COMBINED HEAT AND POWER (CHP)
EN BANC HEARING
MAY 5, 2014,
DREXEL UNIVERSITY, PHILADELPHIA

Overview, Potential Applications & Economic Considerations

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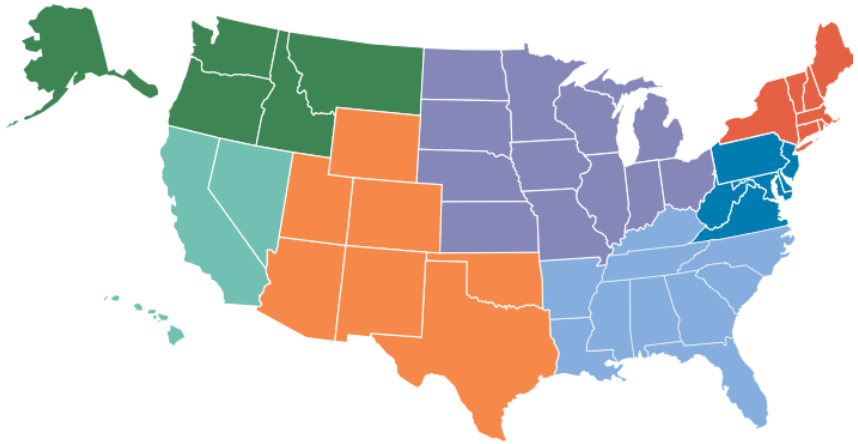
May 5, 2014

U.S. DEPARTMENT OF ENERGY
CHP Technical Assistance Partnerships
MID-ATLANTIC

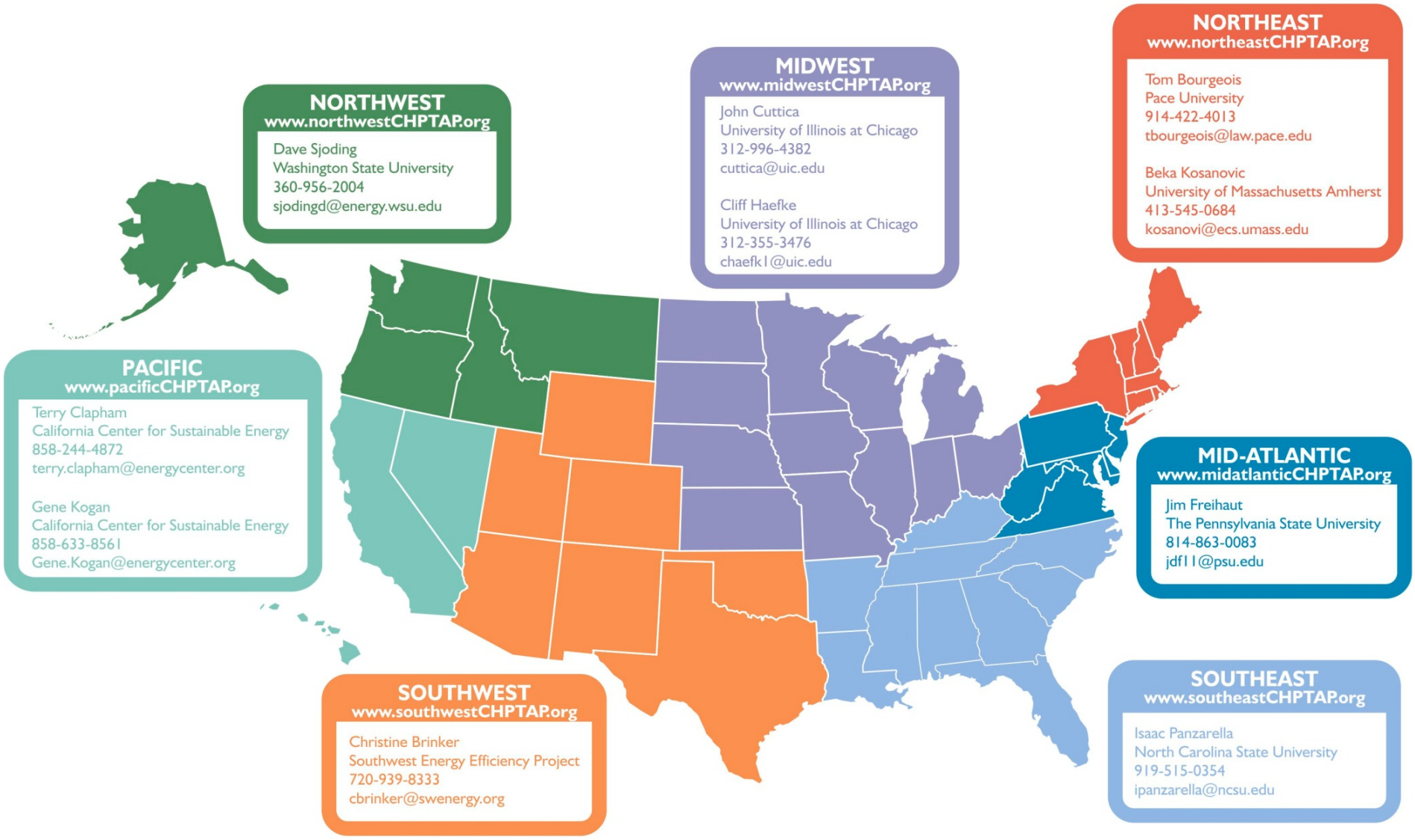
CHP Technical Assistance Partnerships

- Market Opportunity Analysis.
  Supporting analyses of CHP market opportunities in diverse markets including industrial, federal, institutional, and commercial sectors
- Education and Outreach.
  Providing information on the energy and non-energy benefits and applications of CHP to state and local policy makers, regulators, end users, trade associations, and others.
- Technical Assistance.
  Providing technical assistance to end-users and stakeholders to help them consider CHP, waste heat to power, and/or district energy with CHP in their facility and to help them through the development process from initial CHP screening to installation.



http://eere.energy.gov/manufacturing/distributedenergy/chptaps.html

DOE CHP Technical Assistance Partnerships (CHP TAPs)



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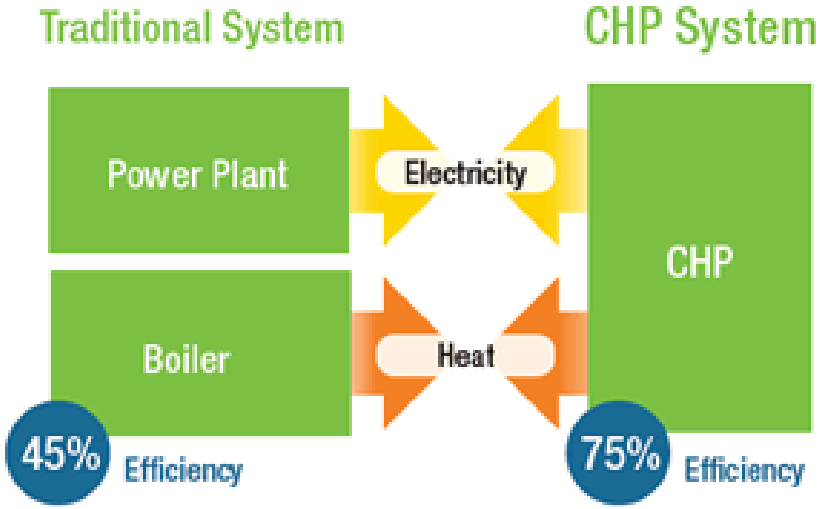
Agenda

- CHP Overview
- Potential Applications
- CHP Drivers & Considerations
- Mid-Atlantic CHP Update
- Impact of Wider Adoption in Pennsylvania

What is CHP

- Form of Distributed Generation (DG)
- An integrated system
- Located at or near a building / facility
- Provides at least a portion of the electrical load and
- Uses thermal energy for:
  - Space Heating / Cooling
  - Process Heating / Cooling
  - Refrigeration/Dehumidification

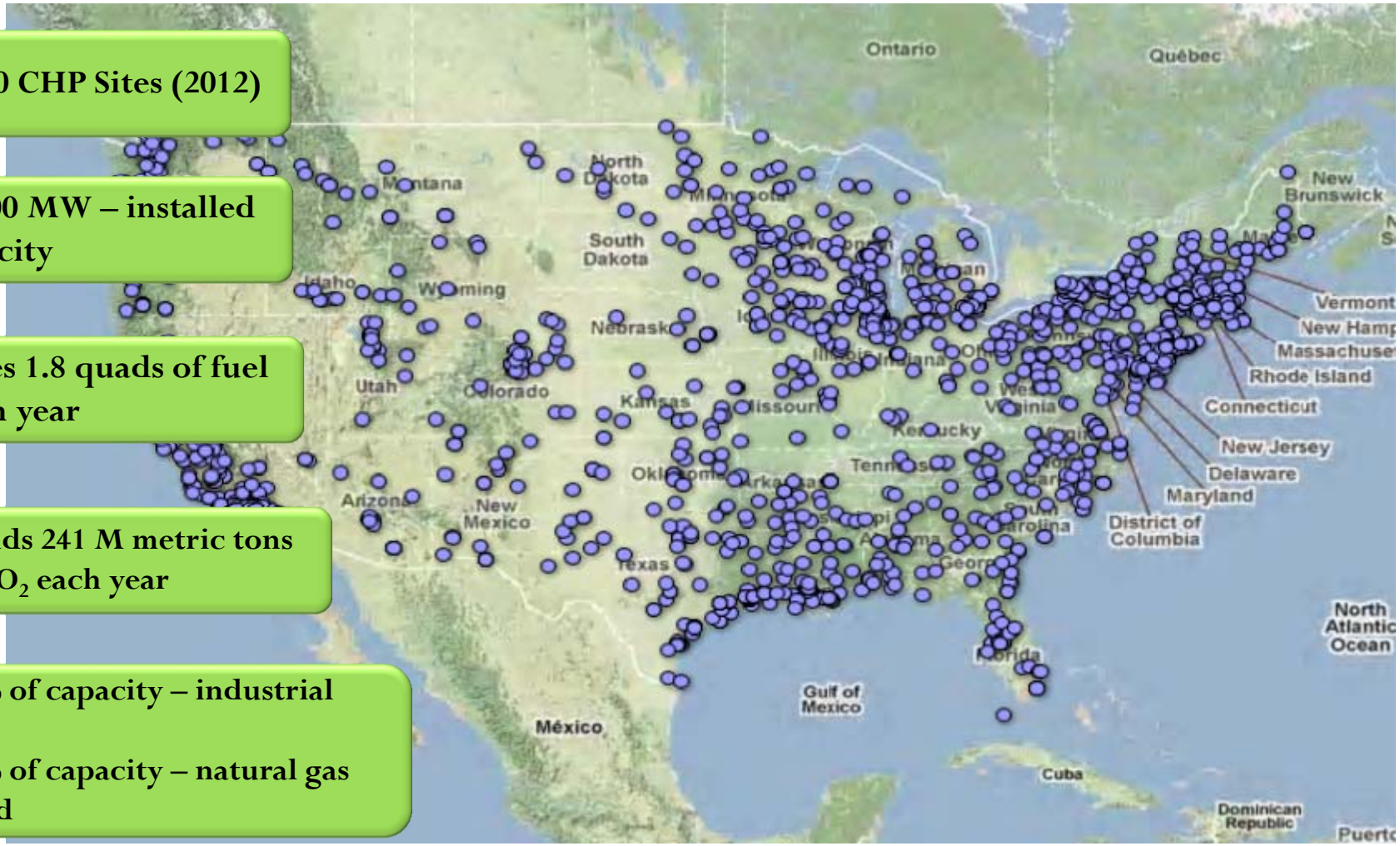


Source: http://www1.eere.energy.gov/manufacturing/distributedenergy/chp_basics.html

CHP provides cost-effective, clean and reliable energy – today and for the future.

CHP Is Used at the Point of Demand

- 4,200 CHP Sites (2012)
- 82,400 MW – installed capacity
- Saves 1.8 quads of fuel each year
- Avoids 241 M metric tons of CO_2 each year
- 87% of capacity – industrial
- 71% of capacity – natural gas fired



Source: ICF International

U.S. Department of Energy
CHP Technical Assistance Partnerships
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CHP Applications

- Industrial Process Integration, PA

- Adding second 50 MW CHP System for total installed capacity of 100 MW internal use only
- Total CHP plant will provide most of the plant's electric and thermal energy needs driven by local Shale Gas.

- Food Processing, CT

Food processing plant gets 100% of its power and 80% of its thermal energy from a 4.6 MW CHP plant with duct burner and HRSG.

CHP Applications

- University Campus, NJ

  - The 15 MW CHP plant provides steam and chilled water throughput the campus and is integrated with the wholesale and transmission markets.
  - Through the efficiency of CHP, Princeton has dramatically reduced its fuel use, avoiding over 27,900 metric tons of carbon emissions and making it one of the leading campus energy plants in the country in both efficiency and environmental sustainability

- Hospital, NY
  - 2 x 250 kW Reciprocating Engines
  - Designed to island from grid during outage
  - Provided 100% of electric and thermal needs for 15 days during and after Hurricane Sandy.

CHP Applications

- Office Building, CA
  - 1 MW Reciprocating Engine Plant with 320 Ton Chiller
  - Reduces grid peak loads with chiller output as well as generator output. Operates concurrent with grid load
  - Provides power, space heating and space cooling.

- Bank, NE
  - In order to assure the highest quality power, the bank installed four 200 kW Fuel Cells and operates with a 99.99999% reliability factor.
  - The waste heat is used to provide space heating and snow melting in winter and dehumidification in summer.

CHP Drivers

- Cost Savings #1

  Offset Utility/3rd Party kWh's + Therms
- Emissions Reductions

  Supported by US DOE & US EPA
- Reliability

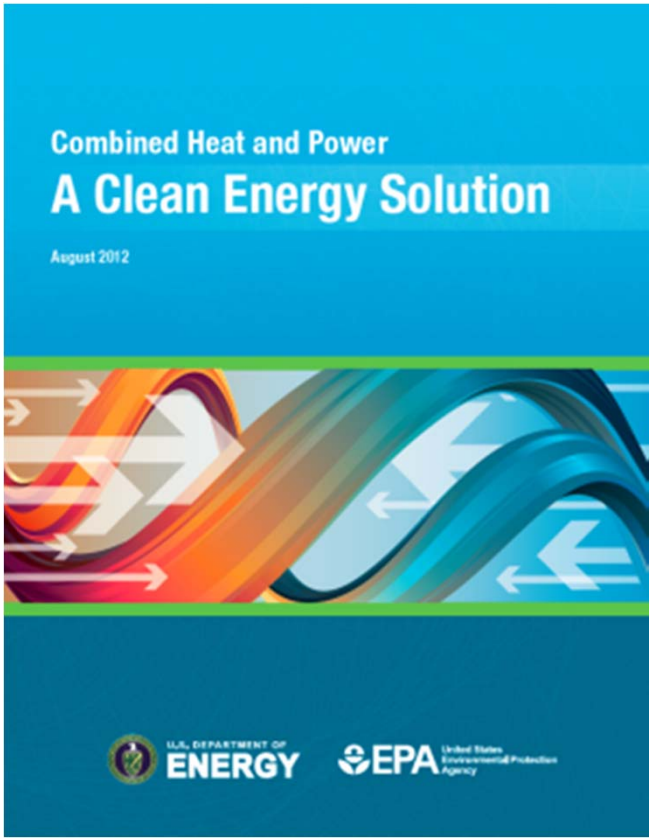
  Provides local grid support and improves power quality
- Resiliency

  CHP is emerging as a key tool in developing cost-effective Microgrids that improve energy resiliency and can provide emergency power back-up
- National Security

  Reduced fossil fuel usage extends US resources and multiple points of power generation are less subject to catastrophic failure or attack

CHP Drivers

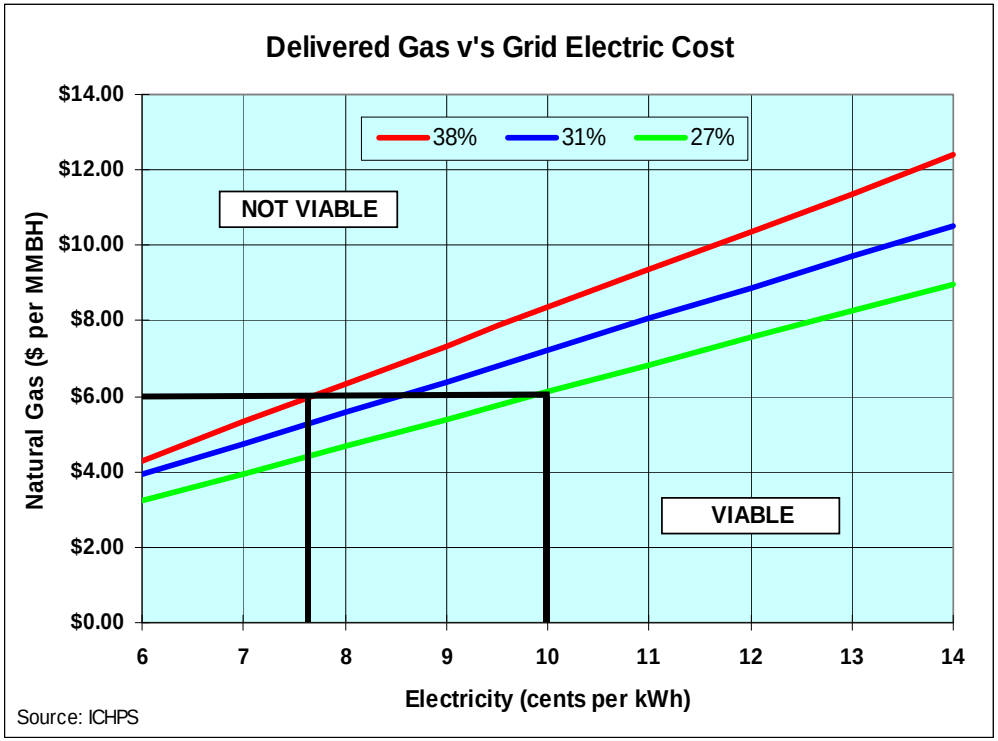
- Benefits of CHP recognized by policymakers
  - President Obama signed an Executive Order to accelerate investments in industrial EE and CHP on 8/30/12 that sets national goal of 40 GW of new CHP installation over the next decade
  - State Portfolio Standards (RPS, EEPS, Tax Incentives, Grants, standby rates, etc.)
- Favorable outlook for natural gas supply and price in North America
- Opportunities created by environmental drivers
- Energy resiliency and critical infrastructure



DOE / EPA CHP Report (8/2012)

Cost to Generate Power with CHP

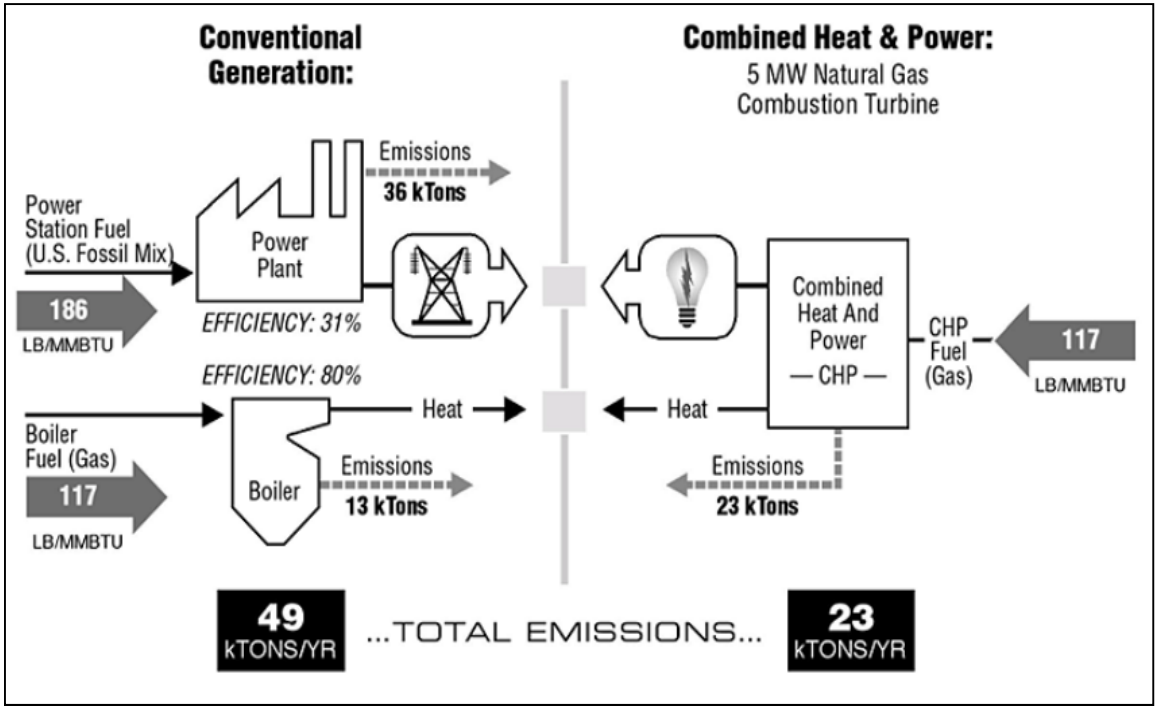
- At a natural gas cost of $6/MMBH, on-site generators will produce power at between 7½ and 10 cents/kWh*
- With high thermal load factor, CHP produces power at an effective 5½ to 7½ cents/kWh*
- Spark spread is required to overcome capital cost , load risks and make investment 'worthwhile' to owner



* Includes maintenance

Emissions

- CHP provides highly efficient use of clean fossil or renewable fuel.
- CHP reduces carbon emissions by over 50% versus PA grid power and natural gas boilers.



Source: EPA's Handbook of CHP Technologies

Emissions

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

Outputs are based on:

10 MW Gas Turbine CHP—28% electric efficiency, 68% total CHP efficiency, 15 ppm NOx emissions

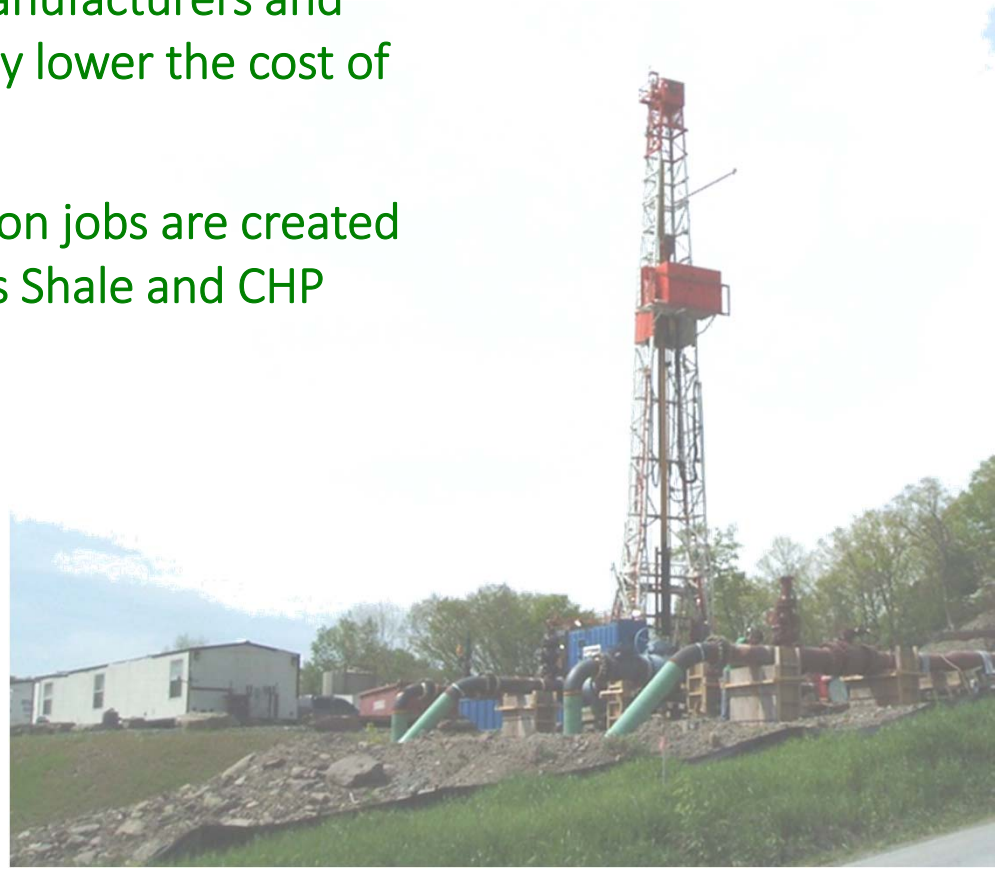
Capacity factors and capital costs for PV and Wind based on utility systems in DOE's Advanced Energy Outlook 2011 (AEO 2011)

Capital cost and efficiency for natural gas combined cycle system based on AEO 2011 (540MW system proportioned to 10 MW), NGCC 48% electric efficiency, NOx emissions 9 ppm

CHP, PV, Wind and NGCC electricity displaces National All Fossil Average Generation resources (eGRID 2012) - 9,572 Btu/kWh, 1,743 lbs CO_2/MWh, 1.5708 lbs NOx/MWh, 6.5% T&D losses; CHP thermal output displaces 80% efficient on-site natural gas boiler with 0.1 lb/MMBtu NOx emissions

Economic Development

- In-situ use of Marcellus Shale for combined heat and power generation allows manufacturers and large energy users to significantly lower the cost of energy
- New engineering and construction jobs are created in the development of Marcellus Shale and CHP plants
- Efficient use of Marcellus Shale Gas through CHP will provide a competitive advantage for existing and new energy intensive industries in Pennsylvania



Relative Value of Benefits

- Owner/Host Site Benefits
  - Cost Savings
  - Environmental Stewardship/Good PR
  - Power Quality/Availability
  - Reliability – Keep Operations Running

- Societal Benefits
  - Lower Energy & Infrastructure Costs
  - Emissions Reductions/Health Care Benefits
  - Increased Grid Reliability
  - Resource Extension/National Security
  - Job Creation/Retention
  - Underpin Expansion of NG Distribution Network

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Mid-Atlantic CHP Update and Impact of Wider CHP Adoption in Pennsylvania

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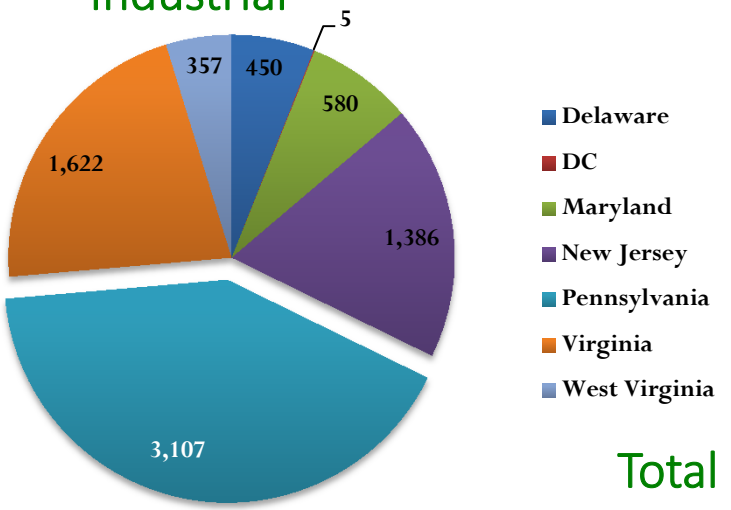
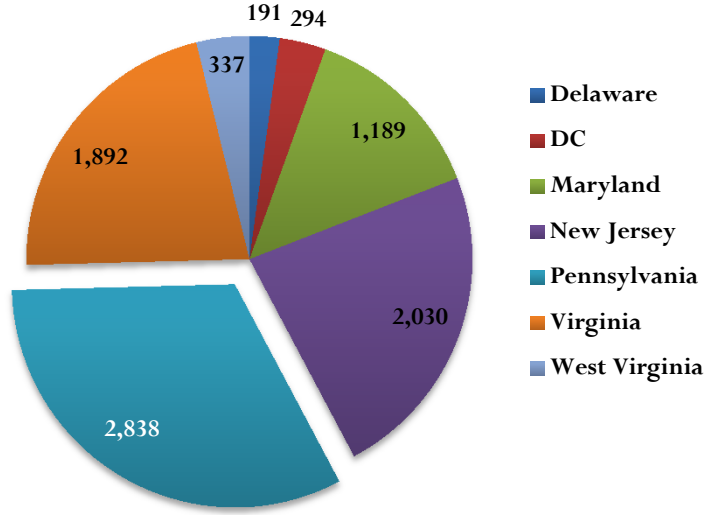
CHP Technical Potential

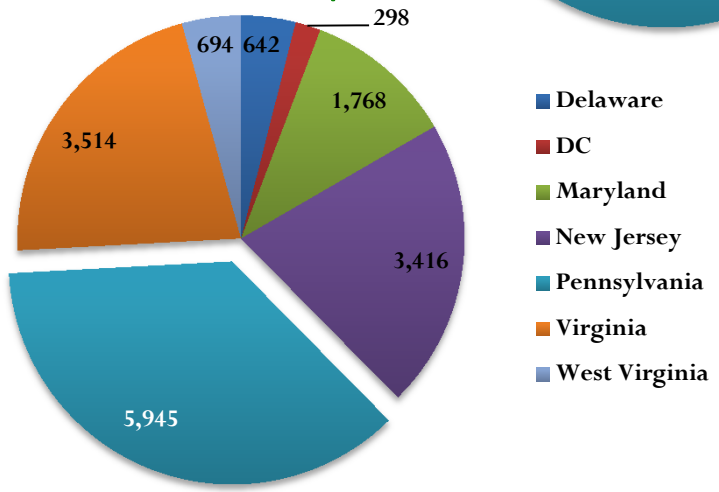
Industrial



Commercial

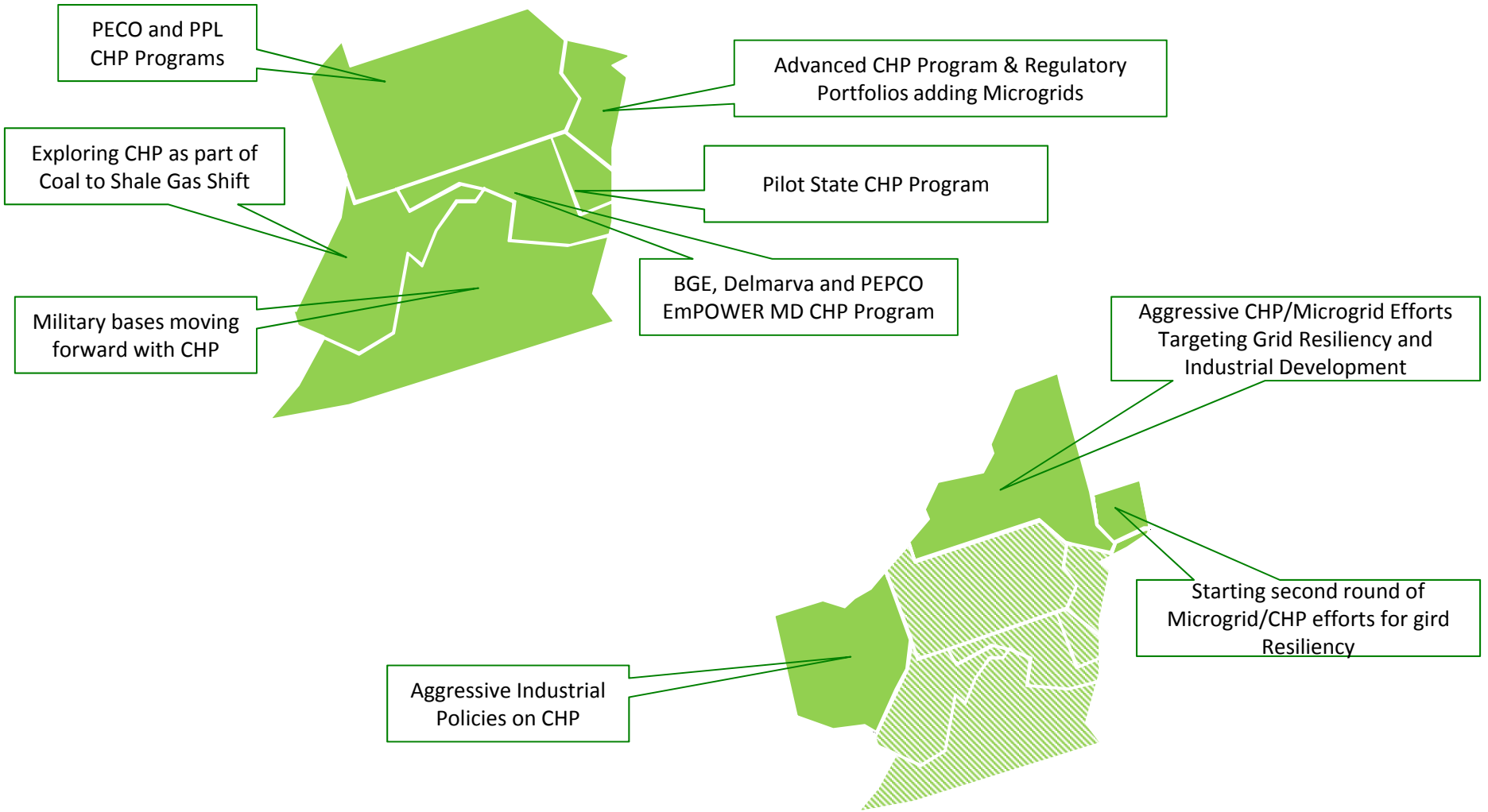


Total Non-Export



Source: ICF International

CHP Mid-Atlantic Update



New Jersey Programs and Regulations

- NJ BPU OCE CHP/Fuel Cell Grant Program
- NJ BPU 'REIP' Grant Program for Biofuelled CHP
- No SUT (7% sales tax) on Natural Gas for CHP
- Permit sales of electricity and thermal energy among non-affiliated entities for sale of electricity, the CHP plant must supply thermal to customer
- Air Permit-by-Rule adopted (up to ~ 5 MW)
- Utility Standby Rates currently under review
- NJ HUD Funded 'Energy Resiliency Bank'

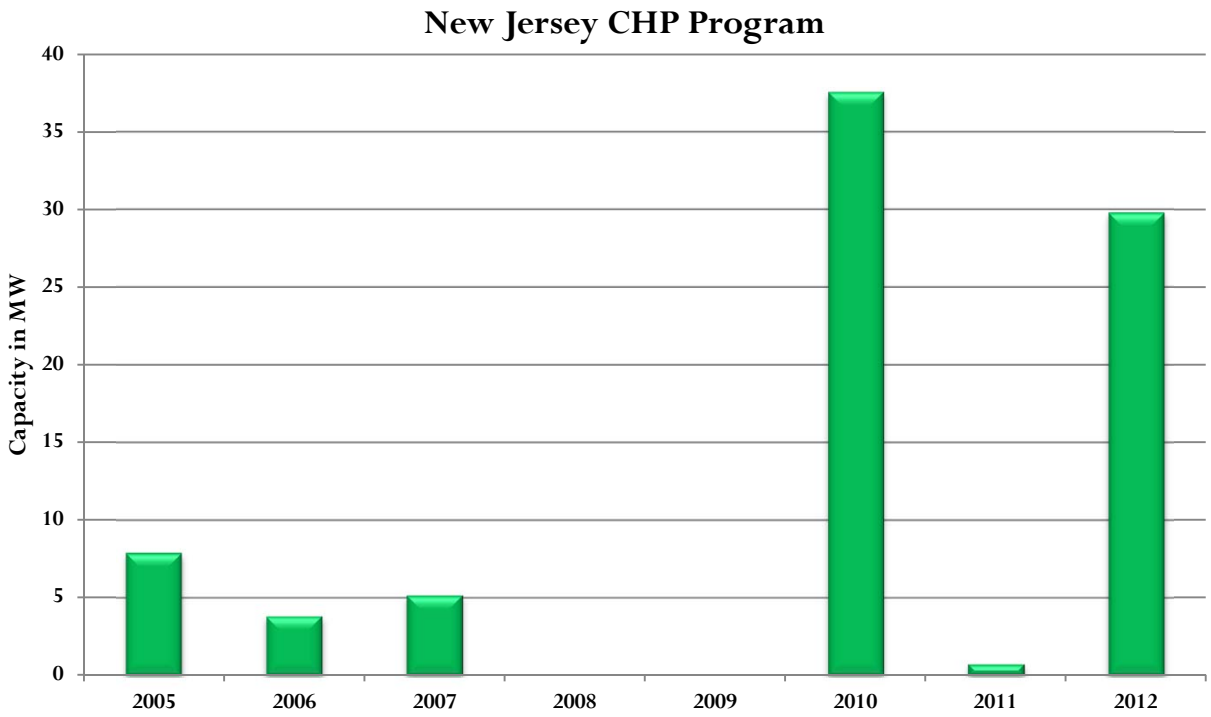
NJ BPU CHP/FC Grant Program

Eligible Technology	Size (Installed Rated Capacity)	Incentive ($/Watt)	P4P Bonus ($/Watt) (cap $250,000)	% of Total Cost Cap per project	$ Cap per project
Combined Heat & Power	≤500 kW	$2.00	$0.25	30-40%	$2 million
Powered by non-renewable fuel source					
Gas Internal Combustion Engine	>500 kW – 1 MW	$1.00			
Gas Combustion Turbine	>1 MW – 3 MW	$0.55		30%	$3 million
Microturbine	>3 MW	$0.35			
Fuel Cells	≤1 MW w/ waste heat	$4.00		60%	$2 million
Powered by non-renewable fuel source. Incentives available for systems both with and without waste heat recovery.	≤1 MW	$3.00			
	>1 MW w/ waste heat	$2.00		45%	$3 million
	>1 MW	$1.50			
Heat Recovery	≤1 MW	$1.00		30%	$2 million
Powered by non-renewable fuel source. Heat recovery or other mechanical recovery from existing equipment utilizing new electric generation equipment (e.g. steam turbine)	>1 MW	$0.50		30%	$3 million

http://www.njcleanenergy.com/commercial-industrial/programs/combined-heat-power/combined-heat-power-fuel-cells-incentives

New Jersey CHP Status

- During this period program consistency was and Issue
  - Inconsistent funding
  - Economic Turmoil
  - Program terminations and restarts



Source: NJ EDA, TRC and BPU

Maryland CHP Program

- CHP Program
  - Applications run through utilities $20MM in first round with additional $20MM approved
  - Provides incentives up to $2 million
  - Design incentive ($75/kW)
  - Installation incentive ($175/kW)
  - Design and Installation capped at $1 million
  - 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. (capped at $1 million)
- A minimum of 65% efficiency (Higher Heating Value) on an annual basis
- Must not export electricity to the grid
- Projects must be pre-approved by December 31, 2014
- All projects must be commissioned and operational by December 31, 2016

http://energy.maryland.gov/SEN/CHP.html)

BGE Results

- BGE initially received 16 proposals
  - CHP program in April 2012 and received Commission approval in June 2012
  - BGE ($10.3 million
  - Proposals were solicited through a RFP process with bids due in December 2012
  - 11 projects initially passed the technical and engineering reviews
  - Gas service upgrades were required on several projects but upgrade costs to customers have been minimum
  - In August 2013 received Commission approval to increase its CHP budget by $10.7 million and provide incentives for projects approved by BGE by 2014 and completed by 2016
  - Twelve (of 18) CHP proposals making progress towards implementation

http://www.aceee.org/files/pdf/conferences/mt/2014/C4-Wolf.pdf

Pennsylvania

- PA Act129 – see individual utilities for details
  - Mandates electric utilities reduce demand and throughput on their systems.
  - PECO prescriptive CHP program
  - CHP as custom measure for most other utilities

  www.puc.pa.gov/filing_resources/issues_laws_regulations/act_129_information.aspx

- Commonwealth Financing Authority (CFA)
  - The Alternative and Clean Energy Program (ACE) provides financial assistance in the form of grant and loan funds for the utilization, development and construction of alternative and clean energy projects in the state. The program is administered jointly by the Department of Community and Economic Development (DCED) and the Department of Environmental Protection (DEP), under the direction of the CFA.

  www.newpa.com/find-and-apply-for-funding/commonwealth-financing-authority

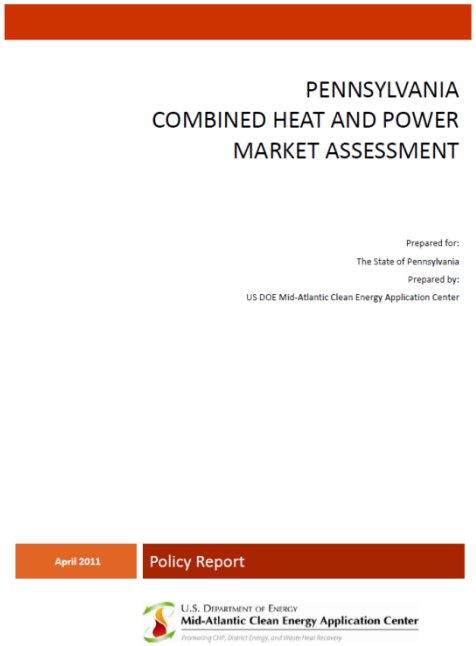
Lessons Learned

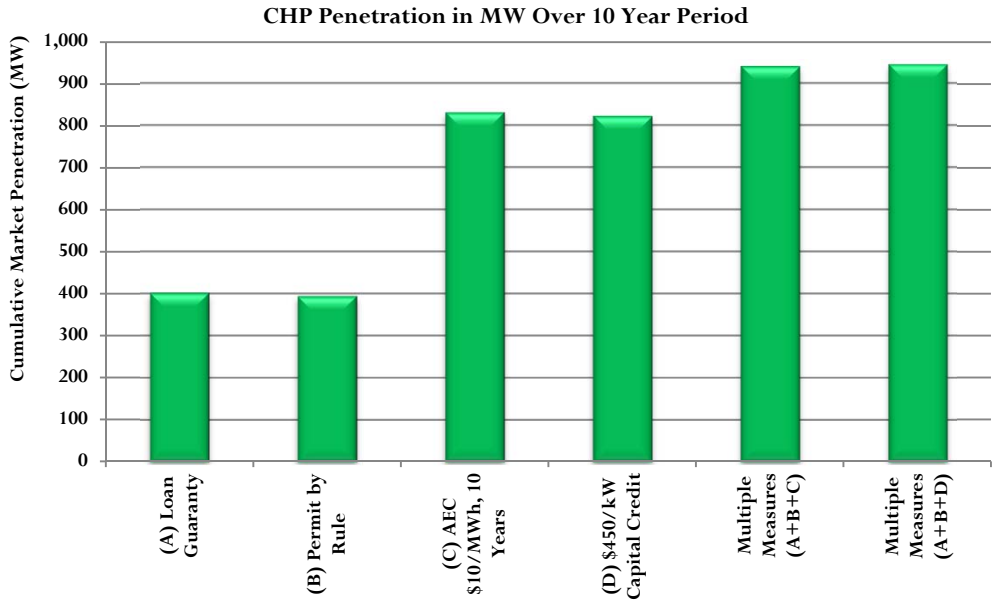
- Capital Investment Requirements and Load Risk
  - BGE and other experience shows incentives move the market typically require 30% CapX support
  - Smaller size (< 1 MW) CHP plants require higher incentives
  - CFA Grants have been available but not predictable
  - Act 129 EE measures can include CHP but not prescriptive like PV
  - Long-Term (multi year), Transparent & Consistent metrics
- Poor Recognition of 'Externalities' or Societal Benefits and Emissions
  - Cost/Benefit Analysis including Externalities (Societal Cost Test)
  - Better Outreach to all Stakeholders
  - Permit-by-Rule for CHP

Lessons Learned

- Electric Grid Interconnection, Standby Tariff and No Recognition by PJM as Capacity Resource
  - Expansion of existing Standard Interconnection to greater than 3 MW (Maryland is 10 MW)
  - Standby Tariff Review and Assessment
  - Need alignment of multiple state constituents on PJM issues
- Lack of CHP Industry Infrastructure
  - Long-term outlook is main industry consideration
  - Requires clear policy signals
  - Owner benefits alone are not sufficient
  - Developers and support industry need to see opportunity

Potential Future





This analysis identified the potential for 3,000 to 7,000 new jobs over ten years and retaining between 12,000 and 30,000 jobs. Subsequent to this report the significant development of Marcellus Shale gas adds a potential new and substantial economic development potential from CHP that need to be studied.

Marcellus Shale Gas Utilization & CHP

- Expanding the PA gas grid to deliver Marcellus Shale gas to the market, particularly PA residents, businesses and industry would benefit from CHP end-use.
- High load factor CHP can help to offset connection costs for low load factor applications such as residences and space conditioning only applications. Furthermore, connecting stranded communities to Marcellus gas could be justified and/or accelerated with CHP end-use. This not only allows local resources to be used but also increases local disposable income through reduction of energy bills.
- Combining low energy prices (Marcellus Shale Gas) with low operating cost (using CHP) will place Pennsylvania in a leading position to attract the next wave of petrochemical development in the US .

Chemical Industry, MS and CHP

Keeping Pennsylvania Competitive

- "Potential U.S. chemical industry investment linked to plentiful and affordable natural gas has topped $100 billion. These projects—new factories, expansions, and process changes to increase capacity—could lead to $81 billion per year in new chemical industry output and 637,000 permanent new jobs across the economy by 2023"

  http://www.americanchemistry.com/Policy/Energy/Shale-Gas

- "The American Chemistry Council welcomes today's Executive Order that recognizes the important contribution of CHP in improving energy efficiency and easing the major transition underway in America's electricity sector. The President's CHP goal is ambitious, and represents about a 50 percent increase in deployed CHP capacity. Expansion of CHP capacity can make American manufacturers more competitive in the global economy and can stretch our nation's natural gas supplies that benefit a wide variety of industries across the country."

  http://www.americanchemistry.com/Media/PressReleasesTranscripts/ACC-news-releases/ACC-Welcomes-White-House-Executive-Order-to-Boost-Industrial-Energy-Efficiency-and-CHP-Capacity.html

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