Concepts, Data Sources, and Techniques

Handbook of Energy Modeling Methods

World Energy Projection System (WEPS): Coal Supply Module

Independent Statistics & Analysis

www.eia.gov

U.S. Department of Energy

Washington, DC 20585

Last Updated 2021

This report was prepared by the U.S. Energy Information Administration (EIA), the statistical and analytical agency within the U.S. Department of Energy. By law, EIA's data, analyses, and forecasts are independent of approval by any other officer or employee of the United States Government. The views in this report therefore should not be construed as representing those of the U.S. Department of Energy or other federal agencies.

Contents

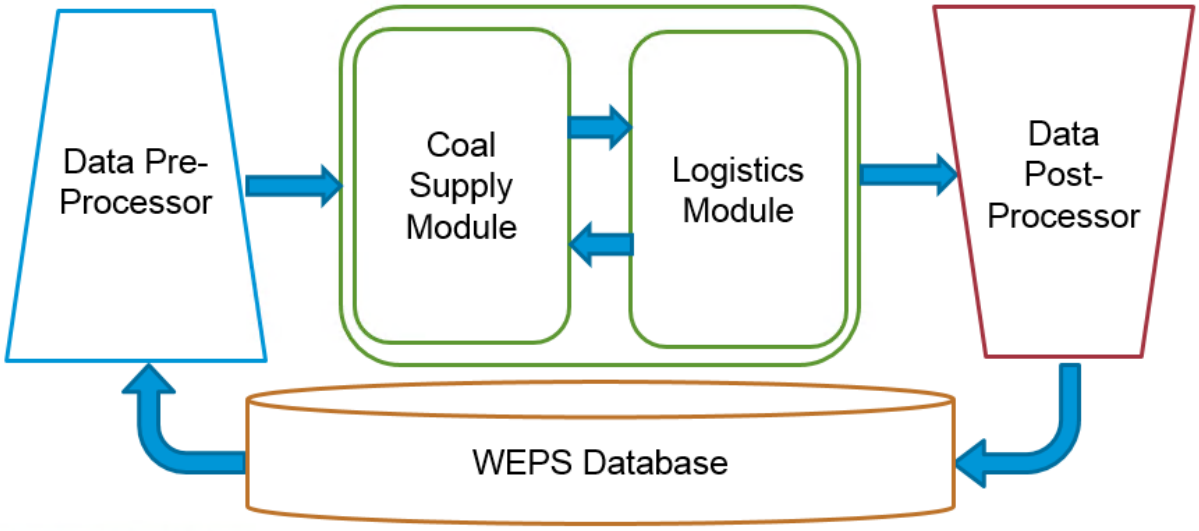
Table of Figures

Table of Tables

Introduction

The WEPS International Coal Market Module (ICMM) projects coal production, imports, exports, and prices by region and coal commodity type for the WEPS.

Figure 1. Modules in the ICMM



Source: U.S. Energy Information Administration

1. The data pre-processor submodule reaggregates data from different sources that use different regional and coal commodity subdivisions.
2. The coal supply submodule estimates coal supply curves.
3. The logistics submodule uses the supply curves to project coal prices.
4. The data post-processor submodule communicates ICMM results to the rest of WEPS.

The coal supply submodule and the logistics submodule have an iterative relationship, where the logistics submodule results are compared with the results from the previous iteration of the coal supply submodule, which adjusts the coal supply curve parameters accordingly. This iterative process enables ICMM to simulate regional production decisions based on the previous year's data. The iterative process stops when the change from the previous iteration is small enough to meet specified convergence criteria.

The logistics submodule is a linear program, where the objective function represents profits from coal shipments from the supply regions to the demand regions. This submodule projects the price of the different coal commodities in the demand regions, the trade quantities of each trade route, and coal production, based on the supply curve response. Because the objective function represents profits, the submodule determines the trade routes with the lowest transportation rates and the supply regions

with the lowest supply prices to provide demand with the lowest delivered cost, thereby maximizing profit.

The production determined by the logistics submodule is fed back to the coal supply submodule to estimate new supply curves for the logistics submodule to use in the next iteration.

Data Sources

The ICMM uses data from three major sources: EIA's International Energy Statistics (IES) data, data from other WEPS modules, and data specifically input for the ICMM.

Regional definitions

Because the ICMM regions differ from the WEPS regions, the ICMM uses IES country-level data to reaggregate regional data and compute region-level weights for use in further aggregation. The ICMM and WEPS regions are listed in Table 1.

Table 1. ICMM Regions and WEPS Regions

ICMM region	WEPS region
Africa—North	Africa
Africa—South	Africa
Australia and New Zealand	Australia and New Zealand
Brazil	Brazil
Canada	Canada
China	China
Other non-OECD Americas	Other non-OECD Americas
Eurasia—Asia	Non-OECD Europe and Eurasia
Eurasia—Europe	Non-OECD Europe and Eurasia
India	India
Japan	Japan
Middle East	Middle East
Mexico and OECD Americas	Mexica and other OECD Americas
Non-OECD Asia—land (Mongolia, North Korea)	Non-OECD Asia
Non-OECD Asia—ocean	Non-OECD Asia
Pakistan	Non-OECD Asia
Russia	Russia
South Korea	South Korea
United States	United States
OECD Europe	OECD Europe

Source: U.S. Energy Information Administration

Coal types

Coal types differ for the three main data sources. The IES, for example, provides data for anthracite, bituminous, sub-bituminous, lignite, and metallurgical coal The WEPS coal types are aggregated into three categories: generalized coal (which includes both steam coal and metallurgical coal), steam coal, and metallurgical coal. The ICMM reaggregates the IES coal data using heat content data into the following categories: bituminous, sub-bituminous, lignite, and metallurgical. Table 2 shows the coal commodity categories for the three data sources.

Table 2. Coal types

IES coal type	ICMM coal type	WEPS coal type
Metallurgical	Metallurgical	Metallurgical
Anthracite	Bituminous	Steam
Bituminous	Bituminous	Steam
Sub-bituminous	Sub-bituminous	Steam
Lignite	Lignite	Steam

Source: U.S. Energy Information Administration

Coal Demand

The WEPS demand modules project quantities of coal consumed in the demand sectors. The electric power and industrial sectors account for most coal consumption. Because the WEPS demand modules only project consumption of general coal (i.e., steam coal and metallurgical coal), steam coal, and metallurgical coal, the ICMM aggregates the IES data to project quantities of bituminous, subbituminous, and lignite coal.

Heat content

ICMM coal results are presented both in quadrillion British thermal units (Btus) (heat content) and metric tons. ICMM uses a specific Btu per metric ton factor for each coal type and supply region.

Transportation costs

The transportation rate is the cost (dollars per ton) of moving coal from the supply region to the demand region. Although transportation can include both rail and ocean freight, the transportation rate is aggregated into one cost. ICMM projects transportation rates based on fuel cost, distance traveled, and loading/unloading costs.

AEO calibration

The ICMM calibrates projected United States coal production to the projections published in our most recent *Annual Energy Outlook* (AEO), with an allowed deviation of 15% for steam coal and 5% for metallurgical coal. The allowed deviations are different because U.S. steam coal production is more sensitive to world coal price changes than U.S. metallurgical coal production.

Supply

The supply submodule calculates regional supply curves that represent the relationships between each region's coal production and coal prices. The supply curves rely on regional data and assumed

elasticities. The submodule shifts the curves based on assumed production growth rates and results from the logistics submodule. The supply and logistics submodules iterate, constantly adjusting the production for all years for the regions when production exceeds or falls short of demand.

Logistics

The logistic submodule is a linear program (LP) which seeks to maximize projected profits (revenues minus costs) subject to network balance constraints.

Objective function

The LP objective function represents sums of revenues obtained from selling coal at the destinations minus all associated production costs and transportation costs.

Constraints

The LP constraints are typical network balance constraints:

- Demand must be saitisfied for each demand region
- Production at a region cannot exceed the region's maximum production capacity
- Flows along a transportation route cannot exceed the route's capacity

Supply-Logistics Iteration

The supply and logistics compents of ICMM iterate via ICMM's growth expansion algorithm. The growth expansion component of the supply submodule projects the supply curve over the projection period. The goal is to shift the supply curves over time based on coal production and trade flows determined by the logistics submodule. The submodule shifts each region's production through a feedback loop that compares the logistics submodule's coal production to the previously projected production and adjusts the production if it's too high or low, according to the following definitions:

- A region's production is too high if production costs are higher than the selling price. In this case, the region's producers must close down expensive mines and reduce their production.
- A region's production is too low if it is not producing enough coal to meet the demand. In this case, the regions' producers must increase their output by increasing mining efficiency or opening more mines.

Each time the supply submodule adjusts a region's projected production in the iterative loop, it also adjusts the projected commodity prices (either up or down) by a percentage of the change in production. The iterative loop continues to adjust projected production and prices until no futher adjustments are needed or until a maximum number of iterations have been performed..

Integration with WEPS

The ICMM is integrated with the WEPS database, through which it communicates with other WEPS modules by retrieving and providing data. The ICMM interacts mainly with the International Energy Market Module (IEMM) and the Industrial Module. It provides coal prices to these modules and receives

coal quantities demanded. The Industrial module is the only WEPS module that needs a metallurgical coal price. The other modules receive prices for steam coal.