Advancing the Next Generation of Coal Conversion Technologies

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An Industry View: Advancing Next Generation Coal Technologies
Arlington, Virginia
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Here, "Next-Generation Technology" means one that is not yet commercial

Some of these might also be labeled as:

- Advanced
- Breakthrough
- Game-changing
- Innovative
- Leap-frog
- Novel
- Radical
- Step-out
- Transformational

Characteristics of Next-Generation Coal Conversion Systems

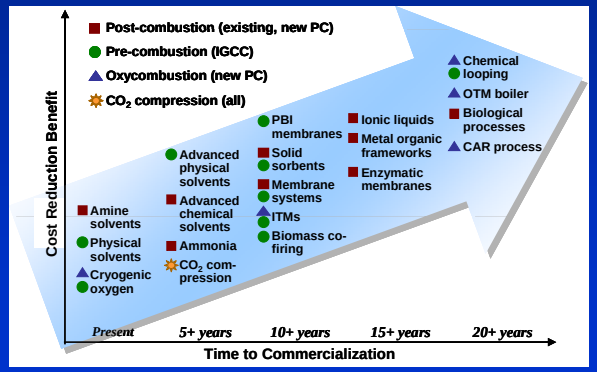
- The technology is not yet deployed or available for purchase at a commercial scale
  - Current stage of development may range from concept to large pilot or demonstration project
- Process design details still preliminary or incomplete
- Process performance not yet validated at scale, or under a broad range of conditions
- May require new components and/or materials that are not yet manufactured or used at a commercial scale

Some Advanced Systems for Low-Carbon Power Generation*

- "Innovative" Systems:
  - High temperature oxy-natural gas / syngas power cycles
    - e.g., NET Power, CES
  - Very high temperature topping cycles
    - e.g., MHD, fuel cell
  - Enhanced efficiency combustion / heat transfer
    - e.g., chemical looping combustion, pressurized air-coal or oxy-coal
- "Baseline" Systems:
  - USC/AUSC PC or FBC w/post- or oxy-combustion CCS
  - IGCC with pre-combustion CO_2 capture
  - NGCC with CO_2 capture

Source: D.Thimsen, EPRI, 2014

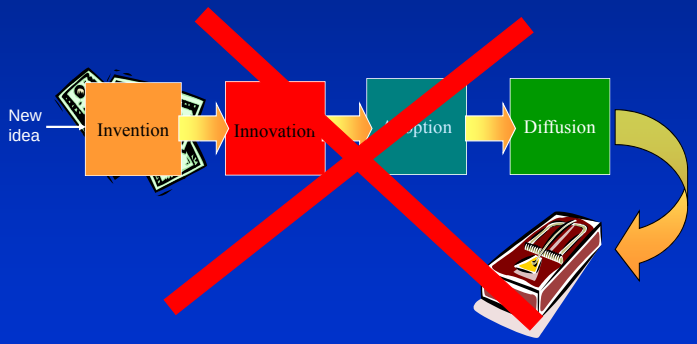
Advanced Technologies for CO_2 Capture



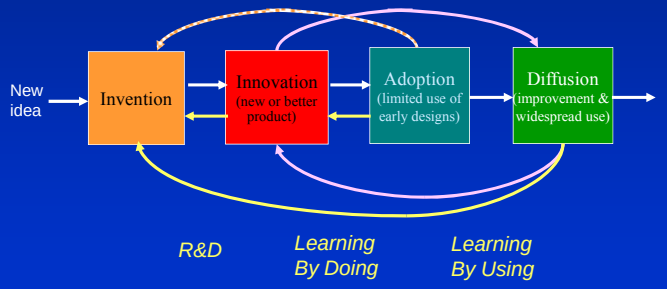
Source: USDOE, 2010

How do we advance next-generation technologies?

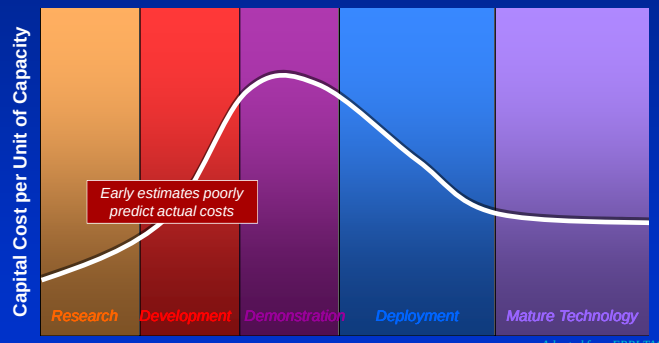
A Common Model of Technological Change



A More Realistic Model of Technological Change



Typical Cost Trend of a New Technology



Adapted from EPRI TAG

Stage of Technology Development and Deployment

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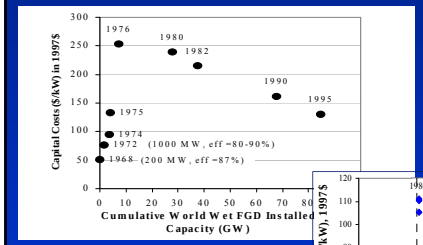
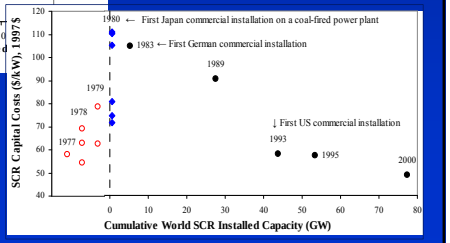
Historical cost of SO_2 and NO_x controls follow trend shown in previous slide



Source: Rubin et al. 2007

Capital Cost of Power Plant Flue Gas Desulfurization (FGD) and Selective Catalytic Reduction (SCR) Technologies

All costs based on a standardized 500 MW coal-fired power plant (except where noted)



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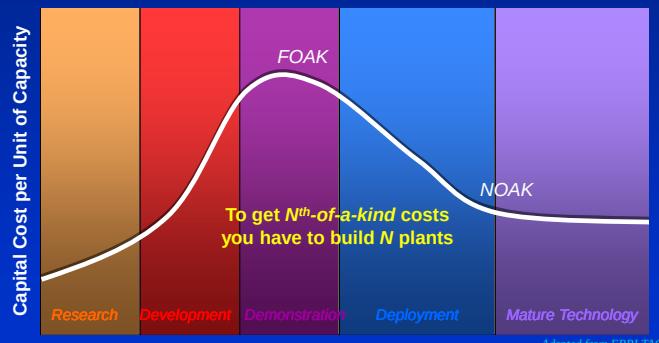

Adspted from EPRI TAG

Stage of Technology Development and Deployment

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Technology Scale-Up Takes Time and Money

TRL	Scale	Cost to achieve	Time to achieve
6 Process Development Unit	Up to ~5% full scale	$ millions to $10s of millions	24-48 months
7 Pilot Plant	At least 5% full scale	$10s of millions to $100s of missions	24-60 months
8 Commercial Pilot Plant	At least 25% full scale	$100s of millions	4-7 years
9 1st Commercial Deployment	Full scale	$100s of millions to $ billions	4-7 years

Source: EPRI, 2014

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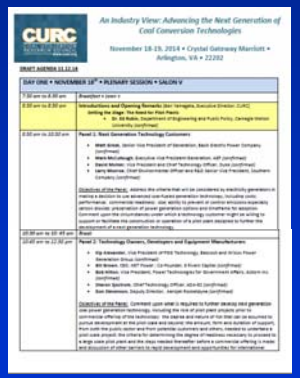
Three Simple Questions for this Workshop

- Are there (or will there be) markets for next-generation coal technologies, and if so, what technologies, or technology characteristics, are (or will be) sought ?
- Which technologies now under development are best positioned to meet these market demands, but require scale-up to a large pilot plant before a commercial system can be offered ?
- Where will the money come from to build and operate large pilot plants (and future demonstration plants)?

I Look Forward to Your Thoughts


CURC

An Industry View: Advancing the Next Generation of Coal Conversion Technologies

November 18-19, 2014 • Crystal Gateway Marriott • Arlington, VA • 22202

DRAFT AGENDA 11.12.14

DAY ONE • NOVEMBER 18th • PLENARY SESSION • SALON V

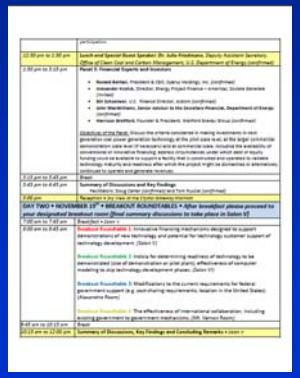
7:00 am to 8:00 am — Breakfast • Lower •

8:00 am to 8:30 am — Introductions and Opening Remarks: Alan Yamagata, Executive Director, CURC
Setting the Stage: The Need for Pilot Plants
• Dr. Ed Rubin, Department of Engineering and Public Policy, Carnegie Mellon University, (confirmed)

8:30 am to 10:30 am — Panel 1. Next Generation Technology Customers
• Matt Grote, Senior Vice President of Generation, Basin Electric Power Company
• Jason Wochenske, Executive Vice President Generation, AEP, (confirmed)
• Duane Monson, Vice President and Chief Technology Officer, Duke (confirmed)
• Jerry Monroe, Chief Environmental Officer and Past Senior Vice President, Southern Company (confirmed)
Objectives of the Panel: Address the criteria that will be considered by electricity generators in making a decision to use advanced coal-fueled generation technology, including costs, performance, commercial readiness, size, ability to prevent or control emissions especially carbon dioxide, preservation of power generation options and timeframe for adoption. Comment upon the circumstances under which a technology customer might be willing to support or facilitate the construction or operation of a pilot plant designed to further the development of a next generation technology.

10:30 am to 10:45 am — Break

10:45 am to 12:30 pm — Panel 2. Technology Owners, Developers and Equipment Manufacturers
• Kip Alexander, Vice President of FEED Technology, Babcock and Wilcox Power Generation Group, (confirmed)
• Bill Brown, CEO, NET Power - Co-Founder, 8 Rivers Capital (confirmed)
• Bob Hilton, Vice President, Fluor Technologies for Government Affairs, Advent Inc. (confirmed)
• Sharon Spollman, Chief Technology Officer, ADA-ES (confirmed)
• Dan Stevenson, Deputy Director, Georgia Aquarium (confirmed)
Objectives of the Panel: Comment upon what is required to further develop next generation coal power generation technology, including the role of pilot plant projects prior to commercial offering of the technology. The scope and nature of the steps can be assumed to pursue development at the pilot scale and beyond. The amount, form and duration of support, from both the public sector and from potential customers and others, needed to undertake a pilot scale project, the criteria for determining the degree of readiness necessary to proceed to a large scale pilot plant and the steps needed thereafter before a commercial offering is made. And discussion of other barriers to R&D development and opportunities for international


12:30 pm to 1:30 pm — Lunch and Special Guest Speaker: Dr. Julie Friedmann, Deputy Assistant Secretary, Office of Clean Coal and Carbon Management, U.S. Department of Energy (confirmed)

1:30 pm to 3:15 pm — Panel 3. Financial Experts and Investors
• Ronald Barbaro, President & CEO, Quercus Holdings, Inc. (confirmed)
• Alexander Knobil, Director, Energy Project Finance – Americas, Societe Generale (confirmed)
• Bill Schuerman, U.S. Project Director, Aubrey (confirmed)
• John Wiechmann, Senior Advisor to the Secretary-Financial, Department of Energy (confirmed)
• Harrison Stratford, Founder & President, Stratford Energy Group (confirmed)
Objectives of the Panel: Discuss the criteria considered in making investments in next generation coal power generation technology at the pilot scale level, at the larger commercial demonstration scale level (if necessary) and at commercial scale. Include the availability of conventional or innovative financing, express circumstances under which debt or equity funding could be available to support a facility that is constructed and operated to validate technology maturity and readiness after which the project might be divested to or alternatively continue to operate and generate revenues.

3:15 pm to 3:45 pm — Break

3:45 pm to 4:45 pm — Summary of Discussions and Key Findings
Facilitators: Doug Carter (confirmed) and Tom Kuuskraa (confirmed)

4:45 pm — Reception • A Toy Train of the Clyde Streetcar Variety!

DAY TWO • NOVEMBER 19th • BREAKOUT ROUNDTABLES • After breakfast please proceed to your designated breakout room (final summary discussions to take place in Salon V)

7:00 am to 7:45 am — Breakfast • Lower •

8:00 am to 8:45 am — Breakout Roundtable 1: Innovative financing mechanisms designed to support demonstrations of new technology and potential for technology customer support of technology development. (Salon V)

Breakout Roundtable 2: Metrics for determining readiness of technology to be demonstrated (size of demonstration or pilot plant), effectiveness of computer modeling to skip technology development phases. (Salon VI)

Breakout Roundtable 3: Modifications to the current requirements for federal government support (e.g. cost-sharing requirements, taxation in the United States). (Alexandria Room)

Breakout Roundtable 4: The effectiveness of international collaboration, including existing government to government mechanisms. (Mt. Vernon Room)

8:45 am to 10:15 am — Break

10:15 am to 12:00 pm — Summary of Discussions, Key Findings and Concluding Remarks • room •

Thank You

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