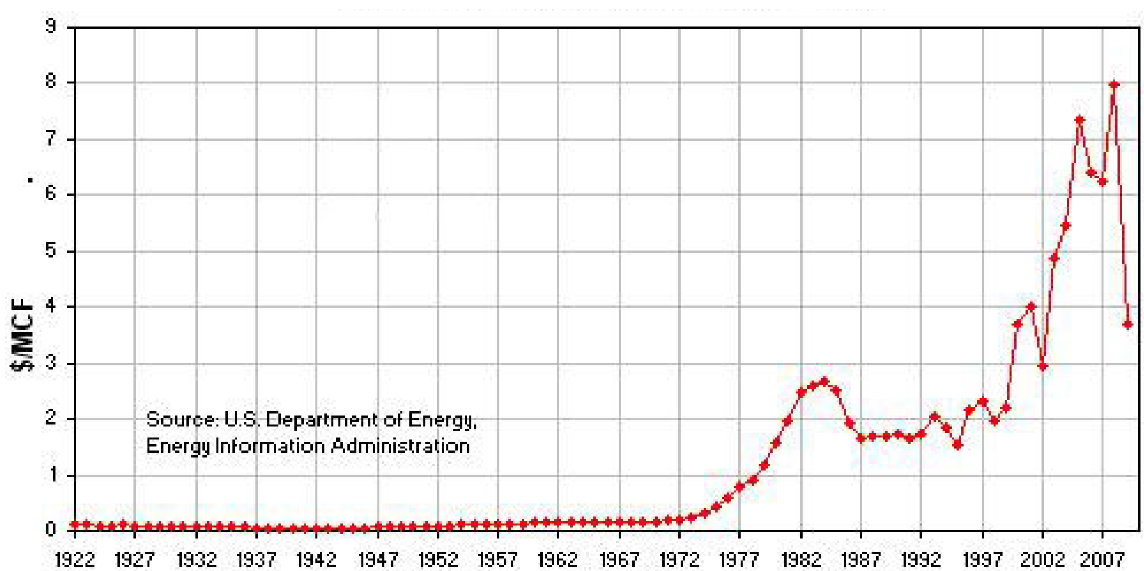


FIGURE 11: WELLHEAD NATURAL GAS PRICE SINCE 1922

of CHP plants, which produce electric power and steam. These plants were encouraged by the law, on the basis that they harness thermal energy (in the form of usable steam) that would be otherwise wasted if electricity alone was produced. These plants were known as 'Qualified Facilities' or QF's . This act provided a federal incentive for states to implement regulations encouraging development of QF's that lead to substantial CHP installations in many states.

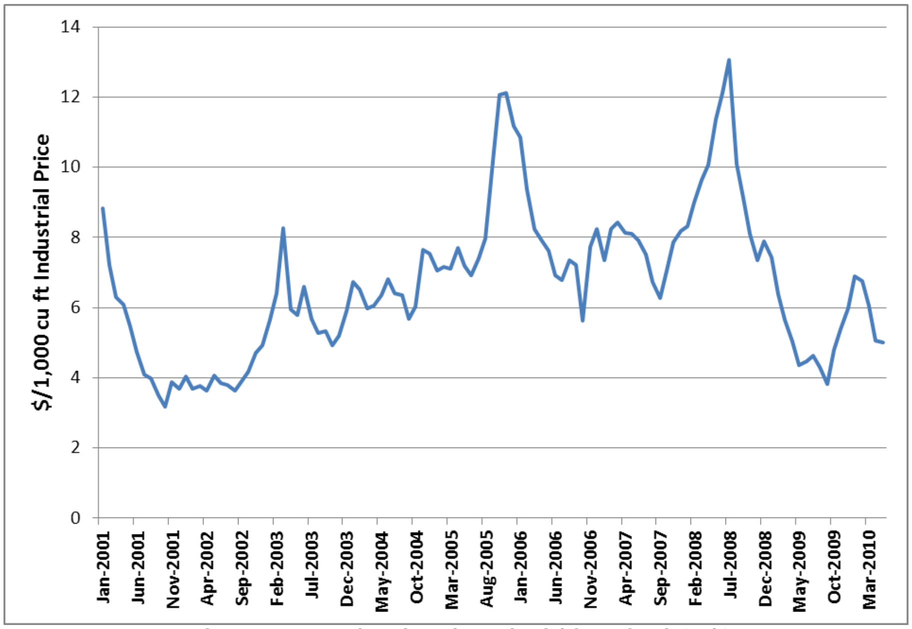


FIGURE 12: INDUSTRIAL NATURAL GAS PRICING (EIA)

4. TECHNICAL MARKET POTENTIAL METHODOLOGY

Technical market potential is a statement of the number of MW's of power that could be produced from CHP plants assuming that all facilities with coincident electric and thermal loads would employ CHP. The estimation of technical market potential is generated by using multiple sources of data and various metrics as described below to identify and quantify in terms of size, sites suitable for the application of CHP. The existing CHP sites are subtracted from the identified sites to determine the remaining technical market potential.

The technical market potential does not consider screening for economic rate of return, or other factors such as ability to retrofit, owner interest in applying CHP, capital availability, natural gas availability, and variation of energy consumption within customer application/size class. The technical potential as outlined is useful in understanding the potential size and size distribution of the target CHP markets in the state. Identifying technical market potential is a preliminary step in the assessment of market penetration.

The basic approach to developing the technical potential is described below:

- *Identify existing CHP in the state.* This existing CHP capacity is deducted from any identified technical potential.
- *Identify applications where CHP provides a reasonable fit to the electric and thermal needs of the user* - Target applications were identified based on reviewing the electric and thermal energy (heating and cooling) consumption data for various building types and industrial facilities. Data sources include the DOE EIA Commercial Buildings Energy Consumption Survey (CBECS), the DOE Manufacturing Energy Consumption Survey (MECS) and various market summaries developed by DOE, EPA's CHP Partnership, and the Mid-Atlantic Clean Energy Application Center. Existing CHP installations in the commercial/institutional and industrial sectors were also reviewed to understand the required profile for CHP applications and to identify target applications.
- *Estimate of CHP Technical Market Potential* - An estimate of the technically suitable CHP applications by size and by industry. This estimate is derived from the screening of customer data based on application and size characteristics that are used to estimate groups of facilities with appropriate electric and thermal load characteristics conducive to CHP.

- *Estimate CHP Technology Cost and Performance* - For each market size range, a set of applicable CHP technologies is selected for evaluation. These technologies are characterized in terms of their capital cost, heat rate, non-fuel operating and maintenance costs, and available thermal energy for process use on-site.
- *Estimate of Energy Price Projections* - Present and future fuel and electricity prices are estimated to provide inputs into the CHP net cost calculation.
- *Estimate Market Penetration* - Within each market size, the competition among applicable CHP technologies is evaluated. Based on this competition, the economic market potential is estimated and shared among competing CHP technologies. The rate of market penetration by technology is then estimated using a market diffusion model.

5. ICF MODEL

The ICF[29] CHP Market Model estimates cumulative CHP market penetration as a function of the competing CHP system specifications, current and future energy prices, and site electric and thermal load characteristics. The ICF CHP Market Model is a multi-layered integrated model that allows review of various measures against market assumptions including market potential and reports their impact on market penetration. The various incentive and policy measures, size segmentation, input assumption parameters and output parameters are summarized in Table 3. A breakout of assumptions and a more detailed review of the input data and results are provided in the following sections.

TABLE 3: ICF CHP MARKET MODEL

Forecast Periods	**2014, 2019, 2024, 2029**
Market Segmentation: Policies	$450 kW Capital Cost Rebate
	$10/MWh AEC
	Loan Guarantee
	Permit by Rule
	Export to Grid
Market Segmentation: Size	50-500 kW
	500-1,000 kW
	1-5 MW
	5-20 MW
	>20 MW
Major Input Assumptions	Technical Market Potential
	Technology Cost and Performance
	Energy Prices
	Application Load Profile
Economic Calculation Engine	CHP Economic Savings by Market and Size
	Payback Comparison
Market Penetration Estimation	Market Acceptance Curve vs. Payback
	Market Penetration of Economic Market
Model Outputs	Cumulative Market penetration in MW
	Electric, thermal and avoided AC Outputs
	Emissions Impacts

[29] ICF International partners with government and commercial clients to deliver professional services and technology solutions in the energy and climate change; environment and infrastructure; health, human services, and social programs; and homeland security and defense markets. ICF is the technical support contractor for the US EPA CHP Partnership and a US DOE support contractor for CHP programs.

6. RESULTS

The ICF model was used to assess the effect of implementing various incentive and policy measures as detailed in Section 9 below on the adoption of CHP. The results provide the expected total MWs of CHP installed as a result of implementing these measures. Figure 13 provides an overarching assessment of the 10-year potential to stimulate adoption of CHP systems in Pennsylvania through the various measures as well as the theoretical base case for the period. Figure 14 provides an overarching assessment of the 20-year potential to stimulate adoption of CHP systems in Pennsylvania through implementation of these same measures as well as the theoretical base case for the period.

The maximum penetration for any single initiative is through a \$10/MWh alternative energy credit (AEC) which would add 2,050 MW over 20 years (with export). The 'Multiple Measures 1' scenario examines the impact of a \$10/MWh AEC, loan guarantee and permit by rule combined scenario over 20 years (with export and avoided cooling). The Multiple Measures scenario would result in:

1. 2,281 MW of CHP being implemented in Pennsylvania
2. Annual Primary Energy Savings of 79,929 billion Btu/year
3. Total investment to public investment leveraging of incentive funds by about 2.6 to 1
4. Annually reducing CO_2 emissions by 110,993,000 MT at a 20 year cumulative cost to the state of \$14/MT
5. Increasing employment in the state by 848 construction/operations jobs and 1,000s of industrial jobs.

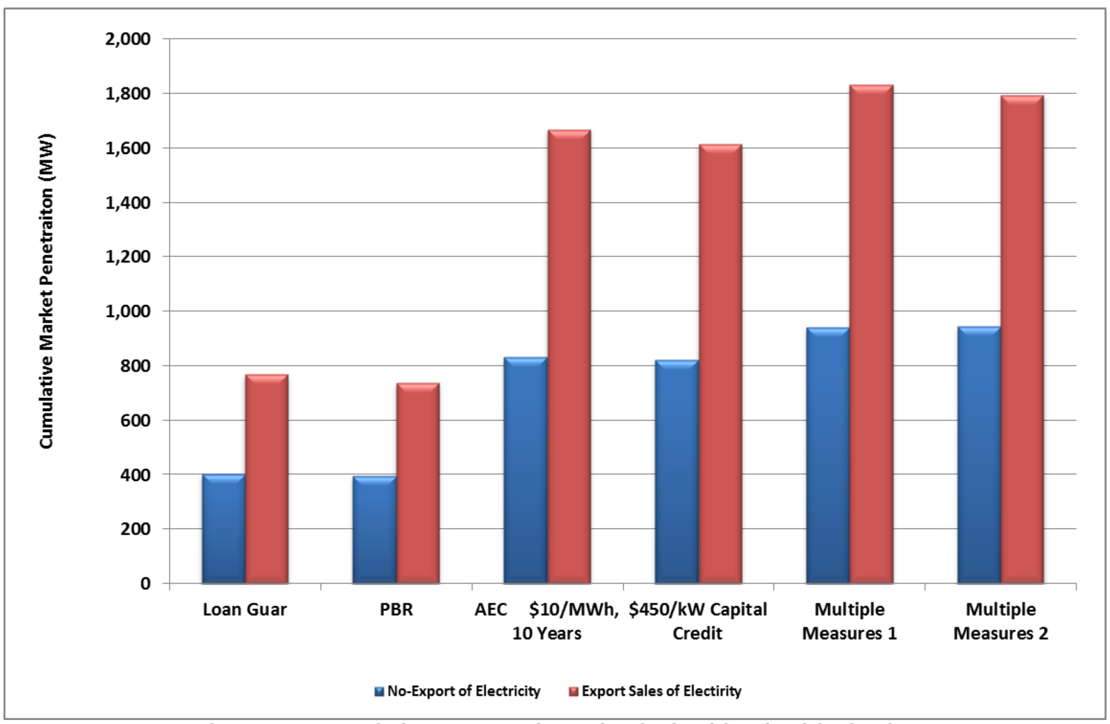


FIGURE 13: MW INSTALLED; 10-YEAR PROJECTION SCENARIOS FOR CHP

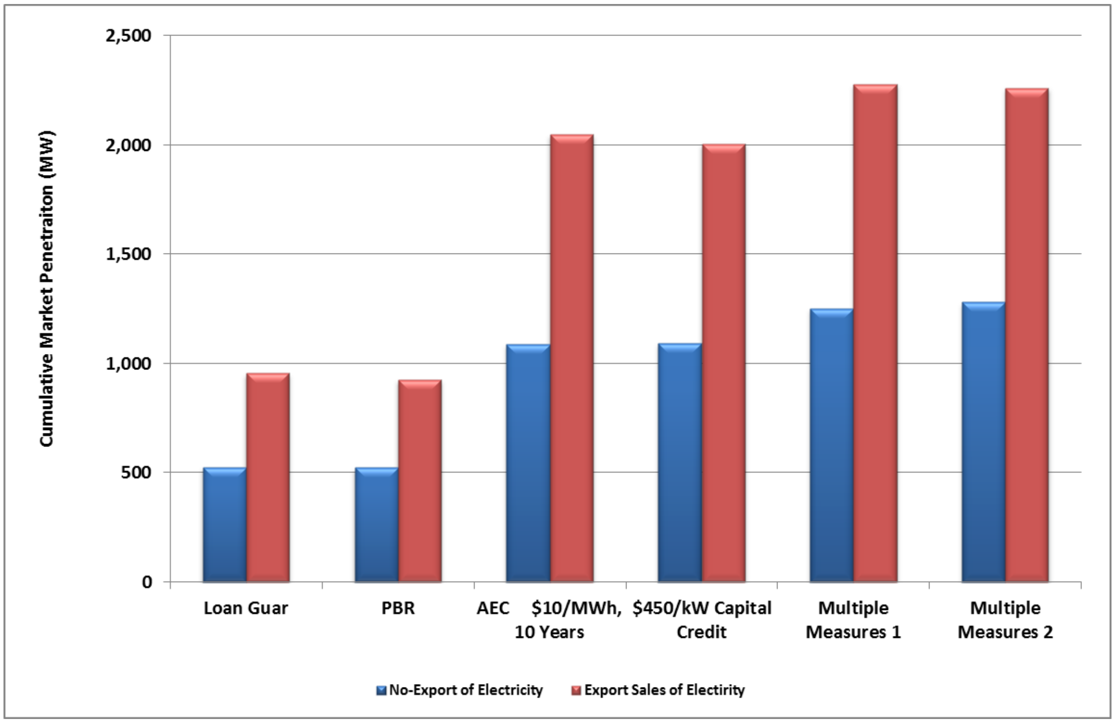


FIGURE 14: MW INSTALLED; 20-YEAR PROJECTION SCENARIOS FOR CHP

The following tables 4 and 5 provide a detailed breakout of the model results for the first 10 years with and without power export respectively. Tables 6 and 7 provide a detailed breakout of the model results for the full 20-year review period with and without power export respectively.

TABLE 4: 10-YEAR CHP MARKET PENETRATION SCENARIOS WITH NO EXPORT

CHP Measurement	Base	Loan Guar	PBR	AEC $10/MWh, 10 Years	$450/kW Capital Credit	Multiple Measures 1	Multiple Measures 2
Economic Potential, MW	485	523	522	1070	1073	1232	1265
Cumulative Market Penetraiton (MW)							
Industrial	335	358	349	713	693	791	770
Commercial/Institutional	40	44	45	118	130	151	176
Total	375	403	395	832	823	941	947
Avoided Cooling	4	5	5	14	16	18	23
Scenario Grand Total	379	407	399	845	839	960	969
Delta CHP power		28	20	457	449	567	572
Delta with avoided cooling		28	21	467	460	581	591
Annual Electric Energy (Million kWh)							
Industrial	2,610	2,790	2,711	5,526	5,362	6,094	5,926
Commercial/Institutional	298	330	336	840	889	1,052	1,164
Total	2,907	3,119	3,047	6,366	6,250	7,146	7,090
Avoided Cooling	14	15	16	43	47	56	66
Scenario Grand Total	2,921	3,134	3,063	6,409	6,297	7,202	7,156
Annual Primary Electric Energy Use (billion Btu/year) - CHP Power	29,185	31,311	30,590	63,905	62,741	71,732	71,173
Annual Primary Electric Energy Use(billion Btu/year) - w avoided coo	29,321	31,464	30,750	64,340	63,212	72,297	71,830
Incremental Onsite Fuel (billion Btu/year)							
Industrial	13,815	14,782	14,398	29,316	28,477	32,449	31,594
Commercial/Institutional	1,898	2,115	2,178	5,564	5,929	7,080	7,961
Total	15,713	16,897	16,576	34,880	34,407	39,529	39,555
Annual Primary Electric Energy Reduction (billion Btu/year) - CHP Po	13,472	14,414	14,014	29,025	28,334	32,203	31,618
Annual Primary Electric Energy Reduction (billion Btu/year) - w avoid	13,608	14,568	14,174	29,460	28,805	32,768	32,275
Delta Annual Primary Savings (billion Btu/year) - CHP Power		942	542	15,553	14,863	18,731	18,146
Delta Annual Primary Savings (billion Btu/year) - w avoided cooling		960	566	15,852	15,197	19,160	18,667
Financial Impact							
Cumulative Investment (million 2010 $)	$434	$459	$460	$984	$611	$1,123	$700
Cumulative Capital Incentives (Million 2010 $)	$0	$2	$0	$0	$370	$6	$429
Annual Operating Incentives (Million 2010 $)	$0.0	$0.0	$0.0	$63.7	$0.0	$71.5	$0.0
Cumulative Operating Incentives (Million 2010$)	$0.0	$0.0	$0.0	$302.3	$0.0	$335.1	$0.0
State Leverage		197.0		4.3	2.6	4.4	2.6
Annual Electric Energy (Million 2010 $)							
Industrial	186	199	194	396	384	438	427
Commercial/Institutional	22	24	25	62	66	78	88
Total	208	224	219	458	450	517	515
Avoided Cooling	1	1	1	4	4	5	6
Scenario Grand Total	209	225	221	462	455	522	521
Incremental Onsite Fuel (million 2010 $)							
Industrial	71	76	74	150	146	166	162
Commercial/Institutional	10	11	11	29	30	36	41
Total	81	87	85	179	176	203	203
Calculated Averages (2010 $)							
Average Capital Cost $/kW	$1,158.62	$1,141.19	$1,166.12	$1,183.38	$741.70	$1,192.73	$739.07
Average Incentive Rate $/kW	$0.00	$5.82	$0.00	$363.59	$450.00	$362.04	$453.77
Equivalent Operating Incentive, $/kWh	$0.0000	$0.0001	$0.0000	$0.0062	$0.0077	$0.0062	$0.0079
Average Electric Cost Saved ($/kW)	$0.0717	$0.0718	$0.0720	$0.0721	$0.0722	$0.0725	$0.0728
Average Incremental Gas Cost ($/MMBtu)	$5.13	$5.13	$5.13	$5.13	$5.13	$5.13	$5.13
Average Incremental Heat Rate (Btu/kWh HHV)	5,379	5,391	5,411	5,442	5,464	5,488	5,528
Cumulative Market Penetration by Size and Year, MW							
50-500 kW	11.7	13.6	17.5	31.1	32.3	47.2	58.4
500kW-1,000kW	2.2	2.7	3.4	8.5	9.0	12.7	13.2
1-5 MW	38.6	44.8	51.7	126.4	139.8	178.8	197.1
5-20 MW	83.1	89.3	83.1	193.2	192.4	205.3	204.6
>20 MW	239.0	252.2	239.0	472.4	449.7	497.3	473.2
Total Market	374.6	402.5	394.7	831.5	823.2	941.3	946.5
CO2 Impact							
Avoided CO2 Emissions, Annual basis, thousand MT	1,368	1,466	1,430	2,981	2,921	3,332	3,295
Cumulative Avoided CO2 Emissions, thousand MT	6,903	7,378	7,120	15,047	14,641	16,641	16,300
Cum Incentive Cost for Cum MT CO2 Reduced		$0.32	$0.00	$20.09	$25.30	$20.13	$26.35
Average unit Emissions savings, lb/MWh	1032.6	1031.3	1028.8	1025.3	1022.7	1019.8	1015.2

TABLE 5: 10-YEAR CHP MARKET PENETRATION SCENARIOS WITH EXPORT

CHP Measurement	Base	Loan Guar	PBR	AEC $10/MWh, 10 Years	$450/kW Capital Credit	Multiple Measures 1	Multiple Measures 2
Economic Potential, MW	950	1016	987	2098	2048	2321	2298
Cumulative Market Penetraiton (MW)							
Industrial	676	721	690	1,539	1,472	1,667	1,597
Commercial/Institutional	40	44	45	118	130	151	176
Total	715	766	735	1,657	1,601	1,818	1,773
Avoided Cooling	4	5	5	14	16	18	23
Scenario Grand Total	719	770	740	1,671	1,617	1,836	1,796
Delta CHP power		50	20	941	886	1,102	1,058
Delta with avoided cooling		51	21	951	898	1,117	1,077
Annual Electric Energy (Million kWh)							
Industrial	5,347	5,706	5,448	12,134	11,591	13,110	12,539
Commercial/Institutional	298	330	336	840	889	1,052	1,164
Total	5,645	6,035	5,785	12,974	12,480	14,161	13,703
Avoided Cooling	14	15	16	43	47	56	66
Scenario Grand Total	5,658	6,051	5,801	13,018	12,527	14,217	13,768
Annual Primary Electric Energy Use (billion Btu/year) - CHP Power	56,662	60,585	58,067	130,239	125,274	142,153	137,552
Annual Primary Electric Energy Use(billion Btu/year) - w avoided cooling	56,799	60,739	58,227	130,674	125,745	142,718	138,210
Incremental Onsite Fuel (billion Btu/year)							
Industrial	27,943	29,836	28,527	63,526	60,731	68,776	65,842
Commercial/Institutional	1,898	2,115	2,178	5,564	5,929	7,080	7,961
Total	29,841	31,951	30,704	69,090	66,661	75,856	73,803
Annual Primary Electric Energy Reduction (billion Btu/year) - CHP Power	26,821	28,634	27,363	61,149	58,613	66,297	63,749
Annual Primary Electric Energy Reduction (billion Btu/year) - w avoided co	26,957	28,788	27,523	61,584	59,084	66,862	64,407
Delta Annual Primary Savings (billion Btu/year) - CHP Power		1,813	542	34,328	31,792	39,476	36,928
Delta Annual Primary Savings (billion Btu/year) - w avoided cooling		1,831	566	34,627	32,127	39,904	37,449
Financial Impact							
Cumulative Investment (million 2010 $)	$797	$839	$824	$1,869	$1,096	$2,063	$1,198
Cumulative Capital Incentives (Million 2010 $)	$0	$4	$0	$0	$721	$11	$804
Annual Operating Incentives (Million 2010 $)	$0.0	$0.0	$0.0	$129.7	$0.0	$141.6	$0.0
Cumulative Operating Incentives (Million 2010$)	$0.0	$0.0	$0.0	$632.9	$0.0	$686.2	$0.0
State Leverage		197.0		4.0	2.5	4.0	2.5
Annual Electric Energy (Million 2010 $)							
Industrial	365	390	373	827	791	896	858
Commercial/Institutional	22	24	25	62	66	78	88
Total	387	414	398	889	857	974	946
Avoided Cooling	1	1	1	4	4	5	6
Scenario Grand Total	388	415	399	893	861	980	952
Incremental Onsite Fuel (million 2010 $)							
Industrial	143	153	146	326	312	353	338
Commercial/Institutional	10	11	11	29	30	36	41
Total	153	164	158	354	342	389	379
Calculated Averages (2010 $)							
Average Capital Cost $/kW	$1,114.81	$1,096.46	$1,120.03	$1,128.14	$684.12	$1,134.86	$675.78
Average Incentive Rate $/kW	$0.00	$5.59	$0.00	$381.98	$450.00	$383.29	$453.45
Equivalent Operating Incentive, $/kWh	$0.0000	$0.0001	$0.0000	$0.0064	$0.0076	$0.0064	$0.0077
Average Electric Cost Saved ($/kW)	$0.0686	$0.0686	$0.0688	$0.0686	$0.0687	$0.0689	$0.0692
Average Incremental Gas Cost ($/MMBtu)	$5.13	$5.13	$5.13	$5.13	$5.13	$5.13	$5.13
Average Incremental Heat Rate (Btu/kWh HHV)	5,274	5,280	5,293	5,307	5,322	5,335	5,360
Cumulative Market Penetration by Size and Year, MW							
50-500 kW	11.7	13.6	17.5	31.1	32.3	47.2	58.4
500kW-1,000kW	2.2	2.7	3.4	8.5	9.0	12.7	13.2
1-5 MW	38.6	44.8	51.7	133.1	146.9	188.2	207.0
5-20 MW	97.7	105.2	97.7	251.7	250.1	268.3	266.7
>20 MW	565.1	599.3	565.1	1,232.4	1,163.3	1,301.3	1,227.7
Total Market	715.3	765.6	735.4	1656.8	1601.5	1817.8	1773.0
CO2 Impact							
Avoided CO2 Emissions, Annual basis, thousand MT	2,682	2,866	2,743	6,147	5,906	6,692	6,463
Cumulative Avoided CO2 Emissions, thousand MT	13,489	14,413	13,706	31,693	30,278	34,322	32,907
Cum Incentive Cost for Cum MT CO2 Reduced		$0.30	$0.00	$19.97	$23.80	$19.99	$24.43
Average unit Emissions savings, lb/MWh	1044.9	1044.2	1042.6	1041.0	1039.3	1037.7	1034.8

TABLE 6: 20-YEAR CHP MARKET PENETRATION SCENARIOS WITH NO EXPORT

CHP Measurement	Base	Loan Guar	PBR	AEC $10/MWh, 10 Years	$450/kW Capital Credit	Multiple Measures 1	Multiple Measures 2
Economic Potential, MW	795	856	858	1597	1651	1850	1901
Cumulative Market Penetraiton (MW)							
Industrial	407	437	429	860	839	960	939
Commercial/Institutional	81	91	94	229	256	292	342
Total	488	528	524	1,089	1,095	1,252	1,281
Avoided Cooling	11	12	13	33	38	43	53
Scenario Grand Total	499	540	537	1,122	1,133	1,296	1,333
Delta CHP power		39	35	601	606	764	792
Delta with avoided cooling		41	37	623	633	796	834
Annual Electric Energy (Million kWh)							
Industrial	3,147	3,371	3,302	6,618	6,444	7,349	7,171
Commercial/Institutional	583	649	670	1,567	1,684	1,964	2,187
Total	3,730	4,020	3,972	8,185	8,127	9,313	9,358
Avoided Cooling	33	37	38	92	101	118	135
Scenario Grand Total	3,763	4,056	4,010	8,277	8,228	9,431	9,493
Annual Primary Electric Energy Use (billion Btu/year) - CHP Power	37,444	40,352	39,868	82,164	81,584	93,484	93,942
Annual Primary Electric Energy Use(billion Btu/year) - w avoided cooling	37,771	40,719	40,250	83,087	82,594	94,666	95,295
Incremental Onsite Fuel (billion Btu/year)							
Industrial	16,760	17,973	17,659	35,289	34,401	39,348	38,453
Commercial/Institutional	3,933	4,401	4,574	10,821	11,712	13,740	15,469
Total	20,693	22,374	22,234	46,110	46,114	53,088	53,922
Annual Primary Electric Energy Reduction (billion Btu/year) - CHP Power	16,751	17,978	17,634	36,054	35,471	40,396	40,020
Annual Primary Electric Energy Reduction (billion Btu/year) - w avoided cooling	17,078	18,345	18,016	36,977	36,480	41,577	41,372
Delta Annual Primary Savings (billion Btu/year) - CHP Power		1,227	883	19,302	18,719	23,645	23,268
Delta Annual Primary Savings (billion Btu/year) - w avoided cooling		1,268	938	19,900	19,402	24,500	24,295
Financial Impact							
Cumulative Investment (million 2010 $)	$585	$624	$635	$1,342	$874	$1,566	$1,029
Cumulative Capital Incentives (Million 2010 $)	$0	$3	$0	$0	$493	$8	$582
Annual Operating Incentives (Million 2010 $)	$0.0	$0.0	$0.0	$18.2	$0.0	$21.7	$0.0
Cumulative Operating Incentives (Million 2010$)	$0.0	$0.0	$0.0	$740.7	$0.0	$838.6	$0.0
State Leverage		197.0		2.8	2.8	2.9	2.8
Annual Electric Energy (Million 2010 $)							
Industrial	248	266	261	523	509	583	569
Commercial/Institutional	48	53	55	130	140	164	185
Total	295	319	317	652	649	747	754
Avoided Cooling	3	4	4	10	11	13	15
Scenario Grand Total	299	323	321	662	660	759	769
Incremental Onsite Fuel (million 2010 $)							
Industrial	98	105	103	206	201	230	224
Commercial/Institutional	23	26	27	63	68	80	90
Total	121	131	130	269	269	310	315
Calculated Averages (2010 $)							
Average Capital Cost $/kW	$1,198.12	$1,182.05	$1,213.72	$1,232.03	$798.08	$1,250.80	$803.11
Average Incentive Rate $/kW	$0.00	$6.03	$0.00	$679.95	$450.00	$676.03	$454.10
Equivalent Operating Incentive, $/kWh	$0.0000	$0.0001	$0.0000	$0.0118	$0.0079	$0.0118	$0.0081
Average Electric Cost Saved ($/kW)	$0.0794	$0.0795	$0.0799	$0.0800	$0.0802	$0.0805	$0.0810
Average Incremental Gas Cost ($/MMBtu)	$5.84	$5.84	$5.84	$5.84	$5.84	$5.84	$5.84
Average Incremental Heat Rate (Btu/kWh HHV)	5,500	5,516	5,545	5,571	5,605	5,629	5,680
Cumulative Market Penetration by Size and Year, MW							
50-500 kW	28.5	32.8	40.0	77.2	84.5	110.0	129.2
500kW-1,000kW	6.9	8.1	9.2	24.5	28.2	35.5	44.8
1-5 MW	71.7	82.6	93.0	206.2	226.7	282.2	309.6
5-20 MW	116.3	124.5	116.3	258.9	258.0	274.7	273.8
>20 MW	265.0	279.6	265.0	522.4	497.4	549.9	523.3
Total Market	488.4	527.5	523.5	1089.3	1094.8	1252.4	1280.7
CO2 Impact							
Avoided CO2 Emissions, Annual basis, thousand MT	1,738	1,871	1,843	3,793	3,755	4,292	4,295
Cumulative Avoided CO2 Emissions, thousand MT	23,095	24,779	24,206	50,373	49,493	56,448	55,999
Cum Incentive Cost for Cum MT CO2 Reduced		$0.13	$0.00	$14.70	$9.95	$14.86	$10.39
Average unit Emissions savings, lb/MWh	1018.5	1016.6	1013.2	1010.2	1006.2	1003.3	997.4

TABLE 7: 20-YEAR CHP MARKET PENETRATION SCENARIOS WITH EXPORT

CHP Measurement	Base	Loan Guar	PBR	AEC $10/MWh, 10 Years	$450/kW Capital Credit	Multiple Measures 1	Multiple Measures 2
Economic Potential, MW	1591	1693	1657	3084	3074	3417	3401
Cumulative Market Penetraiton (MW)							
Industrial	799	853	821	1,788	1,715	1,945	1,869
Commercial/Institutional	81	91	94	229	256	292	342
Total	880	945	916	2,017	1,971	2,237	2,211
Avoided Cooling	11	12	13	33	38	43	53
Scenario Grand Total	891	957	929	2,050	2,009	2,281	2,264
Delta CHP power		64	36	1,137	1,091	1,357	1,331
Delta with avoided cooling		66	38	1,159	1,118	1,390	1,373
Annual Electric Energy (Million kWh)							
Industrial	6,290	6,715	6,447	14,038	13,449	15,225	14,607
Commercial/Institutional	583	649	670	1,567	1,684	1,964	2,187
Total	6,873	7,364	7,117	15,605	15,133	17,189	16,794
Avoided Cooling	33	37	38	92	101	118	135
Scenario Grand Total	6,906	7,401	7,155	15,697	15,233	17,306	16,928
Annual Primary Electric Energy Use (billion Btu/year) - CHP Power	68,993	73,924	71,442	156,646	151,906	172,545	168,579
Annual Primary Electric Energy Use(billion Btu/year) - w avoided cooling	69,319	74,291	71,823	157,570	152,915	173,727	169,932
Incremental Onsite Fuel (billion Btu/year)							
Industrial	32,941	35,194	33,854	73,627	70,605	80,057	76,893
Commercial/Institutional	3,933	4,401	4,574	10,821	11,712	13,740	15,469
Total	36,874	39,595	38,428	84,448	82,317	93,797	92,362
Annual Primary Electric Energy Reduction (billion Btu/year) - CHP Power	32,119	34,329	33,013	72,198	69,589	78,748	76,217
Annual Primary Electric Energy Reduction (billion Btu/year) - w avoided co	32,446	34,696	33,395	73,122	70,598	79,929	77,570
Delta Annual Primary Savings (billion Btu/year) - CHP Power		2,209	894	40,079	37,469	46,629	44,097
Delta Annual Primary Savings (billion Btu/year) - w avoided cooling		2,250	949	40,676	38,152	47,484	45,124
Financial Impact							
Cumulative Investment (million 2010 $)	$999	$1,056	$1,050	$2,329	$1,413	$2,615	$1,583
Cumulative Capital Incentives (Million 2010 $)	$0	$5	$0	$0	$887	$13	$1,003
Annual Operating Incentives (Million 2010 $)	$0.0	$0.0	$0.0	$26.3	$0.0	$30.3	$0.0
Cumulative Operating Incentives (Million 2010$)	$0.0	$0.0	$0.0	$1,445.7	$0.0	$1,587.1	$0.0
State Leverage		197.0		2.6	2.6	2.6	2.6
Annual Electric Energy (Million 2010 $)							
Industrial	490	523	503	1,093	1,048	1,188	1,141
Commercial/Institutional	48	53	55	130	140	164	185
Total	537	576	558	1,223	1,188	1,352	1,326
Avoided Cooling	3	4	4	10	11	13	15
Scenario Grand Total	540	580	562	1,232	1,199	1,365	1,341
Incremental Onsite Fuel (million 2010 $)							
Industrial	192	205	198	430	412	467	449
Commercial/Institutional	23	26	27	63	68	80	90
Total	215	231	224	493	481	548	539
Calculated Averages (2010 $)							
Average Capital Cost $/kW	$1,134.96	$1,117.93	$1,146.32	$1,154.93	$716.75	$1,168.92	$715.77
Average Incentive Rate $/kW	$0.00	$5.70	$0.00	$716.81	$450.00	$715.29	$453.65
Equivalent Operating Incentive, $/kWh	$0.0000	$0.0001	$0.0000	$0.0121	$0.0077	$0.0122	$0.0078
Average Electric Cost Saved ($/kW)	$0.0783	$0.0784	$0.0786	$0.0785	$0.0787	$0.0789	$0.0792
Average Incremental Gas Cost ($/MMBtu)	$5.84	$5.84	$5.84	$5.84	$5.84	$5.84	$5.84
Average Incremental Heat Rate (Btu/kWh HHV)	5,340	5,350	5,371	5,380	5,404	5,420	5,456
Cumulative Market Penetration by Size and Year, MW							
50-500 kW	28.5	32.8	40.0	77.2	84.5	110.0	129.2
500kW-1,000kW	6.9	8.1	9.2	24.5	28.2	35.5	44.8
1-5 MW	73.1	84.2	94.8	216.7	237.6	296.6	324.5
5-20 MW	138.1	148.0	138.1	332.0	330.1	353.0	351.1
>20 MW	633.6	671.4	633.6	1,366.5	1,290.6	1,442.3	1,361.5
Total Market	880.2	944.5	915.7	2016.9	1971.0	2237.5	2211.1
CO2 Impact							
Avoided CO2 Emissions, Annual basis, thousand MT	3,249	3,478	3,354	7,352	7,115	8,069	7,860
Cumulative Avoided CO2 Emissions, thousand MT	44,325	47,399	45,445	101,698	97,857	110,933	107,335
Cum Incentive Cost for Cum MT CO2 Reduced		$0.11	$0.00	$14.22	$9.06	$14.31	$9.35
Average unit Emissions savings, lb/MWh	1037.2	1036.0	1033.6	1032.5	1029.7	1027.8	1023.6

7. MODELED TECHNICAL POTENTIAL FOR CHP

The CHP technical potential is an estimation of market size constrained only by technological limits – the ability of CHP technologies to fit customer energy needs. CHP technical potential is calculated in terms of CHP electrical capacity that could be installed at existing and new industrial and commercial facilities based on the estimated electric and thermal needs of the site as described in Section 4 above.

Figure 15 summarizes the technical potential for additional CHP in the state by market segment. The estimate includes both additional CHP (including CCHP) potential at existing businesses and CHP potential from the expected growth in new facilities over the next 10 years. The export market potential is composed solely of industrial sites that have large thermal loads. No CHP export potential was assumed to come from commercial or institutional facilities. The total technical potential is close to 11,000 MW. Most of this potential is in industrial and commercial facilities that exist today; only a small portion is due to the growth in new businesses.

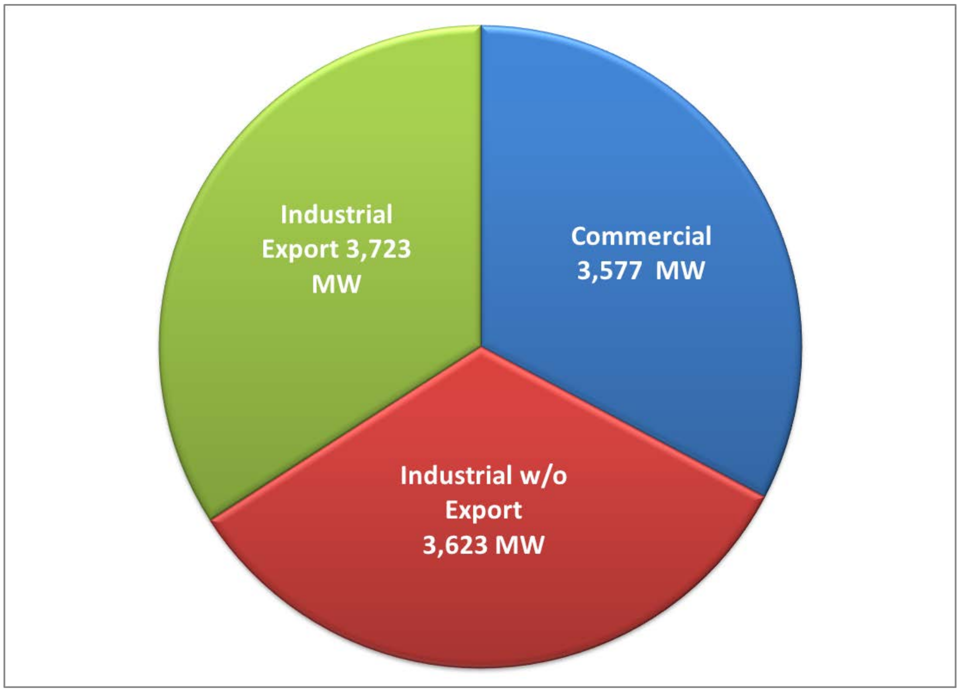


FIGURE 15: TECHNICAL PENNSYLVANIA CHP MARKET POTENTIAL IN MW BY APPLICATION

The technical potential derived by ICF is based on EIA data updated with Hoover's data together with input from the MA-CEAC. Tables 8, 9 and 10 provide a breakout of the technical market potential for commercial, industrial and export by standard industrial classification (SIC) code. Multi-family buildings are incorporated in the Commercial Potential table below.

TABLE 8: TECHNICAL MARKET POTENTIAL FOR COMMERCIAL CHP

SIC	Application	50-500 kW Sites	50-500 kW MW	500-1 MW Sites	500-1 MW (MW)	1-5 MW Sites	1-5 MW (MW)	5-20 MW Sites	5-20 MW (MW)	>20 MW Sites	>20 MW (MW)	Total Sites	Total MW
6512	Commercial Buildings	2,316	347.4	1,158	694.8	463	555.6	0	0.0	0	0.0	3,937	1,597.8
5411	Food Stores	944	122.6	15	9.9	3	5.3	0	0.0	0	0.0	962	137.7
52	Retail	877	139.4	30	19.2	10	17.7	0	0.0	0	0.0	917	176.3
8211	Schools	889	79.1	5	3.2	0	0.0	0	0.0	0	0.0	894	82.3
7011	Hotels	573	78.9	39	23.2	25	37.6	1	6.3	0	0.0	638	146.0
8051	Nursing Homes	599	104.2	19	12.3	11	16.1	1	7.3	0	0.0	630	139.9
9100	Government Buildings	568	75.6	30	20.9	27	51.1	4	42.4	1	21.0	630	211.0
6513	Multifamily Buildings	416	62.3	151	90.4	23	28.1	0	0.0	0	0.0	590	180.8
5812	Restaurants	429	32.5	1	0.9	0	0.0	0	0.0	0	0.0	430	33.4
8062	Hospitals	132	27.3	39	27.7	98	209.9	9	56.8	0	0.0	278	321.7
7997	Golf/Country Clubs	243	31.1	3	1.8	1	1.2	0	0.0	0	0.0	247	34.1
8221	College/Univ	115	22.8	23	14.5	31	48.7	6	67.2	1	61.0	176	214.2
7374	Data Centers	103	16.0	10	6.6	10	18.2	1	10.1	0	0.0	124	50.9
4952	Water Treatment	97	11.1	3	2.3	1	1.1	0	0.0	0	0.0	101	14.5
9223	Prisons	46	8.5	13	10.1	23	60.4	7	42.4	2	73.3	91	194.7
7991	Health Clubs	82	9.7	0	0.0	0	0.0	0	0.0	0	0.0	82	9.7
7211	Laundries	39	6.7	5	3.1	0	0.0	0	0.0	0	0.0	44	9.8
7542	Car Washes	37	2.7	2	1.4	0	0.0	0	0.0	0	0.0	39	4.1
4222	Refridgerated Warehouses	30	3.7	5	3.6	1	1.3	0	0.0	0	0.0	36	8.6
8412	Museums	27	3.5	1	0.8	1	1.3	0	0.0	0	0.0	29	5.6
43	Post Offices	24	2.9	1	0.5	0	0.0	0	0.0	0	0.0	25	3.4
4581	Airports	7	0.7	0	0.0	0	0.0	0	0.0	0	0.0	7	0.7
7832	Movie Theaters	2	0.1	0	0.0	0	0.0	0	0.0	0	0.0	2	0.1
Total		**8,595**	**1,189.0**	**1,553**	**947.2**	**728**	**1,053.3**	**29**	**232.5**	**4**	**155.2**	**10,909**	**3,577.2**

TABLE 9: TECHNICAL MARKET POTENTIAL FOR INDUSTRIAL CHP

SIC	Application	50-500 kW Sites	50-500 kW MW	500-1 MW Sites	500-1 MW (MW)	1-5 MW Sites	1-5 MW (MW)	5-20 MW Sites	5-20 MW (MW)	>20 MW Sites	>20 MW (MW)	Total Sites	Total MW
20	Food	425	72.0	66	47.5	84	175.1	10	67.0	0	0.0	585	361.6
28	Chemicals	244	46.5	63	45.7	127	298.7	52	489.0	14	1,142.5	500	2,022.4
24	Lumber and Wood	357	50.1	19	14.5	9	22.4	2	14.6	0	0.0	387	101.7
30	Rubber/Misc Plastics	247	39.6	19	12.2	12	19.8	1	13.1	0	0.0	279	84.7
26	Paper	160	32.4	43	30.1	36	72.1	17	176.1	3	106.2	259	416.9
33	Primary Metals	77	16.7	17	12.5	21	58.3	13	129.6	8	189.7	136	406.8
22	Textiles	100	16.9	13	9.7	10	15.8	0	0.0	0	0.0	123	42.4
29	Petroleum Refining	61	10.1	12	8.7	18	41.4	1	10.2	1	30.5	93	101.0
37	Trasportation Equip.	61	11.1	8	5.9	6	10.5	0	0.0	0	0.0	75	27.5
34	Fabricated Metals	73	9.1	2	1.1	0	0.0	0	0.0	0	0.0	75	10.1
27	Printing	45	6.4	3	1.7	1	1.6	0	0.0	0	0.0	49	9.7
39	Misc. Manufacturing	24	2.2	2	1.3	1	4.0	2	17.7	0	0.0	29	25.3
38	Instruments	10	1.2	2	1.5	0	0.0	0	0.0	0	0.0	12	2.7
32	Stone/Clay/Glass	3	1.0	4	3.3	1	2.1	0	0.0	0	0.0	8	6.4
25	Furniture	7	0.9	1	0.6	0	0.0	0	0.0	0	0.0	8	1.4
35	Machinery/Computer Equip	4	0.7	2	1.5	0	0.0	0	0.0	0	0.0	6	2.2
	Total	**1,898**	**316.7**	**276**	**197.8**	**326**	**722.0**	**98**	**917.4**	**26**	**1,468.9**	**2,624**	**3,622.8**

TABLE 10: TECHNICAL MARKET POTENTIAL FOR EXPORT CHP

SIC	Application	50-500 kW Sites	50-500 kW MW	500-1 MW Sites	500-1 MW (MW)	1-5 MW Sites	1-5 MW (MW)	5-20 MW Sites	5-20 MW (MW)	>20 MW Sites	>20 MW (MW)	Total Sites	Total MW
20	Food	425	72.0	66	47.5	82	182.3	11	103.3	1	20.3	585	425.4
22	Textiles	100	16.9	13	9.7	10	15.8	0	0.0	0	0.0	123	42.4
24	Lumber and Wood	357	50.1	19	14.5	3	12.6	6	48.3	2	61.1	387	186.7
25	Furniture	7	0.9	1	0.6	0	0.0	0	0.0	0	0.0	8	1.4
26	Paper	160	32.4	43	30.1	21	70.9	17	138.3	20	1,346.5	261	1,618.3
27	Printing	45	6.4	3	1.7	1	1.6	0	0.0	0	0.0	49	9.7
28	Chemicals	244	46.5	62	45.1	109	274.8	55	633.3	30	3,167.9	500	4,167.5
29	Petroleum Refining	61	10.1	12	8.7	6	20.7	12	87.5	2	181.6	93	308.7
30	Rubber/Misc Plastics	247	39.6	19	12.2	12	19.8	1	13.1	0	0.0	279	84.7
32	Stone/Clay/Glass	3	1.0	4	3.3	1	2.1	0	0.0	0	0.0	8	6.4
33	Primary Metals	77	16.7	17	12.5	21	58.3	13	129.6	8	189.7	136	406.8
34	Fabricated Metals	73	9.1	2	1.1	0	0.0	0	0.0	0	0.0	75	10.1
35	Machinery/Computer Equip	4	0.7	2	1.5	0	0.0	0	0.0	0	0.0	6	2.2
37	Trasportation Equip.	61	11.1	8	5.9	6	10.5	0	0.0	0	0.0	75	27.5
38	Instruments	10	1.2	2	1.5	0	0.0	0	0.0	0	0.0	12	2.7
39	Misc. Manufacturing	24	2.2	2	1.3	0	0.0	2	17.5	1	24.4	29	45.4
	Total	**1,898**	**316.7**	**275**	**197.2**	**272**	**669.4**	**117**	**1,171.1**	**64**	**4,991.6**	**2,626**	**7,345.9**

8. MARKET ANALYSIS UNDER ALTERNATIVE SCENARIOS

Figures 16 and 17 show the theoretical cumulative market penetration over the 20-year review period. In order to achieve the benefits of CHP it will be necessary for the state to support CHP implementation as well as address existing barriers. This will not only improve the adoption of CHP over the base case but also allow realization of the base case itself. The study assessed seven state-based CHP incentive and/or regulatory changes that would significantly increase CHP installations in the State of Pennsylvania. These 10 year cumulative changes are summarized as follows:

- **Capital Grant Program:** Pennsylvania has not supported a capital grant program in support of CHP systems. This type of program has been successful in establishing and grouping a CHP industry in other states like: New York, New Jersey, Connecticut and Massachusetts. These programs are generally funded with monies collected through dedicated funds such as a Societal Benefits Charge or other levy on electric rates and are paid to the developer of a CHP plant based on a dollar value per kW of plant capacity. The model assumed a $5 million cap on the capital reduction incentive and no limitation on installed capacity. The $450/kW case produces 839 MW[30] (1,617 MW[31]) increase in total market penetration in the first 10 years.
- **Alternative Energy Credit Program:** This program would add a Tier III to the current Pennsylvania Renewables Portfolio Standard covering high efficient clean power including CHP and waste heat-to-power that meet local air emissions regulations and meet a minimum annual efficiency requirement of 65%. The model assumed a $10/MW/hr credit paid over a seven year period. This case produces a 845 MW[30] (1,671 MW[31]) increase in total market penetration in the first 10 years
- **Loan Guarantee:** This policy addresses the lack of suitable long term financing for CHP development. While the loan guarantee essentially is a zero cost option for the government, it can have significant impact on assisting the development of CHP through long-term amortization of development costs compared with the terms currently made available by commercial institutions. It also has some material effect on helping to reduce the cost of money. This case produces a 406 MW[30] (770 MW[31]) increase in total market penetration in the first 10 years.
- **Permit-by-Rule regulation:** Currently, CHP plants in Pennsylvania must undergo new source review. A long-term goal would be to create a Pennsylvania DEP "Permit by Rule" regulation that would apply to all CHP systems meeting the requisite EPA/DEP emissions requirements resulting in substantial time and applications cost savings. This case produces a 406 MW[30] (770 MW[31]) increase in total market penetration in the first 10 years.
- **The "Multi-Incentive 1" Case:** This scenario is based on combining the $10/MW/hr AEC program, loan guarantee program and permit-by-rule measures. Combining these measures produces a 960[30] MW (1,836 MW[31]) increase in total market penetration in the first 10 years.
- **The "Multi-Incentive 2" Case:** This scenario is based on combining the $450/kW capital reduction program, loan guarantee program and permit-by-rule measures. Combining these measures produces a 969[30] MW (1,796 MW[31]) increase in total market penetration in the first 10 years.
- **Export:** Export potential was developed based on power limited facilities. These facilities have large thermal loads that can be serviced by CHP systems; however, to meet these thermal loads, excess electricity must be generated.

[30] This figure includes additional avoided cooling MW savings but does not include export potential
[31] This figure includes additional avoided cooling MW savings and includes export potential

Figure 16 presents the time phased view of individual scenarios and Figure 17 focuses on the multiple measure cases.

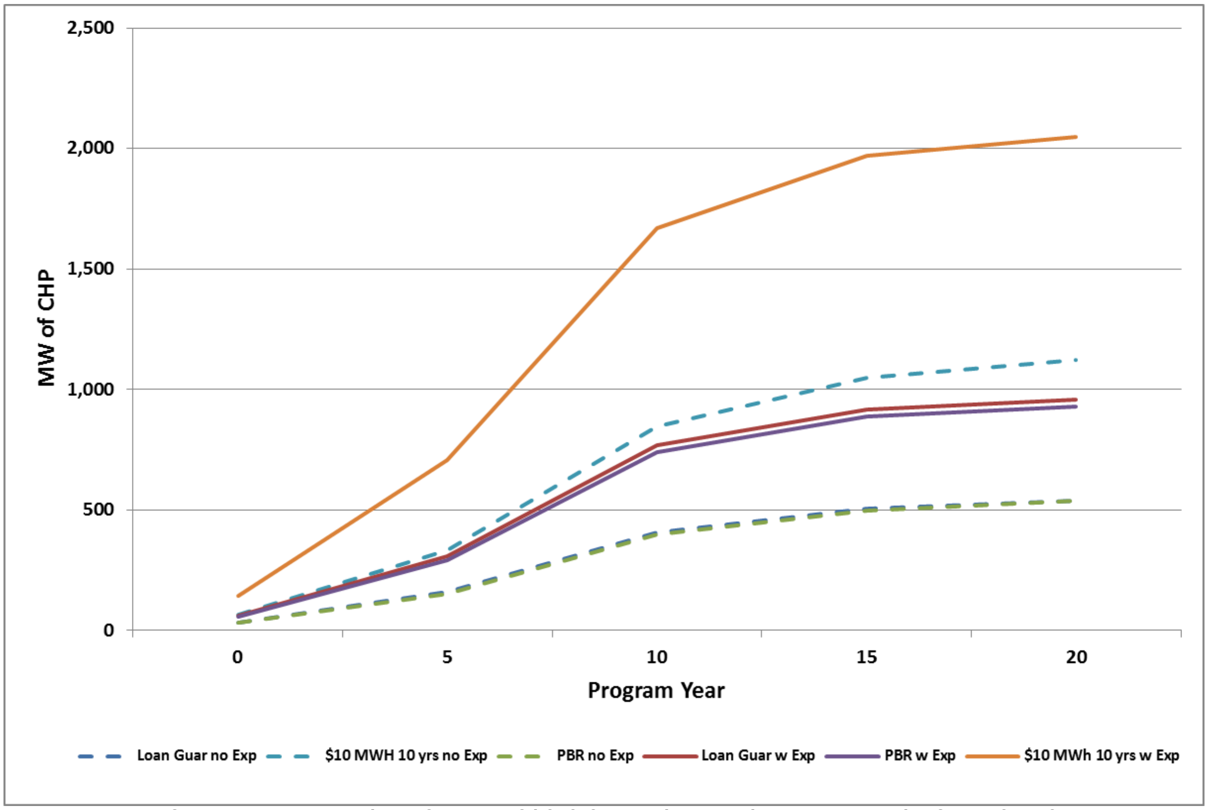


FIGURE 16: INDIVIDUAL INCENTIVE CASES CUMULATIVE MARKET PENETRATION RESULTS
Source: ICF CHP Market Model

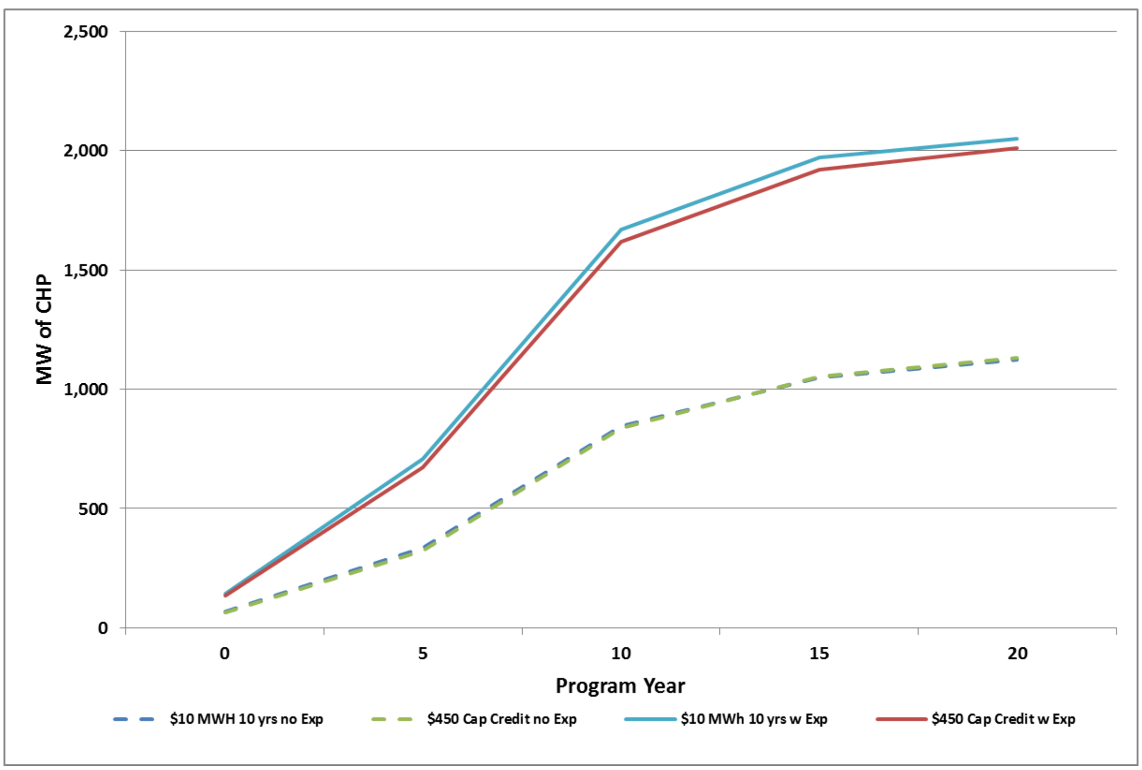


FIGURE 17: MULTIPLE INCENTIVE CASES CUMULATIVE MARKET PENETRATION RESULTS
Source: ICF CHP Market Model

9. CONCLUSIONS

The principle reason to consider providing policies and incentives supporting CHP in Pennsylvania is that it is the lowest cost means of providing additional power generation.

The state of Pennsylvania historically is viewed as disinterested in implementing CHP as an electricity supply option which has naturally led to declining market and ultimately the current non-existent market for CHP[32]. While natural gas prices have dropped and are expected to remain low for the next 10 to 20 years[33], Pennsylvania has not developed the regulatory, policy or incentive environment to attract CHP investors and developers.

Several no-cost and low-cost state investment strategies have been explored in this report. Both capital reduction and alternative energy credit methods appear to be important factors in reducing investment risk to the point that will assure significant CHP investment is made by the private sector.

The societal benefits of CHP combined with the relatively low cost of power production should lead Pennsylvania policy makers to reconsider CHP as a natural clean energy complement to their solar and wind efforts.

[32] except for certain federal facilities seeking to meet federal mandates for energy efficiency or GHG targets or to provide site energy security
[33] based on recent shale gas projections in the region

APPENDIX A: BACKGROUND DATA FOR FIGURE 1

CHP Cost to Generate Power Estimator	Small CHP
Operating Assumptions	
CHP Electric Efficiency, %	28.4%
CHP Power to Heat Ratio	0.56
CHP Fuel, Btu/kWh	12,014
CHP Thermal Output, Btu/kWh	6,093
CHP Efficiency	79.1%
Displaced Boiler Efficiency	80.0%
CHP Thermal Utilization, %	80.0%
Incremental CHP O&M Costs, $/kWh	$0.0250
CHP Fuel Cost, $/MMBtu	$6.15
Displaced Boiler Fuel Cost, $/MMBtu	$6.15
Operating Cost to Generate	
CHP Fuel Costs, $/kWh	$0.0739
Thermal Credit, $/kWh	($0.0375)
Incremental O&M, $/kWh	$0.0250
Operating Costs to Generate Power, $/kWh	***$0.0614***
Capital Cost	
Installed CHP System Cost, $/kW	$2,500
Operating Hours	5,500
Equipment Life, Yrs	15
Cost of Capital, %	10.0%
Capital Charge, $/kWh	$0.0598
Total Costs to Generate Power, $/kWh	***$0.1212***

CHP Cost to Generate Power Estimator	Mediun CHP
Operating Assumptions	
CHP Electric Efficiency, %	36.0%
CHP Power to Heat Ratio	0.97
CHP Fuel, Btu/kWh	9,478
CHP Thermal Output, Btu/kWh	3,518
CHP Efficiency	73.1%
Displaced Boiler Efficiency	80.0%
CHP Thermal Utilization, %	80.0%
Incremental CHP O&M Costs, $/kWh	$0.0150
CHP Fuel Cost, $/MMBtu	$5.80
Displaced Boiler Fuel Cost, $/MMBtu	$5.80
Operating Cost to Generate	
CHP Fuel Costs, $/kWh	$0.0550
Thermal Credit, $/kWh	($0.0204)
Incremental O&M, $/kWh	$0.0150
Operating Costs to Generate Power, $/kWh	***$0.0496***
Capital Cost	
Installed CHP System Cost, $/kW	$1,600
Operating Hours	7,000
Equipment Life, Yrs	15
Cost of Capital, %	10.0%
Capital Charge, $/kWh	$0.0301
Total Costs to Generate Power, $/kWh	***$0.0796***

CHP Cost to Generate Power Estimator	Large CHP
Operating Assumptions	
CHP Electric Efficiency, %	36.0%
CHP Power to Heat Ratio	0.97
CHP Fuel, Btu/kWh	9,478
CHP Thermal Output, Btu/kWh	3,518
CHP Efficiency	73.1%
Displaced Boiler Efficiency	80.0%
CHP Thermal Utilization, %	80.0%
Incremental CHP O&M Costs, $/kWh	$0.0100
CHP Fuel Cost, $/MMBtu	$5.80
Displaced Boiler Fuel Cost, $/MMBtu	$5.80
Operating Cost to Generate	
CHP Fuel Costs, $/kWh	$0.0550
Thermal Credit, $/kWh	($0.0204)
Incremental O&M, $/kWh	$0.0100
Operating Costs to Generate Power, $/kWh	***$0.0446***
Capital Cost	
Installed CHP System Cost, $/kW	$1,243
Operating Hours	8,000
Equipment Life, Yrs	15
Cost of Capital, %	10.0%
Capital Charge, $/kWh	$0.0204
Total Costs to Generate Power, $/kWh	***$0.0650***

Central Station Cost to Generate Power Estimator - Natural Gas CC	
Operating Assumptions	
Electric Efficiency, %	47.0%
Fuel, Btu/kWh	7,260
Variable O&M Costs, $/kWh	$0.0021
Fixed O&M Costs, $/kW	$12.76
Fuel Cost, $/MMBtu	$5.29
Operating Cost to Generate	
Fuel Costs, $/kWh	$0.0384
Variable O&M Costs, $/kWh	$0.0021
Fixed O&M, $/kWh	$0.0036
Operating Costs to Generate Power, $/kWh	***$0.0441***
Capital Cost	
Installed Cost, $/kW	$984
Operating Hours	3,565
Equipment Life, Yrs	30
Cost of Capital, %	8.5%
Capital Charge, $/kWh	$0.0257
Total Costs to Generate Power, $/kWh	***$0.0698***

APPENDIX B: GREEN WORKS GRANTS

Bradford: Craftmasters -- $1,358,869 to install and operate a back-pressure steam turbine that would use existing excess steam to generate up to 1,000 kilowatts of electricity. The electricity produced would offset current electrical consumption.

Cumberland: East Pennsboro Township -- $500,000 to purchase and install equipment to recover and use excess biogas from an existing anaerobic digester at a wastewater treatment plant and convert it to electrical power and heat. Digester gas is currently wasted.

McKean: American Refining Group Inc. -- $831,072 to install a steam turbine and an 875 kilowatt generator to produce electricity from existing high pressure steam while still using low pressure steam.

Lancaster: Mount Joy Wire Corporation -- $1,181,250 to purchase and install a 1 megawatt microturbine combined heat and power system to provide nearly all of its manufacturing process energy requirements.

Lycoming: Susquehanna Health -- $1,500,000 to install a new primary heat source at the Divine Providence Hospital. The project includes a 3.1 megawatt cogeneration unit with a reciprocating natural gas engine, backup boilers and chiller.

Montgomery: Abington Memorial Hospital -- $3,000,000 for the installation of a 4.5 megawatt natural gas-fired combustion turbine that will produce steam as a byproduct and serve approximately 66 percent of its onsite electricity needs.

Montour: Geisinger Medical Center -- $2,250,000 to install and operate a 5 megawatt gas-fired turbine generator coupled with a waste heat-fired tube boiler. This project is anticipated to generate approximately 20,000 megawatt hours of electricity per year that will be used onsite. Geisinger predicts saving more than $1.4 million annually.

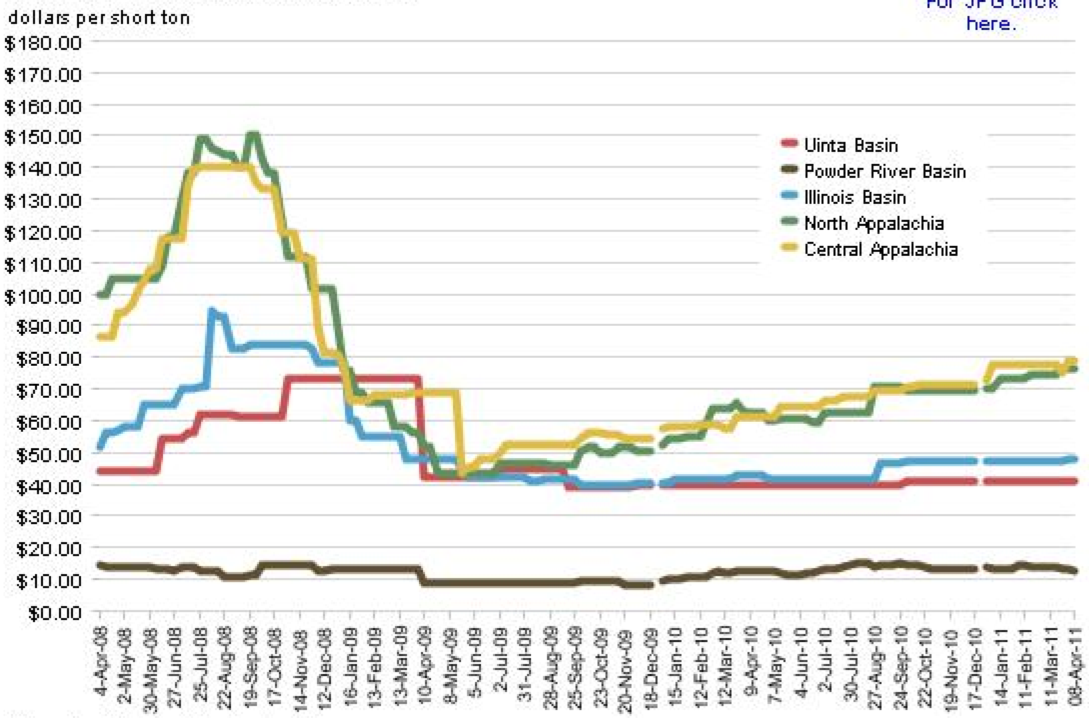
Philadelphia: AIMCO -- $1,087,100 for the installation of eight, 75 kilowatt natural gas-fired reciprocating engines that will provide space heat and hot water at four separate apartment buildings serving approximately 40 percent of the onsite electrical needs.

Philadelphia Gas Works -- $465,000 for the installation of a 300 kilowatt natural gas-fired microturbine and absorption chiller that will provide approximately 40 percent of the electrical needs and provide supplemental building heat and cooling.

APPENDIX C: COAL PRICING

Historical average weekly coal commodity spot prices
business week ended April 08, 2011

For JPG click here.



Key to Coal Commodities by Region'
Central Appalachia: Big Sandy/Kanawha 12,500 Btu, 1.2 lb SO2/mmBtu
Northern Appalachia: Pittsburgh Seam 13,000 Btu, <3.0 lb SO2/mmBtu
Illinois Basin: 11,800 Btu, 5.0 lb SO2/mmBtu
Powder River Basin: 8,800 Btu, 0.8 lb SO2/mmBtu
Uinta Basin in Colo.: 11,700 Btu, 0.8 lb SO2/mmBtu

1 Coal prices shown are for a relatively high-Btu coal selected in each region, for delivery in the "prompt quarter." The prompt quarter is the quarter following the current quarter. For example, from January through March, the 2nd quarter is the prompt quarter. Starting on April 1, July through September define the prompt quarter.
Source: With permission, selected from listed prices in Platts Coal Outlook, "Weekly Price Survey."
Note: The historical data file of spot prices is proprietary and cannot be released by EIA; see Coal News and Prices.