Methodology for estimating the potential for energy bill savings in commercial buildings, 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 commercial buildings. 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 as in Figure 1. The blue boxes are data collected as input. While using these inputs, the green boxes characterize the steps and associated intermediate results. Finally, the red boxes illustrate how these steps generate the final outputs, state level energy (electricity and natural gas) bills by business type. The rest of this document will further explain the data sources and detailed process of projection.

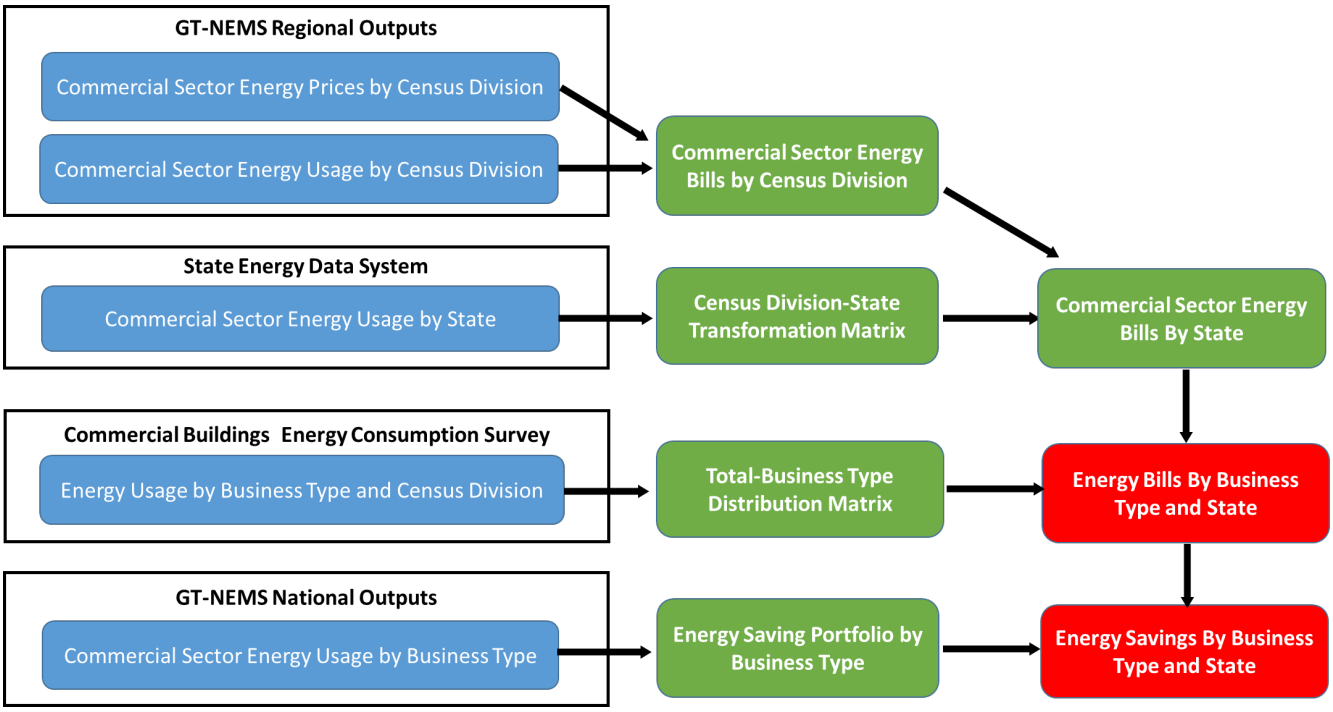

Figure 1. Logic Diagram of the Methodology for Projecting Utility Bills of Commercial Buildings

2. Data Source

Four main data sources are necessary to forecast commercial building utility bills for different building types in each state. First, electricity and natural gas rates and usage by census divisions are collected

[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/sites/default/files/attachments/NEMS_CPP_Paper_06-24-2016.pdf#

from GT-NEMS outputs. Second, we introduce commercial building energy usage in 2014 by state from the Energy Information Administration's State Energy Data System (SEDS). Third, the survey results from the most recent 2012 Commercial Buildings Energy Consumption Survey (CBECS) are used: total usage by commercial building types by state. And last, GT-NEMS national outputs provide the data for commercial buildings' energy usage by business type. The details of these data sources are listed in Table 1.

Table 1. Data Collected and Sources

Data	**Source**		**Reference**
Commercial Sector Electricity Rates by Census Division	GT-NEMS Regional Outputs	Table 2 Line 21	GT-NEMS
Commercial Sector Natural Gas Rates by Census Division	GT-NEMS Regional Outputs	Table 2 Line 24	GT-NEMS
Commercial Sector Electricity Usage by Census Division	GT-NEMS Regional Outputs	Table 3 Line 13	GT-NEMS
Commercial Sector Natural Gas Usage by Census Division	GT-NEMS Regional Outputs	Table 3 Line 19	GT-NEMS
Commercial Sector Energy Usage by State	State Energy Data System (SEDS):1960-2014	Table C6	http://www.eia.gov/state/seds/seds-data-complete.cfm?sid=US
Energy Usage by Business Type and Census Division	Commercial Buildings Energy Consumption Survey 2012	Microdata	http://www.eia.gov/consumption/commercial/data/2012/index.cfm?view=microdata
Commercial Sector Energy Usage by Business Type	GT-NEMS National Outputs	Table 32 Line 4-14	GT-NEMS

3. Detailed Descriptions of the Projection Process

3.1. Calculating Utility Bills for Census divisions

GT-NEMS (Georgia Tech - National Energy Modeling System) provides the data necessary for estimating commercial sector utility bills for the nine U.S. Census divisions. To model the demand for energy in commercial buildings, NEMS employs a least-cost function within a set of rules governing the set of

options from which consumers may choose technologies. Capital costs are amortized using "hurdle rates", which are calculated for end-uses by year for different subsets of the population by summing the yield on US government ten year notes (endogenously determined) and the time preference premium of consumers (exogenous inputs to the model). By characterizing nearly 350 distinct commercial building technologies in nine end-uses and eleven types of commercial buildings, the model offers the potential for a rich examination of policy impacts and an assessment of technology choice, energy consumption, price and expenditures, carbon abatement, and pollution prevention over time and across nine Census divisions of the US.

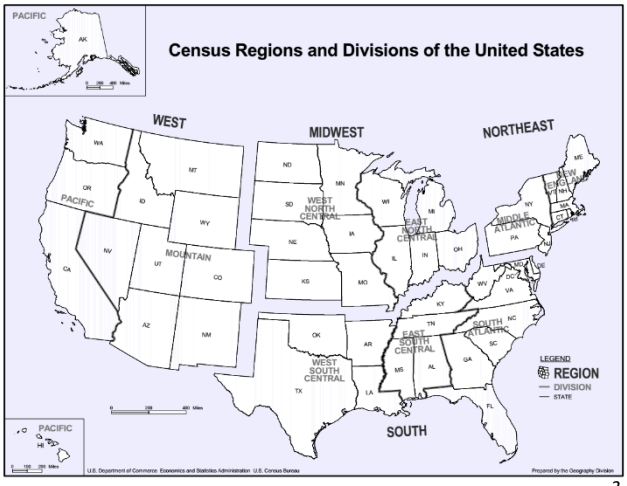

Figure 2. The Residential Module's Census divisions[2]

In GT-NEMS outputs, the natural gas and electricity prices and usage by residential sector are recorded to Census divisions, as shown in Figure 2. Census divisions 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 West. Each of these four Census regions is divided into two or more census divisions[3]. Thus, accordingly we can calculate the commercial building natural gas and electricity bills for each Census division.

3.2. Transforming Electricity and Natural Gas Bills to State Level

The State Energy Data System (SEDS) is the source of the U.S. Energy Information Administration's (EIA) comprehensive state energy statistics. EIA's goal in maintaining SEDS is to create historical time series of energy production, consumption, prices, and expenditures by state that are defined as consistently as possible over time and across sectors for analysis and forecasting purposes.[4] In our analysis, we assume that the state bills are proportioned to the relative weighting of commercial buildings energy consumption in the corresponding census division. According to this proportion, we apply state level energy usage data in 2014 to create the census division-state matrix.

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[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.

[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 SEDS", http://www.eia.gov/state/seds/ Accessed July 1, 2016.

With the transformation matrix, we proportion the electricity and natural gas bills by census division into state level data. After the transformation, the commercial building electricity and natural gas bills by state are generated and recorded respectively.

3.3. Separating State-Level Electricity and Natural Gas Bills to Different Building Types

The Commercial Buildings Energy Consumption Survey (CBECS) is a national sample survey that collects information on the stock of U.S. commercial buildings, their energy-related building characteristics, and their energy consumption and expenditures[5]. From CBECS 2012, we introduce the electricity usage and natural gas usage by building type. In our analysis, we assume that the energy bill in each state is positive correlated with energy usage. Respectively, natural gas bills are correlated to natural gas usage and electricity bills are correlated to electricity usage. Thus, the electricity or natural gas usage for each building type are part of the state-level electricity or natural gas bills by the proportion of the energy usage of particular building type as to all housing types. According to the state-level usage data by housing type, the electricity and natural gas bills are separated into different building type categories.

3.4. Identifying Electricity and Natural Gas Savings for Different Building Types

According to previous steps, the electricity and natural gas bills for each building type can be calculated for the business-as-usual scenario and the clean power pathway, which is the "CPP_All+EE+Solar" scenario described in the Georgia Tech report "The Clean Power Plan and Beyond."[6] Furthermore, to calculate the savings, these data are benchmarked with GT-NEMS national output. GT-NEMS provides the commercial sector energy usage by business type, from which we can calculate the proportion of savings by each building type. It is reasonable to assume that the state energy savings for each building type is also proportioned to the total state savings and according to the state energy saving portfolios, we adjust the state savings by building type.

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[5] Energy Information Administration, "Commercial Buildings Energy Consumption Survey (CBECS)", http://www.eia.gov/consumption/commercial/ Accessed July 9, 2016.

[6] 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/sites/default/files/attachments/NEMS_CPP_Paper_06-24-2016.pdf#