22ND ERRA ANNUAL CONFERENCE

Progressing Energy Transition via Effective Policies and Regulation

5 – 6 May, 2025
MUSCAT, OMAN

Hosted and sponsored by:
هيئة تنظيم الخدمات العامة
Authority for Public Services Regulation

— Session V —

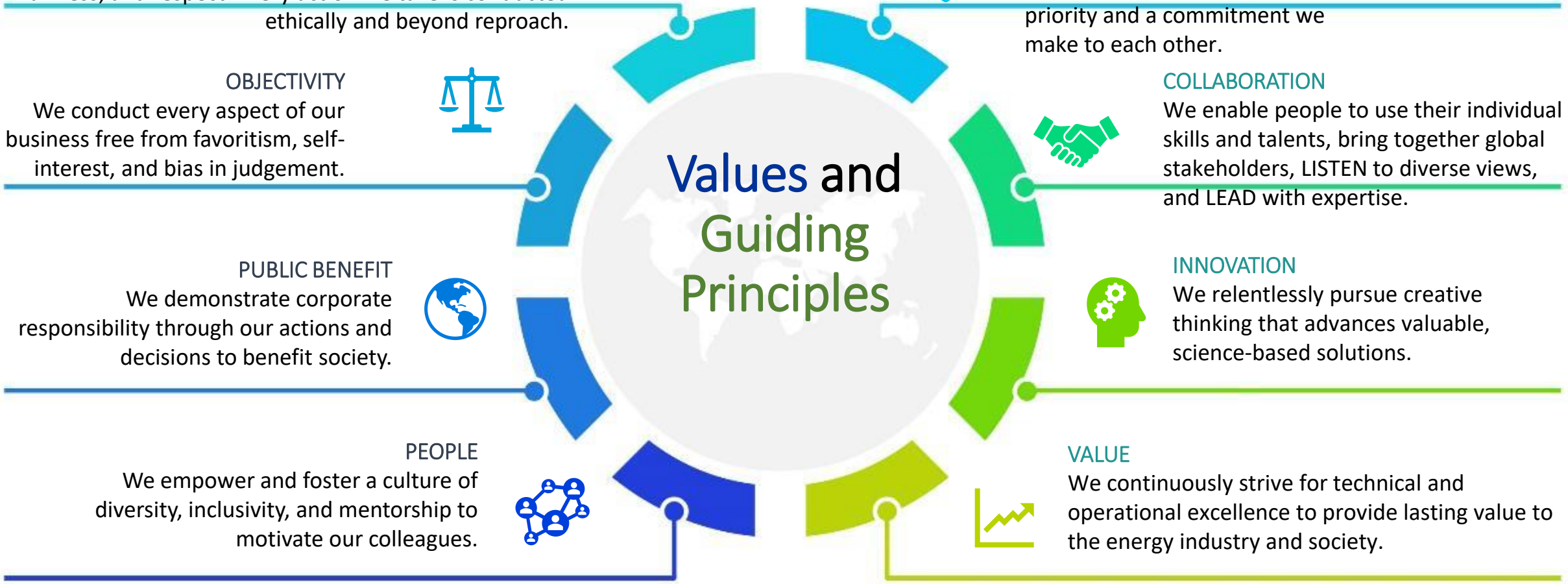
THE ROLE OF TRANSITION FUELS IN TRANSFORMING THE SECTOR

RESEARCH DRIVEN ENERGY-TRANSITION: THE ROLE OF HYDROGEN AND LOW CARBON RESOURCES

Gergo Varhegyi, *Technical Executive*
EPRI Gulf
UAE

EPRI – Who we are?

Values and Guiding Principles



INTEGRITY
We interact and transact with honesty, transparency, fairness, and respect. Every action we take is conducted ethically and beyond reproach.

OBJECTIVITY
We conduct every aspect of our business free from favoritism, self-interest, and bias in judgement.

PUBLIC BENEFIT
We demonstrate corporate responsibility through our actions and decisions to benefit society.

PEOPLE
We empower and foster a culture of diversity, inclusivity, and mentorship to motivate our colleagues.

SAFETY
Safety and security are the top priority and a commitment we make to each other.

COLLABORATION
We enable people to use their individual skills and talents, bring together global stakeholders, LISTEN to diverse views, and LEAD with expertise.

INNOVATION
We relentlessly pursue creative thinking that advances valuable, science-based solutions.

VALUE
We continuously strive for technical and operational excellence to provide lasting value to the energy industry and society.

OUR VALUES
The core of our reputation, a non-negotiable reflection of our mission and commitment to do the right thing, based on trust that society extends to us

OUR GUIDING PRINCIPLES
Behaviors and outcomes that we strive for, providing orientation in our day-to-day work and helping us when facing difficult decisions

EPRI Research & Development

TECHNOLOGY INNOVATION

Driving thought leadership, advanced R&D, and technology scouting and incubation to sustain a full pipeline of solutions

Nuclear Power

Energy Supply and Low-Carbon Resources

Electrification and Sustainable Energy Strategy

Transmission and Distribution Infrastructure

Integrated Grid and Energy Services

STRATEGIC RESEARCH

Low-Carbon Resources

End-Use/ Economy-Wide Carbon Reduction

Electric System Reliability/Resilience

Electric System Flexibility

Market Transformation/ Policy/Regulatory Education

Decarbonization Pathways Enabled by Innovation

Decarbonization

Accelerate economy-wide, low-carbon solutions

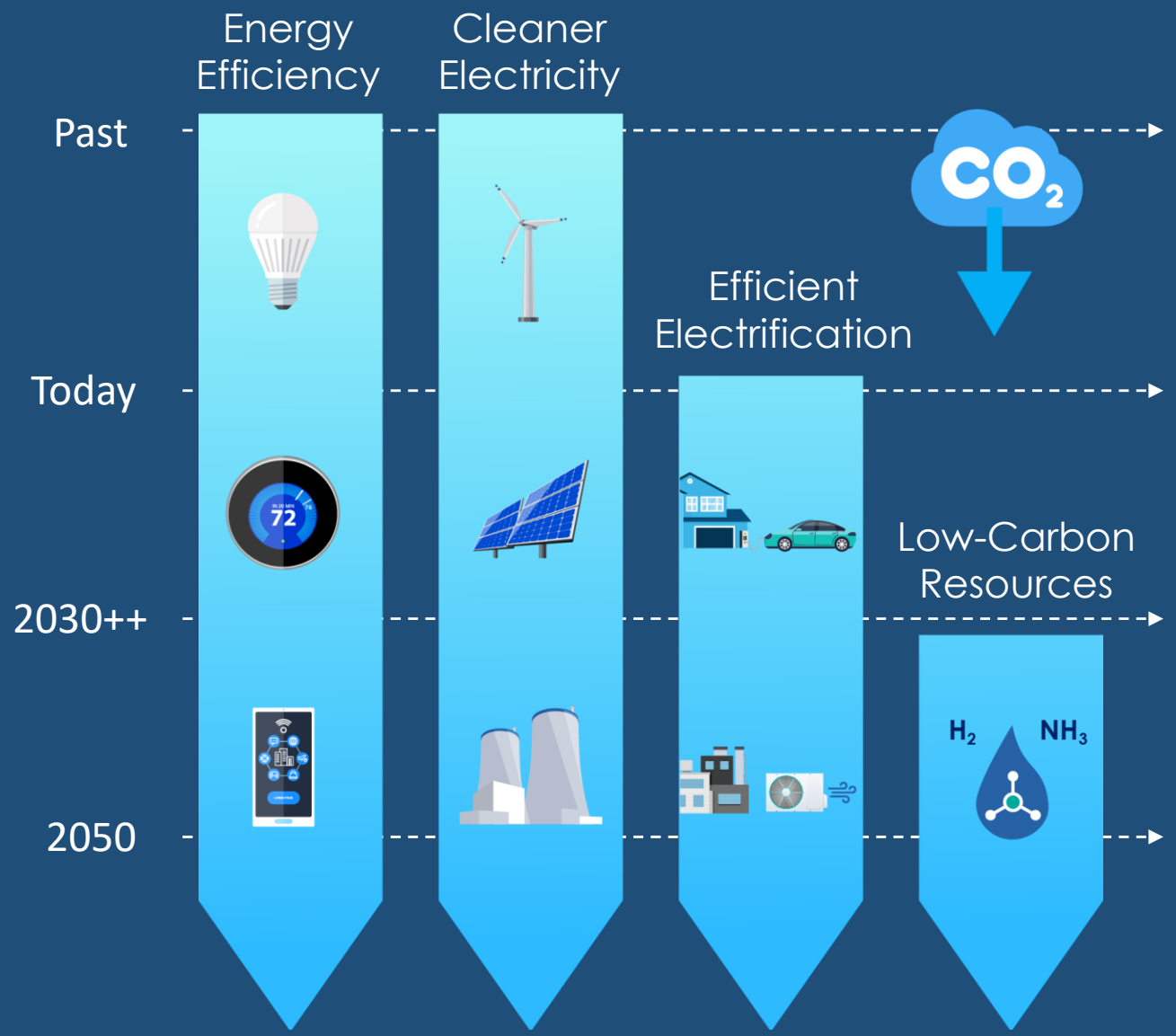
- Electric sector decarbonization
- Electric transmission and grid flexibility: storage, demand, EVs
- Efficient electrification and natural gas, hybrid systems
- Mitigate methane emissions

Achieve a net-zero clean energy system

- Ubiquitous clean electricity: renewables, advanced nuclear, CCS
- Negative-emission technologies
- Low-carbon resources: hydrogen and related, low-carbon fuels, biofuels, and biogas

~5-15 years

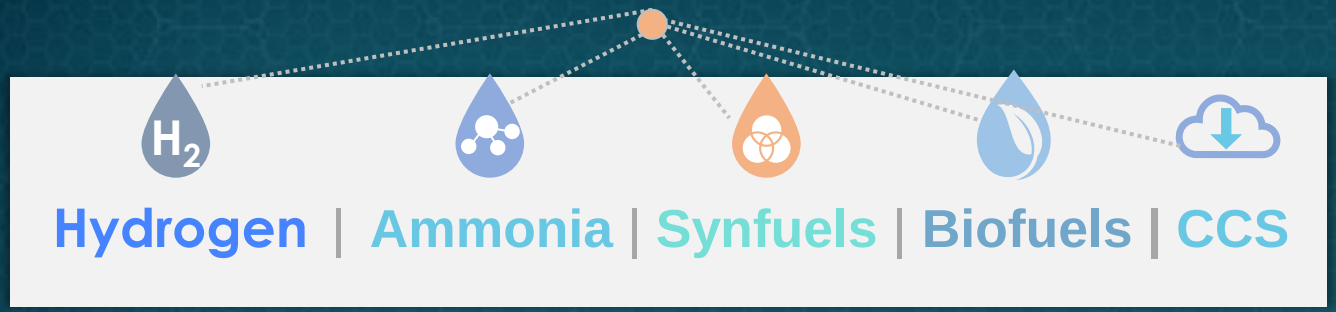
~15-30 years



EPRI - LCRI

2020 — **2030** — 2050+

LCRI
LOW-CARBON
RESOURCES INITIATIVE



Achieving **net zero emissions across the economy** by 2050 will require accelerating a safe, affordable, and reliable energy transition through advancements in a **variety of clean energy technologies and options**.

The LCRI evaluates pathways for deploying of **low-carbon technologies, fuels, and energy carriers** in support of decarbonization across the energy economy.

The LCRI is focused on a vision of the future global energy system that is **decarbonized, consumer-focused, sustainable, and resilient**.

Renewable & Synthetic Fuels

Hydrocarbon-Based Processes & Negative Emissions

Electrolytic Processes

Transport, Delivery, & Storage: H_2, Ammonia, CO_2

Power Generation

End Uses: Transportation, Industry, & Buildings

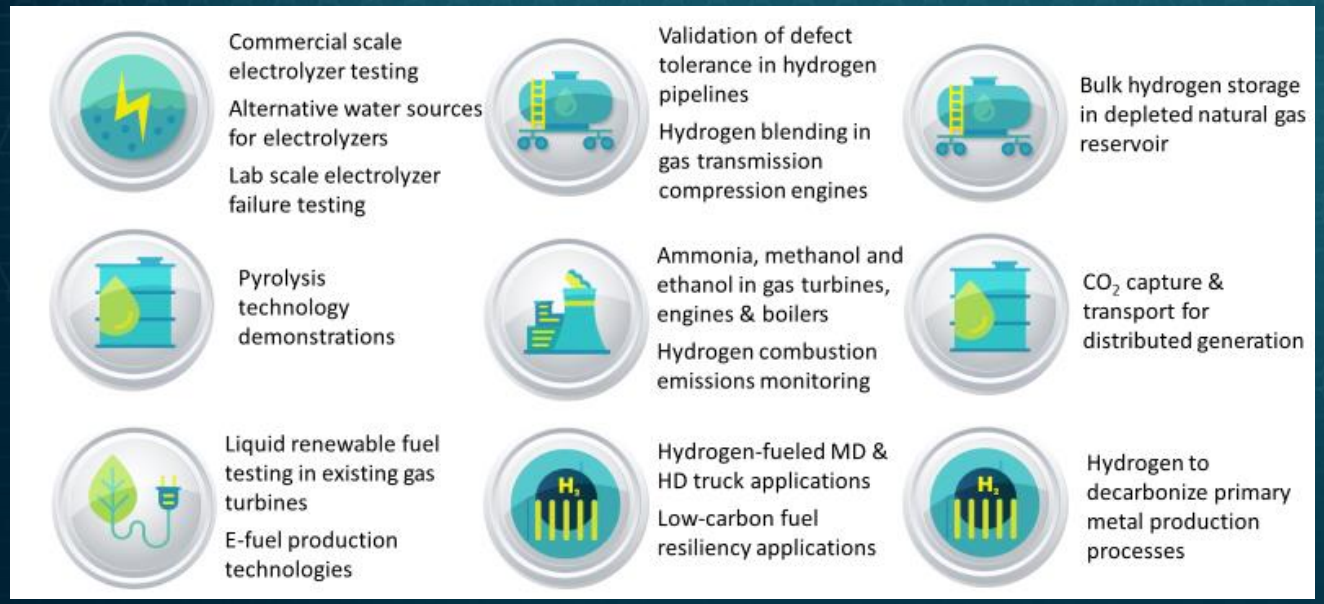
Safety and Environmental Aspects

Integrated Energy System Analysis

LCRI Efforts in Accelerating Technology Development

Upcoming LCRI Efforts to Accelerate Technology Commercialization

24 New Demonstration Projects Across the Low-Carbon Fuels Value Chain



Completed & Ongoing LCRI Demonstrations

- **3** Electrolyzer demonstrations
- **4** Natural gas & bio-feedstock to hydrogen related demonstrations
- **6** Hydrogen in power generation demonstrations (4 gas turbines, 1 reciprocating engine, 1 fuel cell)
- **3** Fundamental tests of ammonia combustion
- **3** Carbon capture / direct air capture related demonstrations
- **4** Commercial & industrial decarbonization demonstrations
- **2** Transport application demonstrations
- **1** Jet fuel and gasoline production demonstration
- **3** Delivery and storage infrastructure related demonstrations

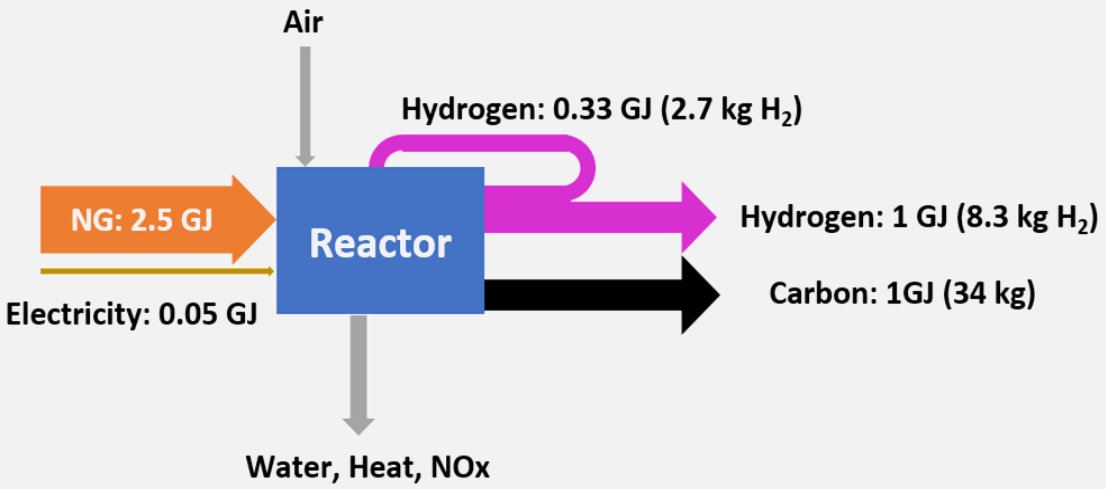
Natural Gas to Hydrogen

Demonstration Project Summary

Pyrolysis for NG to H_2 End Use Applications

- Emerging H_2 production technologies – most are in pilot-scale development
- Onsite H_2 production with solid carbon management
- Methane from Natural Gas or Renewable Natural Gas

Pyrolysis: Natural Gas to Hydrogen



Project Plan

- Residential & commercial heating appliances – Low-pressure NG supply
- Microwave plasma system (estimated 90% conversion efficiency); prior testing with CH_4 but not NG
- 2-month, lab-scale evaluation
- Measure performance & characterize carbon byproduct

100% Load		20% Load	
Electricity, IN	100 kWh	Electricity, IN	20 kWh
NG, IN	30 kg/h	NG, IN	6 kg/h
H_2, OUT	7 kg/h	H_2, OUT	1.5 kg/h
Carbon, OUT	22 kg/h	Carbon, OUT	4.5 kg/h
NG, OUT	2 kg/h	NG, OUT	0.6 kg/h

Total test: 450 kg NG, 100 kg H_2

Testing starts January 2025

Pyrolysis OEM | ConEd | Stony Brook Univ | Brookhaven Nat'l Lab

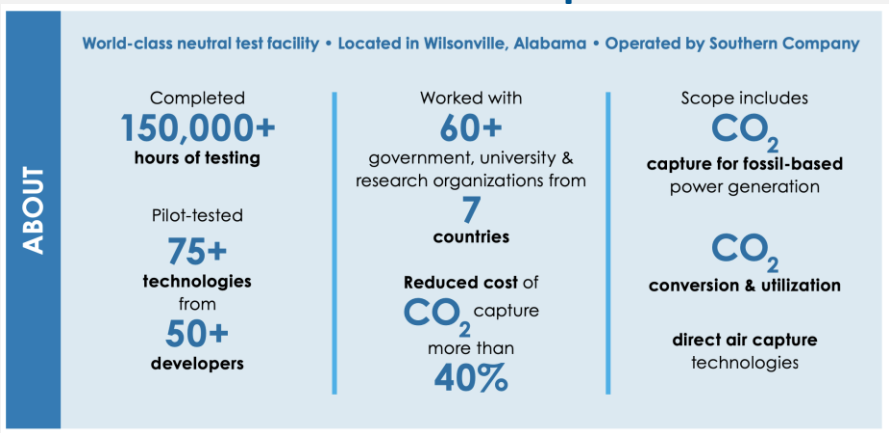
CO_2 Management & Hydrogen

Demonstration Project Summary

Hydrogen to Molecules

- Emerging H_2 production & molecular synthesis technologies – provide independent test facility (potentially ~1,000 kg/h H_2 production)
- Continuous H_2 production, CO_2 capture, & synthesis
- NG Pyrolysis, NG Reforming, Electrolysis, Biofuels
  → Fuels & Chemicals production

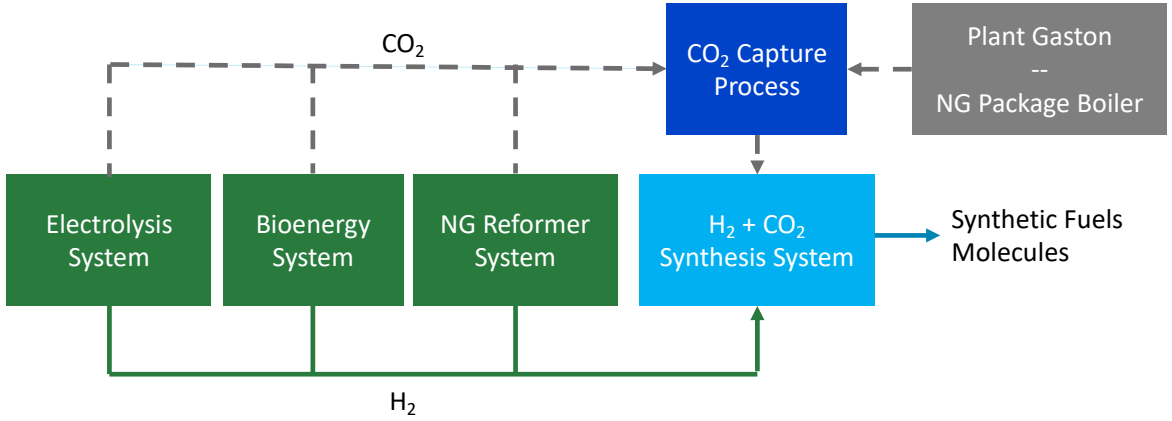
U.S. National Carbon Capture Center



https://nationalcarboncapturecenter.com

Project Plan

- Pending DOE capital improvement proposal
- Design expansion of NCCC testing capabilities, leveraging existing CO_2 capture equipment & personnel
- Select technologies for H_2 production and fuels synthesis, conduct engineering design for cost/detailed plan
- Conduct initial demonstrations of technologies



Analysis starts 2024 | DOE issues Funding Opp 2024

Southern Company | U.S. DOE | NCCC Collaborators

ELECTROLYSIS

Demonstration Project Summary

Planning to Practice

Direct integration of renewables (2MW electrolyzer)

Design → Construction → Startup

Improve industry specifications & guidelines

Alto Rodrigues PV Plant
Rio Grande do Norte, Brazil

Petrobras | ISI-ER | 2024 Start

Real-Time Performance [3 projects]

Collect electrolyzer data operational limits & flexibility for solar load following

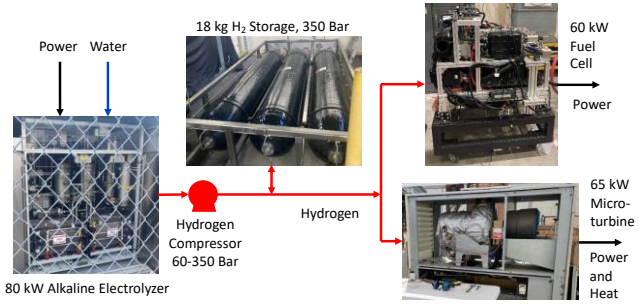
Provide data across various operating scenarios (demand profiles, electricity price points/rates, solar availability)

NOx measurement methods for 100% hydrogen operation (gas turbine & microturbine)

Novel H_2 storage testing

DeBary Hydrogen Rendering

GKN H_2 Metal Hydride



UC Irvine Lab Systems

Duke Energy | GE Vernova | UC Irvine | 2024/25 Start

Hydrogen Storage

Demonstration Project Summary

Main Objective

Safe and cost-effective hydrogen storage

- Reduce delivered H_2 cost
- Maximize value of H_2
- Minimize new infrastructure requirements

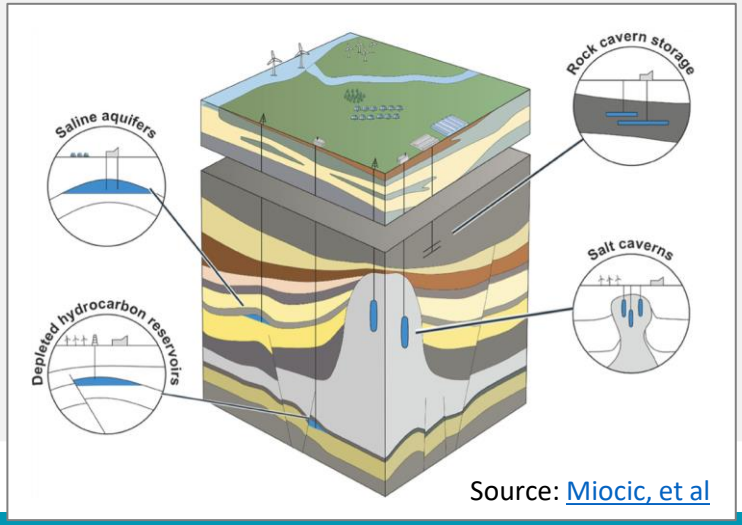
These demonstrations are designed to provide…

- First-of-a-kind demonstrations of hydrogen storage in depleted gas reservoir
- Testing to determine suitability of saline aquifers for hydrogen storage
- Safety and operations best practices

Demonstration Projects

Hydrogen Underground

- NG Aquifer Storage Conversion
- NG Porous Rock Storage Conversion



Source: Miocic, et al

e-Fuels and Resiliency

Demonstration Project Summary

Main Objective

Resilient decarbonization without sacrificing affordability and reliability

- Energy coupling to decarbonize multiple sectors
- Provide reliable back-up fuels for resiliency
- Improve likelihood of customer adoption

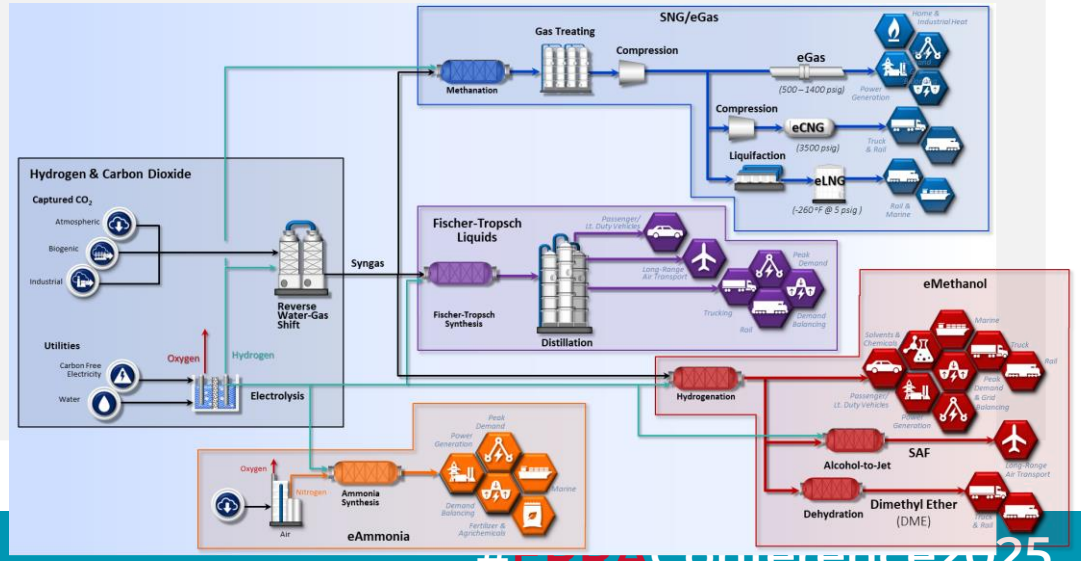
These demonstrations are designed to provide…

- Integrated demonstrations that include production, storage, and use of low-carbon fuels
- Collaboration involving the entire value chain of fuels and different stakeholders
- Scalable solutions for multiple sectors to decarbonization

Demonstration Projects

End Use Decarbonization

- Data center resilient back-up
- Energy coupling with low-carbon fuels



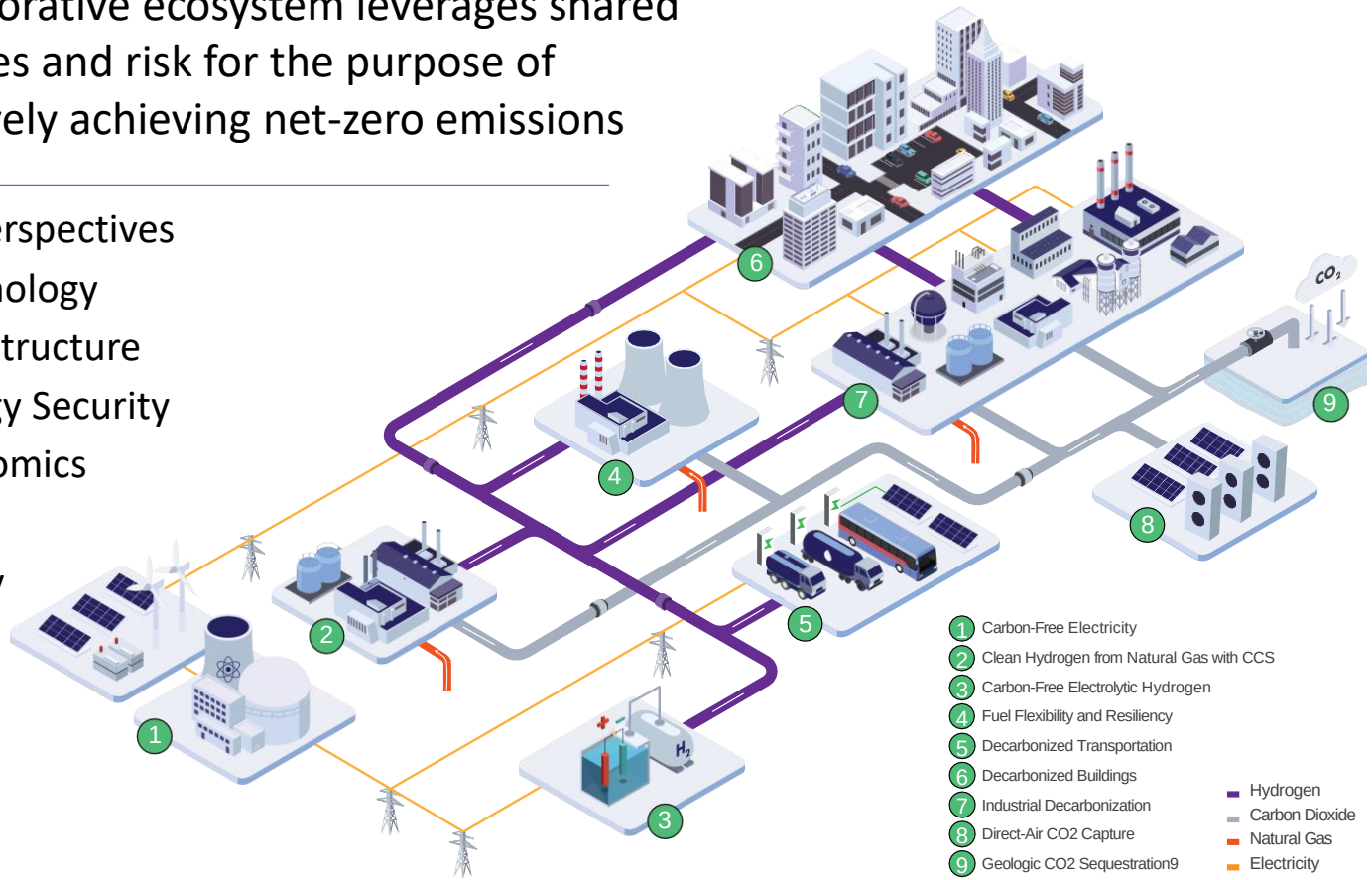
INTEGRATED APPROACH TO DECARBONIZATION

LCRI is focused on reducing risks and maximizing impact while prioritizing safety, reliability, and affordability

A collaborative ecosystem leverages shared resources and risk for the purpose of collectively achieving net-zero emissions

Value Perspectives

- Technology
- Infrastructure
- Energy Security
- Economics
- Jobs
- Policy



Maximize Emissions Reductions

Enhance Economic Efficiency

Reduce Technology Risks

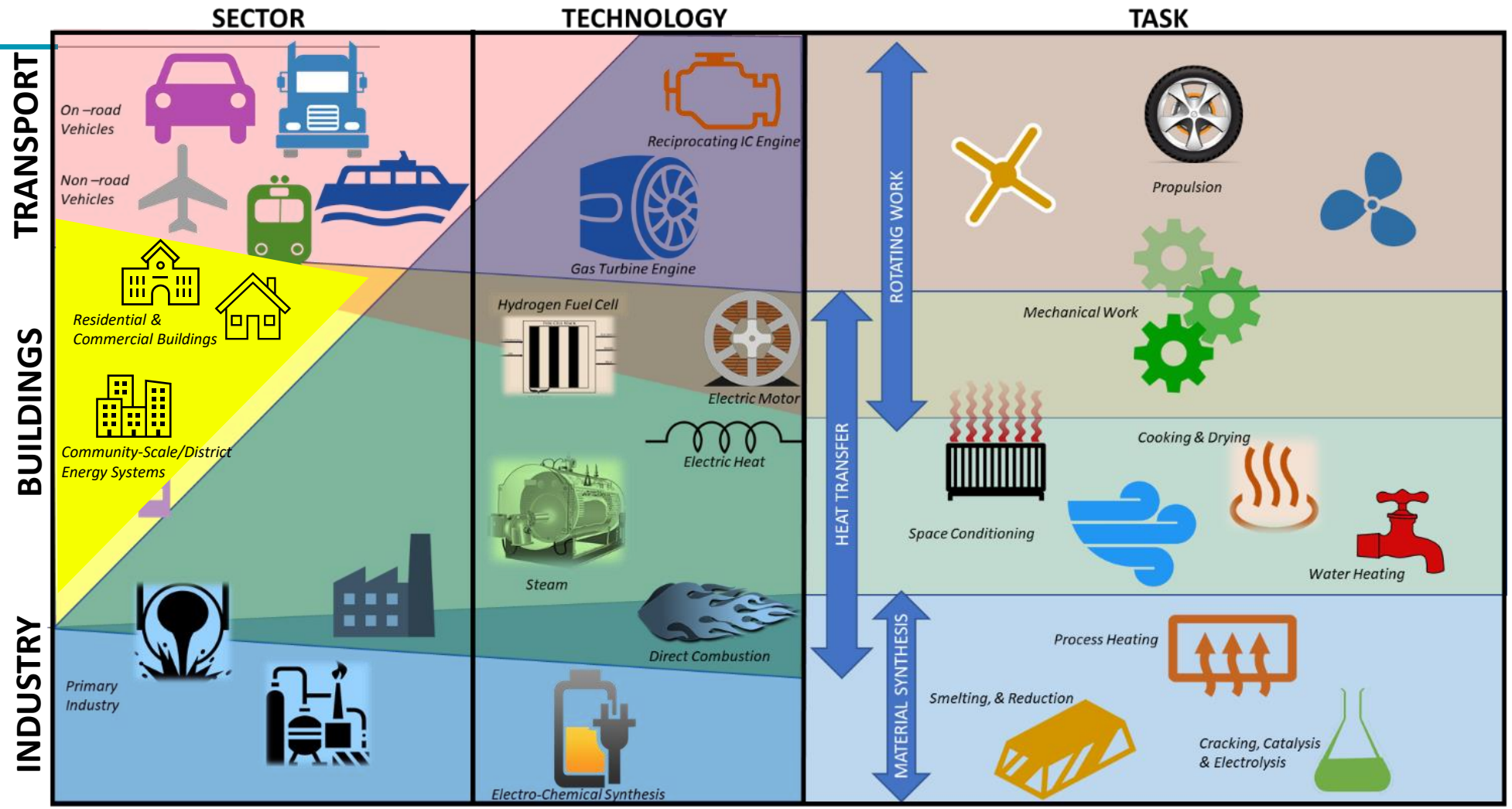
Enable Energy Flexibility & Resilience

Align Policies and Regulations

Realize Environmental and Social Benefits

Develop Long-Term Sustainability

LCRI End Use R&D Scope: Decarbonization of Final Energy



Learn More About LCRI

Technical Areas

Integrated Energy System Analysis
Renewable Fuels
Hydrocarbon-Based Processes
Electrolytic Processes
Storage, Delivery, & Transport
End Use Applications
Power Generation
Safety
Environmental Aspects

Public Webpage

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LCRI Research Vision

https://lcri-vision.epri.com

Quick Links & Information

LCRI General Info

- LCRI 1 Pager
- LCRI Scope
- LCRI FAQ

LCRI Introductory Videos

- LCRI Advisory Structure
- LCRI Roadmap Approach
- LCRI Technology Pipeline
- LCRI Roadmap Reviews
- Colors of Hydrogen
- Who is EPRI – Who is GTI

LCRI References

LCRI Launch Document

Low-Carbon Fuels White Paper

THANK YOU FOR YOUR ATTENTION!

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