Advanced Energy

21st Century Coal: An Essential Role in Our Energy Future

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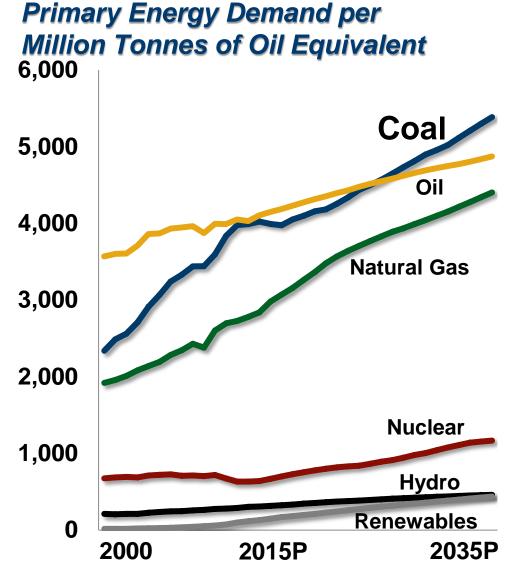
Key Themes

- Coal is the world's fastest-growing fuel and will continue to be vital to our energy future
- A technology path is the solution to achieve the world's ambitious environmental goals
- U.S., China and other nations must accelerate advancement of clean coal technologies



Coal Expected to Overtake Oil as Largest Energy Source by 2025





- Coal is the world's fastest growing major fuel this century
- Coal fuels ~ 40% of U.S. and global electricity
- Coal is highly reliable and the least expensive form of electricity generation to meet rising demand

Source: Wood Mackenzie; BP Statistical Review of World Energy 2015.

China Leads the World in Build Out of Super and Ultra-Supercritical Coal Plants



Advanced Coal With Controls Drives Major Emission Reductions

391 700+ GW of Advanced High-efficiency plants **Coal Generation** achieve a 25% lower **Online or Under** Gigawatts **CO**₂ profile than the Construction oldest U.S. plants 94 68 62 33 28 16 thing U.S. India Japan Korea many ussia ROW

Supercritical and ultrasupercritical plants in operation and under construction through 2016. Source: Platts World Electric Power Plant Database, March 2015.

China Achieving Air Quality Measures in 4-6 Years That Took U.S. Several Decades



Can-Do Approach Leads to 55% of World's High-Efficiency Coal Fleet

- Coal provides approximately 70 percent of China's power
- China credits coal with lifting 650 million people from poverty in the past 25 years; Use of coal-fueled power increased eight-fold during this period
- China leads the world in deploying high-efficiency coal plants
- Effort to deploy emission controls for nitrogen oxides and particulates on a scale equivalent to equipping half the U.S. coal fleet



The World's Leadership Needed to Bring CCS to Commercial Scale



Excluding CCS from a mitigation-technology portfolio would more than double the cost of achieving climate-stabilization goals through 2100. 99

– Intergovernmental Panel on Climate Change

With coal and other fossil fuels remaining dominant in the fuel mix, there is no climate friendly scenario in the long-run without CCS.

Maria van der Hoeven
Executive Director, International
Energy Agency

 Excluding CCUS as a technology option for the power sector alone would increase mitigation costs by \$2 trillion over 40 years, representing a 40 percent increase if CCUS is not available.

- International Energy Agency

⁶⁶ Rapid commercial development and deployment of clean coal technologies, particularly carbon capture and storage, will help position the United States as a leader in the global clean energy race. ⁹⁹

- The Honorable Barack Obama President of the United States

Sources: The New York Times, "Does Clean Coal Technology Have a Future?," Howard Herzog, Nov. 23, 2014; Fierce Energy, "Is China Embracing Clean Coal?," Barbara Vergetis Lundin, Feb. 13, 2015; "The Global Status of CCS", 2014, Global Carbon Capture and Storage Institute; IEA, Energy Technology Perspectives, 2012; Presidential Memorandum: A Comprehensive Federal Strategy on Carbon Capture and Storage, Feb. 10, 2010.

U.S. Can Learn from Canada, China in Developing Low-Carbon Energy



Canada

- Boundary Dam first carbon capture and storage project for power sector
- Captures CO₂ for enhanced oil recovery
- Sask Power believes it can achieve 25-30% cost reduction on next project
- Early success makes it a world model

China

- GreenGen conceived, permitted, built and brought online while FutureGen was being contemplated
- CCS for EOR in later stages
- Project would be among world's largest near-zero emissions coal plants at full build
- China a leader advancing highefficiency coal plants

United States

- U.S. should expand leadership role in the research and development required to commercialize technology
- EPA's climate plan widely opposed; would raise electricity costs and force caps for no notable benefit under climate theory

Sources: Australian Bureau of Statistics Consumer Price Index, December 2013; "Impacts and Consequences for Low-Income Australian Households of Rising Energy Prices," University of Sydney, 2013; "Maintaining the Advantage: Why the U.S. Should Not Follow the EU's Energy Policies," Manhattan Institute 2014; "Ontario and Energy: Making Power a Luxury Good," 2014; Dr. Frank Clemente, Professor Emeritus of Social Science, Penn State University.

22 Large-Scale CCUS Projects in Operation or Under Construction



Substantial Increase Needed in Development of Large CCUS Projects **Boundary Dam** Snøhvit CO₂ Storage Project Saskatchewan GreenGen Canada **Barents Sea Tianjin**, China Norway **Sleipner CCS** Project North Sea Norway **Abu Dhabi CCS** Project **United Arab** Emirates Petra Nova **Carbon Capture** Project Texas Large-Scale CCS Projects in **Petrobras Lula** Operation **Gorgon CO**₂ **Oil Field CCS** Injection Project Large-Scale CCUS Projects Under Australia Brazil Construction Planned Use of CCUS

Source: Global Carbon Capture and Storage Institute, "The Global Status of CCS: 2014."

A Policy Path Toward a Low-Carbon Energy Future



- 1. Recognize the importance of providing all citizens with energy access and keeping energy available, reliable and affordable.
- 2. Recognize the important role of HELE (high-efficiency, low-emissions) technologies in a true "all of the above" energy strategy and the immediate benefits for carbon reduction.
- Provide policy support and investment in clean coal technologies; especially in U.S. and China – the two largest consumers of energy in the world
- 4. Encourage funding by public financial institutions and international development funds to expand clean electricity access in emerging markets.
- 5. Accelerate development of next generation carbon capture utilization and storage technologies by bringing CCUS to scale.





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