

# Chemical Engineering Strategies and Advancements in Industrial Decarbonization

SOUTHWEST RESEARCH INSTITUTE®



Michael Hartmann  
Lead Engineer  
Chemical Engineering Department, Div. I

# SwRI Addressing “Climate Change”

- Transportation

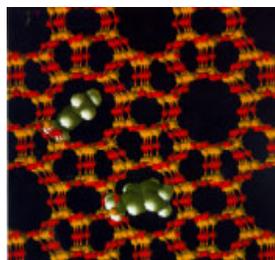
- Electric Vehicles
- Emissions
- Batteries

- Energy

- Solar Panels
- Windmills
- Storage
- Generation
- Infrastructure
  - Grid
  - Pipelines

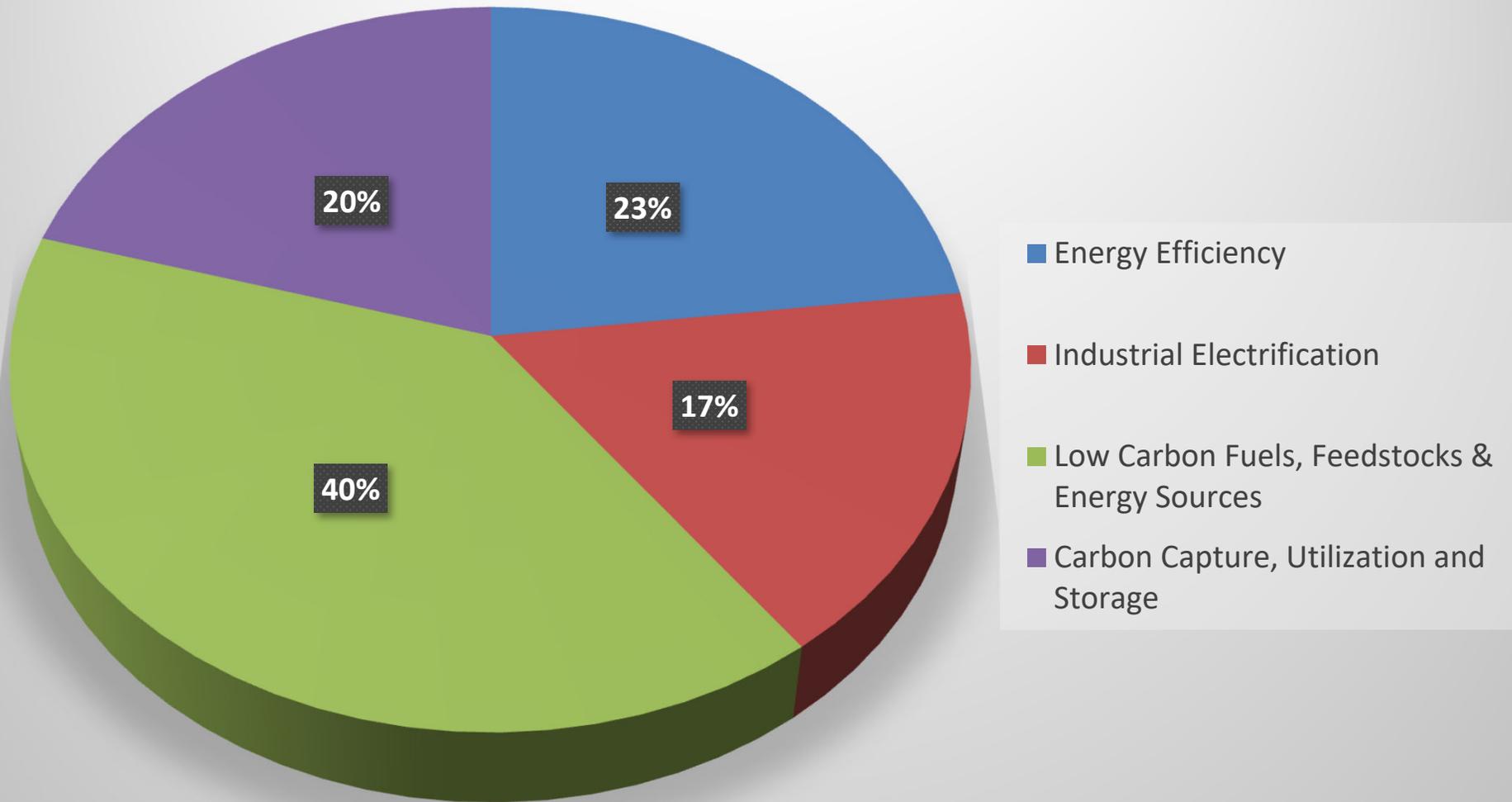
- Industry

- Energy
  - Post/Pre-Combustion
- Petrochemical
- Refining
- Nuclear
- Cement
- Steel
- Environmental



# SwRI Supporting Decarbonization Roadmap

SwRI RFP's (Past 5-Months)  
DOE Industrial Decarbonization Roadmap Pillars



# Carbon Dioxide Emission Reduction and Utilization



## Alternative Feedstocks and Fuels

- Enhance the carbon cycle with more fuels from renewable and recyclable sources.



## Capture

- Mineralization, MOFs, amines, other novel solvents, direct air capture, and membranes.



## Conversion & Utilization

- Direct CO<sub>2</sub> conversion to something useful.



## Process Optimization

- Process reconfiguration, intensification, and electrification

# Advanced BioFuels and Chemicals from Waste and Recyclable Sources

- Biomass, animal fat, municipal wastes, plastics, algae, and crops into “green” fuels and products: biodiesel, green diesel, gasoline, jet
- SwRI produces specification-grade gasoline, diesel, and jet fuels and other specialty products or chemicals



# Post Combustion and Direct Carbon Capture

- Lab and pilot-scale build up and demonstration
- Supported commercial demonstration design
- Electrochemical and thermal decomposition of minerals
- Developing “next generation” of carbon dioxide mineralization technology
- Novel capture solvent development and analytical testing
- Working with direct capture technologies to create new product streams



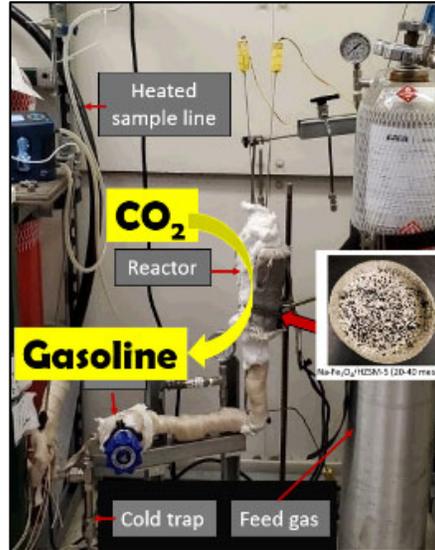
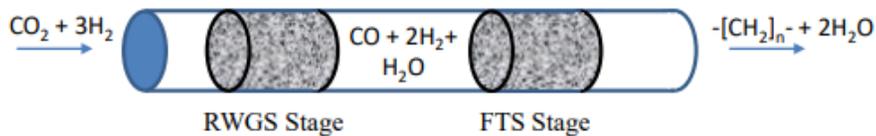
# CO<sub>2</sub> Catalyst Development for Utilization

- CO<sub>2</sub> Conversion
  - Fuels
  - Chemicals
- UTSA-SwRI Connect



Patented high pressure circulating fluidized bed reactor

## Single Reactor Concept for Converting CO<sub>2</sub> to Fuel

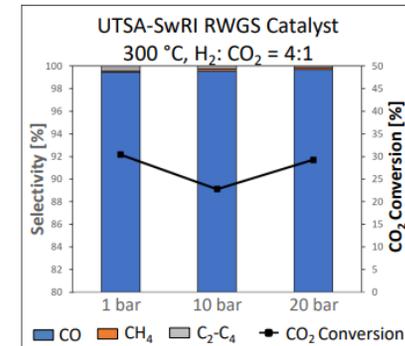
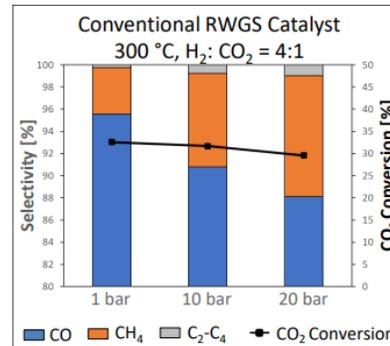


CO<sub>2</sub> to aromatics catalyst testing



CO<sub>2</sub> to olefins and high pressure fluid bed testing

## RWGS Stage



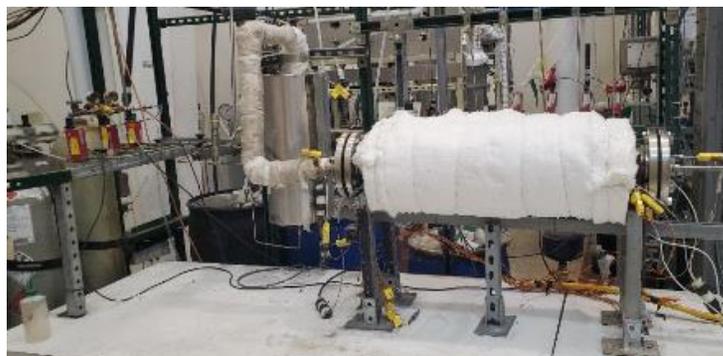
Superior CO Selectivity

# Pyrolysis and Gasification

- Methane pyrolysis for hydrogen production
  - $\text{CH}_4 \rightarrow 2\text{H}_2 + \text{C}$
- Demonstration and scale-up of turquoise, green & blue hydrogen to fuels and chemicals
- Fluid beds with solid feed for gasification.
  - $\text{C}_x\text{H}_x \rightarrow \text{CO} + \text{H}_2$
  - Plastics, coal, biomass, biosolids, liquids, gases
- High temperature reactors
- Plasma gasification
  - $\text{CO}_2 \rightarrow \text{CO} + \text{H}_2$
- Reverse Boudouard
  - $\text{CO}_2 + \text{C} = 2\text{CO}$
- Process conditions for materials of construction / hydrogen embrittlement



CFB pyrolysis pilot plant



Process conditions test system for material of construction testing



Designed, fabricated and operated specialty high temperature reactor



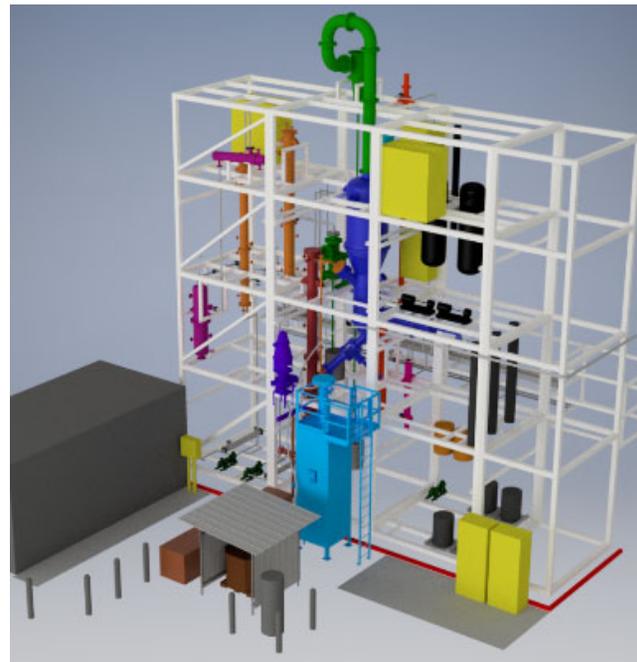
Thermal Plasma Gasification

# Waste Plastic Recycling

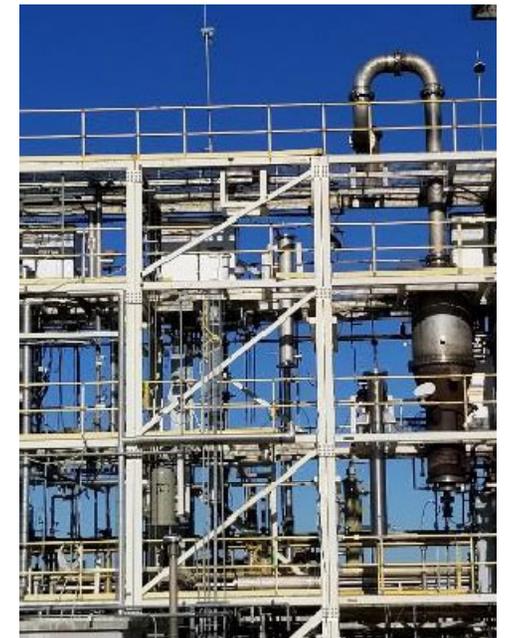
- Refinery integration
- Naphtha cracking
- Chlorine removal
- Pyrolysis, gasification and hydrotreating



Mixed plastics



Design and Build Fluid Bed Pyrolysis Unit



Current Buildup at SwRI

# Biomass To Value Added Products

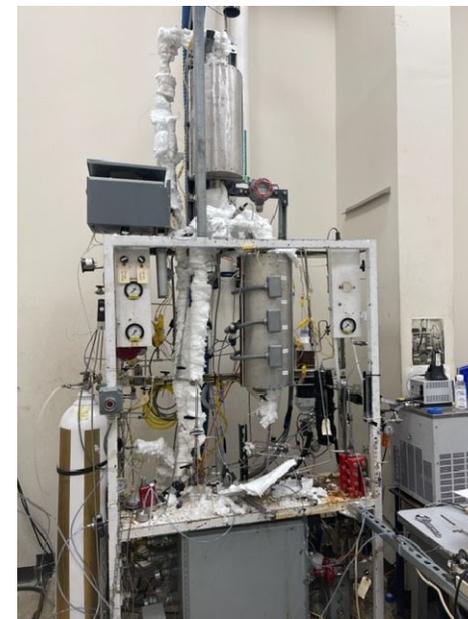
- Biomass conversion to furfural compounds (reactive building blocks)
- Renewable/Sustainable feedstock
- 100% bioderived polymers (PET)
- Green chemicals such as FDCA



**Biomass Feed / Product**



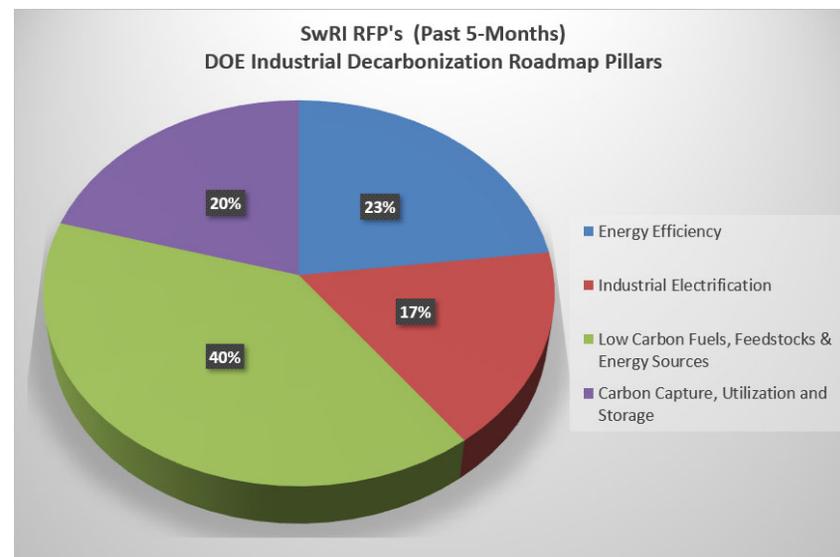
**CSTR Pilot Unit**



**Fixed Bed Pilot Unit**

# Future Decarbonization Roadmap

- Driving Forces Directly Impacting R&D:
  - IRA / 45Q
  - SAF / 10% and Net Zero Targets
  - Hydrogen Economy/Hubs
  - Corporate Social Responsibility
- Expect Increases In:
  - Carbon capture technologies → Implementation/Commercialization
  - Hydroprocessing alternative feedstocks to meet SAF targets
    - EPA Part 79 fuel registration
  - Biomass/plastics processing to value added products
  - CO<sub>2</sub> utilization



Thank You!

