Concepts, Data Sources, and Techniques

Handbook of Energy Modeling Methods

Short-Term Energy Outlook Coal Module

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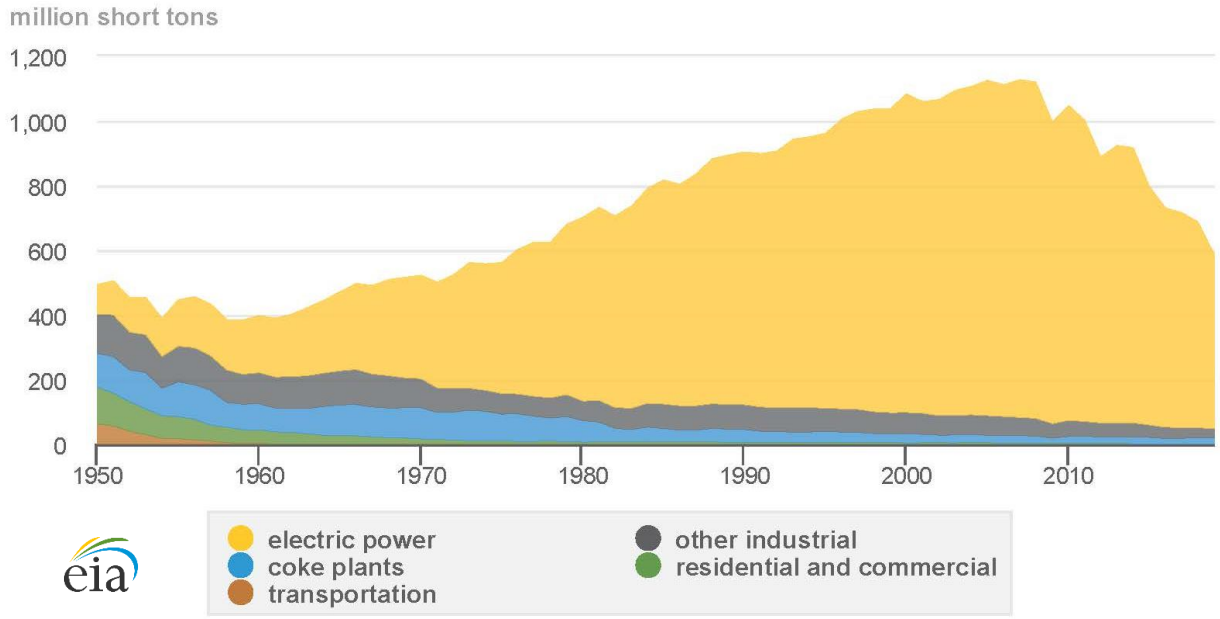
1. Introduction

In 2018, about 756 million short tons of coal were produced in 23 U.S. states. More than 70% of U.S. coal comes from Wyoming, West Virginia, Pennsylvania, Illinois, and Kentucky. Although coal was once commonly used in the industrial, transportation, residential, and commercial sectors, today the main use of coal in the United States is to generate electricity.

Many industries also use coal and coal byproducts. The concrete and paper industries burn large amounts of coal to produce heat. The steel industry makes coal coke by baking coal in furnaces and then using the coal coke to smelt iron ore into iron to make steel. Figure 1 shows the changing uses of coal over time.

Figure 1 U.S. coal consumption by major end users, 1950 – 2019



Source: U.S. Energy Information Administration, *Monthly Energy Review*, Table 6.2, May 2020
Note: *Coke plants* are industrial coking coal plants; *other industrial* includes all other, non-coking coal industrial use.

The *Short-Term Energy Outlook* (STEO) Coal Module provides forecasts of

- Coal supply (production, stocks, and waste coal)
- Trade (imports and exports)
- Consumption
- Prices
- Coal coke (production, consumption, trade, and stocks)
- Raw steel production

The Coal Module contains 73 equations, of which 23 equations are linear regression models (see Section B1). The remaining 50 equations are *balancing* equations, used to ensure that forecasts add up; for example, the sum of all coal stocks across regions must equal the national total.

Some of the input variables to the Coal Module come from other STEO modules (such as natural gas and petroleum prices or regional demand for coal from the electric power sector) or from forecasts produced by other organizations, such as weather forecasts from the National Oceanic and Atmospheric Administration. The Coal Module projects national coal prices and passes them to several other modules in STEO. The Coal Module, in conjunction with the STEO Electricity Supply Model, returns a projection of national coal demand. To forecast coal and coal coke stocks and consumption, the module relies on inputs from the STEO Electricity Supply Model.

2. Coal Module Outputs

The STEO Coal Module forecasts the following data series for the United States and regionally as noted:

- Coal supply
    - Production by major producing region (Appalachia, Interior, and Western)
    - *Primary stocks*, which are stocks held by coal producers and distributors
    - *Secondary stocks,* which are stocks held by end-use sectors, including:
        - Electric power sector, by demand region (Northeast, Midwest, South, and West)
        - Coke plants
        - Industrial sector (excluding coke plants)
        - Commercial and institutional sector
    - Waste coal
- International coal trade
    - Imports
    - Steam coal exports
    - Metallurgical coal exports
- Coal consumption by end-use sector
    - Coke plants
    - Industrial sector (excluding coke plants)
    - Commercial and institutional sector
- Coal prices
    - Composite spot coal price
    - Electric power sector coal price
- Raw steel production
- Coal coke
    - Production
    - Consumption
    - International trade, including imports, exports, and net imports
    - Stocks
- Coal market balances

3. Data Sources and Aggregations

We update the Coal Module each month with data from three primary EIA publications:

- *Weekly Coal Production* (WCP)
- *Electric Power Monthly* (EPM)
- *Monthly Energy Review* (MER)

We also update coal production each quarter with data from the *Quarterly Coal Report* (QCR), which provides revised monthly estimates for coal production. Each month, we obtain model input data from several EIA publications and external resources:

- Coal production
- Preliminary monthly estimate of coal production from the WCP, represented as the sum of weekly estimates
  - When a week extends into a new month, the model allocates production to individual days and adds each day's production to the production for the appropriate month.
- Quarterly coal production data from EIA's Quarterly Coal Report (QCR)
  - The data are used to revise monthly values for state-level coal production.
- Coal consumption (passed indirectly by the STEO Electricity Market Module)
- Monthly data for coal consumption for electricity generation and electricity for useful thermal output from the EPM, Tables ES1.A, 2.1A, 2.1B, and 2.1C
- Monthly estimates of coal consumption by sector, excluding coal used at facilities generating electricity, from the MER, Table 6.2
- International coal trade
- Monthly data for total coal imports and exports from the MER, Table 6.1
- Quarterly breakouts of coal imports and exports from the QCR, Tables 9 and 11, respectively
- Information on coal imports and exports we reported based on the U.S. Department of Commerce, Bureau of the Census, Monthly Reports IM 145 (imports), and EM 545 (exports)
- Coal inventories
- Monthly coal inventories held by the electric power sector from the EPM, Tables 3.1 and 3.3
- Monthly coal inventories held by non-electric-power sectors from the MER, Table 6.3
- Quarterly coal inventories by census region held at manufacturing plants and by commercial and industrial users from the QCR, Tables 40 and 42, respectively
- U.S. total coal inventories by sector from the QCR, Table 37
  - Monthly changes in inventories are estimated by using one-third of the reported quarterly change.
- Waste coal supplied from the MER, Table 6.1
- Coal coke production, consumption, and international trade
- Monthly estimates for raw steel production based on weekly production provided by the American Iron and Steel Institute
- Monthly data for coal coke imports and exports as collected by the U.S. Department of Commerce, U.S. Census Bureau

- Monthly data for coal coke imports and exports from the MER, Tables 1.4a and 1.4b, respectively
- Quarterly data for coal and coke imports and exports from the QCR Table ES-2
- Monthly estimates for coal coke production, coal coke consumption, and coal coke stocks based on quarterly data published in the QCR Table ES-2
- Coal prices
- Monthly prices for coal delivered to the electric power sector in dollars per million British thermal units as reported in the EPM, Table ES2.B
- Weekly coal commodity spot prices, in dollars per short ton, for five domestic coal commodity regions as reported in EIA's *Coal Markets Report* (CMR):
  - Central Appalachia (CAPP)
  - Northern Appalachia (NAPP)
  - Illinois Basin (ILB)
  - Powder River Basin (PRB)
  - Uinta Basin (UIB)

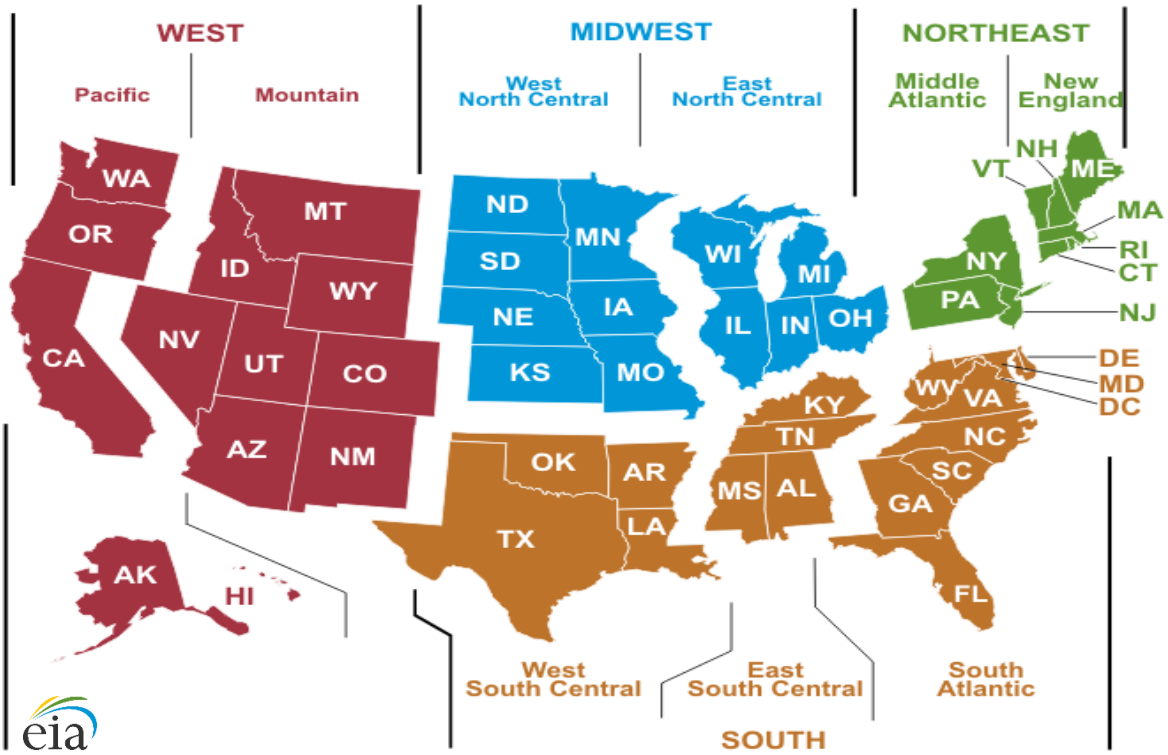
We aggregate state-level coal production data to the level of producing regions for the coal production equations. The coal-producing regions, which aggregate to the U.S. total, are defined as:

- Appalachia region: Alabama, Eastern Kentucky, Maryland, Ohio, Pennsylvania, Tennessee, Virginia, and West Virginia
- Interior region: Arkansas, Illinois, Indiana, Kansas, Louisiana, Mississippi, Missouri, Oklahoma, Texas, and Western Kentucky
- Western region: Alaska, Arizona, Colorado, Montana, New Mexico, North Dakota, Utah, Washington, and Wyoming

We aggregate state-level data for coal consumption by the electric power sector into coal demand regions for the coal production equations. The coal demand regions sum to the U.S. total and correspond to the U.S. census regions, as illustrated in Figure 2 and as defined as:

- Midwest: Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin
- Northeast: Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont
- South: Alabama, Arkansas, Delaware, District of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia
- West: Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming

Figure 2 U.S. census regions and divisions



Source: U.S. Energy Information Administration, Regional Dashboards and Tables.

4. Linear Regression Models

The STEO Coal Model uses linear regression to estimate coefficients that represent relationships between important variables, for example, supply, demand, and prices. To achieve satisfactory model fits, many of the regression models described below also include independent variables of the following types:

- Monthly dummy variables to capture seasonal effects
- Dummy variables for months before or after a certain date to pick up significant shifts in market conditions needed to estimate some relationships
- A one-month lagged dependent variable to capture the effect of the previous month's dependent variable on the current month's dependent variable and to reduce autocorrelation in the regression model residuals
- Month-year specific dummy variables (sometimes called *intervention effects*) to reduce the influence of anomalous monthly data observations caused, for example, by survey errors or extreme weather

4.1. Regional coal production estimations

Regional coal production is driven primarily by coal consumption and by stocks the electric power sector holds in relevant coal demand regions, and depending on the coal production region, exports of metallurgical or steam coal, along with seasonal factors. Although coal consumption and exports positively correlate with coal production, stocks of coal that electric utilities hold are negatively correlated because relatively high inventories typically indicate less need for coal. Electric utilities represent approximately 90% of the demand for U.S. coal production. The module uses regional coal consumption volumes if they represent a large share of a coal-producing region's sales to the electric utility sector.

To capture the primary effects driving coal production, the linear regression models for regional coal production include combinations of the following monthly independent variables:

- Coal consumption by the electric power sector, by coal demand region (thousand tons per day)
- Metallurgical coal exports (million short tons per day)
- Steam coal exports (million short tons per day)
- Stocks of coal held by electric power sector, by coal demand region (million tons)

We model Appalachian coal production as a function of these variables:

- Domestic coal consumption
- Coal stocks held by electric utilities, particularly in the South and Northeast coal demand regions
- Total U.S. coal exports (both metallurgical and steam)
- Monthly seasonal dummy variables
- The previous month's regional coal production

Most domestic sales of Appalachian coal production are to utilities in the eastern United States, including the Northeast and South. Appalachia produces nearly all of the U.S. metallurgical coal for export from the United States, as well as a significant volume of steam coal exports. In about January 2010, the market for Appalachian coal transitioned from one characterized by stable-to-increasing sales to one of declining sales.

We model Interior coal production as a function of these variables:

- Domestic coal consumption
- Coal stocks held by electric utilities, particularly in the Midwest and South coal demand regions
- U.S. exports of steam coal
- The previous month's regional coal production
- Intervention effect variables that reduce the effects of anomalies for certain month-year combinations (July 2014 and July 2015)

Most domestic sales of Interior coal production are to utilities in the central and southern United States, including the South and Midwest. Interior does not produce metallurgical coal, but it has historically exported significant volumes of steam coal. In about January 2010, the market for Interior coal transitioned from one characterized by stable-to-increasing sales to one of declining sales.

We model Western coal production as a function of these variables:

- Domestic coal consumption
- Coal stocks held by electric utilities
- The previous month's regional coal production
- Intervention effect variables that reduce the effects of anomalies for certain month-year combinations (July 2011, December 2014, February 2015, and January 2016)

The Western region is the largest coal-producing region in the United States, sourced primarily from the Powder River Basin (PRB). Although small amounts of Western coal are exported, most coal produced in the West is consumed primarily for electricity generation throughout the United States, rather than by one or more specific regions. In about January 2008, the market for Western coal transitioned from one characterized by stable-to-increasing sales to one of declining sales.

4.2. Coal trade estimations

The factors used to estimate coal imports are different from those for coal exports, and the factors used to estimate coal exports vary between steam and metallurgical coal. To capture the primary effects driving coal trade, the linear regression models include combinations of the following types of monthly independent variables:

- Coal consumption by the electric power sector by coal demand region (thousand tons per day)
- Total U.S. coal production (million short tons per day)
- Total U.S. steam coal consumption, defined as total U.S. coal consumption net of metallurgical coal used to produce coal coke (million short tons per day)
- Real U.S. dollar exchange rate, index (January 2010=100)
- World oil consumption-weighted gross domestic product (GDP) (index 2010 Q1 = 100)

Total coal imports

We model coal imports as a function of these independent variables:

- Electric power sector coal consumption in the South region
- The previous month's coal imports
- An indicator variable indicating whether or not the reference month is on or after January 2009

Imports are a small component of overall U.S. coal consumption. Steam coal imports account for the majority of imports, and this coal is primarily consumed by power generators located on the East Coast and the Gulf Coast. In about January 2009, the market for imported coal transitioned from one characterized by stable-to-increasing imports to one of declining imports.

Steam coal exports

We model steam coal exports as a function of the following independent variables:

- Total U.S. coal production
- Total U.S. steam coal consumption
- Real U.S. dollar exchange rate, world oil consumption-weighted GDP
- The previous month's steam coal exports
- Intervention effect variables that reduce the effects of anomalies for certain month-year combinations (September 2008, January 2009, May 2012, March 2013, and March 2015)

Steam coal is used primarily for electricity generation in the United States but is also used in the industrial, commercial, and residential sectors to produce steam and direct heat by other importing countries. Steam coal for export is produced in all of the coal-producing regions, but the majority of exports have traditionally originated from the Appalachia and Interior regions. U.S. steam coal exports are sensitive to global market conditions. We use the real U.S. dollar exchange rate to capture the competitiveness of U.S. coal exports in relation to coal exported from other countries. We use world oil consumption-weighted GDP to capture the worldwide demand for electricity because short-term changes in electricity use are often positively correlated with changes in economic output.

Metallurgical coal exports

We model metallurgical coal exports as a function of the following independent variables:

- Real U.S. dollar exchange rate
- World oil consumption-weighted GDP
- The previous month's metallurgical coal exports
- Intervention effect variables that reduce the effects of anomalies for certain month-year combinations (June 2008, September 2008, and April 2009)

Metallurgical coal is used to produce coal coke, which, in turn, is used as a fuel and as a reducing agent for smelting iron ore in blast furnaces. Most exported metallurgical coal is produced in the Appalachia region, but smaller quantities are produced in the Western region. Similar to steam coal exports, U.S. metallurgical coal exports are sensitive to global market conditions. We use the real U.S. dollar exchange rate to capture the competitiveness of U.S. coal exports in relation to coal exported from other countries. We use world oil consumption-weighted GDP to capture the worldwide demand for steel and, hence, coke, because short-term changes in coal use for steel production are often positively correlated with changes in economic output.

4.3. Regional electric power coal stocks (inventories) estimations

Electric power plant operators hold coal inventories to regulate the fluctuations in coal use needed to meet changes in expected generation requirements, usually caused by expected seasonal weather patterns, such as summer or winter peak load conditions. Maintenance outages in the spring and fall months, when temperatures are milder, as well as typical monthly weather patterns, result in monthly differences in inventory holdings. A base level of inventories is also held to manage the risk of supply

disruptions. We assume that these base levels of regional coal inventory holding patterns vary based on differences in forecast heating and cooling requirements from the region's 20-year average, as well as monthly seasonal patterns. These inventories also take into account the variance between coal supply and coal demand, minimizing forecast divergence between the two.

To capture the primary effects driving regional electric power coal stocks, the linear regression models include combinations of the following monthly independent variables:

- Regional average deviation of cooling degree days from normal (20-year average, 1991–2010), divided by the number of days in the reference month (included for each region)
- Regional average deviation of heating degree days from normal (20-year average, 1991–2010), divided by the number of days in the reference month (included for South and West regions only)

Heating degree days (HDD) measure how cold the temperature was on a given day relative to a standard temperature during the winter (October to March), and cooling degree days (CDD) measure how warm the temperature was during the summer (April to September). Monthly HDD and CDD variables are sums of the daily measures. We calculate a region's average deviation of HDD or CDD from the seasonal norm for a given month by taking the difference between the monthly value for regional HDD or CDD and the corresponding 30-year average (1981–2010) and dividing this difference by the number of days in the month.

Because the Northeast and Midwest coal demand regions experience annual peak load only during the summer (because of the prevalence of natural gas or fuel oil used for heating during the winter), we only include the average monthly deviations for CDD in the STEO models for these regions. The South and West regions experience milder winter conditions in the major metropolitan areas and rely more on electric heat during the winter, often resulting in a corresponding winter peak load. The models for these regions therefore, include average monthly deviations for both CDD and HDD. Dummy variables are used to indicate whether a month is in the winter or summer, and, hence, whether or not to include the average monthly deviations for CDD or HDD in the models. The models also include the previous month's electric power coal stocks for the region, as well as monthly seasonal dummy variables.

4.4. Other coal stocks (inventories) estimations

Users hold coal inventories consistent with their production, heating, or self-generation requirements, including metallurgical coal used by coal coke producers and steam coal used by industrial and commercial/institutional consumers. The total of inventories held by electric utilities and end-use customers constitute total *secondary* inventories. Coal producers and distributors also hold *primary* inventories to manage fluctuations in deliveries to customers.

To capture the primary effects driving other end-user coal stocks, the linear regression models include combinations of the following monthly independent variables:

- Coal consumption by end-use sector, including coke, industrial, and commercial/institutional (million tons per day)
- Coal production for the Appalachia and Interior coal supply regions (million tons per day; from coal production estimations in section 4.1)

Coke plant coal stocks

We model coal stocks held at coke plants as a function of these independent variables:

- The reference month's coke plant coal consumption
- The previous month's coal inventory
- Monthly seasonal dummy variables

Industrial sector coal stocks

We model coal stocks held by the industrial sector as a function of these independent variables:

- The reference month's industrial sector coal consumption
- The previous month's coal inventory
- Monthly seasonal dummy variables
- Intervention effect variables that reduce the effects of anomalies for certain month-year combinations (October 2008, November2008, December 2008, and March 2020)

Commercial/institutional sector coal stocks

Some regression models in the STEO Coal Module include intervention effect variables that cover multiple month/year combinations. The combined intervention effect variables are sums of intervention effects for the individual months. In this document, we indicate these combined intervention effects by showing the months and years in brackets and with + signs between the names of the months. For example, [October+November+December 2012] indicates an intervention effect (a temporary level shift) during the months of October through December 2012.

We model coal stocks held by the commercial/institutional sector as a function of these independent variables:

- The reference month's commercial/institutional sector coal consumption
- The previous month's coal inventory
- Monthly seasonal dummy variables
- An indicator variable indicating whether or not the reference month is on or after January 2014.
- Intervention effect variables that reduce the effects of anomalies for certain month-year combinations (January 2008; [October+November+December 2012], and 2012+2013)

In about January 2011, coal use by the commercial/institutional sector transitioned from one characterized by stable-to-increasing consumption to one of declining consumption, which decreases the amount of total inventories needed.

Producer/distributor (primary) coal stocks

We model coal stocks held by producers and distributors as a function of these independent variables:

- The reference month's coal production from the Appalachia and Interior coal supply regions
- The previous month's coal inventory
- Monthly seasonal dummy variables
- Intervention effect variables that reduce the effects of anomalies for certain month-year combinations (July 2011, January 2012, all months of 2016, July 2017, August 2018, April 2019, and August 2019)

We revise the Producer/Distributor (Primary) Coal Stocks regression model when new annual data become available.

Monthly coal stock withdrawals by end-user category

We estimate monthly stock withdrawals (additions) per day for each end-user category by subtracting the current month's coal stocks from the previous month's coal stocks and dividing by the number of days in the reference month.

4.5. Coal coke consumption, trade, production, and inventories

Domestic coke plants use coal primarily to produce coal coke, a key input for producing raw steel. The demand for raw steel is, therefore, a key indicator of coal coke consumption by the domestic coal coke sector. Macroeconomic indicators of raw steel demand include changes in investment and inventories. The United States actively trades limited volumes of coal coke as a product internationally. Steel manufacturers primarily hold coal coke inventories and use them to manage fluctuations in steel production.

To capture the primary effects driving coal coke consumption, trade, and production, the linear regression models include combinations of these monthly independent variables:

- Industrial production index, primary metals (index, 2012=100), available from the Federal Reserve System, which measures change in the real output of primary metals-producing establishments in the United States, regardless of their ownership
- Real fixed investment (billion chained 2012 dollars), available from the Bureau of Economic Analysis, which measures additions and replacements to the stock of private fixed assets, without deducting depreciation, and consists of nonresidential fixed investment and residential fixed investment
- Business inventory change (billion chained 2009 dollars), available from the Bureau of Economic Analysis, which measures the change in physical volume of inventories owned by private business valued at the average prices at the end of the period
- A trend that begins with 1 in January 2009 and increases by 1 each month

Raw steel production

We model seasonally adjusted raw steel production as a function of these independent variables:

- The primary metals industrial production index
- Real fixed investment
- Business inventory change
- The previous month's raw steel production level
- A trend variable from January 2009 onward to track the effect of declining domestic steel production since that time
- Intervention effect variables that reduce the effects of anomalies for certain month-year combinations (February 2015, November 2015, and March through May 2020)

We estimate raw steel production (not seasonally adjusted) by multiplying seasonally adjusted raw steel production by its seasonal adjustment factor, which accounts for seasonal fluctuations in historical production.

Coal coke consumption

We model domestic coal coke consumption as a function of these independent variables:

- The reference month's and previous month's raw steel production
- The previous month's coal coke consumption level
- Monthly seasonal dummy variables
- Intervention effect variables that reduce the effects of anomalies for certain month-year combinations ([October 2000 + January 2009], August 2010, August 2012)

Coal coke exports

We model coal coke exports as a function of these independent variables:

- The reference month's coal coke consumption and production levels
- The previous month's coal coke consumption and production levels
- Monthly seasonal dummy variables

Coal coke net imports

We model coal coke net imports as a function of these independent variables:

- The reference month's and previous month's coal coke consumption
- The previous month's coal coke net imports
- Monthly seasonal dummy variables

Coal coke imports are a balancing item, calculated as the sum of coal exports and coal net imports.

Coal coke production

We model coal coke production as a function of these independent variables:

- The reference month's and previous month's coal coke consumption

- Coal coke net imports
- The previous month's coal coke production
- Monthly seasonal dummy variables

Coal coke stocks

The STEO assumes that the coal coke market is balanced, so any differences between coal coke demand and supply are met by coal coke stock change (build or withdrawal). To calculate coal coke stocks for the reference month, we subtract the calculated coal coke stock change from the previous month from the coal coke stock value for the previous month.

4.6. Industrial and commercial coal consumption

The level of coal coke demand from domestic consumption and from net imports primarily drive coal consumption for producing coal coke. Industrial coal consumption, not including coal used for combined heat and power or synthetic fuel production, is driven primarily by industrial processes that use steam coal for process heat as a direct fuel (cement kilns) or as a feedstock to manufacture chemicals and pharmaceuticals. Commercial and institutional coal consumption, not including coal used for combined heat and power, is primarily used to produce steam for heating, and it is, therefore, seasonal, driven by heating degree days (HDD) in regions where coal use for heating is prevalent.

To capture the primary effects driving industrial and commercial coal consumption, the linear regression models include combinations of these monthly independent variables:

- Coal coke production (million tons per day; from coal coke estimations in Section 3.5)
- Coal coke net imports (million tons per day; from coal coke estimations in Section 3.5)
- Heating degree days for the East North Central and Middle Atlantic weather zones
- Coal-weighted industrial production index (2007=100)
- A trend that begins with 1 in January 1975 and increases by 1 each month

We calculate the coal-weighted industrial production index as a weighted index of industrial production indexes from six major industry groups:

- Food manufacturing, NAICS (North American Industry Classification System) 311
- Paper manufacturing, NAICS 322
- Chemical manufacturing, NAICS 325
- Petroleum and coal products, NAICS 324
- Non-metallic mineral products manufacturing, NAICS 327
- Primary metal manufacturing, NAICS 331

The indexes are weighted by the proportions of coal consumed in the industry groups they represent.

The Coal Module does not forecast national coal consumption for the electric power sector or large-scale industrial and commercial combined-heat-and-power generators. The STEO Electricity Supply Model forecasts these variables and passes them to the Coal Module.

Coke plant coal consumption

We model coke plant coal consumption as a function of these independent variables:

- Coal coke production
- Coal coke net imports
- The previous month's coke plant consumption
- Monthly seasonal dummy variables

Commercial/institutional coal consumption (excluding combined heat and power)

We model commercial/institutional sector coal consumption at facilities not classified as combined heat and power or as *electricity only* as a function of these independent variables:

- Heating degree days in the East North Central Census Division and Middle Atlantic Census Division
- The previous month's consumption
- Monthly seasonal dummy variables
- Intervention effect variables that reduce the effects of anomalies for certain month-year combinations (February 2015, November 2015, and March through May 2020)

Industrial coal consumption

We model non-combined-heat-and-power industrial coal consumption as a function of these independent variables:

- The coal-weighted industrial production index
- The previous month's other industrial coal consumption
- Monthly seasonal dummy variables
- A trend variable from January 1975 onward to track the effect of declining domestic industrial coal consumption since that time
- Intervention effect variables that reduce the effects of anomalies for certain month-year combinations (April 2000, February 2001, and July 2002)

4.7. Coal prices

In our *Coals Markets* (CM) report, we report weekly spot prices, in dollars per short ton, for five domestic coal commodity regions:

- Central Appalachia (CAPP)
- Northern Appalachia (NAPP)
- Illinois Basin (ILB)
- Powder River Basin (PRB)
- Uinta Basin (UIB)

We cannot release the proprietary historical data for the spot prices but, instead, use them to develop the published STEO forecasts. We calculate monthly estimates for each regional coal price by averaging the weekly estimates. When a week extends into a new month, we allocate the prices to days and incorporates each day's price into the average for the appropriate month. We convert the prices from dollars per ton to dollars per million British thermal units, using the British thermal units per ton information provided in the CM report. We develop monthly proxies, based on EIA data, for coal production for each of the five commodity regions and calculate a composite spot price based on the prices and their corresponding production proxies.

We report prices for coal delivered to the electric power sector in the EPM in dollars per ton and dollars per million British thermal units. The STEO model uses the latter, so price comparisons to other power sector fuels such as natural gas and petroleum, which are also reported in dollars per million British thermal units, are appropriate.

To enable the estimation of reportable price series, the linear regression models include combinations of these monthly independent variables:

- Total U.S. coal production (million tons per day; from coal production estimations in Section 3.1)
- Coal consumption by the electric power sector by coal demand region (thousand tons per day)
- Total and regional electric power sector coal stocks (million tons; from coal stocks estimations in Section 3.3)
- Total coal exports (million tons per day; from coal trade estimations in Section 3.2)
- Diesel fuel retail price (cents per gallon; from the STEO Petroleum Product Price Module)
- Henry Hub natural gas spot price (cents per million British thermal units; from the STEO Natural Gas Price Module)

Composite spot price

We represent the composite spot price of coal in dollars per million British thermal units and model it as a function of the following independent variables:

  - Total U.S. coal production
  - Electric power sector coal stocks (inventories)
  - Total U.S. coal exports
  - Intervention effect variables that reduce the effects of anomalies for certain month-year combinations.

Electric power sector coal price

We model the price of coal delivered to the electric power sector, in dollars per million British thermal units, as a function of these independent variables:

  - The composite spot coal price
  - The diesel fuel retail price

- Electric power sector coal stocks (inventories)
- Monthly seasonal dummy variables
- Intervention effect variables that reduce the effects of anomalies for certain month-year combinations (December 2014)

We include diesel prices in our estimate to reflect the role of transportation costs in the delivered price of coal to the electric power sector. We expect higher coal stocks held by electric utilities to be negatively correlated with coal prices because relatively high coal inventories typically indicate less demand for coal, and, hence, lower commodity prices. The coal model passes price forecasts to several other STEO modules.

Regional electric power sector coal prices

The STEO Electricity Supply Model requires forecasts of delivered regional coal prices for the electric power sector that correspond to the four coal demand regions. We model the prices separately for each region. For each census region, we calculate a historical delivered coal fuel cost (price) series for the electric power sector to use as the dependent variable in the regression model. We estimate the composite national-level spot price for coal as a weighted average of the regional prices.

We use regression models to estimate the prices for each of the four main regions (in cents per million British thermal units) as functions of these independent variables:

- Composite spot coal price
- Henry Hub natural gas spot price
- Retail diesel fuel price (on-highway)
- Regional power sector coal stocks (inventories)
- Monthly seasonal dummy variables

We would have considered regional delivered natural gas prices as a substitute for the Henry Hub gas price, but the STEO model does not currently forecast them.

To ensure consistency between the regional and national price forecasts, we derive the national price forecast as an average of the regional forecasts, weighted by coal receipts. This method is similar to the one we use to derive historical national prices. Because the STEO model does not currently forecast regional coal volumes the electric power sector receives, we estimate monthly coal receipts for the electric power sector as coal consumption by this sector less the change in the sector's coal inventories, forecast for each of the four regions.

5. Coal Balance

Historically, in any given period, the actual amount of coal supplied to the end-use sectors does not equal what the end-use sectors actually received and consumed because of measurement error, coal lost during distribution, reporting errors, or survey coverage. We calculate this discrepancy as follows:

Balance Discrepancy = Production − Consumption + Imports + Waste Coal − Exports − Change in Consumer Stocks

In the forecast period, we generally assume coal supply and demand to be in equilibrium; in other words, no imbalance exists, and the balance discrepancy is, therefore, equal to zero. In practice, markets do not always operate at peak efficiency, and as a result, a discrepancy generally exists. Typically, this value is relatively small, representing less than 2% of total consumption.

Because we assume forecast consumption values are reliable, we adjust supply side values to resolve as much of the balance discrepancy as reasonably possible. When we adjust the major supply component (production) to account for the difference, we allocate the national discrepancy by proportionally adjusting forecast coal production in each region up or down so that total U.S. production equals the sum of estimated total coal use, net exports, and inventory change. However, unusual market circumstances may require us to adjust other portions of the coal balance equation, most commonly inventories.

We calculate the discrepancy between coal supply and demand for the United States as the difference between the total coal supplied less the total coal consumption. The initial total coal supplied is the sum of these values:

- Initial total coal production
- Net imports (imports minus exports)
- Primary (producer and distributor) inventory change
- Waste coal supplied
- Secondary (end-use sectors) inventory change

We calculate waste coal estimates as identities by applying annual growth rates based on the *Annual Energy Outlook* (AEO) projections to the latest waste coal supply data available from these EIA surveys:

- Form EIA-923, *Power Plant Operations Report*
- Form EIA-3, *Quarterly Survey of Industrial, Commercial & Institutional Coal Users*

We prepare the waste coal forecasts outside of the STEO system and enter them into the STEO identity modules, which, in turn, pass the values to the Coal Module.