Coal Mining - US

US production to continue sharp, secular decline absent carbon capture development

» US coal production will continue a steady, secular decline without policy support for, and continued investment in, carbon capture and storage (CCS) technology. CCS is a technology that can capture up to 90% of the carbon dioxide (CO2) emissions produced from burning fossil fuels to generate electricity or industrial heat. We believe any positive effect CCS development could have on the US coal industry is many years away. It would also require significant policy support and a substantial ramp-up in investment.

» If coal were to become more cost-competitive vis-a-vis other fuels such as natural gas, environmental concerns would likely still keep the industry in decline, unless CCS technology were widely adopted. Although we do not expect economics to change in coal’s favor in the near-term, its competitive position may be helped in the long run by, for example, growth in liquefied natural gas (LNG) exports.

» A number of entities, including the International Energy Agency (IEA) are calling carbon capture technology essential to curbing global warming, because some coal-fired electricity generation will remain in the global fuel mix if all of the world’s population is to enjoy access to electricity and modern lifestyle.

» Thanks to several CCS projects already in operation, many technological barriers to its continued deployment have been lifted. Its continued development could be a game-changer for US coal producers in the long run, in that it could curb the slide of coal consumption at home.

» However, the necessary investment has been lagging, because of local cost economics as well as political and regulatory factors. Most CCS projects currently in operation or under development are in Canada and the US. This is partially due to using captured CO2 to enhance oil recovery, which offers an additional revenue stream in these areas. Nevertheless, the developed nations are focusing their decarbonization efforts on shifting the fuel mix away from coal, primarily due to abundant availability of cost-competitive (and often subsidized) alternative fuels.
Clean-coal technologies are essential to ensuring environmental sustainability in Asia. This is where developing economies are poised to drive a steady growth in global coal consumption over the next two decades. However, due to the lack of opportunities to use captured CO2 in oil fields, CCS development has not gained momentum in the region. Implementing CCS in these areas would require the development of carbon transport and storage infrastructure. This is a complex and costly undertaking that would likely require cooperation among governments, substantial funding, and a system to manage related long-term environmental liabilities.

**US coal will remain in sharp secular decline unless CCS technology alters the dynamics**

Coal consumption by US power generators has steadily declined, with coal’s share of the nation’s fuel mix falling from roughly 45% in 2010 to 30% in 2017 (see Exhibit 1). The rapid contraction was brought on by cheap natural gas, advancements in renewable technology, regulatory uncertainty and consumer demand for green energy. Absent disruptive changes in available technology, policy and prices, we expect this trend to continue, with coal’s share of US energy generation likely dropping to 20%-25% within a decade. At the same time, international thermal coal markets seem unlikely to bring material long-term relief to US producers, which are higher on the global cost curve and geographically removed from the growing coal-consuming regions in Asia.³

![Exhibit 1](image)

**US coal consumption is in secular decline**

While the long-term trend is not promising for US coal miners, the beleaguered industry may find a ray of hope in an unlikely place — the global climate-change movement, where a number of voices are calling CCS technology essential to curbing global warming.

**Carbon capture looms large for Paris Agreement goals**

Worldwide concerns about the risks from climate change led to the December 2015 signing of the Paris Agreement, which reflects a near-universal commitment to the goal of limiting global temperature increase, relative to pre-industrial levels, to 2 degrees Celsius by the end of the century. CCS can capture up to 90% of the carbon-dioxide emissions produced from the combustion of fossil fuels, preventing the CO2 from being released into the atmosphere, and could be an important part of keeping global temperatures under control.
Despite the fact that government policies continue to support renewable electricity worldwide, the projected decline in carbon emissions over the next several decades is “far from enough to avoid severe impacts of climate change,” if only the existing policy commitments are enforced, according to the International Energy Agency. The IEA considers development of CCS essential to its Sustainable Development Scenario, which contemplates the changes in the energy landscape that would ensure universal access to modern energy by 2030, as well as achieve a dramatic reduction in greenhouse gas emissions aligned with the two degree limit goal (see Exhibit 2). The world faces “an unprecedented challenge” to achieve the objectives, the IEA said in its report, *Five keys to unlock CCS investment.* “Without CCS, this challenge becomes infinitely greater.”

Exhibit 2

<table>
<thead>
<tr>
<th>Year</th>
<th>New Policies Scenario</th>
<th>Sustainable Development Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>20%</td>
<td>16%</td>
</tr>
<tr>
<td>2020</td>
<td>28%</td>
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</tr>
<tr>
<td>2030</td>
<td>36%</td>
<td>36%</td>
</tr>
<tr>
<td>2040</td>
<td>44%</td>
<td>44%</td>
</tr>
</tbody>
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The Intergovernmental Panel on Climate Change's Fifth Assessment similarly concluded that achieving the Paris Agreement objectives will be 138% more expensive and may very well be impossible without the deployment of CCS technology. Likewise, a 2014 overview of the Stanford Energy Modeling Forum Study stated technology is "a key element for reaching climate targets" and that "versatile technologies such as CCS and bioenergy have the largest value" in achieving them, in part due to their combined ability to achieve negative emissions by co-firing biomass in CCS-equipped plants.

To achieve the IEA’s Sustainable Development Scenario, 60% of coal-based electricity generation would have to come from plants equipped with CCS. We note however, that this assumes that only 6% of global electricity generation will be derived from coal by 2040, versus its 37% share in 2016. We believe such a drastic reduction in global coal consumption is unlikely and would be very difficult to achieve, given that more than a third of the global power fleet is less than 10 years old. These existing plants, along with planned new capacity in Asia (discussed below), represent a significant investment unlikely to be abandoned.

**Carbon capture is now real, but further development is needed**

Despite repeated indications that CCS is essential to reaching the Paris Agreement goals, progress in development and commercial application of coal-based CCS technologies has been slow. According to the IEA, global investment in low-carbon energy, including energy-efficiency and renewable-energy technologies, reached $850 billion in 2016, but only $1.2 billion was invested in carbon capture and storage technology during that period. Moreover, the CCS project pipeline has declined over the past several years (see Exhibit 3).
That said, the major barrier to deployment is no longer technological, but political and commercial, as there are currently 21 large scale CCS projects operating or under construction throughout the world and across industries.\(^9\) The Petra Nova project in Texas, completed in 2016, is one of the largest CCS-equipped power plants to have become operational (see Appendix). The vast majority of CCS projects are located in Canada and the US, and are incentivized by availability of additional revenue from using the captured CO2 in enhanced oil recovery, such as with Petra Nova.

The opportunities to use captured carbon for oil production are limited, however, by region and geology. Where this option is not available, carbon would have to be transported and stored, which means the need for investment in transport and storage networks that could service multiple plants, not to mention extensive international cooperation and legal systems to ensure adequate management of carbon storage reserves and to address long-term liabilities. According to the IEA, the theoretical global storage resources are more than adequate to accommodate future requirements. However, further work is needed to assess this capacity and develop globally standardized classifications of potential reserves. In some areas, the infrastructure will be shared across countries and industries.

In addition, potential long-term liabilities remain an important concern with carbon storage, along with maturation of technology and legal structures. Carbon storage could last thousands of years, and someone (presumably governments) would have to be responsible for monitoring the gas and ensuring continued safety, since CO2 leakage from geological storage sites in large amounts could be fatal.

In light of these complexities, “for every CCS project that has successfully reached a final investment decision, at least two large-scale projects have been canceled,” according to the IEA. This is due to factors such as lack of policy support and inability to resolve risks that cannot be managed by commercial entities — such as long-term liability or cross-chain default risks. So far CCS development was predominantly privately funded — however the nature of the technology is such that its widespread development requires substantial government support.

**Policy makers in China, US, Europe focused on shifting the fuel mix away from coal**

CCS investment has not received the government support it needs to gain momentum in part because policy makers in the US, Europe, and China pursued decarbonization by shifting towards other fuels such as natural gas (which emits about half the CO2 coal does) and renewables.

In the US, investment in renewable technologies was incentivized by state-level mandates and federal tax subsidies for wind and solar generation.\(^{10}\) While some of these technologies are now cost-competitive, even on a non-subsidized basis, the tax impact can be significant (see Exhibit 4).
Renewable energy has received substantial tax incentives in the US

Average estimated levelized cost of electricity (LCOE) for new generation resources entering service in 2022, net of tax credits
The effect of tax credits, bringing the total to LCOE without tax incentives

Source: US Energy Information Administration

Meanwhile, the UK and Italy have committed to eliminate coal for electricity generation by 2025, and several countries in Europe have incentivized use of renewables, while running full-day periods without relying on coal-fired generation. 11

According to the IEA, China will remain the world’s largest coal consumer over the next two decades, but is projected to slowly shift toward gas, nuclear, and renewables. Close to 100 GW of new renewable generation is under development in the country, outpacing the increase in coal generation of less than 60GW through 2020. 12

Global coal consumption continues to grow as new coal capacity is built throughout Asia

Despite the ongoing investment in renewables, however, global coal consumption will continue to grow under the existing policy commitments (the IEA’s “New Policies Scenario”). According to the IEA, India and Southeast Asia will become the engine of growth for coal demand in the coming years, offsetting the declining consumption in OECD countries and China (see Exhibit 5).

Global coal consumption is projected to grow, with India and Southeast Asia responsible for the growing proportion

There is a significant new coal-powered generating capacity coming online globally in the coming years, to accommodate growing economies and continued urbanization (see Exhibit 6).

Coal is often the fuel of choice to meet developing nations’ growing energy needs because it is abundant, inexpensive, secure and easy to store. At a September 2017 meeting, energy ministers of countries in the Association of Southeast Asian Nations (ASEAN), said they discussed the outlook for rising coal use in the region through 2040 and reaffirmed the need for increased promotion of clean coal technologies.

So far, however, the countries that need it most have not pursued CCS. According to the IEA, large-scale CCS experience is today limited to the US, Canada, China, Australia, Norway, Algeria, Brazil, Saudi Arabia, and the United Arab Emirates. Lower construction and operational costs in emerging economies can make CCS investment more attractive relative to other regions. However, many Asian countries do not have opportunities to use carbon in oil recovery — and legal and technological complexities associated with storage will likely continue to hold them back.

**US market dynamics are not in coal's favor now, but this could change if policies supported CCS**

Even without tax credits, and without CCS, building a new coal plant in the US today would be generally more costly relative to combined cycle natural gas, solar PV, and onshore-wind generation (see Exhibit 7). We also note that the cost estimates for a new CCS-equipped coal-fired plant on average are 25% higher than a conventional coal-fired plant, based on the current technology.

Costs vary widely, however, depending on region. If CCS were to be deployed in a more cost-effective manner, coal plants could become attractive investments in some areas from the economic, as well as environmental, perspective. According to the IEA, there is rich potential for cost efficiencies in further CCS development, with the first-of-a-kind CCS projects already identifying future cost reductions close to 30%.

Source: Australian Government, Department of Industry, Innovation and Science

Exhibit 6

**Number of advanced technology coal fired power stations planned or under construction**

[Map showing number of power stations]
CCS cost efficiencies and tax subsidies are needed to make clean coal plants cost-competitive with other fuels

**LCOE** is represented for new generation resources entering service in 2022 (with no effect given to tax credits). Conventional coal LCOE is presented for coal plants entering service in 2018.

Source: US Energy Information Administration

At the moment, no new coal plants are being built in the US, partially due to the uncertainty surrounding the Clean Power Plan (CPP), issued by the Environmental Protection Agency (EPA) in August 2015. The Clean Power Plan essentially prohibited the building of new coal-fired power plants, unless they were equipped with CCS technology. Although EPA proposed to repeal the CPP in October, public hearings with respect to this move are ongoing and the future of the regulation is uncertain.

Coal is an abundant resource that plays an important role in grid reliability and fuel diversity, and these factors could move to the forefront of policy considerations, particularly if the environmental footprint was less of a concern. The recent study on grid reliability by the US Department of Energy noted baseload power generation, critical for grid stability, is generally provided by nuclear, coal, or natural gas steam generators. The DOE called for further study and reform to address services essential to grid reliability and resilience. For example, it highlighted that the increasing use of variable renewable energy (VRE) sources such as wind and solar could make grid resource management more complex.  

Such reliability considerations, along with deep decarbonization requirements, could support CCS development over time. Policy support and continued investment in CCS could be a game-changer for US coal miners, particularly if there was a material change in price dynamics between coal and natural gas. Although we don’t expect economics to change in coal’s favor in the near-term, its competitive position could be changed in the long run, for example, by growth in liquefied natural gas (LNG) exports which could increase the price of natural gas. It’s worthwhile noting, for example, that IEA expects the US to become the leading LNG exporter by mid-2020s.
CCS SPOTLIGHT:  
PETRA NOVA - WA PARISH GENERATING STATION

BACKGROUND
Petra Nova is a 50/50 joint venture between NRG and JX Nippon Oil & Gas Exploration. It runs a commercial-scale post-combustion carbon capture facility at NRG’s WA Parish generating station southwest of Houston, Texas. The project is to receive up to $190 million as part of the Clean Coal Power Initiative Program (CCPI) by the United States Department of Energy.

The 240 MW carbon capture facility is installed on an existing coal-fired power plant and captures more than 90 percent of the carbon generated.

The Petra Nova Project uses a proven carbon capture process whereby a high-performance solvent facilitates CO2 absorption and desorption. The captured carbon will be used to enhance recovery at the West Ranch oil field operated by Hilcorp Energy Company.

HOW CARBON CAPTURE WORKS
source: www.nrg.com
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The CO2 Capture Process
The proprietary KM-CDR Process®, jointly developed by Mitsubishi Heavy Industries, Ltd. and the Kansai Electric Power Co., Inc., will capture approximately 1.6 million tons of CO2 each year from the existing 610MW coal-fired Unit 8.

Beneficial use of the captured CO2
The captured CO2 will be transported via an 81-mile pipeline to the West Ranch Oil Field in Jackson County, Texas, where it will be used in an enhanced oil recovery process to produce an estimated 60 million barrels of oil.
Moody's related publications

**Outlook**

» Coal - North America: Restructured Coal Industry Buoyed by Price Relief but Faces Secular Headwinds, June 2017

**Sector In-Depth**

» Renewable Energy - Global: Falling cost of renewables reduces risks to Paris Agreement compliance, September 2017

» Project Finance - PFI/PPP: Coal terminals benefitting from favorable coal prices, but face longer term challenges, November 2017

**Issuer In-Depth**

» Enviva LP: FAQ on Biomass' Place Among Renewables, Growth Potential, Shifting Climate Ground, September 2017

**Sector Comment**

» Coal Industry - North America: Energy Department Study on Grid Reliability Will Not Save Coal, August 2017
Endnotes

1 See our 29 June 2017 report *Restructured Coal Industry Buoyed by Price Relief but Faces Secular Headwinds*


3 *Five keys to unlock CCS investment, IEA 2017*


5 *The role of technology for achieving climate policy objectives: overview of the EMF 27 study on global technology and climate policy strategies*, January 2014, Kriegler, Weyant, Blanford, Krey and others; published in Springer Science and Business Media. This article provides an overview of EMF 27 study, a comparison of eighteen different energy-economy models to investigate the relative importance of different climate mitigation options.

6 For further discussion of the role of biomass in climate objectives, see our September 27, 2017 Issuer-in-Depth on Enviva Partners L.P. - FAQ on Biomass’ Place Among Renewables, Growth Potential, Shifting Climate Ground


8 *Five keys to unlock CCS investment, IEA 2017*

9 *Five keys to unlock CCS investment, IEA 2017*

10 See our 6 September 2017 report *Falling cost of renewables reduces risks to Paris Agreement compliance*

11 See our 27 September 2017 Issuer-in-Depth on Enviva L.P., FAQ on Biomass’ Place Among Renewables, Growth Potential, Shifting Climate Ground

12 See our 28 November 2017 Sector-in-Depth *Coal terminals benefitting from favourable coal prices, but face longer term challenges*

13 *Five keys to unlock CCS investment, IEA 2017*

14 See our 29 August 2017 report *Energy Department Study on Grid Reliability Will Not Save Coal*
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