


U.S. DEPARTMENT OF ENERGY | Office of Fossil Energy

Overview of the Fossil Energy sCO_2 Program

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Administration Energy Goals

President's ***America First Energy Plan***:

- Strong domestic energy production
- Energy security at home
- Commitment to revitalizing coal
- Expanded global markets for U.S. energy.

Strong support from DOE Office of Fossil Energy's **Clean Coal R&D** program, emphasizing:

- Advanced Coal Energy Systems
- Technologies to increase the *reliability and efficiency* of *new and existing* coal-fired plants that support and help stabilize the grid.

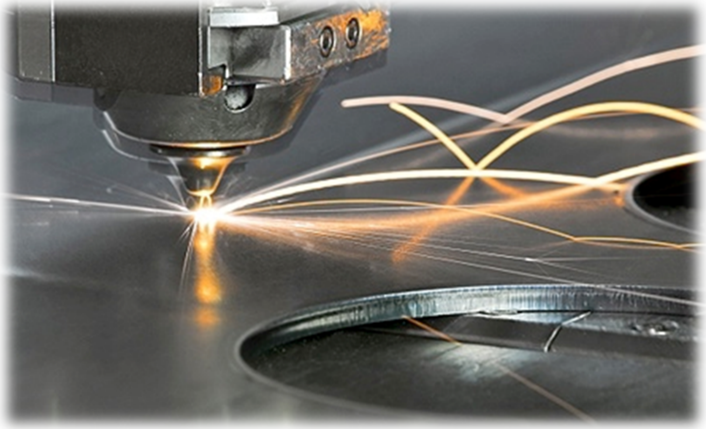
Next-Generation Coal Plants

Improved Existing Coal Fleet

- Advance and demonstrate technologies to enhance economics, e.g.,
  - Topping cycles to boost efficiencies (5%)
  - Cycling capabilities
- Apply advanced materials and processes to maximize efficiency and minimize emissions.

Coal Plants of the Future

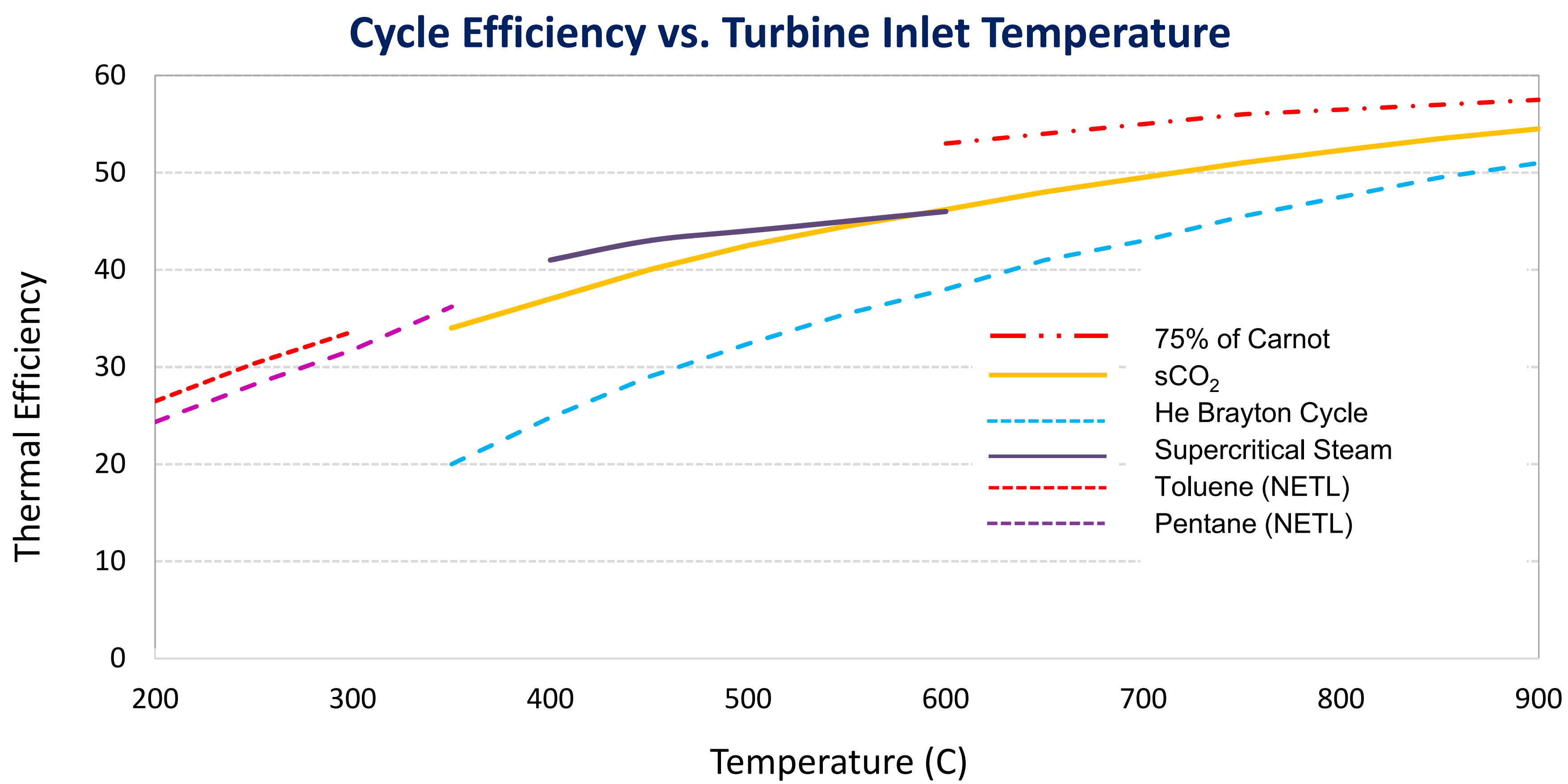
- Modular design (50-200 MW) and capable of distributed generation
- Uses advanced materials and processes to maximize its efficiency and minimize emissions
- Provides stable power that can also be flexibly dispatched to meet the needs of the grid



Why sCO_2 Brayton Cycle: Benefits

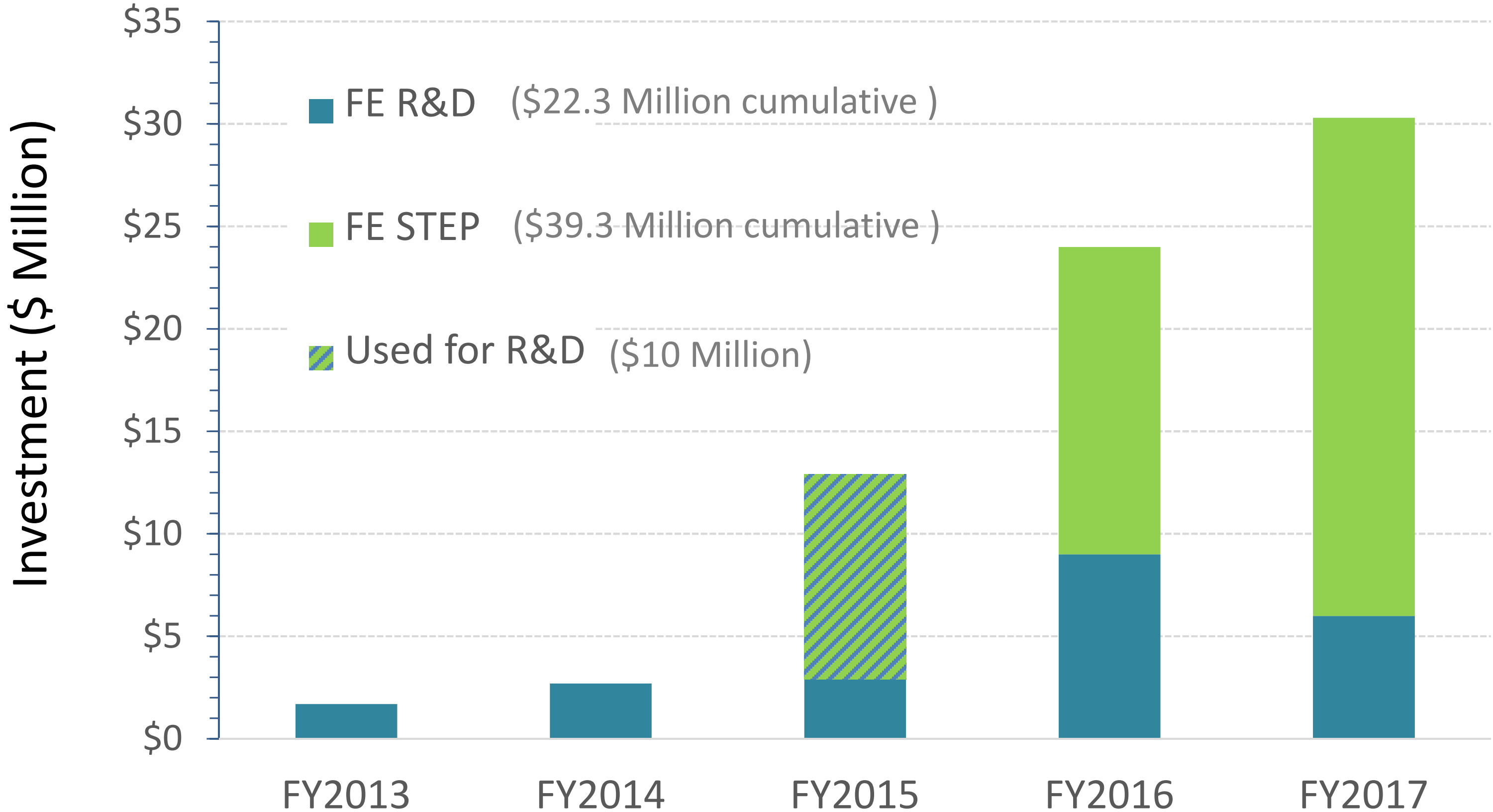
- **Smaller Footprint:** High fluid density enables order-of–magnitude smaller turbo machinery and components
- **Higher Efficiency:** Cycle offers up to 4% efficiency points > advanced Ultra supercritical coal-fired steam with 90% capture and compression
- **Reduced Water Use:** Indirectly heated sCO_2 cycle reduces water withdrawals ~ 8%. Preliminary studies indicate condensing sCO_2 cycles lower cost and efficiency penalties for dry cooling.
- **Lower CO_2 Emissions:** Direct-fire configuration provides intrinsic separation and compression.
- **Scalability:** sCO_2 turbomachinery is projected to maintain high efficiency at smaller scales (<10 MWe), lowering capital costs and diversifying energy sources for distributed generation.

Why sCO_2: Thermodynamics



Source: Dostal MIT thesis

FE Investments in sCO_2 Power Cycle Technology



International and Domestic Developments

- **ARPA-E:** exploring high efficiency/temperature/pressure modular systems for stationary and mobile applications
- **DOE Large-Scale Pilot Program Selections:** University of North Dakota EERC/NetPower, Echogen – Fossil proviso Phase 1 Feasibility study.
- **STEP status**: EA issued for public review March 19. Public review will conclude on April 18 after which facility clearing can begin. Selected main heater vendor, majority of equipment out for bid. PFD and P&IDs completed and frozen. Turbine design head for CDR.
- **International:**
  - **Saudi Arabia.** Secretary Perry and Prince Abdulaziz signed MOU on Dec. 4th re: cooperation on sCO_2 and other technologies. Discussions on going.
  - **Korea:** R&D related to turbomachinery, recuperators, systems modeling, pilot projects, collaboration with Saudi Aramco sCO2 power cycles.

Source: Saudi Press Agency

Opportunities and Challenges

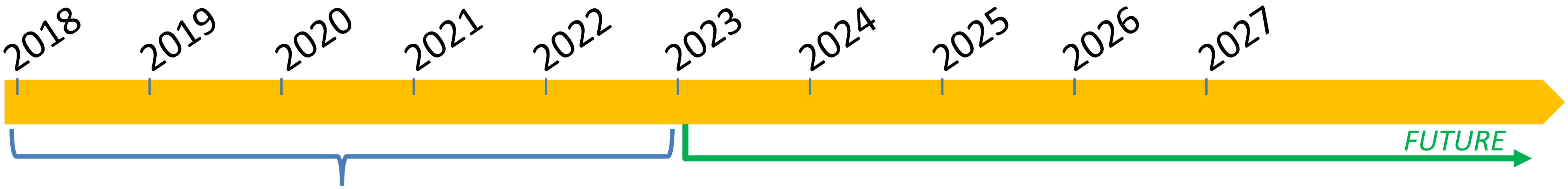
Technology Benefits: | **Applications & Impacts**

Technology Benefits	Applications & Impacts
Small foot print/scalability	• Load centers • Intermittent sources
Fuel flexible, low water requirement	• Reduced siting restrictions
Direct-fire provides zero-cost, pure CO_2 stream as byproduct	• EOR • Food processing • Other value-added use

Challenges:

- Affordable extreme-environment materials
- Understanding combustion in sCO_2 environment
- Improved component designs that offer better performance at reduced cost

R&D Strategy



Pilot test:

- STEP 10MW testing 550–700^{o}C

R&D:

- Improve cost and performance of turbomachinery, recuperators, sensors, control strategy
- Enable sCO_2/O_2 and syngas combustion at 300bar
- Develop material for severe, high-temperature environments

Pilot test:

- Higher temperature indirect cycles
- Directly fired cycle

R&D:

- Develop hi-temp. corrosion-resistant material (focus on water and other syngas contaminants)
- Design components (e.g., combustor, recuperator) to address syngas contaminants challenges
- Enhance sCO_2/O_2 and syngas combustion in off-design conditions
- Develop ultra-high temperature recuperators (indirect and direct)

Thank You

Clean Coal and Carbon Management: R&D Overview

Discover and develop advanced coal technologies that ensure America's access to and use of secure, affordable, and reliable fossil energy resources.

Advanced Energy Systems*

- High performance materials
- Solid oxide fuel cells
- Modular design
- Gasification
- Advanced cycles, e.g., sCO_2
- Advanced turbines
- Advanced combustion
- Transformational power

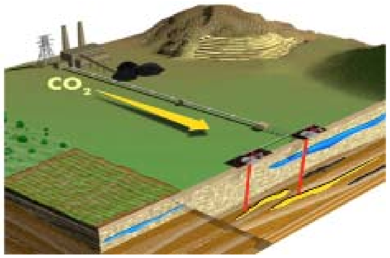
Crosscutting Research*

- Water management
- Critical mineral extraction from coal and coal byproducts
- Sensors and controls

CO_2 Capture*

- Post-combustion capture
- Pre-combustion capture

CO_2 Utilization and Storage*



- New pathways to utilize captured CO_2
- Safe use & permanent storage of CO_2 from power generation and industry

* Programmatic not necessarily budgetary groupings