



POLARIS MEMBRANE SYSTEMS FOR HIGH CAPTURE RATES

Tim Merkel, VP Technology

Net-Zero Flexible Power

High Capture Rate Project Review Meeting

June 6-7, 2024



150 TPD Large Pilot at WITC

MTR Development Timeline

▼

15 Year
Development
History

▼

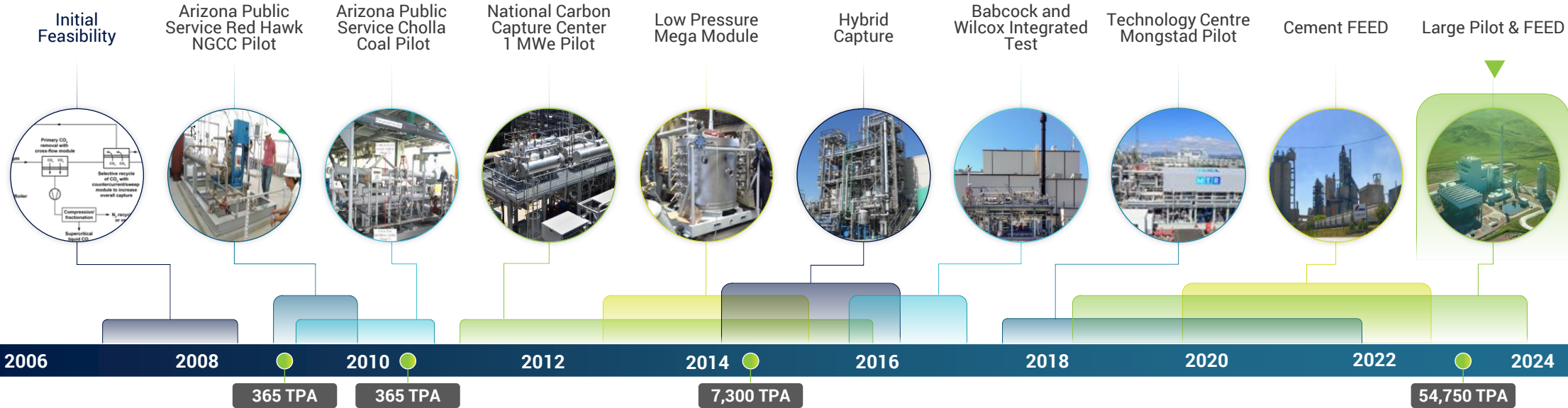
20+
DOE Awards
Won

▼

>\$140mm
Total Funding
Received from DOE

- Support from the DOE through many competitive awards has helped MTR bring membrane carbon capture technology from early concept to near commercialization
- Together, the DOE and MTR have collaborated to provide U.S. plants with sustainable carbon management options

MTR / DOE Development Timeline



MTR Large Pilot at WITC will be the Largest Membrane Capture Plant in the World

Pilot Plant Progress

Ceremonial Groundbreaking Event, May 2, 2023



- Todd Telesz**
CEO
Basin Electric
- Tim Merkel**
MTR
- Brice Freeman**
MTR
- Mark Gordon**
WY
Governor
- Brett Andrews**
MTR

Membrane Container Arrival, May 2024



Construction at WITC is nearing completion and the pilot is expected to be fully operational by Q4 2024



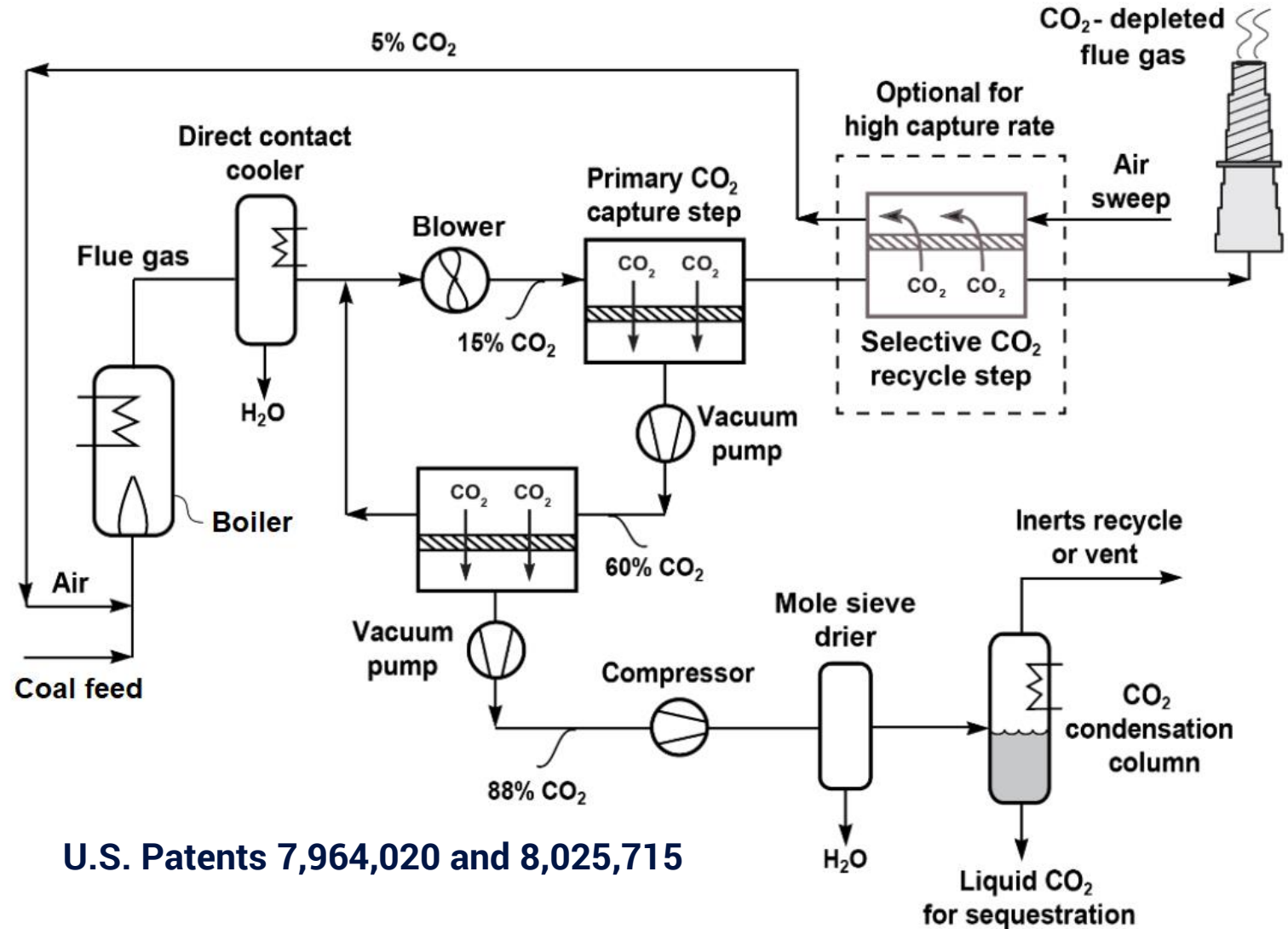
Pilot Plant Statistics

- ▶ **150 TPD CO₂**
~55,000 TPA of CO₂
- ▶ **Q4-2024**
Begin Operations

Project Team

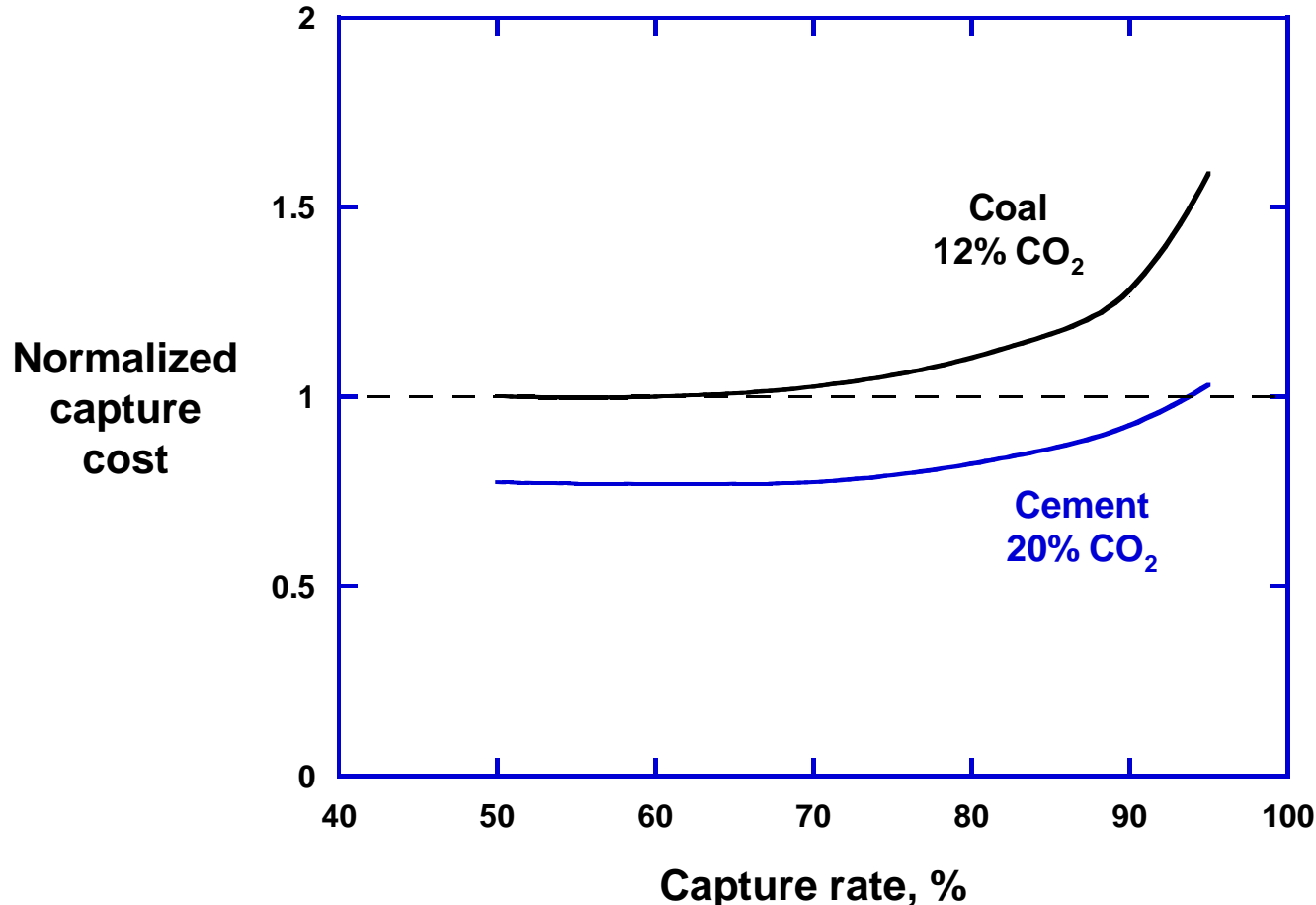
Simplified MTR Capture Process Diagram

- Typically, a two-stage membrane design with CPU is used for 90% capture at pipeline spec purity
- Selective recycle and/or hybrid steps can be used for high capture rates >95%
- As passive, modular technology, membranes are inherently flexible → high turndown, near instantaneous response



U.S. Patents 7,964,020 and 8,025,715

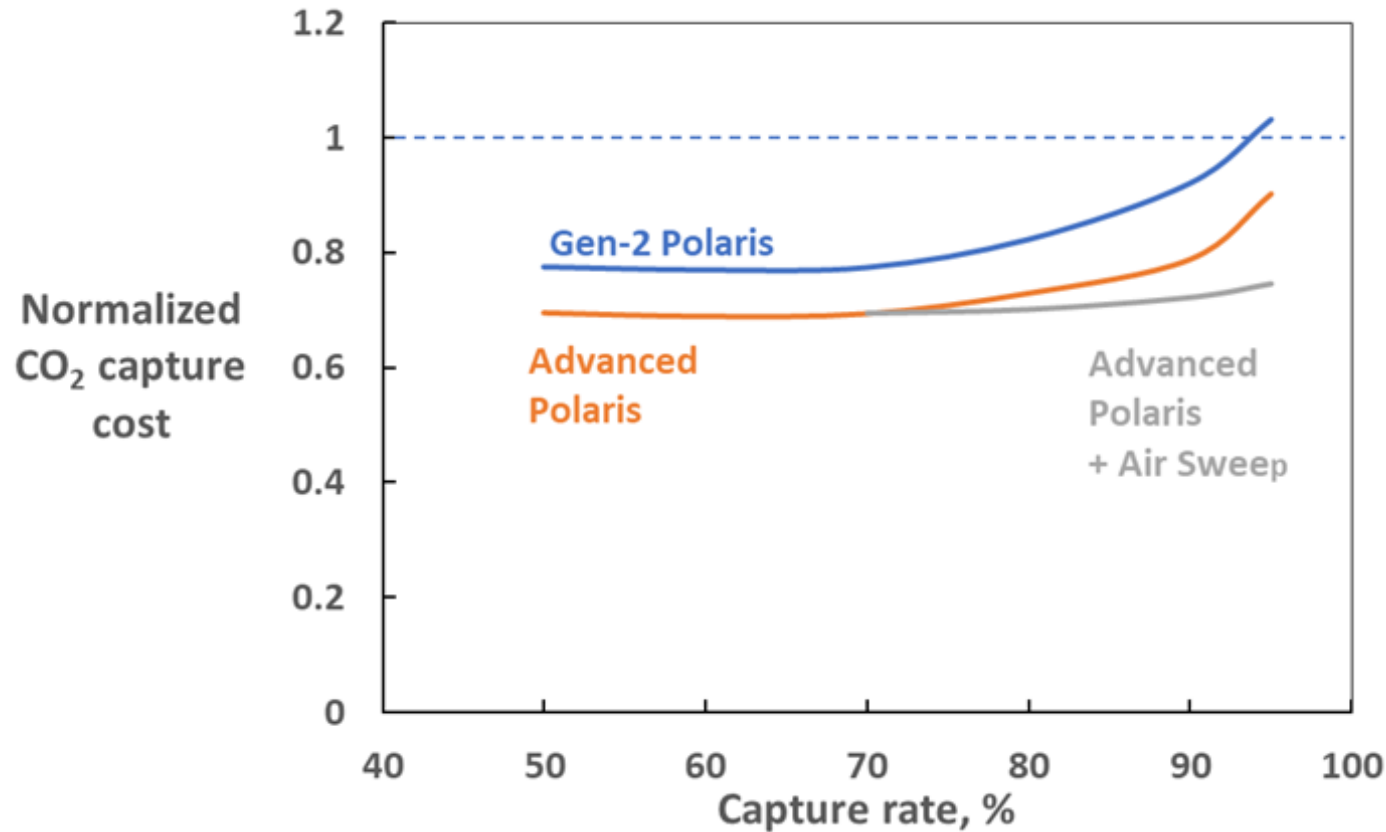
High Capture Rates with Membranes are More Affordable for High CO₂ Content Industrial Streams



Capture cost is normalized to 60% capture from coal using Polaris Gen2 membranes

- Membrane capture costs increase with increasing capture rate, particularly above 90% capture
- However, membrane cost is less sensitive to capture rate for higher feed CO₂ content; higher capture is more affordable for industrial streams (cement, steel, refinery, etc)
- Membranes are an all-electric capture process; high capture rates when electricity prices are low?
- Calculations are for a two stage membrane with no selective recycle

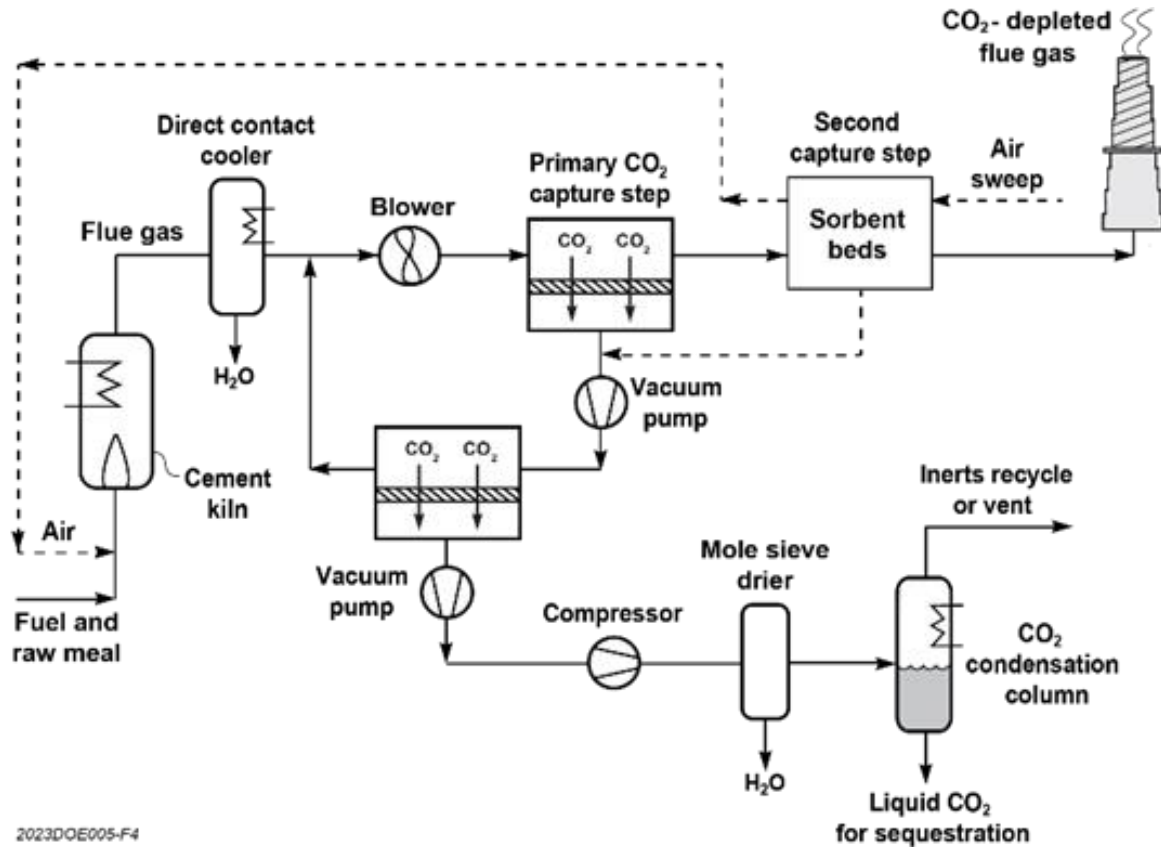
Better Membranes and Selective Recycle can Reduce Costs at High Capture Rate



Capture cost is normalized to 60% capture from coal using Polaris Gen2 membranes

- Advanced Gen3 membrane reduces capex for all capture rates
- Selective exhaust gas recycle (SEGR) is particularly effective in reducing cost at high capture rate where driving force is low
- SEGR adds complexity by recycling gas to the combustion source; it has been demonstrated for coal boilers but not yet on other industrial sources
- Calculations are for a 20% CO₂ feed stream (cement)

Hybrid Designs also have Potential to Reduce Costs at High Capture Rates



2023DOE005-F4

- Recently awarded a DOE small pilot project titled “Membrane Hybrid Process for Deep Decarbonization of Industry”
- Will use MTR Gen3 membrane combined with TDA sorbent to achieve >95% capture from a cement flue gas
- Follows successful testing of a hybrid membrane/sorbent system at TCM that showed stable ~95% capture

