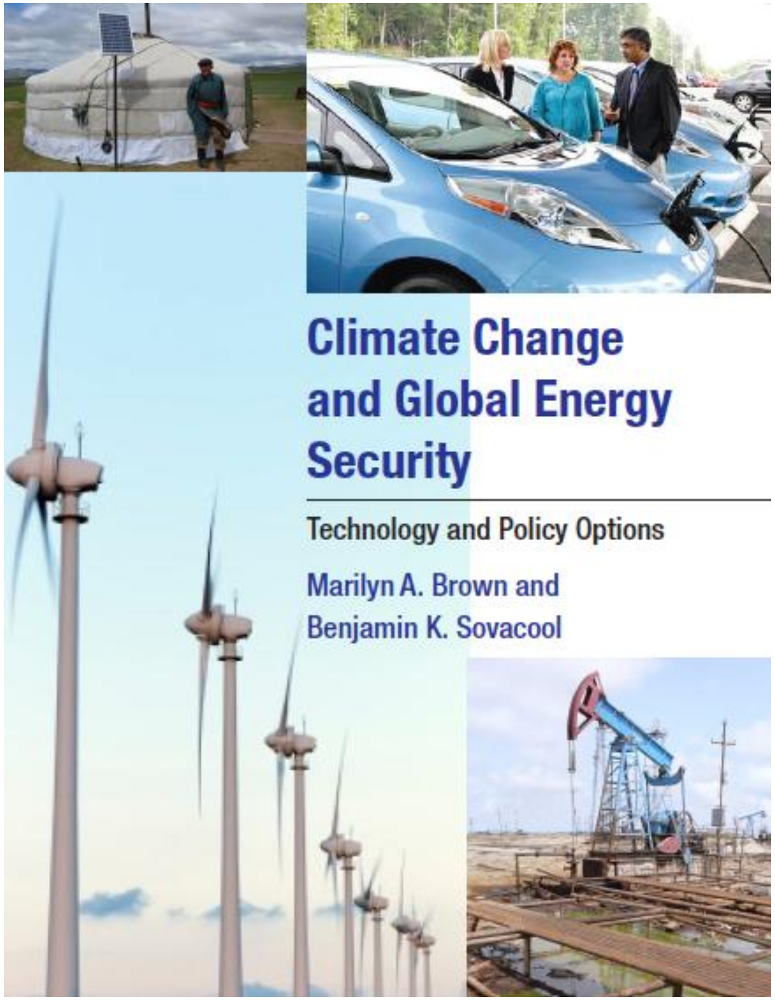
Evaluating a Federal Cogeneration Policy: Could It Strengthen U.S. Competitiveness and Generate Energy Jobs?



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U.S. Clean Heat & Power Association
Annual Meeting

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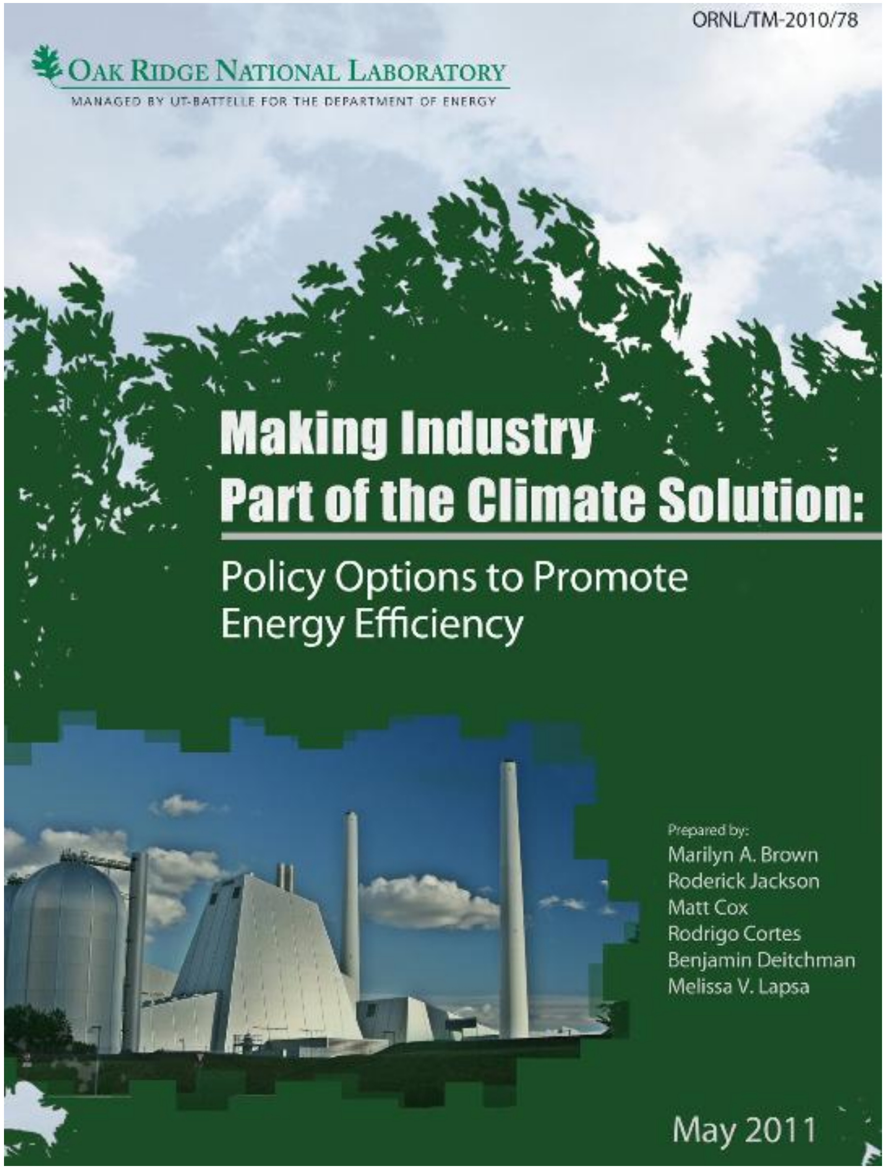
U.S. DEPARTMENT OF ENERGY
Georgia Tech College of Liberal Arts
OAK RIDGE NATIONAL LABORATORY
MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

RESEARCH QUESTION

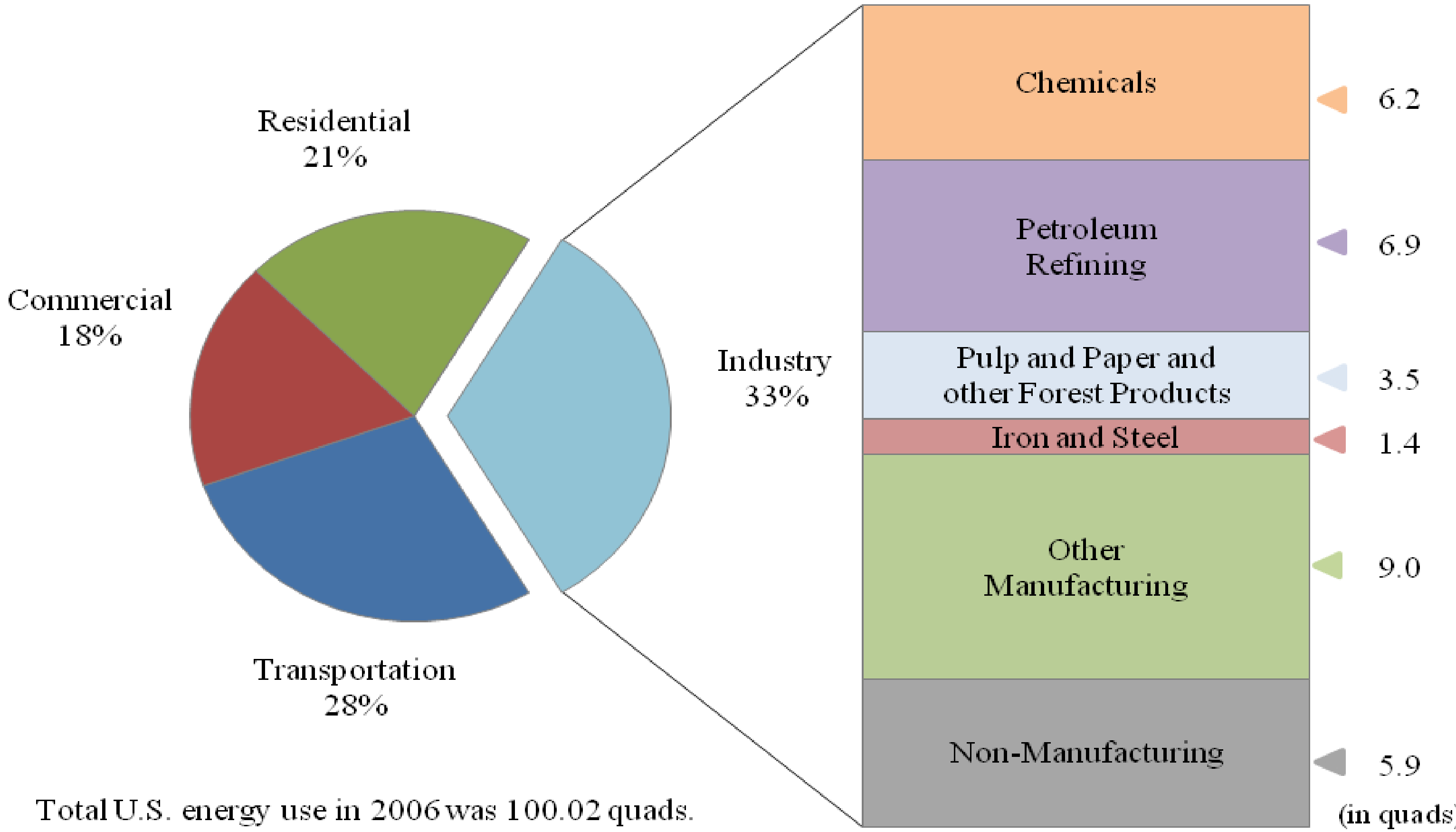
What Federal policies could motivate industrial enterprises to expand their investments in improving the energy efficiency of their facilities, processes, and practices?

http://www.ornl.gov/sci/eere/publications.shtml

Two notable recent events: a report by the President's Council on Science and Technology (PCAST, 2011) on *Ensuring American Leadership in Advanced Manufacturing,* and President Obama's announcement of an Advanced Manufacturing Program (AMP).

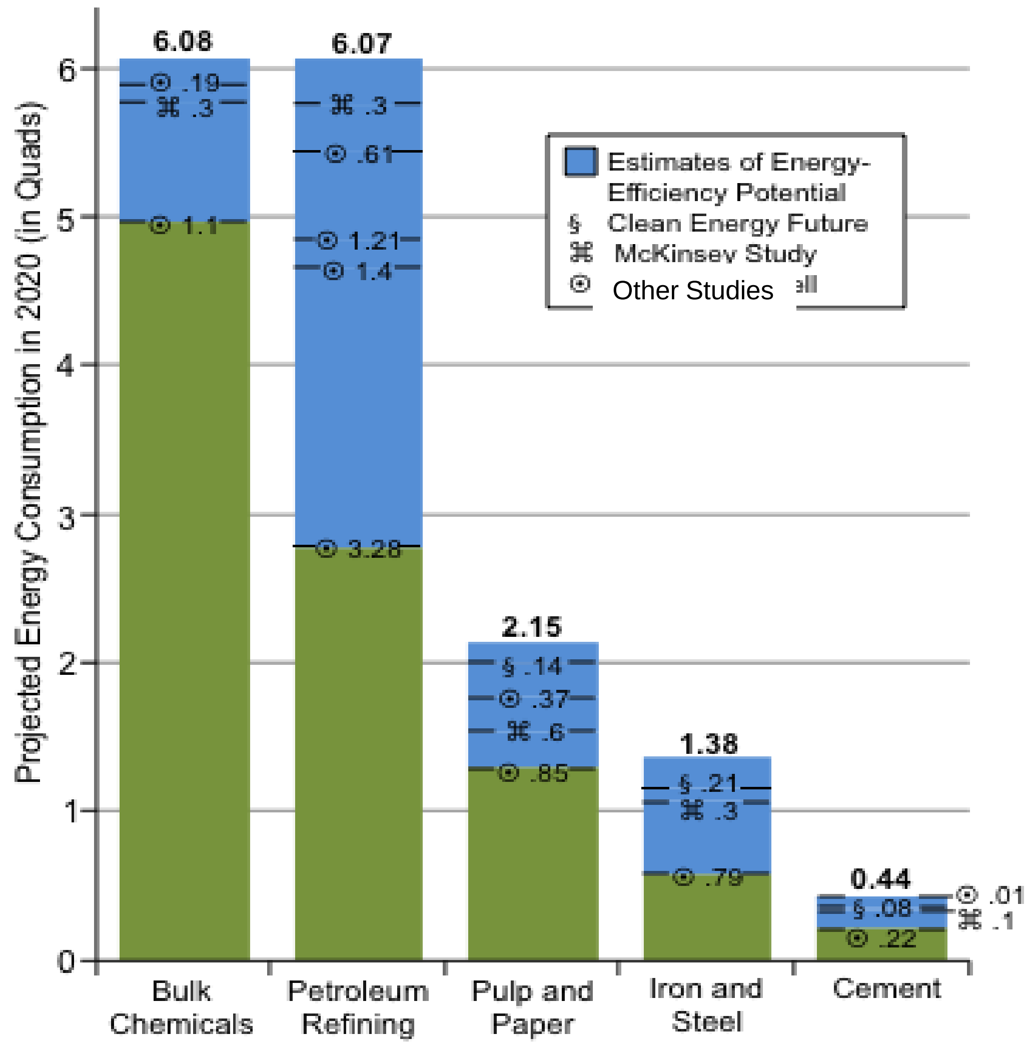


Industry Accounts for One-Third of U.S. Energy Consumption



Total U.S. energy use in 2006 was 100.02 quads.

The "Energy Efficiency Gap" is Large

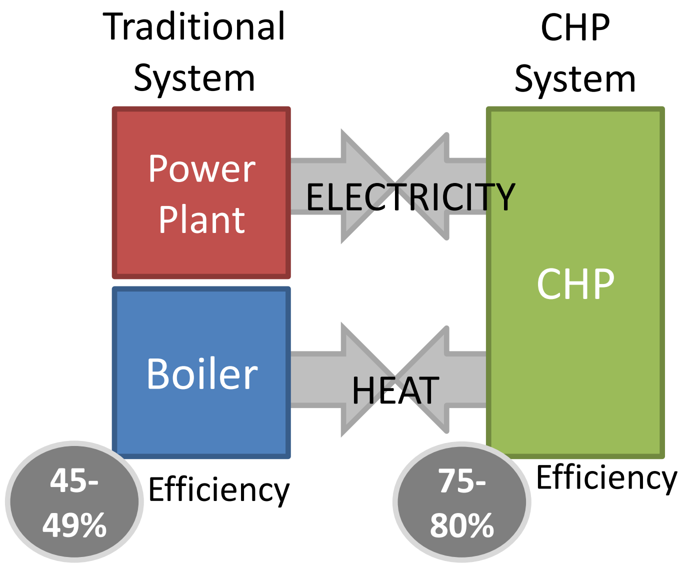


(3-18%) (5-65%) (6-37%) (15-57%) (19-50%)

Potential for Energy Efficiency Improvements in Five Industries in 2020

Why isn't there more Combined Heat and Power (CHP)?

- **Regulatory barriers**
  - Input-based emissions standards, the Sarbanes-Oxley Act of 2002, utility monopoly power, and grid access difficulties
- **Financial barriers**
  - Lack of access to credit and project competition within firms
- **Information and workforce barriers**
  - Lack of adequate workforce engineering know-how



What Drivers Could Motivate more CHP?

- **Volatile and rising energy prices**
  - "The sustained pain" of rising oil, coal, natural gas, and electricity prices is motivating a renewed interest in energy efficiency
- **Environmental concerns and regulations**
  - Potential lucrative streams of payments from NOx and SO_2 offsets in non-attainment zones, RES/EERS, and tradable carbon allowances
- **Demand charges and additional revenue streams**
  - The ability of industrial CHP to help meet peak electric loads and develop an additional revenue stream from electricity sales

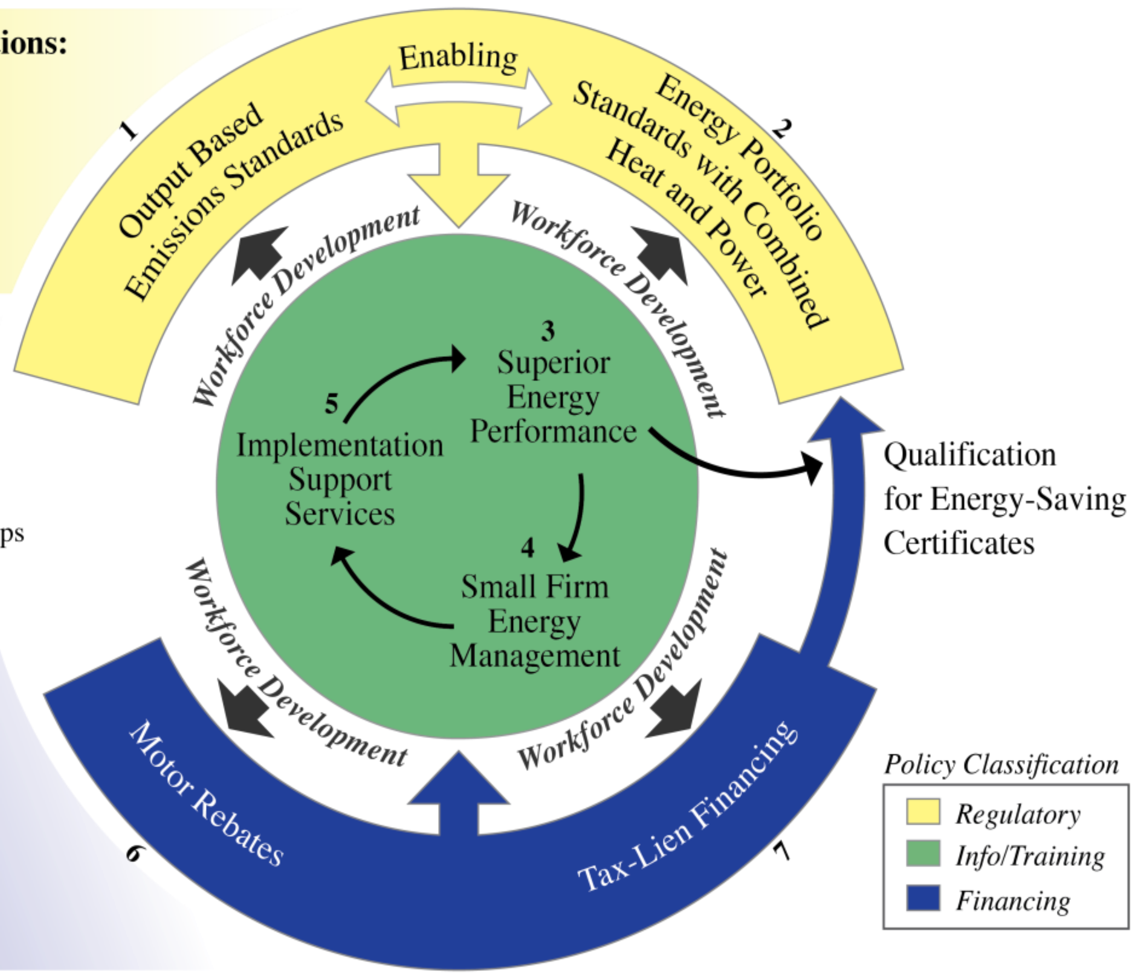
Seven Synergistic Policy Options

Existing Federal Policies

Overcoming Inadequate Regulations:
- Corporate Sustainability Efforts
- Carbon Credits
- White Certificates
- New Source Review Reform
- Flexible Air Permits
- Plant-wide Applicability Limits

Overcoming Information Barriers:
- Industrial Assessment Centers
- Save Energy Now
- Association of Energy Engineers
- Manufacturing Extension Partnerships
- Industry-Specific Roadmapping

Overcoming Financial Barriers:
- Corporate Financing
- Energy Service Companies
- Lending Institutions
- SBIR Program
- Loan Guarantees
- State Energy Program Grants
- Pollution Prevention Grants



First Cogeneration/CHP Policy

Output-Based Emissions Standards (OBES):
This policy would provide financial incentives and technical assistance to states to spur adoption of OBES – as authorized by the EPA – to reduce energy consumption, emissions of criteria air pollutants and GHG, and regulatory burdens. This program would use authorities of the State Energy Program to achieve this regulatory change. A national effort could lead to widespread cogeneration at factories and large facilities over the near and long terms.

See: Cox, Matt, Marilyn Brown and Roderick Jackson. 2011. “Regulatory Reform to Promote Clean Energy: The Potential of Output-Based Emissions Standards,” *Proceedings of the ACEEE Summer Study on Energy Efficiency in Industry*, July 24, Niagara Falls, NY, pp. I-57 – I-67.

Second Cogeneration/CHP Policy

A Federal Energy Portfolio Standard with CHP and a 30% Investment Tax Credit (ITP):
An EPS with CHP and an ITP. This policy would require federal legislation that mandates electric distributors to meet an EPS with CHP as an eligible resource and to extend and expand the current investment tax credits for CHP. This policy option would concurrently establish measurement and verification methods for qualifying CHP resources and encourage a national market for trading energy-efficiency credits.

Analysis from Many Different Perspectives

Market Penetration

- Individually estimated for each policy
- NEMS analysis performed when possible

Energy

- Reference case is AEO 2010
- Energy price forecasts from AEO 2010

Carbon Dioxide

- Emissions from fuel carbon intensity or industry composite
- Costs included from Interagency Working Group on the Social Cost of Carbon

Criteria Pollutants

- Costs included from NRC 2010 for SO_2, NO_x, PM_{10}, and $PM_{2.5}$

Policy Sensitivities

- Multiple policy outcomes are tested for each policy
- Sensitivity analysis is used to provide a plausible range of results

Discount Rates

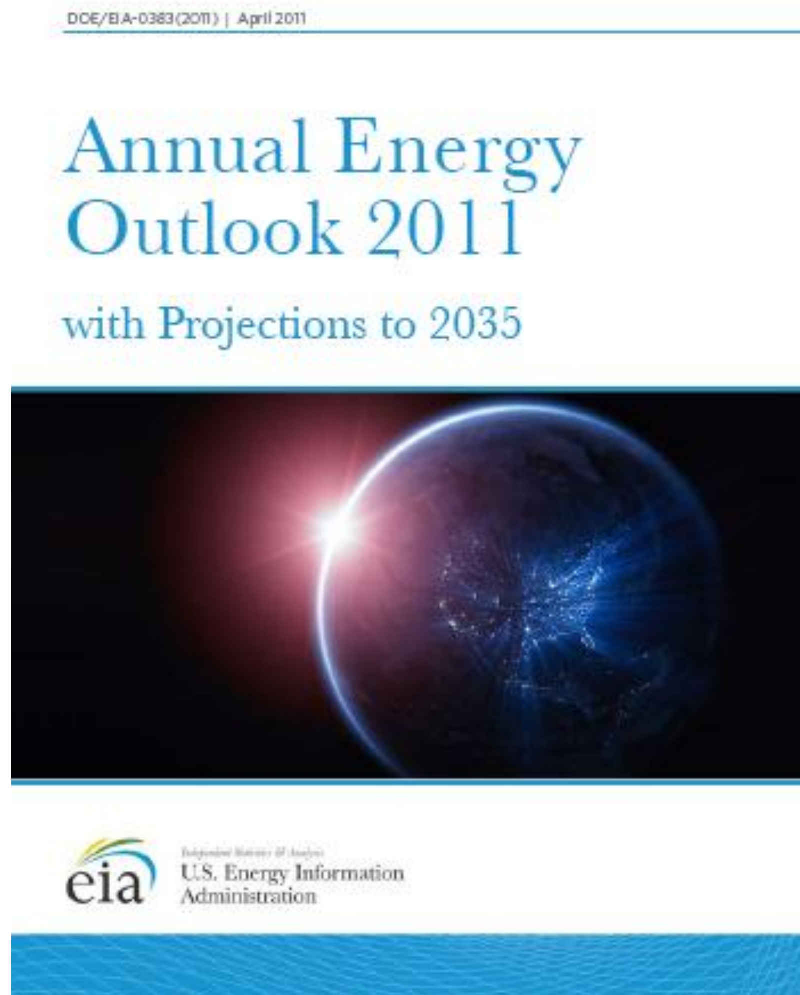
- Social: 3%, with sensitivities at 7%
- Industrialist: 7% used to represent industrial sector perspective

Benefit/Cost and Leveraging Ratios

- Social Benefit/Cost: PV of energy savings and mitigated emissions: PV of public and private costs
- Leveraging Ratios: e.g., PV of public costs: MMBtu of energy saved
- CO_2 Leveraging Ratio: PV of public costs: Avoided MMT CO_2

National Energy Modeling System (NEMS 2011)

- Large, regional energy-economy model of the United States
- Annual Projections to 2035:
  - Consumption by sector, fuel type, region
  - Production by fuel
  - Energy imports/exports
  - Prices
  - Technology trends
  - CO_2 emissions
  - Macroeconomic measures and energy market drivers



Eight Cogeneration Systems are Modeled in GT-NEMS: Significant Reductions in Total Installed Costs (in 2005$/KW)

System	2005	2010	2020	2035
1 Internal Combustion Engine—1,000 KW	1373	1440	1129	576
2 Internal Combustion Engine—3,000 KW	1089	1260	949	396
3 Gas Turbine—3,000 KW	1530	1719	1646	1496
4 Gas Turbine—5,000 KW	1180	1152	1101	1023
5 Gas Turbine—10,000 KW	1104	982	929	869
6 Gas Turbine—25,000 KW*	930	987	898	860
7 Gas Turbine—40,000 KW	805	876	856	830
8 Combined Cycle—100,000 KW**	846	723	1099	684

*Assumed system for cost analysis

**Two 40 MW Gas Turbine & 20 MW Steam

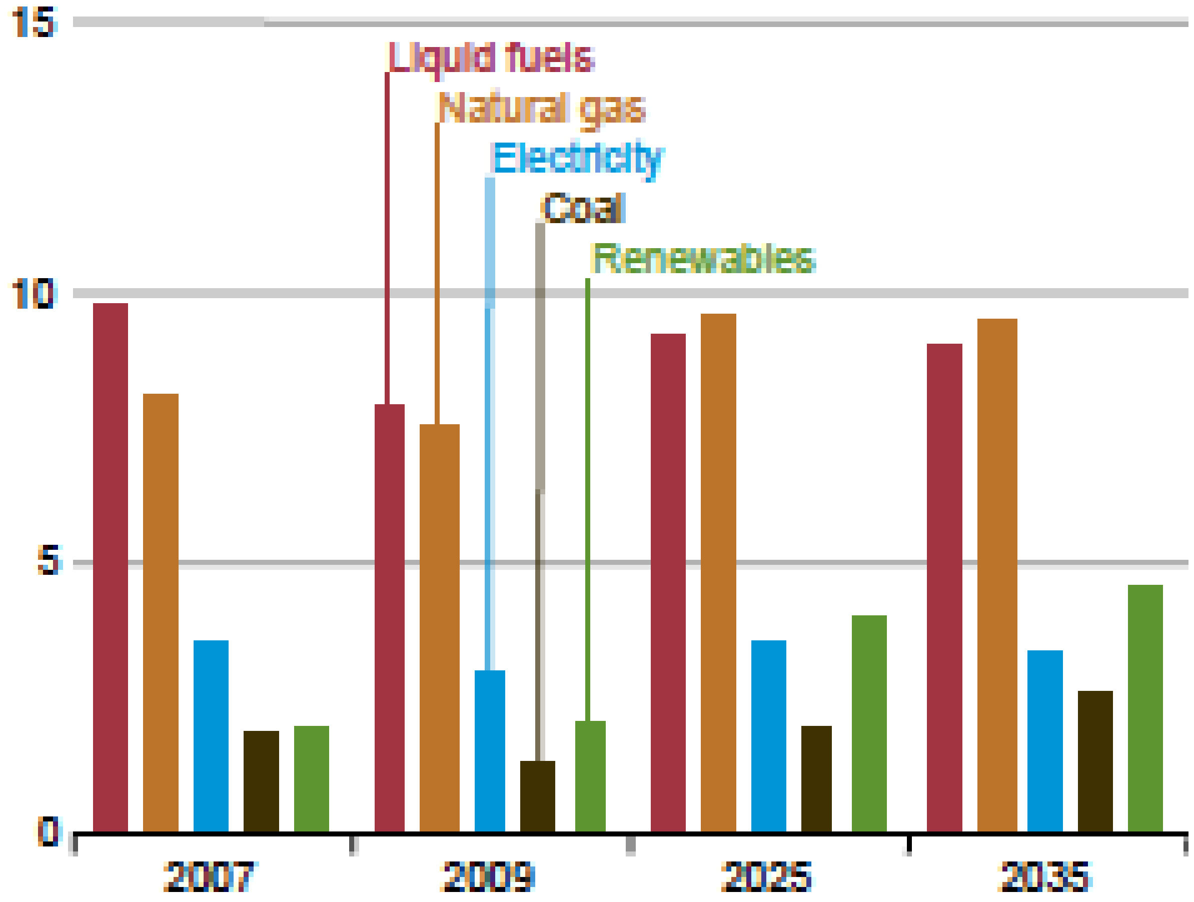
Overall Efficiency of CHP Systems: Assumptions in GT-NEMS (Modest Rates of Improvement)

System	2005	2010	2020	2035
1 Internal Combustion Engine—1,000 KW	0.70	0.81	0.84	0.89
2 Internal Combustion Engine—3,000 KW	0.70	0.83	0.87	0.92
3 Gas Turbine—3,000 KW	0.69	0.76	0.77	0.78
4 Gas Turbine—5,000 KW	0.70	0.77	0.78	0.78
5 Gas Turbine—10,000 KW	0.70	0.77	0.77	0.78
6 Gas Turbine—25,000 KW*	0.70	0.71	0.71	0.73
7 Gas Turbine—40,000 KW	0.72	0.72	0.73	0.74
8 Combined Cycle—100,000 KW**	0.70	0.70	0.72	0.73

*Assumed system for cost analysis

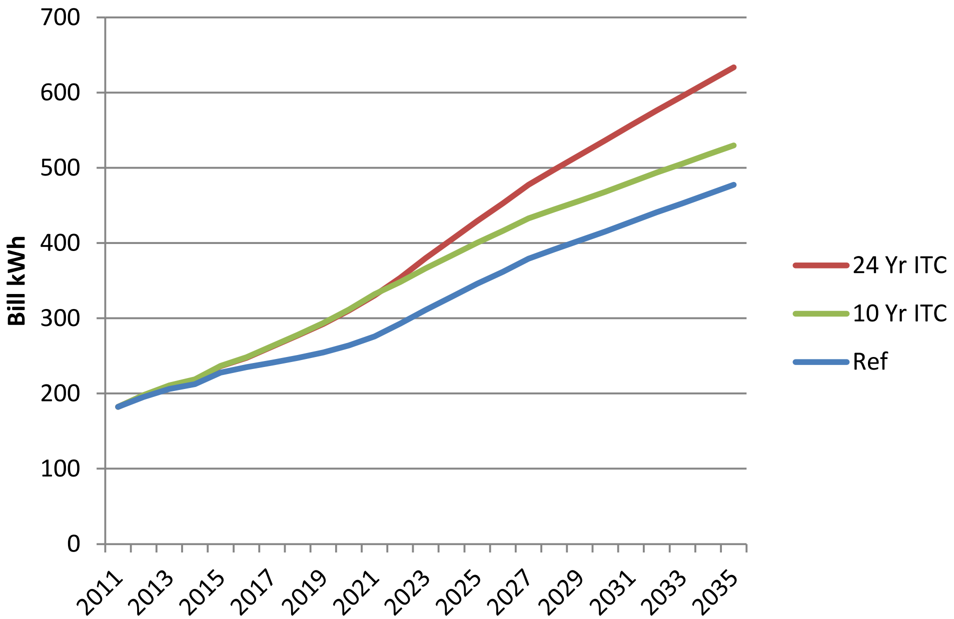
**Two 40 MW Gas Turbine & 20 MW Steam

Forecasted Changes in Industrial Fuel Mix (AEO 2011)



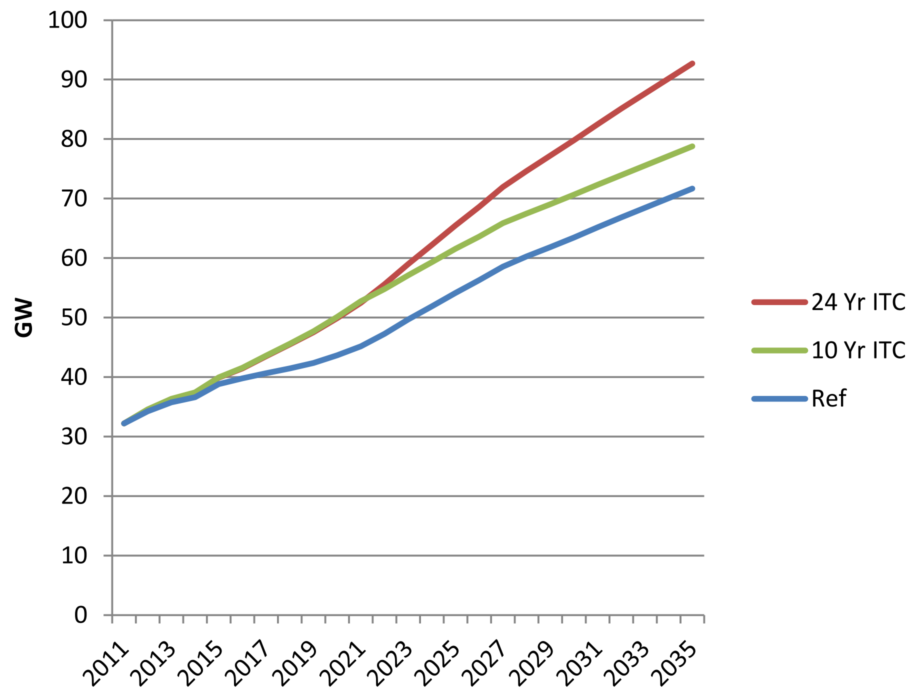
Low natural gas prices spur an increase in CHP in EIA's Reference Case Forecast (Source: Annual Energy Outlook 2011)

Total Industrial CHP Generation & Capacity as a Result of the CHP Policy

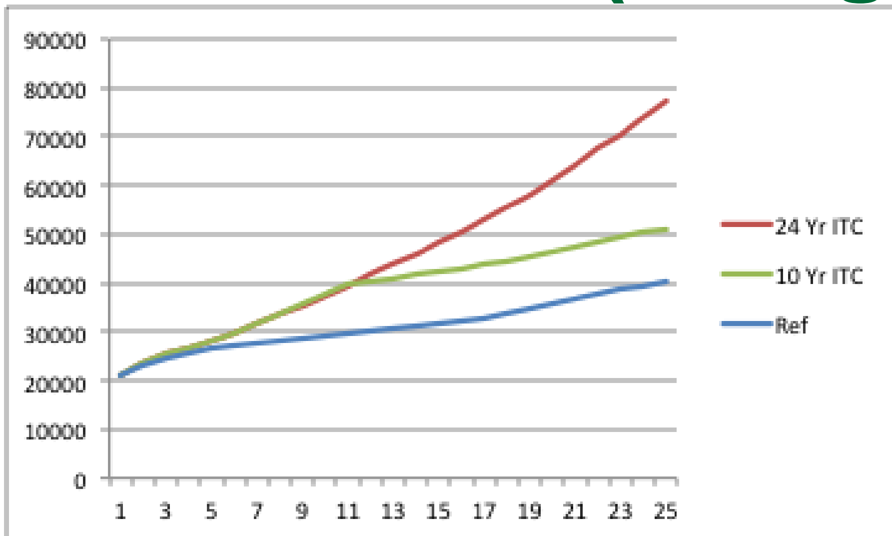


CHP capacity and generation more than doubles in the reference case between 2011 and 2035.

The CHP policy results in about a 30% increase in capacity and generation above the reference case.



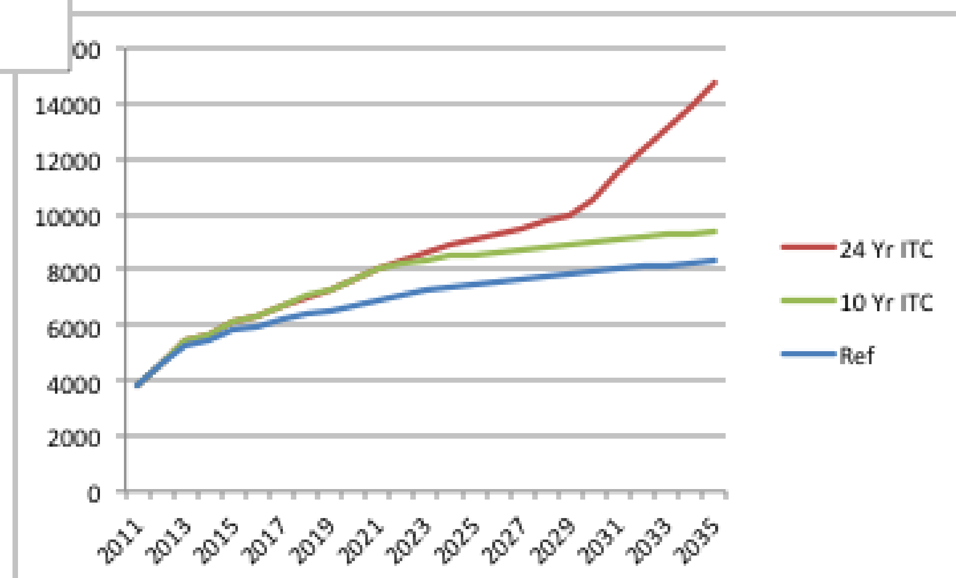
Industry as Electricity Providers: Sales of Electricity from Industrial CHP to the Grid (in Gigawatt-hours)



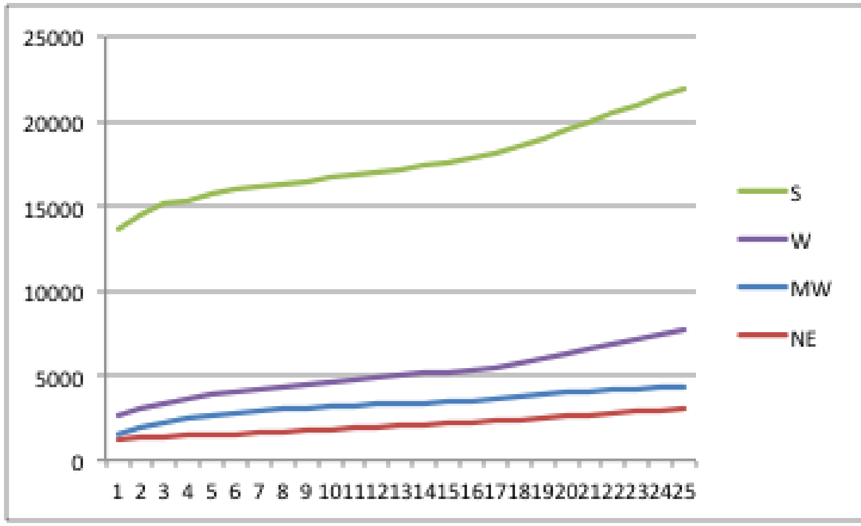
National Grid Sales

Industries with large growth in CHP include chemical, paper, food processing, petroleum refining, primary metals, and lumber and wood (consistent with ICF study).

Grid Sales from the Paper Industry (note significant upturn in 2030—which characterizes several industries)

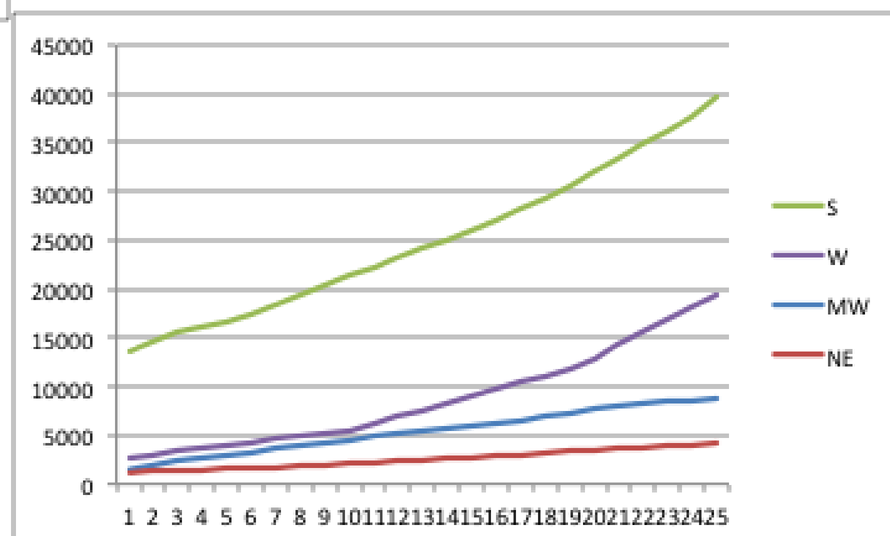


Sales of Electricity from Industrial CHP to the Grid, by Region: CHP in the West Grows Most Rapidly

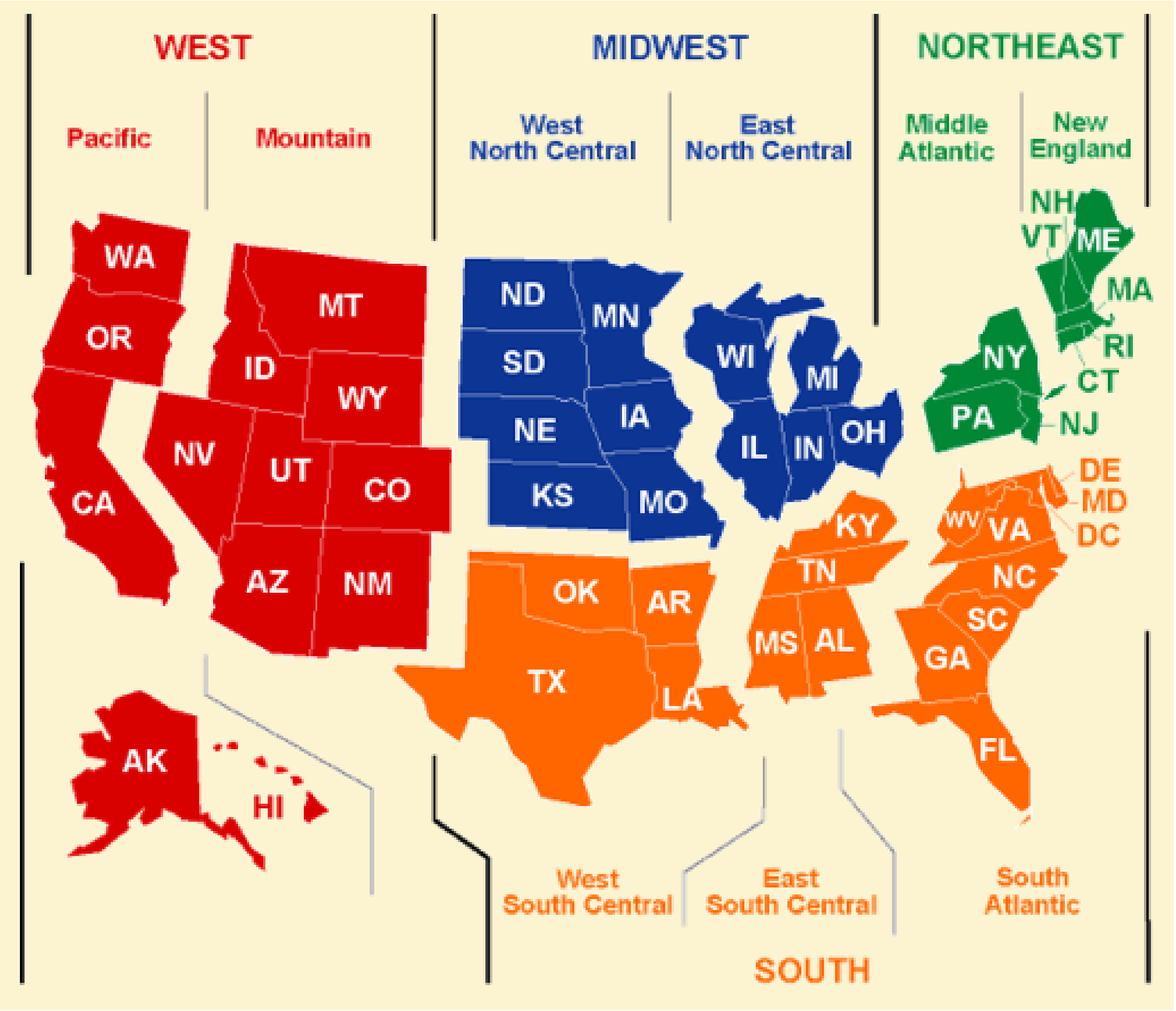


Reference Case

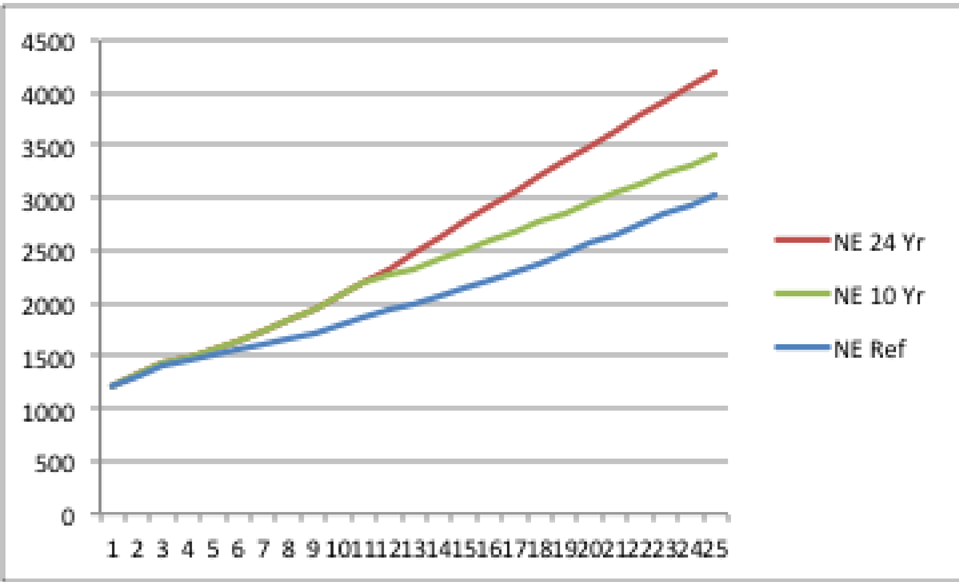
24-Year Investment Tax Credit

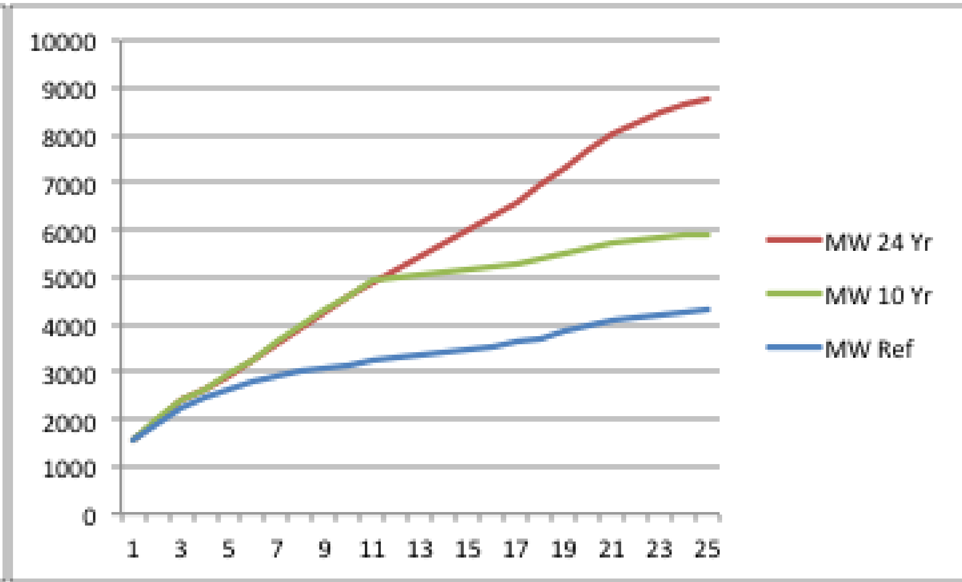


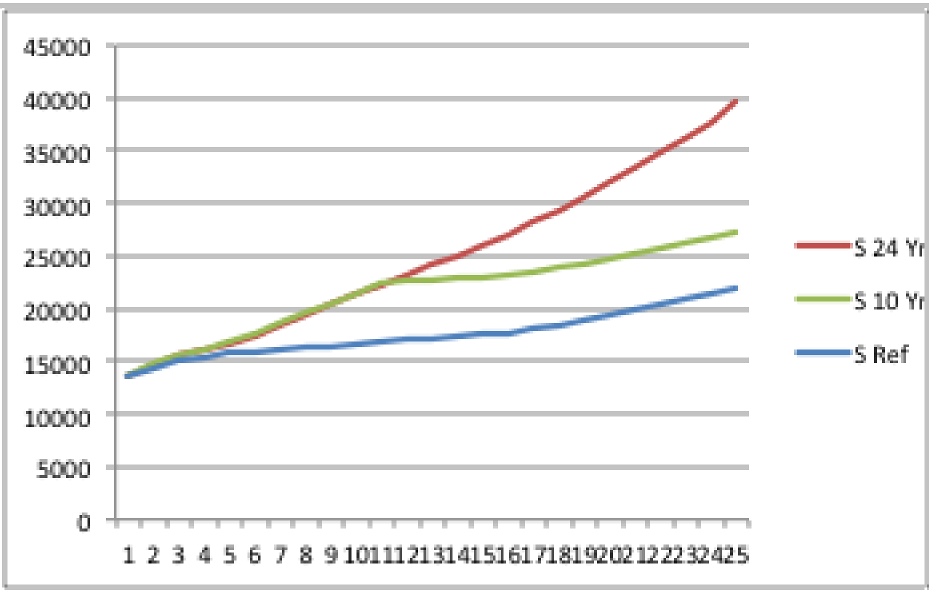
Census Regions of the U.S.

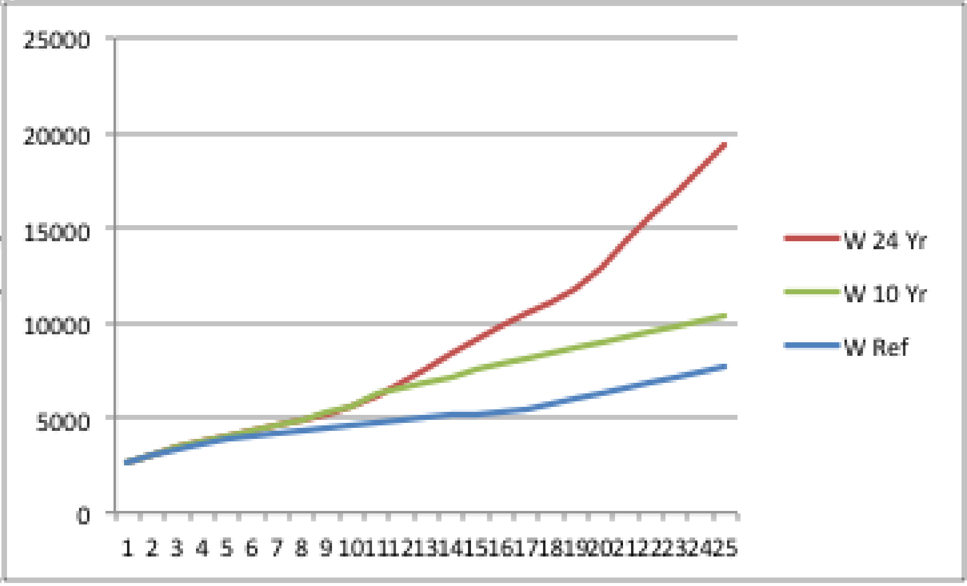


GWh of CHP Grid Sales by Region: The South Continues to Dominate









Benefit-Cost Analysis from the Manufacturers' Perspective

Year	BAU Energy Consumption**	Annual Energy Savings***			Cumulative Energy Savings****		Annual Private Cost	Cumulative Private Cost
	Trillion Btu	Trillion Btu	$M (2008)	%	Trillion Btu	$M (2008)	$M (2008)	$M (2008)
2012	25,205							
2020	26,899	133	1,223	0.50	395	5,897	229	1,326
2035	24,747	463	1,065	1.87	5,365	25,591	34	1,927
2055	--	--	--	--	9,767	35,712	--	1,927

* Present value of costs and benefits were calculated using a 7% discount rate.

** Reference case industrial energy consumption excludes refining. These Business-as-Usual (BAU) estimates are output from the GT-NEMS model.

*** The percentages refer to the percent of energy use and carbon dioxide emissions from industrial energy use.

****Investments stimulated from the policy occur through 2035. Energy savings are then modeled to degrade at a rate of 5% after 2035, such that all benefits from the policy have ended by 2055.

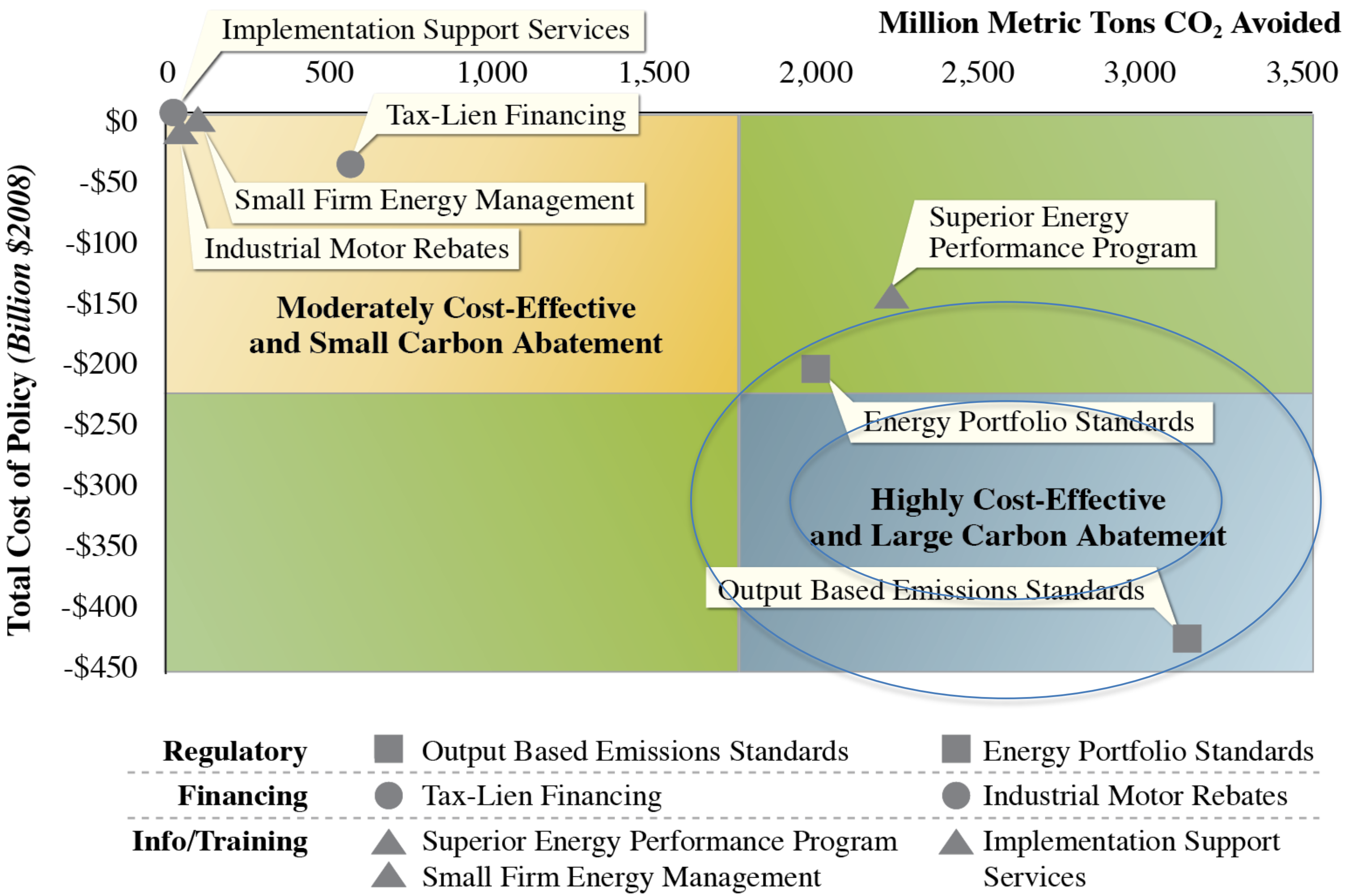
Benefit-Cost Analysis from the Public's Perspective

	Cumulative Social Benefits (Billions 2008-$)				Cumulative Social Costs (Billions 2008-$)			Benefit/Cost Analysis	
Year	Energy Savings	Value of Avoided CO_2	Value of Avoided Criteria Pollutants	Total Social Benefits**	Public Costs	Private Costs	Total Social Costs**	Social B/C Ratio	Net Societal Benefits (Billions 2008-$)
2020	7.3	0.50	2.09	9.9	3.78	1.7	5.5		
2035	44.0	6.4	16.5	67.0	11.6	2.8	14.4		
2055	68.4	11.6	27.0	107.0	11.6	2.8	14.4	7.4	93

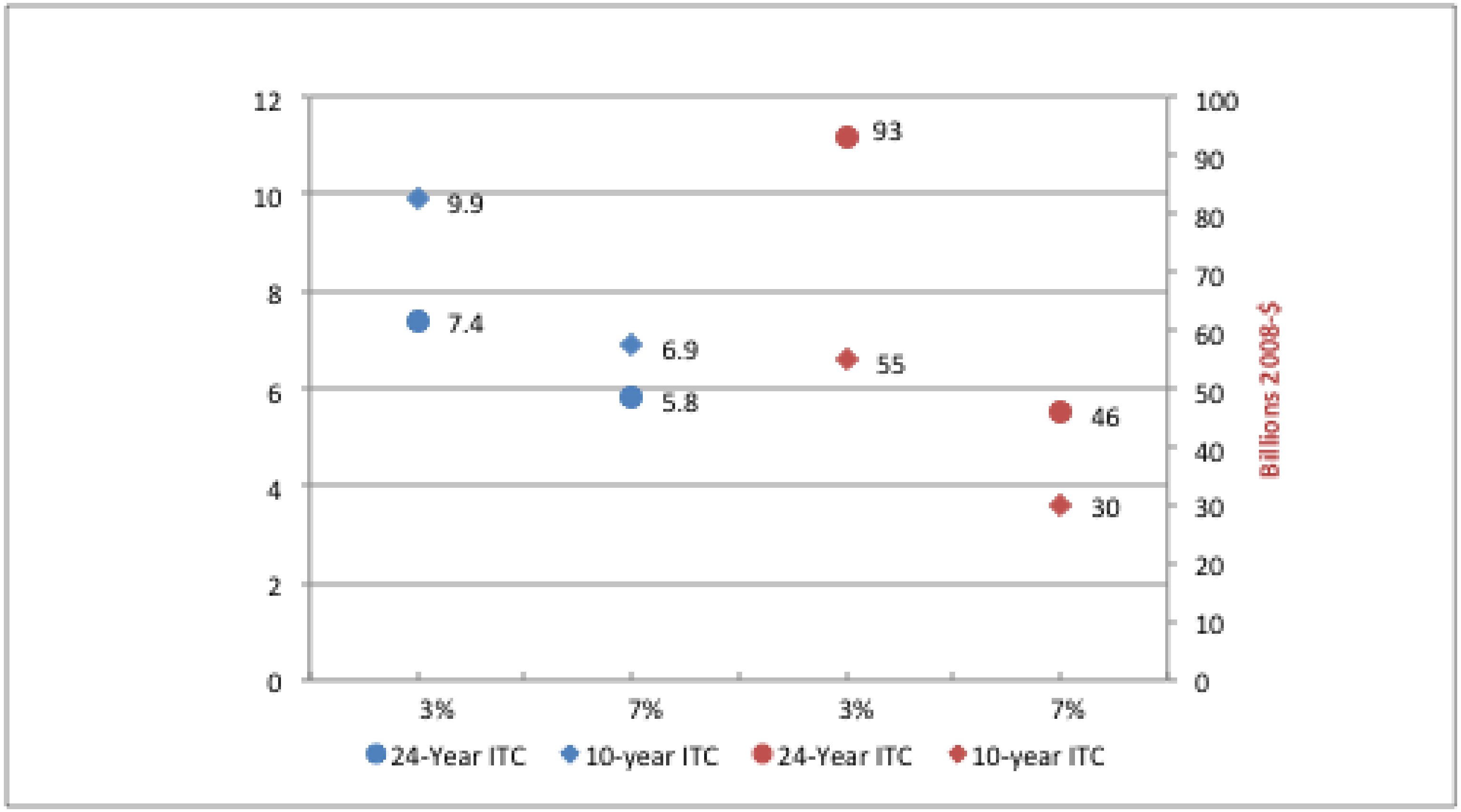
* Present value of costs and benefits were calculated using a 3% discount rate.

**Total costs and benefits do not include various non-monetized values (e.g. mercury pollution reduction, increased productivity, water quality impacts, etc.).

Two CHP Policies are Highly Cost-Effective



The 10-Year ITC has a Higher B-C Ratio tha, But Lower Total Benefits



Is there a political appetite for directed government expenditures to stimulate private spending and investment?

Employment Analysis Objectives

- Further develop hybrid employment analysis techniques using NEMS and Input-Output Analysis
  - Improved accounting for first and second-order impacts
  - Comparison of NEMS versus NEMS-I/O estimates
  - Assess uncertainties and limitations
- Apply techniques to national policy scenarios
  - Industrial sector
  - Residential sector
  - Utility sector
- Phase I studies
  - Policies to promote Combined Heat and Power (CHP)

Input-Output Economics

- Input-Output (I-O) models are one of several means to estimate the macroeconomic impacts of environmental policy (Berck & Hoffman 2002).
- I-O models are based on the “flows of goods” and the “fundamental relationship” of inputs and output in the economic structure (Leontief 1966).
- I-O models are linear, static, transparent and widely used in clean energy economics (Pollin et al. 2010).

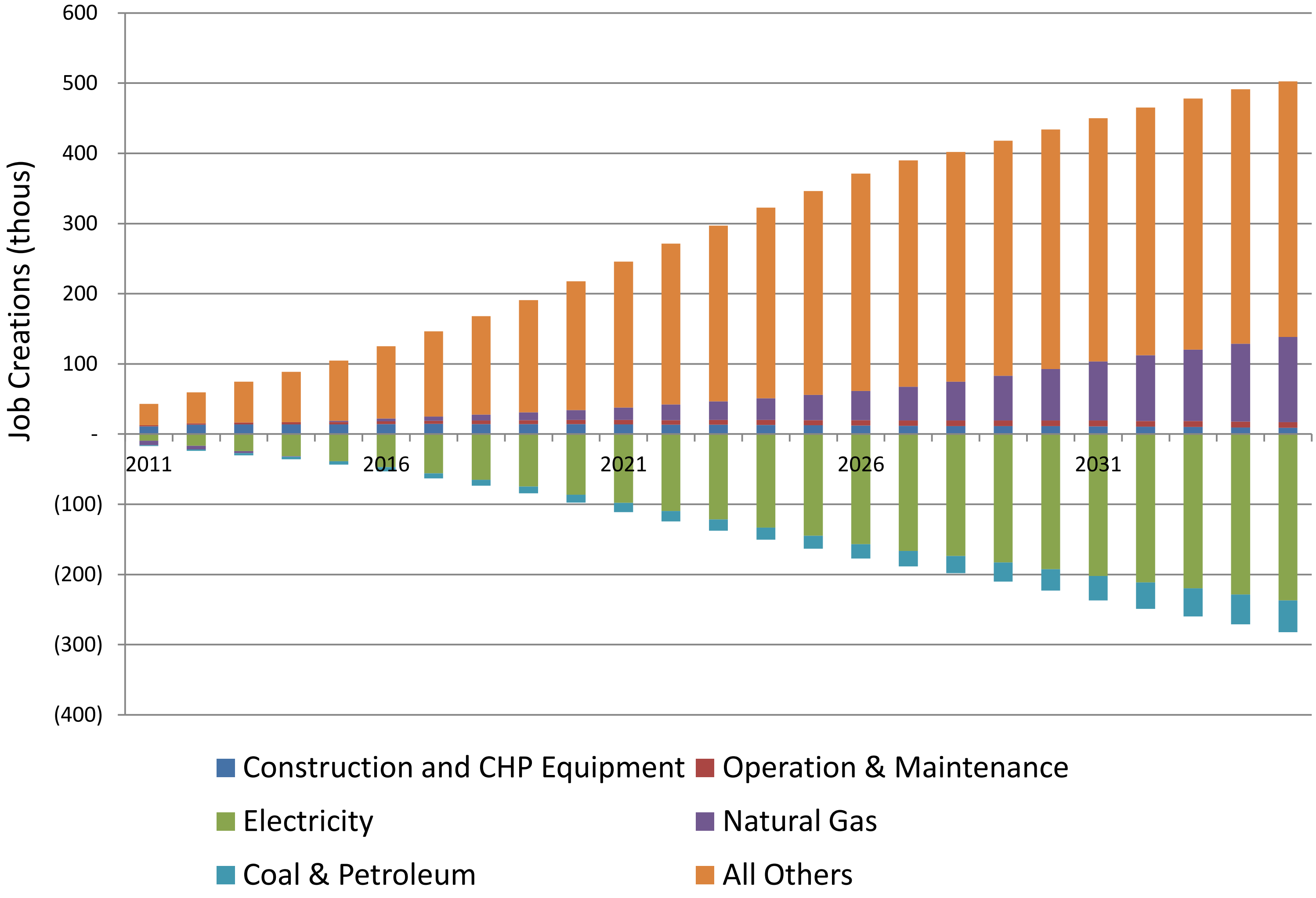
Preliminary “Bill of Goods” for CHP

IMPLAN Code and Industrial Sector	weights (%)	Jobs per $1 million
Installation	**100%**	**14.84**
Electronic Components	10.0%	14.1
234: Electronic computer manufacturing		10.38
245: Electronic connector manufacturing		15.12
244: Electronic capacitor, resistor, coil, transformer, and other inductor manufacturing		16.67
Electrical Equipment	25.0%	12.4
222: Turbine and turbine generator set units manufacturing		12.26
266: Power, distribution, and specialty transformer manufacturing		10.94
267: Motor and generator manufacturing		11.24
275: All other miscellaneous electrical equipment and component manufacturing		13.73
253: Electricity and signal testing instruments manufacturing		13.89
Machinery	15.0%	13.6
230: Other general purpose machinery manufacturing		13.55
Fabricated Metal	15.0%	13.3
188: Power boiler and heat exchanger manufacturing		13.21
201: Fabricated pipe and pipe fitting manufacturing		12.98
202: Other fabricated metal manufacturing		13.57
189: Metal tank (heavy gauge) manufacturing		13.44
Construction	20.0%	16.6
35: Construction of new nonresidential manufacturing structures		16.57
Scientific and Technical Services	15.0%	20.0
374: Management, scientific, and technical consulting services		18.90
369 Architectural, engineering, and related services		21.28
375: Environmental and other technical consulting services		19.69

Preliminary “Bill of Goods” for CHP

IMPLAN Code and Industrial Sector	weights (%)	Jobs per $1 million
Operation & Maintenance: FUEL	100.0%	**10.30**
Logging	30.0%	21.1
15: Forestry, forest products, and timber tract production		23.94
16: Commercial logging		18.32
Natural gas	70.0%	5.66
32: Natural gas distribution		5.66
Operation & Maintenance - NON FUEL	100.0%	**19.21**
39: Maintenance and repair construction of nonresidential structures		21.53
385: Facilities support services		25.67
416: Electronic and precision equipment repair and maintenance		15.13
417: Commercial and industrial machinery and equipment repair and maintenance		14.50
Electricity	**100.0%**	**5.56**
31: Electrical power generation, transmission, and distribution		5.56
Coal & Petroleum	**100.0%**	**7.35**
21: Mining coal		11.22
115: Petroleum refineries		4.20
119: All other petroleum and coal products manufacturing		6.64

Preliminary Results of an I-O Analysis of an OBES Policy: Job Creation Exceeds Job Destruction



Next Steps

- Improve "bill of goods" for CHP expansion through professional interviews in practice
- Evaluate the results and compare between I/O model and NEMS analysis
- Consider job imports and exports by sector
- Preliminary uncertainty analysis
- Provide framework for NEMS employment analysis of Homes, Industry, and Commercial Building policies

CONCLUSIONS

- The energy-efficiency gap in the U.S. industrial sector is large & the electric system remains inefficient
- If key barriers could be removed, industry could expand its role in solving the global climate challenge
- Improved energy economics could result from the promulgation of a federal energy portfolio standard that qualifies CHP, accompanied by tax credits for CHP investments.
- The energy-saving benefits of such a CHP policy could outweigh the policy's costs several times over, offering a positive cash-flow investment opportunity for manufacturers to sell electricity and recycle those profits into more competitively priced products.

For More Information

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