EPA v5.13 Base Case Documentation Supplement to Support
EPA's Proposed Carbon Pollution Guidelines for Existing Electric Generating Units

Overview

This supplement includes details on several modeling assumptions used as part of EPA's analysis of the Clean Power Plan (Carbon Pollution Guidelines for Existing Electric Generating Units) using the EPA v5.13 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 state goals that are part of the proposed rule.

Heat Rate Improvements (HRI)

A new capability has been introduced to offer 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 6% heat rate improvement through two types of changes: best practices that have the potential to improve heat rate by 4%, and equipment upgrades that have the potential to improve heat rate by 2%. This assumption of 6% heat rate improvement is represented in the heat rate improvement retrofit option offered in modeling scenarios analyzing the proposed regulatory option (Option 1). An alternative level of 4% heat rate improvement is represented in the heat rate improvement retrofit option offered in modeling scenarios analyzing the regulatory alternative (Option 2).

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 (the same cost is used for both Option 1 and Option 2).

Biomass Emissions Calculation

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

[1] See chapter 2 of the Greenhouse Gas Abatement Measures Technical Support Document (TSD) in support of the Proposed Carbon Pollution Guidelines for Existing Electric Generating Units

fuel available to all coal-fired power plants. EPA Base Case v.5.13 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.

In all the scenarios analyzed for the Proposed 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 State Guidelines

In the illustrative compliance scenarios analyzed, the average emissions rate of the source types included in the calculation of the state goals must be, on average, less than or equal to the proposed goals over the entire compliance period. That is, the CO_2 emission rate constraints imposed to represent the state goals are applied only to the sources whose generation was originally included in the calculation of the state goals being analyzed. Electricity savings (in megawatt-hours avoided) from assumed improvements in demand-side energy efficiency are also incorporated, in the same manner as zero-emitting generation is incorporated, into the average emission rates that must not exceed the CO_2 emission rate constraints.

Generation and emissions from the following sources are included in the average emissions rates that are evaluated against the state goals for compliance:

- Existing IGCC and fossil steam boilers with nameplate capacity greater than 25 MW
- Existing NGCC units
- Simple cycle combustion turbines with nameplate capacity greater than 25 MW, capacity factor greater than a 33%, and 2012 (historical) generation greater than 219,000 MWh
- New and existing non-hydro renewable capacity[3]
- At risk and under construction nuclear.[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] CO_2 emissions from landfill gas and municipal solid waste (MSW) are not included in the average emissions rate subject to the CO_2 constraints, but they are included in projections of total emissions. CO_2 emissions from biomass consumption are included in the average emissions rate subject to the CO_2 constraints.

[4] All generation from under-construction units and 7.97% of generation from existing units is included in the average emissions rate evaluated for compliance. Because this modeling was conducted before the associated rule was issued, the amount of at-risk generation quantified and included in this modeling is slightly higher than the amount ultimately quantified and included in state goals in the proposed Clean Power Plan. For more

- Demand-side energy efficiency savings

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 analyses conducted for the proposed Clean Power Plan. The quantification of these data is explained in the Greenhouse Gas Abatement Measures TSD for the proposed Clean Power Plan. Table 1 also reflects the proportion of those electricity savings that is incorporated into the average emissions rate subject to the CO_2 constraints modeled. The preamble for the proposed Clean Power Plan explains why only a subset of the absolute electricity savings quantified for certain states (whose historic data showed a net importation of electricity) is incorporated into the computation of the relevant state goal and, correspondingly, incorporated into the average emission rate in these modeled scenarios that is subject to the CO_2 constraint representing that state goal.

Table 1. Demand-Side Energy Efficiency Savings Included in Emission Rate Calculation in Option 1 Modeled Scenarios (GWh)

State	2020	2025	2030	2040	2050
Alabama	1,350	6,472	11,108	15,149	16,547
Arizona	4,782	9,243	12,162	14,301	16,241
Arkansas	829	3,663	6,100	8,094	8,714
California	11,434	22,845	30,030	34,268	37,272
Colorado	2,387	5,638	7,812	9,454	10,584
Connecticut	1,495	3,058	3,974	4,287	4,353
Delaware	71	379	663	882	916
District Of Columbia	0	0	0	0	0
Florida	5,135	18,896	29,906	39,373	44,029
Georgia	2,526	10,150	16,490	21,811	23,837
Idaho	543	1,305	1,803	2,141	2,334
Illinois	6,943	15,024	19,926	22,095	22,925
Indiana	3,727	10,008	14,054	16,235	16,795
Iowa	2,413	5,006	6,589	7,337	7,763
Kansas	557	2,840	4,920	6,549	6,933
Kentucky	1,929	7,325	11,643	15,057	16,154
Louisiana	1,083	5,831	10,327	14,163	15,246
Maine	673	1,260	1,596	1,691	1,719
Maryland	1,911	4,245	5,684	6,390	6,683
Massachusetts	2,114	4,512	5,932	6,451	6,546
Michigan	5,411	11,276	14,778	16,159	16,686
Minnesota	3,305	6,705	8,770	9,724	10,291
Mississippi	774	3,618	6,138	8,227	8,857
Missouri	1,441	6,169	10,087	12,905	13,487
Montana	555	1,454	2,056	2,481	2,701
Nebraska	764	2,634	4,014	4,945	5,198

information on quantification of at-risk nuclear generation, please see the Greenhouse Gas Abatement Measures TSD.

Nevada	1,224	3,505	5,083	6,237	6,781
New Hampshire	329	954	1,365	1,577	1,593
New Jersey	856	4,286	7,372	9,722	10,096
New Mexico	867	2,413	3,501	4,395	4,969
New York	6,903	14,763	19,425	21,148	21,452
North Carolina	3,264	10,822	16,512	21,134	23,339
North Dakota	230	1,073	1,806	2,359	2,476
Ohio	6,531	14,587	19,504	21,755	22,562
Oklahoma	1,280	4,952	7,920	10,278	11,102
Oregon	2,603	5,424	7,232	8,379	9,147
Pennsylvania	7,601	15,704	20,627	22,878	23,950
Rhode Island	322	752	1,011	1,118	1,133
South Carolina	2,095	7,047	10,800	13,861	15,306
South Dakota	188	796	1,300	1,669	1,753
Tennessee	1,860	6,435	9,891	12,530	13,450
Texas	7,345	29,206	47,140	61,549	66,619
Utah	1,286	3,202	4,461	5,327	5,803
Vermont	0	0	0	0	0
Virginia	956	4,914	8,633	11,981	13,208
Washington	4,687	10,419	14,131	16,565	18,068
West Virginia	603	2,381	3,792	4,757	4,902
Wisconsin	3,143	6,477	8,466	9,257	9,563
Wyoming	324	1,382	2,284	3,040	3,295

Table 2. Demand-Side Energy Efficiency Savings Included in Emission Rate Calculation in Option 2 Modeled Scenarios (GWh)

State	2020	2025	2030	2040	2050
Alabama	1,069	4,753	7,809	10,490	11,504
Arizona	3,212	6,278	8,340	9,927	11,282
Arkansas	675	2,707	4,303	5,606	6,060
California	8,211	15,860	20,768	23,797	25,922
Colorado	2,022	4,103	5,500	6,550	7,355
Connecticut	1,145	2,168	2,773	2,980	3,033
Delaware	53	276	464	612	638
District Of Columbia	108	555	935	1,232	1,285
Florida	4,425	14,118	21,217	27,246	30,592
Georgia	2,122	7,543	11,665	15,100	16,572
Idaho	467	953	1,272	1,484	1,623
Illinois	5,596	10,813	13,984	15,343	15,963
Indiana	3,375	7,442	9,991	11,255	11,694
Iowa	1,860	3,556	4,599	5,096	5,403
Kansas	427	2,074	3,452	4,539	4,823

Kentucky	1,644	5,464	8,255	10,426	11,236
Louisiana	813	4,242	7,230	9,811	10,603
Maine	452	856	1,095	1,177	1,198
Maryland	1,577	3,076	3,999	4,435	4,652
Massachusetts	1,692	3,242	4,161	4,482	4,561
Michigan	4,232	8,048	10,338	11,227	11,621
Minnesota	2,466	4,713	6,097	6,756	7,162
Mississippi	617	2,662	4,320	5,699	6,159
Missouri	1,181	4,566	7,125	8,945	9,387
Montana	496	1,074	1,457	1,719	1,878
Nebraska	666	1,966	2,851	3,426	3,618
Nevada	1,108	2,605	3,608	4,318	4,715
New Hampshire	297	712	972	1,093	1,110
New Jersey	660	3,134	5,176	6,739	7,028
New Mexico	786	1,791	2,483	3,041	3,452
New York	5,535	10,614	13,631	14,692	14,947
North Carolina	2,879	8,081	11,724	14,624	16,222
North Dakota	183	789	1,271	1,635	1,723
Ohio	5,434	10,594	13,738	15,102	15,710
Oklahoma	1,086	3,689	5,611	7,117	7,720
Oregon	1,982	3,835	5,036	5,815	6,361
Pennsylvania	5,834	11,140	14,391	15,892	16,673
Rhode Island	276	550	715	776	789
South Carolina	1,842	5,259	7,665	9,592	10,639
South Dakota	154	589	918	1,157	1,220
Tennessee	1,623	4,797	7,018	8,674	9,356
Texas	6,182	21,720	33,366	42,621	46,325
Utah	1,132	2,351	3,153	3,691	4,035
Vermont	216	409	523	562	572
Virginia	736	3,589	6,053	8,296	9,180
Washington	3,814	7,510	9,915	11,487	12,565
West Virginia	507	1,771	2,687	3,297	3,413
Wisconsin	2,418	4,600	5,910	6,432	6,660
Wyoming	268	1,023	1,613	2,105	2,291

All compliance scenarios modeled include an assumption that affected sources are able to meet state goals collectively, by averaging all of their emissions relative to all of their generation. This approach enables some sources to emit at rates higher than the relevant goal, as long as there is corresponding generation coming from sources that emit at a lower rate such that the goal (in lbs/MWh) is met across all affected sources collectively.

The illustrative compliance scenarios also assume that state plans allow for intertemporal averaging in the initial compliance periods for both Option 1 and Option 2. That is, for the initial compliance period for which the "interim" state goal is applied, the average emissions rate at affected sources must be less than or equal to the applicable state goal, on average, over the entire compliance period, but not in any particular year. The initial compliance period for Option 1 is 2020 to 2029, and for Option 2 it is 2020 to 2024. After the initial compliance period, the average emission rate of the affected sources in each year must be less than or equal to the "final" state goal in each model run-year thereafter.

The intertemporal flexibility described above for the initial compliance periods is represented in these modeling scenarios by a combination of:

- an endogenous "banking" behavior, whereby the model may choose to reduce emission rates below the interim goal levels in earlier years to offset exceedances of the interim goals in later years of the initial compliance period[5]; and
- an exogenously assumed "borrowing" pattern, whereby states are assumed to exceed the interim goal in earlier years while offsetting those exceedances with additional emission rate reductions below the interim goal levels in later years of the initial compliance period.

The exogenously assumed borrowing pattern is represented by imposing intermediate CO_2 emission rate constraints in each run-year of the initial compliance period that are consistent with the annual values used to calculate the interim state goals for the relevant regulatory option. Those annual values are reported in the Goal Computation TSD, and Tables 3 through 5 below show the CO_2 intermediate CO_2 emission rate constraints derived from those values and imposed for each state in these modeling scenarios.

For combined heat and power (CHP) units that are covered under the rule, the emissions and energy output associated with the useful thermal output not used for electricity production are included in the state goal and would be reported under the proposed Clean Power Plan's reporting guidelines if the unit meets the rule's applicability criteria. The emissions and energy output associated with the useful thermal output are explained in the Goal Computation TSD. The state goals, as shown in the proposed rule and Tables 2 through 4 below, reflect total emissions divided by total net energy output (i.e., net electricity generation + useful thermal output). For purposes of IPM modeling, state goals are adjusted by removing non-electric useful thermal output (which is not simulated in IPM) from the denominator in an amount based on the unit-level 2012 electric generation and energy output data

The proposed state goals are shown in Table 3. Table 4 shows the corresponding, CO_2 emission rates that have been adjusted to exclude useful (non-electric) thermal output that is captured in the state goals but is not simulated in IPM at combined heat and power (CHP) units. Table 5 shows the CO_2 emission rate constraints that were modeled in IPM to inform the illustrative compliance scenarios that are the basis of the costs and benefits analysis found in the

[5] Banking is not allowed in the modeling to contribute to compliance with the final state goals imposed beyond the initial compliance period. In other words, the model must demonstrate full compliance with the interim state goals in the initial compliance periods independently from demonstrating compliance with the final state goals in subsequent years.

RIA. The rates in Table 5 differ slightly from the proposed state goals because they have been adjusted to exclude useful (non-electric) thermal output that is captured in the state goals but is not simulated in IPM at combined heat and power (CHP) units. These rates also reflect minor adjustments to the proposal's computations of state goals that were made after this modeling was conducted.

Table 3. Proposed State Goals, Interim and Final (Adjusted MWh-Weighted-Average Pounds of CO_2 Per Net MWh from Affected Generation Included in State Goals) for Options 1 & 2

	OPTION 1		OPTION 2	
STATE[6]	Interim Goal (2020-2029)	Final Goal (2030 Forward)	Interim Goal (2020-2024)	Final Goal (2025 Forward)
ALABAMA	1,147	1,059	1,270	1,237
ALASKA	1,097	1,003	1,170	1,131
ARIZONA *	735	702	779	763
ARKANSAS	968	910	1,083	1,058
CALIFORNIA	556	537	582	571
COLORADO	1,159	1,108	1,265	1,227
CONNECTICUT	597	540	651	627
DELAWARE	913	841	1,007	983
FLORIDA	794	740	907	884
GEORGIA	891	834	997	964
HAWAII	1,378	1,306	1,446	1,417
IDAHO	244	228	261	254
ILLINOIS	1,366	1,271	1,501	1,457
INDIANA	1,607	1,531	1,715	1,683
IOWA	1,341	1,301	1,436	1,417
KANSAS	1,578	1,499	1,678	1,625
KENTUCKY	1,844	1,763	1,951	1,918
LOUISIANA	948	883	1,052	1,025
MAINE	393	378	418	410
MARYLAND	1,347	1,187	1,518	1,440
MASSACHUSETTS	655	576	715	683
MICHIGAN	1,227	1,161	1,349	1,319
MINNESOTA	911	873	1,018	999
MISSISSIPPI	732	692	765	743
MISSOURI	1,621	1,544	1,726	1,694
MONTANA	1,882	1,771	2,007	1,960
NEBRASKA	1,596	1,479	1,721	1,671
NEVADA	697	647	734	713

[6] The EPA has not developed goals for Vermont and the District of Columbia because current information indicates those jurisdictions have no affected EGUs. Also, as noted above, EPA is not proposing goals for tribes or U.S. territories at this time. Alaska and Hawaii also have state goals, but they are not modeled in IPM.

NEW HAMPSHIRE	546	486	598	557
NEW JERSEY	647	531	722	676
NEW MEXICO *	1,107	1,048	1,214	1,176
NEW YORK	635	549	736	697
NORTH CAROLINA	1,077	992	1,199	1,156
NORTH DAKOTA	1,817	1,783	1,882	1,870
OHIO	1,452	1,338	1,588	1,545
OKLAHOMA	931	895	1,019	986
OREGON	407	372	450	420
PENNSYLVANIA	1,179	1,052	1,316	1,270
RHODE ISLAND	822	782	855	840
SOUTH CAROLINA	840	772	930	897
SOUTH DAKOTA	800	741	888	861
TENNESSEE	1,254	1,163	1,363	1,326
TEXAS	853	791	957	924
UTAH *	1,378	1,322	1,478	1,453
VIRGINIA	884	810	1,016	962
WASHINGTON	264	215	312	284
WEST VIRGINIA	1,748	1,620	1,858	1,817
WISCONSIN	1,281	1,203	1,417	1,380
WYOMING	1,808	1,714	1,907	1,869

* Excludes EGUs located in Indian country.

Table 4. Adjusted CO_2 Emission Rates Excluding Useful Thermal Output

	OPTION 1			**OPTION 2**	
STATE	**2020**	**2025**	**2030-2050**	**2020**	**2025**
ALABAMA	1,228	1,138	1,059	1,301	1,237
ARIZONA *	778	728	703	797	763
ARKANSAS	1,089	1,014	960	1,165	1,113
CALIFORNIA	627	581	567	638	606
COLORADO	1,247	1,138	1,111	1,307	1,229
CONNECTICUT	663	589	541	677	628
DELAWARE	973	908	841	1,029	983
FLORIDA	851	786	739	933	885
GEORGIA	967	877	835	1,030	965
IDAHO	266	239	228	270	254
ILLINOIS	1,504	1,365	1,287	1,568	1,475
INDIANA	1,708	1,599	1,539	1,759	1,691
IOWA	1,398	1,331	1,301	1,457	1,417
KANSAS	1,707	1,554	1,499	1,747	1,625
KENTUCKY	1,934	1,829	1,763	1,984	1,918
LOUISIANA	1,174	1,080	1,011	1,233	1,169

MAINE	415	389	378	426	410
MARYLAND	1,544	1,322	1,187	1,597	1,441
MASSACHUSETTS	739	645	576	749	683
MICHIGAN	1,410	1,301	1,242	1,482	1,411
MINNESOTA	972	907	879	1,046	1,005
MISSISSIPPI	783	721	692	783	736
MISSOURI	1,705	1,607	1,544	1,757	1,694
MONTANA	2,037	1,888	1,793	2,087	1,987
NEBRASKA	1,724	1,577	1,479	1,771	1,671
NEVADA	759	693	652	762	718
NEW HAMPSHIRE	637	526	486	639	557
NEW JERSEY	803	661	548	808	708
NEW MEXICO *	1,197	1,087	1,048	1,253	1,176
NEW YORK	763	648	570	809	725
NORTH CAROLINA	1,183	1,060	992	1,243	1,158
NORTH DAKOTA	1,852	1,811	1,783	1,894	1,870
OHIO	1,573	1,441	1,340	1,634	1,547
OKLAHOMA	996	916	896	1,056	986
OREGON	475	391	375	485	423
PENNSYLVANIA	1,337	1,203	1,080	1,403	1,307
RHODE ISLAND	867	815	782	871	840
SOUTH CAROLINA	921	829	772	962	898
SOUTH DAKOTA	870	787	741	914	861
TENNESSEE	1,353	1,239	1,163	1,402	1,326
TEXAS	1,049	941	881	1,108	1,027
UTAH *	1,446	1,366	1,322	1,503	1,453
VIRGINIA	990	852	806	1,074	968
WASHINGTON	381	285	241	394	322
WEST VIRGINIA	1,860	1,748	1,624	1,902	1,823
WISCONSIN	1,382	1,271	1,208	1,462	1,386
WYOMING	1,899	1,798	1,714	1,944	1,896

* Excludes EGUs located in Indian country.

Table 5. Modeled CO_2 Emission Rate Constraints (Adjusted MWh-Weighted-Average Pounds of CO_2 Per Net MWh from Affected Generation Included in State Goals) for Options 1 & 2

	OPTION 1			OPTION 2	
STATE	2020	2025	2030 forward	2020	2025 forward
ALABAMA	1,196	1,105	1,024	1,274	1,208
ARIZONA	767	716	691	785	751

ARKANSAS	1,077	1,003	950	1,153	1,101
CALIFORNIA	618	573	558	630	599
COLORADO	1,254	1,136	1,112	1,317	1,232
CONNECTICUT	651	580	533	664	617
DELAWARE	985	917	848	1,058	1,010
FLORIDA	811	741	692	818	771
GEORGIA	962	869	826	1,025	958
IDAHO	264	236	225	268	252
ILLINOIS	1,512	1,372	1,293	1,577	1,484
INDIANA	1,723	1,611	1,549	1,774	1,704
IOWA	1,409	1,340	1,310	1,468	1,428
KANSAS	1,728	1,571	1,516	1,769	1,644
KENTUCKY	1,955	1,846	1,778	2,006	1,937
LOUISIANA	1,170	1,067	993	1,242	1,171
MAINE	445	419	407	456	440
MARYLAND	1,521	1,298	1,166	1,573	1,417
MASSACHUSETTS	732	636	567	741	675
MICHIGAN	1,433	1,321	1,261	1,508	1,434
MINNESOTA	948	880	851	1,023	981
MISSISSIPPI	775	705	673	777	729
MISSOURI	1,705	1,607	1,544	1,757	1,694
MONTANA	2,034	1,881	1,781	2,084	1,980
NEBRASKA	1,713	1,568	1,471	1,760	1,661
NEVADA	757	688	644	760	714
NEW HAMPSHIRE	630	523	485	632	553
NEW JERSEY	783	641	531	788	688
NEW MEXICO	1,188	1,074	1,000	1,244	1,163
NEW YORK	749	634	557	799	715
NORTH CAROLINA	1,172	1,046	977	1,233	1,145
NORTH DAKOTA	1,857	1,815	1,788	1,899	1,874
OHIO	1,594	1,453	1,349	1,657	1,566
OKLAHOMA	984	900	879	1,061	986
OREGON	472	388	375	483	418
PENNSYLVANIA	1,323	1,189	1,067	1,389	1,293
RHODE ISLAND	866	809	773	871	837
SOUTH CAROLINA	880	790	736	921	858
SOUTH DAKOTA	868	780	731	913	856
TENNESSEE	1,336	1,219	1,142	1,384	1,307
TEXAS	1,029	917	855	1,101	1,016
UTAH	1,446	1,364	1,318	1,502	1,451
VIRGINIA	978	840	793	1,061	955
WASHINGTON	376	279	235	389	316
WEST VIRGINIA	1,872	1,760	1,636	1,915	1,835

WISCONSIN	1,363	1,249	1,185	1,444	1,366
WYOMING	1,897	1,790	1,701	1,941	1,862

* Excludes EGUs located in Indian country.

Partial list of recent heat rate improvement studies:

"Coal-fired Power Plant Heat Rate Reductions", Sargent & Lundy SL-009597 Final Report (Project 12301-001), (January 2009), available at http://www.epa.gov/airmarkets/resource/docs/coalfired.pdf

"Reducing CO_2 Emissions by Improving the Efficiency of the Existing Coal-fired Power Plant Fleet", DOE/NETL-2008/1329, (July 2008), available at http://www.netl.doe.gov/energy-analyses/pubs/CFPP%20Efficiency-FINAL.pdf

"Power Plant Performance Reporting and Improvement under the Provision of the Indian Energy Conservation Act – Output 1.1", Evonik/VGB (2008), available at http://www.emt-india.net/PowerPlantComponent/Output1.1/Output1.1.pdf

"Opportunities to Improve the Efficiency of Existing Coal-fired Power Plants, Workshop Report", NETL (July 2009), available at http://www.netl.doe.gov/energy-analyses/pubs/NETL%20Power%20Plant%20Efficiency%20Workshop%20Report%20Final.pdf

"Improving the Efficiency of Coal-fired Power Plants for Near Term Greenhouse Gas Emission Reductions", DOE/NETL-2010/1411 (April 2010), available at http://www.netl.doe.gov/energy-analyses/pubs/ImpCFPPGHGRdctns_0410.pdf

"Power Generation from Coal - Measuring and Reporting Efficiency Performance and CO_2 Emissions", OECD/IEA-CIAB (2010), available at http://www.iea.org/ciab/papers/power_generation_from_coal.pdf

"Opportunities to Enhance Electric Energy Efficiency in the Production and Delivery of Electricity", EPRI Technical Report