

# 1. Introduction

This document describes the nature, structure, and capabilities of the Integrated Planning Model (IPM) and the assumptions underlying the base case (designated EPA Base Case v.5.13) that was developed by the U.S. Environmental Protection Agency (EPA) with technical support from ICF, Inc. (ICF). IPM is a multi-regional, dynamic, deterministic linear programming model of the U.S. electric power sector. It provides forecasts of least cost capacity expansion, electricity dispatch, and emission control strategies while meeting energy demand and environmental, transmission, dispatch, and reliability constraints. IPM can be used to evaluate the cost and emissions impacts of proposed policies to limit emissions of sulfur dioxide (SO<sub>2</sub>), nitrogen oxides (NO<sub>x</sub>), carbon dioxide (CO<sub>2</sub>), mercury (Hg), and HCl from the electric power sector.

This new base case (v.5.13) incorporates important structural improvements and data updates with respect to the previous version (v.4.10). A new version number (moving from v.4 to v.5) indicates a substantial change to Base Case architecture (such as this version's significant increase in the number of model regions). Changing the portion of the version name after the 'dot' (moving from .10 to .13) indicates the calibration of the model to more recent information (most importantly electricity demand projections) from a particular iteration of the Energy Information Agency's (EIA) Annual Energy Outlook (AEO), in this case AEO 2013.

Base cases, like EPA Base Case v.5.13, serve as the starting point against which policy scenarios are compared. Base Case v.5.13 is a projection of electricity sector activity that takes into account only those Federal and state air emission laws and regulations whose provisions were either in effect or enacted and clearly delineated at the time the base case was finalized in August 2013 (prior to publication of this documentation). Section 3.9 contains a detailed discussion of the environmental regulations included in EPA Base Case v.5.13, which are summarized below.

- EPA Base Case v.5.13 includes the Clean Air Interstate Rule (CAIR), a Federal regulatory measure for achieving the 1997 National Ambient Air Quality Standards (NAAQS) for ozone (8-hour average of 0.08 ppm) and fine particles (24-hour average of 65 µg/m<sup>3</sup> or less and annual average of 15 µg/m<sup>3</sup> for particles of diameter 2.5 micrometers or less, i.e., PM 2.5). Originally issued on March 10, 2005, CAIR was remanded back to EPA by the U.S. Court of Appeals for the District of Columbia Circuit in December 2008 and EPA was required to correct legal flaws in the regulations that had been cited in a ruling by the Court in July 2008. CAIR remains in effect until replaced by EPA pursuant to the Court's ruling. CAIR's provisions were still in effect when EPA Base Case v.5.13 was released.
- EPA Base Case v.5.13 includes NAAQS to the extent that state regulations included in EPA Base Case v.5.13 contain measures to bring non-attainment areas into attainment. A summary of these state regulations can be found in Appendix 3-2. Apart from these state regulations, individual permits issued by states in response to NAAQS are captured (a) to the extent that they are reflected in the NO<sub>x</sub> rates reported to EPA under CAIR, Title IV and the NO<sub>x</sub> Budget Program which are incorporated in the base case and (b) to the extent that SO<sub>2</sub> permit limits are used in the base case to define the choice of coal sulfur grades that are available to specific power plants.
- EPA Base Case v.5.13 includes the Mercury and Air Toxics Rule (MATS), which was finalized in 2011. MATS establishes National Emissions Standards for Hazardous Air Pollutants (NESHAPS) for the "electric utility steam generating unit" source category.
- EPA Base Case v.5.13 also reflects the final actions EPA has taken to implement the Regional Haze Rule. This regulation requires states to submit revised State Implementation Plans (SIPs) that include (1) goals for improving visibility in Class I areas on the 20% worst days and allowing no degradation on the 20% best days and (2) assessments and plans for achieving Best Available Retrofit Technology (BART) emission targets for sources placed in operation between 1962 and 1977. Since 2010, EPA has approved SIPs or, in a very few cases, put in place regional haze Federal Implementation Plans for several states. The BART limits approved in these plans (as of August 29, 2013) that will be in place for EGUs are represented in the EPA Base Case v.5.13.

Table 1-1 lists updates included in EPA Base Case v.5.13 listed in the order they appear in this documentation report. Updates that are highlighted in gray were “non-routine” in the sense that they constituted new modeling capabilities, notable extensions beyond the capabilities provided in previous EPA base cases, or significant reviews of important assumptions.

**Table 1-1 Updates in the EPA Base Case v.5.13**

Description	For More Information
<b>Modeling Framework</b>	
Expansion of US model regions from 32 to 64	Section 3.1
Incorporation of three stages of environmental retrofits	Section 7.2
<b>Power System Operation</b>	
Updated capacity deployment constraints (for new advanced coal with carbon capture, carbon capture retrofits, and new nuclear)	Section 3.10 and Attachment 3-1
Updated inventory of state emission regulations, including RGGI and AB32 (as of August 2013)	Table 3-12
Updated inventories of NSR, state, and citizen settlements (as of August 2013)	Table 3-13
Updated transmission TTC's (2012-2013 ISO/RTO and NERC reports)	Table 3-4 and Table 3-5
Updated regional reserve margins (NERC 2012)	Table 3-9
AEO NEMS region level electricity demand is disaggregated to IPM model region level	Table 3-2
<b>Generating Resources</b>	
Updates to NEEDS, the database of existing and planned-committed units and their emission control configurations (Primary Sources: 2010, 2011 EIA Form 860, ETS 2011, NERC ES&D 2011, AEO 2013)	Table 4-1
Updated cost and performance characteristics for potential (new) conventional, nuclear and renewable generating units (AEO 2013 and NETL)	Table 4-13 and Table 4-16
New renewable units including biomass, wind, solar, geothermal and landfill gas are modeled at a state level within each IPM region (Resource assumptions from NREL)	Section 4.4.5
<b>Emission Control Technologies</b>	
Complete update of cost and performance assumptions for SO <sub>2</sub> , NO <sub>x</sub> , Hg and HCl emission controls based on engineering studies by Sargent and Lundy	
Updated cost and performance assumptions for coal-to-gas and retrofit options	Section 5.7
<b>Set-Up Parameters and Rules</b>	
Modeling time horizon with seven model run years (2016, 2018, 2020, 2025, 2030, 2040, 2050)	Section 7.1
CAIR, MATS, and BART are part of Base Case	Section 7.3
All costs and prices are in 2011 dollars	
<b>Financial assumptions</b>	
Update of discount and capital charge rate assumptions based on a hybrid capital cost model of utility and merchant finance structures for new units	Section 8.2.2
Use of separate capital charge rates for retrofits based on utility and merchant finance structures	Section 8.3.2
<b>Coal</b>	
Complete update of coal supply curves and transportation matrix (Wood Mackenzie 2012-2013 and Hellerworx 2012-2013)	Table 9-23 and Table 9-24
Coal demand regions are now disaggregated to the coal facility (ORIS) level	Table 9-2
<b>Natural Gas</b>	
Update of unconventional gas resource base (ICF 2013)	Section 10.4
<b>Other Fuels</b>	
Update of price assumptions for fuel oil, nuclear fuel and waste fuel (AEO 2013)	Section 11.1
Incorporation of biomass supply curves at a state level (AEO 2013)	Section 11.2
Biomass storage costs are added to the agricultural residues component of the biomass supply curves	Section 11.2

Table 1-2 lists the types of plants included in the EPA Base Case v.5.13.

**Table 1-2 Plant Types in EPA Base Case v.5.13**

<b>Fossil Fuel Fired</b>
Coal Steam
Oil/Gas Steam
Combustion Turbine
Combined-Cycle Combustion Turbine
Integrated Gasification Combined-Cycle (IGCC) Coal
Advanced Coal with Carbon Capture
Fluidized Bed Combustion
<b>Non-Fossil Fuel Fired</b>
Nuclear
<b>Renewables and Non-Conventional Technologies</b>
Hydropower
Pumped Storage
Biomass
Onshore Wind
Offshore Shallow Wind
Offshore Deep Wind
Fuel Cells
Solar Photovoltaics
Solar Thermal
Geothermal
Landfill Gas
Other <sup>a</sup>

Note:

<sup>a</sup> Includes fossil and non-fossil waste plants.

Table 1-3 lists the emission control technologies available for meeting emission limits in EPA Base Case v.5.13.

**Table 1-3 Emission Control Technologies in EPA Base Case v.5.13**

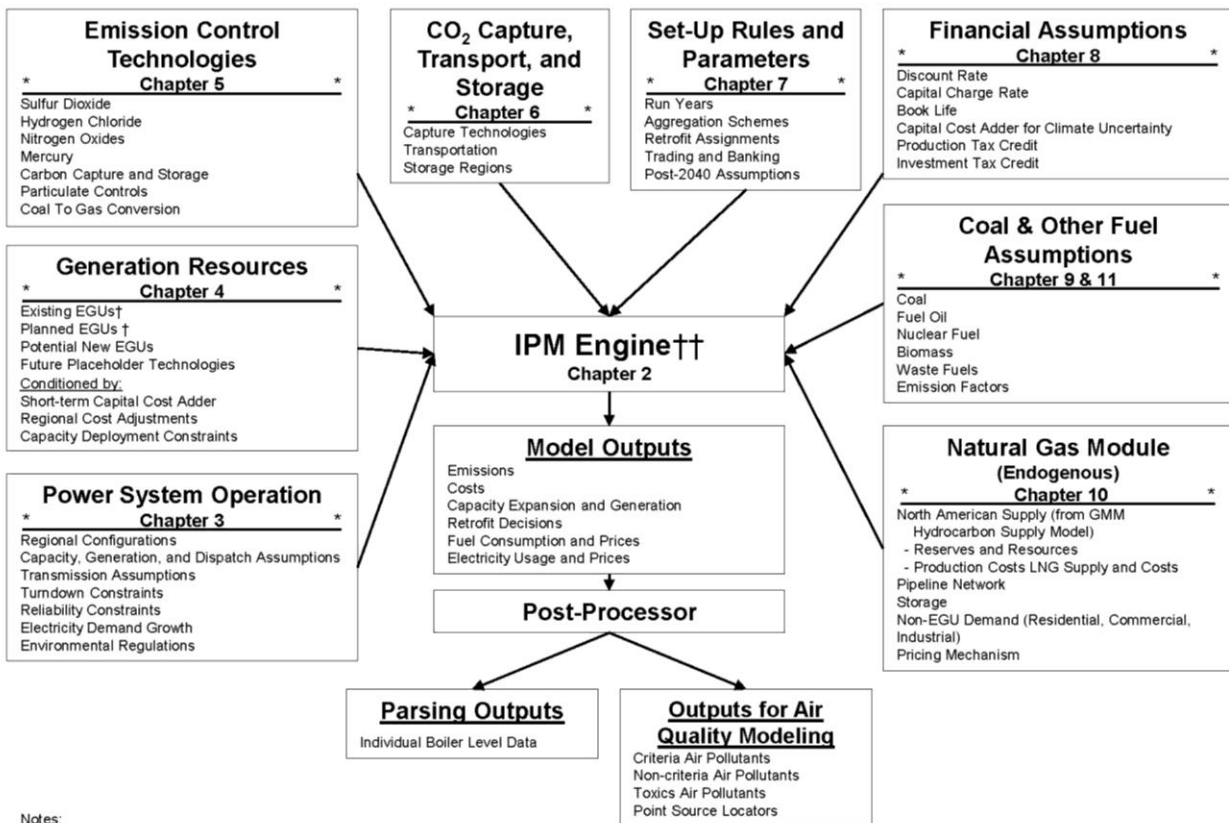
<b>Sulfur Dioxide (SO<sub>2</sub>) and Hydrochloric Acid (HCl)</b>
Limestone Forced Oxidation (LSFO)
Lime Spray Dryer (LSD)
Dry Sorbent Injection (with milled Trona)
FGD Upgrade Adjustment
<b>Nitrogen Oxides (NO<sub>x</sub>)</b>
Combustion controls
Selective catalytic reduction (SCR)
Selective non-catalytic reduction (SNCR)
<b>Mercury (Hg)</b>
Combinations of SO <sub>2</sub> , NO <sub>x</sub> , and particulate control technologies
Activated Carbon Injection
<b>Particulate Matter (PM)</b>
Pulse-Jet Fabric Filter (FF)
Electrostatic Precipitator (ESP) Upgrade Adjustment
<b>Carbon Dioxide (CO<sub>2</sub>)</b>
Heat rate improvement
Coal-to-gas
Carbon Capture and Sequestration

Notes:

<sup>a</sup> Units may also select among different coal types to manage emissions in EPA Base Case v.5.13.

Figure 1-1 provides a schematic of the components of the modeling and data structure used for EPA Base Case v.5.13. This report devotes a separate chapter to all the key components shown in Figure 1-1. Chapter 2 provides an overview of IPM's modeling framework (sometimes referred to as the "IPM Engine"), highlighting the mathematical structure, notable features of the model, programming elements, and model inputs and outputs. The remaining chapters are devoted to different aspects of EPA Base Case v.5.13. Chapter 3 covers the power system operating characteristics captured in EPA Base Case v.5.13. Chapter 4 explores the characterization of electric generation resources. Emission control technologies (chapter 5) and carbon capture, transport and storage (chapter 6) are then presented. Chapter 7 describes certain set-up rules and parameters employed in EPA Base Case v.5.13. Chapter 8 summarizes the base case financial assumptions. The last three chapters discuss the representation and assumptions for fuels in the base case. Coal is covered in chapter 9, natural gas in chapter 10, and other fuels (i.e., fuel oil, biomass, nuclear fuel, and waste fuels) in chapter 11 (along with fuel emission factors).

**Figure 1-1 Modeling and Data Structures in EPA Base Case v.5.13**



**Notes:**

† Information on existing and planned electric generating units (EGUs) is contained in the National Electrical Energy Data System (NEEDS) data base maintained for EPA by ICF International. Planned EGUs are those which were under construction or had obtained financing at the time that the EPA Base Case was finalized.

††IPM Engine is the model structure described in Chapter 2