EPA v5.15 Base Case Documentation Supplement
to Support EPA's Clean Power Plan

Overview

This supplement includes details on several modeling assumptions used as part of EPA's analysis of the Clean Power Plan using the EPA v5.15 Base Case using Integrated Planning Model (IPM). The modifications include an enhanced capability for existing coal steam-fired units to adopt improvements to their heat rates and a modified calculation for stack emissions associated with biomass combustion. This supplement also includes more detail on the specific modeling parameters that were used to reflect the emission performance rates that are part of the CPP.

Heat Rate Improvements (HRI)

As in the modeling that supported the proposed rule, the modeling supporting the final rule also offers coal steam model plants a heat rate improvement option that is fully integrated into the IPM modeling framework. This capability enables IPM to solve for the optimal deployment of heat rate improvement (HRI) technologies on a plant-by-plant basis in the regulatory scenarios analyzed.

EPA has conducted a thorough technical assessment of the engineering and cost parameters of potential heat rate improvements that reduce auxiliary power and fuel consumption so as to increase net electrical output per unit of heat input (i.e., heat rate).[1] EPA has relied upon an analysis of historical data, as well as several recent studies that have examined opportunities for efficiency improvements as a means of reducing heat rate and emissions from coal-fired power plants (see list of technical reports and studies below).

The EPA's analysis finds that on average, coal steam generation can realize a heat rate improvement of 4.3% in the Eastern Interconnection, 2.3% in the Texas Interconnection, and 2.1% in the Western Interconnection. This assumption of 2.1% to 4.3% heat rate improvement, based on the location of generator, is represented in the heat rate improvement retrofit option offered in modeling scenarios analyzing the CPP.

Most of the methods that can be applied to achieve a sustained HRI on a coal-steam EGU will entail a capital cost. The modeling assumes $100/kW as a combined HRI capital cost to achieve the aforementioned HRI levels.

Biomass Emissions Calculation

As in the modeling that supported the proposed rule, biomass is included in the model as a fuel for existing dedicated biomass power plants and potential (new) biomass direct fired boilers. It is also included in the model as a co-firing fuel available to all coal-fired power plants. EPA Base Case v.5.15 uses biomass supply curves based on those in AEO 2013. In past EPA modeling applications of IPM, biomass was not assigned a CO_2 emission factor associated with its combustion, unlike other fuels that emit CO_2 when combusted such as coal, natural gas, oil, and waste fuels.

[1] See chapter 2 of the Greenhouse Gas Mitigation Measures Technical Support Document (TSD)

In all the scenarios analyzed for the Clean Power Plan, including both the base case and the illustrative compliance scenarios, an emission factor of 195 lbs/MMBtu (88.45 kg/MMBtu) has been assigned to combustion from biomass fuels (including dedicated biomass facilities and coal steam-fired sources that are co-firing biomass, as determined by the model).[2] This factor reflects the average CO_2 emissions that result from the combustion of biogenic feedstocks, and does not include any evaluation of stack biogenic CO_2 emissions relative to the net landscape and process-related carbon fluxes associated with the production and use of the biogenic feedstocks combusted.

Modeling of Emission Performance Rates

The EPA modeled two illustrative plan approaches, each at the state level, based on a rate-based approach and a mass-based approach. The rate-based plan approach requires affected sources in each state to achieve a single average emissions rate in each period as represented by the statewide goals. The mass-based plan approach requires affected sources in each state to limit their aggregate emissions not to exceed the mass goal for that state.

In each of these scenarios, affected EGUs include:

- Existing fossil steam boilers with nameplate capacity greater than 25 MW
- Existing NGCC units

In the rate-based scenario, the affected EGUs within each state are required to achieve an average emissions rate that is less than or equal to the state goals for each state. The generation (or avoided generation) from these additional sources represented in the model is counted toward meeting state goals:

- All renewable capacity (hydro, solar PV, wind, geothermal) that comes online after 2012
- Under-construction nuclear[3]
- Demand-side energy efficiency in addition to levels implicit in base case electricity demand.

Furthermore, in the rate-based scenario, the affected sources have the ability to do one or both of the following:

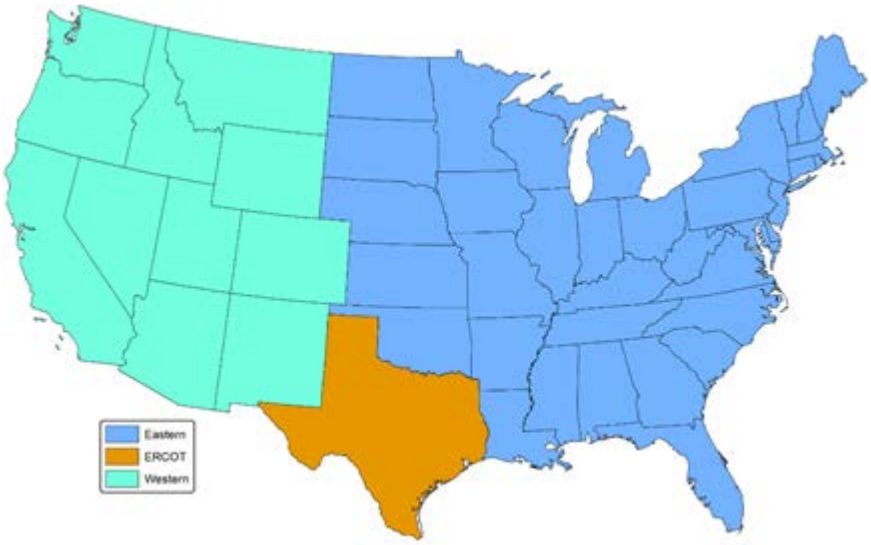
- generate in amounts within that state such that the average emissions rate is achieved, and/or
- include in the average emissions rate calculation new renewable generation or demand-side energy efficiency located outside of the state but within each of the illustrative Interconnection-based regions shown in Figure 1 below.[4]

[2] Taken from EIA - Accounting for carbon dioxide emissions from biomass energy combustion (Annual Energy Outlook 2010 Issues in Focus), 2010. http://www.eia.gov/oiaf/archive/aeo10/carbon_dioxide.html.

[3] Includes three nuclear facilities at which construction has already commenced: Watts Barr (TN), Vogtle (GA), and Summer (SC)

[4] In this illustrative scenario, energy efficiency/renewable energy procurement is limited to within one of the three illustrative regions. Since the interconnections do not always follow state borders, certain states that fall into more than one region were grouped in regions where there was a majority of geographic territory (area) or generation. Depending on the elements of their respective state's plan, sources in states that have adopted certain rate-based

Figure 1. Illustrative Regions for Demand-Side Energy Efficiency/Renewable Energy Procurement Used in this Analysis



The mass-based scenario includes a 5 percent set-aside of allowances that would be allocated to recognize deployment of new renewable capacity, which is represented by lowering the capital cost of new renewable capacity in a compliance period by the estimated value of the allowances in the set-aside in that period. The value of the set-aside is estimated in each model run year as the total allowances in the set-asides of each state in the contiguous U.S. multiplied by the projected average allowance price over the contiguous U.S. for that year. This total value is then assumed to apply evenly to all new renewable capacity.

Table 1 presents the absolute electricity savings in each model run-year for each state from assumed demand-side energy efficiency improvements that are included in the illustrative compliance analyses conducted for the Clean Power Plan. The quantification of these data is explained in the Demand-Side Energy Efficiency TSD for the Clean Power Plan.

Table 1. Demand-Side Energy Efficiency Savings Included in CPP Scenarios (GWh)

	2020	2025	2030	2040	2050
Alabama	91	3,290	7,266	9,822	10,584
Arizona	795	4,791	7,215	8,605	9,433
Arkansas	241	2,517	4,275	5,290	5,747
California	2,724	16,221	24,125	28,007	30,069
Colorado	522	3,349	5,079	6,060	6,615
Connecticut	305	1,802	2,651	2,989	3,052
Delaware	1	351	847	1,126	1,160
District of Columbia	51	555	936	1,099	1,133
Florida	389	9,054	18,673	24,551	26,617

plans may be able to procure energy efficiency/renewable energy from states outside of these illustrative regions. See the preamble for discussion.

Georgia	357	5,894	11,327	14,582	15,720
Idaho	136	1,318	2,175	2,617	2,802
Illinois	1,452	8,584	12,641	14,287	14,744
Indiana	1,002	6,311	9,383	10,628	10,968
Iowa	483	2,869	4,250	4,882	5,112
Kansas	2	1,264	3,077	4,196	4,416
Kentucky	338	4,252	7,591	9,541	10,251
Louisiana	23	2,903	6,976	9,733	10,564
Maine	121	716	1,054	1,188	1,213
Maryland	631	3,723	5,468	6,137	6,326
Massachusetts	565	3,338	4,912	5,539	5,656
Michigan	1,051	6,199	9,106	10,222	10,508
Minnesota	710	4,217	6,246	7,175	7,514
Mississippi	119	2,157	4,240	5,529	6,005
Missouri	419	4,312	7,203	8,525	8,872
Montana	79	765	1,262	1,519	1,627
Nebraska	49	1,201	2,488	3,211	3,360
Nevada	175	1,850	3,133	3,806	4,076
New Hampshire	17	424	873	1,108	1,130
New Jersey	530	4,195	6,498	7,400	7,629
New Mexico	138	1,295	2,129	2,605	2,855
New York	1,478	8,643	12,551	13,648	13,598
North Carolina	813	7,371	11,953	14,436	15,604
North Dakota	3	516	1,238	1,678	1,755
Ohio	1,539	9,098	13,399	15,144	15,628
Oklahoma	168	2,739	5,262	6,818	7,431
Oregon	498	2,967	4,420	5,154	5,519
Pennsylvania	1,350	8,662	12,884	14,499	14,947
Rhode Island	80	470	692	780	796
South Carolina	384	4,151	7,098	8,744	9,451
South Dakota	16	463	981	1,277	1,336
Tennessee	321	4,607	8,556	10,914	11,724
Texas	800	16,340	32,907	43,447	47,574
Utah	256	1,828	2,804	3,295	3,529
Vermont	57	338	497	560	572
Virginia	28	3,699	8,882	12,307	13,289
Washington	970	5,785	8,617	10,048	10,760
West Virginia	79	1,339	2,558	3,165	3,265
Wisconsin	707	4,174	6,142	6,924	7,131
Wyoming	31	695	1,420	1,846	1,976
Continental U.S. Total	23,043	193,044	325,023	395,563	420,514

The rate-based and mass-based performance rates analyzed in these illustrative scenarios are included in Table 2. Note that the performance rates in Table 2 differ slightly from performance rates of the interim and final periods. For purposes of modeling the illustrative CPP compliance plan scenarios, the CPP goals for the year 2025 are applied in the IPM modeling run year for that same year, which represents the interim period. In 2030, the final rule 2030 goals are the modeled goals for the 2030 IPM analysis year and all subsequent IPM analysis years.

Table 2. Modeled CO_2 Emission Constraints, Illustrative Rate-Based Scenario and Mass-Based Scenario

	Rate-Based Scenario (Adjusted MWh-Weighted-Average Pounds of CO_2 Per Net MWh from Affected Generation)		**Mass-Based Scenario** (Adjusted Output-Weighted-Average Short Tons of CO_2 From All Affected Fossil Fuel-Fired EGUs)	
	2025	2030-2050	2025	2030-2050
Alabama	1,186	1,018	62,301,383	56,787,453
Arizona	1,203	1,031	33,141,475	30,149,400
Arkansas	1,333	1,130	33,777,688	30,301,183
California	936	828	51,128,347	48,412,792
Colorado	1,391	1,174	33,478,664	29,871,662
Connecticut	881	786	7,244,349	6,936,604
Delaware	1,052	916	5,072,066	4,708,488
District of Columbia				
Florida	1,056	919	113,188,612	105,017,231
Georgia	1,227	1,049	51,052,586	46,314,052
Idaho	862	771	1,458,943	1,402,956
Illinois	1,484	1,245	75,038,487	66,430,150
Indiana	1,480	1,242	85,888,253	76,060,014
Iowa	1,533	1,283	28,350,412	25,003,581
Kansas	1,547	1,293	24,941,614	21,975,278
Kentucky	1,538	1,286	71,547,475	63,081,489
Lands of the Fort Mojave Tribe	862	771	611,571	588,102
Lands of the Navajo Nation	1,562	1,305	24,639,838	21,685,245
Lands of the Uintah and Ouray Reservation	1,562	1,305	2,570,003	2,261,830
Louisiana	1,321	1,121	39,419,262	35,401,962
Maine	872	778	2,159,689	2,072,189
Maryland	1,539	1,287	16,262,767	14,337,483
Massachusetts	932	824	12,755,593	12,089,027
Michigan	1,384	1,169	53,213,012	47,510,437
Minnesota	1,442	1,213	25,511,952	22,662,330
Mississippi	1,090	945	27,392,465	25,286,424

Missouri	1,519	1,272	62,772,857	55,423,669
Montana	1,562	1,305	12,834,064	11,295,116
Nebraska	1,551	1,296	20,712,602	18,243,038
Nevada	971	854	14,364,505	13,514,005
New Hampshire	976	858	4,249,634	3,994,748
New Jersey	915	811	17,445,663	16,587,984
New Mexico	1,354	1,146	13,855,088	12,403,822
New York	1,054	918	33,621,701	31,201,703
North Carolina	1,340	1,136	57,146,893	51,229,970
North Dakota	1,562	1,305	23,711,776	20,868,467
Ohio	1,412	1,190	82,774,830	73,717,634
Oklahoma	1,252	1,068	44,724,737	40,459,552
Oregon	993	871	8,656,441	8,112,904
Pennsylvania	1,287	1,095	99,596,269	89,758,762
Rhode Island	862	771	3,660,189	3,519,728
South Carolina	1,366	1,156	29,053,443	25,980,578
South Dakota	1,380	1,166	3,948,744	3,526,611
Tennessee	1,439	1,211	31,882,568	28,328,349
Texas	1,217	1,041	208,600,955	189,454,688
Utah	1,397	1,179	26,645,320	23,761,376
Vermont				
Virginia	1,076	934	29,636,920	27,413,690
Washington	1,140	983	11,705,162	10,731,571
West Virginia	1,562	1,305	58,277,140	51,289,055
Wisconsin	1,393	1,176	31,350,938	27,967,194
Wyoming	1,556	1,300	35,899,031	31,612,047