EPA's Updates to EPA Base Case v3.01 from EPA Base Case 2006 (v3.0) Using the Integrated Planning Model (IPM)

This document catalogs the list of updates in EPA Base Case v3.01 from EPA Base Case 2006 (v3.0).

IPM and EPA Modeling Applications Using IPM:

EPA uses the Integrated Planning Model (IPM®) to analyze the projected impact of environmental policies on the electric power sector in the 48 contiguous states and the District of Columbia. Developed by ICF Resources, Inc. and used to support public and private sector clients, IPM is a multi-regional, dynamic, deterministic linear programming model of the electric power sector. It provides forecasts of least-cost capacity expansion, electricity dispatch, and emission control strategies for meeting electricity demand, 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_2), nitrogen oxides (NOx), carbon dioxide (CO_2), and mercury (Hg) from the electric power sector. IPM was a key analytical tool in developing the Clean Air Interstate Rule (CAIR) and the Clean Air Mercury Rule (CAMR) rulemakings.

Among the factors that make IPM particularly well suited to model multi-emissions control programs are (1) its ability to capture complex interactions among the electric power, fuel, and environmental markets; (2) its detail-rich representation of emission control options encompassing a broad array of retrofit technologies along with emission reductions through fuel switching, changes in capacity mix and electricity dispatch strategies; and (3) its capability to model a variety of environmental market mechanisms, such as emissions caps, allowances, trading, and banking. IPM's ability to capture the dynamics of the allowance market and its provision of a wide range of emissions reduction options are particularly important for assessing the impact of multi-emissions environmental policies like CAIR and CAMR.

EPA's IPM Base Case 2006 (v3.0) and v3.01:

In the Fall of 2006, EPA released Base Case 2006 (v3.0) using IPM, which included extensive updates of EPA Base Case using IPM's assumptions, inputs, and capabilities. To perform the update, EPA obtained input from nationally recognized experts in fuels, technology, and power system operation. Power companies provided information on generating resources and emission controls. EPA also obtained input from Regional Planning Organizations, States, and their constituent organizations. Key update areas included:

- Coal Supply and Transportation Assumptions
- Natural Gas Assumptions
- Federal and State Emission Regulations and Enforcement Actions
- Cost and Performance of Generating Technologies and Emission Controls
- Sulfur Dioxide (SO_2), Nitrogen Oxide (NO_x), and Heat Rates
- Power System Operating Characteristics and Structure
- Electric Generating Unit Inventory
- Modeling Time Horizon and Run Years (2010, 2015, 2020, 2025)

More recently, EPA incorporated additional assumptions to EPA Base Case using IPM (v3.01), with the following updates for purposes of modeling carbon policies:

1) Carbon capture and storage for potential (new) units
2) Biomass co-firing capability for existing coal boilers
3) Updated constraints on new nuclear and renewable capacity builds

The detailed assumptions for IPM v3.0, titled "Documentation for EPA Base Case 2006 (v3.0) Using the Integrated Planning Model" (November 2006), can be found at: http://www.epa.gov/airmarkets/progsregs/epa-ipm/index.html#docs. This update (IPM v3.01) documents any changes from IPM v3.0.

1. Potential (New) Units

In addition to the potential build units modeled in EPA Base Case v3.0, two more types of potential build units have been added for EPA Base Case v3.01. Specifically, an Integrated Gasification Combined Cycle (IGCC) with Carbon Capture and Sequestration (CCS) and an Advanced Combined Cycle (ACC) w/CCS have been modeled. The IGCC w/CCS and ACC w/CCS are based on the characteristics of the IGCC and ACC, respectively, in EPA Base Case v3.0 with cost adders and heat rate penalties which are based on the differentials from AEO2006 Table 38.

Both the IGCC w/CCS and ACC w/CCS are assumed to have a 90% CO_2 capture rate with a $15 per metric ton of CO_2 transportation and storage cost that is added to the variable operating cost of the unit.[1] Tables 1a and 1b show the cost and performance characteristics of the newly modeled potential build units. EPA Base Case v3.01 does not allow a retrofit option at an existing conventional coal plant because of the relative economics of a new coal facility w/ CCS compared to the retrofit option.

Table 1a: Performance and Unit Cost Assumptions for Potential Capacity from Fossil Technologies in EPA Base Case v3.01 with Carbon Capture and Storage (CCS)

Characteristics/Types	Integrated Gasification Combined Cycle (IGCC) with CCS	Advanced Combined Cycle (ACC) with CCS
Size (MW)	380	400
First Year Available	2015	2015
Lead Time (Years)	4	3
Vintage #1 (Years Covered)	2010-2014	2010-2014
Vintage #2 (Years Covered)	2015-2019	2015-2019
Vintage #3 (Years Covered)	2020-2024	2020-2024
Vintage #4 (Years Covered)	2025-2035	2025-2035
Availability	85%	87%
Vintage #1 (Technology is not available in the 2010-2014 time period)		
Vintage #2		
Heat Rate (Btu/kWh)	8,748	8,196
Capital (2004$/kW)	2,008	1,127
Fixed O&M (2004$/kW/yr)	60.0	23.3
Variable O&M (2004$/MWh)	3.09 - 5.82	3.27 – 7.87
Vintage #3		
Heat Rate (Btu/kWh)	8,424	8,106
Capital (2004$/kW)	1,962	1,104
Fixed O&M (2004$/kW/yr)	60.0	23.3
Variable O&M (2004$/MWh)	3.09 - 5.82	3.27 – 7.87

[1] Dooley, et al. Carbon Dioxide Capture and Geologic Storage (pg 36). Battelle Memorial Institute, April 2006.

Vintage #4		
Heat Rate (Btu/kWh)	8,424	8,106
Capital (2004$/kW)	1,887	1,089
Fixed O&M (2004$/kW/yr)	60.0	23.3
Variable O&M (2004$/MWh)	3.09 - 5.82	3.27 – 7.87

Sources: AEO 2006, Tables 38 & 48.
Notes: 1) Vintage #1 is not currently allowed to come online in EPA Base Case v3.01 because the CCS technology is not feasible in 2010.
2) Since the Variable Operation and Maintenance (VOM) costs of fossil-fired plant in EPA Base Case v3.01 change according to the segment(s) of the load duration curve in which a plant operates; VOM is expressed as a range of values.

Table 1b: Explicit Calculated Differential for Carbon Capture and Storage (CCS) Technologies (2004 $)

Type	**Capital Cost Adder** ($/kW)	**Fixed O&M Adder** ($/MW)	**Variable O&M Adder** ($/MWh)	**Heat Rate Penalty** (%)
Integrated Gasification Combined Cycle (IGCC) with CCS	622	6.23	1.39	17
Advanced Combined Cycle (ACC) with CCS	572	7.47	.86	28

Source: AEO 2006, Table 38.

2. Biomass Co-Firing

Conventional coal units in EPA Base Case v3.01 have the ability to co-fire biomass up to 15% of their fuel mix. Extra transportation cost adders have been added to the biomass fuel being consumed in each coal demand region in order to approximate the biomass co-firing cost methodology used in AEO2006. Table 2 summarizes the assumptions and final transportation cost adders.

Table 2: AEO 2006 Biomass Co-Firing Assumptions

Boiler Type	**Cyclone, FBC, Stokers**		**Pulverized Coal Plants**		
Size (MW)	>500	≤500	>500	201-500	≤200
Capital Cost (2004$/kW)	109	109	109	218	251
Fixed O&M Cost (2004$/kW)	7.63	7.63	7.63	7.63	7.63
Biomass Co-firing Rate (associated with the existing biomass transportation costs)	2.5%	5%	2%	10%	15%
Maximum Biomass Co-firing Rate possible (at higher biomass transportation costs)	15%	15%	15%	15%	15%
Other Biomass Co-firing rates and associated incremental biomass transportation costs in 2004$/MMBtu	5% (0.26)	10% (0.26)	4% (0.26)	15% (.14)	None
	7.5% (0.43)	15% (0.47)	6% (0.47)		
	10% (0.67)		8% (0.63)		
	12.5% (0.79)		12% (0.92)		
	15% (0.92)		15% (1.10)		

Source: AEO 2006.

3. Feasibility Constraints

Feasibility constraints have been added to EPA Base Case v3.01 to limit the market penetration of the various non-carbon emitting electricity generating sources to ensure realistic build patterns from IPM as CO_2 regulatory policies are modeled. These limits are imposed on all renewable potential build types individually, all renewable potential build types collectively, and the nuclear units. In addition, a 20% cap is set on the amount of electricity generation in a model region that can come from existing and potential wind units. This cap is not set in EPA's Base Case 2006 (v3.0) because wind generation does not penetrate beyond 20% in any particular region. The feasibility assumptions for new nuclear and total new renewable capacity used in IPM v3.01 are taken from a recent Electric Power Research Institute report titled "Electricity Technology in a Carbon-Constrained Future." The constraints are detailed in Tables 3a-3e.

Table 3a: Cumulative Nuclear Potential Build Limits

Run Years	**Cumulative New Capacity Allowed Online** (MW)
2010	Not Available
2015	4,000[2]
2020	24,000
2025	44,000

Source: EPRI

Table 3b: Cumulative All Renewables Potential Build Limits

Run Years	**Cumulative New Capacity Allowed Online** (MW)
2010	4,000
2015	24,000
2020	44,000
2025	64,000

Source: EPRI

Table 3c: Cumulative Coal with Carbon Capture and Storage Potential Build Limits

Run Years	**Incremental New Capacity Allowed Online (MW)**	**Cumulative New Capacity Allowed Online** (MW)
2010	Not Available	Not Available
2015	5,000	5,000
2020	70,000	75,000
2025	70,000	145,000

Table 3d: Performance and Unit Cost Assumptions for Potential Nuclear Capacity in EPA Base Case v3.01

Characteristics/Types	Nuclear
Size (MW)	1,000
First Year Available	2015
Lead Time (in years)	6
Availability	90%
Vintage #1 (years covered)	2015-2021
Vintage #2 (years covered)	2022-2028

[2] The 2015 limitation for new nuclear builds from the EPRI study used in EPA's IPM v3.01 differs from the level used in EPA's Base Case 2006 (v3.0) using IPM. For v3.0, EPA uses the projections of 6 GW of additional nuclear capacity found in EIA's AEO 2006, and applies those builds in 2015.

Vintage #1	
Heat Rate (btu/kwh)	10,400
Capital Cost ($/kwh)	1,913
Fixed O&M (2004$/KW-YR)	61.82
Variable O&M ($/MWh)	0.45
Vintage #2	
Heat Rate (btu/kwh)	10,400
Capital Cost ($/kwh)	1,832
Fixed O&M (2004$/KW-YR)	61.82
Variable O&M ($/MWh)	0.45

Source: AEO 2006 , Table 38