

Richard Boardman, Ph.D.

Randy Petri, ChE, MBA



# Firming Renewables with Nuclear Sourced Hydrogen

United Nations Economic Commission for Europe (UNECE)

October 6, 2021



# Transforming the energy paradigm

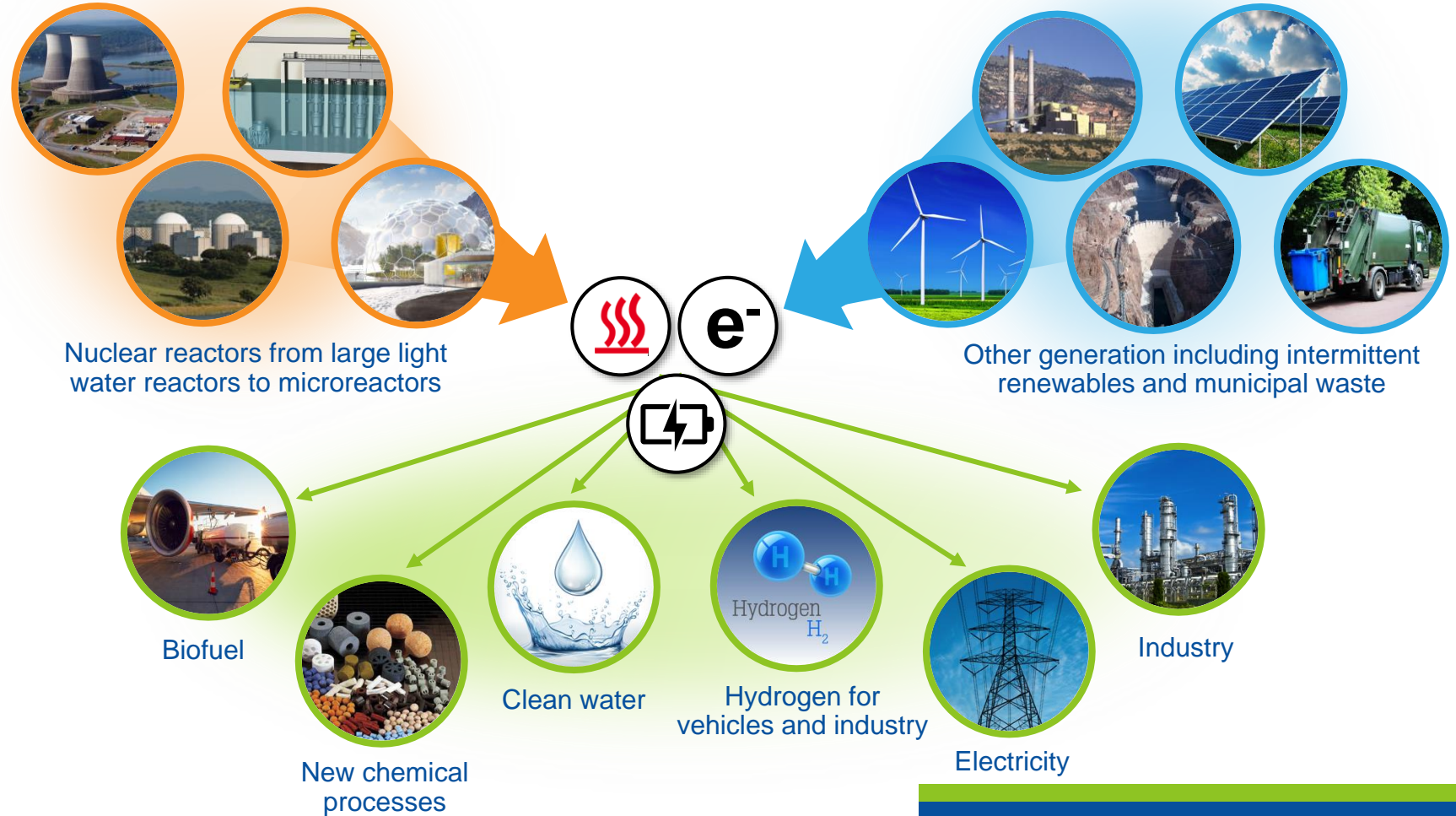
## Today

Electricity-only focus



## Future Energy System

Integrated grid system leverages contributions from nuclear fission beyond electricity



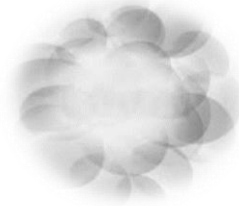


# How to produce clean hydrogen

## Steam / Methane Reforming



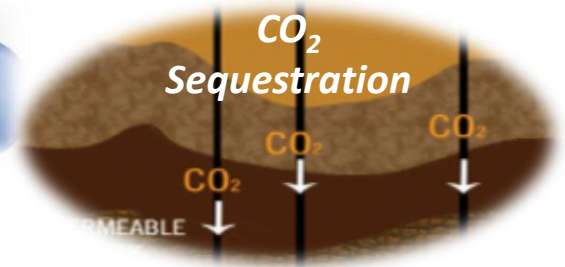
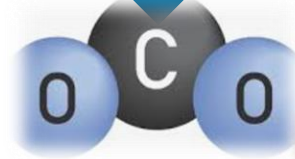
Steam



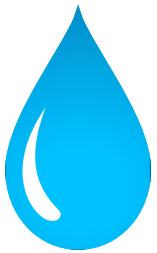
More Heat



Hydrogen



## Electrolysis



Water



Low-Temperature Electrolysis (LTE)

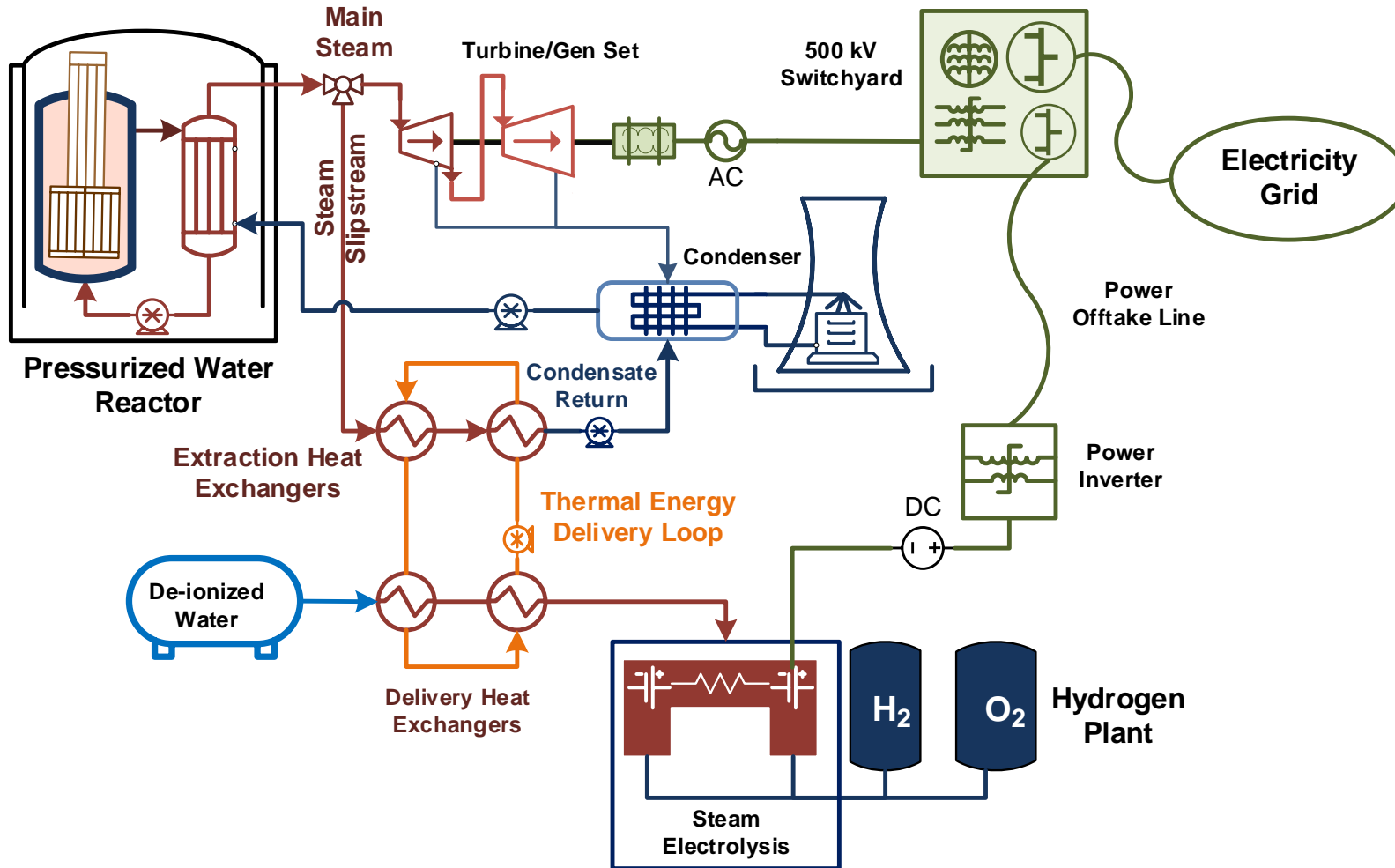


High-Temperature Electrolysis (HTE)



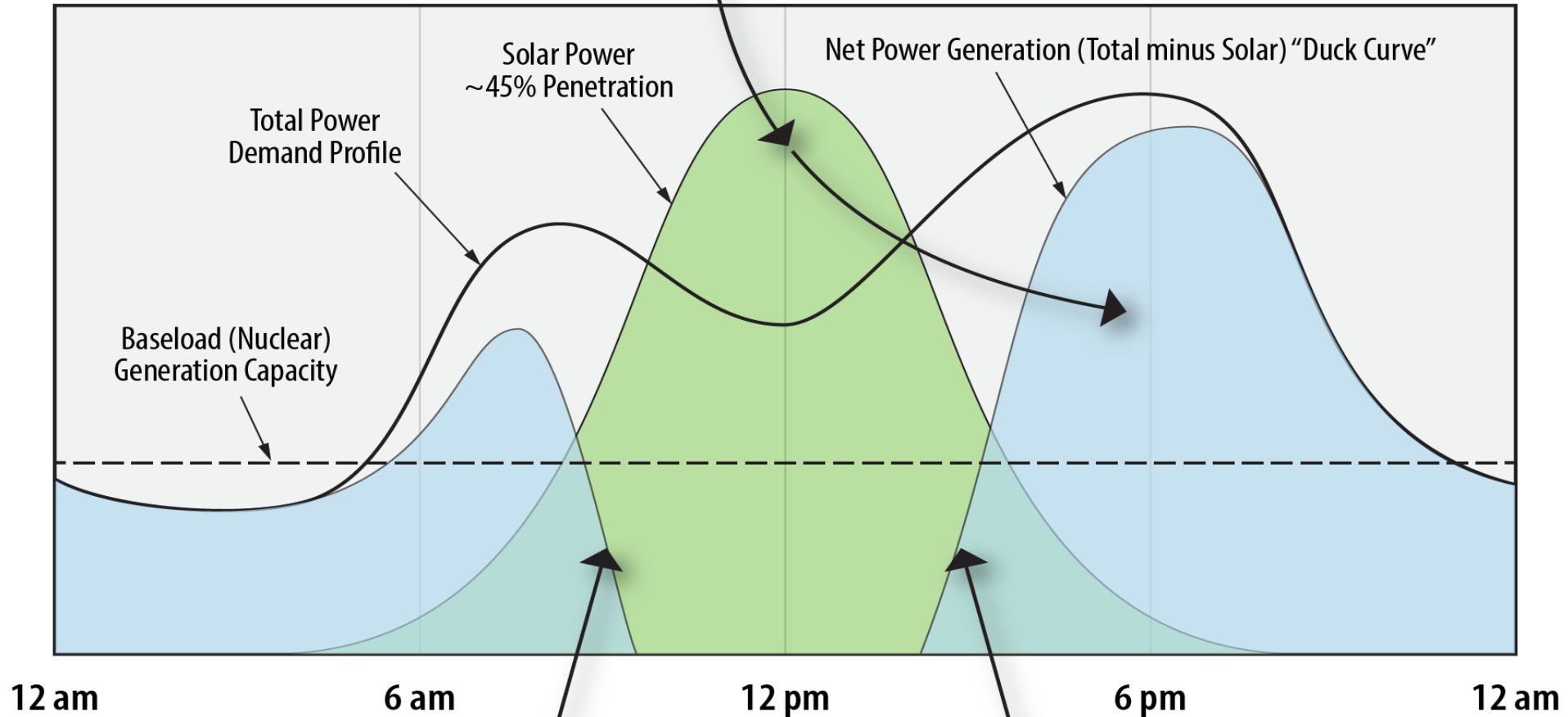
Hydrogen

# High Temperature Electrolysis with Nuclear Energy



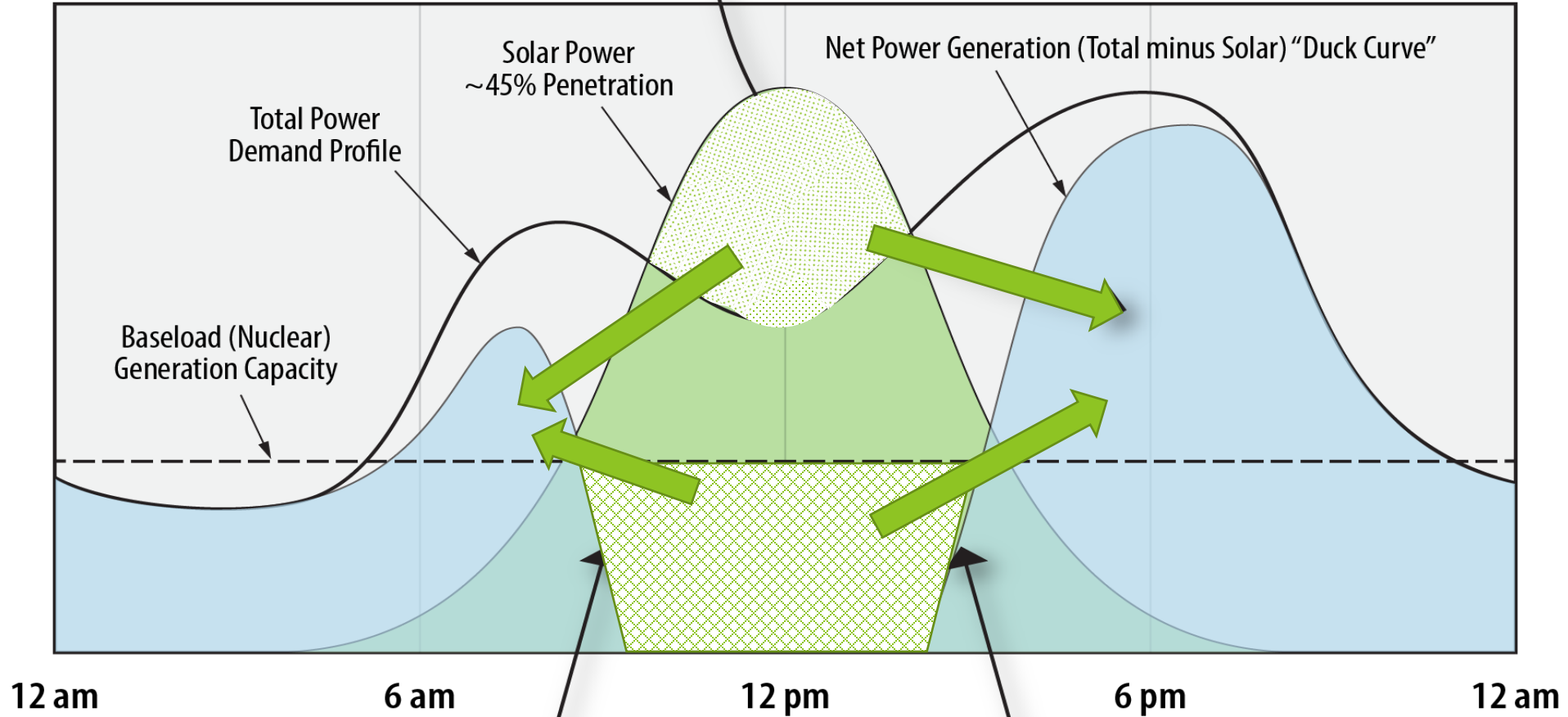
- Nuclear plants can provide thermal and electrical power to high temperature steam electrolysis
- High temperature steam electrolysis can be 20-40% more efficient than conventional electrolysis

**Energy storage is needed to shift excess generation to the evening hours**



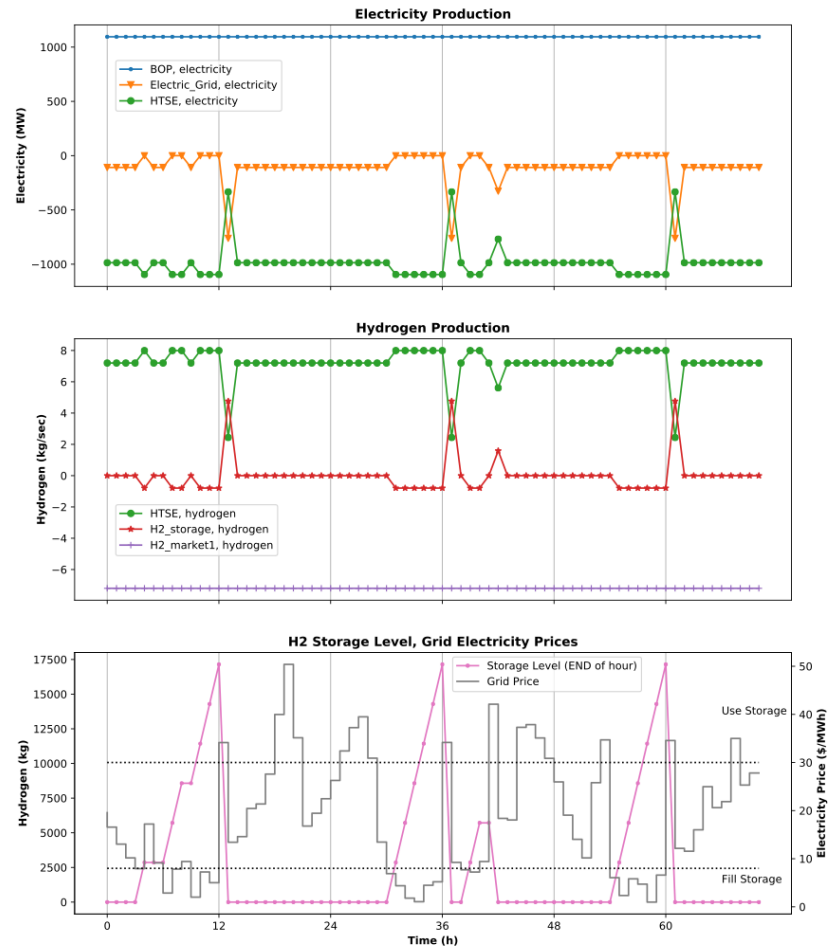
**Thermal power plants will be curtailed and then ramped up as solar energy tails off**

Energy storage is needed to shift excess generation to the evening hours

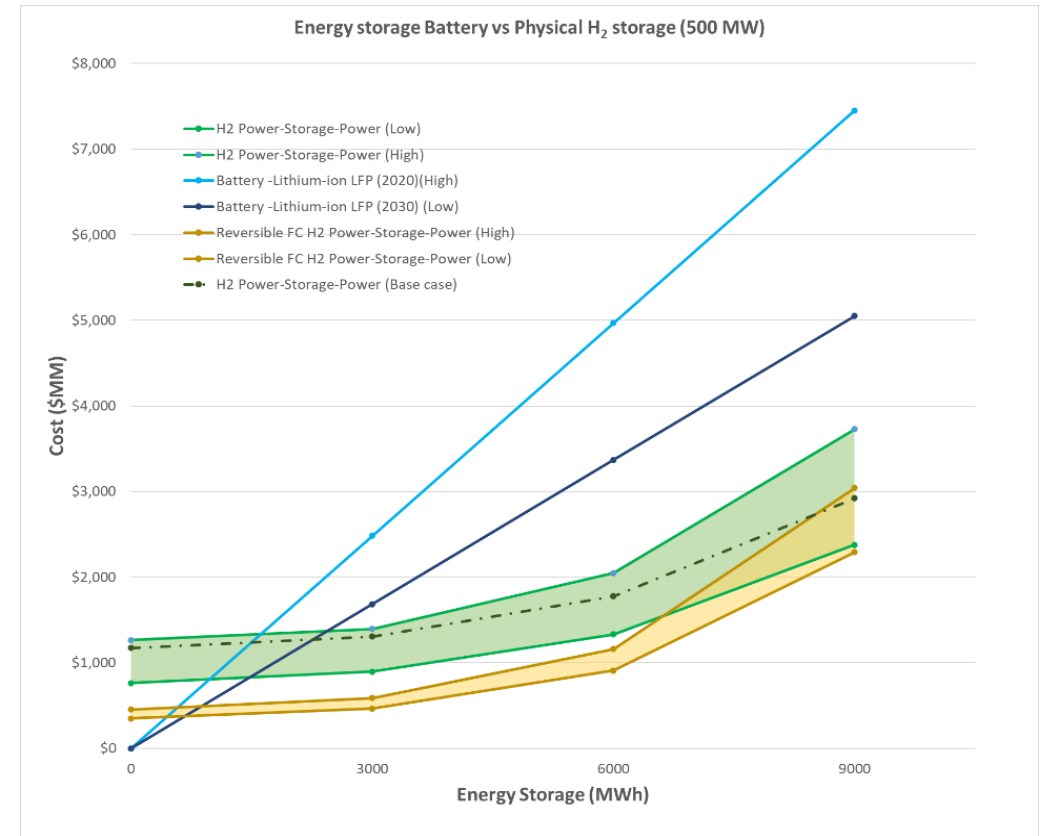


Thermal power plants will be curtailed and then ramped up as solar energy tails off

# Switching between electricity and hydrogen markets will be economically advantageous



- DOE is proving electrolysis plants can be ramped up and down as renewables sources vary



- Hydrogen storage for power production outcompetes batteries when storage capacity exceeds 500-800 MWh.



# INL Dynamic Energy Transport and Integration Lab (DETAIL)

Electricity  
Grid  
Simulation



Thermal Energy  
Generation and Transport



New Operating Concepts  
for Nuclear Reactors



Steam Electrolysis  
Stacks and  
Modular Systems





# Joint EERE-NE Hydrogen Production Demonstration Projects at NPP



- Demonstrate hydrogen production using direct electrical power offtake from a nuclear power plant (NPP)
- Develop monitoring and controls procedures for scaleup to large commercial-scale hydrogen plants
- Evaluate power offtake dynamics on NPP power transmission stations to avoid NPP flexible operations
- Produce hydrogen for captive use by NPPs and first movers of clean hydrogen

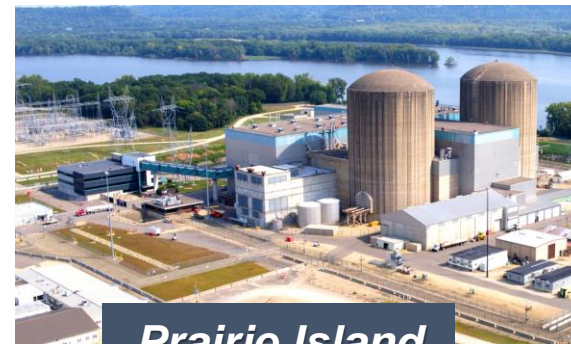
*Davis-Besse Nuclear Power Plant  
LTE-PEM Vendor 1*



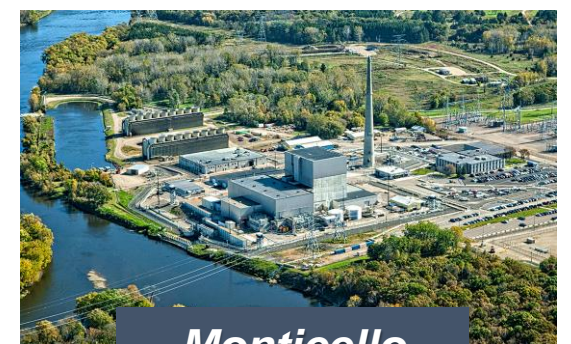
*Nine Mile Point Nuclear Power Plant  
LTE/PEM Vendor 2*



*Thermal & Electrical Integration at an Xcel Energy Nuclear Plant HTE/Vendor 1*



*Prairie Island*

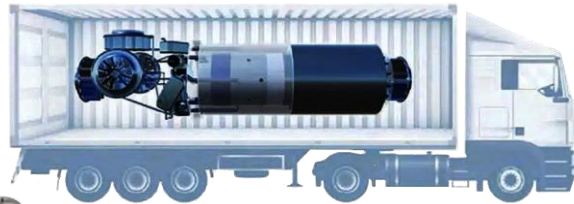


*Monticello*

# Accelerating advanced reactor demonstration and deployment



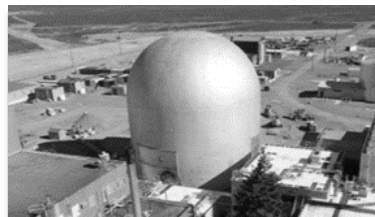
**MARVEL**  
DOE  
2022-2023



**Project Pele Microreactor**  
DoD  
2023-2024



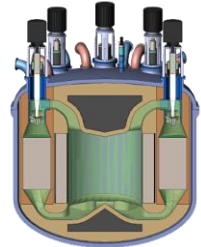
**DOME Test Bed**  
NRIC  
2023-2024



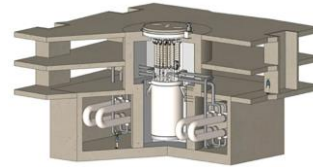
**LOTUS Test Bed**  
NRIC  
2024



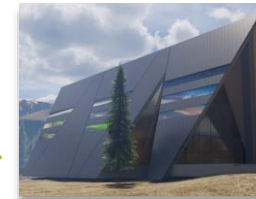
**NRIC** National Reactor  
Innovation Center



**MCRE**  
Southern Co. & TerraPower  
2025

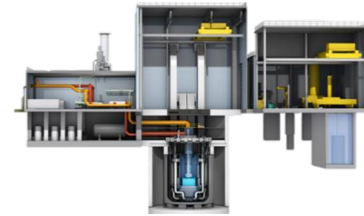


**Hermes Kairos**  
Kairos Power  
2026



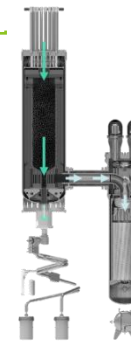
**Aurora Oklo Inc.**  
TBD  
OKLO

**Sodium Reactor**  
TerraPower & General Electric  
2028



**Natrium Reactor**  
TerraPower & General Electric  
2028

**Xe-100**  
X-energy  
2027  
energy



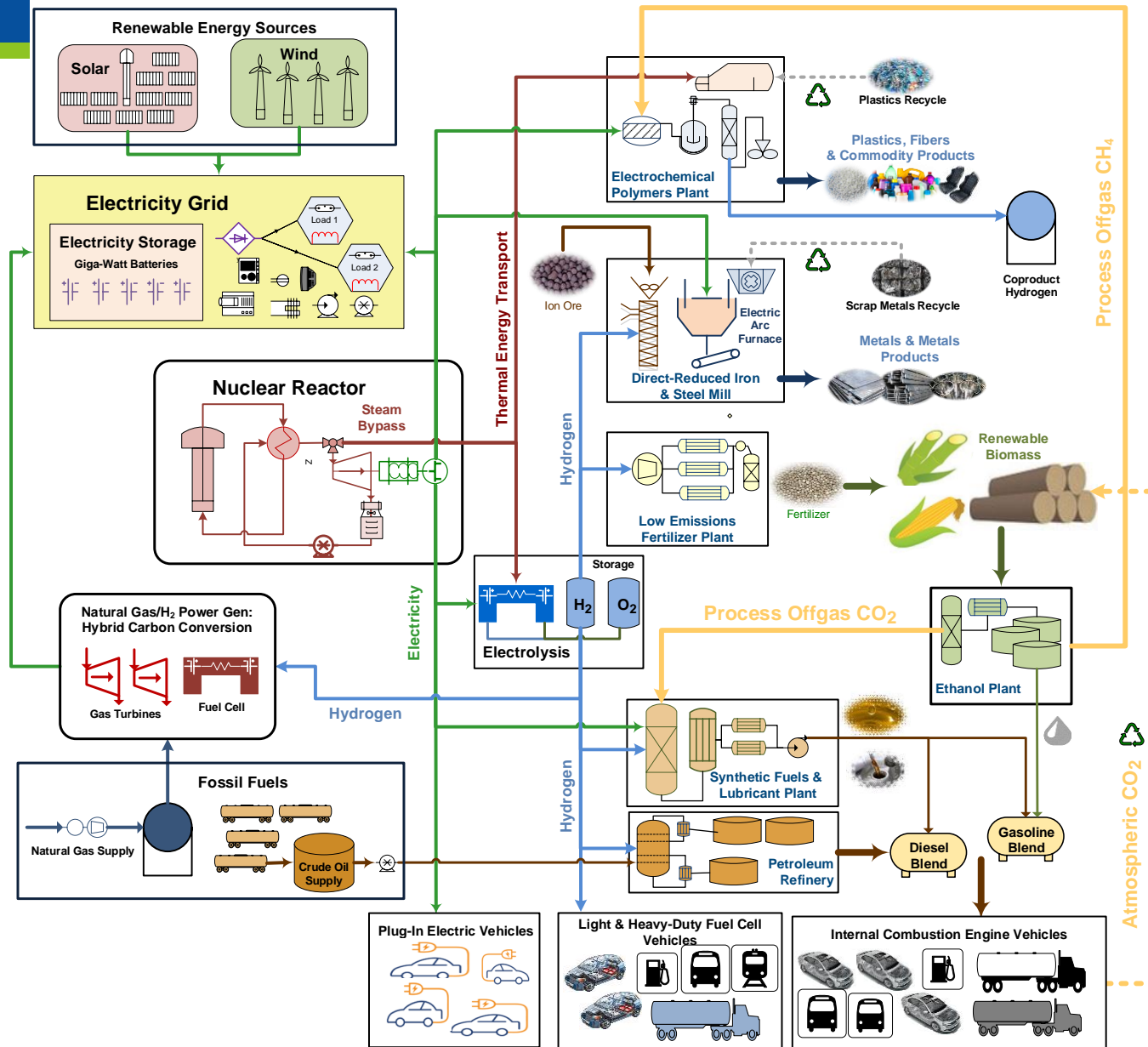
**SMR**  
UAMPS &  
NuScale  
2029  
UAMPS  
NUSCALE  
Power for all humankind

2030

Business Sensitive

IDAHO NATIONAL LABORATORY

# A new Paradigm: Integrated Energy Systems with Nuclear



## Industrial energy needs

- Electricity
- Steam
- Heat (Thermal Power)

## Target Large Industries

- Transportation fuels
- Fired heaters / Steam boilers
- Polymers & Plastic
- Iron & Steel
- Fertilizers
- Minerals

## Keys to success

1. Hydrogen is key energy currency
2. Flexible operations can support the grid
3. Energy storage is imperative





Idaho National Laboratory