Concepts, Data Sources, and Techniques
Handbook of Energy Modeling Methods

World Energy Projection System (WEPS): Commercial Demand Model

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1. Introduction

The WEPS Commercial Demand Model projects energy consumption by businesses, institutions, and service organizations. Most commercial energy use 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 use. The model projects commercial sector energy consumption for a number of energy sources in each of the WEPS regions over the projection horizon. The Commercial Demand Model 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

To project commercial energy consumption, we assume that the following factors determine consumption changes over time:

- Changes in *services 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 services gross output and prices
- A linear trend

Increased services gross output generally leads to higher consumption, while price increases encourage consumption declines. The sensitivity of energy consumption to changes in services gross output and prices varies by region, fuel, and time period and is represented by an elasticity parameter. The 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 services 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:

$$\text{This Year's Consumption} = (\text{Base Year's Consumption}) \times (\text{Index of Change Due to Services Gross Output Changes}) \times (\text{Index of Change Due to Price Changes}) \times (\text{Change Due to a Long-term Trend}).$$

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 Model provides the necessary projections of services gross output, and various other WEPS models provide commercial fuel price projections.

We set the Index of Change Due to Changes in Services Gross Output equal to 1 for the 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 services 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), while the Output Elasticity indicates the impact of services gross output change on the commercial consumption of the particular fuel. For example, a value of 0 for these parameters indicates no effect, while a value of 1 indicates a strong effect. We derive the parameter values by analyzing projections from EIA's U.S. National Energy Modeling System (NEMS) and applying adjustments for the WEPS regions, as discussed in Section 3. The values of services gross output represent the total value of commercial output for the region, adjusted for purchasing power parity.

Similarly, for each fuel, we set the Index of Change Due to Price Change equal to 1 for the base year. Then, for each region and projection year, we calculate an index value by updating the previous year's value as follows:

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

The Price Elasticity indicates the effect of price change on commercial consumption of the particular fuel.

We calculate the Change Due to a Long-term Trend as a simple multiplicative growth factor. 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.

We adjust the commercial consumption projections for the first two projection years to agree with those published in EIA's *Short-Term Energy Outlook*.

The method described above is used for all fuels except biomass and solar, primarily because no price data are available for these fuels for the WEPS regions. Very little solar energy is used in commercial activities. Although a larger amount of biomass is used in some regions, much of it is unmarketed (e.g., 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 model are largely based on the behavior of projections from the NEMS Commercial Model 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 services gross output. We then repeat the process, examining differences between the Reference case and the low Economic Growth case projections. Because the estimated Income Elasticity parameters from the two analyses differ, EIA analysts generally compute the model parameter by averaging the two values. In cases where the resulting parameter seems inappropriate, analysts use alternative elasticity estimates, e.g., 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 manner, 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 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 described above provides reasonable projections for most fuels, regions, and WEPS cases, EIA analysts adjust the method as needed to account for unusual conditions.

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 model allows analysts to modify the trend factor by adding an inflection point to the linear trend.

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 decrease 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 to 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) requires substitution, and the respective shares of natural gas, coal, and electricity are 0.4, 0.0, and 0.6, then natural gas will increase by 40 trillion Btu, coal will be unchanged, and electricity will increase by 60 trillion Btu.