

# **World Energy Projection System Plus Model Documentation 2010: Commercial Model**

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# 1. Introduction

## Purpose of This Report

The Commercial Model of the World Energy Projection System Plus (WEPS+) is an energy demand modeling system of the world commercial end-use sector at a regional level. This report describes the version of the Commercial Model that was used to produce the commercial sector projections published in the *International Energy Outlook 2010 (IEO2010)*. The Commercial Model is one of 13 components of the WEPS+ system and can also be run as a separate, individual model. The WEPS+ is a modular system, consisting of a number of separate energy models that are communicate and work with each other through an integrated system model. The model components are each developed independently, but are designed with well-defined protocols for system communication and interactivity. The WEPS+ modeling system uses a shared database (the “restart” file) that allows all the models to communicate with each other when they are run in sequence over a number of iterations. The overall WEPS+ system uses an iterative solution technique that forces convergence of consumption and supply pressures to solve for an equilibrium price.

This report documents the objectives, analytical approach and development of the WEPS+ Commercial Model. It also catalogues and describes critical assumptions, computational methodology, parameter estimation techniques, and model source code. This document serves three purposes. First, it is a reference document providing a detailed description for model analysts, users, and the public. Second, it meets the legal requirement of the Energy Information Administration (EIA) to provide adequate documentation in support of its models (*Public Law 93-275, section 57.b.1*). Third, it facilitates continuity in model development by providing documentation from which energy analysts can undertake and analyze their own model enhancements, data updates, and parameter refinements for future projects.

## Model Summary

The WEPS+ Commercial Model for the *IEO2010* projects energy consumed by businesses, institutions, and service organizations. Commercial sector energy use covers a broad range of activities and services and includes energy used in schools, stores, correctional institutions, restaurants, hotels, hospitals, museums, office buildings, banks, and sports arenas. 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 Commercial Model projects commercial consumption for 11 energy sources in each of the 16 WEPS+ regions on an annual basis to 2035. The model primarily uses a dynamic econometric equation for the key energy sources, basing the projection on assumptions about future growth in gross domestic product (GDP), commercial retail energy prices for nine fuels, and a trend factor. The dynamic equation uses a lagged dependent variable to imperfectly represent stock accumulation. The GDP and price projections are available to the Commercial Model from the WEPS+ Macroeconomic Model and the supply models through the restart file, which is shared by all WEPS+ models. The trend factor is meant to represent continuing impacts on energy use not directly represented in GDP

and price, and may include a variety of behavioral, structural, and policy-induced activities. The consumption projections generated by the Commercial Model are in turn put into the restart file for use by other models.

## **Model Archival Citation**

This documentation refers to the WEPS+ Commercial Model, as archived for the *International Energy Outlook 2010 (IEO2010)*.

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## **Organization of This Report**

Chapter 2 of this report discusses the purpose of the Commercial Model, the objectives and the analytical issues it addresses, the general types of activities and relationships it embodies, the primary input and output variables, and the relationship of the model to the other models in the WEPS+ system. Chapter 3 of the report describes the rationale behind the Commercial Model design, providing insights into further assumption utilized in the model. Chapter 4 describes the model structure in more detail, including flowcharts, variables, and equations.

## 2. Model Purpose

### Model Objectives

The primary objective of the WEPS+ Commercial Model is to generate regional projections of commercial sector energy use. These projections are computed annually for the period of 2008 through 2035 by fuel type and region. As an integral component of the WEPS+ system, the Commercial Model provides consumption inputs to the transformation and supply models of WEPS+ and contributes to the calculation of the overall energy supply and demand balance. The consumption inputs are also used by the Greenhouse Gases Model to calculate energy-related carbon dioxide emissions.

As part of the WEPS+ system, the Commercial Model provides projections for the 16 WEPS+ world regions (Table 1). These regions consist of countries and country groupings within the broad divide of the Organization of Economic Cooperation and Development (OECD) membership.

**Table 1. Regional Coverage of the World Energy Projection System Plus Model**

OECD Regions	Non-OECD Regions
United States	Russia
Canada	Other Non-OECD Europe and Eurasia
Mexico	China
OECD Europe	India
Japan	Other Non-OECD Asia
Australia/New Zealand	Middle East
South Korea	Africa
	Brazil
	Other Central and South America

### Model Inputs and Outputs

#### Inputs

The Commercial Model uses macroeconomic and commercial price projections that are imported from the WEPS+ restart file. These inputs have been previously projected by the Macroeconomic Model and by the transformation and supply models (Table 2).

**Table 2. WEPS+ Models that Provide Inputs to the Commercial Model**

<b>Commercial Model Input</b>	<b>Source</b>
Gross domestic product	Macroeconomic Model
Commercial motor gasoline retail price	Refinery Model
Commercial distillate retail price	Refinery Model
Commercial residual retail price	Refinery Model
Commercial kerosene retail price	Refinery Model
Commercial LPG retail price	Refinery Model
Commercial natural gas retail price	Natural Gas Model
Commercial coal retail price	Coal Model
Commercial electricity retail price	World Electricity Model
Commercial district heat retail price	District Heat Model

A number of exogenous data series are also imported into the Commercial Model from the ComInput.xml file (Table 3).

**Table 3. Major Exogenous Commercial Model Input Data Series**

<b>Source Input File</b>	<b>Model Input</b>
<b>ComInput.xml</b>	GDP elasticities by fuel and region
	GDP lag coefficients by region and fuel
	Regional by-fuel price elasticities
	Regional by-fuel price lag coefficients
	Regional by-fuel growth trend factors
	User adjustment factors (not currently used)
	Regional by-fuel multiplicative factors applied to GDP and price elasticities (currently not used)
	Total liquids consumption (hard-wired into input file from Reference case run; only used in High Oil Price case)
	Increment of additional liquids that must be allocated to natural gas, coal, and electricity (only used in High Oil Price case)

## Outputs

The Commercial Model projects energy consumption in the commercial or service sector by fuel and region (excluding transportation energy use). Upon completion of a model run, these values are exported into the WEPS+ restart file for use by other models (Table 4).

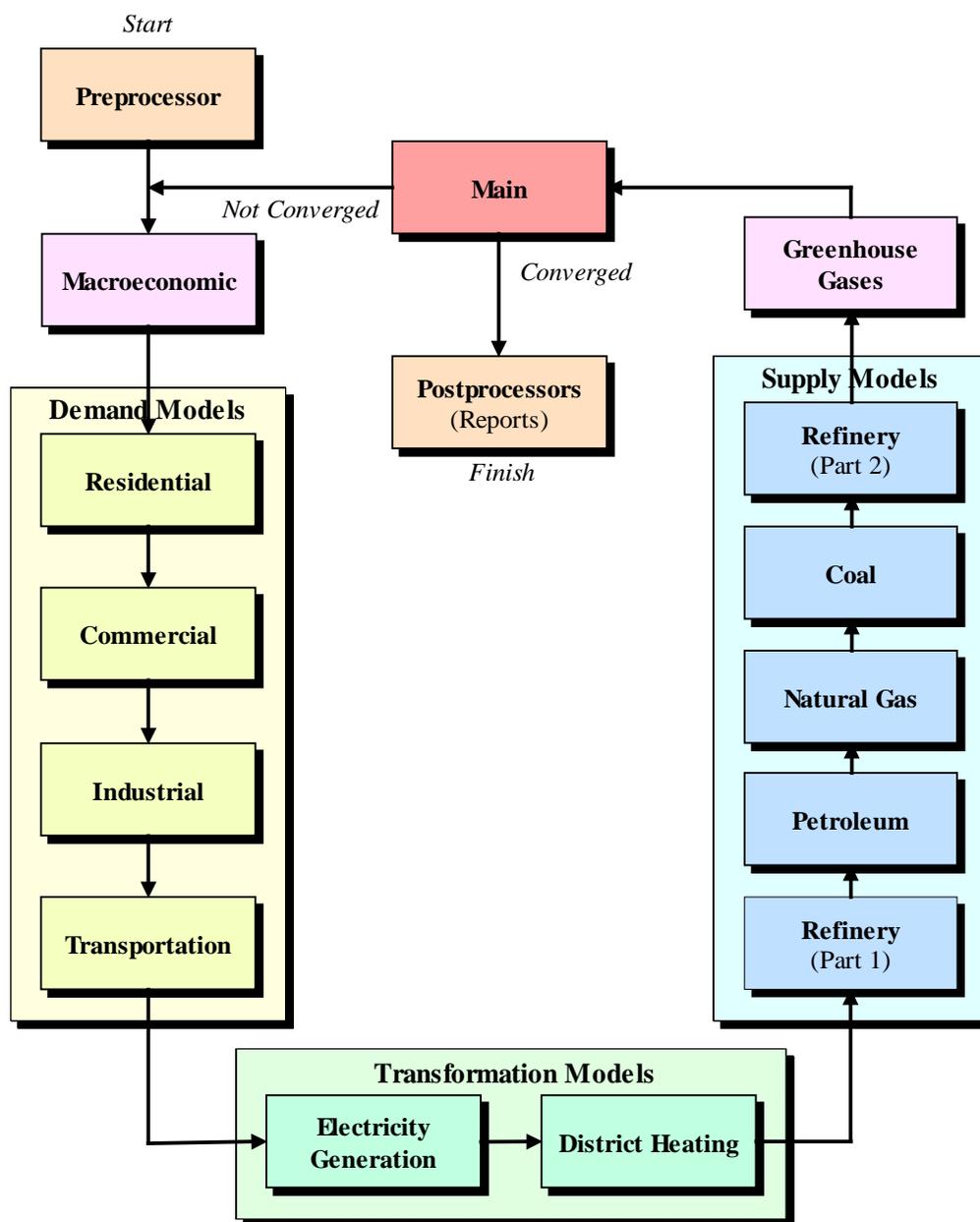
**Table 4. Commercial Model Outputs and the WEPS+ Models that Use Them**

<b>Commercial Model Output</b>	<b>Destination</b>
Motor gasoline consumption	Petroleum Model and Refinery Model
Distillate consumption	Petroleum Model and Refinery Model
Residual fuel consumption	Petroleum Model and Refinery Model
Kerosene consumption	Petroleum Model and Refinery Model
LPG consumption	Petroleum Model and Refinery Model
Natural gas consumption	Natural Gas Model
Coal consumption	Coal Model
Electricity consumption	World Electricity Model
Heat consumption	District Heat Model
Biomass consumption	(Placeholder)
Solar consumption	(Placeholder)

### **Relationship to Other Models**

The Commercial Model is an integral component of the WEPS+ system, and depends upon other models in the system for some of its key inputs. In turn, the Commercial Model provides projections of commercial energy consumption, which are key inputs to other models in the system (Figure 1). A summary description of the models, flows, and mechanics of the WEPS+ system used for the *IEO2010* report is available in a separate *Overview* documentation.

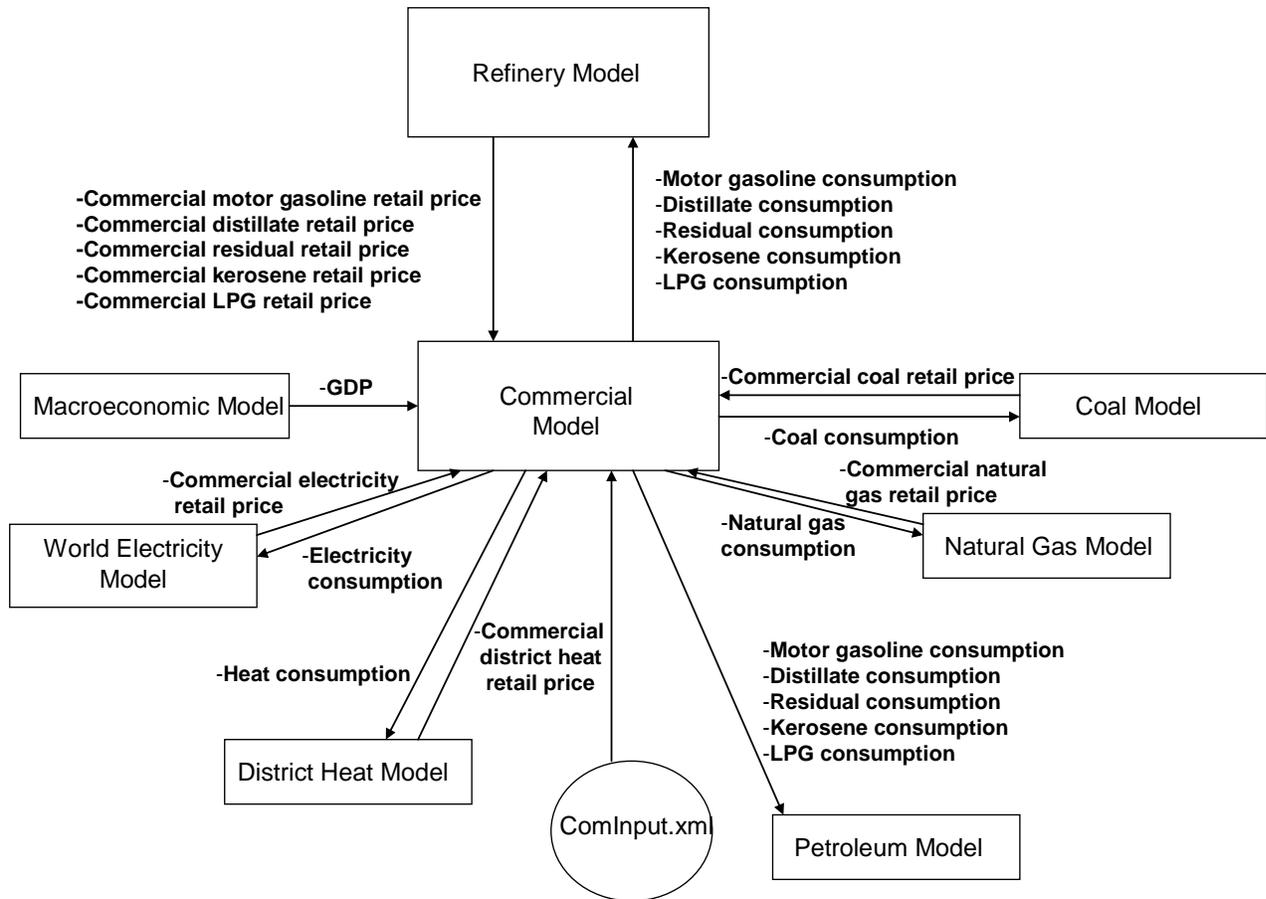
**Figure 1. World Energy Projection System Plus (WEPS+) Model Sequence**



Through the system, the Commercial Model receives GDP projections from the Macroeconomic Model, and receives a variety of Commercial retail price projections from various supply and transformation models (Figure 2). In turn, the Commercial Model provides consumption projections through the system back to the various supply models.

Although the Commercial Model is an integral part of the WEPS+ system, it can also be easily run as a standalone, outside of the system. To do that, the Commercial Model would input macroeconomic and price projections from the WEPS+ system “restart” file as created in a previous system run.

**Figure 2. The Commercial Model Relationship to Other WEPS+ Models**



## 3. Model Rationale

### Theoretical Approach

The Commercial Model makes projections of commercial sector energy consumption based on changes in GDP, energy prices, and a trend factor. Commercial energy consumption is assumed to follow an overall trend while increasing with GDP and responding inversely to price changes. Thus we project energy consumption by applying a trend factor and a series of exponential ratio adjustments to the most recent historical estimates. The exponents of the ratio adjustments, which are imported from other modeling systems, may be interpreted as elasticity estimates: they represent the extent to which energy consumption changes in response to changes in GDP and price. Special adjustments are applied to simulate energy source substitution in the “High World Oil Price” case. Finally, we calibrate the projections to force consistency with EIA’s short term energy projections.

### Model Assumptions

The Commercial Model makes projections of:

- Commercial sector energy consumption, based upon the assumption that changes in consumption are related to changes in GDP
- Commercial sector energy prices, based upon an elasticity measure and the dynamics of a stock-adjustment represented by a lagged dependent variable

The projections are also based upon assumptions about autonomous trends representing behavioral, structural, and/or policy-induced activities. More specifics and the values of the elasticities and trends are presented in the model structure section below.

## 4. Model Structure

### Structural Overview

The main purpose of the Commercial Model is to estimate annual commercial sector energy consumption for 2008 to 2035, by region and fuel type. The Commercial energy consumption calculations are based on regional estimates of GDP, commercial fuel prices (by type), and adjustment trend factors. Consumption is estimated for each of the 16 WEPS+ regions for 11 energy sources: motor gasoline, distillate fuel, residual fuel, kerosene, liquefied petroleum gas (LPG), natural gas, coal, electricity, heat, biomass, and solar energy.

The basic structure of the Commercial Model is illustrated in Figure 3. A call from the WEPS+ interface to the Commercial Model initiates importation of the supporting information from the restart file needed to complete the projection calculations. The Commercial Model then executes the Comm subroutine, the major component of the model, which performs all model computations. Finally, the model executes a subroutine that exports all projections to the restart file for use by other WEPS+ models.

When the Comm subroutine (Figure 4) is initiated by a call from the main Commercial Model, it initiates a call of the CInXML subroutine (Figure 5), which imports from the ComInput.xml file several exogenous data series that the model requires. ComInput.xml includes:

- The economic (GDP) and price elasticities and lag regression coefficients associated with regions, fuels, and years. The economic elasticities indicate the extent to which commercial energy consumption changes in response to changes in GDP.
- Multiplicative and shape and elasticity adjustment factors that are associated with each region and projection year and used if a user-specified adjustment based upon expert judgment is to be incorporated into the projection

After importing these data, the CInXML subroutine recalculates the GDP and price elasticity factors, incorporating any shape-and-elasticity adjustment factors. The adjustment factors were not used for *IEO2010* model runs.

The Comm subroutine then begins to compute commercial sector energy consumption projections by fuel. First, it computes GDP and commercial sector price and trend indices across the projection period by region and fuel. Next, it calculates an overall commercial sector quantity index as the product of the GDP, price, and trend indices. If the user has specified additional adjustments, the Comm subroutine calculates an adjustment index and recalculates the overall commercial sector quantity index to incorporate the adjustment. It then calculates projections of commercial sector energy consumption by fuel, region, and year, both with and without any user-specified multiplicative factors.

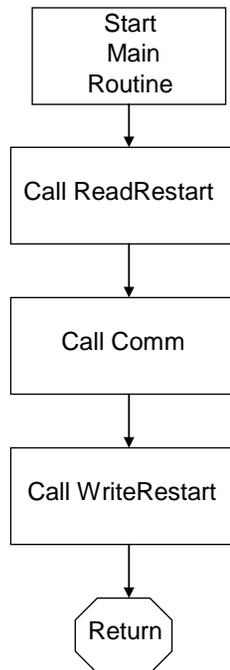
When a High Oil Price case is being implemented, the Comm subroutine imports two additional data series from the ComInput.xml file: total liquids consumption by region and year from the Reference case projections, and a factor that indicates the portion of liquids that will be allocated to natural gas,

coal, and electricity. These amounts are then calculated and allocated to the total commercial sector natural gas, coal, and electricity projections. Finally, the subroutine calculates commercial sector liquids consumption by region and benchmarks the projections to regional *Short-Term Energy Outlook* projections through 2011 (in the case of the *IEO2010*, the January 2010 release was used). The Comm subroutine generates several output files are generated and returns them to the main Commercial Model routine.

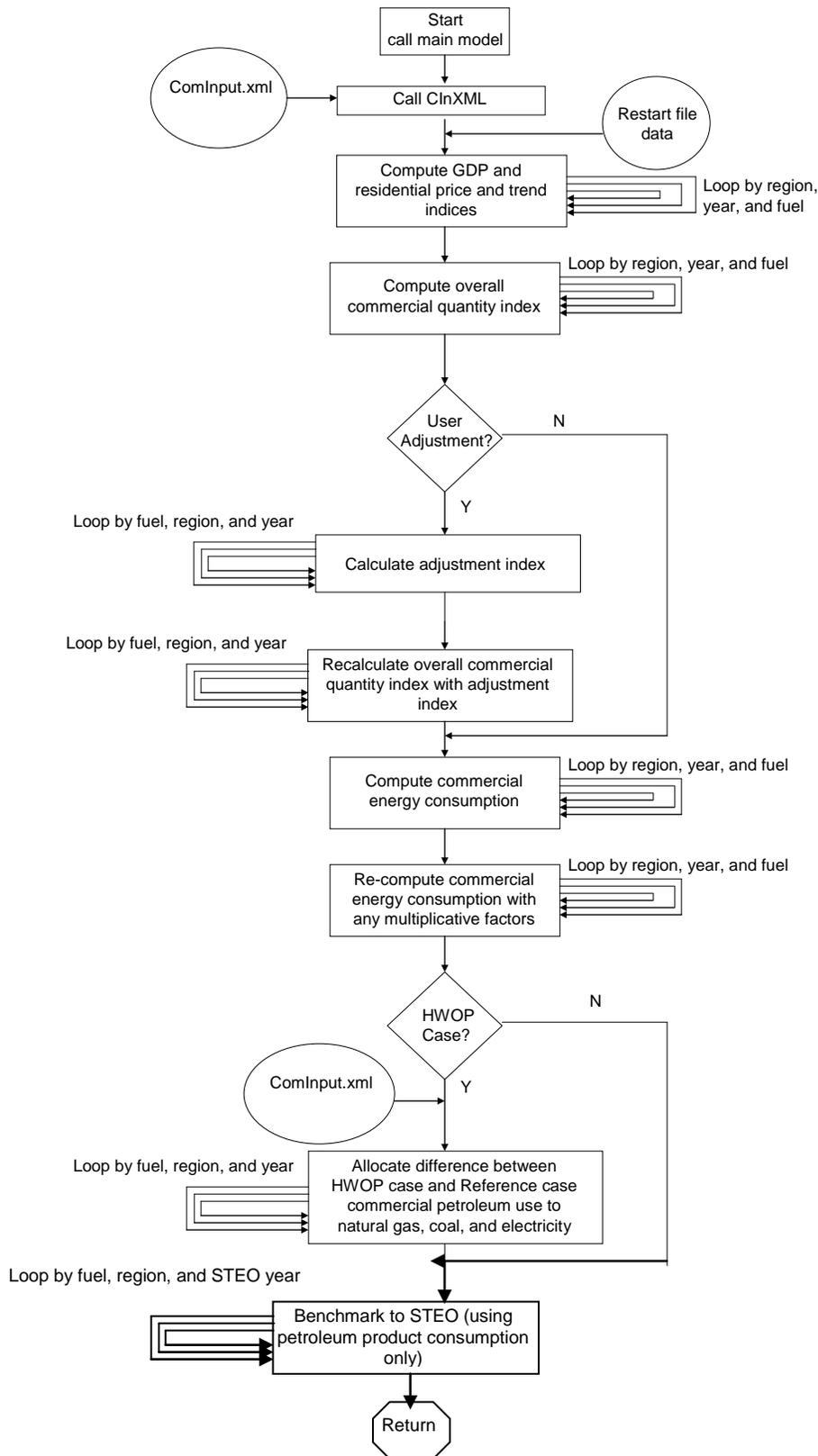
After the Comm subroutine has executed, the WriteRestart subroutine writes the projections to the restart file for use in future iterations of WEPS+, notably in the refinery model. These output data series include projections of regional commercial energy use by fuel.

## Flow Diagrams

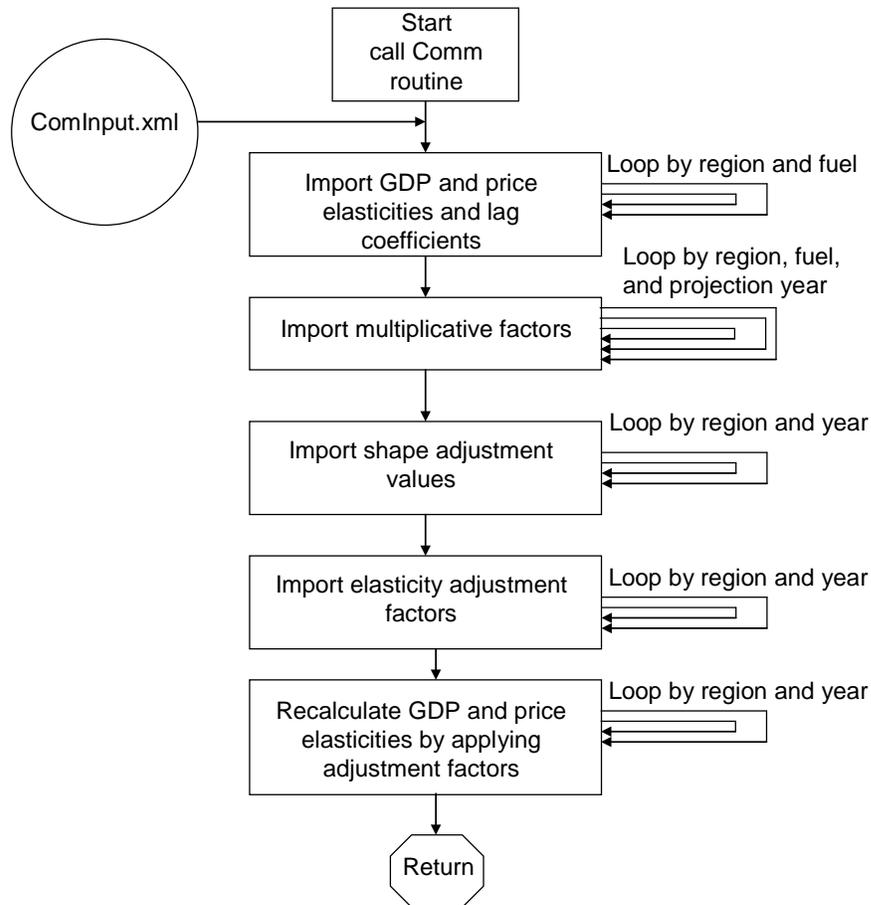
**Figure 3. Flowchart for the Commercial Model**



**Figure 4. Flowchart for the Comm Subroutine**



**Figure 5.** Flowchart for the CInXML Subroutine



## Key Computations

The Commercial Model projects energy that is consumed 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 16 WEPS+ regions over the projection horizon to the year 2035. The Commercial Model projects energy consumption for 11 energy sources:

- Motor gasoline
- Distillate fuel
- Residual fuel

- Kerosene
- LPG
- Natural gas
- Coal
- Electricity
- District Heat (steam or hot water)
- Biomass
- Solar

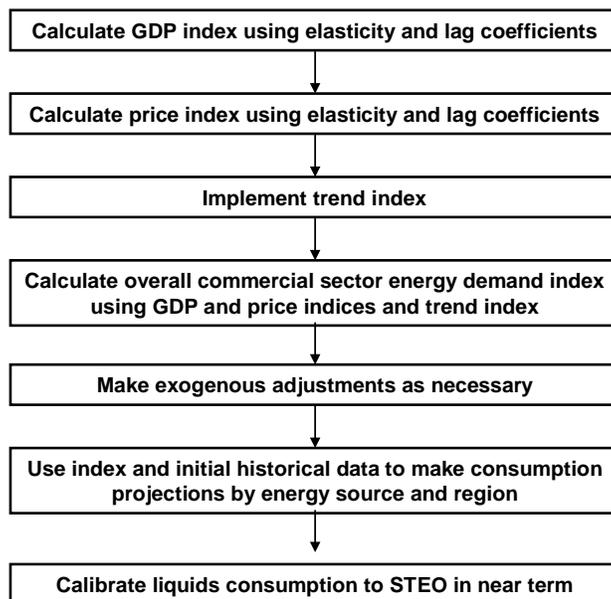
The Commercial Model begins by importing the historical data from the WEPS+ shared restart file. Compiled from the International Energy Agency’s *OECD and Non-OECD Statistics and Balances* databases, these data cover detailed energy end-use consumption in the commercial sector. The data are calibrated to be consistent with the more aggregated energy consumption data from the Energy Information Administration’s International Statistics Database. These data are processed prior to the execution of the Commercial Model and are stored in the restart file to provide a common starting point for all WEPS+ models. The Commercial Model uses the historical data for all years up to the most recent year available (2007 in the case of the *IEO2010*) for each of the 16 regions and 11 energy sources.

Macroeconomic and price projections are also imported into the Commercial Model from the restart file. These data series are projected in previous system iterations by the Macroeconomic Model and by various transformation and supply models (see Table 2).

## Projection Equations

Figure 6 is a flowchart of the Commercial Model’s major computations, which we discuss in detail here. The Commercial Model primarily uses econometric assumptions to estimate change in commercial energy consumption from the year of the most recent historical data (2007). It bases projections for the key energy sources on a GDP projection, commercial retail energy price projections (for 11 energy sources—no prices are used for solar or biomass), and a trend factor. The dynamic equation uses a lagged dependent variable to (imperfectly) represent accumulation of commercial stock—e.g., appliances, lighting, and heating and cooling equipment. The Commercial Model obtains the GDP projections from the WEPS+ Macroeconomic Model through the shared restart file. The GDP projections are expressed in terms of purchasing power parity in real 2005 dollars. Through the restart file, the WEPS+ supply models provide by-fuel price projections to the Commercial Model. The prices are all in terms of real 2008 dollars per million Btu. The trend term is meant to represent continuing impacts on energy use not directly influenced by GDP and/or price; it may account for the effects of a variety of behavioral, structural, and policy-induced activities.

### Figure 6. WEPS+ Commercial Model Basic Flows



The variables used in the projection equations are all expressed in terms of indices indicating change relative to the most recent available historical value (2007). The indexing approach allows the model to consider only changes in the GDP and prices, not their actual levels. The effects of the three drivers of the projection—GDP, prices, and the trend term—are each estimated separately and then multiplied together to get an overall index reflecting projected change in commercial energy consumption. The overall index is then applied to the most recent historical consumption value to compute the projection.

### ***GDP Index Equation***

For each region  $r$  and projection year  $y$ , we first compute the ratio of the GDP in year  $y$  to the GDP in the most recent historical data year,  $LHYr$  (both adjusted to reflect purchasing power parity):

$$GDPI(r, y) = \frac{GDP\_PPP(r, y)}{GDP\_PPP(r, y = LHYr)}$$

The index for the GDP-influenced part of the projection for fuel  $f$  and region  $r$  in year  $y$  is then given by

$$GDPI_{dx}(f, r, y) = \exp(GDPE_{las}(f, r) * \ln(GDPI(r, y)) + GDPL_{ag}(f, r) * \ln(GDPI_{dx}(f, r, y - 1)))$$

Where:  $GDPElas(f,r)$  and  $GDPLag(f,r)$  are exogenous coefficients (read from an input file) for the GDP and for the lag term, respectively, for fuel  $f$  in region  $r$ .

The elasticity coefficient,  $GDPElas(f,r)$ , reflects the extent to which commercial energy consumption increases (or decreases) with GDP. The index  $GDPIIdx(f,r,y)$  starts with a value of 1.0 in the last historical year of 2007.

### **Price Index Equation**

The effect of prices on commercial energy consumption is estimated in similar fashion, except that the price change ratio is estimated separately for each fuel. Let

$$CPIIdx(f, r, y) = \frac{RetailPrice(f, r, y)}{RetailPrice(f, r, y = LHYr)}$$

Where:  $RetailPrice(f,r,y)$  is the retail price of fuel  $f$  in region  $r$  and year  $y$ .

The effect of prices on commercial energy consumption is then estimated as

$$PrIdx(f, r, y) = \exp(PrElas(f, r) * \ln(CPIIdx(f, r, y)) + PrLag(f, r) * \ln(PrIdx(f, r, y - 1))),$$

Where:  $PrElas(f,r)$  and  $PrLag(f,r)$  are exogenous coefficients (read from an input file) for the price ratio and the lag term, respectively. The elasticity coefficient,  $PrElas(f,r)$ , reflects the extent to which commercial consumption of fuel  $f$  in region  $r$  changes in response to changes in price.

Prices are available for all primary nonrenewable fuels (i.e., all except electricity, district heat, solar, and biomass).

### **Trend Index**

The trend coefficient,  $TrendGR(f,r)$ , which is read from an input file, represents a constant as an annual growth rate applied to consumption projections for all years to 2035. The growth rate is used to calculate the trend index term for the last model year of 2035, applying the growth rate over the period from the last historical year of 2007 to the last model year of 2035. The index begins in 2007 with a value of 1.0. Once the implied value for 2035 has been calculated, the model fills in all the intervening years by linear interpolation:

$$EffIdx(f, r, y = 2035) = EffIdx(f, r, y = 2007) * TrendGR(f, r, y)^{(2035 - 2007)}$$

For years from 2008 to 2034:

$$EffIdx(f, r, y) = EffIdx(f, r, y = 2007) + (EffIdx(f, r, y = 2035) - EffIdx(f, r, y = 2007)) / \left( \frac{y - 2007}{2035 - 2007} \right)$$

## **Overall Projection Index**

The overall projection index for each region and fuel is calculated by multiplying by the GDP index, price index, and efficiency index:

$$CQIdx(f, r, y) = GDPIdx(f, r, y) * PrcIdx(f, r, y) * EffIdx(f, r, y)$$

Where:  $CQIdx$  is the overall projection index in each region, for each fuel, over the projection horizon.

## **Exogenous Inflection Algorithm**

The model projection described thus far consists of an index based on a GDP projection, a price projection, and a trend factor. The trend projection is computed by linear interpolation between the 2005 value and a target value for 2030. In some cases, however, linear interpolation may not be appropriate for the particular projection, because a different structural or behavioral trend is expected. For example, consumption of a specific fuel in a specific region may have grown rapidly in recent years and be expected to reach saturation, resulting in a moderation of the trend. The model therefore allows the user to modify the projection index by adding an exogenous inflection.

To accomplish this, the user specifies the year for the midpoint of the inflection and a fraction indicating the strength of the inflection. The fraction would be a number such as 1.1, indicating that in the specified year the projection index should be 1.1 times its original value. A value of 1.0 has no effect and a value of 0.9 means the projection index in the inflection year should be 0.9 times its original value. The algorithm then will also modify all the other projection index points to smooth the series on each side of the inflection point. For example, if the inflection point is at 2010, then the values from 2006 through 2009 are smoothed based up the values in 2005 and 2010, and the values from 2011 through 2029 are smoothed based up the values in 2010 and 2030. The smoothing algorithm uses a sine wave so that points close to the inflection point are modified more than the points nearer to the end points of the series. This approach is meant to approximate a spline smoothing technique without the computational complexity of the spline calculation.

For the *IEO2010* Reference case, exogenous inflection factors were used only for adjusting electricity projections for the following regions and years:

- Mexico in 2015, inflection factor = 1.15
- OECD Europe in 2012, inflection factor = 1.10
- Australia/New Zealand in 2012, inflection factor = 1.15
- China in 2010, inflection factor = 1.15
- India in 2011, inflection factor = 1.15
- Brazil in 2017, inflection factor = 1.15
- Other Central and South America in 2014, adjustment factor = 1.04

Exogenous inflection factors therefore affect only 7 out of the 176 *IEO2010* Reference case series (11 fuels crossed by 16 regions).

### **Consumption Projection**

Finally, the historical starting consumption values are multiplied by the projection indices to project consumption over the projection horizon for each fuel  $f$ , region  $r$ , and year  $y$ :

$$CQty(f, r, y) = CQIdx(f, r, y) * HQty(f, r, y = 2007)$$

Where:  $CQIdx$  is the overall projection index in each region, for each fuel, over the projection horizon

$HQty$  is the historical consumption in 2007 by region and fuel

$CQty$  is the resulting consumption projection over the projection horizon by region and fuel

The above equation is for all of the fuels except biomass and solar. The consumption of biomass and solar is not part of the equation primarily because there are no prices for solar and biomass, but also because these fuels account for a small percentage of commercial energy consumption. Very little solar energy is being used in commercial activities. Although a comparatively large amount of biomass is used in some regions, much of it is unmarketed and therefore not captured in the Energy Information Administration's historical international energy data.

### **Adjustment Factors**

In order to provide user control over the projections, the input file contains factors that users can set to adjust estimates for any fuel in any region and year. The system simply multiplies the specified consumption projection value by the user-specified factor. This function is not expected to be widely used and was not used for the *IEO2010*.

### **High World Oil Price Fuel Substitution**

In the High World Oil Price (HWOP) scenario, the level of petroleum consumption declines significantly. The model formulation shown above, however, assumes no elasticity of substitution across fuels. This assumption was considered appropriate for the original Reference case, because the model was "calibrated" through user judgment for each of the individual fuels. However, because high oil prices may cause considerable substitution away from petroleum-based fuels, a simple algorithm was built into the model to recognize this fuel substitution.

In the HWOP case, a portion of the decline in petroleum consumption from the level in the Reference case is replaced by increases in consumption of other fuels. In order to determine how

much petroleum consumption has declined from the Reference case, the system first reads in some data that specify the level of petroleum consumption in the Reference case. These data are supplemented with other data that provide the fractional increment of the petroleum that will be replaced by other fuels. In the input file, the fractional increment is set to be 0.5 in all regions, meaning that 50 percent of the petroleum decrease in the HWOP case will be replaced by an increase in other fuel substitutions. The model achieves the substitution over the years 2010 to 2030, and modifies the fractional increment so that it starts at 0 in 2010, gradually increases to its full value in 2020, then remains constant to 2030.

Once the model determines how much petroleum will be replaced by other fuels, it allocates consumption increases to natural gas, coal, and electricity, based on the current relative shares (expressed in Btu) of each of these fuels. For example, if 100 trillion Btu will be replaced, and the respective consumption 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.

### **STEO Calibration**

The Energy Information Administration's *Short-Term Energy Outlook (STEO)* projects worldwide liquid fuels consumption to 2011. The regions in the *STEO* are more aggregate than in the WEPS+, and the consumption projections are for total petroleum with no sectoral or product differentiation. The *IEO2010* projections must be consistent with the values in the *STEO* for the projection years. Outside of the Commercial Model but within the WEPS+, the Main Model reads the *STEO* data in each iteration. Based on the results from the current iteration, the Main Model allocates the total petroleum consumption to some sub-regions and to all the detailed end use sectors. The exception to this step is the electric power sector, where liquids-fired generation is not included, because electricity generation is a small liquids-consuming sector, and it is complicated due to its transformation of energy. Instead, the amount of liquids consumed in the electricity generation sector is subtracted from the total *STEO* liquids consumption. After that, the remaining amount of liquids consumption is allocated to the remaining sectors, based on the remaining share of liquids consumption. These quantities are then exported to the restart file for use by each of the WEPS+ models for calibration to *STEO*. It is worth noting that these sector allocations are performed by the Main Model for each WEPS+ iteration. Thus the allocated amounts adapt to changes in the sector-level consumption shares as the model moves towards the equilibrium solution.

The Commercial Model reads the *STEO* petroleum allocations for the commercial sector from the restart file, and then computes calibration factors for each petroleum product in each region for each of the years from 2008 through 2011. These factors are simply the ratios of the *STEO* commercial sector energy consumption allocation to the model's projection consumption in those years:

For each region  $r$  and year  $y$ , from 2008 through 2011,

$$STEOFac(r, y) = \frac{STEOQty(r, y)}{CQty(f = petroleum, r, y)}$$

Where:  $STEOQty(r, y)$  is the *STEO* Commercial consumption allocation

$CQty(f=petroleum, r, y)$  is the model's total petroleum consumption

$STEOFac(r,y)$  is the *STEO* calibration factor.

The *STEO* calibration factors are then multiplied against the model petroleum consumption projections in the years 2008 through 2011, so that the model projects the *STEO* consumption levels.

$$QMGRS(r, y) = QMGRS'(r, y) * STEOFac(r, y)$$

$$QDSRS(r, y) = QDSRS'(r, y) * STEOFac(r, y)$$

$$QRSRS(r, y) = QRSRS'(r, y) * STEOFac(r, y)$$

$$QKSRS(r, y) = QKSRS'(r, y) * STEOFac(r, y)$$

$$QLGRS(r, y) = QLGRS'(r, y) * STEOFac(r, y)$$

Where:  $QMGRS$  is the commercial motor gasoline consumption

$QDSRS$  is the commercial distillate consumption

$QRSRS$  is the commercial residual consumption

$QKSRS$  is the commercial kerosene consumption

$QLGRS$  is the commercial LPG consumption

Because the magnitude of *STEO* calibration adjustment for 2011 can be significant, a break in series could result if the WEPS+ consumption levels for 2012 were left unadjusted. The 2011 *STEO* calibration factors are therefore applied, in mitigated form, to the projections for 2011 to 2021. The mitigated adjustment factors gradually converge to 1.0 over the 10-year period from 2011 to 2021, providing a smooth transition from the *STEO*-calibrated projections to the uncalibrated WEPS+ projections.

## Appendix A. Model Abstract

**Model Name:**

Commercial Model of the World Energy Projection System Plus

**Model Acronym:**

Commercial Model

**Model Description:**

The Commercial Model of the World Energy Projection System Plus (WEPS+) models world commercial energy demand and provides consumption projections for 11 energy sources in 16 international regions. For the *IEO2010*, the Commercial Model provided energy consumption projections for the commercial or services sector. The 11 energy sources covered include motor gasoline, distillate fuel, residual fuel, kerosene, liquid petroleum gas, natural gas, coal, electricity, heat, solar, and biomass. The 16 WEPS regions cover the globe, and the projection period extends to the year 2035.

**Model Purpose:**

As a component of the World Energy Projection System Plus (WEPS+) integrated modeling system, the Commercial Model generates long-term projections of commercial sector energy consumption. The model also provides consumption inputs for a variety of the other WEPS+ models. The model provides a tool for analysis of international commercial sector energy use within the WEPS+ system, and can be run independently as a standalone model.

**Most Recent Model Update:**

December 2009.

**Part of Another Model:**

World Energy Projection System Plus (WEPS+).

**Model Interfaces:**

The Commercial Model receives inputs from and provides output to the Macroeconomic Model, Refinery Model, Natural Gas Model, Coal Model, World Electricity Model, and District Heat Model through the common, shared interface file of the WEPS+. In addition, the Commercial Model provides output to the Petroleum Model, again through the common, shared interface file.

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**Documentation:**

Energy Information Administration, U.S. Department of Energy, *Commercial Model of the World Energy Projection System Plus: Model Documentation 2010*, DOE/EIA-M075(2010) (Washington, DC, July 2010).

**Archive Information:**

The model is archived as part of the World Energy Projection System Plus archive of the runs used to generate the *International Energy Outlook 2010*.

**Energy System Described:**

International commercial sector energy consumption.

**Coverage:**

- Geographic: Sixteen WEPS+ regions: U.S., Canada, Mexico, OECD Europe, Japan, Australia/New Zealand, South Korea, Russia, Other non-OECD Europe and Eurasia, China, India, other non-OECD Asia, Middle East, Africa, Brazil, and other Central and South America.
- Mode: total commercial energy consumption.
- Time Unit/Frequency: Annual, 2008 through 2035.

**Modeling Features:**

The Commercial Model makes projections of commercial sector energy consumption based upon changes in GDP, energy prices, and a trend term. The model uses a dynamic simulation approach, using elasticities to model the changes over time and a lagged dependent variable to simulate dynamic adjustments.

**DOE Input Sources:**

Energy Information Administration, International Energy Statistics Database, web site [www.eia.gov/emeu/international](http://www.eia.gov/emeu/international) (as of November 30, 2009).

Energy Information Administration, *Short Term Energy Outlook* (STEO), Washington, D.C., (January 2010 release).

***Non-DOE Input Sources:***

International Energy Agency (IEA), *Energy Balances of OECD Countries*, Paris, 2009.

International Energy Agency (IEA), *Energy Balances of Non-OECD Countries*, Paris, 2009.

IHS Global Insight, *World Overview, Third Quarter 2009* (Lexington, MA, November 2009).

***Independent Expert Reviews:***

None

***Computing Environment:***

*Hardware/Operating System:* Basic PC with Windows XP (or other Windows OS).

*Language/Software Used:* Fortran 90/95 (Currently using Compaq Visual Fortran), not required at runtime.

*Run Time/Storage:* Standalone model with one iteration runs in about 3-4 seconds, CPU memory is minimal, inputs/executable/outputs require less than 20MB storage.

*Special Features:* None.

## Appendix B. Input Data and Variable Descriptions

The following variables represent data input from the file ComInput-JH121609.txt.

Classification: Input variable.

<i>GDPElas(f,r):</i>	GDP elasticity by fuel (motor gasoline, distillate, residual, kerosene, LPG, natural gas, coal, electricity, and heat; excludes renewable energy sources) and region
<i>GDPLag(f,r):</i>	GDP lag coefficient by region and fuel
<i>PrcElas(f,r):</i>	Regional by-fuel price elasticity
<i>PrcLag(f,r):</i>	Regional by fuel price lag coefficient
<i>TrendGR(f,r):</i>	Regional growth trend term by fuel
<i>MltFac(f,r,y):</i>	Commercial multiplicative factor by region, fuel (motor gasoline, distillate, residual fuel kerosene, LPG, natural gas, coal, electricity, heat, solar, and biomass) and projection year
<i>AdjYr(f,r):</i>	User adjustment term to change shape of Commercial consumption trend path by fuel and region (note: not currently used in the model)
<i>EGDPFac(f, r):</i>	Regional by-fuel multiplicative factors applied to GDP elasticities (note: currently all set to 1.0)
<i>EPrcFac(f,r):</i>	Regional by-fuel multiplicative factors applied to price elasticities (note: currently all set to 1.0)
<i>PetRef(r,y):</i>	Total liquids consumption in the Reference case by region and year (note: this must physically be updated to current reference case when user intends to run a High Oil Price scenario)
<i>PetFacA(r):</i>	Increment of additional liquids in the High Oil Price case that must be allocated to natural gas, coal, and electricity by region

The following variables represent data input from the restart file.

Classification: Input variable from the Macroeconomic Model, Refinery Model, and supply models.

<i>GDP_PPP(r,y):</i>	Regional GDP expressed in purchasing power parity by year (note r = 17 is total world GDP)
<i>PMGCM(r,y):</i>	Retail price of motor gasoline for commercial sector energy use by region and year
<i>PDSCM(r,y):</i>	Retail price of distillate fuel for commercial sector energy use by region and year
<i>PRSCM(r,y):</i>	Retail price of residual fuel for commercial sector energy use by region and year
<i>PKSCM(r,y):</i>	Retail price of kerosene for commercial sector energy use by region and year

<i>PLGCM(r,y):</i>	Retail price of liquefied petroleum gas for commercial sector energy use by region and year
<i>PNGCM(r,y):</i>	Retail price of natural gas for commercial sector energy use by region and year
<i>PCLCM(r,y):</i>	Retail price of coal for commercial sector energy use by region and year
<i>PELCM(r,y):</i>	Retail price of electricity for commercial sector energy use by region and year
<i>PHTCM(r,y):</i>	Retail price of heat for commercial sector energy use by region and year
<i>AMGSCM(r,y):</i>	Carbon price increment to the commercial sector motor gasoline price associated with the carbon allowance price by region and year (dollars per million Btu)
<i>ADSCM(r,y):</i>	Carbon price increment to the commercial sector distillate (diesel) fuel price associated with the carbon allowance price by region and year (dollars per million Btu)
<i>ARSCM(r,y):</i>	Carbon price increment to the commercial sector distillate (diesel) fuel price associated with the carbon allowance price by region and year (dollars per million Btu)
<i>AKSCM(r,y):</i>	Carbon price increment to the commercial sector kerosene price associated with the carbon allowance price by region and year (dollars per million Btu)
<i>ALGCM(r,y):</i>	Carbon price increment to the commercial sector liquefied petroleum gas price associated with the carbon allowance price by region and year (dollars per million Btu)
<i>ANGCM(r,y):</i>	Carbon price increment to the commercial sector natural gas price associated with the carbon allowance price by region and year (dollars per million Btu)
<i>ACLCM(r,y):</i>	Carbon price increment to the commercial sector coal price associated with the carbon allowance price by region and year (dollars per million Btu)
<i>AELCM(r,y):</i>	Carbon price increment to the commercial sector electricity price associated with the carbon allowance price by region and year (dollars per million Btu)
<i>AHTCM(r,y):</i>	Carbon price increment to the commercial sector heat price associated with the carbon allowance price by region and year (dollars per million Btu)
<i>QHMGCM(r,y):</i>	Historical motor gasoline consumption in the commercial sector by region and year (years 2004 through 2007)
<i>QHDSCM(r,y):</i>	Historical distillate fuel consumption in the commercial sector by region and year (years 2004 through 2007)
<i>QHKSCM(r,y):</i>	Historical kerosene consumption in the commercial sector by region and year (years 2004 through 2007)

<i>QHRSCM(r,y):</i>	Historical residual fuel consumption in the commercial sector by region and year (years 2004 through 2007)
<i>QHLGCM(r,y):</i>	Historical liquefied petroleum gas consumption in the commercial sector by region and year (years 2004 through 2007)
<i>QHSPCM(r,y):</i>	Historical sequestered petroleum fuel consumption in the commercial sector by region and year (years 2004 through 2007)
<i>QHNGCM(r,y):</i>	Historical natural gas consumption in the commercial sector by region and year (years 2005 through 2007)
<i>QHCLCM(r,y):</i>	Historical coal consumption in the commercial sector by region and year (years 2005 through 2007)
<i>QHELCM(r,y):</i>	Historical electricity consumption in the commercial sector by region and year (years 2005 through 2007)
<i>QHHTCM(r,y):</i>	Historical heat consumption in the commercial sector by region and year (years 2005 through 2007)
<i>QHBMC(r,y):</i>	Historical biomass consumption in the commercial sector by region and year (years 2005 through 2007)
<i>QHSLCM(r,y):</i>	Historical solar energy consumption in the commercial sector by region and year (years 2005 through 2007)
<i>STEOPTCM(r,y):</i>	Projections of liquids for the commercial sector based upon EIA's <i>Short-Term Energy Outlook</i> by region and year (years 2008 through 2011)

The following variables represent data calculated in the subroutine Comm.

Classification: Computed variable.

<i>XPr(f,r,y):</i>	By-fuel regional price adjusted according to carbon price
<i>CQIdx(f,r,y):</i>	Commercial sector overall index combining GDP, price, and trend by fuel, region, and year
<i>GDPIIdx(f,r,y):</i>	GDP index by fuel, region, and year
<i>PrIdx(f,r,y):</i>	Price index by fuel, region, and year
<i>EffIdx(f,r,y):</i>	Trend term growth index by fuel, region, and year
<i>AdjIdx(f,r,y):</i>	Adjustment index to apply a user adjustment term to the consumption curves to effect a trend change (not currently used in the model)
<i>QMGCM(r,y):</i>	Consumption of commercial sector motor gasoline by region and year
<i>QDSCM(r,y):</i>	Consumption of commercial sector distillate fuel by region and year
<i>QRSCM(r,y):</i>	Consumption of commercial sector residual fuel by region and year

$QKSCM(r,y)$ :	Consumption of commercial sector kerosene by region and year
$QLGCM(r,y)$ :	Consumption of commercial sector liquefied petroleum gas by region and year
$QNGCM(r,y)$ :	Consumption of commercial sector natural gas by region and year
$QCLCM(r,y)$ :	Consumption of commercial sector coal by region and year
$QELCM(r,y)$ :	Consumption of commercial sector electricity by region and year
$QHTCM(r,y)$ :	Consumption of commercial sector district heat by region and year
$QBMCM(r,y)$ :	Consumption of commercial sector biomass by region and year
$QSLCM(r,y)$ :	Consumption of commercial sector solar energy by region and year

### **Coefficient Sources**

The elasticity and the lag coefficients used in the Commercial Model were largely developed from the U.S. National Energy Modeling System (NEMS) Commercial Module and adapted to the WEPS+ international regions. These elasticities were computed in an Excel spreadsheet through an analysis of the relationship between a previous *Annual Energy Outlook* Reference case, the corresponding High and Low Economic Growth cases, and the corresponding High and Low Oil Price cases. For example, GDP elasticities were calculated for each year, by sector and fuel, by first examining the difference in energy demand, relative to the difference in GDP, between the Reference case and the high GDP case. This comparison process was repeated using the Reference case and the low Economic Growth (i.e., low GDP) case.

The estimated GDP elasticities varied across scenarios. In general, the average of the High and Low Economic Growth cases was used in the WEPS+. In some cases, modifications based on analyst judgment were applied to ensure reasonability.

The price elasticities were calculated in essentially the same manner, using the results of NEMS runs were for high and low world oil prices. In these runs, prices for the non-petroleum fuels also changed, and the changes were used for sensitivity analysis. When the price elasticity coefficients were used and placed into WEPS+, the level of the GDP elasticities were increased by a factor of 1.25 for many of the developing or rapidly changing regions, including Mexico, South Korea, and all of the non-OECD regions.

The Commercial Model coefficients were used in a calibration process to provide a projection for each energy source based on the previous Commercial Model projections for the *IEO*. This was accomplished by calculating a target growth pattern resulting in growth similar to that in previous *IEO* reports, but accounting for subsequent GDP and price changes. This is done in an attempt to capture the extent of future efficiency or usage trends that have been established through accumulated expert judgment and built into previous projections. This final calibration, based on the trends incorporated in previous projections and on expert judgment, provides some consistency with

previous projections, but is ultimately validated during the run process with newer and more current information or understanding.

### ***Coefficients Used for IEO2010***

Table 5 provides the coefficients that were used in the projection equation for the *IEO2010*. These are largely determined in the process described above, but in several cases, various coefficients (typically the trend factor) were changed based on analyst judgment. It is worth noting that in most cases the elasticities and lag coefficients vary little from region to region (GDP varies somewhat more) and among the petroleum products.

**Table 5 Commercial Model Projection Equation Coefficients**

		<b>GDPElas</b>	<b>GDPLag</b>	<b>PrcElas</b>	<b>PrcLag</b>	<b>TrendGR</b>
USA	MG	0.083	0.695	-0.136	0.533	-0.0064
USA	DS	0.083	0.695	-0.136	0.533	-0.0064
USA	RS	0.083	0.695	-0.136	0.533	-0.0064
USA	KS	0.083	0.695	-0.136	0.533	-0.0064
USA	LG	0.083	0.695	-0.136	0.533	-0.0064
USA	NG	0.100	0.819	-0.240	0.032	-0.0002
USA	CL	0.100	0.500	-0.100	0.500	-0.0051
USA	EL	0.074	0.865	-0.147	0.609	0.0084
USA	HT	0.037	0.865	-0.074	0.305	0.0004
CAN	MG	0.083	0.695	-0.136	0.533	0.0013
CAN	DS	0.083	0.695	-0.136	0.533	0.0013
CAN	RS	0.083	0.695	-0.136	0.533	0.0013
CAN	KS	0.083	0.695	-0.136	0.533	0.0013
CAN	LG	0.083	0.695	-0.136	0.533	0.0013
CAN	NG	0.100	0.819	-0.240	0.032	0.0050
CAN	CL	0.100	0.500	-0.100	0.500	-0.0036
CAN	EL	0.074	0.865	-0.147	0.609	0.0141
CAN	HT	0.037	0.865	-0.074	0.305	0.0005
MEX	MG	0.104	0.695	-0.136	0.533	0.0039
MEX	DS	0.104	0.695	-0.136	0.533	0.0039
MEX	RS	0.104	0.695	-0.136	0.533	0.0039
MEX	KS	0.104	0.695	-0.136	0.533	0.0039
MEX	LG	0.104	0.695	-0.136	0.533	0.0039
MEX	NG	0.125	0.819	-0.240	0.032	0.0160
MEX	CL	0.125	0.500	-0.100	0.500	-0.0082
MEX	EL	0.093	0.865	-0.147	0.609	0.0353

		<b>GDPElas</b>	<b>GDPLag</b>	<b>PrcElas</b>	<b>PrcLag</b>	<b>TrendGR</b>
MEX	HT	0.046	0.865	-0.074	0.305	-0.0044
EUR	MG	0.083	0.695	-0.136	0.533	-0.0067
EUR	DS	0.083	0.695	-0.136	0.533	-0.0067
EUR	RS	0.083	0.695	-0.136	0.533	-0.0067
EUR	KS	0.083	0.695	-0.136	0.533	-0.0067
EUR	LG	0.083	0.695	-0.136	0.533	-0.0067
EUR	NG	0.100	0.819	-0.240	0.032	-0.0026
EUR	CL	0.100	0.500	-0.100	0.500	-0.0166
EUR	EL	0.074	0.865	-0.147	0.609	0.0091
EUR	HT	0.037	0.865	-0.074	0.305	0.0007
JPN	MG	0.083	0.695	-0.136	0.533	-0.0033
JPN	DS	0.083	0.695	-0.136	0.533	-0.0033
JPN	RS	0.083	0.695	-0.136	0.533	-0.0033
JPN	KS	0.083	0.695	-0.136	0.533	-0.0033
JPN	LG	0.083	0.695	-0.136	0.533	-0.0033
JPN	NG	0.100	0.819	-0.240	0.032	0.0012
JPN	CL	0.100	0.500	-0.100	0.500	-0.0084
JPN	EL	0.074	0.865	-0.147	0.609	0.0051
JPN	HT	0.037	0.865	-0.074	0.305	0.0031
ANZ	MG	0.083	0.695	-0.136	0.533	-0.0022
ANZ	DS	0.083	0.695	-0.136	0.533	-0.0022
ANZ	RS	0.083	0.695	-0.136	0.533	-0.0022
ANZ	KS	0.083	0.695	-0.136	0.533	-0.0022
ANZ	LG	0.083	0.695	-0.136	0.533	-0.0022
ANZ	NG	0.100	0.819	-0.240	0.032	-0.0073
ANZ	CL	0.100	0.500	-0.100	0.500	-0.0075
ANZ	EL	0.074	0.865	-0.147	0.609	0.0061
ANZ	HT	0.037	0.865	-0.074	0.305	-0.0007
SKO	MG	0.104	0.695	-0.136	0.533	-0.0074
SKO	DS	0.104	0.695	-0.136	0.533	-0.0074
SKO	RS	0.104	0.695	-0.136	0.533	-0.0074
SKO	KS	0.104	0.695	-0.136	0.533	-0.0074
SKO	LG	0.104	0.695	-0.136	0.533	-0.0074
SKO	NG	0.125	0.819	-0.240	0.032	0.0021
SKO	CL	0.125	0.500	-0.100	0.500	-0.0074

		<b>GDPElas</b>	<b>GDPLag</b>	<b>PrcElas</b>	<b>PrcLag</b>	<b>TrendGR</b>
SKO	EL	0.093	0.865	-0.147	0.609	0.0087
SKO	HT	0.046	0.865	-0.074	0.305	-0.0039
RUS	MG	0.104	0.695	-0.136	0.533	-0.0159
RUS	DS	0.104	0.695	-0.136	0.533	-0.0159
RUS	RS	0.104	0.695	-0.136	0.533	-0.0159
RUS	KS	0.104	0.695	-0.136	0.533	-0.0159
RUS	LG	0.104	0.695	-0.136	0.533	-0.0159
RUS	NG	0.125	0.819	-0.240	0.032	0.0138
RUS	CL	0.125	0.500	-0.100	0.500	-0.0142
RUS	EL	0.093	0.865	-0.147	0.609	0.0112
RUS	HT	0.046	0.865	-0.074	0.305	-0.0052
URA	MG	0.104	0.695	-0.136	0.533	-0.0084
URA	DS	0.104	0.695	-0.136	0.533	-0.0084
URA	RS	0.104	0.695	-0.136	0.533	-0.0084
URA	KS	0.104	0.695	-0.136	0.533	-0.0084
URA	LG	0.104	0.695	-0.136	0.533	-0.0084
URA	NG	0.125	0.819	-0.240	0.032	-0.0077
URA	CL	0.125	0.500	-0.100	0.500	-0.0077
URA	EL	0.093	0.865	-0.147	0.609	0.0097
URA	HT	0.046	0.865	-0.074	0.305	-0.0073
CHI	MG	0.104	0.695	-0.136	0.533	-0.0182
CHI	DS	0.104	0.695	-0.136	0.533	-0.0182
CHI	RS	0.104	0.695	-0.136	0.533	-0.0182
CHI	KS	0.104	0.695	-0.136	0.533	-0.0182
CHI	LG	0.104	0.695	-0.136	0.533	-0.0182
CHI	NG	0.125	0.819	-0.240	0.032	0.0293
CHI	CL	0.125	0.500	-0.100	0.500	-0.0102
CHI	EL	0.093	0.865	-0.147	0.609	0.0290
CHI	HT	0.046	0.865	-0.074	0.305	-0.0113
IND	MG	0.104	0.695	-0.136	0.533	-0.0158
IND	DS	0.104	0.695	-0.136	0.533	-0.0158
IND	RS	0.104	0.695	-0.136	0.533	-0.0158
IND	KS	0.104	0.695	-0.136	0.533	-0.0158
IND	LG	0.104	0.695	-0.136	0.533	-0.0158
IND	NG	0.125	0.819	-0.240	0.032	-0.0363

		<b>GDPElas</b>	<b>GDPLag</b>	<b>PrcElas</b>	<b>PrcLag</b>	<b>TrendGR</b>
IND	CL	0.125	0.500	-0.100	0.500	0.0172
IND	EL	0.093	0.865	-0.147	0.609	0.0269
IND	HT	0.046	0.865	-0.074	0.305	-0.0099
OAS	MG	0.104	0.695	-0.136	0.533	0.0035
OAS	DS	0.104	0.695	-0.136	0.533	0.0035
OAS	RS	0.104	0.695	-0.136	0.533	0.0035
OAS	KS	0.104	0.695	-0.136	0.533	0.0035
OAS	LG	0.104	0.695	-0.136	0.533	0.0035
OAS	NG	0.125	0.819	-0.240	0.032	0.0027
OAS	CL	0.125	0.500	-0.100	0.500	0.0188
OAS	EL	0.093	0.865	-0.147	0.609	0.0160
OAS	HT	0.046	0.865	-0.074	0.305	-0.0064
MID	MG	0.104	0.695	-0.136	0.533	0.0128
MID	DS	0.104	0.695	-0.136	0.533	0.0128
MID	RS	0.104	0.695	-0.136	0.533	0.0128
MID	KS	0.104	0.695	-0.136	0.533	0.0128
MID	LG	0.104	0.695	-0.136	0.533	0.0128
MID	NG	0.125	0.819	-0.240	0.032	0.0045
MID	CL	0.125	0.500	-0.100	0.500	-0.0086
MID	EL	0.093	0.865	-0.147	0.609	0.0136
MID	HT	0.046	0.865	-0.074	0.305	-0.0049
AFR	MG	0.104	0.695	-0.136	0.533	0.0076
AFR	DS	0.104	0.695	-0.136	0.533	0.0076
AFR	RS	0.104	0.695	-0.136	0.533	0.0076
AFR	KS	0.104	0.695	-0.136	0.533	0.0076
AFR	LG	0.104	0.695	-0.136	0.533	0.0076
AFR	NG	0.125	0.819	-0.240	0.032	0.0263
AFR	CL	0.125	0.500	-0.100	0.500	0.0130
AFR	EL	0.093	0.865	-0.147	0.609	0.0189
AFR	HT	0.046	0.865	-0.074	0.305	-0.0061
BRZ	MG	0.104	0.695	-0.136	0.533	0.0033
BRZ	DS	0.104	0.695	-0.136	0.533	0.0033
BRZ	RS	0.104	0.695	-0.136	0.533	0.0033
BRZ	KS	0.104	0.695	-0.136	0.533	0.0033
BRZ	LG	0.104	0.695	-0.136	0.533	0.0033

		<b>GDPElas</b>	<b>GDPLag</b>	<b>PrcElas</b>	<b>PrcLag</b>	<b>TrendGR</b>
BRZ	NG	0.125	0.819	-0.240	0.032	0.0343
BRZ	CL	0.125	0.500	-0.100	0.500	-0.0075
BRZ	EL	0.093	0.865	-0.147	0.609	0.0210
BRZ	HT	0.046	0.865	-0.074	0.305	-0.0037
CSA	MG	0.104	0.695	-0.136	0.533	0.0054
CSA	DS	0.104	0.695	-0.136	0.533	0.0054
CSA	RS	0.104	0.695	-0.136	0.533	0.0054
CSA	KS	0.104	0.695	-0.136	0.533	0.0054
CSA	LG	0.104	0.695	-0.136	0.533	0.0054
CSA	NG	0.125	0.819	-0.240	0.032	0.0071
CSA	CL	0.125	0.500	-0.100	0.500	-0.0091
CSA	EL	0.093	0.865	-0.147	0.609	0.0081
CSA	HT	0.046	0.865	-0.074	0.305	-0.0054

## Appendix C. References

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# Appendix D. Data Quality

## Introduction

The WEPS+ Commercial Model develops projections of world commercial sector energy use by fuel (motor gasoline, distillate fuel, residual fuel, kerosene, liquid petroleum gas, natural gas, coal, electricity, heat, solar, and biomass) for 16 regions of the world. These projections are based on the data elements detailed in Appendix B of this report. In Chapter 4: Model Structure, the documentation details transformations, estimation methodologies, and resulting inputs required to implement the model algorithms. The quality of the principal sources of input data is discussed in Appendix D. Information regarding the quality of parameter estimates and user inputs is provided where available.

## Source and Quality of Input Data

### **Source of Input Data**

- *STEO* – Short-term liquid fuel consumption data from 2005 to 2011 are provided by region from EIA’s *Short-Term Energy Outlook*. The *IEO2010* results are benchmarked to the *STEO* results from the January 2010 edition of the report.
- *International Statistics Database* – The Energy Information Administration provides historical data on international energy consumption by fuel type from 1980 through 2007. These data are used as the historical basis for all regional projections that appear in the *IEO2010*. While the numbers are continuously updated, WEPS+ used a “snapshot” of the database as it existed on November 30, 2009 as the source of its international data.
- *International Energy Agency* – The subscription site [www.iea.org](http://www.iea.org) provides historical energy consumption data for the OECD and non-OECD balances, along with statistics by end-use sector, product, and country. These data are benchmarked to the historical aggregate energy consumption data provided in the Energy Information Administration’s international statistical data base.
- *NEMS* – The assumptions about price and economic elasticities are drawn largely from assumptions underlying the National Energy Modeling System for the United States. Expert judgment has, in some cases, been used to alter NEMS assumptions based on additional information about specific international regions in the WEPS+ system.

### **Data Quality Verification**

As a part of the input and editing procedure, an extensive program of edits and verifications was used, including:

- Checks on world and U.S. commercial sector fuel consumption, retail prices, and elasticities, based on previous values, responses, and regional and technical knowledge
- Consistency checks

- Technical edits to detect and correct errors, extreme variability