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World Energy Projection System Plus: Global Activity Module (GLAM)

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Update Information

This edition of the Global Activity Module (GLAM) Model Documentation 2016 reflects changes made to GLAM over the past 2 years for the *International Energy Outlook 2016* (IEO2016). These changes include:

- Extension and improvement of the transfer system between GLAM and World Energy Projection System Plus (WEPS+) including:
    - the ability to pass an additional 7 sectors of industrial activity detail between GLAM and WEPS+;
    - a substantial increase in the number of other variables available to pass between WEPS+ and GLAM;
    - the ability to choose which variables to input or output between GLAM and WEPS+; and

the choice of whether to input/output variables in levels or growth rates when transferring variables between GLAM and WEPS+.

1. Introduction

The World Energy Projection System Plus (WEPS+) is a comprehensive, mid-term energy forecasting and policy analysis tool used by EIA. WEPS+ projects energy supply, demand, and prices by country or region, given assumptions about the state of various economies, international energy markets, and energy policies. The Global Activity Module (GLAM) provides projections of economic driver variables for use by the supply, demand, and conversion modules of WEPS+. GLAM's baseline economic projection contains the economic assumptions used in WEPS+ to help determine energy demand and supply. GLAM can also provide WEPS+ with alternative economic assumptions representing a range of uncertainty about economic growth. The resulting economic impacts of such assumptions are inputs to the remaining supply and demand modules of WEPS+.

This report documents the analytical approach of GLAM that is used to develop the International Energy Outlook for 2016 (IEO2016). It serves as a reference document providing a description of GLAM used for the IEO2016 production runs for model analysts, users, and the public. It also facilitates continuity in model development by providing documentation from which energy analysts can undertake model enhancement and modifications. This documentation report is divided into two separate components.

Section 2 presents the structural models that make up the GLAM. These include

1. Oxford Economics Global Economic Model (GEM); and
2. Oxford Economics Global Industrial Model (GIM).

Section 3 focuses on GLAM's interface with WEPS+. This section identifies the set of model levers and simulation rules used to operate the system. This section also views GLAM from the perspective of a programmer focusing on the ties that link the various models together to form GLAM and how GLAM communicates with WEPS+. It concludes with technical detail on the transfer system between GLAM and WEPS+.

Model archival citation

This documentation refers to the WEPS+ Macroeconomic Model, as archived for the International Energy Outlook 2016 (IEO2016).

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2. Model System Overview

The economic activity assumptions driving WEPS+ are determined by an economic modeling system comprising two models:

1. Oxford Economics Global Economic Model (GEM); and
2. Oxford Economics Global Industrial Model (GIM).

GEM is the same model used by Oxford Economics to produce its economic forecasts for the company's monthly assessment of the global economy. The particular GEM release used for the IEO2016 is the June 2015 version. GIM provides the industrial output detail required by WEPS+. The particular GIM release used for the IEO2016 is the Q3 2015 version. GEM and GIM are linked to provide a fully integrated approach to estimating economic activity at the country/regional and industrial levels.

GEM projects each national economy's growth path and the final demand mix. The global industrial model ensures that supply by industry is consistent with the final demands (consumption, investment, government spending, exports and imports) calculated in GEM. Together, GEM and GIM constitute the Global Activity Module (GLAM) of the World Energy Projection System Plus (WEPS+).

To execute its suite of models, GLAM requires exogenous assumptions regarding energy prices and quantities. In the current version, both oil and natural gas prices and demands are extracted from the output of the demand and supply modules of WEPS+. Transformations of the exogenous assumptions are necessary to map these inputs from WEPS+ into more aggregated concepts in GLAM. After the appropriate transformations are done, GEM and GIM execute in sequence to produce estimates of economic activity at the national and industrial levels. Drawn from the projections are economic driver variables that are then passed to the supply, demand and conversion modules of WEPS+, and the system is able to react to the new economic activity assumptions.

Oxford Economics Global Economic Model

Key inputs: National population by age cohort, total factor productivity, tax rates and nominal expenditures, money supply, and energy prices and quantities.

Key outputs: Final demands (consumption, investment, government purchases, exports, imports), inflation, foreign exchange and interest rates, incomes, employment, and balance of payments.

Overview

The Oxford Economics Global Economic Model (GEM) is an international macroeconometric model that covers 46 countries and six additional regions—spanning the globe—and forecasts many variables through 2040. The individual countries are modelled similarly, but larger economies have greater disaggregation and more financial sector detail. All of the countries have forecasts for Gross Domestic Product (GDP), consumer prices, exchange rates, and the current account. Each of the countries and regions are fully linked through trade, prices, exchange rates, and interest rates.

The structure of each country and regional model in GEM is based on standard economic theory. In the long-run, population growth and productivity drive economic activity, but there are fluctuations in the short-run associated with business cycles. These business cycles arise from a number of factors, including wages and prices that do not adjust over short periods, non-competitive behavior by firms, and various regulations, to name a few.

The long-run price level depends on monetary policy, which has no impact on economic activity over this time-horizon. Monetary policy does, however, have a short-run impact on output, which also influences the price level.

Consumption in each country or region depends upon income, wealth, interest rates, and inflation. Investment varies based on its risk-adjusted after-tax return, while exports are a function of world demand and the real exchange rate. Imports are determined by domestic demand and competitiveness.

Coverage of GEM

GEM covers 46 countries in depth and provides high-level details in another six regional groupings, including OPEC (Organization of the Petroleum Exporting Countries). Countries/areas covered in detail appear in Table 1. The model also includes global and multi-region variables such as oil and commodity prices, world GDP and industrial production, OECD (Organisation for Economic Cooperation and Development) average inflation, and others.

Table 1: Global Economic Model Country/Region Coverage

Countries				
Argentina	Denmark	Japan	Singapore	United Kingdom
Australia	Finland	Malaysia	Slovakia	United States
Austria	France	Mexico	South Africa	Africa
Belgium	Germany	Netherlands	South Korea	OPEC
Brazil	Greece	Norway	Spain	Latin America
Bulgaria	Hong Kong	Philippines	Sweden	Eastern Europe
Canada	Hungary	Poland	Switzerland	Rest of OECD
Chile	India	Portugal	Taiwan	Rest of World
China	Indonesia	Romania	Thailand	
Croatia	Ireland	Russia	Turkey	
Czech Republic	Italy	Saudi Arabia	United Arab Emirates	

Each of these countries and regions is mapped into one of the 16 IEO regions shown in Table 2. Most of the countries listed in Table 1 map directly into one of the IEO regions in Table 2; for example, Argentina falls in Other Central and South America and Germany is in OECD Europe. The Oxford regions are broken up where appropriate (according to their share of economic activity within the region) and assigned to the IEO regions. For example, Angola is in Oxford's OPEC region; it is separated from that region and assigned to the IEO's Africa region.

Table 2: 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/Chile	China
OECD Europe	India
Japan	Other Non-OECD Asia
Australia/New Zealand	Middle East
South Korea	Africa
	Brazil
	Other Central and South America

The same procedure is followed for all of the countries that compose the remaining regional groups in the Global Economic Model. The rest of the world and rest of OECD aggregations consist of all countries within those two groupings that are not already in the model.

Detailed model structure

Model variables are divided into demand and supply, core and non-core. Coverage of core variables is standard across all country models; non-core coverage is determined by data availability and country-specific requirements. Core demand variables include all the aggregate expenditure components—consumption, investment, government spending, and net exports—at constant and current prices, monetary policy variables, and financial variables.

The demand non-core variables include disaggregated consumption and investment, as well as important indicator variables such as retail sales and car sales. Core supply variables include variables determining the levels of output, unemployment, and real wages. Prices are also disaggregated within core supply. Non-core supply variables include disaggregated employment and nominal earnings. Other variables related to government and personal and corporate sector flow accounts are based on relationships outside of demand and core supply.

The model variables are expressed either in units of the local currency used by the majority in the country or region under consideration or in unit-less rates or ratios. Lowercase letters denote natural logarithms in the equations below. The data sets used in estimating the model parameters also vary by country.

Consumption

The model equations for consumption take the form

$$\Delta c_t = a_1 \Delta y_t + a_2 \Delta u_t - a_3[c_{t-1} - a_4 y_{t-1} - (1 - a_4)W_{t-1} + a_5 R_{t-1}],$$

where

$\Delta x_t = x_t - x_{t-1}$, for all variables x;

c_t = natural logarithm of consumption during year t;

y_t = natural logarithm of real income during year t;

u_t = natural logarithm of unemployment rate during year t;

W_t = ratio of financial wealth to income during year t;

R_t = real interest rate during year t; and

$a_1, a_2, \text{and } a_3$ are coefficients estimated by ordinary least square

This formulation mimics the dynamics of consumption in a number of countries well.

Investment

Three aspects of gross fixed investment are identified in the model: private business, private housing, and government (exogenous).

The equations for private business investment are based on standard theories of investment. The capital stock is assumed to reach its desired level in the long run, while fluctuating in the short run. These fluctuations occur because capital installation is costly and time-consuming, which means there is a difference between the benefit of an installed unit of capital and its cost. Firms invest when this benefit exceeds the cost, and reduce or scrap capital in the reverse case. The equations take the following general form:

$$\Delta\, i = \, a_1 q_t - \, a_2 (i_{t-1} - \, k_{t-1}) + \, a_3 \, \Delta\, y_t,$$

where

i_t = private sector business fixed investment during year t in local currency;

k_t = value of capital stock during year t in local currency;

y_t = real GDP during year t in local currency;

q_t = relative rate of return on investment during year t, percent; and

$a_1, a_2, \text{and } a_3$ are coefficients estimated by ordinary least squares.

This mechanism can also amplify changes in the economy, as firms may reduce or increase investment in response to changes in the value of q_t. This variable is the ratio of the market value of a company's assets to the replacement cost of the company's assets.

Personal sector housing investment is estimated analogously to consumption, by real income, wealth, and interest rates, because it is considered part of a portfolio of spending decisions taken by households.

International trade

Trade flows are disaggregated into fuel, non-fuel goods, and services. The non-fuel goods components reflect the majority of exports and imports for most countries, and the equations for these are outlined here. Non-fuel exports and imports are specified as

$$\Delta x_t = \Delta wt_t - a_1 cu_t - a_2 \Delta wcr_t - a_3 (x_{t-1} - wt_{t-1} - a_4 trx_t),$$

$$\Delta m_t = b_2 \Delta tfe_t + b_2 \Delta wcr_t - b_2 (m_{t-1} - tfe_{t-1} - b_4 wcr_{t-1} - b_5 cu_{t-1}),$$

where

x_t = exports of non-fuel goods during year t;

m_t = imports of non-fuel goods during year t;

wt_t = world trade during year t;

tfe_t = total final expenditures during year t;

wcr_t = labor costs in the country or region under consideration, relative to those in its trading partners, during year t;

cu_t = capacity utilization rate during year t;

trx_t = exogenous time trend during year t; and

$a_1, \ldots, a_4$ and $b_1, \ldots, b_4$ are coefficients estimated by ordinary least squares.

The sources for data in each of the variables above vary based on national data for each country. The parameters in the equations above capture the effects of non-price factors on a country's world trade share, as well as the impacts of the long-term increase in the specialization of production on imports. In general, a sustained decline in relative labor costs—an improvement in competitiveness—leads to an improvement in the trade balance in the long run.

The equations for trade in services and total trade are analogous to those for non-fuel goods, while fuel trade is calculated as the residual—total trade less the sum of trade in services and non-fuel goods.

Linkages between economies

Through the international trade and import/export equations given above, GLAM links the individual countries and regions in a number of ways:

- Trade;
- Labor costs in a country relative to trading partners—competitiveness;
- Interest and exchange rates;
- Oil and other commodity prices; and
- Prices of manufactured goods.

Oxford Economics Global Industrial Model

Key inputs: Final demands, prices and productivity measures from Oxford Economics model of the global economy.

Key outputs: Real output value—defined by gross output—for both industrial and service sectors.

Overview

GIM has a top-down structure with sector forecasts driven by national trends and by aggregate demand from three regional blocs: the Americas; Asia Pacific and Europe; and Middle East and Africa. Sector demands from the three blocks are allocated to individual industries using weights based upon regional input-output relationships. These relationships – derived from national input-output tables – show the percentage of each industry's output that is driven by consumer expenditure, investment, exports, government spending, and intermediate demand.

The model also takes into account the impacts of changes in competitiveness on an industry's market share both regionally and nationally. Industry classification follows the European standard classification structure—Nomenclature Statistique des Activités Economiques dans la Communauté Européenne revision 2 (NACE 2). There are eight headline manufacturing sectors: basic metals; chemicals; aerospace; intermediate goods; engineering and metal goods; electronics and computers; motor vehicles; and consumer goods. These are further broken down into subsectors, as follows:

- Basic metals: Iron and steel, non-ferrous metals, casting
- Chemicals: Coke, petroleum and nuclear fuel, chemicals and man-made fibers, basic chemicals, excluding agro-chemicals, agro-chemicals, paints and varnishes, pharmaceuticals, soaps and detergents, other chemicals, man-made fibers
- Aerospace
- Intermediate goods: Rubber and plastics, glass, ceramics, bricks, cement, and plaster, wood and wood products, pulp and paper
- Engineering and metal goods: Motors, generators and transformers, electric fittings, other electrical equipment, motors except for vehicles, other general purpose machinery, agricultural machinery, machine tools, other special purpose machinery, weapons and ammunition, domestic appliances
- Electronics and computers: Computers and office equipment, electronic components, telecommunications equipment, consumer electronics, precision and optical instruments
- Motor vehicles: Motor vehicles, motor vehicle bodies and parts

- Consumer goods: Food, beverages and tobacco, textiles, garments, leather goods, printing and publishing, other manufacturing, furniture

Other production sectors include agriculture; extraction; utilities; and construction. In addition, the service sector covers the following subsectors:

- Retail and wholesale distribution
- Accommodation and catering
- Transport and storage
- Information and communications
- Financial services
- Business services
- Public administration services
- Education services
- Health care and social work
- Other services

The industry model also provides forecasts of other variables such as the following:

- Value-added output and gross output across all industries and countries
- Producer prices across all industries for the United Kingdom (U.K.), Germany, France Italy, Japan, the United States, and China
- Employment and real/nominal investment across all industries for the U.K.
- Car/truck registrations and number of vehicles on road for 44+ countries
- Steel production for 11 countries (Belgium, China, France, Germany, Italy, Japan, Netherlands, Spain, Sweden, U.K., and United States)
- Investment across all industries for all countries

3. The GLAM Interface with WEPS+

The Global Activity Module (GLAM) provides macroeconomic projections for use by the other models in the World Energy Projection system Plus (WEPS+), and also takes in energy prices and quantities from other models in WEPS+. Because the time aggregation, country/region mapping, and variable definitions are different between GLAM and other WEPS+ models, there is a transfer system to make them consistent.

Figure 1. Schematic of Global Activity Module (GLAM) Transfer System

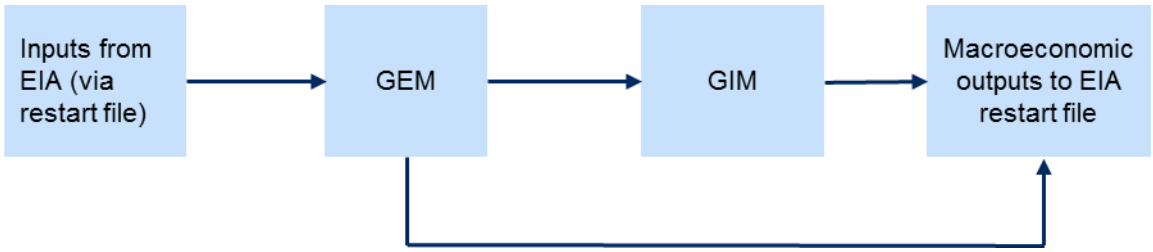


Figure 1. Schematic of Global Activity Module (GLAM) Transfer System

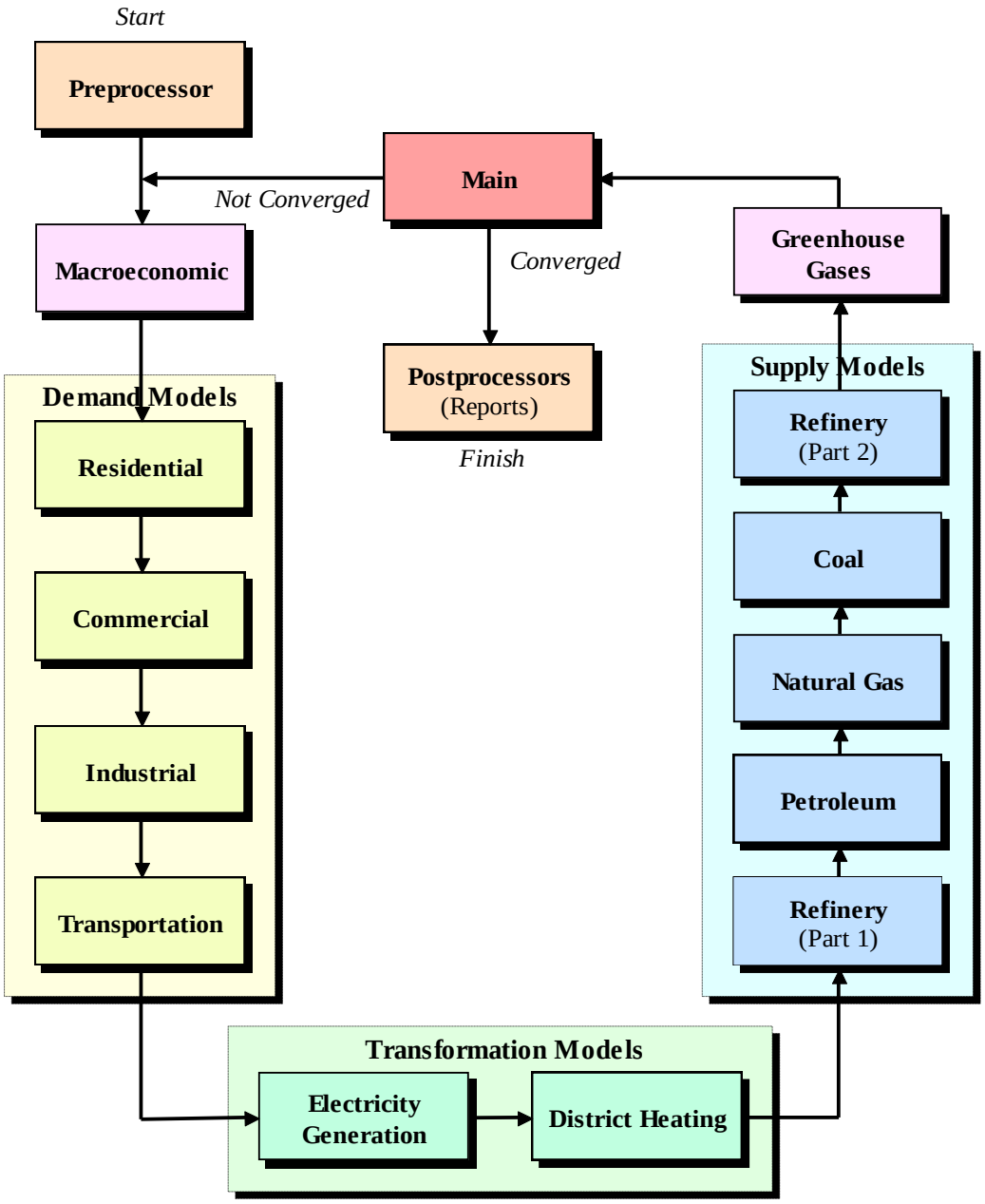
GLAM takes energy inputs from the WEPS+ restart file into GEM, aggregating and modifying as necessary. GEM solves and then passes relevant information to the GIM, which then solves as well, and the restart file. In the final step economic and population variables are passed from the GIM back to WEPS+ via the restart file.

The first subsection below details the relationship between GLAM and other models in WEPS+ generally. The second subsection provides full technical detail on the transfer system between GLAM and WEPS+.

Relationship to other models

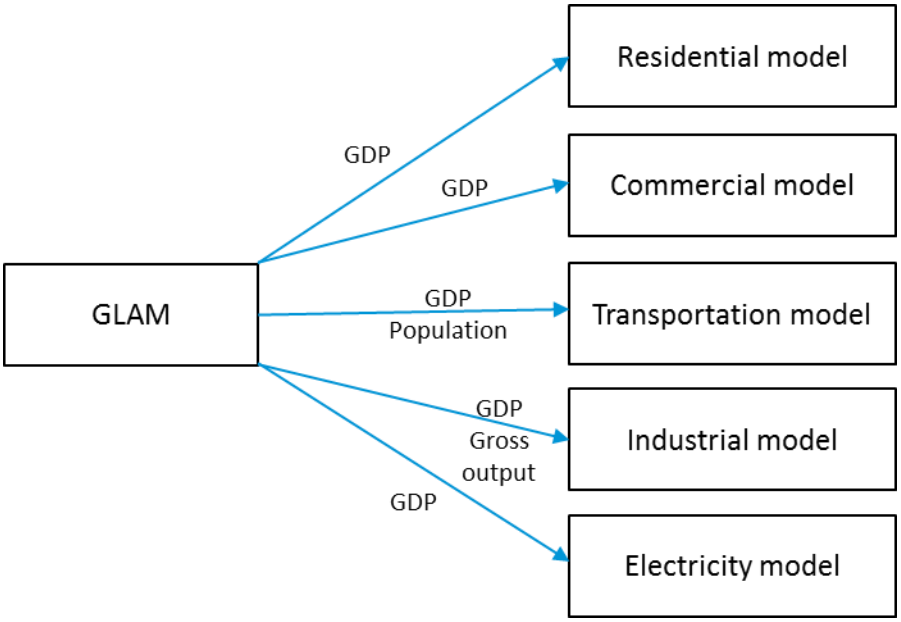
GLAM takes input variables from WEPS+ and passes them on to the WEPS+ demand models after solution. A summary description of the models, flows, and mechanics of WEPS+ used for the IEO2016 report is available in the WEPS+ Overview documentation.

Figure 2. World Energy Projection System Plus (WEPS+) Model Sequence



The basic output structure of GLAM to the different end-use demand models in WEPS+ is illustrated in Figure 3. GLAM also takes in energy prices and quantities from other WEPS+ modules.

Figure 3. The Global Activity Module (GLAM) Relationship to Other WEPS+ Models



GLAM projects many series (as discussed in the next subsection) and currently provides three main projected series to WEPS+:

- Gross Domestic Product (GDP) by region, expressed in purchasing power parity (PPP)
- Population by region
- Gross output by region and economic sector

GLAM is first made consistent with EIA energy prices and then run. The updated results are then exported into the WEPS+ restart file for use by other models.

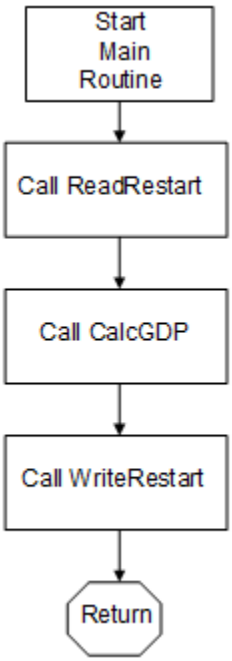
Table 3. Global Activity Module (GLAM) output and destination

GLAM Output	Destination
Gross domestic product (PPP)	Residential Model
	Commercial Model
	World Industrial Model
	International Transportation Model
	World Electricity Model
Population	International Transportation Model
Gross output	World Industrial Model

A call from the WEPS+ interface to GLAM opens the restart file and initiates the CalcGDP subroutine. The CalcGDP subroutine calculates results of GLAM simulations before the execution of the subroutine that exports all projections to the restart file for use by other WEPS+ models.

The CalcGDP subroutine is initiated by a call from the main GLAM. The model requires four exogenous data series. The CalcGDP subroutine begins by initiating a call of the XMLInput subroutine to import data from the MacInput.xml data file. The MacInput.xml includes historical and projected GDP data, by region, in terms of both Purchasing Power Parity (PPP) and Market Exchange Rate (MER), and historical and projected population, each of which are based on GLAM simulations. The file also contains several other elements such as energy prices and quantities. GLAM exports the data series to the restart file, and these are then used in subsequent runs.

Figure 4. Flowchart for the Global Activity Module (GLAM)



GLAM/WEPS+ Transfer System

The GLAM/WEPS+ transfer system links EIA's energy models with Oxford Economics' (OE) Global Economic Model (GEM) and Global Industry Model (GIM). The transfer system allows users to impose their own forecasts for energy production, consumption and prices, and assess the impact this has on GDP and gross output. In addition, it allows users to run their own macroeconomic scenarios, with the impact then fed through WEPS+.

Installing and updating the transfer system

The transfer system has been designed to interact with GEM and GIM. More specifically, it uses databases from both of these models when run in conjunction with the rest of WEPS+.

Overview of the system

The system allows the user to run a so-called forecast case. The forecast case begins with inputs from WEPS+, which enter the system via the restart file. These inputs are then fed through GLAM, and the macroeconomic outputs are passed back to WEPS+ via the restart file.

Forecasting case

See Figure 1 for a visual depiction. If the user desires modifications to macro variables before running through WEPS+—for example to set GDP in a certain country/region—the changes should be made outside of WEPS+ in the Oxford software, and then the system can be run as a forecast case. This makes the input variables exogenous to the system.

GLAM, via the transfer system, provides all available historical data and forecasts—listed in detail below—to WEPS+. Historical data are the latest available each quarter, and typically lag the current date by 3-12 months.

Running the transfer system

The transfer system comprises two sets of files:

- Forecast batch files and accompanying operational files
- Input and output transfer databases

The operational folders for the two batch files—'Controls' and 'Databases'—must be stored together within the same folder.

The batch file folders contain files of five types:

- Database (.db and .bin) files: These files contain inputs and outputs from WEPS+ and GLAM. A number of these files are created during the batch file process; the core starting files are OEMacro.db, OEIndustry.db, Output_Database.db, Input_Database.db, Restart_Oxford.bin, and Restart_Oxford_out.bin.
- Program (.exe and .bat) files: These files contain the underlying code needed to run the forecast process. The .bat files list out the instructions in order, and the .exe files run the necessary programs.
- Files used by genmod.exe (no extension and .run): These files are used by the genmod program, which creates the necessary input databases, GEM and GIM databases, and output databases.
- Files used by the transfer system (.in): These files are used by the transfer system to move data from WEPS+ to GLAM, between OE models, and from GLAM back to WEPS+.
- Other output (.txt and .out) files: Two other types of output files are created by the process. These are used to troubleshoot and shouldn't need to be consulted during normal running of the program.

GEM and GIM databases from OE should be used as the OEMacro and OEIndustry databases in the 'Databases' folder. The user will need to use a version of GIM released specifically to EIA for use in the transfer system—this will be available with the file release associated with a particular IEO. The input and output databases should already be available in this folder.

Within the 'Controls' folder the user can specify whether to input and/or output the levels or growth rates of all variables that are available—by OE country—through the fixtype.txt file. The following variables are available to input from WEPS+ to GLAM:

- Oil - Brent spot price
- Oil - WTI spot price
- Natural gas - Henry Hub price
- Natural gas - Europe price
- Natural gas - Asia price
- Oil demand for each IEO region
- Oil supply for OPEC members
- Oil supply for Non-OPEC members
- Natural gas demand for each IEO region
- Natural gas supply for each IEO region

The following variables are available to output from GLAM to WEPS+ for each IEO region:

- Gross output – MER
- Gross output – PPP
- GDP – MER
- GDP – PPP
- Population
- Working age population
- Employment
- Household income – MER
- Household income – PPP
- Oil prices
- Natural gas prices
- Coal prices
- Oil supply
- Oil demand
- Oil exports
- Oil imports
- Natural gas supply
- Natural gas demand
- Natural gas exports
- Natural gas imports
- Coal supply
- Coal demand
- Coal exports
- Coal imports

Forecasting case details

The system for imposing the WEPS+ energy forecasts within GLAM is triggered by running the batch file named EIABatch_Forecasts.bat. Broadly speaking, the forecasting transfer system has four key steps: (i) draw data from WEPS+; (ii) calculate forecasts for relevant WEPS+ variables; (iii) calculate the impact of these changes on the rest of the economy at the macro and industry level; and (iv) extract the new path for GDP and gross output from GEM and GIM, use these to calculate a new forecast path for the equivalent WEPS+ variables, and transfer the new paths back to WEPS+. The remainder of this subsection will outline each of these steps in detail.

- Draw data from WEPS+

In this first step, the energy consumption, production, and price series from WEPS+ are prepared to be passed to GLAM. This involves three processes:

- The input transfer database is prepared for the updated forecasts. This is done by rolling on the historical fixes to ensure that all historical data are fixed down and don't change when the new forecasts from WEPS+ are fed in. This process is done using the FIXEDIT program (see below) and is completed by running the input transfer database through the GENMOD solver (see below).
- The energy consumption, production, and price series are taken from WEPS+ using the DBTransfer program and input to the input transfer database.
- The baseline historical and forecast data for the equivalent variables in the OE models are taken from GEM, using the DBTransfer program, and inserted into the input transfer database.

i. Calculate projections for relevant WEPS+ variables

In this second step, the WEPS+ projections are used to set the path for equivalent OE variables. This is done by solving the input transfer system using the GENMOD solver. The input transfer database itself maps between the WEPS+ and OE variables and uses the mapping to recalculate the forecast path for the OE variables.

The country/region mapping (Table 4) is specified within the input transfer database.

Table 4. Country and region mapping

GEM country	WEPS+ country/region
Brazil	Brazil
Canada	Canada
China	China
India	India
Japan	Japan
Korea	Korea
Russia	Russia
United States	United States
Chile, Mexico	Chile/Mexico

Table 4. Country and region mapping (cont.)

GEM country	WEPS+ country/region
Australia, ROEC (New Zealand)	Australia/New Zealand
Austria, Belgium, Czech Rep, Denmark, EASTEUR (Estonia, Slovenia), Finland, France, Germany, Greece, Hungary, Ireland, RWOR (Israel), Italy, ROEC (Luxembourg, Iceland), Netherlands, Norway, Poland, Portugal, Slovak Rep., Spain, Sweden, Switzerland, Turkey, U.K.	OECD Europe
South Africa, AFRICA (Benin, Botswana, Burkina Faso, Burundi, Cape Verde, Cameroon, Central African Republic, Chad, Comoros, Congo (Brazzaville), Congo (Kinshasa), Côte d'Ivoire, Djibouti, Egypt, Equatorial Guinea, Eritrea, Ethiopia, Gabon, The Gambia, Ghana, Guinea, Guinea-Bissau, Lesotho, Liberia, Kenya, Madagascar, Malawi, Mali, Mauritania, Mauritius, Morocco, Mozambique, Namibia, Niger, Reunion, Rwanda, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, Somalia, St. Helena, Sudan, Swaziland, Tanzania, Togo, Tunisia, Uganda, Western Sahara, Zambia, Zimbabwe), OPEC (Algeria, Angola, Libya, Nigeria)	Africa
RWOR (Bahrain, Oman, Jordan, Lebanon, Syria, Yemen) , OPEC (Iraq, Iran, Kuwait, Qatar, Saudi Arabia, United Arab Emirates)	Middle East
Hong Kong, Indonesia, Malaysia, Philippines, Singapore, Taiwan, Thailand, RWOR (Afghanistan, American Samoa, Bangladesh, Bhutan, Brunei, Cambodia, Cook Islands, Fiji, French Polynesia, Guam, Kiribati, Laos, Macau, Maldives, Mongolia, Myanmar, Nauru, Nepal, New Caledonia, Niue, North Korea, Pakistan, Papua New Guinea, Samoa, Solomon Islands, Sri Lanka, Timor-Leste, Tonga, U.S. Pacific Islands, Vanuatu, Vietnam, Wake Islands)	Other Non-OECD Asia
Bulgaria, Croatia, Romania, RWOR(Cyprus, Malta) , EASTEUR (Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Macedonia, Moldova, Montenegro, Serbia, Tajikistan, Turkmenistan, Ukraine, Uzbekistan)	Other Non-OECD Europe & Eurasia
Argentina, LATAMER(Bolivia, Colombia, Costa Rica, Honduras, Jamaica, Panama, Peru, Uruguay), OPEC (Ecuador, Venezuela)	Other Central & South America

Further mapping between GLAM and WEPS+ is outlined in the tables below. These use a specific nomenclature. Any variable name that has the form EIA_XXX denotes a WEPS+ region; any name that begins with EIA_, but which has more than three letters after the underscore is a WEPS+ variable name not denoting a region. All other names denote OE regions or variables. Also, the dependent variable is the one being modified while the independent one is the variable that does not change. In this case the independent variables (when available) come from other WEPS+ modules, while the dependent ones are all in GLAM. The next four tables provide variable definitions.

Table 5. Gross output sector mapping with variable mnemonics

Variable Description	Transfer base: Dependent variable	Transfer base: Independent variable	Variable Description
GDP	EIA_XXX: EIA_GDP_PPP	OE Country: GDPPPP	Real GDP converted using PPP exchange rates
	EIA_XXX: EIA_GDP_MER	OE Country: GDP	Real GDP in local currency
Population	EIA_XXX: EIA_POP	OE Country: POP	Population
	EIA_XXX: EIA_POP_WORK	OE Country: POPW	Working-age population
Employment	EIA_XXX: EIA_EMPLOYMENT	OE Country: ET	Employment
Disposable income	EIA_XXX: EIA_DISINC_MER	OE Country: PEDY$	Disposable income
	EIA_XXX: EIA_DISINC_PPP	OE Country: PEDY$	Disposable income
Gross output	EIA_XXX: EIA_MACGOM_AG	OE Country: GY_AG	Agricultural gross output
	EIA_XXX: EIA_MACGOM_CHBA	OE Country: GY_CHBAS	Basic chemical gross output
	EIA_XXX: EIA_MACGOM_CHEM	OE Country: GY_CHEM	Other chemicals gross output
	EIA_XXX: EIA_MACGOM_COM	OE Country: GY_COM	Information and communications gross output

Table 5. Gross output sector mapping with variable mnemonics (cont.)

Variable Description	Transfer base: Dependent variable	Transfer base: Independent variable	Variable Description
	EIA_XXX: EIA_MACGOM_CON	OE Country: GY_CON	Construction gross output
	EIA_XXX: EIA_MACGOM_DIS	OE Country: GY_DIS	Distribution gross output
	EIA_XXX: EIA_MACGOM_FIN	OE Country: GY_FIN	Finance gross output
	EIA_XXX: EIA_MACGOM_FOOD	OE Country: GY_FOOD	Food gross output
	EIA_XXX: EIA_MACGOM_GOV	OE Country: GY_GOV	Government gross output
	EIA_XXX: EIA_MACGOM_IRON	OE Country: GY_IRON	Iron and steel gross output
	EIA_XXX: EIA_MACGOM_MIN	OE Country: GY_MIN	Mining gross output
	EIA_XXX: EIA_MACGOM_NONF	OE Country: GY_NONF	Non-ferrous gross output
	EIA_XXX: EIA_MACGOM_NONM	OE Country: GY_NONM	Non-metallic gross output
	EIA_XXX: EIA_MACGOM_OTHER	OE Country: GY_OTH	Other industrial gross output
	EIA_XXX: EIA_MACGOM_PAPE	OE Country: GY_PAPER	Paper gross output
	EIA_XXX: EIA_MACGOM_REFI	OE Country: GY_REFIN	Refining gross output
	EIA_XXX: EIA_MACGOP_AG	EIA_XXX: EIA_MACGOM_AG, EIA_GDP_PPP, EIA_GDP,MER	Agricultural gross output
	EIA_XXX: EIA_MACGOP_CHBA	EIA_XXX: EIA_MACGOM_CHBA, EIA_GDP_PPP, EIA_GDP,MER	Basic chemical gross output

Table 5. Gross output sector mapping with variable mnemonics (cont.)

Variable Description	Transfer base: Dependent variable	Transfer base: Independent variable	Variable Description
	EIA_XXX: EIA_MACGOP_CHEM	EIA_XXX: EIA_MACGOM_CHEM, EIA_GDP_PPP, EIA_GDP,MER	Other chemicals gross output
	EIA_XXX: EIA_MACGOP_COM	EIA_XXX: EIA_MACGOM_COM, EIA_GDP_PPP, EIA_GDP,MER	Information and communications gross output
	EIA_XXX: EIA_MACGOP_CON	EIA_XXX: EIA_MACGOM_CON, EIA_GDP_PPP, EIA_GDP,MER	Construction gross output
	EIA_XXX: EIA_MACGOP_DIS	EIA_XXX: EIA_MACGOM_DIS, EIA_GDP_PPP, EIA_GDP,MER	Distribution gross output
	EIA_XXX: EIA_MACGOP_FIN	EIA_XXX: EIA_MACGOM_FIN, EIA_GDP_PPP, EIA_GDP,MER	Finance gross output
	EIA_XXX: EIA_MACGOP_FOOD	EIA_XXX: EIA_MACGOM_FOOD, EIA_GDP_PPP, EIA_GDP,MER	Food gross output
	EIA_XXX: EIA_MACGOP_GOV	EIA_XXX: EIA_MACGOM_GOV, EIA_GDP_PPP, EIA_GDP,MER	Government gross output
	EIA_XXX: EIA_MACGOP_IRON	EIA_XXX: EIA_MACGOM_IRON, EIA_GDP_PPP, EIA_GDP,MER	Iron and steel gross output
	EIA_XXX: EIA_MACGOP_MIN	EIA_XXX: EIA_MACGOM_MIN, EIA_GDP_PPP, EIA_GDP,MER	Mining gross output
	EIA_XXX: EIA_MACGOP_NONF	EIA_XXX: EIA_MACGOM_NONF, EIA_GDP_PPP, EIA_GDP,MER	Non-ferrous gross output
	EIA_XXX: EIA_MACGOP_NONM	EIA_XXX: EIA_MACGOM_NONM, EIA_GDP_PPP, EIA_GDP,MER	Non-metallic gross output
	EIA_XXX: EIA_MACGOP_OTHER	EIA_XXX: EIA_MACGOM_OTHER, EIA_GDP_PPP, EIA_GDP,MER	Other industrial gross output
	EIA_XXX: EIA_MACGOP_PAPE	EIA_XXX: EIA_MACGOM_PAPE, EIA_GDP_PPP, EIA_GDP,MER	Paper gross output
	EIA_XXX: EIA_MACGOP_REFI	EIA_XXX: EIA_MACGOM_REFI, EIA_GDP_PPP, EIA_GDP,MER	Refining gross output

Table 6. Oil sector mapping

EIA Variable		OE variable	Variable Description
EIA_QDSRS	Residential distillate consumption	DOIL	Crude oil demand
EIA_QKSRS	Residential kerosene consumption	DOIL	Crude oil demand
EIA_QLGRS	Residential LPG consumption	DOIL	Crude oil demand
EIA_QMGCM	Commercial motor gasoline consumption	DOIL	Crude oil demand
EIA_QDSCM	Commercial distillate consumption	DOIL	Crude oil demand
EIA_QRSCM	Commercial residual consumption	DOIL	Crude oil demand
EIA_QKSCM	Commercial kerosene consumption	DOIL	Crude oil demand
EIA_QLGCM	Commercial LPG consumption	DOIL	Crude oil demand
EIA_QMGIN	Industrial motor gasoline consumption	DOIL	Crude oil demand
EIA_QDSIN	Industrial distillate consumption	DOIL	Crude oil demand
EIA_QRSIN	Industrial residual consumption	DOIL	Crude oil demand
EIA_QKSIN	Industrial kerosene consumption	DOIL	Crude oil demand
EIA_QLGIN	Industrial LPG consumption	DOIL	Crude oil demand
EIA_QPCIN	Industrial petroleum coke consumption	DOIL	Crude oil demand
EIA_QSPIN	Industrial sequestered petroleum consumption	DOIL	Crude oil demand
EIA_QOPIN	Industrial other petroleum consumption	DOIL	Crude oil demand
EIA_QCDIN	Industrial crude oil consumption	DOIL	Crude oil demand
EIA_QMGTR	Transportation motor gasoline consumption	DOIL	Crude oil demand
EIA_QDSTR	Transportation distillate consumption	DOIL	Crude oil demand
EIA_QRSTR	Transportation residual consumption	DOIL	Crude oil demand
EIA_QLGTR	Transportation LPG consumption	DOIL	Crude oil demand
EIA_QJFTR	Transportation jet fuel consumption	DOIL	Crude oil demand
EIA_QSPTR	Transportation sequestered petroleum	DOIL	Crude oil demand
EIA_QOPTR	Transportation other petroleum consumption	DOIL	Crude oil demand
EIA_QCDTR	Transportation crude oil consumption	DOIL	Crude oil demand
EIA_QDSPG	Power generation distillate consumption	DOIL	Crude oil demand
EIA_QRSPG	Power generation residual consumption	DOIL	Crude oil demand
EIA_QCDPG	Power generation crude oil consumption	DOIL	Crude oil demand
EIA_QDSDH	District heat distillate consumption	DOIL	Crude oil demand
EIA_QRSDH	District heat residual consumption	DOIL	Crude oil demand

Table 6. Oil sector mapping (cont.)

EIA Variable		OE variable	Variable Description
EIA_QCDDH	District heat crude oil consumption	DOIL	Crude oil demand
EIA_SupPet	Petroleum product supply	QOIL OIL	Crude oil demand
EIA_XOIL	Crude oil exports	XOIL OIL	Crude oil demand
EIA_MOIL	Crude oil imports	MOIL OIL	Crude oil demand
EIA_WPTPPrc	Brent crude oil price	WPO	Brent crude oil price
EIA_WTIPPrc	WTI crude oil price	WPO_WTI	WTI crude oil price

Table 7. Natural gas sector mapping

EIA Variable		OE variable	Variable Description
EIA_QNGRS	Residential natural gas consumption	DGAS_BU	Buildings NG consumption
EIA_QNGCM	Commercial natural gas consumption	DGAS_BU	Buildings NG consumption
EIA_QNGIN	Industrial natural gas consumption	DGAS_IND	Industrial NG consumption
EIA_QNGTR	Transportation natural gas consumption	DGAS_OTH	Other generation NG consumption
EIA_QNGPG	Power generation natural gas consumption	DGAS_POW	Power generation NG consumption
EIA_QNGDH	District heat natural gas consumption	DGAS_POW	Power generation NG consumption
EIA_SupNGas	Natural gas supply	QGAS	NG production
EIA_XGASLNG	LNG exports	XGAS_LNG	LNG exports
EIA_XGASDRY	Pipeline exports	XGAS_DRY	Pipeline exports
EIA_MGASLNG	LNG imports	MGAS_LNG	LNG imports
EIA_MGASDRY	Pipeline imports	MGAS_DRY	Pipeline imports
EIA_HHNGPrc	Henry Hub price	WPGASHH	Henry Hub price
EIA_EURNGPrc	European natural gas price	WPGASEUR	European natural gas price
EIA_JPNNGPrc	Japanese natural gas price	WPGASJAP	Japanese natural gas price

Table 8. Coal sector mapping

EIA variable		OE variable	Variable Description
QCLRS	Residential coal consumption	DCOAL_BU	Buildings coal consumption
QCLCM	Commercial coal consumption	DCOAL_BU	Buildings coal consumption
QCLTR	Transportation coal consumption	DCOAL_OTH	Other coal consumption
QCLPG	Power generation coal	DCOAL_POW	Power generation coal consumption
QCLDH	District heat coal consumption	DCOAL_POW	Power generation coal consumption
QCLIN	Industrial coal consumption	DCOAL_IND,	Industrial coal consumption
EIA_SUPCOALCOKE	Coking coal supply	QCOAL_CO	Coking coal production
EIA_SUPCOALSTEAM	Steam coal supply	QCOAL_ST	Steam coal production
EIA_XCOALCO	Coking coal exports	XCOAL_CO	Coking coal exports
EIA_XCOALST	Steam coal exports	XCOAL_ST	Steam coal exports
EIA_MCOALCO	Coking coal imports	MCOAL_CO	Coking coal imports
EIA_MCOALST	Steam coal imports	MCOAL_ST	Steam coal imports
EIA_PRCCOALCOKE,EIA_AFR	African price of coking coal	WPCLAFR_CO	African price of coking coal
EIA_PRCCOALCOKE,EIA_ANZ	Australia/NZ price of coking coal	WPCLANZ_CO	Australia/NZ price of coking coal
EIA_PRCCOALCOKE,EIA_BRZ	Brazilian price of coking coal	WPCLBR_CO	Brazilian price of coking coal
EIA_PRCCOALCOKE,EIA_CAN	Canadian price of coking coal	WPCLCA_CO	Canadian price of coking coal
EIA_PRCCOALCOKE,EIA_CHI	Chinese price of coking coal	WPCLCH_CO	Chinese price of coking coal
EIA_PRCCOALCOKE,EIA_MXC	Mexico/Chile price of coking coal	WPCLCM_CO	Mexico/Chile price of coking coal
EIA_PRCCOALCOKE,EIA_CSA	Central and South American price	WPCLCSA_CO	Central and South American price of
EIA_PRCCOALCOKE,EIA_IND	Indian price of coking coal	WPCLIN_CO	Indian price of coking coal
EIA_PRCCOALCOKE,EIA_JPN	Japanese price of coking coal	WPCLJA_CO	Japanese price of coking coal
EIA_PRCCOALCOKE,EIA_SKO	South Korean price of coking coal	WPCLKO_CO	South Korean price of coking coal
EIA_PRCCOALCOKE,EIA_MID	Middle East price of coking coal	WPCLME_CO	Middle East price of coking coal
EIA_PRCCOALCOKE,EIA_URA	Other Europe and Eurasia price of	WPCLNEE_CO	Other Europe and Eurasia price of
EIA_PRCCOALCOKE,EIA_OAS	Non-OECD Asia price of coking	WPCLNOA_CO	Non-OECD Asia price of coking coal
EIA_PRCCOALCOKE,EIA_EUR	OECD Europe price of coking coal	WPCLOECD_CO	OECD Europe price of coking coal
EIA_PRCCOALCOKE,EIA_RUS	Russian price of coking coal	WPCLRU_CO	Russian price of coking coal
EIA_PRCCOALCOKE,EIA_USA	US price of coking coal	WPCLUS_CO	US price of coking coal
EIA_PRCCOALSTEAM,EIA_AFR	African price of steam coal	WPCLAFR_ST	African price of steam coal
EIA_PRCCOALSTEAM,EIA_ANZ	Australia/NZ price of steam coal	WPCLANZ_ST	Australia/NZ price of steam coal
EIA_PRCCOALSTEAM,EIA_BRZ	Brazilian price of steam coal	WPCLBR_ST	Brazilian price of steam coal
EIA_PRCCOALSTEAM,EIA_CAN	Canadian price of steam coal	WPCLCA_ST	Canadian price of steam coal
EIA_PRCCOALSTEAM,EIA_CHI	Chinese price of steam coal	WPCLCH_ST	Chinese price of steam coal

Table 8. Coal sector mapping (cont.)

EIA variable		OE variable	Variable Description
EIA_PRCCOALSTEAM,EIA_MXC	Mexico/Chile price of steam coal	WPCLCM_ST	Mexico/Chile price of steam coal
EIA_PRCCOALSTEAM,EIA_CSA	Central and South American price	WPCLCSA_ST	Central and South American price of
EIA_PRCCOALSTEAM,EIA_IND	Indian price of steam coal	WPCLIN_ST	Indian price of steam coal
EIA_PRCCOALSTEAM,EIA_JPN	Japanese price of steam coal	WPCLJA_ST	Japanese price of steam coal
EIA_PRCCOALSTEAM,EIA_SKO	South Korean price of steam coal	WPCLKO_ST	South Korean price of steam coal
EIA_PRCCOALSTEAM,EIA_MID	Middle East price of steam coal	WPCLME_ST	Middle East price of steam coal
EIA_PRCCOALSTEAM,EIA_URA	Other Europe and Eurasia price of	WPCLNEE_ST	Other Europe and Eurasia price of
EIA_PRCCOALSTEAM,EIA_OAS	Non-OECD Asia price of steam	WPCLNOA_ST	Non-OECD Asia price of steam coal
EIA_PRCCOALSTEAM,EIA_EUR	OECD Europe price of steam coal	WPCLOECD_ST	OECD Europe price of steam coal
EIA_PRCCOALSTEAM,EIA_RUS	Russian price of steam coal	WPCLRU_ST	Russian price of steam coal
EIA_PRCCOALSTEAM,EIA_USA	US price of steam coal	WPCLUS_ST	US price of steam coal

For countries where mapping is one-to-one, the WEPS+ projection is imposed directly on the equivalent OE variable. The variable mapping is also specified within the transfer base and follows the following system for fuel prices:

Table 9. Global fuel price mapping – oil and natural gas

Oxford model: Dependent	Transfer base: Dependent	Transfer base: Independent
WPO,WORLD	BWPO,WORLD	EIA_WPTPPRC,EIA_USA
WPO_WTI,WORLD	BWPO_WTI,WORLD	EIA_WTIPPRC,EIA_USA
WPGASHH,WORLD	BWPGASHH,WORLD	EIA_HHNGPRC,EIA_USA
WPGASEUR,WORLD	BWPGASEUR,WORLD	EIA_EURNGPRC,EIA_USA
WPGASJAP,WORLD	BWPGASJAP,WORLD	EIA_JAPNGPRC,EIA_USA

Because regional coking and steam coal prices are not currently available within WEPS+, they are not included in the input database. These prices are taken directly from OE and modelled directly in the output database.

The energy quantity mappings differ depending upon whether they refer to individual countries or regions. For individual countries, the mapping appears in Table 6.

Table 10. Energy quantity mapping for the United States, Canada, Japan, China, Brazil, India, Russia, and Korea

Variable	Transfer base:	Transfer base: Independent variable
Coal production	EIA_XXX: QCOAL	EIA_XXX: EIA_QCLRS + EIA_QCLCM + EIA_QCLIN + EIA_QCLTR + EIA_QCLPG + EIA_QCLDH
	GEM COUNTRY: QCOAL	EIA_XXX: EIA_SUPCOAL
Coal consumption	GEM country: DCOAL	EIA_XXX: QCOAL
Natural gas production	EIA_XXX: QGAS	EIA_XXX: EIA_QNGRS + EIA_QNGCM + EIA_QNGIN + EIA_QNGTR + EIA_QNGPG + EIA_QNGDH
	GEM COUNTRY: QGAS	EIA_XXX: EIA_SUPNGAS
Natural gas consumption	GEM country: DGAS	EIA_XXX: QGAS
Oil production	EIA_XXX: QOIL	EIA_XXX: EIA_QDSRS + EIA_QDSRS + EIA_QRSRS + EIA_QKSRS + EIA_QLGRS + EIA_QMGCM + EIA_QDSCM + EIA_QRSCM + EIA_QKSCM + EIA_QLGCM + EIA_QMGIN + EIA_QDSIN + EIA_QRSIN + EIA_QKSIN + EIA_QLGIN + EIA_QPCIN + EIA_QSPIN + EIA_QOPIN + EIA_QCDIN + EIA_QMGTR + EIA_QDSTR + EIA_QRSTR + EIA_QLGTR + EIA_QJFTR + EIA_QSPTR + EIA_QOPTR + EIA_QCDTR + EIA_QDSPG + EIA_QRSPG + EIA_QCDPG + EIA_QDSDH + EIA_QRSDH + EIA_QCDDH
	GEM COUNTRY: QOIL	EIA_XXX: EIA_SUPPET
Oil consumption	GEM country: DOIL	EIA_XXX: QOIL

For the countries/regions where there is no one-to-one mapping between WEPS+ and OE, the mapping process between the WEPS+ variable and the OE variable follows a three step process:

- WEPS+ demand and supply for each WEPS+ region is defined.
- Baseline OE demand and supply—from GEM—for each WEPS+ region is defined as a sum of the demand and supply values for all the countries included in the region.
- Forecasts for demand and supply for each OE country/region are defined. Each OE region/country is set to grow in line with the relevant WEPS+ region, with an adjustment made for different paths for fuel usage/production over the forecast period. The adjustment is calculated using each country/region's share of baseline demand/supply from the OE model.

For some countries, baseline oil consumption and production estimates are not currently available. In these cases the input transfer database estimates these values. For consumption, this is done by choosing consumption so that energy intensity—consumption/GDP—matches that of a similar country. For production, this is done by calculating the country's share of the regional total. The regional quantity mapping follows:

Table 11. Energy quantity mapping for regions

Variable Description	Transfer base: Dependent variable	Transfer base: Independent variable
Coal production	EIA_XXX: QCOAL	EIA_XXX: EIA_QCLRS + EIA_QCLCM + EIA_QCLIN + EIA_QCLTR + EIA_QCLPG + EIA_QCLDH
	EIA_XXX: BQCOAL	OE Country: BQCOAL
	OE Country: QCOAL	EIA_XXX: EIA_SUPCOAL, OE Country: BQCOAL, EIA_XXX: BQCOAL
Coal consumption	EIA_XXX: DCOAL	EIA_XXX: QCOAL
	EIA_XXX: BDCOAL	OE Country: BDCOAL
	OE Country: ZDCOAL	EIA_XXX: QCOAL, OE Country: BDCOAL, EIA_XXX: BDCOAL
	OE Country: DCOAL	OE Country: ZDCOAL, EIA_XXX: DCOAL
	EIA_XXX: QGAS	EIA_XXX: EIA_QNGRS + EIA_QNGCM + EIA_QNGIN + EIA_QNGTR + EIA_QNGPG + EIA_QNGDH
Natural gas production	EIA_XXX: BQGAS	OE Country: BQGAS

Table 11. Energy quantity mapping for regions (cont.)

Variable Description	Transfer base: Dependent variable	Transfer base: Independent variable
	OE Country: QGAS	EIA_XXX: EIA_SUPNGAS, OE Country: BQGAS, EIA_XXX: BQGAS
Natural gas consumption	EIA_XXX: DGAS	EIA_XXX: QGAS
	EIA_XXX: BDGAS	OE Country: BDGAS
	OE Country: ZDGAS	EIA_XXX: QGAS, OE Country: BDGAS, EIA_XXX: BDGAS
	OE Country: DGAS	OE Country: ZDGAS, EIA_XXX: DGAS
Oil production	EIA_XXX: QOIL	EIA_XXX: EIA_QDSRS + EIA_QKSRS + EIA_QLGRS + EIA_QMGCM + EIA_QDSCM + EIA_QRSCM + EIA_QKSCM + EIA_QLGCM + EIA_QMGIN + EIA_QDSIN + EIA_QRSIN + EIA_QKSIN + EIA_QLGIN + EIA_QPCIN + EIA_QSPIN + EIA_QOPIN + EIA_QCDIN + EIA_QMGTR + EIA_QDSTR + EIA_QRSTR + EIA_QLGTR + EIA_QJFTR + EIA_QSPTR + EIA_QOPTR + EIA_QCDTR + EIA_QDSPG + EIA_QRSPG + EIA_QCDPG + EIA_QDSDH + EIA_QRSDH + EIA_QCDDH
	EIA_XXX: BQOIL	OE Country: BQOIL
	OE Country: QOIL	EIA_XXX: EIA_SUPPET, OE Country: BQOIL, EIA_XXX: BQOIL
Oil consumption	EIA_XXX: DOIL	EIA_XXX: QOIL
	EIA_XXX: BDOIL	OE Country: BDOIL
	OE Country: ZDOIL	EIA_XXX: QOIL, OE Country: BDOIL, EIA_XXX: BDOIL
	OE Country: DOIL	OE Country: ZDOIL, EIA_XXX: DOIL

ii. Calculate the impact of the changes represented in the input transfer database on the rest of the economy at the macro and industry level—this step is known as "solving the database"

Once the input transfer database has been solved and the forecast path for the OE variables recalculated, the batch process moves on to feed the new forecasts back into the OE models and calculate the impact of the forecast changes on the wider macro economy. This part of the process involves three steps:

- The new forecast path for the energy consumption, production, and price variables are transferred back to GEM using the DBTransfer program.
- GEM is solved using the GENMOD solver to calculate the changes to the wider macro economy.
- The changes to the wider macro economy are transferred to GIM, which is solved using GENMOD, and the impacts on gross output at the sectoral level are calculated.

iii. Extract the new path for GDP and gross output from GEM and GIM, use these to calculate a new forecast path for the equivalent WEPS+ variables, and transfer the new paths back to WEPS+

Once the new macroeconomic environment has been simulated, the final stage of the transfer system extracts the macro variables from the OE databases, computes a new forecast path for the equivalent WEPS+ series, and passes these series back to WEPS+. The first part of this process again makes use of the DBTransfer program to extract the relevant series from GEM and GIM and transfer them to the output transfer database. As with the input transfer database, the output transfer database maps between the WEPS+ and OE variables and uses the mapping to recalculate the forecast path for the WEPS+ variables—this is done by solving the model using the GENMOD solver.

For all of the macroeconomic series, the transfer system transfers historical data and forecasts to WEPS+ via the output database. For these series, the historical data will be the latest available, and will typically lag the actual date by 3-12 months, depending on the series and the time of the year. The output mapping for the OE and WEPS+ variables are in the tables below.

Table 12. GDP mapping

Oxford Economics country	WEPS+ country/region
Brazil	Brazil
Canada	Canada
China	China
India	India
Japan	Japan
Korea	Korea
Russia	Russia
United States	United States
Chile, Mexico	Chile/Mexico
Australia, New Zealand	Australia/New Zealand

Table 12. GDP mapping (cont.)

Oxford Economics country	WEPS+ country/region
Austria, Belgium, Czech Rep, Denmark, Estonia, Slovenia, Finland, France, Germany, Greece, Hungary, Ireland, Israel, Italy, Luxembourg, Iceland, Netherlands, Norway, Poland, Portugal, Slovak Rep, Spain, Sweden, Switzerland, Turkey, U.K.	OECD Europe
South Africa, AFRICA (Benin, Botswana, Burkina Faso, Burundi, Cape Verde, Cameroon, Central African Republic, Chad, Comoros, Republic of Congo, Democratic Republic of Congo, Côte d'Ivoire, Djibouti, Egypt, Equatorial Guinea, Eritrea, Ethiopia, Gabon, The Gambia, Ghana, Guinea, Guinea-Bissau, Lesotho, Liberia, Kenya, Madagascar, Malawi, Mali, Mauritania, Mauritius, Morocco, Mozambique, Namibia, Niger, Reunion, Rwanda, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, Somalia, St. Helena, Sudan, Swaziland, Tanzania, Togo, Tunisia, Uganda, Western Sahara, Zambia, Zimbabwe), Algeria, Angola, Libya, Nigeria	Africa
Bahrain, Oman, Jordan, Lebanon, Syria, Yemen, Iraq, Iran, Kuwait, Qatar, Saudi Arabia, United Arab Emirates	Middle East
Hong Kong, Indonesia, Malaysia, Philippines, Singapore, Taiwan, Thailand, RWOR (Afghanistan, American Samoa, Bangladesh, Bhutan, Brunei, Cambodia, Cook Islands, Fiji, French Polynesia, Guam, Kiribati, Laos, Macau, Maldives, Mongolia, Myanmar, Nauru, Nepal, New Caledonia, Niue, North Korea, Pakistan, Papua New Guinea, Samoa, Solomon Islands, Sri Lanka, Timor-Leste, Tonga, U.S. Pacific Islands, Vanuatu, Vietnam, Wake Islands)	Other Non-OECD Asia
Bulgaria, Croatia, Romania, Cyprus, Malta, EASTEUR (Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Macedonia, Moldova, Montenegro, Serbia, Tajikistan, Turkmenistan, Ukraine, Uzbekistan)	Other Non-OECD Europe & Eurasia
Argentina, Bolivia, Colombia, Costa Rica, Honduras, Jamaica, Panama, Peru, Uruguay, Ecuador, Venezuela	Other Central & South America

Table 13. Gross output country/region mapping

Oxford Economics country	WEPS+ country/region
Brazil	Brazil
Canada	Canada
China	China
India	India
Japan	Japan
Korea	Korea
Russia	Russia
United States	United States
Chile, Mexico	Chile/Mexico
Australia, New Zealand	Australia/New Zealand
Austria, Belgium, Czech Rep, Denmark, Estonia, Slovenia, Finland, France, Germany, Greece, Hungary, Ireland, Israel, Italy, Luxembourg, Netherlands, Norway, Poland, Portugal, Slovak Rep, Spain, Sweden, Switzerland, Turkey, U.K.	OECD Europe
South Africa. GIM calculates total for Cameroon, Kenya, Morocco, Nigeria, Senegal, Tunisia & Zimbabwe	Africa
Bahrain, Oman, Jordan, Lebanon, Syria, Yemen, Iraq, Iran, Kuwait, Qatar, Saudi Arabia, United Arab Emirates	Middle East
Hong Kong, Indonesia, Malaysia, Philippines, Singapore, Taiwan, Thailand, Vietnam. GIM calculates total for Bangladesh & Sri Lanka	Other Non-OECD Asia
Bulgaria, Cyprus, Latvia, Lithuania, Malta, Romania & Ukraine	Other Non-OECD Europe & Eurasia
Argentina, Colombia, Ecuador, Uruguay, Venezuela. GIM calculates total for Bolivia, Costa Rica, Honduras, Jamaica, Panama, and Peru.	Other Central & South America

Table 14. Gross output sector mapping

Oxford Economics sector	WEPS+ sector
Agriculture, forestry, & fishing (xA)	Agriculture, forestry, & fishing
Basic chemicals & fertilizers (xCHBAS)	Chemicals
Chemicals & pharmaceuticals (xCHEM), rubber & plastics (xRUBP), *minus* basic chemicals & fertilizers (xCHBAS)	Other Chemicals
Information & communication (xCOM)	Information & communications
Construction (xC)	Construction
Distribution, accommodation, & catering (xDIS)	Distribution, accommodation, & catering
Financial & business services (xFIBU)	Financial & business services
Food, beverages, & tobacco (xFDBVT)	Food
Public services (xPUBLIC)	Government & community services
Iron & steel (xBMIST), castings (xBMCST)	Iron & steel
Extraction (xE)	Extraction
Non-ferrous metals (xBMNFR)	Non-ferrous metals
Cement, plaster, concrete, etc. (xMLCSN)	Non-metal minerals
Paper & printing (xPAPR)	Paper & pulp
Coke & refined petroleum products (xFUEL)	Refining
Ceramic, clay & refractory products (xMLCER), electric machinery & apparatus (xELEC31), furniture manufacturing (xOTHF), glass (xMLGL), high-tech goods (xELC), mechanical engineering (xMECH), metal products (xMETP), other manufacturing (xOTHM), repair & installation of machinery (xREPAIR), textiles, leather, & clothing (xTEXT), transport equipment (xMOTRA), wood & wood products (xWOOD)	All other

Table 15. Sectors and industries with NACE2 codes

Sector	NACE2 Code
Services sector	G-U 45-99
Distribution, accommodation, transportation, & storage	G 45-47,H 49-53, I 55-56
Information & communications	J 58-63
Finance & business services	K 64-66, L 68, M 69-75, N 77-82
Government	O 84, P 85, Q 86-88, R 90-93, S 94-96, T 97-98, U 99

Table 15. Sectors and industries with NACE2 codes (cont.)

Sector	NACE2 Code
Nonmanufacturing sector	
Construction	F 41-43
Agriculture	A 01-03
Mining/extraction	B 05-09
Manufacturing sector	C 10-33
Energy-intensive	
Food, beverage, & tobacco	C 10-12
Pulp & paper	C 17
Petroleum & coal products	C 19
Basic, resin, & ag. Chemicals	C 20.1-2,6
Non-metal minerals	C 23
Iron and steel	C 24.1-3
Other primary metals	C 24.4-5
Non-energy-intensive	
Other industrial	C 10-33 nec
Other chemicals	C 20.3-5, 21

Note: NACE = Statistical Classification of Economic Activities in the European Community. NACE ("Nomenclature statistique des Activités économiques dans la Communauté Européenne") is the industry standard classification system of the European Union. See http://ec.europa.eu/eurostat/ramon/nomenclatures/index.cfm?TargetUrl=LST_NOM_DTL&StrNom=NACE_REV2.

Using the mapping, the output transfer database then recalculates the forecasts for the WEPS+ regions. For the countries and regions where the country coverage is fully-defined, the output transfer base calculates the new forecasts by imposing the values of each WEPS+ country/region calculated in the OE model. For the WEPS+ regions that draw on one or more of the OE countries or regions, the WEPS+ region's share of GDP is calculated and added to the sum of the individual country GDP values (see mapping table below).

The final stage of the transfer process takes the newly-calculated WEPS+ region series and passes them back to WEPS+ using the DBTransfer program.

GENMOD solver

The GENMOD solver is a program that calculates an equilibrium solution for all of the OE model databases. This includes the GEM, the GIM, and the two transfer databases used in the transfer system.

The GENMOD solver uses the subroutines known as AMODEL, a collection of subroutines, which have been designed to solve econometric models that satisfy the following conditions:

- The model consists of a system of simultaneous time dependent equations which may be nonlinear but which are capable of being solved period by period. The solution in any period may depend on variable values in that or other—earlier or later—periods. Thus, model solutions based only on past behavior and designed to achieve some satisfactory path to a given end condition cannot be obtained easily using AMODEL.
- The model must be solvable using the Gauss Seidel iterative optimization method, or at least any extra sophistication required must be provided by the individual model builder within the overall Gauss Seidel framework. The Gauss Seidel method involves iteratively solving the equations one by one, always using the latest calculated values for the variables on the right-hand side of the equations, until the changes in the values of the variables between iterations are all acceptably small. Normally this raises no problems for econometric models if the equations are solved in a sensible order, but if problems do arise, they can sometimes be overcome by combining two or more closely linked equations and solving analytically for the variables involved. There are facilities available for changing the order of solution, but currently no facilities for optimising that order analytically.

FixEdit program

The FIXEDIT program edits four separate *.RUN files to modify them based on updated data and on the content of the FIXTYPE.TXT file that is generated by the interactive front-end. It is normally run as an initial step in the Batch file process that is either started automatically by the interactive front-end or run as a separate process.

The FIXEDIT program currently performs the following eight steps:

1. The program reads in and processes a file of instructions (FIXTYPE.TXT) that has been generated by the interactive front end. This file contains a list of variables that are to be forecast as growth rates, forecast as levels, or to be included or not included in the results of the run. The contents of this instruction file will be used in steps 4, 5, and 6.
2. The program gets the current date and uses it to determine the current year and quarter. This information will be used in steps 3, 5 and 7.
3. The program reads in a list of variables that cannot change, also called a list of fixes (FIXES.RUN), and adjusts the dates of these fixes based on the current quarter. The results are written to a file called FIXES1.RUN.
4. The program reads in a list of variables to be forecast as growth rates (ENERGY_GROWTH.RUN) and comments out any variables that are not to be forecast as growth rates. The results are written to a file called FIXES2.RUN.
5. The program reads in a list of variables to be forecast as levels (ENERGY_Q1.RUN, ENERGY_Q2.RUN, ENERGY_Q3.RUN, or ENERGY_Q4.RUN, depending on the current quarter) and comments out any variables that are not to be forecast as levels. The dates in this file are modified based on the current quarter. The results are written to a file called FIXES3.RUN.
6. The program reads in a list of variables that cannot change for the OE Macro database (MACRO01.SRC) and comments out the data for any variables that are not to be included in the forecast. The results are written to a file called MACRO01.RUN.

7. The program reads in a list of variable that cannot change (FIXES_OUTPUT.RUN) and adjusts the dates when historical values are allowed to change. The reason for this step is that IEO data are often available with a much larger lag than Oxford data, and this can cause solution problems. Allowing users to change the date when variables become fixed can solve this problem. The results are written to a file called FIXES4.RUN.
8. The program generates various status messages that are written both to the console and to a file called FIXEDIT.OUT. The latter file is scanned—along with a number of other .OUT files—by the Batch process to determine if any errors occurred when it was run.

This version of the FixEdit program ignores any command line parameters that may be given to it.

DBTransfer program

The DBTransfer program transfers data to and from OE and/or WEPS+. When invoked, the DBTransfer program performs one of three transfer functions, depending on its command parameters:

1. Copying variable data from one OE database to another OE database
2. Copying variable data from WEPS+ to an OE database
3. Copying variable data from an OE database to WEPS+

By default, the DBTransfer program takes its commands from a command file in the current directory named "DBTransfer.in". When invoked with a parameter (for example, "DBTransfer c:\foo \myfile.txt"), it will read its commands from the named command file (in this case, "c:\foo\myfile.txt") instead. By default, the DBTransfer program writes informational and error messages to an output file in the current directory called "DBTransfer.out". However, when invoked with a command file ending in ".in", the program will redirect those messages to a corresponding ".out" file (for example, "dbtransfer c:\foo\myfile.in" will cause the program to redirect its messages to "c:\foo\myfile.out"). When something goes wrong, an explanation of the reason why will be found in this output file.

DBTransfer always reads its commands from its input command file using a Fortran-style "list" format—where values are separated by one or more spaces. When there is more than one argument on a command line—and there usually is—each argument should be separated by one or more spaces.

The first line of the command file tells the DBTransfer program basically what kind of run this is going to be. This line contains four parameters: runtype, internal periodicity, first year to process, and last year to process.

Runtype is a value of 1, 2, or 3, and tells the DBTransfer program which of its three functions (referenced above) it is going to perform for this run.

Internal Periodicity tells the DBTransfer program what periodicity to use internally. A value of 1 means treat everything as annual data, and a value of 4 means treat everything as quarterly data. Because WEPS+ runs on annual data, whenever the WEPS+ restart file is involved, the DBTransfer program will use an internal periodicity of 1 regardless of the specified internal periodicity. The OE database(s) involved can be either annual or quarterly; the DBTransfer program will modify the variable data to suit the OE database as needed.

Firstyear and **Lastyear** are the first and last years in yyyy format (for example, "1980") that the DBTransfer program will use when it transfers variable data for this run.

For example, if the first line of the command file is "1 4 1980 2050" then the DBTransfer program will perform an OE-to-OE database transfer treating the data internally as quarterly starting in 1980 and ending in 2050. Note that the actual OE databases can be annual or quarterly; the DBTransfer program will modify the variable data as needed. However, note also that if the OE databases are quarterly databases and the DBTransfer program is told to treat its data internally as annual data, then all of the variable data it processes will be annualized. This may not be the result the user desires.

The second through fifth lines of the command file tell the DBTransfer program where the input and output databases reside. The first two lines describe the "from" database, and the second two lines describe the "to" database.

Where an OE database is involved, the first of the two lines tells the DBTransfer program where the database—usually a .DB file—is located and the second tells the DBTransfer program where its associated SECTORS file is located. All OE databases have associated SECTORS files, which are usually—but not always—named "SECTORS."

Where a WEPS+ database is involved, the first of the two lines tells the DBTransfer program where the database is located and the second line is blank/empty. For example, if the DBTransfer program is to transfer EIA database data to an OE database, those four lines will look something like

\EIADBtransferdirectory\restart.bin

(blank line)

\OEDBtransferdirectory\jan01.db

\OEDBtransferdirectory\sectors.

The remaining lines in the command file specify the variables to be transferred. Each line specifies one variable to transfer (with two exceptions, noted below).

Where both databases use the same sector/variable names, any line contains two entries: a sector/region name and a variable name. For example, an entry of

IRELAND GDP

tells the DBTransfer program to transfer the data from variable GDP of the IRELAND region in the input database into the identically named variable/region of the output database.

Where the two databases use different sector/variable naming conventions, any line contains four entries: the input database region name, the input database variable name, the output database region name, and the output database variable name. For example, an entry of

IRELAND GDP RESTOECD GDPIRE

tells the DBTransfer program to transfer the data from variable GDP in the IRELAND region of the input database into variable GDPIRE in the RESTOECD region of the output database.

If both databases use identical naming conventions, four values may be specified (for example, “IRELAND GDP IRELAND GDP”), but the second two values are unnecessary.

Here are the exceptions:

1) An entry that begins with an exclamation point or percent sign followed by a space is considered to be a comment—or commented-out—entry and is completely ignored. For example, an entry of

! US GDP

or

% US GDP

is ignored under the assumption that this entry should not be used—at least during this run.

2) Because we always want to transfer every sector/region of any specific variable to or from a WEPS+ database from or to its OE equivalent, the DBTransfer program recognizes the special input database sector/region name "EIA_ALL" to mean "expand this line internally into sixteen entries, one per WEPS+ sector/region". For example, an entry of

EIA_ALL EIA_GDP_PPP

causes the program to treat this line as if it were sixteen lines, one per WEPS+ sector/region—EIA_USA, EIA_CAN, EIA_MXC, EIA_EUR, EIA_JPN, EIA_ANZ, EIA_SKO, EIA_RUS, EIA_URA, EIA_CHI, EIA_IND, EIA_OAS, EIA_MID, EIA_AFR, EIA_BRZ, and EIA_CSA. You don't have to use this exception, but it saves typing.