Annual Energy Outlook 2015
1st Coal Working Group

Coal and Uranium Analysis Team
July 30, 2014 | Washington, D.C.
Changes in release cycles for EIA’s AEO and IEO

- To focus more resources on rapidly changing energy markets and how they might evolve over the next few years, the U.S. Energy Information Administration is revising the schedule and approach for production of the *International Energy Outlook* (IEO) and the *Annual Energy Outlook* (AEO).

- Starting with IEO2013, which was released in July, 2013, EIA adopted a two-year production cycle for both the IEO and AEO.

- Under this approach, a full edition of the IEO and AEO will be produced in alternating years and an interim, shorter edition of each will completed in the “off” years.

<table>
<thead>
<tr>
<th></th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>International Energy</strong></td>
<td><strong>Interim Edition will be released in mid 2014</strong>, focusing on the liquids projection, which is used as part of the AEO2014. Summary tables and a short analysis will be included.</td>
<td><strong>Full Edition will be released in the spring 2015</strong></td>
</tr>
<tr>
<td><strong>Outlook</strong></td>
<td><strong>Annual Energy</strong></td>
<td><strong>Interim Edition will be released in late 2014 or early 2015</strong></td>
</tr>
<tr>
<td><strong>Outlook</strong></td>
<td><strong>Final Edition will be released in spring 2014</strong>, including analysis of energy issues and many alternative scenarios.</td>
<td><strong>and will only include the Reference, Low and High Economic Growth, and Low and High Oil Price cases. The shorter version will include tables for these cases and short discussions.</strong></td>
</tr>
</tbody>
</table>

**Coal and Uranium Analysis Team**

**July 30, 2014 | Washington, D.C.**

**WORKING GROUP PRESENTATION FOR DISCUSSION PURPOSES. DO NOT QUOTE OR CITE AS AEO2015 MODELING ASSUMPTIONS AND INPUTS ARE SUBJECT TO CHANGE.**
Scope of changes limited by Interim AEO

• Data Updates
  – Planned retirements, retrofits, repowering, uprates (nuclear), and new builds
  – Historical data updates and overwrites; update to AEO base year
  – Short-Term Energy Outlook (STEO) calibration

• Model Updates and Enhancements
  – Limited to those generally needed to address changes in laws and regulations
  – Complete integration of Coal Market Module AIMMS implementation into the production NEMS system
Legislation and Regulations
AEO2014 legislation and regulation assumptions

- Current laws and regulations included in the AEO2014 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 only
  - California’s cap-and-trade program (AB 32) and the Northeast’s Regional Greenhouse Gas Initiative (RGGI) program
  - Uncertainty with respect to CO₂ 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)
  - Renewable energy sunset provisions as specified in law, e.g., for production tax credits for wind the “effective expiration date” is 2015 for plants under construction by the end of 2013
Changes to the legislative and regulation assumptions in the AEO2015 Reference case (1)

• Updates to NEMS modeling of California SB1368 to remove firm contractual arrangements for coal plants upon expiration
  
  – Prohibits CA utilities from entering into long-term financial commitments for base load generation, unless it complies with the CO2 emissions performance standard. The CO2 emissions level must be equal, or below the emissions performance standard of 1,100 lbs. per megawatt-hour (MWh).
  
  – EIA modeling approach

    • Reduce firm imports to represent expiration of contracts with the Four Corners, Navajo, Reid Gardner, San Juan, and Boardman plants

    • Adjust carbon emission rate for firm imports in accordance with the expiration of contracts

    • Retire Intermountain plant in 2025 in response to announcement by Los Angeles Department of Water and Power. Announcement has not been officially reported to EIA and decision may be reconsidered and plant could be sold or converted to natural gas instead.
Changes to the legislative and regulation assumptions in the AEO2015 Reference case (2)

- Cross-State Air Pollution Rule (CSAPR) to replace Clean Air Interstate Rule (CAIR) in AEO2015 if reinstated timely to EIA development schedule
  - Requires states to reduce emissions that contribute to ozone and fine particle pollution in other states
  - U.S. Supreme Court upheld EPA’s approach to CSAPR on April 29, 2014
  - EPA filed to lift stay on CSAPR on June 26, 2014
  - Appears likely that the rule will be reinstated timely during the AEO2015 cycle
  - Previously incorporated in AEO2012 cycle prior to D.C. Circuit stay in August 2012
Changes to the legislative and regulation assumptions in the AEO2015 Reference case (3)

- EPA’s regional haze program is aimed at protecting national parks through implementation of Best Available Retrofit Technology (BART)
  - Requires states to lower NO\textsubscript{x} and SO\textsubscript{2} emissions over time through state implementation plans (SIPs) or federal implementation plans (FIPs)
  - Implementation to occur between 2014 and 2018
  - Same as AEO2014 – retrofits or retirements associated with finalized plans captured in reporting data (assuming generating unit data updates are completed)
Monitoring other legislative and regulatory actions not addressed in the AEO2014 Reference case

- EPA’s CO$_2$ New and Existing Source Performance Standards per section 111(b) and 111(d) of the Clean Air Act, respectively
- 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 tailoring rule for biomass carbon emissions
CAA 111(b) New Source Performance Standards

• Proposed rule
  – Imposes GHG controls on new generation units.
  – Limits for new coal plants were designed with the assumption that these plants will be built with CCS technologies, which will be capable of capturing a portion of the CO₂ emitted from the new unit.
  – EPA proposed two standards for natural gas-fired stationary combustion units, depending on size.
  – The proposed limits are based on the performance of modern natural gas combined cycle (NGCC) units.

• Current status
  – Expected to be finalized January, 2015

• EIA modeling approach
  – Rule will not be final during the AEO2015 cycle
  – Anticipated for inclusion in AEO2016
CAA 111(d) Existing Source GHG Controls

• Proposed rule
  – Cut power sector emissions 30% by 2030
  – Proposed rule calls for state-specific goals for reduced emissions, where each state can choose an approach appropriate to their situation
  – Proposed rule provides guidelines in the form of four building blocks that could be used to achieve the reductions, including heat-rate improvements, re-dispatch towards lower emitting resources (i.e. coal to natural gas), additions of low and zero-carbon resources, and increased use of demand side resources

• Current status
  – Expected to be finalized in June 2015

• EIA modeling approach
  – Rule not expected to be finalized until the AEO2016 cycle at the earliest
  – Evaluating approaches to modeling proposed rules
CWA 316(b): Cooling Water Intake Structures

• Rule
  – Sets impingement controls for all facilities with design intake flow of at least 2 million gallons per day (MGD), and requires examination of entrainment controls for facilities with design intake flow of at least 125 MGD
  – Final rule requires facilities having >125 MGD design intake flow to conduct studies to help permitting authorities determine what, if any, entrainment controls are needed

• Current status
  – Final rule signed on May 19, 2014; still in pre-publication; supporting technical documents not yet released

• EIA modeling approach
  – To be implemented in AEO2016 as technical documents necessary for determining retrofit costs for the final rule are not yet available
  – ‘Case-by-case’ nature of entrainment controls for the largest facilities difficult to model
  – Actively evaluating EIA data and 2011 EPA documents to determine whether impingement control costs can be estimated – costs expected to be small relative to other retrofit costs
Coal Combustion Residual Proposed Rule

• EPA is evaluating two regulatory options
  – Under the first proposal, residuals would be considered special wastes subject to regulation under subtitle C of RCRA when destined for disposal in landfills or surface impoundments, requiring measures intended to phase out the wet handling of residuals as well as existing surface impoundments
  – Under the second proposal, residuals would be regulated under subtitle D of RCRA as non-hazardous wastes, requiring liners at existing impoundments, and introduce an incentive to close these impoundments and transition to safer landfills which store coal ash in dry form

• Current status
  – Final Rule pending EPA review of supplemental data
  – Final Rule scheduled for December 19, 2014 under consent decree

• EIA modeling approach
  – Rule will not be final during the AEO2015 cycle
  – Anticipated for inclusion in AEO2016
Effluent Limitation Guidelines

• EPA is evaluating four regulatory options
  – Four options are being considered as part of the rulemaking, which would establish new or additional requirements for wastewater streams from the following processes and byproducts associated with steam electric power generation: flue gas desulfurization, fly ash, bottom ash, flue gas mercury control, and gasification of fuels such as coal and petroleum coke

• Current status
  – Proposed rule published on June 7, 2013
  – Final Rule scheduled for September 30, 2015 under consent decree

• EIA modeling approach
  – Rule will not be final during the AEO2015 cycle
  – May be included in the AEO2016 cycle if published with documentation timely
California Post-2020 GHG Emissions Target

• Executive Order
  – EO-S-3-05 (2005) requires California to reduce its emissions to 20% of 2020 levels by 2050
  – This executive order remains in effect and requires no legislative action

• Current status
  – There is considerable uncertainty about how California will achieve the targets of EO-S-3-05 (or if they are feasible)
  – Guidelines for meeting post-2020 targets are expected in 2017

• EIA modeling approach
  – Wait for additional policy certainty from the 2017 guidelines before attempting to model
Tailoring Rule for Biomass Carbon Emissions

• Proposed rule
  – EPA released proposed rules for carbon emission limits for new sources in 2011
  – At that time, they were not ready to propose how to handle emissions from biomass resources
    • Literature was conflicting on extent to which biomass carbon could be considered “net zero”, “net positive”, or even “net negative”
  – Subsequent court rulings said EPA couldn’t wait 3-years

• Current status
  – EPA’s proposed 3-year study period ends in July 2014
  – Indications are that the rule is close to ready for release

• EIA modeling approach
  – Could impact how EIA models biomass’ role in GHG policy cases
Review of AEO2014 Reference Case
Key results for the AEO2014 Reference case

• Coal is no longer the leading fuel for U.S. electricity generation in 2040. Coal’s share of total generation decreases over time to 32% in 2040 from 37% in 2012.

• Coal producers in the Interior region gain share while Appalachia loses share of total U.S. coal production. From 2012 to 2040, the Appalachian region's share of total coal production (on a Btu basis) falls from about 36% to 29%.

• Much of the 51 GW of coal-fired capacity retirements (33 GW planned) occur by 2016 largely because of the combination of MATS, relatively low natural gas prices, and relatively low electricity demand.
Key results for the AEO2014 Reference case

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

- A short-term recovery for coal occurs followed by a decline in consumption in 2015 and 2016 as MATS takes effect, resulting in a net gain of 26 million tons for coal in 2016 compared to 2012. After 2016, coal consumption rises, peaking in 2029 with a small decline thereafter.

- 2.6 GW of coal capacity additions (2.2 GW planned).

- Delivered coal prices increase gradually through 2040 at an average rate of 0.9% 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 to lower-carbon options, led by growth in natural gas and renewable generation.

Source: EIA, Annual Energy Outlook 2014
Electricity sales have decreased in 5 of the last 6 years; prior to 2008, sales declined only twice in 58 years.

Source: Energy Information Administration, Form EIA-923 and predecessor forms.
Growth in electricity use slows, but still increases by 28% from 2012 to 2040

U.S. electricity use
percent growth (3-year rolling average)

<table>
<thead>
<tr>
<th>Period</th>
<th>Annual Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950s</td>
<td>9.8</td>
</tr>
<tr>
<td>1960s</td>
<td>7.3</td>
</tr>
<tr>
<td>1970s</td>
<td>4.7</td>
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<tr>
<td>1980s</td>
<td>2.9</td>
</tr>
<tr>
<td>1990s</td>
<td>2.4</td>
</tr>
<tr>
<td>2000-2012</td>
<td>0.7</td>
</tr>
<tr>
<td>2013-2040</td>
<td>0.9</td>
</tr>
</tbody>
</table>

Source: AEO2014 Reference Case (April 2014)
Delivered prices of natural gas and coal to the electric power sector in the Reference case

Average delivered fuel prices to electric power plants, 2012 dollars per million Btu

Power generation fuel costs
2012 dollars per megawatthour

Shale gas leads U.S. production growth

U.S. dry natural gas production
trillion cubic feet

Source: AEO2014 Reference Case (April 2014)
Non-hydro renewable generation more than doubles between 2012 and 2040

renewable generation
billion kilowatthours per year

Source: EIA, Annual Energy Outlook 2014
Average capacity utilization of natural gas combined cycle and coal generating capacity, 2008-2040

Source: AEO2014 Reference Case (April 2014)
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;
Coal consumption by sector, 1970-2040

Note: Other includes coke plants, other industrial, and commercial/institutional.
Source: AEO2014 Reference Case (April 2014)
U.S. Coal Consumption, Short-Term Energy Outlook, July 2014


WORKING GROUP PRESENTATION FOR DISCUSSION PURPOSES. DO NOT QUOTE OR CITE AS AEO2015 MODELING ASSUMPTIONS AND INPUTS ARE SUBJECT TO CHANGE.
Average levelized electricity costs for new power plants, excluding subsidies, in the Reference case, 2020 and 2040

new power plant costs, 2012 cents per kilowatthour

Source: AEO2014 Reference Case (April 2014)
Gas-fueled units account for most projected capacity additions in the AEO2014 Reference case

U.S. electricity generation capacity additions (gigawatts)

Source: Form EIA-860 & EIA Annual Energy Outlook 2014
## Coal-fired capacity additions: recent completions and units under construction (megawatts)

<table>
<thead>
<tr>
<th>FACILITY CODE</th>
<th>PLANT NAME</th>
<th>GENERATOR ID</th>
<th>STATE</th>
<th>PLANT TYPE</th>
<th>ENERGY SOURCE</th>
<th>START YEAR</th>
<th>START MONTH</th>
<th>SUMMER CAPABILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>56611</td>
<td>Sandy Creek Energy Station</td>
<td>S01</td>
<td>TX</td>
<td>PC</td>
<td>SUB</td>
<td>2013</td>
<td>5</td>
<td>937</td>
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<tr>
<td>1004</td>
<td>Edwardsport</td>
<td>ST,CT1,CT2</td>
<td>IN</td>
<td>IGCC</td>
<td>BIT</td>
<td>2013</td>
<td>6</td>
<td>571</td>
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<tr>
<td>57037</td>
<td>Kemper County IGCC Project</td>
<td>1A,1B,1C</td>
<td>MS</td>
<td>IGCC</td>
<td>LIG</td>
<td>2014</td>
<td>8</td>
<td>522</td>
</tr>
<tr>
<td>56786</td>
<td>Spiritwood</td>
<td>1</td>
<td>ND</td>
<td>PC</td>
<td>LIG</td>
<td>2014</td>
<td>11</td>
<td>62</td>
</tr>
</tbody>
</table>

- Included as existing capacity for 2013 in AEO2015: 1,507
- Included as planned capacity additions in AEO2015: 584

**Source:** U.S. Energy Information Administration, Form EIA-860 “Annual Electric Generator Report”
### Coal-Fired Capacity Reported as Planned but Not Yet Under Construction on the Form EIA-860 (megawatts)

<table>
<thead>
<tr>
<th>FACILITY CODE</th>
<th>PLANT NAME</th>
<th>GENERATOR ID</th>
<th>STATE</th>
<th>PLANT TYPE</th>
<th>ENERGY SOURCE</th>
<th>START YEAR</th>
<th>START MONTH</th>
<th>SUMMER CAPABILITY</th>
</tr>
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<tbody>
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<td>56453</td>
<td>Robinson Power Company LLC</td>
<td>1</td>
<td>PA</td>
<td>PC</td>
<td>BIT</td>
<td>2016</td>
<td>4</td>
<td>132</td>
</tr>
<tr>
<td>56452</td>
<td>Medicine Bow Fuel &amp; Power LLC</td>
<td>1</td>
<td>WY</td>
<td>CTL</td>
<td>BIT</td>
<td>2016</td>
<td>12</td>
<td>350</td>
</tr>
<tr>
<td>55360</td>
<td>Two Elk Generating Station</td>
<td>GEN1</td>
<td>WY</td>
<td>PC</td>
<td>WC</td>
<td>2016</td>
<td>12</td>
<td>275</td>
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<td>56675</td>
<td>Plant Washington</td>
<td>MAIN</td>
<td>GA</td>
<td>PC</td>
<td>SUB</td>
<td>2018</td>
<td>4</td>
<td>850</td>
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<tr>
<td>56454</td>
<td>Taylorville Energy Center</td>
<td>1</td>
<td>IL</td>
<td>IGCC</td>
<td>BIT</td>
<td>2018</td>
<td>6</td>
<td>533</td>
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<tr>
<td></td>
<td><strong>Total Capacity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>2,140</strong></td>
</tr>
</tbody>
</table>

**Note:** Because these units are reported as not yet under construction on the Form EIA-860, these units are not included as planned capacity additions in the AEO2015.

**Source:** U.S. Energy Information Administration, Form EIA-860 “Annual Electric Generator Report”
Coal accounts for more than half of the projected capacity retirements in the AEO2014 Reference case

U.S. electricity generation capacity retirements
gigawatts

Cumulative Totals: 2013-2040

- Renewables/Other: 0.9
- Nuclear: 4.8
- Petroleum: 30.9
- Natural Gas: 9.4
- Coal: 50.8

Source: Form EIA-860 and AEO2014 Reference Case (April 2014)
Electric net summer generating capacity retirements by fuel, 1982-2040


WORKING GROUP PRESENTATION FOR DISCUSSION PURPOSES. DO NOT QUOTE OR CITE AS AEO2015 MODELING ASSUMPTIONS AND INPUTS ARE SUBJECT TO CHANGE.
Reported Net Summer Coal Capacity Retirements By Year
gigawatts

Total Reported Coal Capacity Retirements

AEO2014: 33 GW
AEO2015: 28 GW*

*Reported capacity retirements for the AEO2015 are preliminary and subject to change.

## Electric Net Summer Generating Capacity by Fuel, 2008-2040 (gigawatts)

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<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Coal</td>
<td>311</td>
<td>316</td>
<td>310</td>
<td>290</td>
<td>266</td>
<td>263</td>
<td>262</td>
<td>262</td>
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<tr>
<td>Electric Power Sector</td>
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<td>313</td>
<td>307</td>
<td>286</td>
<td>263</td>
<td>259</td>
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<td>258</td>
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<tr>
<td>End-Use Sectors</td>
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<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; Oil: CC/CT</td>
<td>320</td>
<td>343</td>
<td>352</td>
<td>364</td>
<td>373</td>
<td>381</td>
<td>470</td>
<td>566</td>
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<tr>
<td>Other Natural Gas &amp; Oil</td>
<td>130</td>
<td>120</td>
<td>118</td>
<td>113</td>
<td>113</td>
<td>108</td>
<td>105</td>
<td>118</td>
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<tr>
<td>Nuclear Power</td>
<td>101</td>
<td>101</td>
<td>102</td>
<td>99</td>
<td>100</td>
<td>98</td>
<td>98</td>
<td>102</td>
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<tr>
<td>Renewable Sources</td>
<td>117</td>
<td>143</td>
<td>159</td>
<td>189</td>
<td>192</td>
<td>195</td>
<td>208</td>
<td>242</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>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1004</strong></td>
<td><strong>1049</strong></td>
<td><strong>1066</strong></td>
<td><strong>1081</strong></td>
<td><strong>1070</strong></td>
<td><strong>1069</strong></td>
<td><strong>1168</strong></td>
<td><strong>1316</strong></td>
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</tbody>
</table>

**Source:** AEO2014 Reference Case (April 2014)

*MATS compliance assumed to begin  **Excludes natural gas and oil CC/CT generating capacity in the end-use sectors
Cumulative SO2 scrubber and DSI retrofits, 2013-2040

Source: AEO2014 Reference Case (April 2014)
*MATS compliance assumed to begin; **DSI: Dry Sorbent Injection
Electricity Sector Net Summer Generating Capacity by SO₂ Control Type and Region, 2012 and 2020 in AEO2014

Source: AEO2014 Reference Case (April 2014)

Note: Scrubbed capacity includes capacity equipped with flue gas desulfurization (FGD) equipment and coal plants employing integrated gasification combined (IGCC) cycle or circulating fluidized bed (CFB) combustion technologies.

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Coal demand regions

Source: U.S. Energy Information Administration, Office of Energy Analysis
Net summer coal-fired generating capacity in the electric power sector by coal demand region, 2012 and 2040

Source: AEO2014 Reference Case (April 2014)
Cumulative net summer coal-fired capacity retirements by coal demand region, 2013-2040

gigawatts

Source: AEO2014 Reference Case (April 2014)
U.S. Coal Production, Short-Term Energy Outlook, July 2014

Coal production by region, 1970-2040

Source: AEO2014 Reference Case (April 2014)
Average annual growth in coal mining labor productivity for selected supply regions (percent)

-1.3%
-1.7%*
-2.5%
-1.3%
-3.4%
+0.1%

2012 Production Share
- 3% to 5%
- 12% to 15%
- 38%

U.S. Total: -1.2%

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

Source: 2012 Production Shares : Mine Safety and Health Administration, Form 7000-2, “Quarterly Mine and Employment and Coal Production Report;”
Coal production, AEO2014 in 2040 (vs. 2012) (million short tons)

<table>
<thead>
<tr>
<th>Region</th>
<th>2012 Production</th>
<th>2040 Projection</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S. Total</td>
<td>1,121 (1,016)</td>
<td></td>
</tr>
<tr>
<td>Wyoming's Powder River Basin</td>
<td>5 (2)**</td>
<td></td>
</tr>
<tr>
<td>422 (388)*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 (13)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>26 (46)</td>
<td></td>
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<tr>
<td>35 (30)</td>
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<td>60 (36)</td>
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<td>31 (28)</td>
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<tr>
<td>1 (2)</td>
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<tr>
<td>228 (130)</td>
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<tr>
<td>151 (126)</td>
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<tr>
<td>80 (148)</td>
<td></td>
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<td>17 (19)</td>
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<tr>
<td>61 (48)</td>
<td></td>
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</tr>
</tbody>
</table>

* Includes production from all mines in Wyoming’s Powder River Basin.
** Includes production from mines in both Alaska and Washington.

Average annual growth in coal mining labor productivity for selected supply regions (percent)

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Northern Appalachia</td>
<td>5.4</td>
<td>5.5</td>
<td>-2.7</td>
<td>-3.8</td>
<td>-4.9</td>
<td>-1.3</td>
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<td>Central Appalachia</td>
<td>7.3</td>
<td>4.4</td>
<td>-5.9</td>
<td>-5.9</td>
<td>-3.8</td>
<td>-3.4</td>
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<td>Eastern Interior</td>
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<td>-0.1</td>
<td>6.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Gulf Lignite</td>
<td>2.6</td>
<td>2.4</td>
<td>-2.8</td>
<td>-4.5</td>
<td>-4.2</td>
<td>-1.0</td>
</tr>
<tr>
<td>Dakota Lignite</td>
<td>6.0</td>
<td>1.0</td>
<td>-3.5</td>
<td>-5.2</td>
<td>-4.8</td>
<td>-1.0</td>
</tr>
<tr>
<td>Western Montana</td>
<td>4.6</td>
<td>2.0</td>
<td>-3.7</td>
<td>-6.6</td>
<td>-11.7</td>
<td>-1.3</td>
</tr>
<tr>
<td>WY, Northern Powder River Basin</td>
<td>7.5</td>
<td>3.2</td>
<td>-3.2</td>
<td>-5.0</td>
<td>-5.7</td>
<td>-1.7</td>
</tr>
<tr>
<td>WY, Southern Powder River Basin</td>
<td>7.2</td>
<td>4.9</td>
<td>-3.0</td>
<td>-4.1</td>
<td>-6.4</td>
<td>-1.7</td>
</tr>
<tr>
<td>Rocky Mountain</td>
<td>7.8</td>
<td>5.5</td>
<td>-2.7</td>
<td>-4.4</td>
<td>3.5</td>
<td>-2.5</td>
</tr>
<tr>
<td>U.S. Average</td>
<td>7.1</td>
<td>6.2</td>
<td>-2.4</td>
<td>-2.9</td>
<td>-0.2</td>
<td>-1.2</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;”
Appalachian coal production, 1970-2040

Source: AEO2014 Reference Case (April 2014)

Except for Appalachian total, data for 1978-1985 exclude production from small (<10,000 short tons) coal mines.
Interior coal production, 1970-2040

Source: AEO2014 Reference Case (April 2014)

Except for Interior total, data for 1978-1985 exclude production from small (<10,000 short tons) coal mines

Short Term Energy Outlook
July 2014

WORKING GROUP PRESENTATION FOR DISCUSSION PURPOSES.
DO NOT QUOTE OR CITE AS AEO2015 MODELING ASSUMPTIONS AND INPUTS ARE SUBJECT TO CHANGE.
Western coal production, 1970-2040

Source: AEO2014 Reference Case (April 2014)

Except for Western total, data for 1978-1985 exclude production from small (<10,000 short tons) coal mines.
Average minemouth coal prices by region, 1980-2040

2012 dollars per short ton

History 2012 Projections


Appalachia
U.S. Average
Interior
West

Source: AEO2014 Reference Case (April 2014)
U.S. Coal Exports, Short-Term Energy Outlook, July 2014

million short tons (MMst)  annual change (MMst)

Monthly record for exports (13.6 MMst)

Annual change (MMst) from 2012 to 2015:
- 2012: 0.4
- 2013: -4.2
- 2014: -5.1
- 2015: -8.5

Total Exports (MMST)
- 2012: 125.7
- 2013: 117.7
- 2014: 98.7
- 2015: 94.8

U.S. Coal Exports, 1995-2040

Coal exports by major supply region, 2010-2040

Current Major North American Coal Export Terminals with annual capacity and 2013 export volumes (million short tons)

<table>
<thead>
<tr>
<th>Port</th>
<th>Capacity</th>
<th>2013 Exports</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baltimore</td>
<td>23</td>
<td>15.1</td>
</tr>
<tr>
<td>Norfolk</td>
<td>79</td>
<td>49.7</td>
</tr>
<tr>
<td>Mobile</td>
<td>18</td>
<td>12.6</td>
</tr>
<tr>
<td>New Orleans</td>
<td>63</td>
<td>19.8</td>
</tr>
<tr>
<td>Houston</td>
<td>16</td>
<td>3.3</td>
</tr>
<tr>
<td>Vancouver</td>
<td>54</td>
<td>42.1</td>
</tr>
<tr>
<td>Ridley</td>
<td>13</td>
<td>13.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>266</strong></td>
<td><strong>155.6</strong></td>
</tr>
</tbody>
</table>

Other North American Coal Export Terminals & Proposed Capacity Expansions (million short tons)

<table>
<thead>
<tr>
<th>Port</th>
<th>Capacity</th>
<th>Capacity Expansion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baltimore</td>
<td>23</td>
<td>0</td>
</tr>
<tr>
<td>Norfolk</td>
<td>79</td>
<td>0</td>
</tr>
<tr>
<td>Charleston</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Mobile</td>
<td>18</td>
<td>9</td>
</tr>
<tr>
<td>New Orleans</td>
<td>63</td>
<td>36</td>
</tr>
<tr>
<td>Houston</td>
<td>16</td>
<td>18</td>
</tr>
<tr>
<td>Corpus Christi</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Altamira</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Lazaro Cardenas</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>Guyamas</td>
<td>7</td>
<td>26</td>
</tr>
<tr>
<td>Los Angeles</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>San Francisco</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Oregon</td>
<td>0</td>
<td>52</td>
</tr>
<tr>
<td>Washington</td>
<td>0</td>
<td>48</td>
</tr>
<tr>
<td>Vancouver</td>
<td>54</td>
<td>11</td>
</tr>
<tr>
<td>Ridley</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>291</td>
<td>225</td>
</tr>
</tbody>
</table>

Source: Port Capacities: Wood Mackenzie; Capacity Expansion: Wood Mackenzie, Ridley Terminal website, Ambre Energy website, Gateway Pacific Terminal website, Port of Vancouver website, SNL Energy.
EIA Data Browsers and Energy Mapping System

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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Short-Term Energy Outlook | www.eia.gov/steo
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Assessing Uncertainty: Accelerated Coal and Nuclear Retirement Side Cases
Accelerated power plant retirements and nuclear side case assumptions

• Accelerated Coal Retirements case
  – Starts from AEO2014 High Coal Cost case, with coal prices 68% above Reference case in 2040
  – Annual O&M increase of 3% in real terms from 2012 to 2040, compared to no increase in the Reference case

• Accelerated Nuclear Retirements case
  – No subsequent license renewals for nuclear units past 60 years compared to the Reference case assumption that license renewals allow units to operate beyond 60 years
  – Annual O&M increase of 3% in real terms from 2012 to 2040, compared to no increase in the Reference case

• Accelerated Coal and Nuclear Retirements case
  – Combines assumptions from the previous two cases
Rising costs for coal lead to 60 GW of additional retirements in the Accelerated Coal Retirement case, while 37 GW of additional nuclear capacity would occur between 2030 and 2040 if licenses are not extended beyond 60 years.

cumulative capacity additions

gigawatts

<table>
<thead>
<tr>
<th></th>
<th>Reference</th>
<th>Accelerated Nuclear Retirements</th>
<th>Accelerated Coal Retirements</th>
<th>Accelerated Coal and Nuclear Retirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>30</td>
<td>120</td>
<td>160</td>
<td>200</td>
</tr>
<tr>
<td>Nuclear</td>
<td>100</td>
<td>80</td>
<td>120</td>
<td>160</td>
</tr>
<tr>
<td>Renewables</td>
<td>20</td>
<td>40</td>
<td>60</td>
<td>80</td>
</tr>
<tr>
<td>Natural gas &amp; Oil: Other</td>
<td>50</td>
<td>30</td>
<td>50</td>
<td>70</td>
</tr>
<tr>
<td>Natural gas &amp; Oil: CC and CT*</td>
<td>70</td>
<td>50</td>
<td>90</td>
<td>110</td>
</tr>
</tbody>
</table>

*Excludes retirements of natural gas and oil CC/CT capacity in the end-use sectors


WORKING GROUP PRESENTATION FOR DISCUSSION PURPOSES. DO NOT QUOTE OR CITE AS AEO2015 MODELING ASSUMPTIONS AND INPUTS ARE SUBJECT TO CHANGE.
Natural gas and renewables capacity additions are expected to fill the void left by accelerated coal and nuclear retirements through 2040.

Cumulative capacity additions (gigawatts):

- **Reference Case**
- **Accelerated Coal Retirements**
- **Accelerated Coal and Nuclear Retirements**

Natural gas and renewables generation share increases through 2040 in accelerated retirement cases but overall electricity demand decreases slightly due to higher natural gas prices.
Assessing Uncertainty: CO₂ Policy Side Cases
CO₂ policy side case assumptions

• Greenhouse Gas $10 case (GHG 10)
  – CO₂ fee of $10 per metric ton starting in 2015
  – Increasing by 5% in real terms to $34 per metric ton CO₂ by 2040
  – Results in an approximately 35% reduction in CO₂ emissions compared to the Reference case

• Greenhouse Gas $25 case (GHG 25)
  – CO₂ fee of $25 per metric ton starting in 2015
  – Increasing by 5% in real terms to $85 per metric ton CO₂ by 2040
  – Results in an approximately 80% reduction in CO₂ emissions compared to the Reference case
Average levelized electricity costs for new power plants, excluding subsidies, in the Reference case, 2020 and 2040

new power plant costs, 2012 cents per kilowatthour

Source: AEO2014 Reference Case (April 2014)
Average levelized electricity costs for new power plants, excluding subsidies, in the GHG 25 case, 2020 and 2040

new power plant costs, 2012 cents per kilowatthour

*Fuel cost includes CO₂ fee.

Generating capacity additions and retirements in reference and carbon dioxide allowance fee side cases (cumulative through 2040)

Changing electricity generation mix in Reference case and carbon dioxide fee allowance side cases

U.S. electricity net generation

2014 Reference Case

$10 CO2 Allowance Fee Case

$25 CO2 Allowance Fee Case


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Carbon dioxide emissions from the electric power sector in the GHG cases compared to the Reference case

![Graph showing carbon dioxide emissions in million metric tons from 1990 to 2040. The graph includes projections for different CO2 allowance fees ($10 and $25) and a reference case. The data source is EIA, Annual Energy Outlook 2014.](image-url)
Assessing Uncertainty: Other Side Cases
## Key differences between alternate cases

<table>
<thead>
<tr>
<th></th>
<th>AEO2014 Reference</th>
<th>Low Economic Growth</th>
<th>High Economic Growth</th>
<th>Low Coal Cost</th>
<th>High Coal Cost</th>
<th>High Oil and Gas Resource</th>
<th>Low Oil and Gas Resource</th>
<th>GHG10 (CO2 fee of $10 in 2015 increasing to $34 in 2040)</th>
<th>GHG25 (CO2 fee of $25 in 2015 increasing to $85 in 2040)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP growth (avg. annual change from 2012)</td>
<td>2.4%</td>
<td>1.9%</td>
<td>2.8%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electricity demand (avg. annual change from 2012)</td>
<td>0.9%</td>
<td>0.6%</td>
<td>1.2%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delivered natural gas price to the electricity sector, 2040 (2012 dollars per million Btu)</td>
<td>$8.16</td>
<td>$5.17</td>
<td>$10.82</td>
<td>$9.57*</td>
<td>$12.38*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delivered coal price to the electricity sector, 2040 (2012 dollars per million Btu)</td>
<td>$3.19</td>
<td>$1.89</td>
<td>$5.36</td>
<td></td>
<td>$6.08*</td>
<td></td>
<td>$10.27*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minemouth coal price, 2040 (2012 dollars per short ton)</td>
<td>$59.16</td>
<td>$32.29</td>
<td>$113.47</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Western coal transportation rates (percent change from 2012, constant dollar basis)</td>
<td>-0.4%</td>
<td>-25%</td>
<td>25%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coal mining productivity (avg. annual change from 2012)</td>
<td>-1.2%</td>
<td>1.0%</td>
<td>-4.0%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coal with CCS in power sector, 2040 (gigawatts)</td>
<td>0.9</td>
<td></td>
<td></td>
<td>8.5</td>
<td>3.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NGCC with CCS in power sector, 2040 (gigawatts)</td>
<td>0.3</td>
<td></td>
<td></td>
<td>13.2</td>
<td>67.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Includes CO₂ fee
U.S. Coal Production, 2020 and 2040

Coal production by region, 2040

Million short tons


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2040 electricity generation shares


WORKING GROUP PRESENTATION FOR DISCUSSION PURPOSES. DO NOT QUOTE OR CITE AS AEO2015 MODELING ASSUMPTIONS AND INPUTS ARE SUBJECT TO CHANGE.
Cumulative coal-fired capacity retirements, 2012-2040

Cumulative coal-fired capacity additions, 2012-2040

gigawatts

Reference, Low Economic Growth, High Economic Growth, Low Coal Cost, High Coal Cost, High Oil and Gas Resource, Low Oil and Gas Resource, No GHG Concern, GHG 10, GHG 25