High-Rate Carbon Capture & Flexible Power – Technology Tradeoffs

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NATIONAL CARBON CAPTURE CENTER

U.S. DEPARTMENT OF ENERGY | NATIONAL ENERGY TECHNOLOGY LABORATORY

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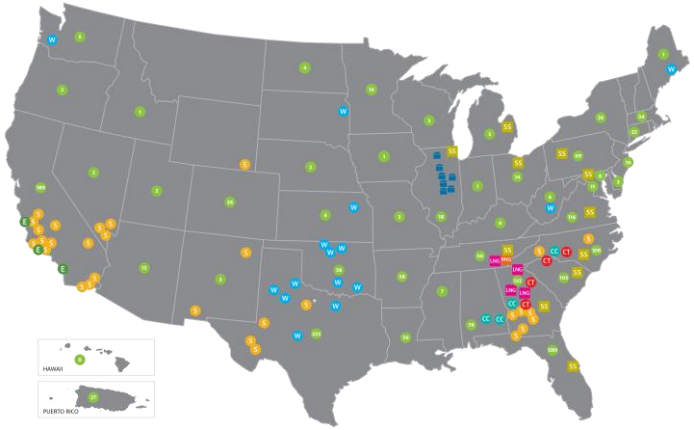


- Capabilities in **50 States**
- **7** Electric & Natural Gas Utilities
- **9 Million** Customers
- **28,000+** Employees
- **~44,000 MW** of Generating Capacity

GHG Emissions Reduction Goals

National Carbon Capture Center

Sponsored by:
U.S. government & energy industry leaders

Managed by:
Southern Company

Located:
Wilsonville, Alabama

Infrastructure:
Real-world industrial operating conditions

Expertise:
Technical staff for design, installation, testing support & analysis

Global collaboration:
Co-founded International Test Center Network

Completed
150K+
Hours of Testing

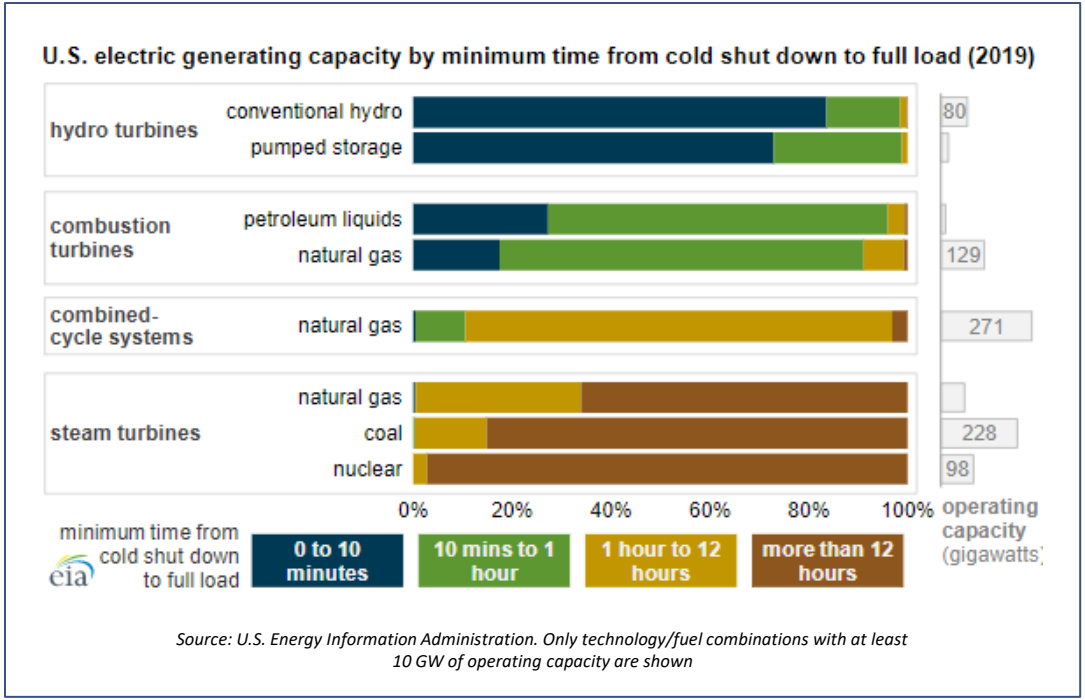
Pilot-tested
80+
Technologies

Developers from
7+
Countries

CO_2 capture cost
40%
Reduction

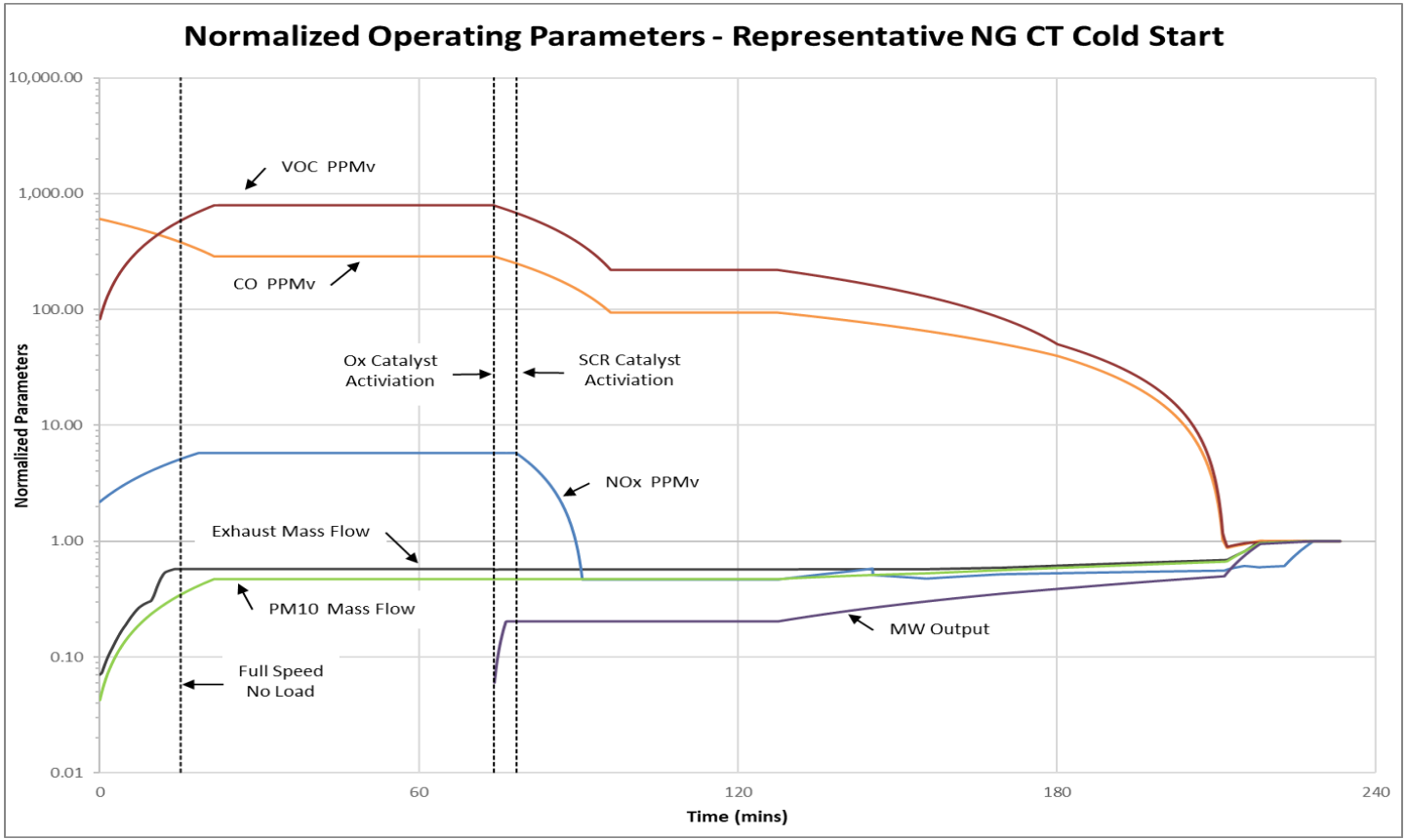
Startup and Transient Emissions

- Startup duration & emissions are unit-specific & variable
  - Impacted by unit type, environmental controls installed, equipment sizes, process & permit requirements
- 3 startup modes – cold, warm, hot
  - Defined by starting boiler/HRSG & steam turbine temperatures
- Emissions driven by time required to place controls in service/optimize performance (combustion & environmental)
  - NGCC – SCR/Ox catalyst temp. in proper range
  - Coal – SCR catalyst temp. in proper range, particulate & sorbent controls meet process requirements
- Impact on CO_2 capture depends in part on level of integration & capture process startup timing



Source: U.S. Energy Information Administration. Only technology/fuel combinations with at least 10 GW of operating capacity are shown

Example of NGCC Cold Startup – Normalized Parameters



Carbon Capture Technologies – Benefits and Challenges

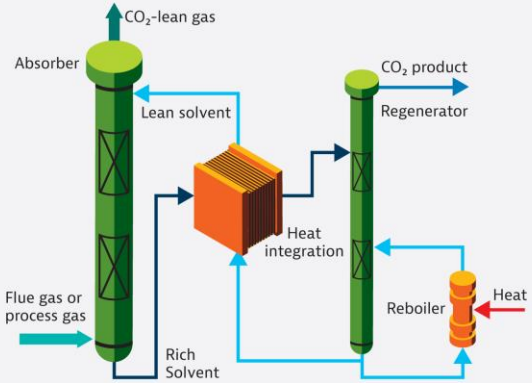
Absorption

Benefits

- Liquid solvent could be stored rich or lean to decouple absorption and regeneration
- Capture turns up as rates are turned down

Challenges

- Limit on ramp-up is how quickly you can heat the working solvent to required temperature
- Potential for higher degradation during higher emission periods



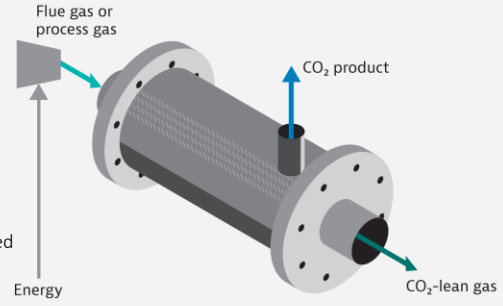
Membrane Separation

Benefits

- Does not require heat input so ramp rate is determined based on compression ramp
- Modularity could help maintain energy efficiency at reduced loads

Challenges

- Material durability/reliability could be impacted by startup or transient conditions
- Reduced feed CO_2 concentration could eliminate possible turndown benefits



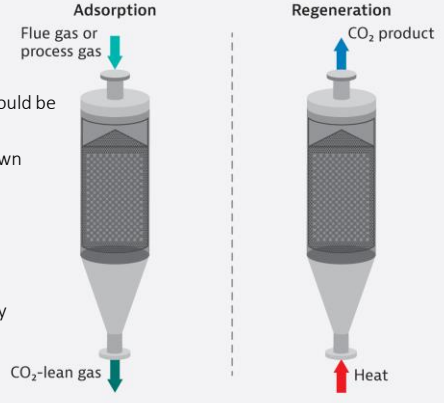
Adsorption

Benefits

- Adsorption could be ready very quickly; system would be designed for the highest rates
- Capture capacity increases as rates are turned down

Challenges

- System will be limited by how quickly heat can be delivered for regeneration
- Material durability/reliability could be impacted by startups/transients



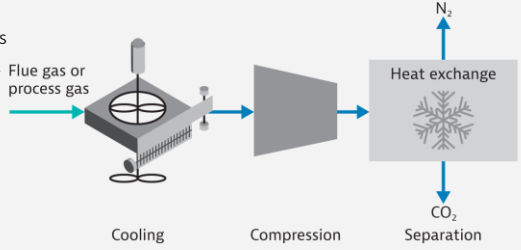
Cryogenic Separation

Benefits

- Potential co-capture of other pollutants could insulate impact of startups/transients
- Liquid product offers opportunity for back-end triaging of CO2 for storage

Challenges

- Will require an ability to "store cold" to drive phase-change
- Ramping/transients may have multiple variables that impact rates



Future R&D Recommendations

- Dynamic testing and control development
  - Example: Carbon Capture Simulation for Industry Impact (CCSI^2)
    Carbon-Capture-Simulation-for-Industry-Impact-CCSI2-Steady-State-and-Dynamic-MEA-Modeling-2017.pdf (nationalcarboncapturecenter.com)
- Development of more robust strategies to decouple carbon capture from transient generator operation
- Emission measurement/characterization and control testing across entire duty cycle
- More detailed understanding of degradation pathways during both transient and non-transient operation

Thanks for your attention!

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