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EERC Partnership for CO_2 Capture (Including Fort Nelson and Zama Project)

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Energy & Environmental Research Center

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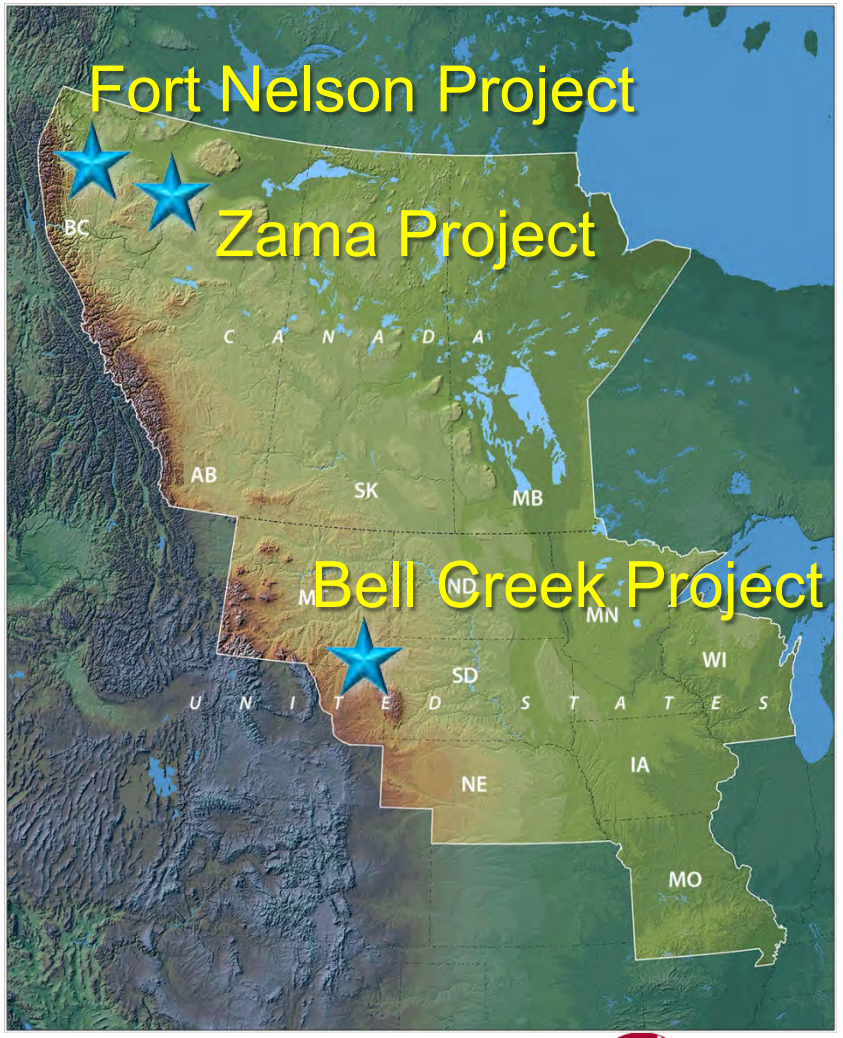
Plains CO2 Reduction Partnership (PCOR) Commercial-Scale Demonstration Phase

- Two 1-million-ton/year-or-greater-scale demonstrations
  - Saline
  - Enhanced oil recovery (EOR)
- Ongoing and effective public outreach
- Continuing regional characterization
- Continued involvement in other carbon dioxide (CO_2) storage projects in the region.
- Continued involvement in carbon capture and storage (CCS) and CO_2/EOR regulations



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Fort Nelson Organizational Chart

Commercial Partners

Regulatory Partners

BC Oil & Gas COMMISSION

BRITISH COLUMBIA
The Best Place on Earth
Ministry of Energy, Mines and Petroleum Resources

Natural Resources Canada

DEPARTMENT OF ENERGY · UNITED STATES OF AMERICA

NETL
NATIONAL ENERGY TECHNOLOGY LABORATORY

EERC
PCOR Partnership
Fort Nelson Demonstration

Research Partners

Spectra Energy SM

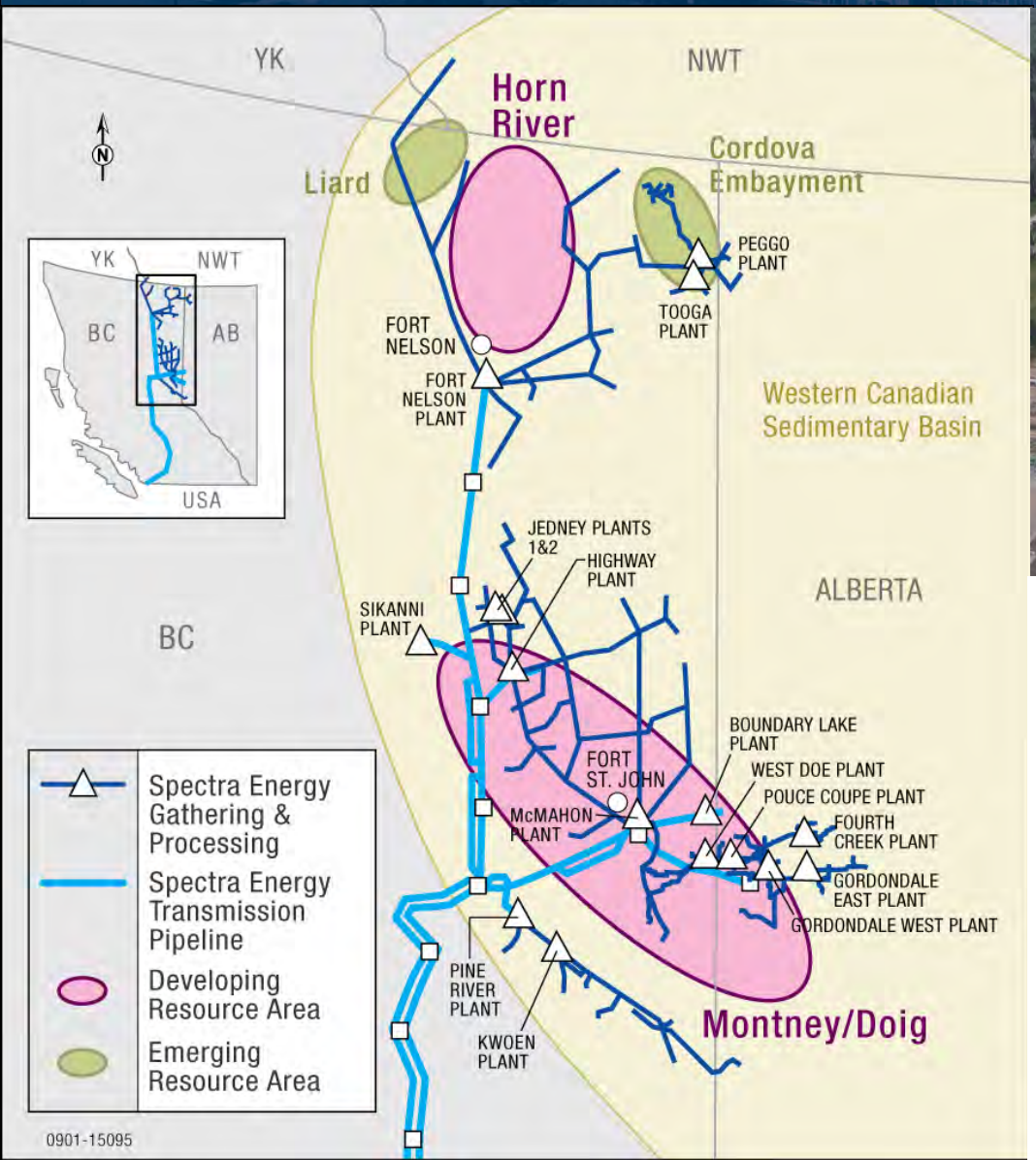
CMG
COMPUTER MODELLING GROUP LTD.

Schlumberger
Carbon Services

RPS Energy

Alberta Innovates
Technology Futures

Fort Nelson Gas Plant



- 1 Bcf/d raw gas-processing capacity – largest facility of its kind in North America.
- Spectra Energy gathering and processing assets are strategically positioned in the growing Horn River Basin, processing both conventional and unconventional shale gas resources.
- The Fort Nelson CCS project is a potential solution to mitigate CO_2 emissions as shale gas production grows.

Bell Creek Organizational Chart

Commercial Partners

Regulatory Partners

Wyoming Office of State Lands and Investments

Montana Board of Oil and Gas Conservation

Wyoming Oil and Gas Conservation Commission

Wyoming Pipeline Authority

EERC
PCOR Partnership
Bell Creek Demonstration

Research Partners

Denbury

Baker Hughes

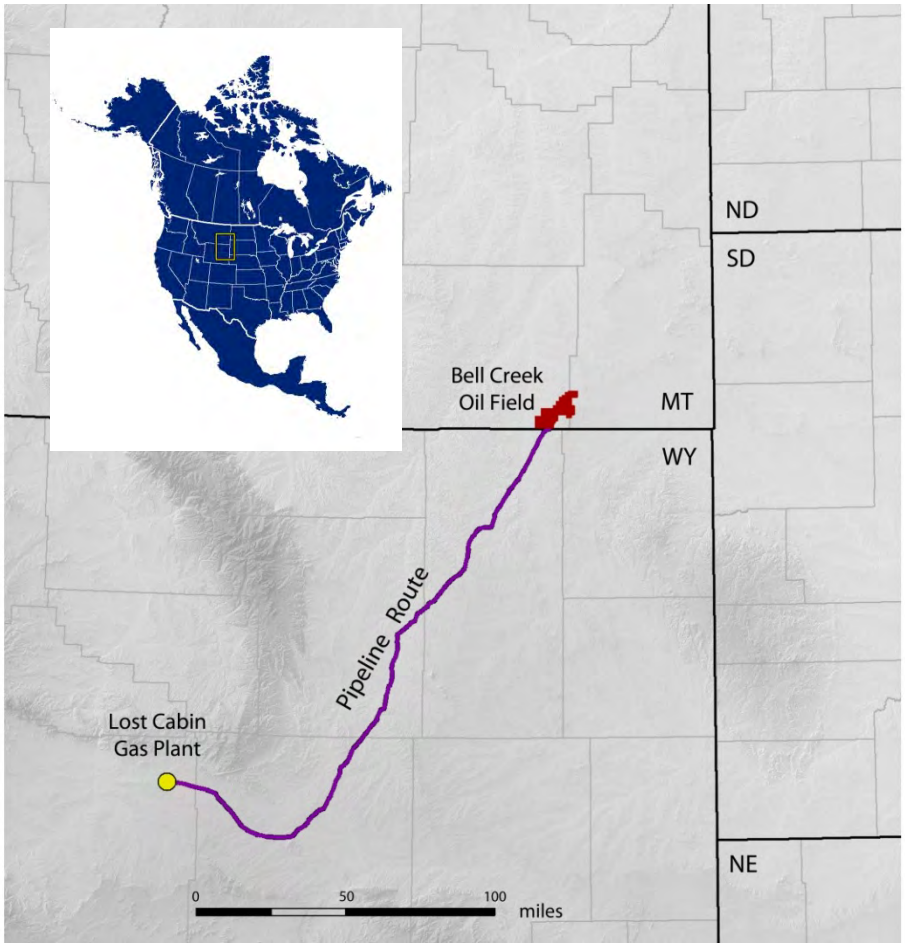
Schlumberger Carbon Services

CMG Computer Modelling Group Ltd.

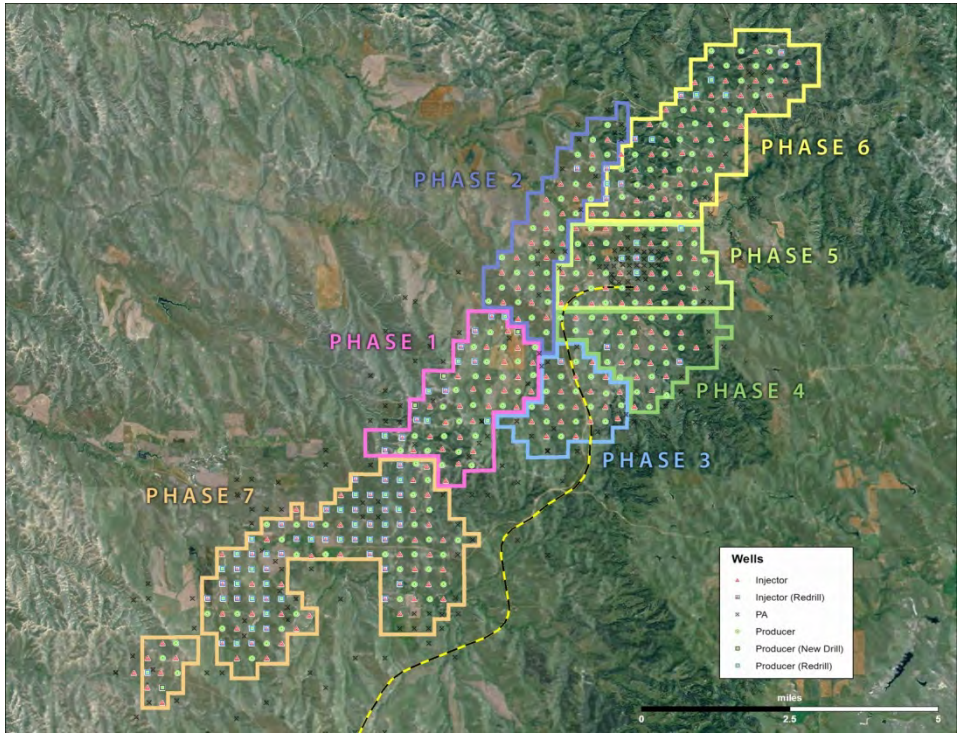
Halliburton

Bell Creek Logistics

232-mile pipeline operational by December 2012.



CO_2 injection to begin in December 2012.

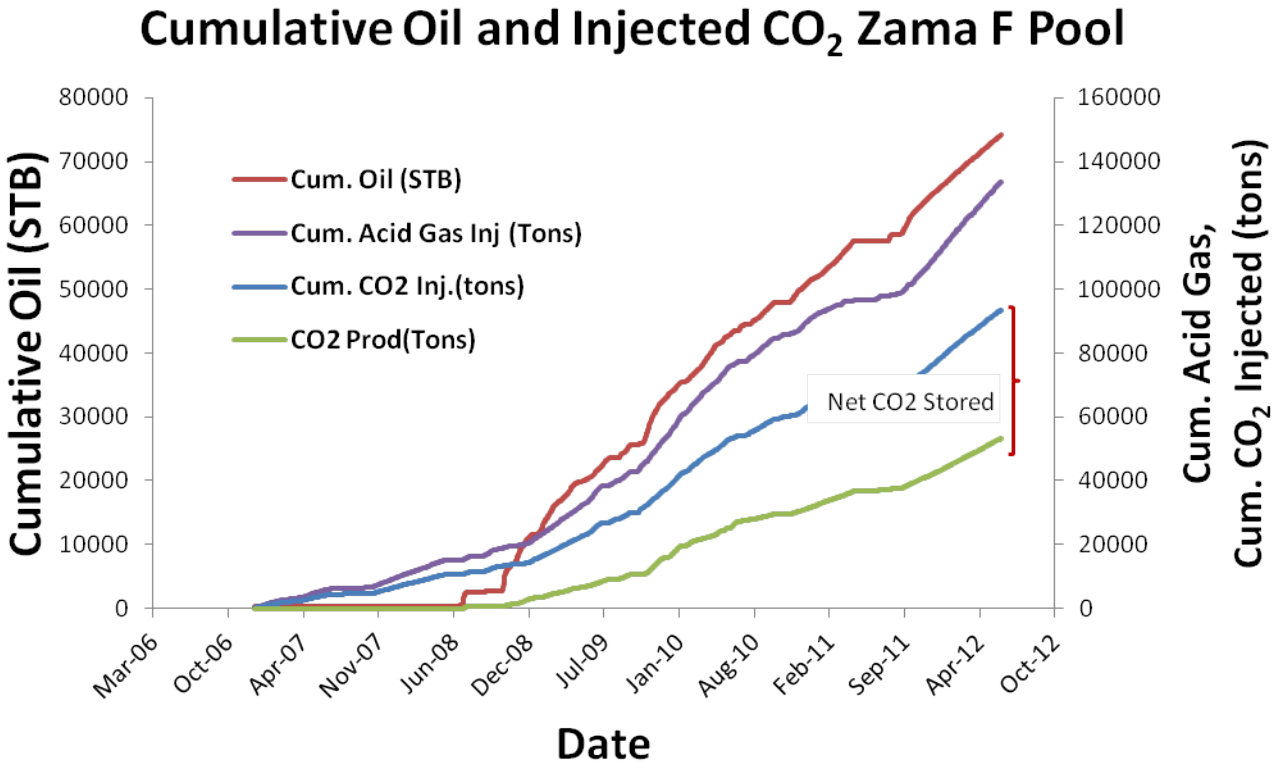


Bell Creek Project Benefits

35 million barrels
of incremental oil

. . . millions of tons of CO_2 safely in storage

Zama Project Update - Cumulative Injection and Production through May 28, 2012

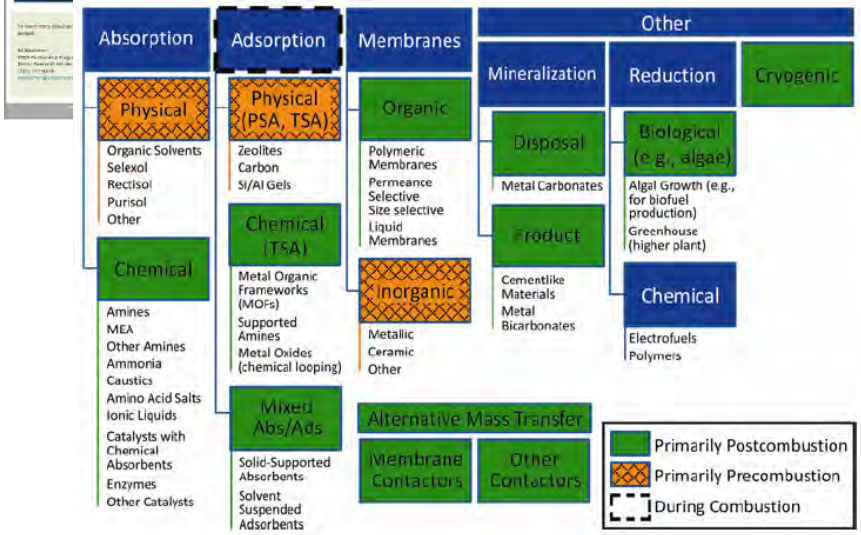


- Acid Gas Injected: 133,550 tons
  - CO_2: 93,485 tons
- Oil Produced (bbls): 74,202 bbls
- Net CO_2 Stored: 40,357 tons

Conclusion

The PCOR Partnership region has huge CCUS potential!

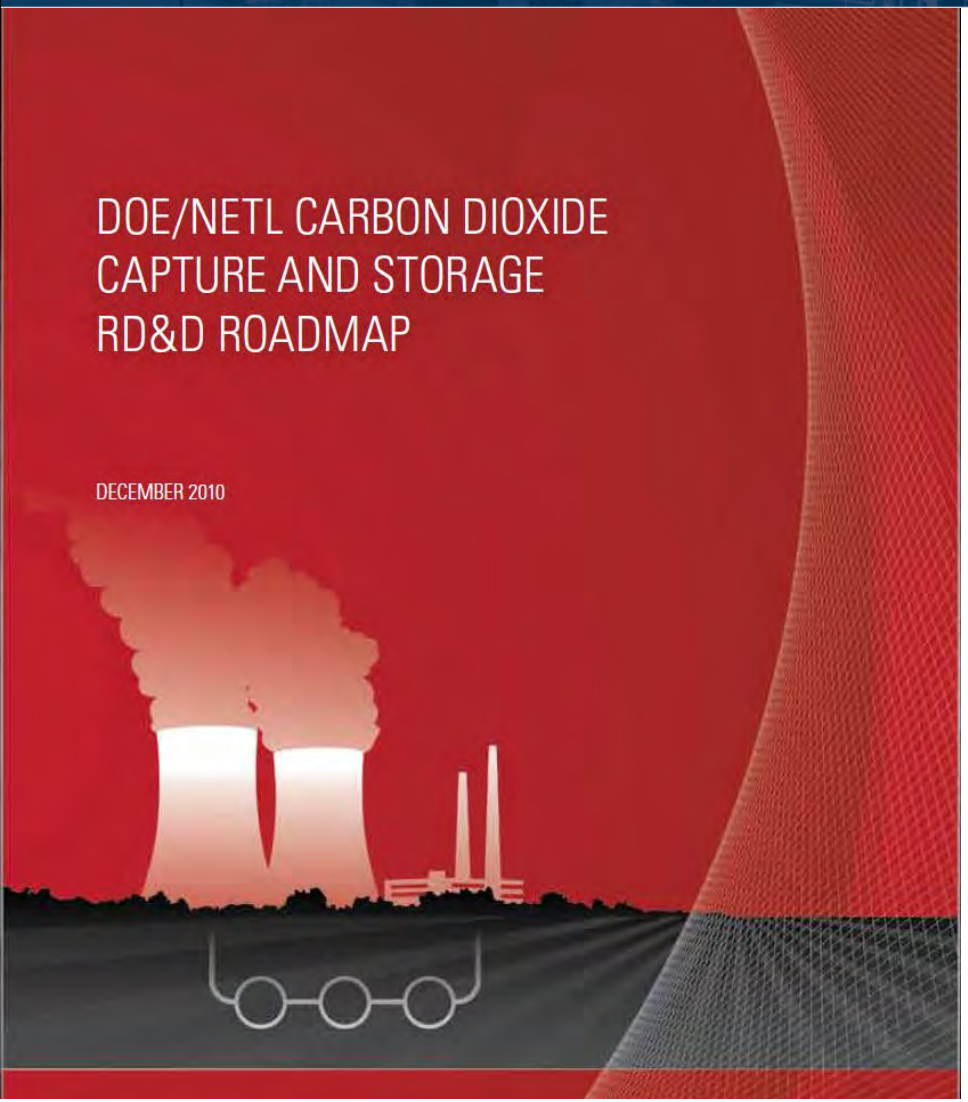
Interactive CO_2 Capture Technology Summary



The CO_2 capture technology document is being adapted for inclusion on the PCOR Partnership Partners-Only Decision Support System. **Interactive features** will allow the user to access:

- Summaries of the three capture platforms (pre-, during, and postcombustion)
- Summaries of the various technology types (adsorption, absorption, membrane, cryogenic, etc.)
- Specific technology information
  - Description
  - Development status
  - Developer name(s)
  - Process schematic
  - References

DOE NETL Program Goals



U.S. Department of Energy (DOE) National Energy Technology Lab (NETL) technology goal: "To develop, by 2020, fossil fuel conversion systems that offer 90% CO_2 capture with 99% storage permanence at less than a 10%–35% increase in the cost of energy services."

CO_2 Capture Technology Status

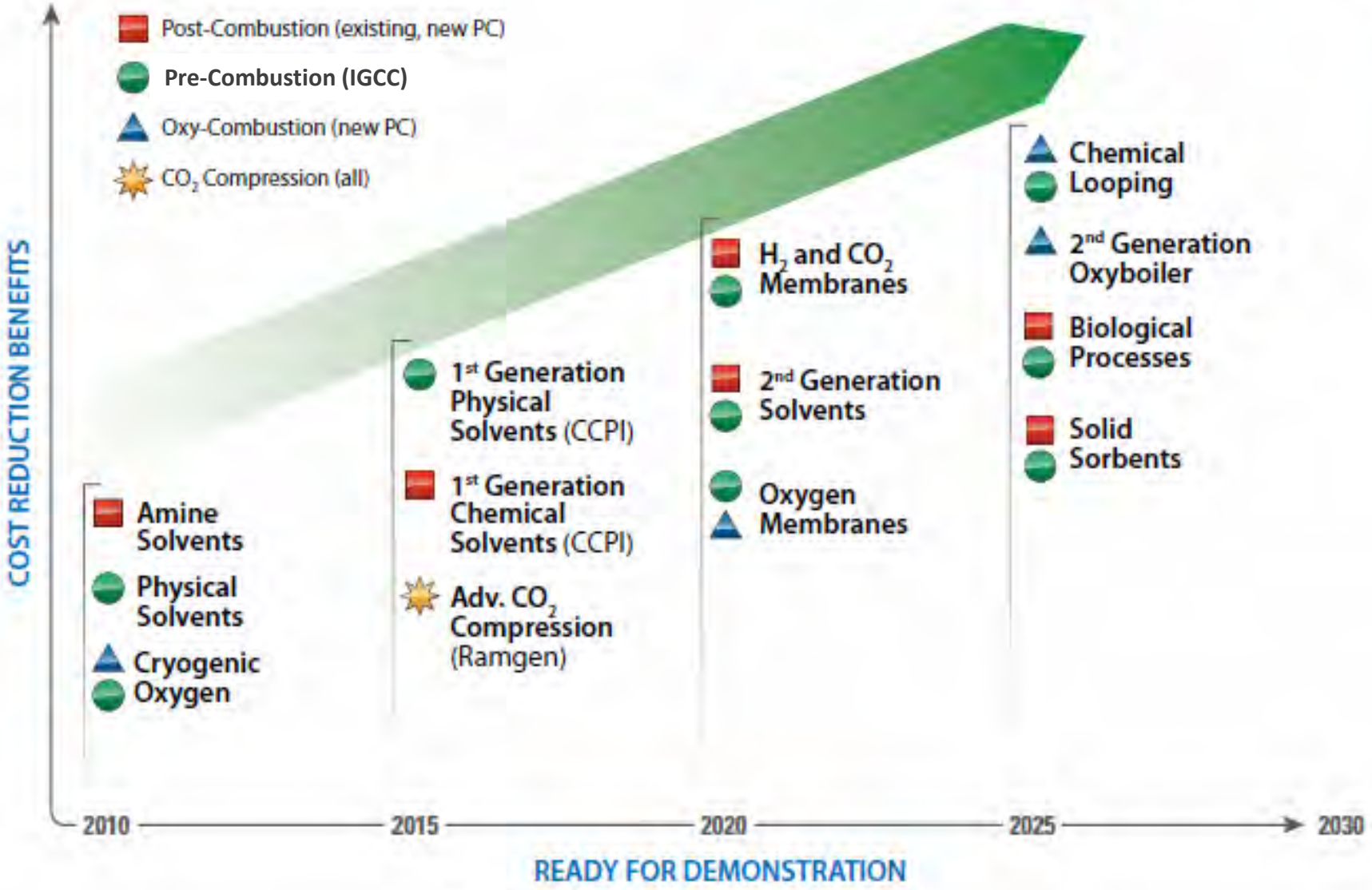


Figure 2-13. DOE/NETL CO_2 Capture Technology Development

PCO_2C Summary

Advancing the state of CO_2 capture by evaluating and developing those technologies that are nearest to commercial viability for utility applications.

- Multiple-phase program.
- Includes funding from private sector sponsors (27), the North Dakota Industrial Commission, and the U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL).
- Identify technology challenges and develop strategies for cost-effective and efficient implementation at the power utility scale.

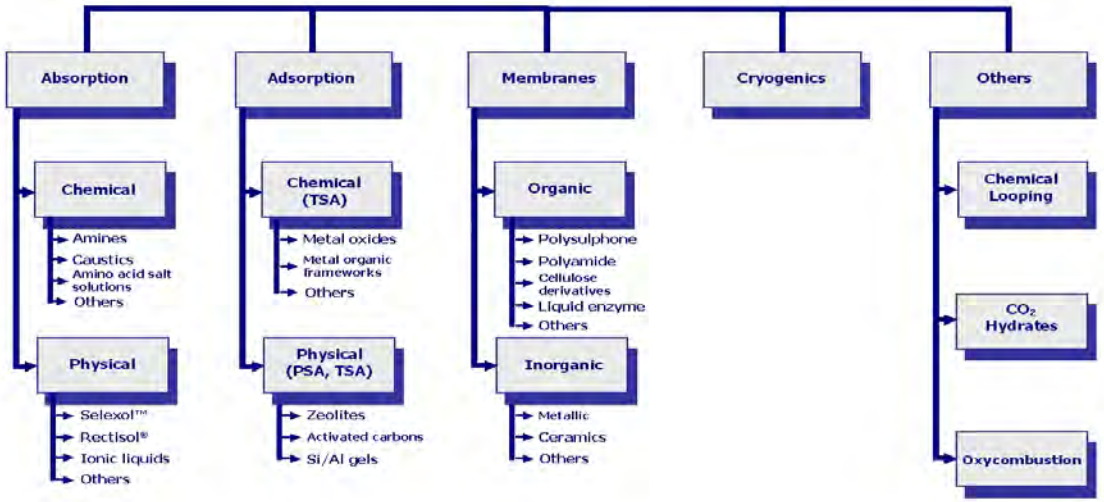
PCO_2C Sponsors

State of Wyoming
Clean Coal
Technology Fund

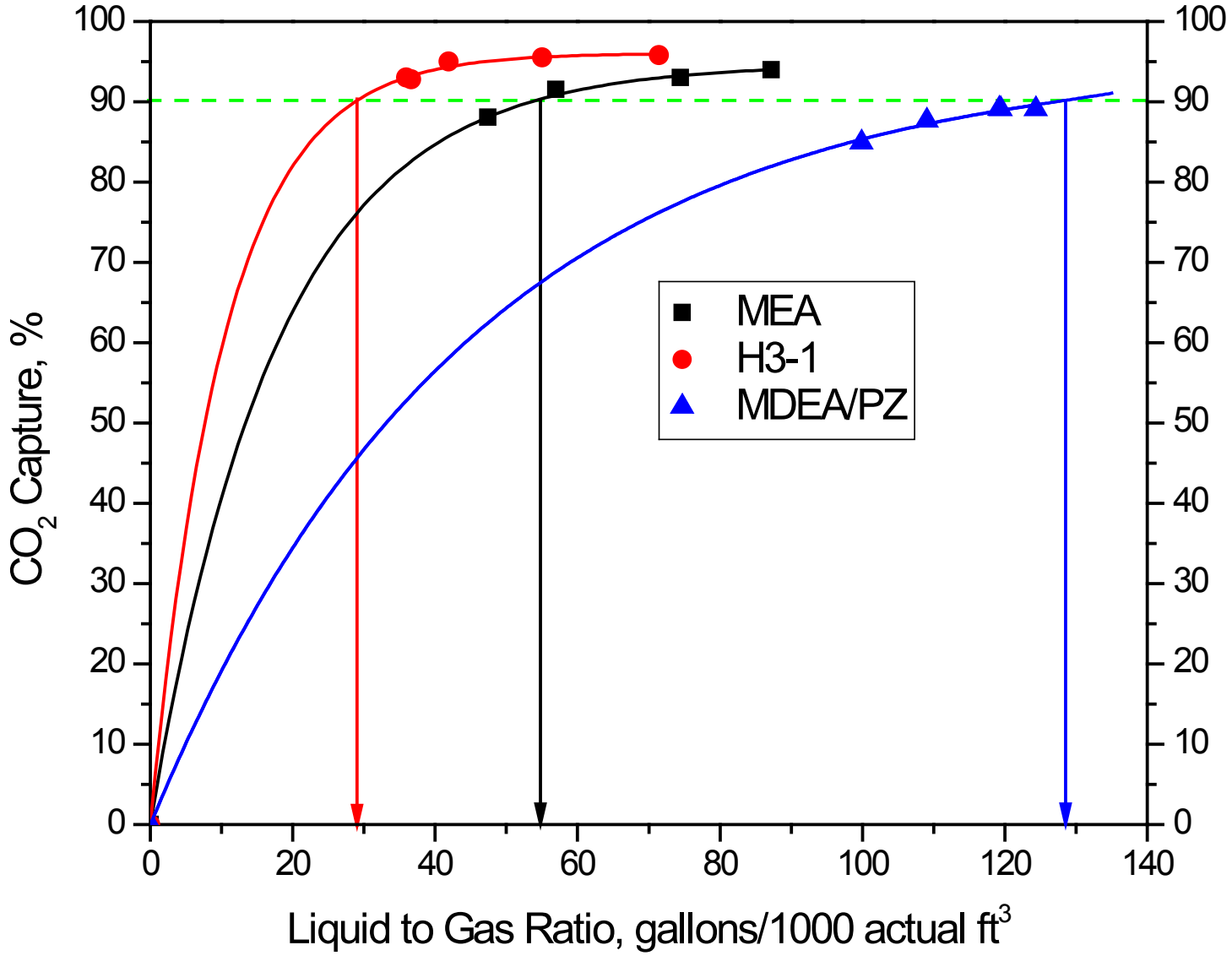
Summary of CO_2 Capture Technologies

Technologies Under Evaluation

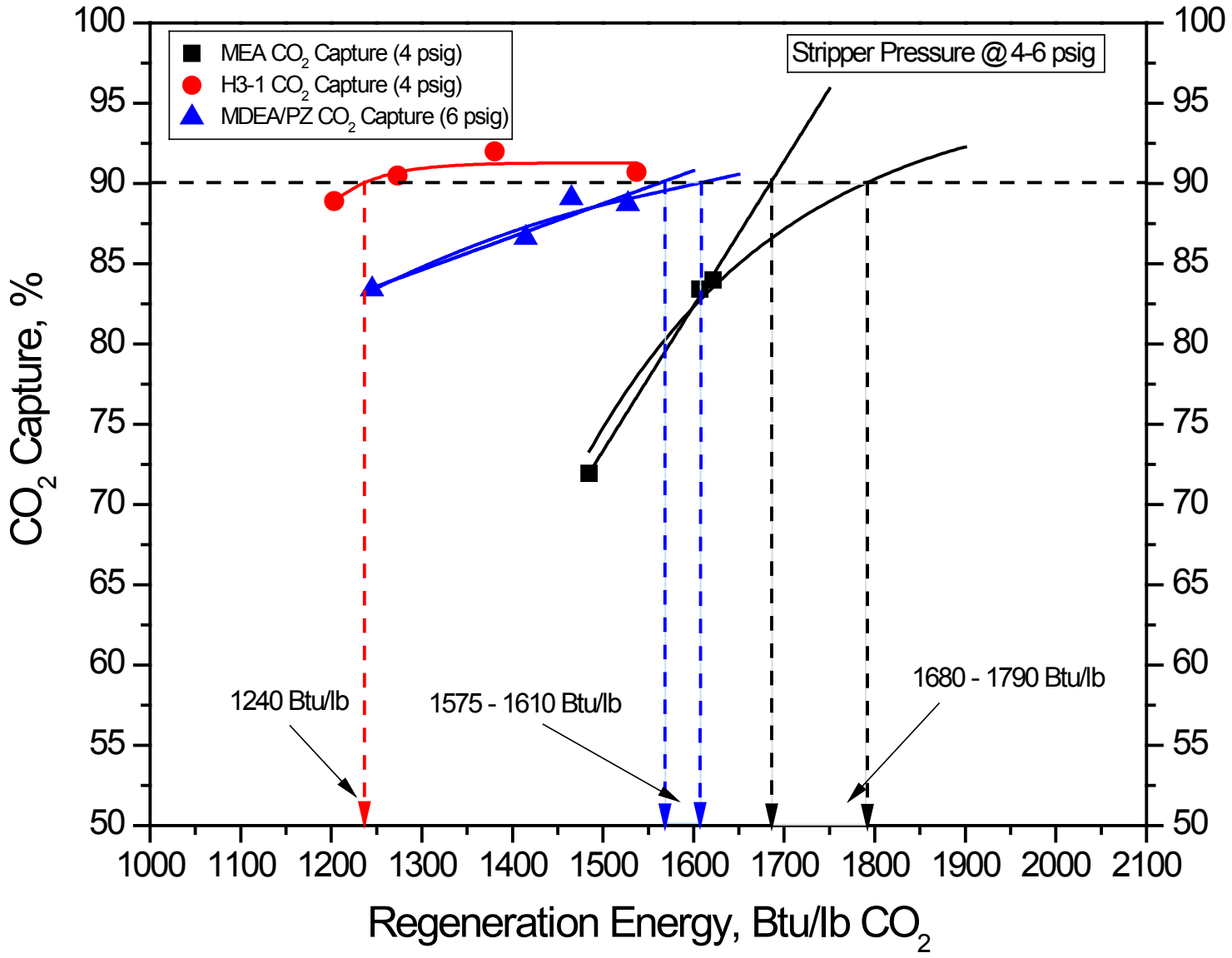
- Solvents
  - Monoethanolamine (MEA) – Phase 1
  - Hitachi H3-1 – Phase 1 & 2
  - Methyldiethanolamine (MDEA)–piperazine – Phase 1
  - Cansolv – Phase 2
  - Huntsman – Phase 2
  - ION Engineering – Phase 2
- Oxy-Combustion – P1 & 2
- Solid Sorbents – Phase 2
  - NETL
- Other
  - C-Quest (slurry based) – Phase 2
- Solvent Additives
  - Baker Hughes – Phase 1
  - Huntsman – Phase 1 & 2
  - Advanced Solvent Contactor (NSG)



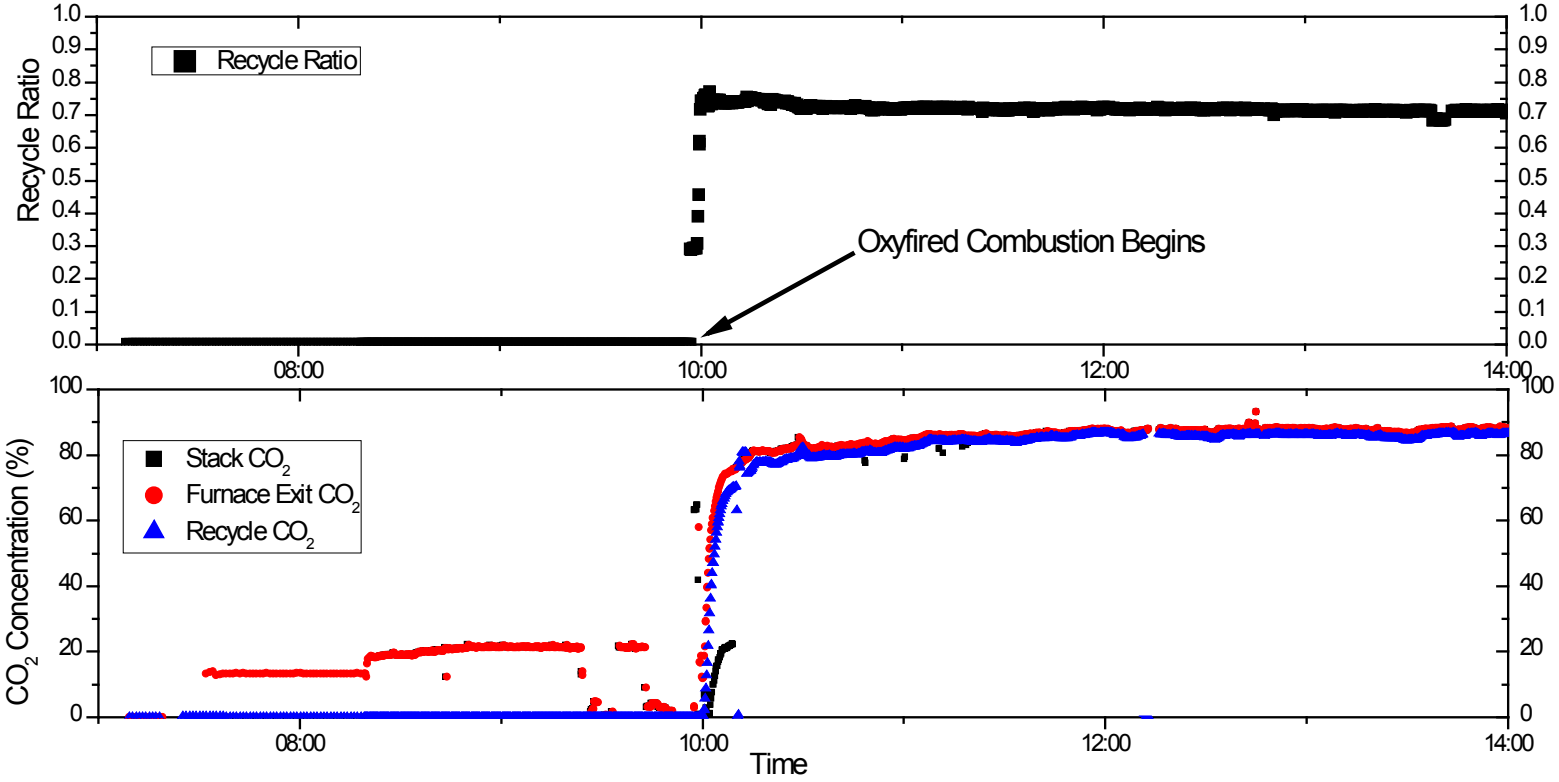
CO_2 Capture vs. Liquid-to-Gas Ratio



CO_2 Capture vs. Regeneration Energy

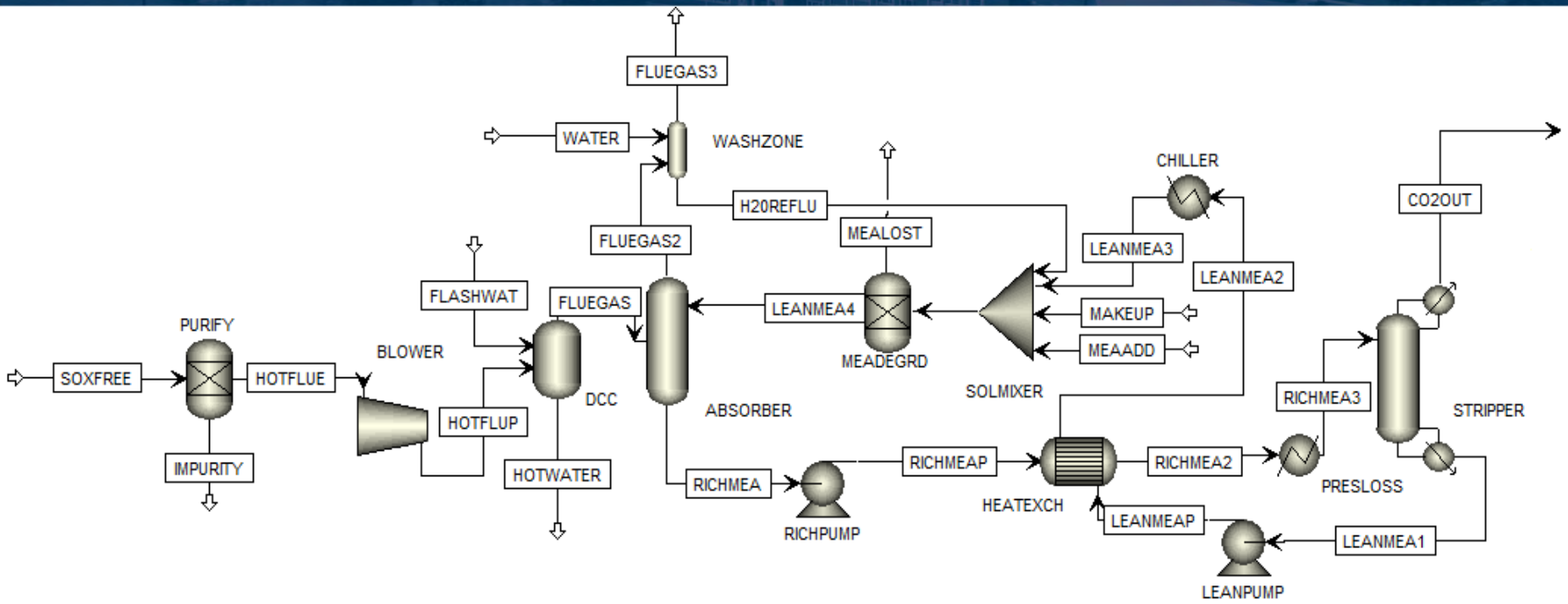


Example of CO_2 Concentration



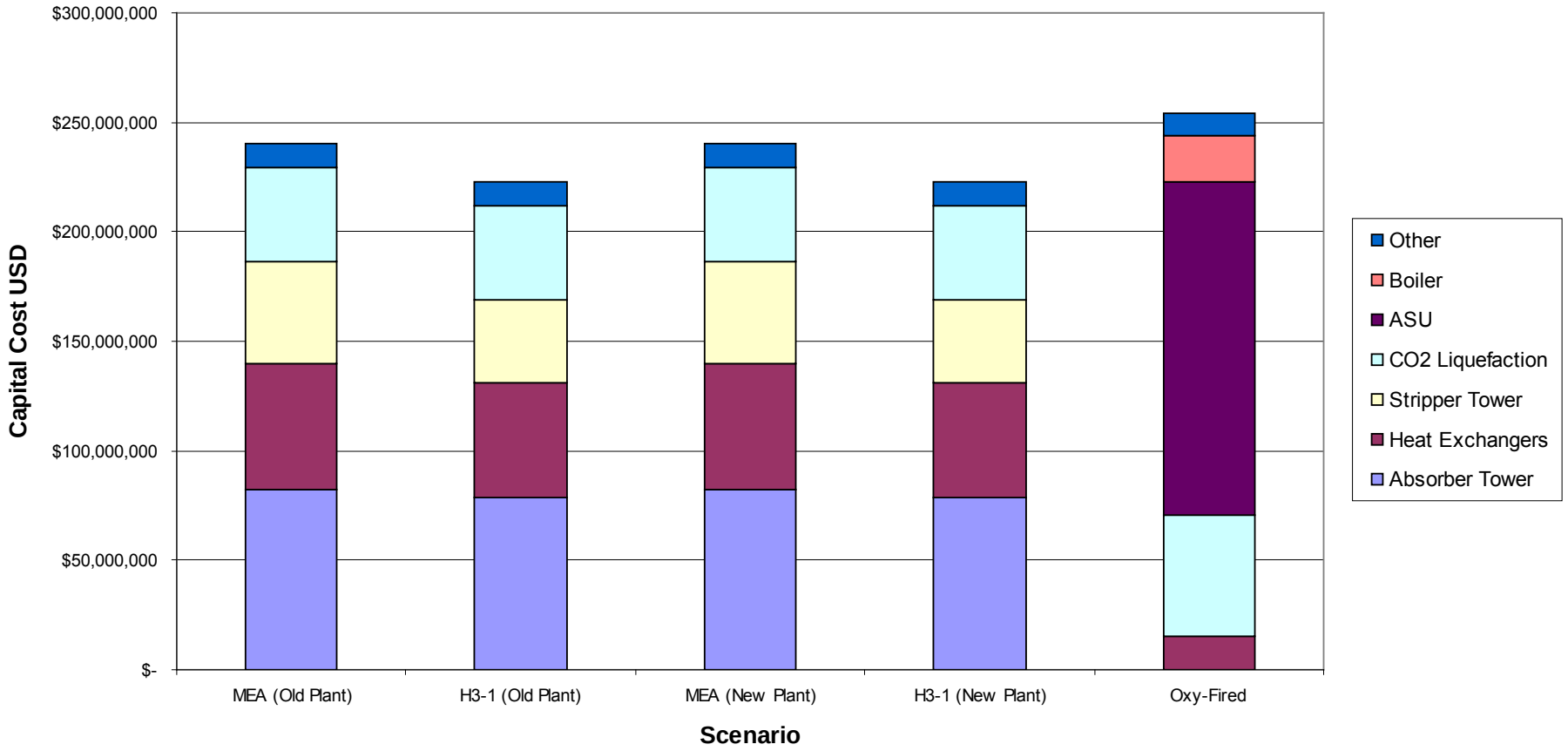
Flue Gas CO_2 Concentration from Run 1046 Using Paintearth Subbituminous

500-MW Aspen Plus® Model for CO_2 Capture

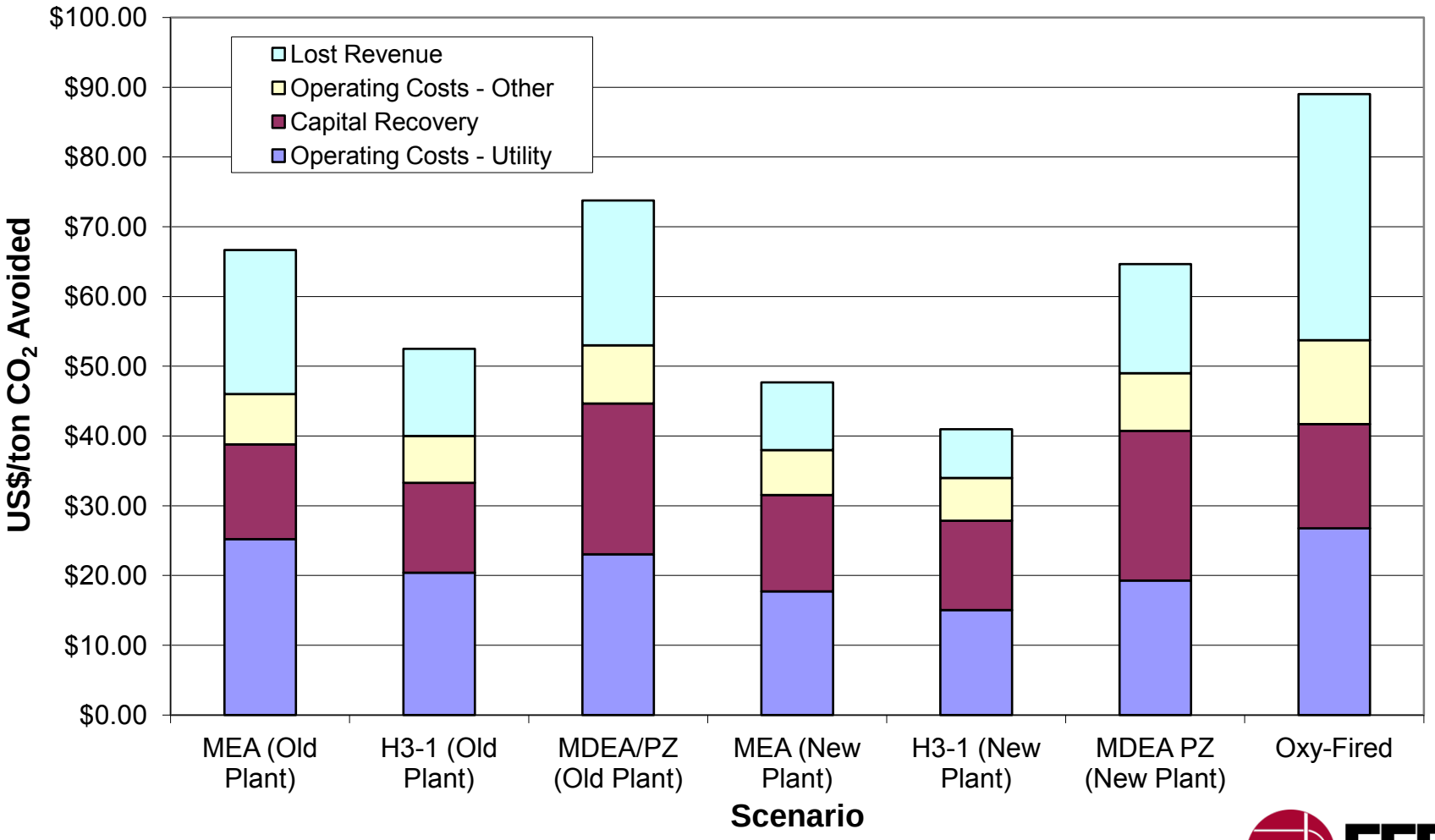


- 90% of CO_2 is removed from flue gas in absorber tower by MEA solvent.
- MEA losses from degradation are estimated from pilot-scale data.
- Wash zone minimizes MEA evaporation losses in absorber tower.

Capital Cost Comparison



Cost of CO_2 Avoided



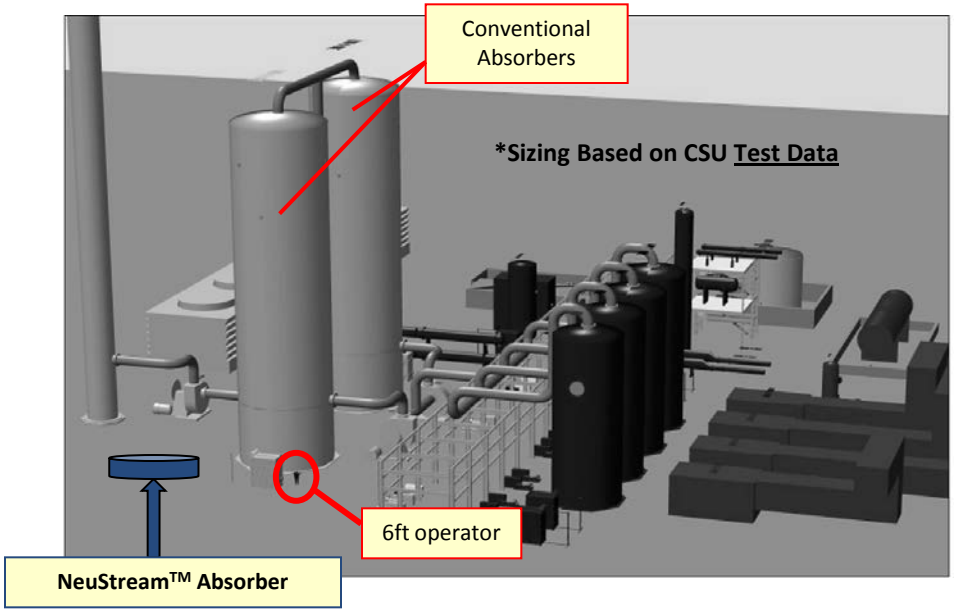
Development Focus Areas for CO_2 Capture Implementation in Coal-Fired Power Plants

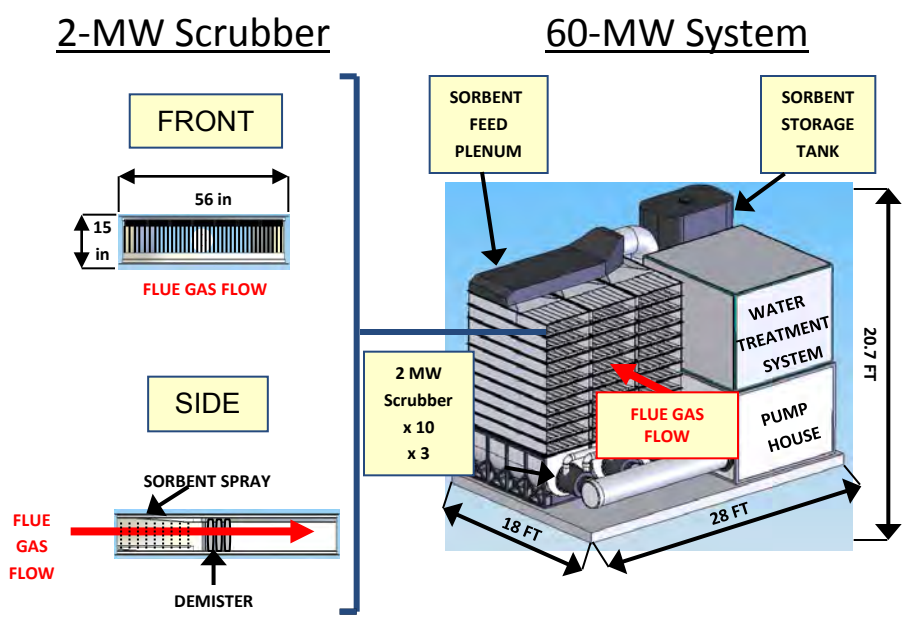
- Scale-up
- Energy penalty
  - 20% to 30% less power output
- Cost
  - Current costs are $40 to $80 per ton of CO_2 (80% ICOE).
  - Very capital intensive ($1500 to $2000/kW).
- Contaminants
- Resource availability and sector readiness
  - Supply of solvents or sorbents will be limited.
  - Manufacture of air separation units (ASUs) and other large equipment will be a handcuff to implementation.
- Regulatory framework
  - Lots of unknowns and liability issues.

Evaluation of Novel Technologies for CO_2 Capture

- Neumann Systems Group's NeuStream-C™ system.
- Pilot-scale evaluation to determine the performance and economics of the NeuStream-C system.
- The end result of the program is focused on the development of lower-cost and more effective capture technologies and their integration into a total system that provides substantial economic and environmental benefits.

NeuStream Capture and Processing Systems





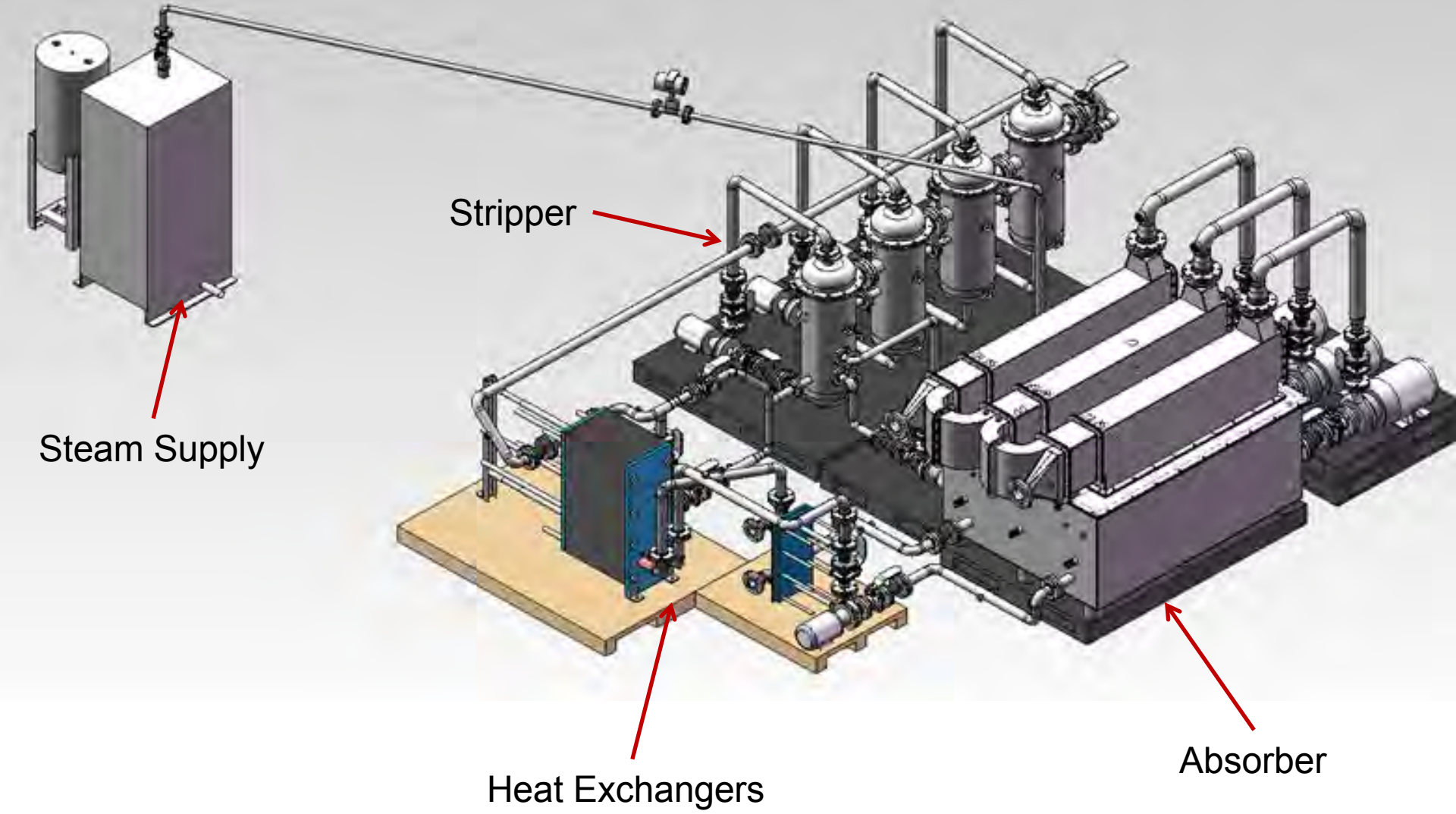
Up to 90% Smaller

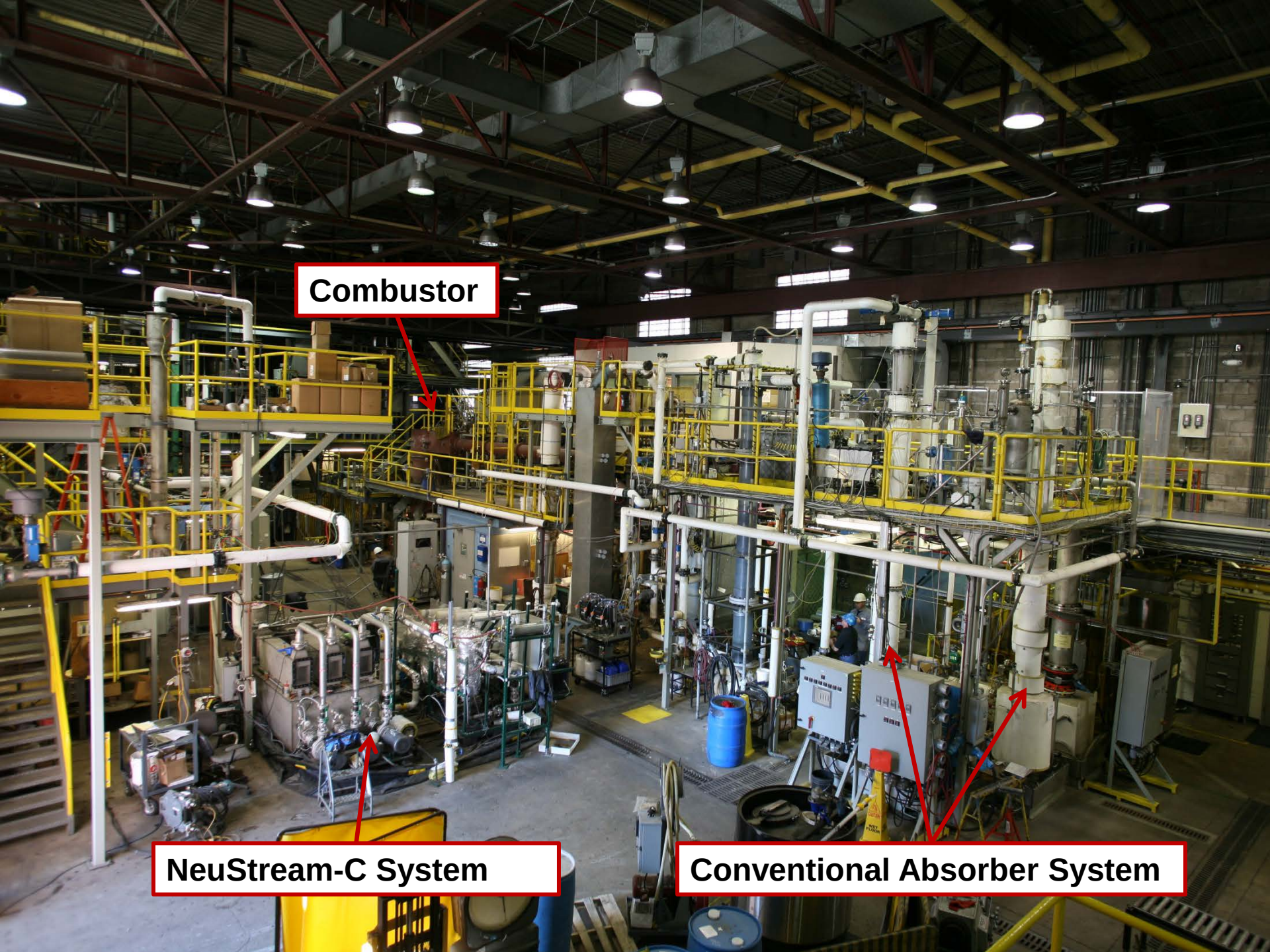
Modular Design

Up to 50% Lower CapEx
Up to 40% Lower OpEx

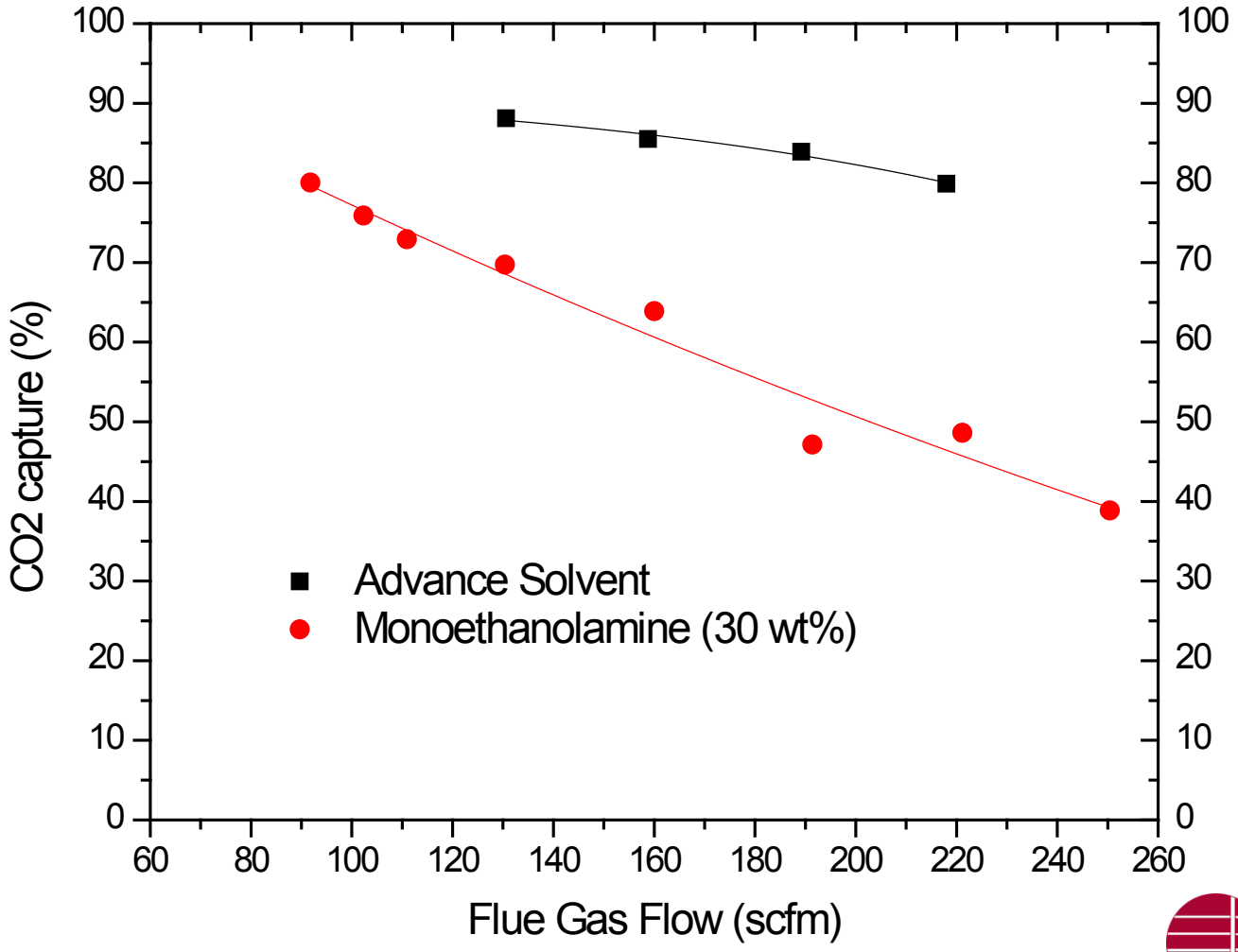
Through NSG Mechanical Advancement
Useful with Variety of Chemistries

Current System Design

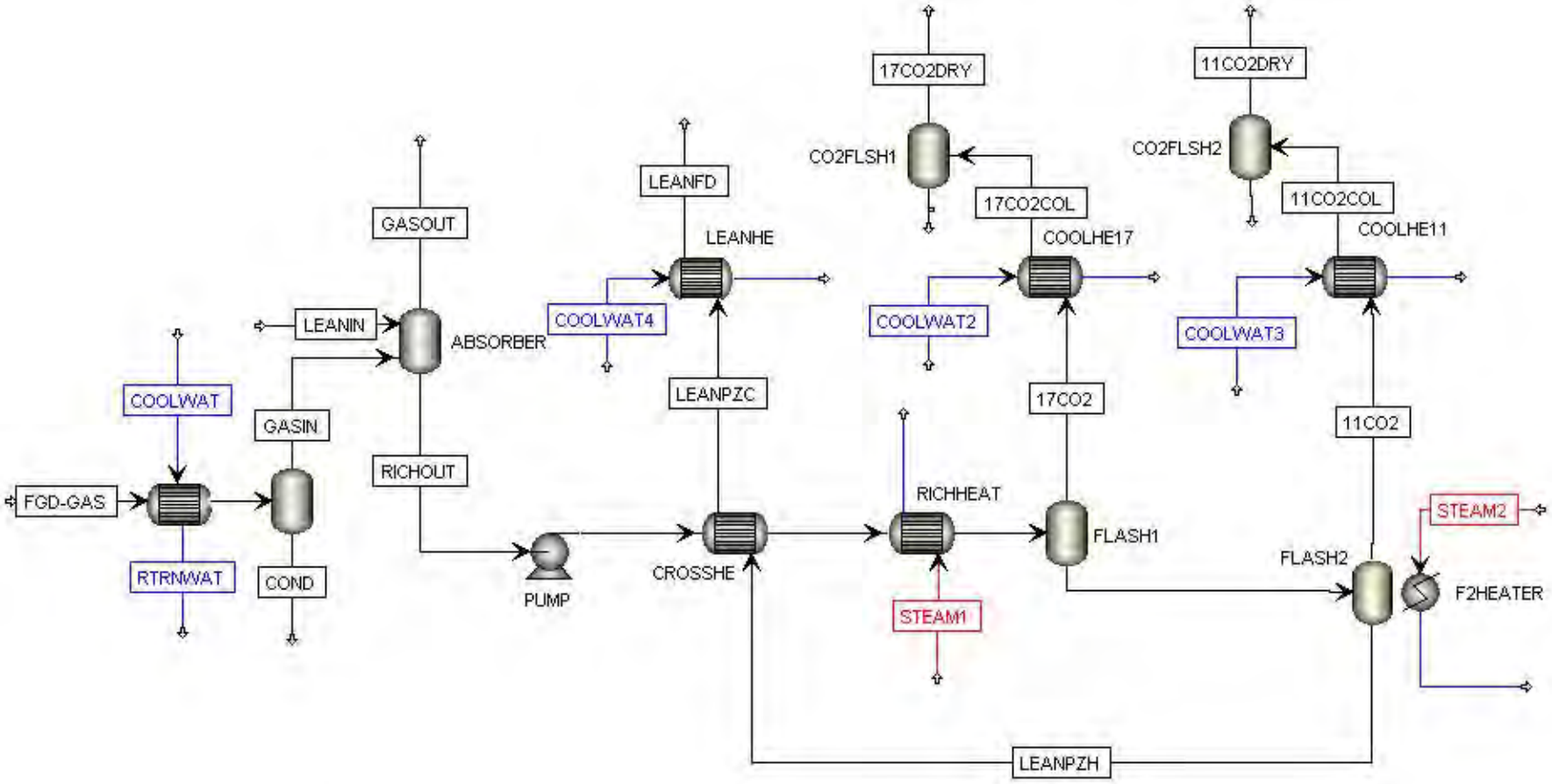



Combustor
NeuStream-C System
Conventional Absorber System

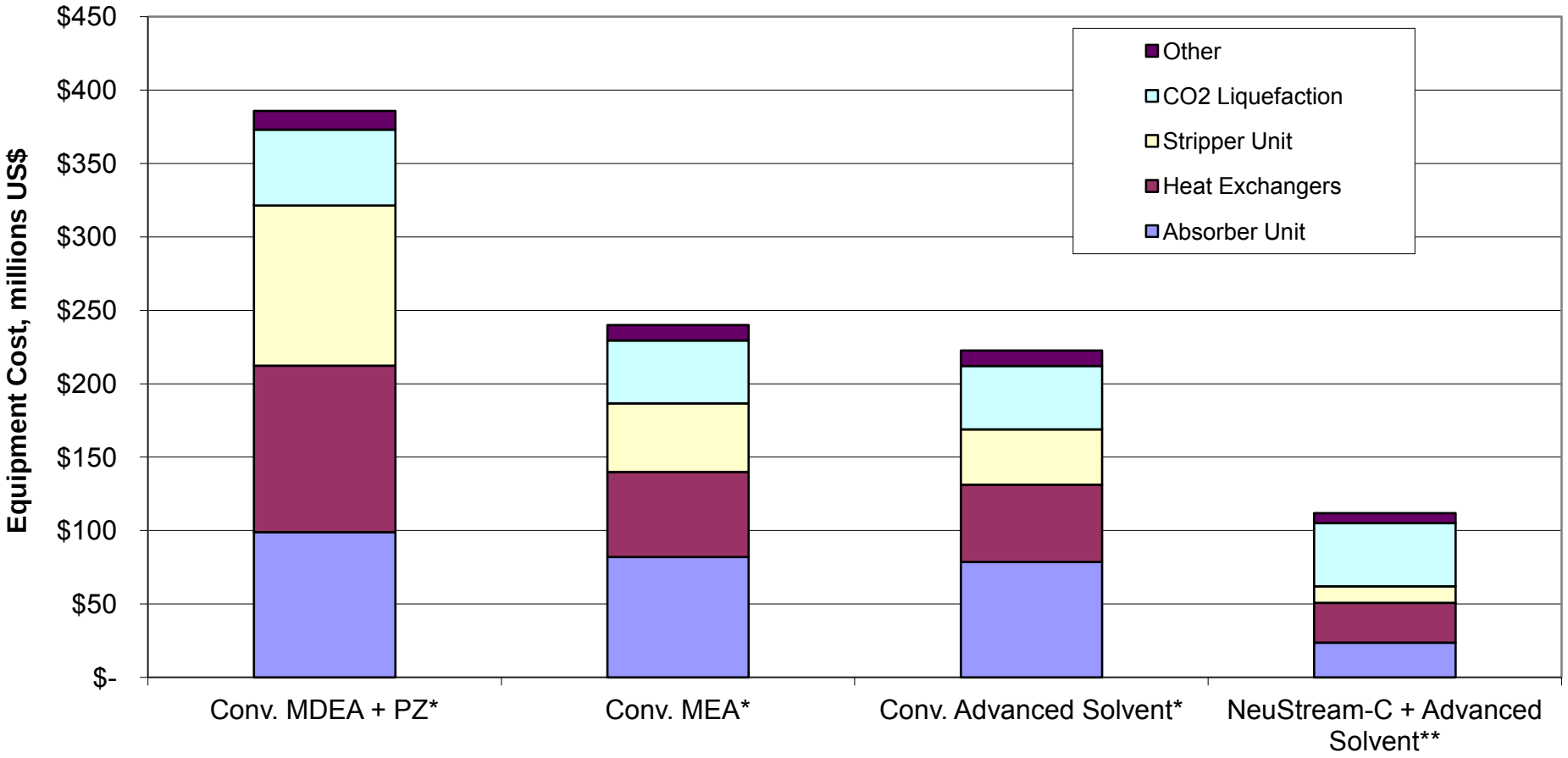
Preliminary Capture Results



Preliminary Modeling Results



Capital Cost Comparison



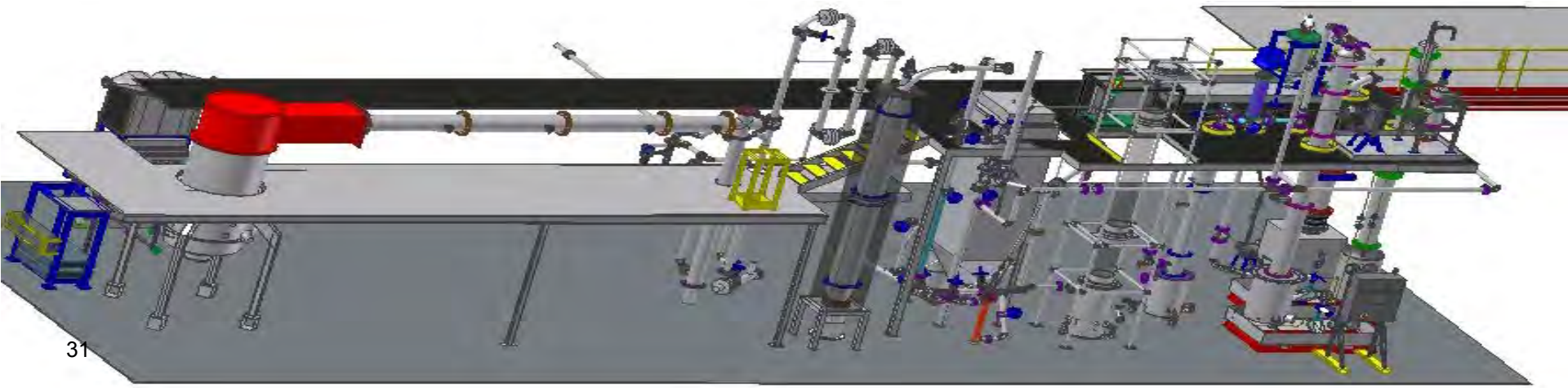
* Based on PCO_2C Phase I results scaled up to a 500-MWe plant.
** Based on preliminary data scaled up to a 550-MWe plant.

Partnership for CO_2 Capture: Phase II

Pilot-scale testing of CO_2 capture technologies

Over 10 test campaigns evaluating eight different technologies

- **Several technologies will be further evaluated, and new novel approaches will be tested.**
  - Solvents: Huntsman, Hitachi, CanSolv (Shell), and Advanced Systems (NSG Contactor)
  - Solid sorbents (NETL)
  - Oxy-fired combustion (completed)
  - Other solvent-based technologies: ION Engineering
  - Slurry-based approach (C-Quest)



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