Testimony of Shannon Angielski

Executive Director

Carbon Utilization Research Council (CURC)

Before the

Committee on Science, Space, and Technology

Subcommittees' on Energy and Environment

Hearing on the Future of Fossil: Energy Technologies Leading the Way

CURC Testimony:

"Advancing Fossil Energy Technology Innovation in the U.S."

Washington, D.C.

July 17, 2018

EXECUTIVE SUMMARY OF CURC TESTIMONY: KEY POINTS

CURC is an industry coalition focused on technology solutions for the responsible use of our U.S. fossil energy resources in a balanced portfolio to support our nation's need for secure, reliable and affordable electricity. CURC serves as an industry voice and advocate by identifying technology pathways that enable the nation to enjoy the benefits of abundant and low-cost fossil fuels in a manner compatible with societal energy needs and goals. CURC believes that future energy needs can be effectively met through collaborative public and private sector research to expand technology choices for private sector commercialization. Members of CURC work together to evaluate technology development needs, design appropriate research and development programs to enable those technology choices, and identify federal programs and policies needed to support this activity.

The U.S. has made significant strides in the development of advanced coal and natural gas technologies to improve the utilization of these resources. Similar to how a new car today can travel further on a single gallon of gasoline than one built in the 1980s, the most advanced coal units operating in the U.S. today are 25% more efficient than the previous generation of coal units. With further technology improvements, additional efficiency gains of similar magnitudes can be achieved for both coal and natural gas combined cycle systems.

New technologies have also resulted in significant emissions reductions since the early 1970s, even while fossil fuel use substantially increased. Additionally, technology has substantially reduced the use and discharge of water from fossil fueled power plants.

Consumption of fossil fuels is on the rise both domestically and internationally, and this trend is projected to continue well into the future due to the role fossil fuels play in providing easily accessible, reliable and low-cost energy. There is growing international consensus that technologies are needed to reduce the carbon footprint from the use of fossil fuels. As a result, more recent efforts have focused on technologies to reduce carbon dioxide emissions. There is a first-of-a-kind carbon capture project successfully operating on a coal-fired power plant in the U.S. today that is selling its carbon dioxide to enhance recovery of oil in a nearby oil field – the Petra Nova project in Texas. This innovative project relied on federal financial support to launch. While research is advancing that will result in improved technologies, carbon capture is not yet economic for widespread application in the power sector.

Later this month, CURC and the Electric Power Research Institute, Inc. (EPRI) will release the 2018 Advanced Fossil Energy Technology Roadmap that identifies the research, development and demonstration for a suite of technologies that will transform the way fossil fuels are converted to electricity. EPRI conducts research, development, and demonstration projects for the benefit of the public in the United States and internationally. As an independent, nonprofit organization for public interest energy and environmental research, they focus on electricity generation, delivery, and use in collaboration with the electricity sector, its stakeholders and others to enhance the quality of life by making electric power safe, reliable, affordable, and environmentally responsible. EPRI does not advocate or aim to influence policy or regulation. If implemented, the Roadmap identifies technologies that can be available by the 2025-2035 timeframe that generate electricity from fossil fuels with significantly reduced carbon dioxide emissions that could be cost competitive with other sources of electricity generation.

This will be the fifth Roadmap that CURC and EPRI have published since 2003. The 2018 Roadmap includes new data on recent advances in fossil fuel technologies. It also reflects the technology development needs that can support an evolving U.S. power sector impacted by several emerging trends driving innovation and investment decisions for new generation. Some of these trends include increased and low- cost domestic supplies of natural gas, slow, and in some areas of the country, declining, load growth and electricity demand, and the need for generation to rapidly adjust to cycling load demands with increased intermittent renewables on the grid.

There are several technologies identified in the Roadmap that address these issues to transform the way we use our coal and natural gas resources. These include novel fossil power cycles or key processes in such cycles that are designed to facilitate the capture of CO_2 at a lower energy penalty and cost than conventional methods. These processes are inherently more efficient, resulting in fewer emissions of both CO_2 and criteria pollutants, and require fewer fossil fuels to be used to produce electricity. There is specific research identified in the Roadmap that is also necessary to support these new cycles, including advancements in turbine technologies, and high-temperature materials necessary to achieve higher efficiencies. In addition, the Roadmap outlines advances in carbon capture technologies designed to lower costs, and the development and testing of these technologies at test centers such as the Wyoming Integrated Test Center and the National Carbon Capture Center in Alabama. Research on breakthrough technologies is also needed to ensure “out-of-the-box” thinking or fundamentally new approaches to solving fossil fuel’s challenges are developed.

Many of the technologies identified in the Roadmap are readying for pilot testing now and a few are preparing for commercial-scale demonstration. It is critical that federal policies support not only the R&D outlined in the Roadmap, but also the piloting and demonstrating of these innovative, first of a kind technologies.

Companion analysis conducted by CURC and ClearPath, with modeling provided by NERA Economic Consulting and Advanced Resources International, shows that there are significant economic benefits to the U.S. if the technology development outlined in the Roadmap is undertaken under a wide range of scenarios. Our analysis projects up to 87 GW of market-driven carbon capture deployment paired with enhanced oil recovery by 2040, resulting in a significant increase in domestic oil production and lower cost retail electricity rates, all of which contribute to substantial increases in annual GDP as well as over 800,000 new jobs through 2040. These macroeconomic benefits are described in more detail in my written testimony.

While both CURC and EPRI developed the Roadmap, I am speaking only on behalf of CURC, and CURC is pleased to support the House Science, Space and Technology Committee efforts to explore next generation fossil power technologies and discuss technology solutions that will enable our nation to continue to responsibly benefit from the utilization of our fossil energy resources.

Thank you for the opportunity to provide this testimony.

INTRODUCTION AND BACKGROUND

CURC is an industry coalition focused on technology solutions for the responsible use of our fossil energy resources in a balanced portfolio to support our nation's need for secure, reliable and affordable energy.[1] CURC serves as an industry voice and advocate by identifying technology pathways that enable the nation to enjoy the benefits of abundant and low-cost fossil fuels in a manner compatible with societal energy needs and goals. CURC believes that future energy needs can be effectively met through collaborative public and private sector research to expand technology choices for private sector commercialization. Members of CURC work together to evaluate technology development needs, design appropriate research, development and demonstration (RD&D) programs to enable those technology choices, and identify federal programs and policies needed to support this activity.

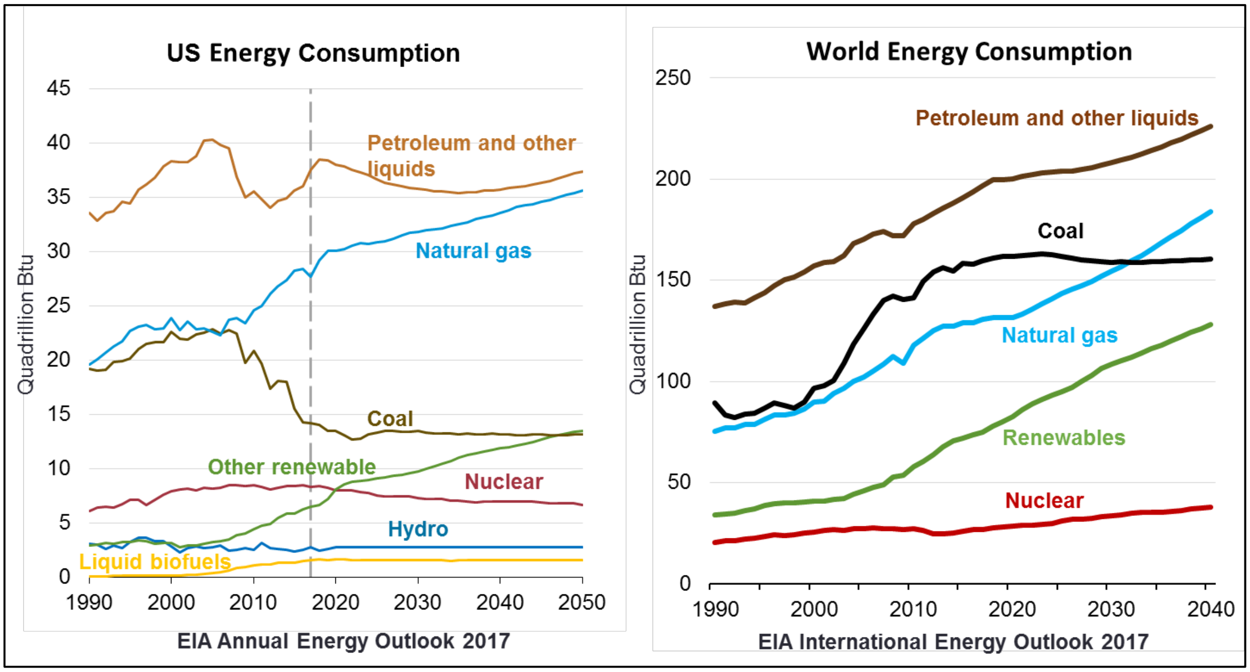
The U.S. has made significant strides in the development of advanced coal and natural gas technologies to improve the utilization of these resources. Similar to how a new car today can travel further on a single gallon of gasoline than one built in the 1980s, the most advanced coal units operating in the U.S. today can produce 20% more electricity than the previous generation of coal units with the same amount of fuel. With further technology improvements, additional efficiency gains of similar magnitudes can be achieved for both coal and natural gas combined cycle systems.

New technologies have also resulted in significant emissions reductions since the early 1970s, even while coal use substantially increased. Additionally, technology has substantially reduced the use and discharge of water from fossil fueled power plants.

Our nation's coal and fossil fuels play a significant role in the global and domestic energy economy. Domestically, coal and natural gas comprised 43% of total U.S. energy consumption and 47% of net electricity generation in 2017. The U.S. Energy Information Administration (EIA) estimates that coal and natural gas will provide 56% of total U.S. net electricity generation in 2040 (see Figures 1 and 2). Globally, consumption of coal and natural gas are projected to provide 45% of our energy consumption in 2030 and will grow to nearly 50% of global consumption by 2040 (see Figure 1).

[1] CURC's members include coal producers, electric utilities that rely upon coal and natural gas for electricity production, equipment manufacturers and technology innovators, national associations that represent the power generating industry, and state, university and technology research organizations. See Appendix for a list of CURC members, as well as our website: http://curc.net/curc-members

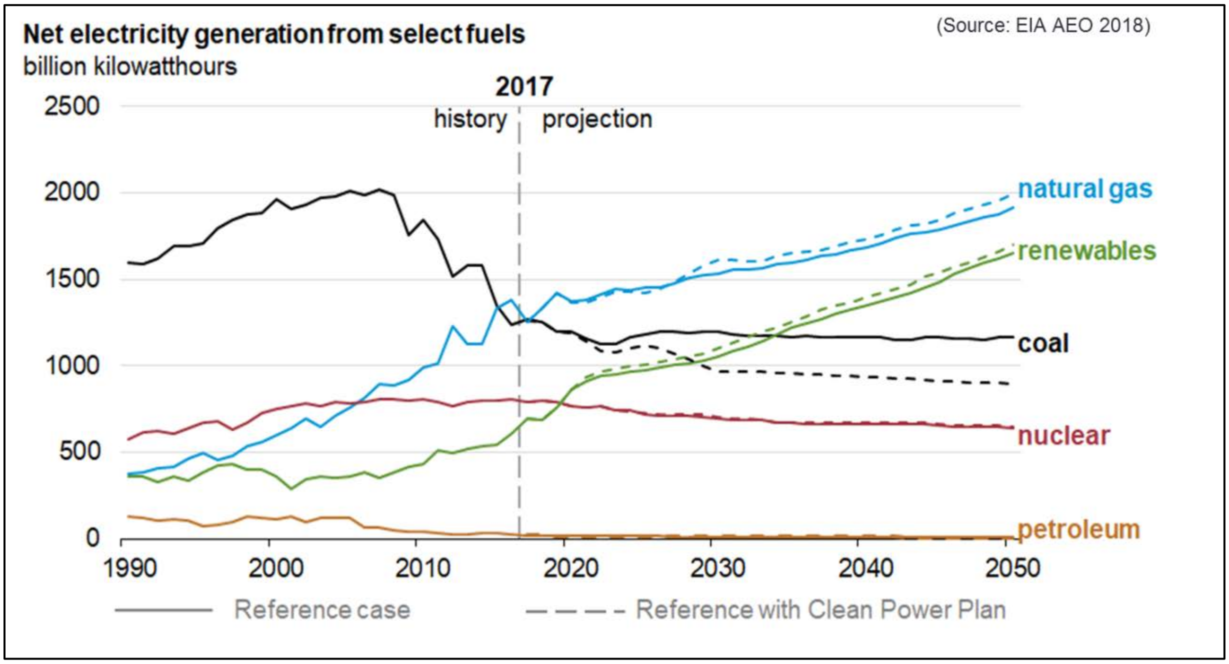
Figure 1 - U.S. and World Energy Consumption[2]



Technologies to address the growing use of fossil fuels in the power sector must be developed and deployed to reduce the carbon footprint from the use of fossil fuels. Models show the need for technologies that significantly reduce carbon dioxide (CO_2) emissions profiles to meet global climate targets (see Figure 3). Yet cost-effective, commercially-tested technologies to enable a transformational change in the conversion of fossil fuels to electricity with carbon capture, utilization and storage (CCUS) are not available today.

[2] EIA Annual Energy Outlook 2017, EIA International Energy Outlook 2017.

Figure 2 - U.S. Electricity Generation Projections[3]



CURC, in collaboration with the Electric Power Research Institute, Inc. (EPRI), will next week release an *Advanced Fossil Energy Technology Roadmap* ("Roadmap"). EPRI conducts RD&D projects for the benefit of the public in the United States and internationally. As an independent, nonprofit organization for public interest energy and environmental research, they focus on electricity generation, delivery and use in collaboration with the electricity sector, its stakeholders and others to enhance the quality of life by making electric power safe, reliable, affordable and environmentally responsible. EPRI does not advocate or aim to influence policy or regulation. .

The Roadmap outlines several RD&D pathways for both new and existing coal and natural gas technologies that will result in a suite of low-carbon, fossil-fuel platforms capable of being cost competitive with other forms of electricity generation in future electricity markets. The Roadmap reflects the technology development needs that can support an evolving U.S. power sector impacted by multiple trends driving innovation and investment decisions for new generation. The Roadmap also takes into consideration that technology development must ensure a minimal environmental footprint from the use of fossil fuels, including reduced water consumption and utilization or conversion of byproducts including CO_2. The comments provided in my testimony today are based on the findings of the *2018 CURC-EPRI Advanced Fossil Energy Technology Roadmap* and reflect only CURC's comments regarding the Roadmap.[4]

SUMMARY OF CURC-EPRI ROADMAP FINDINGS

The Roadmap emphasizes development of technologies that can result in cost-competitive and low or near-zero CO_2 emissions generation technologies, in addition to other technology areas that mitigate the environmental footprint of using fossil fuels. The 2018 Roadmap includes new data on recent advances in fossil fuel technologies and identifies the research, development and demonstration (RD&D) for a suite of technologies that will transform the way fossil fuels are converted to electricity. Our analysis determined that many technologies are applicable to

[3] U.S. EIA Annual Energy Outlook 2018.
[4] CURC-EPRI Advanced Fossil Energy Technology Roadmap, 2018.

both coal- and natural gas-fired power generation, through which public-private sector funding and support can be leveraged to develop technologies for applications using both resources.

The Roadmap identifies a suite of transformational technologies to generate a new learning curve or use new approaches for power generation and/or carbon capture that enable substantial breakthrough performance improvements and cost reductions. These encompass a broad range of technology improvements, including thermodynamic improvements in energy conversion and heat transfer, turbines and CO_2 capture systems that all drive cost reductions as well as reduce the consumption of energy needed to operate the CO_2 capture system. These technologies will result in a step change improvement in performance, efficiency, flexibility, environmental performance and cost from the use of fossil fuels (see Table 1 in Appendix). For each of these technologies, the Roadmap identifies the cost and performance targets and the technology development necessary to bring each technology to commercialization to achieve those targets. The development needs and funding requirements for each technology are rolled up into an overall technology development timeline and funding schedule. The Roadmap identifies a level of RD&D to ensure timely solutions are developed and pursued through aggressive public-private partnerships.

The transformational technologies examined in the Roadmap include pressurized oxy-combustion (P-Oxy), chemical looping combustion (CLC) and supercritical carbon dioxide (sCO_2) cycles, which would replace steam with sCO_2 as the working fluid – including both the direct- and indirect-fired sCO_2 cycles. New turbines and other components to support the higher temperatures and pressures of these systems, particularly the sCO_2 cycles, were also considered. Each of these new technologies is projected to be extremely efficient, be more compact and lower cost, and are designed to yield lower costs and energy penalties associated with the capture of CO_2.

The Roadmap also evaluates the cross-cutting RD&D needed for a range of technologies applicable to both coal- and natural gas-firing units. Cross-cutting technologies include high-efficiency materials development, carbon capture, carbon utilization and storage, turbines, and a program that evaluates other cross-cutting research such as water management, sensors and controls.

Advanced Ultra-supercritical (A-USC) materials enable Rankine cycles with steam temperatures of 700°C or higher and are also needed for the transformational high-temperature and pressure power cycles. The Roadmap identifies the RD&D needs for A-USC materials development, the testing of A-USC materials and components under real operating conditions and demonstrating supply-chain fabrication capability for key full-scale A-USC components.

The Roadmap also considers carbon capture development paths for solvents, sorbents and membranes for post-combustion capture and chemical and physical absorbents and membranes for pre-combustion capture systems, which are projected to have much lower energy penalties, yielding higher efficiencies and lower costs. Carbon capture technologies in the Roadmap address pathways for both coal-fired power plants and NGCC plants. CURC recommends that any federal program for carbon capture supports both coal and natural gas technology pathways.

CO_2 utilization and storage is an important effort to evaluate geologic CO_2 storage reservoirs, necessary to ensure there will be readily accessible storage facilities for CO_2 produced from the advanced power systems under development. The Roadmap includes a program to advance technologies in this area that will help grow our economy and increase our energy independence through the utilization of CO_2, and for which low-cost, industrial sources of CO_2 will be sought for enhanced oil and gas recovery. There are also niche opportunities to convert CO_2 into other products, including chemicals, fuels and cement that should be pursued with federal RD&D support.

Lastly, the Roadmap identifies a program for "breakthrough" technology advances that reflect "out-of-the-box" thinking for fundamentally new approaches to solving fossil fuel's challenges. Examples of breakthrough technologies include the substitution of bio-systems for current chemical processes and CO_2 sorbents based on new human-made compounds. Support for these kinds of activities is consistent with RD&D supported through the DOE's Advanced Research Projects Agency-Energy program or the fundamental research conducted in the applied energy programs at DOE.

DEVELOPMENT EFFORTS IDENTIFIED IN THE ROADMAP

Early in the technology-development cycle, the technical risks for new energy technologies are incredibly high, particularly when moving an idea from concept designed on paper and turning that concept into an actual working technology. Not only are technologies at this stage a long way from commercialization, each phase of development carries significant technical risk. Since energy technologies are capital intensive, costs increase with each scale-up in development. Each of these factors makes it difficult to attract the private sector investment required to finance technologies at an earlier stage and even mid-stages of development, making federal support for scale-up stages of technology critical to attracting the necessary private sector cost-share. Given the timing of commercialization to achieve a return on investment for energy sector technologies, federal support at all of these stages is critical to successfully commercialize such technologies.

The ultimate value of a new energy technology is generally not realized until several commercial-scale replications have occurred, which can take 20 years from concept to commercialization for large, capital-intensive energy systems. The good news is that the higher costs associated with new energy technologies can be reduced through learning by doing, which means the second-of–a-kind replication will cost less than the first.

New commercial-scale technologies cannot leap from a conceptual stage to commercial deployment in a single step. The Roadmap includes support of large-scale pilots for testing new technologies under real operating conditions at a scale beyond laboratory- and bench-scale, and before testing technologies in a commercial-scale demonstration. Large-scale pilot projects are mostly still early in the technology development timeline; the remaining time to commercialization and the risk that the process might not work at scale makes both commercial and internal financing often more challenging than either basic research or full-scale commercial-scale demonstrations. The success of technologies at the pilot scale can help to understand and overcome the risks inherent in early phase technology development and, if successful, encourage industry to make investments to advance the technologies to commercial implementation.

PROJECTED BENEFITS OF ROADMAP

Successful implementation of the Roadmap can result in significant environmental, economic and energy security benefits for the U.S., including:

1. Further reduction of water use and air pollutants, including nitrogen oxides (NOx), sulfur dioxide ($SO_{2)}$, mercury (Hg) and particulate matter (PM) (see Figures 3 and 4 below);
2. Reduction of CO_2 emissions;
3. Production and preservation of affordable electricity essential for U.S. competitiveness through a diverse generation technology portfolio;
4. Enabling U.S. engineering and manufacturing expertise to grow, resulting in a robust U.S. supply chain and positioning the U.S. to be even more of a global leader in innovative fossil-fuel technologies;

5. Significant growth in gross domestic product (GDP) and jobs due to the macroeconomic impacts of increased domestic oil production and reductions in the cost of electricity (COE);
6. Improved energy security by:
    a. Generating affordable power for electricity consumers including increased industrial and advanced manufacturing customers;
    b. Improving the operational flexibility of existing and future generating plants to ensure continued electricity grid reliability and stability; and
    c. Using captured CO_2 as a commodity to recover crude oil, thereby increasing domestic oil production.

Figure 3 - Emissions Reductions from New Coal Plants Projected in CURC-EPRI Roadmap

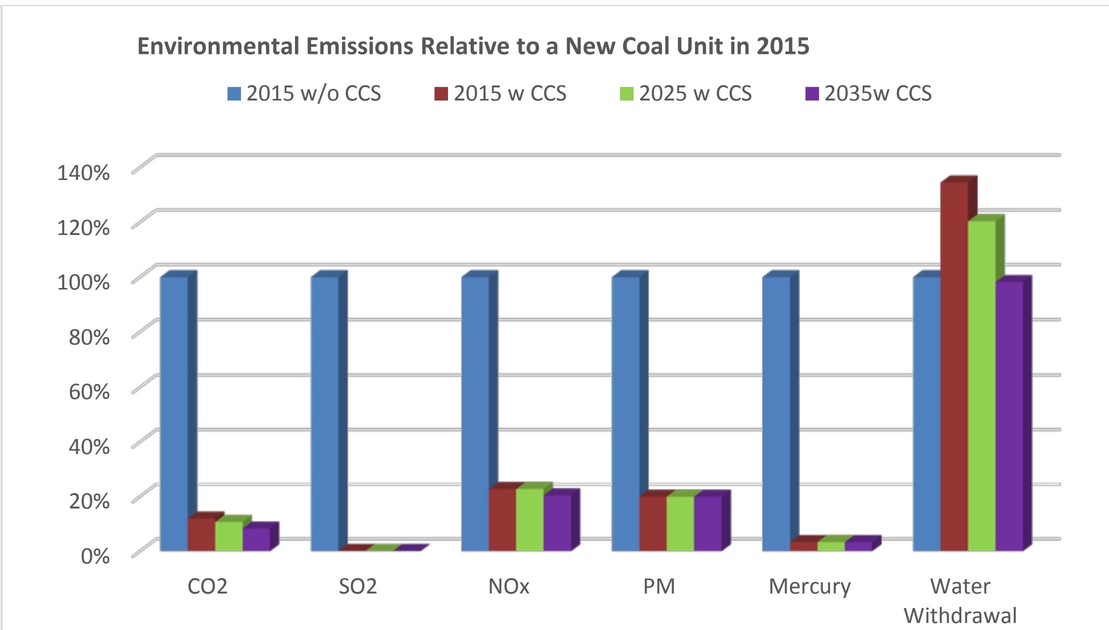
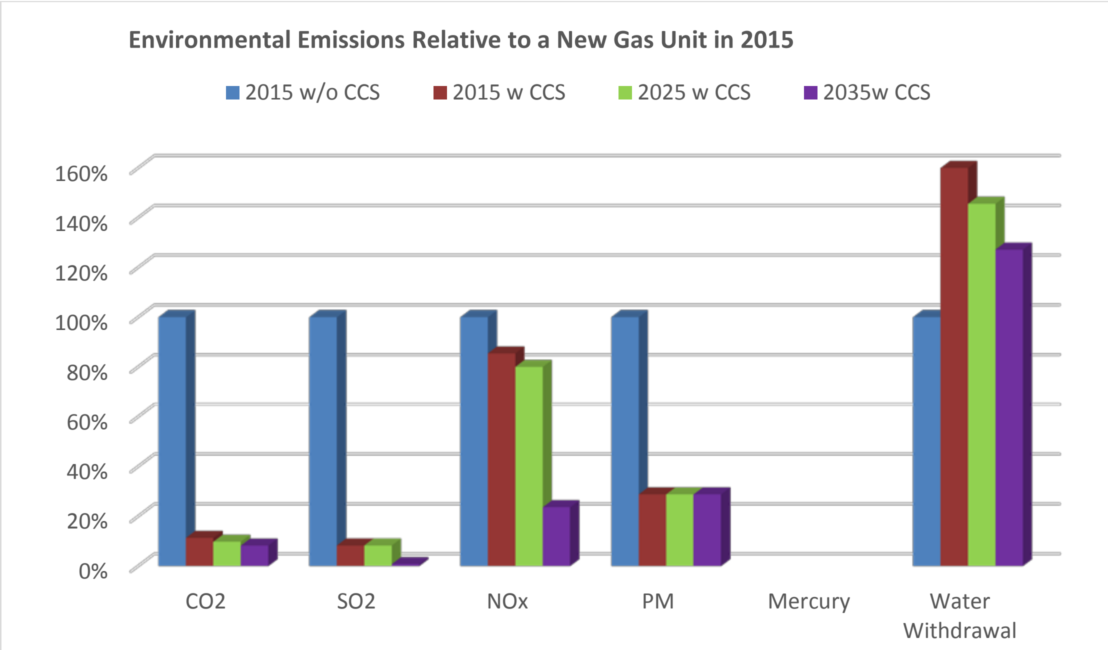


Figure 4 - Emissions Reductions from a new Gas Unit Projected in the CURC-EPRI Roadmap



If the RD&D outlined in the Roadmap is undertaken, the following COE projections are estimated with improved technology:

New Coal Unit with 90% Carbon Capture:

- 2030 – 20% reduction in COE compared to a new unit built with CCS in 2015
- 2040 – 40% reduction in COE compared to a new unit built with CCS in 2015

These projected cost improvements meet the cost reduction goals set by DOE in its 2013 Carbon Capture Technology Program plan for coal-based CCS systems.

New Natural Gas Unit with 90% Carbon Capture:

- 2030 – 15% reduction in COE compared to a new unit built with CCS in 2015
- 2040 – 30% reduction in COE compared to a new unit built with CCS in 2015

CURC and ClearPath Foundation will publish next week the results of a study that projects the macroeconomic benefits to the U.S. of new, lower-cost fossil energy technologies with CCUS as projected by the Roadmap.[5] The study estimates that if an aggressive RD&D program is implemented that achieves the above cost targets, market-driven deployment of 62 to 87 GW of power-sector projects with installed carbon capture technologies for enhanced oil recovery can be enabled by 2040.

Under an aggressive RD&D scenario that achieves the CURC-EPRI cost targets, the macroeconomic impacts of CO_2 captured from the power sector for use in enhanced oil recovery (EOR) can:

[5] CURC and ClearPath Foundation, "Making Carbon a Commodity: the Potential of Carbon Capture RD&D," July 2018.

- Contribute up to 925 million barrels of annual domestic oil production
- Increase coal production for power by as much as 40% between 2020 and 2040
- Add 270,000 to 780,000 new jobs relating to increased oil production
- Result in a $70 to $190 billion increase in annual GDP by 2040.

The study also estimates that lower-cost electricity generated from low-cost carbon capture-enabled systems also yield significant macroeconomic benefits. Aggressive RD&D is estimated to reduce the retail COE up to 2.0% by 2040, which would increase annual GDP by $30 to $55 billion and create an additional 210,000 to 380,000 jobs.

CONGRESSIONAL EFFORTS IN SUPPORT OF FOSSIL ENERGY RD&D

Since the 2015 Roadmap, there has been growing support for policies that favor CCUS and the technology recommendations that achieve the Roadmap objectives, including a program for large-scale pilots. In FY 2017, Congress appropriated $50 million for the U.S. Department of Energy (DOE) to undertake a new, transformational coal pilot program. The DOE program has solicited projects for both processes and components, along with post-combustion carbon capture, aimed at enabling step-change improvements in coal-powered system efficiency, COE and carbon capture performance.[6] The program will be carried out in three phases, with the first phase nearing completion with nine projects having been selected to develop initial design concepts.[7] The intent of the program solicitation is to ultimately design, construct and operate two large-scale pilots with these transformational attributes. Congress appropriated an additional $35 million in FY 2018 to support the total $100 million program.

In the last Congress, legislation that originated in this Committee through the America COMPETES Act (H.R. 1806) and in the Senate the Energy Policy Modernization Act (S. 2012), included provisions reflecting the 2015 Coal Technology Roadmap programs. While the House and Senate each passed their version of comprehensive energy bills, the Conference Committee could not agree on a final package. Despite this, the Fossil Energy RD&D provisions of both bills focused on programs aimed at improving the efficiency, effectiveness and environmental performance of fossil energy use consistent with CURC's priorities and the Roadmap programs.

The Senate reintroduced their comprehensive bill in this Congress, S. 1460, which includes the Fossil Energy RD&D provisions from the earlier bill, S. 2012. The "FUEL Act" (S. 2803) was also introduced in May 2018, which amends the S. 2012 RD&D provisions to reflect the new CURC-EPRI Roadmap programs that will be published in our 2018 report. In the House, H.R. 5745 has been introduced, which would likewise authorize several programs that align with the direction of the 2018 CURC-EPRI Roadmap technology programs.

While both CURC and EPRI developed the Roadmap, I am speaking only on behalf of CURC, and CURC is pleased to support legislation that will advance the Roadmap technology objectives. CURC looks forward to working with the House Science, Space and Technology Committee Members as you continue to explore next generation fossil power technologies and discuss technology solutions that will enable our nation to continue to responsibly benefit from the utilization of our fossil energy resources.

Thank you for the opportunity to provide this testimony.

---

[6] https://www.energy.gov/articles/department-energy-announces-50-million-large-scale-pilot-fossil-fuel-projects
[7] https://www.energy.gov/articles/department-energy-invest-65-million-large-scale-pilot-fossil-fuel-projects

APPENDIX

Table 1 - Technology Programs Supported in the CURC-EPRI Roadmap

Transformational Advanced Energy Systems		
Pressurized Oxy-Combustion (P-Oxy)	Coal and Natural Gas	Oxy-combustion power plants remove nitrogen from air cryogenically and perform the combustion of fossil fuels with oxygen and recycled flue gas to produce a stream largely comprised of CO_2 and water, greatly simplifying carbon capture. P-Oxy operates at elevated pressure, improving efficiency and allowing smaller components that combine to potentially reduce costs.
Chemical Looping Combustion (CLC)	Coal and Natural Gas	CLC is a form of oxy-combustion in which oxygen from air is separated using a metal oxide or limestone oxygen carrier, eliminating the need for cryogenic air separation and its significant energy penalty, while maintaining the relatively easy carbon capture provided by oxy-combustion.
Direct-Fired Supercritical CO_2 (sCO_2) Cycles	Coal and Natural Gas	A form of oxy-combustion, direct-fired sCO_2 cycles burn natural gas or syngas (provided by coal gasification) in a high-pressure oxy-combustor, producing very high-temperature CO_2 and water that drive a sCO_2 turbine to make power. Water and CO_2 (at pipeline pressure) are then removed downstream to conserve mass, producing a very-high-efficiency, potentially low-cost carbon capture system.
Indirect-Fired sCO_2 Cycles	Coal and Natural Gas	Replace steam-Rankine cycles with sCO_2 cycles which, due to the superior thermodynamic qualities of CO_2, have higher efficiency and utilize more compact turbomachinery. Can be used on any cycle that currently uses a steam-Rankine cycle, including solar thermal, geothermal, nuclear, biomass and any type of fossil fuel. The process results in higher efficiency and can be coupled with a low-cost carbon capture system.
Gasification	Coal	Coal can be gasified in either an air- or oxygen-blown gasifier to produce synthetic gas (syngas) that can be used in an efficient integrated gasification combined cycle system. Pre-combustion carbon capture can be added. New, highly efficient, compact gasifiers can be used in poly-generation plants that combine electricity generation with co-production of transportation fuels, fertilizer and/or other chemicals to improve the overall economics.
Compact Hydrogen Generator	Natural Gas	New, highly efficient method for producing hydrogen (alternative to steam-methane reforming).
Cross-Cutting Technologies		
A-USC Materials	Coal and Natural Gas	A-USC materials are needed to allow working fluid temperatures up to 760°C to support highly efficient combustion and heat exchange systems for both steam-Rankine and sCO_2 power systems and other high-temperature technologies. Can be applicable to both new and existing plants.
Turbines	Coal and Natural Gas	RD&D and testing of steam turbines, combustion turbines, and sCO_2 turbines and pressure-gain combustion, all in an effort to improve efficiency, reliability and

Transformational Advanced Energy Systems		
		flexibility and support power systems evaluated in the Roadmap.
CO_2 Capture	Coal and Natural Gas	Advances in solvents, sorbents and membranes for both pre- and post-combustion carbon capture focused on lowering energy requirements and overall cost of capture. Technologies will need to be adjusted to handle the differences between coal and natural gas flue gas, which include different CO_2 concentrations and trace species.
CO_2 Storage	Coal and Natural gas	Saline reservoirs, enhanced oil and gas recovery, and other geologies are being explored for storing CO_2 both onshore and offshore. RD&D as well as large-scale CO_2 storage and regional infrastructure strategies related both to storage and transportation in the U.S. are needed
Existing Plants	Coal and Natural Gas	RD&D to support flexibility and reliability of operations of existing plants
Cross-Cutting	Coal and Natural Gas	RD&D on technologies that support all Roadmap areas, including: • Advanced manufacturing • Breakthrough technologies • Sensors and controls • Water management

Carbon Utilization Research Council (CURC) Members

Coal Producers
Arch Coal, Inc.
Cloud Peak Energy Resources LLC *
Lignite Energy Council
Peabody Energy*

Equipment Suppliers
B&W Power Generation Group, Inc.
Caterpillar Global Mining
General Electric*
Mitsubishi Heavy Industries America, Inc. (MHIA)

Labor Unions
United Mine Workers of America
International Brotherhood of Boilermakers
International Brotherhood of Electrical Workers

NGOs
ClearPath Action
EnergyBlue Project

Technology Developers
Jupiter Oxy Corp
NET Power

Research Organizations
Battelle
Electric Power Research Institute (EPRI)
Gas Technology Institute
University of North Dakota Energy & Environmental Research Center

State Organizations
Energy Industries of Ohio
Greater Pittsburgh Chamber of Commerce
Illinois Coal Association
Kentucky Energy & Environment Cabinet
Southern States Energy Board
West Virginia Coal Association
Wyoming Infrastructure Authority

Trade Associations
American Coal Council
American Coalition for Clean Coal Electricity (ACCCE)
Edison Electric Institute (EEI)
National Rural Electric Cooperative Association (NRECA)

Universities
Lehigh University
Ohio State University
Pennsylvania State University
Southern Illinois University
University of Illinois/PRI
University of Kentucky/CAER
University of Wyoming
West Virginia University

Utilities
American Electric Power (AEP)
Basin Electric Power Cooperative*
Duke Energy Services
LG & E and KU Services Company
Southern Company*
Tri-State Generation & Transmission Association

Companies in orange indicate Steering Committee Members

*CURC Leadership Council

1