Methodology for Estimating the Potential for Industrial Energy Bill Savings, by State

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1. Brief Introduction and Logic Diagram

This document describes the methodology developed by the Georgia Institute of Technology's Climate and Energy Policy Lab to estimate the impact of Clean Power Pathways on the utility bills of industrial enterprises. For an overview of the larger project, see the School of Public Policy working paper on "The Clean Power Plan and Beyond."[1]

This methodology can be summarized in the following logic diagram (Figure 1). The blue boxes describe data collected as input. While using these inputs, the green boxes characterize the steps and associated intermediate results. Finally, the red box illustrates how these steps produce the final output, state level energy (electricity and natural gas) bills by business type. The rest of this memo further explains the data sources and methodology.

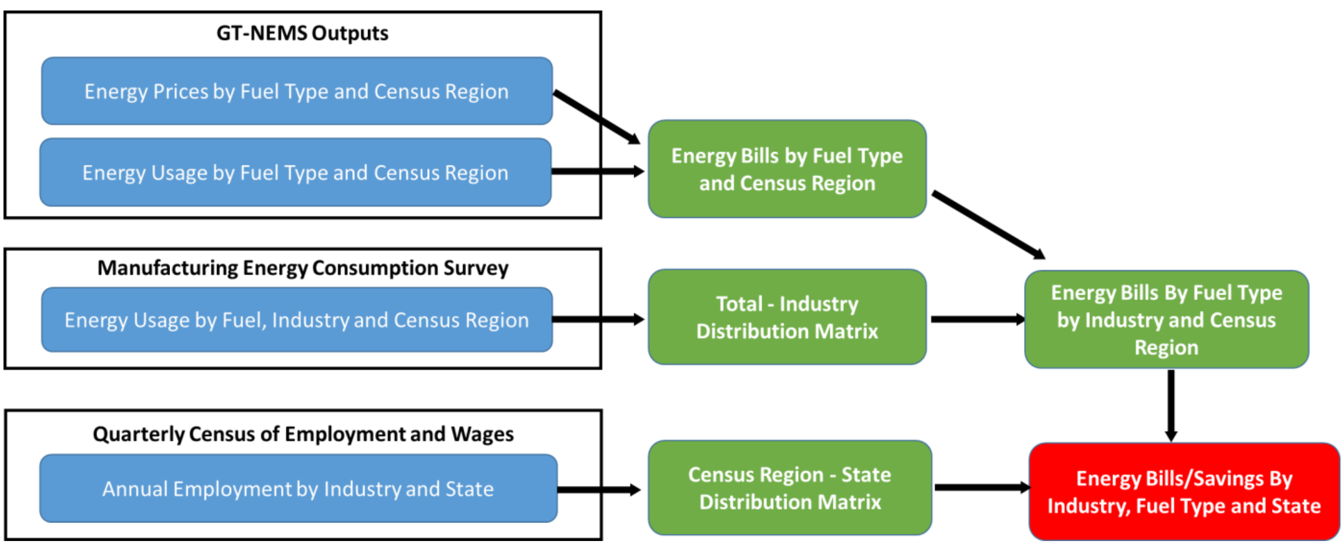

Figure 1. Logic Diagram of the Methodology for Projecting Industrial Energy Bills

2. Data Source

Three main data sources are necessary to forecast industrial energy bills for different types of manufacturing establishments in each state. First, energy rates and usage by fuels by census regions are collected from GT-NEMS outputs. Second, we introduce energy usage by fuel, industry and census region from Manufacturing Energy Consumption Survey (MECS). Lastly,

[1] Marilyn A. Brown, Gyungwon Kim, and Alexander M. Smith. 2016. *The Clean Power Plan and Beyond*, School of Public Policy, Georgia Institute of Technology, Working Paper #89, http://www.cepl.gatech.edu/projects/ppce.

census of employment data from the Bureau of Labor Statistics provides annual employment by industry and state. The details of these data sources are listed in Table 1.

Table 1. Data Collected and Sources

Data	Source		Reference
Industrial Sector Energy Rates by Fuel Type and Census Region	GT-NEMS Regional Outputs	Regional Table 2 Line 29-51	GT-NEMS
Industrial Sector Energy Usage by Fuel Type and Census Region	GT-NEMS Regional Outputs	Regional Table 2 Line 15-23	GT-NEMS
Energy Usage by Fuel, Industry and Census Region	Manufacturing Energy Consumption Survey, 2010	Table 3.2	http://www.eia.gov/consumption/manufacturing/data/2010/
Annual Employment by Industry and State	Quarterly Census of Employment and Wages, 2012	Microdata	http://data.bls.gov/cew/apps/data_views/data_views.htm#tab=Tables

3. Detailed Descriptions of the Projection Process

3.1. Calculating Energy Bills for Census Regions

Outputs from GT-NEMS (Georgia Tech - National Energy Modeling System) provide the data necessary for estimating industrial sector utility bills for nine U.S. Census divisions (Figure 2).

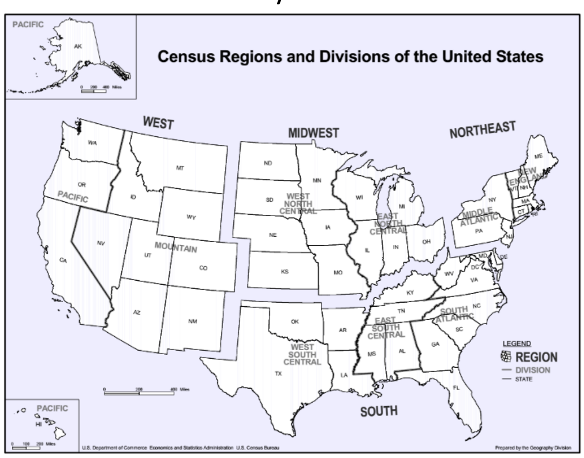

Figure 2. The Industrial Module's Census Divisions[2]

To model the demand for energy in manufacturing industries, NEMS employs a least-cost function within a set of rules governing the set of options from which companies may choose

[2] U.S. Census Bureau, "*Census divisions and Divisions of the United States*", https://www2.census.gov/geo/pdfs/maps-data/maps/reference/us_regdiv.pdf. Accessed May 17, 2016.

technologies (combined heat and power systems and motor and drive systems are modeled explicitly). Manufacturing enterprises can also invest in generic means to reduce unit energy consumption using technology possibility curves (TPC). The amount of energy to produce a unit of output, or unit energy consumption (UEC), is derived based on the given TPC. TPCs are based on assumptions made about trajectories of the relative energy intensity (REI) in each industrial sector. TPC rates are estimated for existing facilities (where retrofit activities can lead to energy-efficiency upgrades) and for new facilities (EIA, 2013). Strong policies are needed to encourage manufacturers to invest in energy-saving devices and practices to delivery these sizeable energy bill savings.

The CPP scenario assumes that investment tax credits for cogeneration systems are extended through 2040 and raised to 30%, which in turn reduces cogeneration system costs through economies of scale and technology learning. In addition, we assume an expansion of state incentives for industrial efficiency and more stringent federal standards for industrial motors and drives.

The model offers the potential for a rich examination of policy impacts on energy consumption, price and expenditures, carbon abatement, and pollution prevention over time and across nine Census divisions of the U.S. In GT-NEMS outputs, energy usage by fuel type and census region are recorded to Census divisions, which are groupings of states and the District of Columbia that subdivide the United States for the presentation of census data. There are four Census regions Northeast, Midwest, South, and – and each of these regions is divided into two or more census divisions[3]. Thus, accordingly we can calculate the petroleum, coal, natural gas and electricity bills for each census division.

3.2. Separating Industrial Sector Energy Bills into Manufacturing Industries

The Manufacturing Energy Consumption Survey (MECS) is a national sample survey that collects information on the stock of U.S. manufacturing establishment, their energy-related characteristics, and their energy consumption and expenditures.[4] In our analysis, we assume that the energy bills for each industry are proportioned to the relative weighted of energy consumption in the corresponding census region sectoral total. According to this proportion, we apply energy usage by fuel type to create total-industry distribution matrix.

With the transformation matrix, we proportion the energy bills by total into the data by industry. After the transformation, the energy bills by fuel type and industry for each census region are generated and recorded respectively.

[3]U.S. Census Bureau, "*Geographic Terms and Concepts - Census Divisions and Census divisions",* https://www.census.gov/geo/reference/gtc/gtc_census_divreg.html. Accessed May 17, 2016.
[4]U.S. Energy Information Administration, "*About the Manufacturing Energy Consumption Survey"* https://www.eia.gov/consumption/manufacturing/about.cfm. Accessed August 11, 2016.

3.3. Separating Energy Bills from Census Region to State-Level Data

The Quarterly Census of Employment and Wages (QCEW) program, supported by Bureau of Labor Statistics, publishes a quarterly count of employment and wages reported by employers covering 98 percent of U.S. jobs, available at the county, state, census divisions and national levels by industry. From Quarterly Census of Employment and Wages, we introduce the annual employment by industry. In our analysis, we assume that the energy bill in each state is positive correlated to the energy usage. Thus, the energy usage for each industry are part of the electricity or natural gas bills by the proportion of the energy usage of particular industry subsectors as to all of industry. According to the state-level usage data by housing type, the electricity and natural gas bills are separated into different industrial subsectors.

3.4. Identifying Energy Savings by Fuel Type for Different Manufacturing Subsectors

According to previous steps, the electricity and natural gas bills for each manufacturing subsector can be calculated for business-as-usual scenario and clean power pathway scenario. Furthermore, to calculate the savings, these data are benchmarked with GT-NEMS national output. GT-NEMS provide the commercial sector energy usage by business type, from which we can calculate the proportion of savings by each manufacturing subsector. It is reasonable to assume that the state energy savings for each manufacturing subsector is also proportioned to the total state savings and according to the state energy saving portfolios, we adjust the state savings by manufacturing subsector.

We examine the following 11 manufacturing subsectors (see Table 2). The categories are from the North American Industry Classification System (NAICS).

Table 2. List of Eleven Manufacturing Subsectors

Category Name	NAICS	Original Name
Food	311	Food
	312	Beverage and Tobacco Products
Wood Products	321	Wood Products
Paper Products	322	Paper
	323	Printing and Related Support
Petroleum and Coal Products	324	Petroleum and Coal Products
Chemicals	325	Chemicals
Plastics Products	326	Plastics and Rubber Products
	327	Nonmetallic Mineral Products
Iron and Steel	331	Primary Metals
Fabricated Metal Products	332	Fabricated Metal Products
Machinery	333	Machinery
Computers and Electronics	334	Computer and Electronic Products
	335	Electrical Equip., Appliances, and Componen
Transport Equipment	336	Transportation Equipment

Source: http://www.census.gov/cgi-bin/sssd/naics/naicsrch?chart_code=31&search=2012%20NAICS%20Search

3.5 Energy Prices

The 2012-2015 changes in energy bills across energy fuels shown in the industrial CPP profiles are largely due to changes in fuel prices (Table 3). EIA fuel price projections through 2040 are much less volatile.

Table 3. Fossil Fuel and Electricity Prices in the BAU Scenario (in 2013$/Million Btu)

Region/Year	Petroleum	Natural Gas	Coal	Electricity
United States				
2012	27.01	3.84	5.01	19.98
2015	18.33	4.54	4.00	21.02
2020	20.68	6.11	4.34	21.37
2025	22.18	6.81	4.57	22.55
2030	23.92	6.74	4.78	22.64
Percent Increase				
2015-2020	11.39	25.76	7.75	1.63
2015-2025	17.37	33.42	12.42	6.76
2015-2030	30.55	48.53	19.38	7.66

In the Business-as-Usual scenario, energy prices increase between 2015 and 2030 across all of the major fuels, ranging from 7.7% for electricity to 48.5% for natural gas (Table 3). In the Clean Power Pathways scenario, energy prices increase between 2015 and 2030 across all of the major fuels, ranging from 12.7% for electricity to 48.2% for natural gas (Table 4).

Table 4. Fossil Fuel and Electricity Prices in the CPP Scenario (in 2013$/Million Btu)

Region/Year	Petroleum	Natural Gas	Coal	Electricity
United States				
2012	27.01	3.84	5.01	19.98
2015	18.33	4.47	4.00	20.94
2020	21.26	5.39	4.24	20.87
2025	22.55	6.32	4.32	22.28
2030	24.45	6.62	4.41	23.61
Percent Increase				
2015-2020	13.80	17.09	5.81	-0.37
2015-2025	18.72	29.37	7.48	6.01
2015-2030	33.40	48.15	10.21	12.74

Figure 3 illustrates the differences across the two scenarios, showing that the Clean Power Pathways have a variable impact across fuels and time periods.

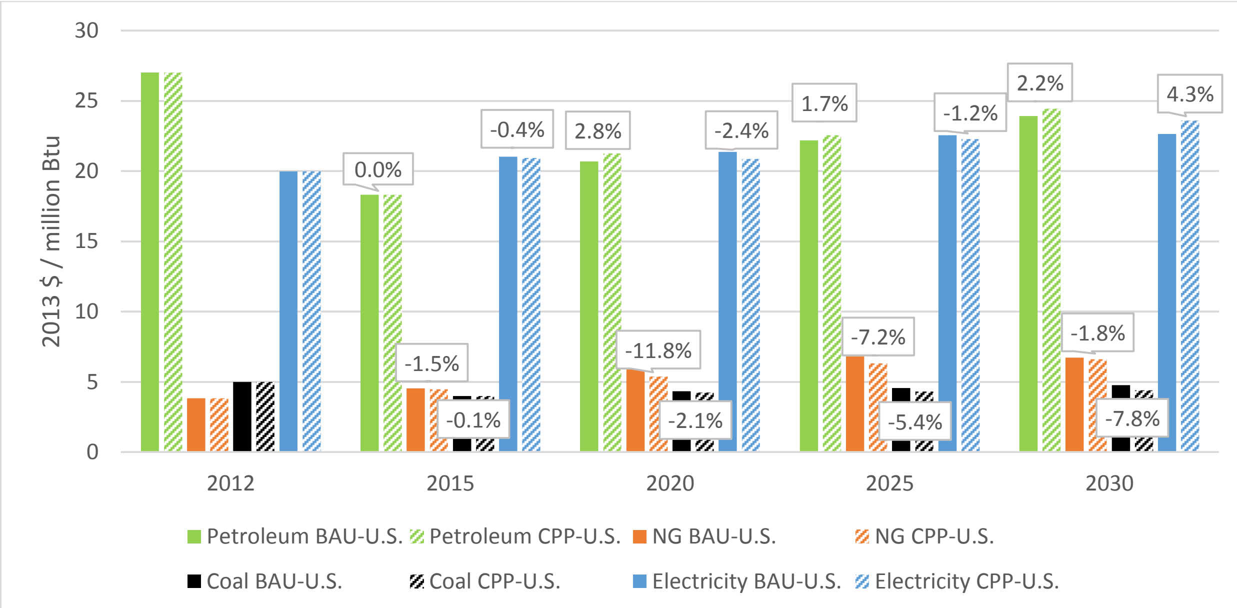

Figure 3. U.S. National Energy Prices for Energy Resources: BAU vs CPP Scenarios

3.6 Allocation of Energy Consumption in 2030 Across Manufacturing Subsectors

Table 5 documents the percentage of 2030 energy consumption that is is estimated to be used in each of the manufacturing subsectors in the U.S. and in the South. This is a key intermediary input into the distribution of energy bills in 2030.

Table 5. Allocation of Energy Consumption in 2030 Across Manufacturing Subsectors

US					South			
	Petroleum	NG	Coal	Electricity	Petroleum	NG	Coal	Electricity
Food	15%	12%	16%	12%	14%	6%	5%	8%
Wood Products	9%	1%	0%	2%	6%	1%	0%	3%
Paper Products	17%	8%	17%	10%	24%	7%	27%	10%
Petroleum & Coal Products	24%	18%	1%	7%	16%	19%	0%	9%
Chemicals	8%	34%	16%	18%	11%	49%	18%	24%
Plastics Products	11%	7%	18%	11%	14%	6%	20%	10%
Iron and Steel	5%	10%	31%	16%	5%	6%	28%	14%
Fabricated Metal Products	3%	3%	0%	5%	3%	2%	0%	4%
Machinery	2%	1%	0%	3%	2%	1%	0%	2%
Computers and Electronics	1%	1%	0%	6%	0%	1%	0%	5%
Transport Equipment	3%	2%	0%	5%	3%	1%	0%	4%

3.7 Size of the Market for Emission Reduction Credits and Carbon Allowances

Based on the methodology used by the Alliance for Industrial Efficiency (2016), we estimate the size of the national market for emission rate credits (ERCs) and carbon allowances that can be generated from industrial electricity efficiency. The calculation builds on the conclusion of *The Clean Power Plan and Beyond,* that 108 million MWh of electricity could be saved with cost-effective industrial energy efficiency improvements (Brown, Smith, and Kim, 2016).

The final Clean Power Plan rule allows industrial hosts to generate revenue from the sale of ERCs and carbon allowances. Thus, a market value is estimated based on the 108 million MWh of electricity efficiency potential that the CPP pathways could generate in the year 2030. To estimate the size of this market, we assume that one ERC equals one MWh of industrial electricity savings, and that one MWh of industrial electricity savings equals 0.8 short tons of CO_2. If ERC and carbon allowance prices both range from $10 to $20, the size of the ERC market in 2030 would range from $1.08 billion to $2.16 billion (in $2013), and the size of the carbon allowance market in 2030 would range from 0.86 to 1.73 billion (in $2013).

References:

Alliance for Industrial Efficiency. 2016. *State Ranking of Potential Carbon Dioxide Emission Reductions through Industrial Energy Efficiency* (Arlington, VA: Alliance for Industrial Efficiency), September. http://alliance4industrialefficiency.org/resources/state-industrial-efficiency-ranking/

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U.S. Energy Information Agency. 2013. *Model Documentation Report: Industrial Demand Module of the National Energy Modeling System.* Washington, DC: U.S. Energy Information Administration.

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