Coal Outlook through 2040: Annual Energy Outlook 2015 Reference Case and the Proposed Clean Power Plan

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December 1, 2015 | Rail Energy Transportation Advisory Committee to the Surface Transportation Board, Washington, D.C.
The *AEO2015* - abridged compared to *AEO2014*

- The U.S. Energy Information Administration revised the schedule for production of the *Annual Energy Outlook (AEO)* and the *International Energy Outlook (IEO)*. The AEO and IEO now alternate annually between full and short versions.

- The *AEO2015* is the first short version of the Annual Energy Outlook.
- The shorter version includes an abbreviated discussion and results from select cases.
Legislation and Regulations
AEO2015 legislation and regulation assumptions

• Current laws and regulations included in the AEO2015 Reference case
  - Clean Air Interstate Rule (CAIR)
  - Mercury and Air Toxics Standards (MATS) with full compliance by 2016
  - Regional Haze Rule plans are captured in annual reporting data
  - California’s cap-and-trade program (AB 32) and the Northeast’s Regional Greenhouse Gas Initiative (RGGI) program
  - Uncertainty with respect to CO$_2$ policy addressed through a 3% higher cost of capital for new coal-fired power and coal-to-liquids plants and capital investment projects at existing coal-fired power plants
  - State Renewable Portfolio Standards (RPS)
  - Wind facilities under construction by 2015 are allowed to take the production tax credit (a 2.3 cent per kilowatthour tax incentive)
Legislative and regulatory actions not addressed in the AEO2015 Reference case

- EPA’s cooling water intake regulations per section 316(b) of the Clean Water Act
- EPA’s coal effluent guidelines and coal combustion residuals
- California post-2020 Greenhouse Gas (GHG) emissions target
- EPA’s CO₂ New and Existing Source Performance Standards per section 111(b) and 111(d) of the Clean Air Act (aka Clean Power Plan), respectively
Review of AEO2015 Reference Case
Current trends already having an impact on coal consumption even before the CPP

• Nationally
  – Slowing growth in electricity demand
  – Competition with relatively low-cost natural gas
  – Increasing competition with renewable energy
  – Compliance with the Mercury Air Toxics Standard (MATS)
  – High plant construction costs relative to natural gas

• Regionally
  – Central Appalachia encountering thinning seams and reserve depletion
  – Illinois Basin coals competing more effectively as plants add SO2 controls
  – Coal export markets weakening
Key results for the AEO2015 Reference case

• Coal is the leading fuel for U.S. electricity generation in 2040. But, coal’s share of total generation decreases over time to 34% in 2040 from 39% in 2013.

• The Interior region increases both production and share of total production.
  – Coal producers in the Interior region gain share while Appalachia loses share of total U.S. coal production. From 2013 to 2040, the Appalachian region's share of total coal production (on a Btu basis) falls from about 35% to 27%.
  – From 2013 to 2040, Interior coal production rises by 113 million tons while West production rises by 59 million tons.

• Much of the 40 GW of coal-fired capacity retirements occur by 2016 largely because of the combination of MATS, relatively low natural gas prices, and relatively low electricity demand. (32 GW have been reported to EIA.)
Key results for the AEO2015 Reference case

• Expanding development of shale gas resources drives increased production and competitive prices for natural gas.

• In the years around MATS implementation (2016), coal use is low compared to history. But, as overall electricity demand and natural gas prices rise, coal use also increases. Coal consumption is steady -- about 1 billion tons in the 2020 time frame and then remains at about 990 million tons after 2030.

• Between 2015 and 2040, coal exports rise by about 60 million tons – predicated on rising demand for coal internationally.

• 1.1 GW of coal capacity additions (0.7GW planned)

• Delivered coal prices increase gradually through 2040 at an average rate of 0.7% per year (on a per ton basis) due to declining coal mine productivity and slightly higher transportation costs.
Over time the electricity mix gradually shifts towards larger shares of natural gas and renewable generation

Source: EIA, Annual Energy Outlook 2015
Electricity Generation by Fuel, 1980-2040

Note: Includes generation from plants in both the electric power and end-use sectors.

Source: History: U.S. Energy Information Administration (EIA), Annual Energy Review;
Electricity Generation for Coal and Gas in the Reference case and the High Oil and Gas Resource Case, 1980-2040

Note: Includes generation from plants in both the electric power and end-use sectors.

Delivered prices of natural gas and coal to the electric power sector in the Reference case

average delivered fuel prices to electric power plants, 2013 dollars per million Btu

2013

History

Projections

Power generation fuel costs
2013 dollars per megawatthour

2005 2015 2025 2035 2040

natural gas

coal steam

Average capacity utilization of natural gas combined cycle and coal generating capacity, 2008-2040

Source: AEO2015 Reference Case (April 2015)
28 Gigawatts of coal capacity to retire in 2015 and 2016

U.S. electricity generation capacity retirements

Source: Form EIA-860 and AEO2015 Reference Case (April 2015)
## Electric Net Summer Generating Capacity by Fuel, 2008-2040 (gigawatts)

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Coal</td>
<td>311</td>
<td>316</td>
<td>304</td>
<td>290</td>
<td>269</td>
<td>263</td>
<td>260</td>
<td>260</td>
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<tr>
<td>Electric Power Sector</td>
<td>308</td>
<td>313</td>
<td>300</td>
<td>286</td>
<td>266</td>
<td>260</td>
<td>257</td>
<td>257</td>
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<tr>
<td>End-Use Sectors</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Natural Gas &amp; Petroleum</td>
<td>450</td>
<td>463</td>
<td>470</td>
<td>480</td>
<td>486</td>
<td>482</td>
<td>519</td>
<td>595</td>
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<tr>
<td>Nuclear Power</td>
<td>101</td>
<td>101</td>
<td>99</td>
<td>100</td>
<td>100</td>
<td>101</td>
<td>102</td>
<td>105</td>
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<tr>
<td>Renewable Sources</td>
<td>117</td>
<td>143</td>
<td>167</td>
<td>192</td>
<td>202</td>
<td>207</td>
<td>227</td>
<td>275</td>
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<tr>
<td>Other (includes pumped storage)</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>26</td>
<td>26</td>
<td>26</td>
<td>26</td>
<td>26</td>
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<tr>
<td>Total</td>
<td>1004</td>
<td>1049</td>
<td>1065</td>
<td>1085</td>
<td>1082</td>
<td>1079</td>
<td>1133</td>
<td>1261</td>
</tr>
</tbody>
</table>

**Source:** AEO2015 Reference Case (April 2015)

*MATS compliance assumed to begin*
Coal demand regions

Source: U.S. Energy Information Administration, Office of Energy Analysis
Cumulative net summer coal-fired capacity retirements by coal demand region, 2014-2040

Source: AEO2015 Reference Case (April 2015)
Coal production by region, 1970-2040

Source: AEO2015 Reference Case (April 2015)
Average annual growth in coal mining labor productivity for selected supply regions (percent)

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern Appalachia</td>
<td>5.4</td>
<td>5.5</td>
<td>-2.2</td>
<td>-4.9</td>
<td>3.7</td>
<td>-1.2</td>
</tr>
<tr>
<td>Central Appalachia</td>
<td>7.3</td>
<td>4.4</td>
<td>-5.2</td>
<td>-3.8</td>
<td>3.1</td>
<td>-2.9</td>
</tr>
<tr>
<td>Eastern Interior</td>
<td>4.8</td>
<td>3.7</td>
<td>-0.2</td>
<td>6.1</td>
<td>7.1</td>
<td>0.7</td>
</tr>
<tr>
<td>Gulf Lignite</td>
<td>2.6</td>
<td>2.4</td>
<td>-2.8</td>
<td>-4.2</td>
<td>-1.2</td>
<td>-1.0</td>
</tr>
<tr>
<td>Dakota Lignite</td>
<td>6.0</td>
<td>1.0</td>
<td>-3.3</td>
<td>-4.8</td>
<td>-1.7</td>
<td>-0.6</td>
</tr>
<tr>
<td>Western Montana</td>
<td>4.6</td>
<td>2.0</td>
<td>-2.4</td>
<td>-11.7</td>
<td>15.4</td>
<td>-1.0</td>
</tr>
<tr>
<td>WY, Northern Powder River Basin</td>
<td>7.5</td>
<td>3.2</td>
<td>-3.2</td>
<td>-5.7</td>
<td>-2.6</td>
<td>-1.1</td>
</tr>
<tr>
<td>WY, Southern Powder River Basin</td>
<td>7.2</td>
<td>4.9</td>
<td>-2.4</td>
<td>-6.4</td>
<td>4.9</td>
<td>-1.1</td>
</tr>
<tr>
<td>Rocky Mountain</td>
<td>7.8</td>
<td>5.5</td>
<td>-2.4</td>
<td>3.5</td>
<td>1.3</td>
<td>-1.5</td>
</tr>
<tr>
<td>U.S. Average</td>
<td>7.1</td>
<td>6.2</td>
<td>-1.8</td>
<td>-0.2</td>
<td>6.7</td>
<td>-0.9</td>
</tr>
</tbody>
</table>

**Source:** History: U.S. Energy Information Administration (EIA), *Annual Coal Report*; and Mine Safety and Health Administration, Form 7000-2, “Quarterly Mine and Employment and Coal Production Report;”

**Projections:** AEO2015 Reference Case (April 2015).
Average minemouth coal prices by region, 1980-2040

2013 dollars per short ton

Source: AEO2015 Reference Case (April 2015) and AEO2014 Reference Case (April 2014)
Coal exports by major supply region, 2010-2040

Proposed Clean Power Plan
Draft EPA Clean Power Plan (CPP) cases considered by EIA demonstrate potential impacts that may occur under the Final Rule

<table>
<thead>
<tr>
<th>Case name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference (AEO)</td>
<td>EIA’s AEO2015 Reference case presents long-term annual projections of energy supply, demand, and prices through 2040. The Reference case is based generally on federal, state, and local laws and regulations in effect as of the end of October 2014.</td>
</tr>
<tr>
<td><strong>Policy Cases</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Base Policy (CPP)</strong></td>
<td>Regional CO₂ emission intensity targets were developed and added as a modeling constraint, based on specified state-level CO₂ emission intensity targets.</td>
</tr>
<tr>
<td><strong>Policy Extension (CPPEXT)</strong></td>
<td>The Base Policy case models the proposed Clean Power Plan using the AEO2015 Reference case as the underlying baseline, allowing regions to choose compliance strategies endogenously from among the four building blocks in EPA’s proposed Best System of Emissions Reduction.</td>
</tr>
<tr>
<td><strong>Policy with New Nuclear (CPPNUC)</strong></td>
<td>The Policy Extension case extends CO₂ reduction targets beyond 2030, in order to reduce CO₂ emissions from the power sector by 45% below 2005 levels in 2040, using the AEO2015 Reference case as the baseline.</td>
</tr>
<tr>
<td><strong>Policy with New Nuclear (CPPNUC)</strong></td>
<td>The CPPNUC case assumes that generation from new nuclear power plants that are not currently under construction is counted in compliance calculations in the same manner as new renewable generation.</td>
</tr>
</tbody>
</table>
Coal production levels for the Base Policy case (CPP) are substantially below baseline – 20% lower in 2020 and 32% lower in 2025

- Coal production in the Base Policy case increases by 151 million tons after 2024 as utilization of remaining coal units improves due to increasing electricity demand, expanded use of renewables, rising natural gas prices, and static CPP targets in the post-2030 period.

U.S. Coal Production, 2020 and 2040

Regional coal production impacts vary across regions and Proposed Clean Power Plan scenario

Coal production by region, 2040

Million short tons

The proposed CPP rule causes a significant reduction in generation from coal

The diagram shows the trend in total electricity generation from various sources over the years, with a focus on the impacts of different policies (Reference, Base Policy, Policy Extension) compared to historical data. Coal generation is expected to decrease significantly under the proposed rule, with natural gas and renewables projected to increase.
2040 electricity generation shares

From 2014-2040, CPP case retirements (mostly coal) are 66 GW above Reference; renewable capacity adds are 174 GW above Reference

Cumulative additions and retirements, 2014-40
gigawatts

0 100 200 300 400 500 600

Reference

Clean Power Plan (CPP) Base Policy

CPP Extension

CPP with New Nuclear

additions
other renewables
wind
solar
natural gas
clean
capacity
nuclear
retirements
capacity
coalf
nuclear

Cumulative coal-fired capacity retirements, 2012-2040

### Proposed Rule vs. Final Rule

<table>
<thead>
<tr>
<th>Proposed Rule</th>
<th>Final Rule</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compliance begins in 2020 with one interim period from 2020 – 2029; Final targets in 2030</td>
<td>Compliance start delayed to 2022 with three interim periods (2022–2024, 2025-2027, 2028-2029); Final targets in 2030</td>
</tr>
<tr>
<td>Four building blocks (heat rate improvement, switching to NG, zero-carbon technologies, EE)</td>
<td>Three building blocks (heat rate improvement, switching to NG, zero-carbon technologies); EE counts for compliance but is not included in target calculation</td>
</tr>
<tr>
<td>Existing nonhydro renewables and incremental (new) renewables are included; end-use renewables excluded</td>
<td>Existing renewables excluded; incremental (post-2012) additions only; end-use renewables (incremental) included</td>
</tr>
<tr>
<td>Existing “at-risk” and incremental (post-2012) nuclear included</td>
<td>Existing (“at-risk”) nuclear excluded; incremental (post-2012) additions only</td>
</tr>
<tr>
<td>Fossil emission rates based on each State’s existing capacity resulting in considerable variation</td>
<td>Source specific (fossil steam, NGCC) rates determined at interconnect level reducing variation</td>
</tr>
<tr>
<td>Existing fossil steam, NGCC, and “large” or “higher-utilization” combustion turbines included</td>
<td>Existing fossil steam, NGCC; all combustion turbines excluded</td>
</tr>
<tr>
<td>Mass-based targets described but not specified</td>
<td>Two mass-based targets specified for fossil (existing, all)</td>
</tr>
<tr>
<td>Credit trading described but not sufficiently specified</td>
<td>Credit trading options more fully defined</td>
</tr>
</tbody>
</table>
EIA Data Browsers and Energy Mapping System

Analysis of the proposed Clean Power Plan - 
http://www.eia.gov/analysis/requests/powerplants/cleanplan/

Electricity Data Browser - http://www.eia.gov/electricity/data/browser/

Coal Data Browser (Beta) - http://www.eia.gov/beta/coal/data/browser/

Nuclear Outage Browser (Beta) - http://www.eia.gov/beta/outages/


Short-Term Energy Outlook - http://www.eia.gov/forecasts/steo/query/


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Supplemental Slides
## Key differences between alternate AEO cases

<table>
<thead>
<tr>
<th>AEO2015 Reference</th>
<th>Low Economic Growth</th>
<th>High Economic Growth</th>
<th>High Oil and Gas Resource</th>
<th>High Oil Price</th>
<th>Low Oil Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP growth (avg. annual change from 2013)</td>
<td>2.4%</td>
<td>1.8%</td>
<td>2.9%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electricity demand (avg. annual change from 2013)</td>
<td>0.8%</td>
<td>0.5%</td>
<td>1.2%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delivered natural gas price to the electricity sector, 2040 (2013 dollars per million Btu)</td>
<td>$8.28</td>
<td></td>
<td></td>
<td>$4.67</td>
<td>$7.77</td>
</tr>
</tbody>
</table>
Cumulative coal-fired capacity additions, 2012-2040

Average levelized electricity costs for new power plants, excluding subsidies, in the Reference case, 2020 and 2040

new power plant costs, 2013 cents per kilowatthour

Source: AEO2015 Reference Case (April 2015)
Growth in electricity use slows, but electricity use still increases by 24% from 2013 to 2040

U.S. electricity use and GDP
percent growth (rolling average of 3-year periods)

<table>
<thead>
<tr>
<th>Period</th>
<th>Average Growth</th>
</tr>
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<tbody>
<tr>
<td>Electricity use</td>
<td>GDP</td>
</tr>
<tr>
<td>1950s</td>
<td>9.8</td>
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<tr>
<td>1960s</td>
<td>7.3</td>
</tr>
<tr>
<td>1970s</td>
<td>4.7</td>
</tr>
<tr>
<td>1980s</td>
<td>2.9</td>
</tr>
<tr>
<td>1990s</td>
<td>2.4</td>
</tr>
<tr>
<td>2000-2013</td>
<td>0.7</td>
</tr>
<tr>
<td>2013-2040</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Source: EIA, Annual Energy Outlook 2015 Reference case
Coal production, AEO2015 in 2040 (vs. 2013) (million short tons)

- **U.S. Total:** 1,117 (985)
  - 130 (125) in Wyoming’s Powder River Basin
  - 83 (128) in mines in both Alaska and Washington
  - 16 (19) in mines in both Alaska and Washington
  - 60 (46) in mines in both Alaska and Washington

*Includes production from all mines in Wyoming’s Powder River Basin.

**Includes production from mines in both Alaska and Washington.

U.S. Coal Exports, 1995-2040

million short tons

<table>
<thead>
<tr>
<th>Year</th>
<th>Coking</th>
<th>Steam</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>50</td>
<td>30</td>
<td>80</td>
</tr>
<tr>
<td>2000</td>
<td>60</td>
<td>40</td>
<td>100</td>
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<tr>
<td>2005</td>
<td>70</td>
<td>30</td>
<td>100</td>
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<tr>
<td>2010</td>
<td>80</td>
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<td>2013</td>
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<td>2015</td>
<td>100</td>
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<td>2020</td>
<td>120</td>
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<td>140</td>
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<td>2025</td>
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<td>30</td>
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<td>2030</td>
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<td>40</td>
<td>200</td>
</tr>
<tr>
<td>2035</td>
<td>180</td>
<td>50</td>
<td>230</td>
</tr>
<tr>
<td>2040</td>
<td>200</td>
<td>60</td>
<td>260</td>
</tr>
</tbody>
</table>

Shale resources remain the dominant source of U.S. natural gas production growth

U.S. dry natural gas production
trillion cubic feet

Source: EIA, Annual Energy Outlook 2015 Reference case
Non-hydro renewable generation grows to double hydropower generation by 2040

renewable electricity generation by fuel type
billion kilowatthours

Source: EIA, Annual Energy Outlook 2015 Reference case
Gas-fueled units account for most projected capacity additions in the AEO2015 Reference case

U.S. electricity generation capacity additions

History

2013

Projected

Source: Form EIA-860 & EIA Annual Energy Outlook 2015
Net summer coal-fired generating capacity in the electric power sector by coal demand region, 2013 and 2040

Source: AEO2015 Reference Case (April 2015)
Appalachian coal production, 1970-2040

Source: AEO2015 Reference Case (April 2015)
Except for Appalachian total, data for 1978-1985 exclude production from small (<10,000 short tons) coal mines.
Interior coal production, 1970-2040

Source: AEO2015 Reference Case (April 2015)
Except for Interior total, data for 1978-1985 exclude production from small (<10,000 short tons) coal mines
Western coal production, 1970-2040

million short tons

History

2013

Projections

Total Western

Short Term Energy Outlook November 2015

Wyoming PRB

Other West

Source: AEO2015 Reference Case (April 2015)
Except for Western total, data for 1978-1985 exclude production from small (<10,000 short tons) coal mines