

Process Development for Industrial Process Emissions Reduction

SOUTHWEST RESEARCH INSTITUTE®



Michael Hartmann

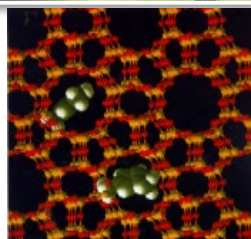
Manager-R&D

Carbon Capture & Utilization Process Development

Chemical Engineering Department, Div. I

SwRI Addressing “Climate Change”

- Transportation
 - Electric Vehicles
 - Emissions
 - Batteries
- Energy
 - Solar
 - Windmills
 - Storage
 - Generation
 - Infrastructure
 - Grid
 - Pipelines
- Industry
 - Energy
 - Post/Pre-Combustion
 - Petrochemical
 - Refining
 - Nuclear
 - Cement
 - Steel
 - Environmental

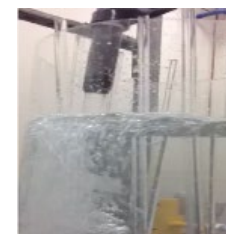


Contract Research in Decarbonization

- **CO₂ Sources** (Feedstock and Logistics)
 - Transportation – precombustion and post combustion
 - Industry flue gases – post combustion
 - Industrial processes – heating and byproducts
 - Atmospheric
- **Technology Areas in Chemical Engineering at SwRI**
 - Renewable Fuels – Transportation – Industrial
 - Biomass /Organic wastes
 - Microbial
 - Carbon Capture and Utilization – Industry flue gases
 - CO₂ separation
 - CO₂ to useful products
 - Low carbon energy
 - Hydrogen
 - Battery recycling – critical materials
 - Process improvements
 - Coal, natural gas, GHGs, biomass, plastics to fuels and chemicals
 - Hazardous waste handling and neutralization

- **Drivers**

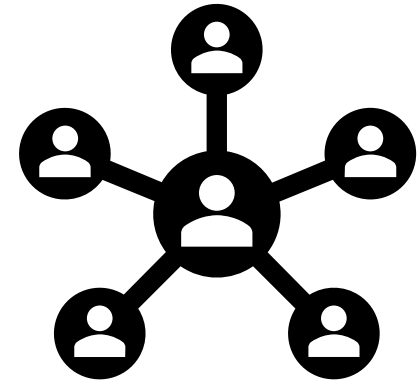
- Social
- Govt. incentives / penalties
- ESG



Integrated Sections

Chemical Engineering Department

- Fuels & Energy Development
- Pilot Plant Design & Fabrication
- Refinery & Catalyst Pilot Plant Services
- Carbon Capture and Utilization Process Development
- Process Chemistry



Scaling Technologies For Commercialization

Process Development

- Design
- Fabrication & Buildup
- Refining
- Industrial Processing
- Testing & Simulations
- Optimization
- Troubleshooting
- Unit & System Operations



Advancing the U.S. Department of Energy's Goals

- ✓ Waste to Power
- ✓ Hydrogen Production <math>< \\$1/\text{kg}</math> of H₂
- ✓ Sustainable Aviation Fuels
- ✓ Industrial Emissions Reduction
- ✓ Greenhouse Gas Capture & Conversion
- ✓ Process Intensification
- ✓ TechnoEconomics



Sustainability & Low Carbon Technologies

Carbon Dioxide Capture & Utilization

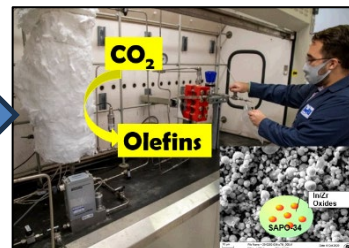
Emissions



Capture



Conversion



Minerals



Alcohols



Fuels



Sustainability & Low Carbon Technologies

Biofuels & Bio-based Chemicals

Plastics
&
Biomass



Thermo-Catalytic
Conversion



Biocrude
&
Platform
Chemicals



Hydroprocessing
&
Refining



Gasoline
Diesel
Aviation Fuel
Hydrogen
Methane

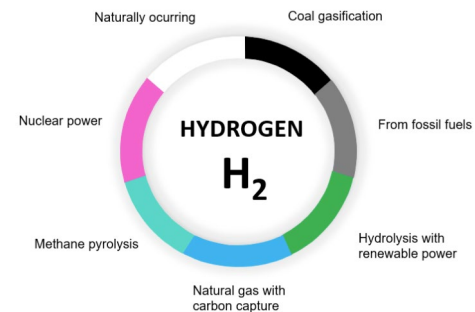
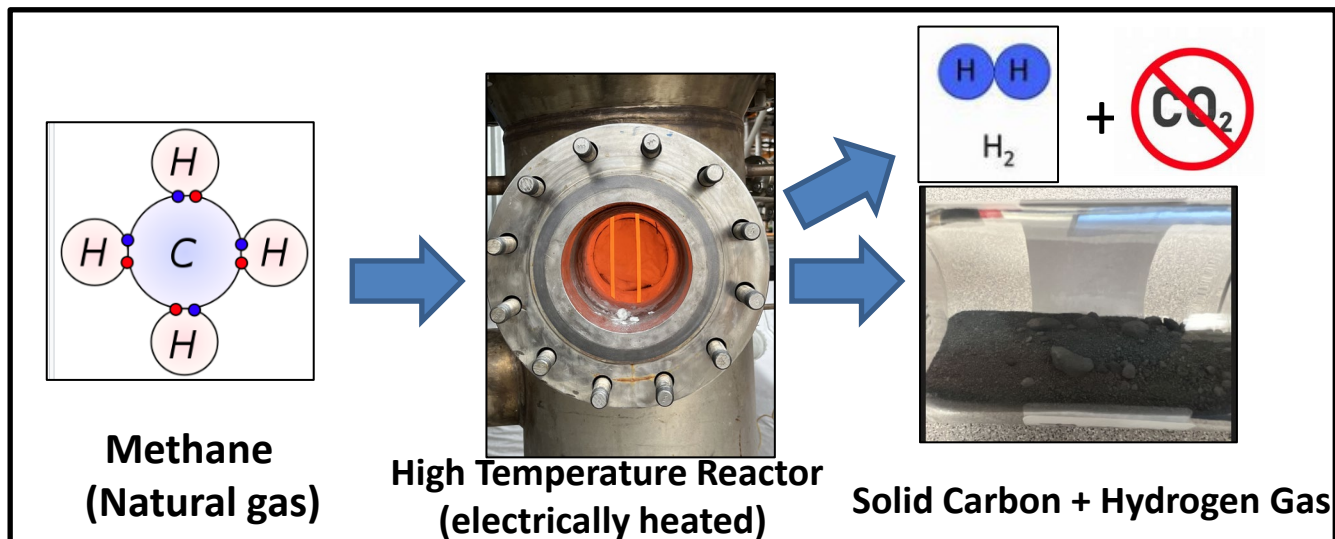


Chemicals
Fertilizers
Additives
Monomers



Sustainability & Low Carbon Technologies

Methane Decarbonization / Hydrogen Production



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
 - Support steel and cement production industries
- Novel capture solvent development, MOFs and analytical testing
- Working with direct capture technologies to create new product streams

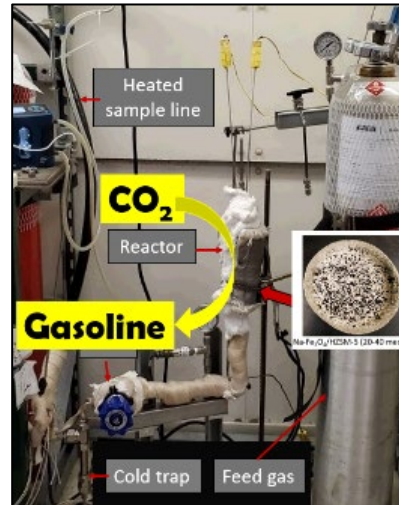


CO₂ Catalyst Development for Utilization

- CO₂ Conversion
 - Fuels
 - Chemicals
- UTSA-SwRI Connect



Patented high pressure circulating fluidized bed reactor

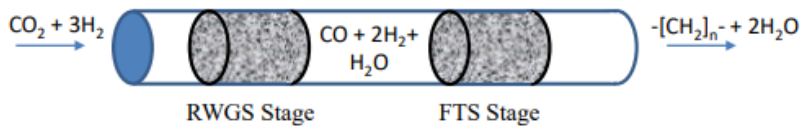


CO₂ to aromatics catalyst testing

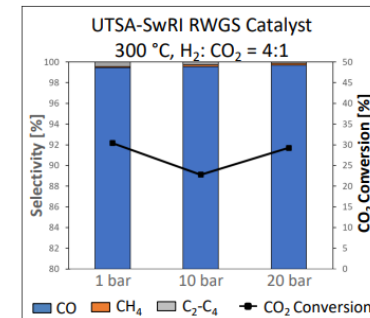
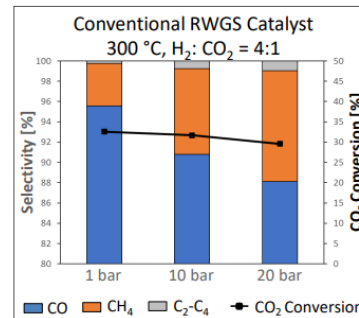


CO₂ to olefins and high pressure fluid bed testing

Single Reactor Concept for Converting CO₂ to Fuel



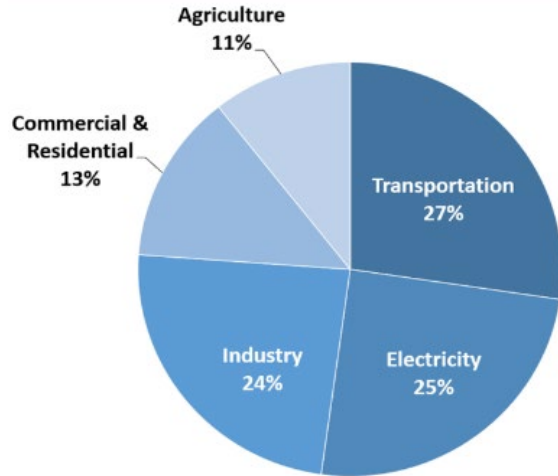
RWGS Stage



Superior CO Selectivity

Decarbonization through Renewables

Total U.S. Greenhouse Gas Emissions by Economic Sector in 2020

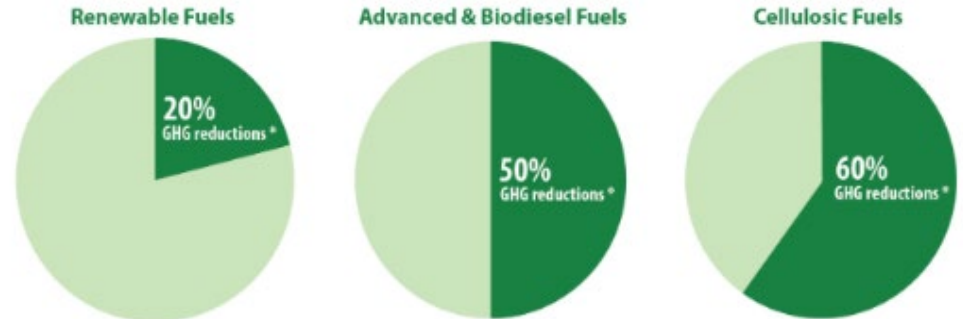


“Over 90% of the fuel used for transportation is petroleum based, which includes primarily gasoline and diesel.”

– US EPA

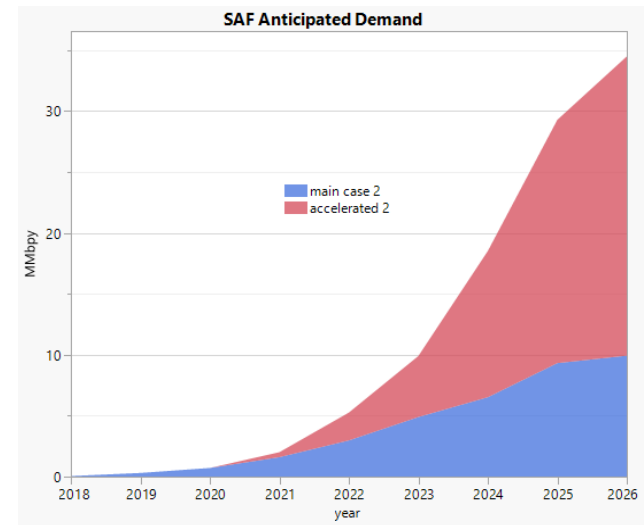
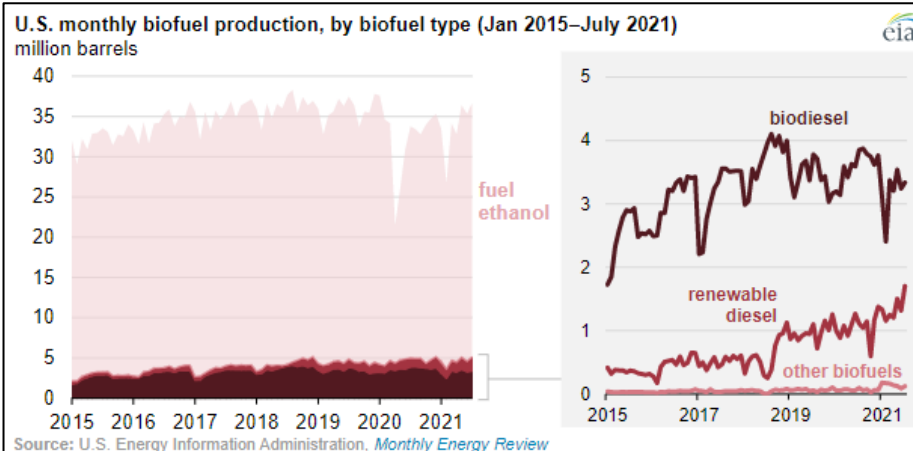
Lifecycle Greenhouse Gas (GHG) Emissions

GHG emissions must take into account direct and significant indirect emissions, including land use change.



* compared to a 2005 petroleum baseline

www.epa.gov/renewable-fuel-standard-program/overview-renewable-fuel-standard



<https://www.iea.org/reports/renewables-2021/biofuels?mode=transport®ion=World&publication=2021&flow=Production&product=Biojet>

Advanced Biofuels and Chemicals from Waste and Renewable Sources

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

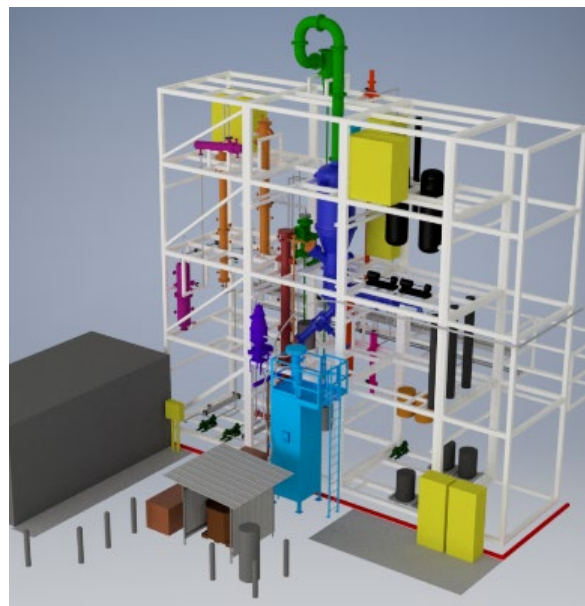


Waste Plastic Recycling

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



Mixed plastics



Design and Build Fluid Bed Pyrolysis Unit

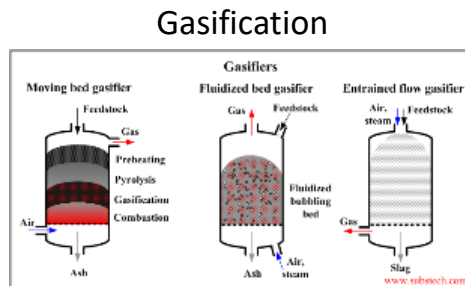


Buildup at SwRI

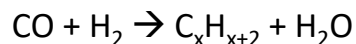
Municipal Solid Waste to Fuels

Proprietary

- Designing processes for municipal solid waste to specification gasoline, diesel, methane and hydrogen.

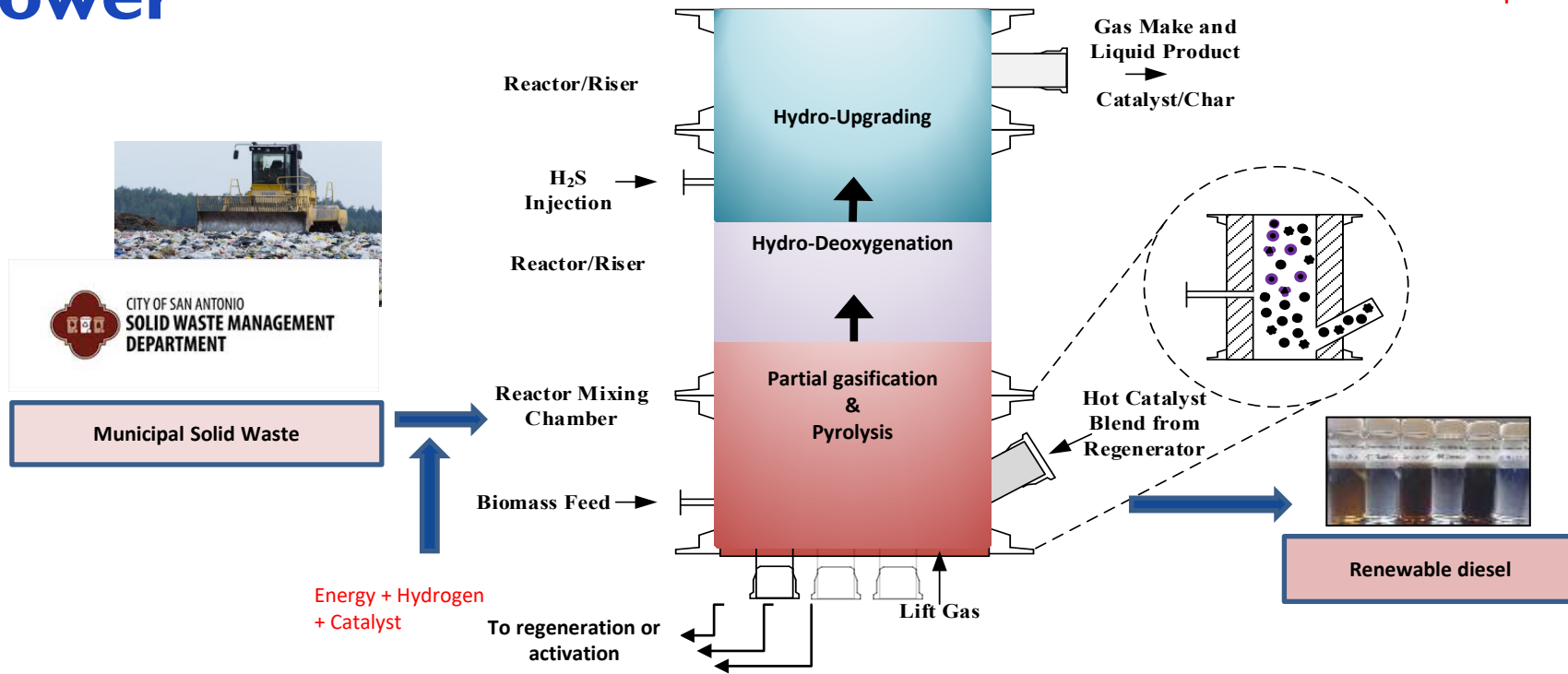


Fischer Tropsch Synthesis



CoSA (City of San Antonio) Waste to Power

Proprietary



CITY OF SAN ANTONIO
SOLID WASTE MANAGEMENT
DEPARTMENT

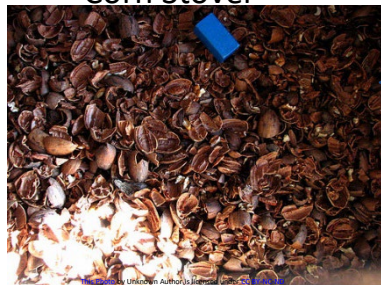
High Pressure Fluidized Bed Concept
Patent# US 10,266,774 B2

Monterrey Tech – SwRI Joint Research

- Biochar for Carbon Sequestration and CO₂ adsorption from agro-industrial waste



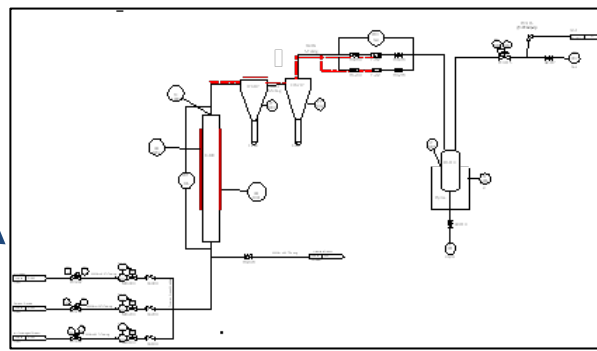
Corn Stover



Pecan Shells



Waste Plastics



High Pressure Fluidized Bed Reactor



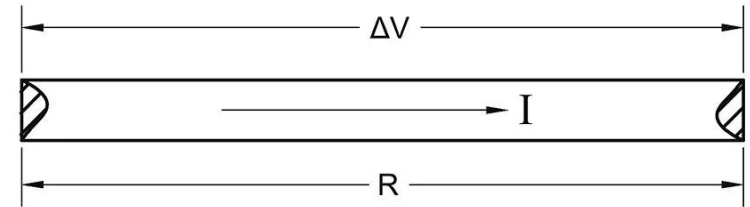
Liquid Hydrocarbons



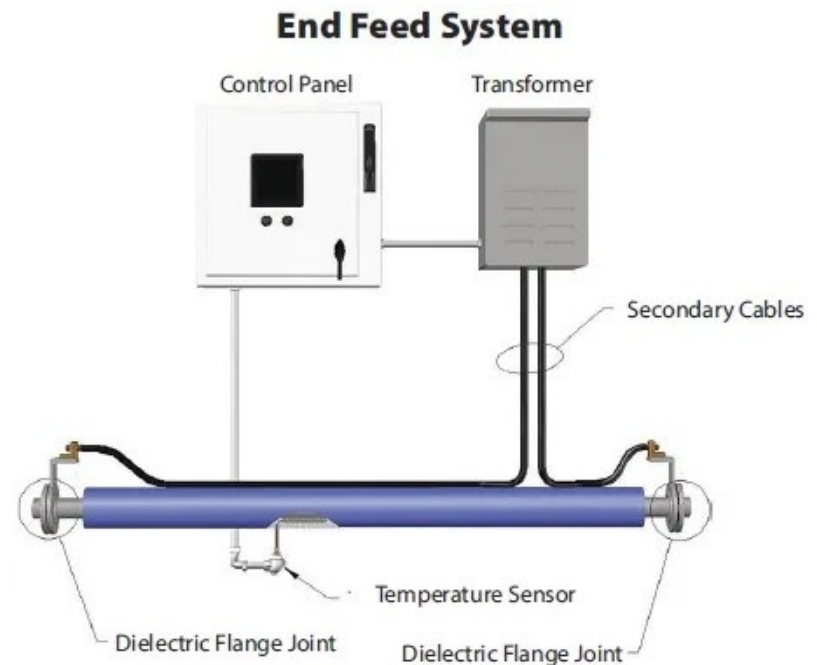
Biochar

High Pressure / Temp Process Development

- Process Electrification
 - Direct/Impedance Heating
 - Cross divisional collaborations (Applied Power)
 - Efficiency gains from going from Fossil to Electric sources
- High Press/Temp Reactor Systems
 - Designed 2000°C/200psig reactor system
 - Molten salts/Impedance systems
 - Hydrogen embrittlement testing
 - Materials/corrosion testing
 - Materials of construction and destruction analysis testing



Apply Voltage, heat generated by resistance to flow of current through wall of pipe



Thank You!

SOUTHWEST RESEARCH INSTITUTE®



Michael Hartmann

Manager-R&D

Carbon Capture & Utilization Process Development

Chemical Engineering Department, Div. I