Concepts, Data Sources, and Techniques

Handbook of Energy Modeling Methods

World Energy Projection System (WEPS): Commercial Demand Module

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1. Introduction

The WEPS Commercial Demand Module projects energy consumption by businesses, institutions, and service organizations. Most commercial energy consumption occurs in buildings or structures, supplying services such as space heating, water heating, lighting, cooking, and cooling. Energy consumed for services not associated with buildings, such as for traffic lights and city water and sewer services, is also categorized as commercial energy consumption. The module projects commercial sector energy consumption for a number of energy sources in each of the WEPS regions over the projection period. The Commercial Demand Module projects energy consumption for the following energy sources:

- Motor gasoline
- Distillate fuel
- Residual fuel
- Kerosene
- Liquid petroleum gases (LPG)
- Natural gas
- Coal
- Electricity
- District heat (steam or hot water)
- Biomass
- Solar

Our commercial solar projections include only solar thermal energy consumed onsite in commercial buildings. Solar photovoltaic systems are modeled in the International Electricity Market Module. To project commercial energy consumption, we assume that the following factors determine changes in energy consumption over time:

- Changes in *service sector gross output*, defined as the total dollar value of services provided by commercial establishments, adjusted to reflect purchasing power parity
- Changes in commercial energy prices
- The sensitivity of energy consumption to changes in service sector gross output and prices
- A linear trend

Increased service sector gross output generally leads to higher energy consumption, but price increases generally support declines in consumption. The sensitivity of energy consumption to changes in service sector gross output and prices varies by region, fuel, and time period and is represented by an elasticity parameter. A linear trend accounts for other factors such as energy efficiency improvements, energy conservation efforts, and policy effects.

2. Description of the Projection Method

The projection method for commercial energy consumption is similar to the method used for residential energy consumption. For each WEPS region and for each fuel and projection year, we calculate a multiplicative index representing the change in commercial energy consumption that results from the projected change in service sector gross output since the base year. We then compute similar factors to represent the effects of changes in commercial energy prices and a linear trend. To arrive at a projection for the current year, we multiply the base year's energy consumption estimate by the product of these three factors:

This Year's Consumption = (Base Year's Consumption)
× (Index of Change Due to Service Sector Gross Output Changes)
× (Index of Change Due to Price Changes)
× (Change Due to a Long-Term Trend)

To compute *Last Year's* Consumption, we start with an actual estimate for the *base year*, the most recent historical year for which data are available. We update the estimate sequentially for each year in the projection period. The WEPS Global Activity Module provides the necessary projections of service sector gross output, and other WEPS modules provide commercial fuel price projections.

We calculate an index of change in service sector gross output relative to the module base year. Then, for each region, fuel, and projection year, we calculate an index value by updating the previous year's value as follows:

$$\text{This Year's Index} = (\text{Last Year's Index})^{\text{Lag Effect Parameter}} \times \left(\frac{\text{This Year's Output}}{\text{Base Year's Output}}\right)^{\text{Output Elasticity}},$$

where *Output* refers to service sector gross output.

The *Lag Effect Parameter* indicates the effect of the previous year's index value on the current year's index value (a measure of consistency), and the *Output Elasticity* indicates the impact of change in service-sector gross output on the commercial consumption of the particular fuel. For example, a value of 0 for these parameters indicates no effect, and a value of 1 indicates a strong effect. We calculate each of these parameters by analyzing projections from our *National Energy Modeling System* (NEMS) and applying adjustments for the WEPS regions, as discussed in Section 3. The values of service sector gross output represent the total value of commercial output for the region, adjusted for purchasing power parity.

Similarly, for each fuel, we index the change in fuel price relative to the module base year in each region and projection year, updating the previous year's value as follows:

$$\text{This Year's Index} = (\text{Last Year's Index})^{\text{Lag Effect Parameter}} \times \left(\frac{\text{This Year's Price}}{\text{Base Year's Price}}\right)^{\text{Price Elasticity}}$$

The *Price Elasticity* indicates the effect of price change on the commercial sector's consumption of the particular fuel.

We also apply a multiplicative growth factor, or an index of change in the long-term growth trend relative to the module base year. We set the factor equal to 1 for the base year, and we set it equal to a target value for the final projection year (currently 2050). We then compute the annual growth rate by linear interpolation.

For the reference case, we adjust the commercial consumption projections for the first two projection years to match values published in our *Short-Term Energy Outlook*.

The method just described is used for all fuels except biomass and solar, primarily because no price data are available for these fuels by WEPS region. Very little solar thermal energy is used in commercial activities. Although a larger amount of biomass is used commercially in some regions, much of it is unmarketed (for example, wood gathered in rural areas) and therefore not captured in EIA's historical international energy data.

3. Deriving the Parameters

The elasticities and the *Lag Effect Parameters* in the module are largely based on the behavior of projections from the NEMS *Commercial Demand Module* and adapted to the WEPS regions. To develop these parameters, we analyze the projections from a previous year's *Annual Energy Outlook* Reference case and compare them to those from the corresponding High and Low Economic Growth cases and the corresponding High and Low Oil Price cases.

For example, we estimate the *Output Elasticity* parameters for each year and fuel by examining the differences in projected fuel consumption between the Reference case and the High Economic Growth case relative to the projected changes in service sector gross output. We then repeat the process, examining differences between the Reference case and the Low Economic Growth case projections. Because the estimated Output Elasticity parameters from the two analyses differ, we generally compute the module parameter by averaging the two values. In cases where the resulting parameter seems inappropriate, we use alternative elasticity estimates (for example, estimates based on data from other fuels or sectors) along with expert judgment to arrive at an acceptable parameter value.

We estimate the price elasticities in essentially the same way, using different NEMS projections that reflect changes in specific fuel prices and comparing the projected changes in fuel consumption to those projected for the Reference case. In general, the elasticity for each fuel is an average of estimated elasticities for that fuel, but our analysts use expert judgment when the NEMS-based elasticities don't seem appropriate.

4. Adjusting the Projection Method for Unusual Conditions

Although the basic method just described provides reasonable projections for most fuels, regions, and WEPS cases, we adjust the method as needed to account for unusual conditions.

4.1 Adjusting the trend factor

Under some conditions, a straight-line trend might not be appropriate for a particular projection because we expect a different structural or behavioral trend. For example, consumption of a specific fuel in a specific region might have been recently growing very rapidly and may, therefore, be expected to reach saturation, resulting in a moderation in the trend. The module allows analysts to modify the trend factor by adding an inflection point to the linear trend.

4.2 Accounting for fuel substitution in the High World Oil Price (HWOP) case

When the price of one fuel increases relative to the prices of other fuels, some commercial establishments switch to the cheaper fuel. Because the basic method described in Section 2 involves no fuel cross-price elasticities, it doesn't generally account for fuel substitution. In the HWOP case, however, we modify the method to ensure that the projected decline in petroleum-based fuel consumption (from the Reference case level) results in increases in the projected consumption of other fuels.

We assume that 50% of the petroleum-based fuel consumption decreases in the HWOP case (relative to the Reference case) will be replaced by increases in consumption of other fuels. We estimate the substitution over the years in the projection period (currently from the base year to 2050) so that it starts at 0 in in the base year and gradually increases to its full value five years after the base year. The annual proportion then remains the same through the end of the projection period.

Once we determine, for each year, the amount of petroleum-based fuel consumption to be replaced by consumption of other fuels, we allocate the total amount to natural gas, coal, and electricity, based on the previously projected relative shares of each of these fuels. For example, if 100 trillion British thermal units (Btu) require substitution, and the respective fractional shares of natural gas, coal, and electricity are 0.4, 0.0, and 0.6, respectively, then natural gas will increase by 40 trillion Btu, coal will be unchanged, and electricity will increase by 60 trillion Btu.