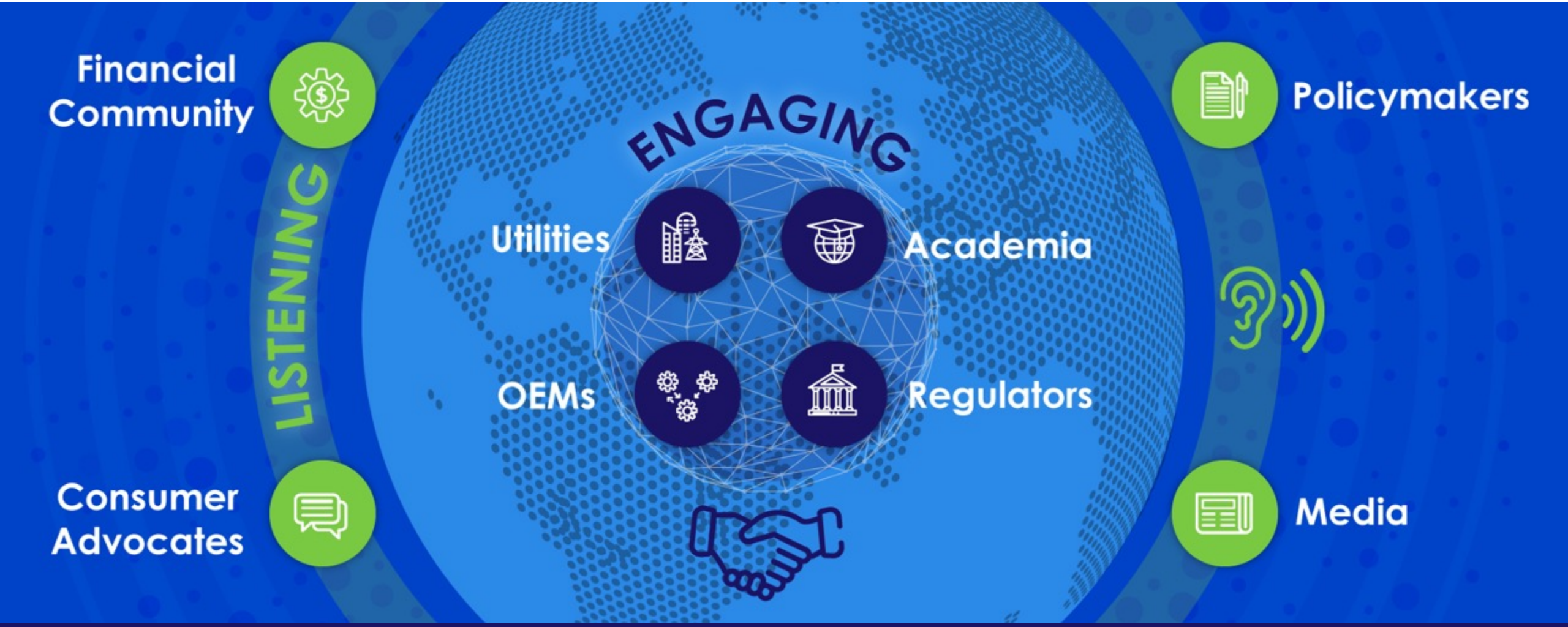
Meeting Tomorrow's Electricity Needs

2021 NEPPA Annual Conference

Arshad Mansoor
President & CEO
EPRI

August 24, 2021

EPRI: Leading Collaborative Energy R&D Around the World



EPRI advances energy technologies and informs decision-making through ~$420M in collaborative annual research involving nearly 400 entities in ~40 countries - spanning the generation, delivery, and use of electricity.

Reimagining the Future Energy System

Decarbonization

~10-15 years

Accelerate economy-wide, low-carbon solutions

- Electric sector decarbonization
- Transmission and grid flexibility: storage, demand, EVs
- Efficient electrification

~15-30 years

Achieve a net-zero clean energy system

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

Transformation

Drive affordability of a clean and resilient energy system through digital transformation

- Power system modernization: pervasive sensors, monitoring, advanced analytics using AI
- Upgraded and expanded communications infrastructure and control systems

Resiliency

~10-15 years

Mitigate climate impacts and cyber/physical risks

- System and asset hardening
- Improved response
- Faster recovery
- Cybersecurity

~15-30 years

Future proof energy system design basis

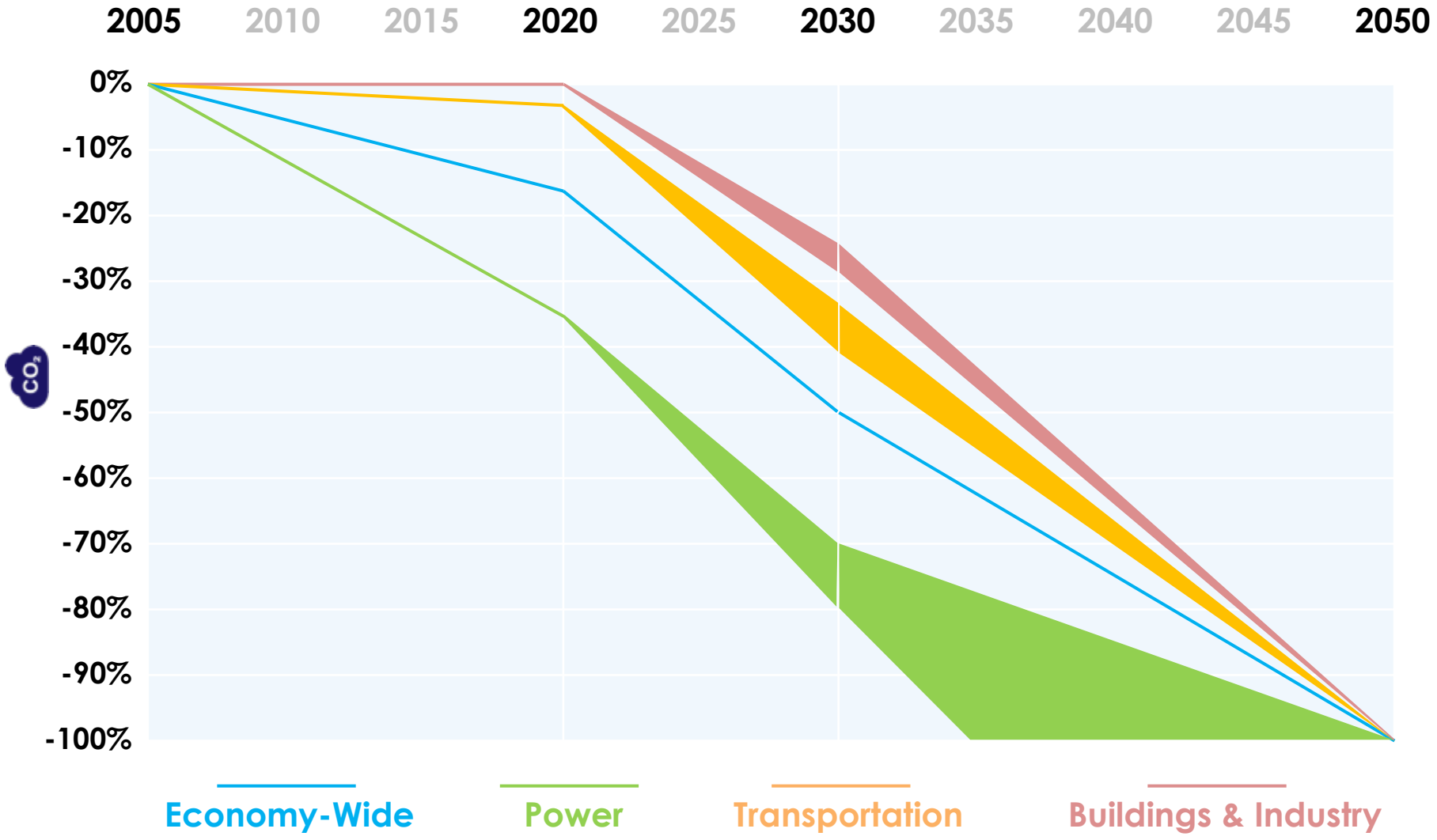
- Resilient power system design
- Advanced asset design and strategic undergrounding
- Smart integration of energy carriers

Making Energy More

Clean | **Affordable** | **Reliable**

Examining the Pace of U.S. Carbon Reduction Based on 2030 Goals

Collaborative innovation essential to an affordable and reliable energy future



Decarbonization Pathways Enabled by Innovation

Decarbonization

~10-15 years

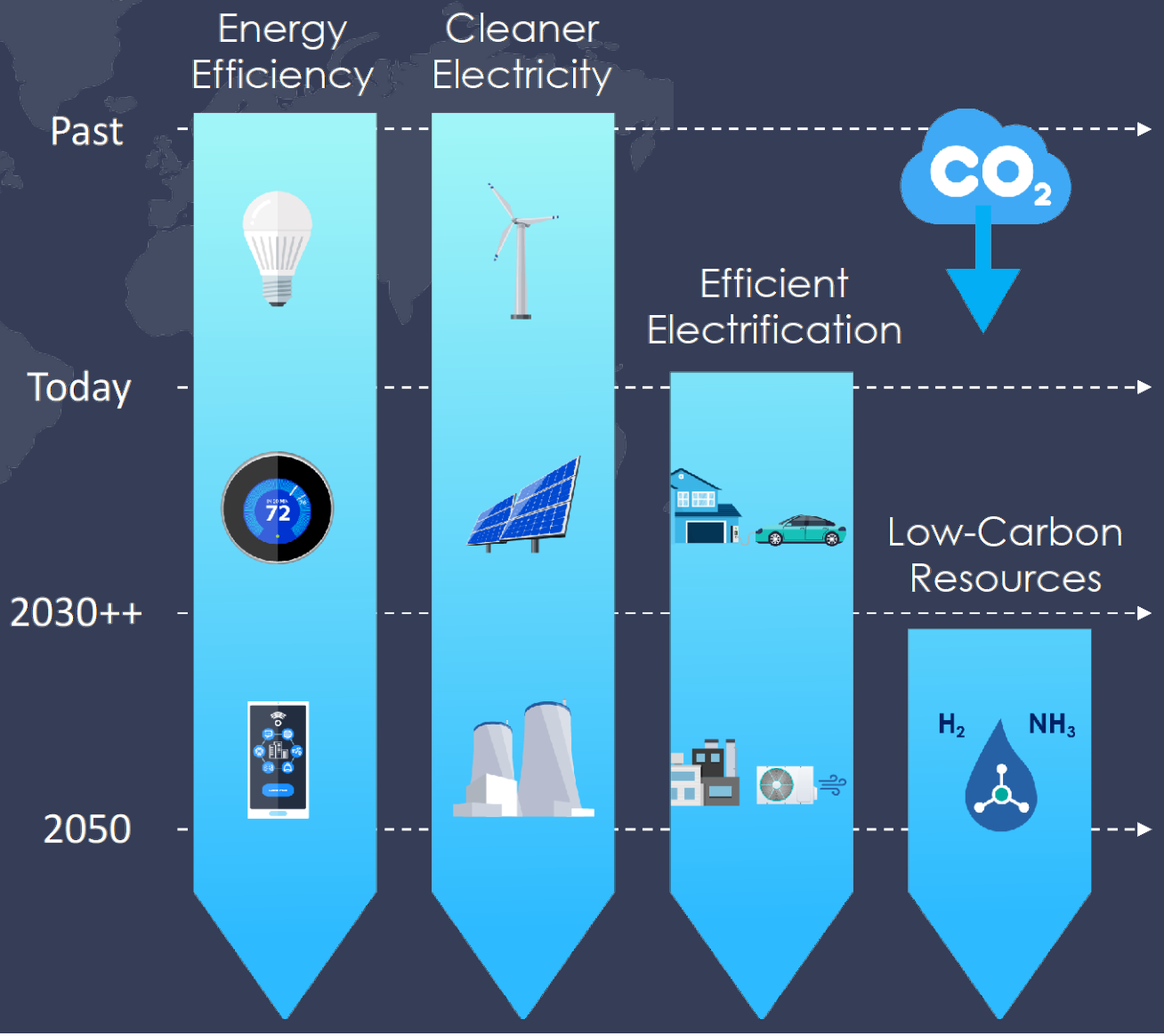
Accelerate economy-wide, low-carbon solutions

- Electric sector decarbonization
- Transmission and grid flexibility: storage, demand, EVs
- Efficient electrification

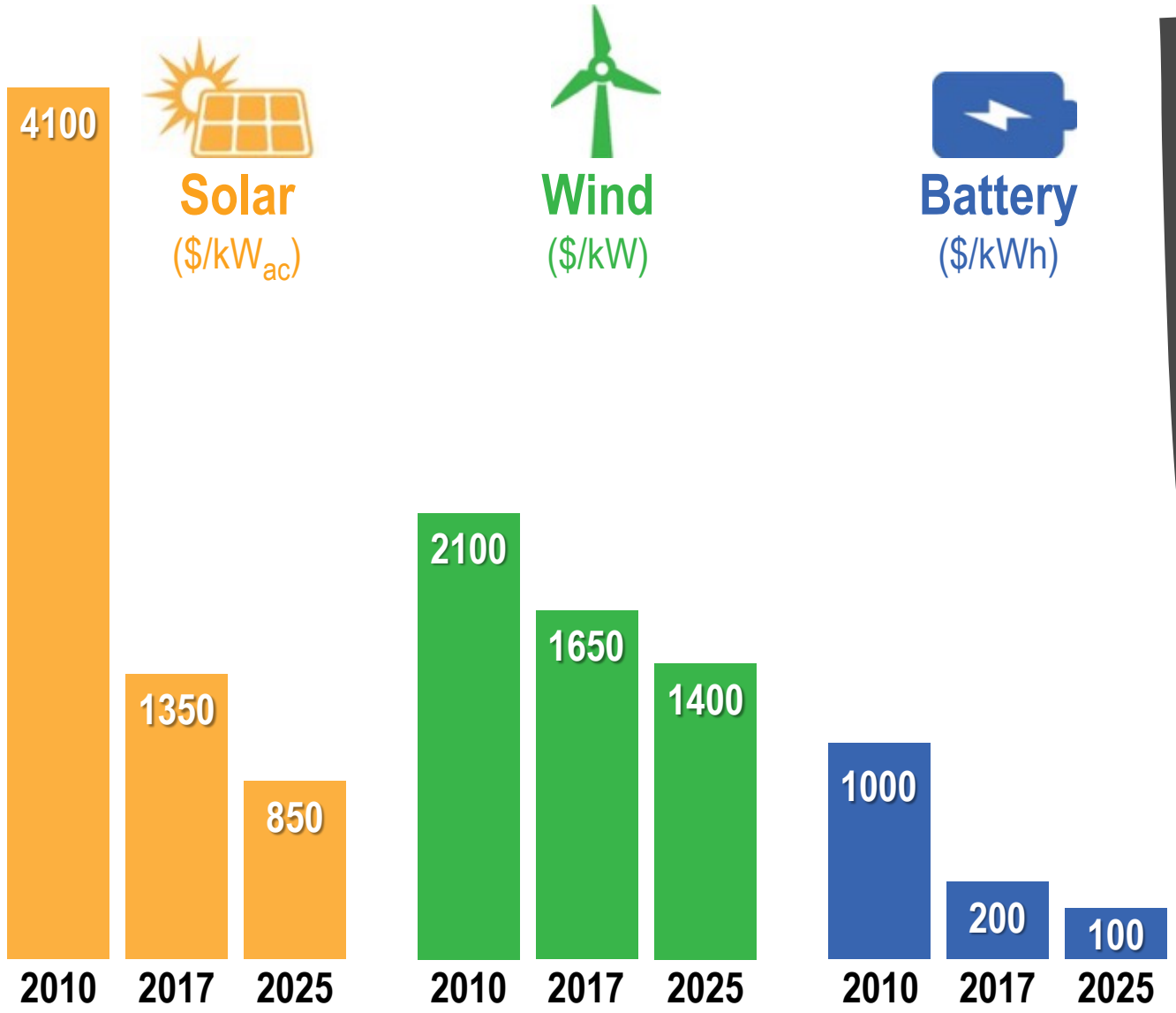
~15-30 years

Achieve a net-zero clean energy system

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



Renewable & Li Ion Battery Cost Trend: Unlocked Potential by 2025



- Universal Solar PV: ~$0.02/kWh in high solar region but still almost half the cost of rooftop solar
- Wind LCOE: ~ $0.03/kWh in high wind region
- Electric vehicle (~300miles): ~$7,000 decrease
- Commercial building batteries: 2-year payback
- Solar/wind + 4-6 hour storage cost = natural gas power plant

Reimagine Grid Integration

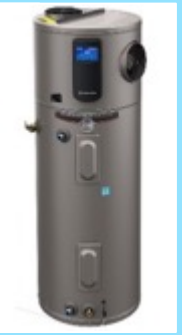
Technology Evolution and Impact on Capacity and Energy

ENERGY

Central Station Generation

Variable Generation

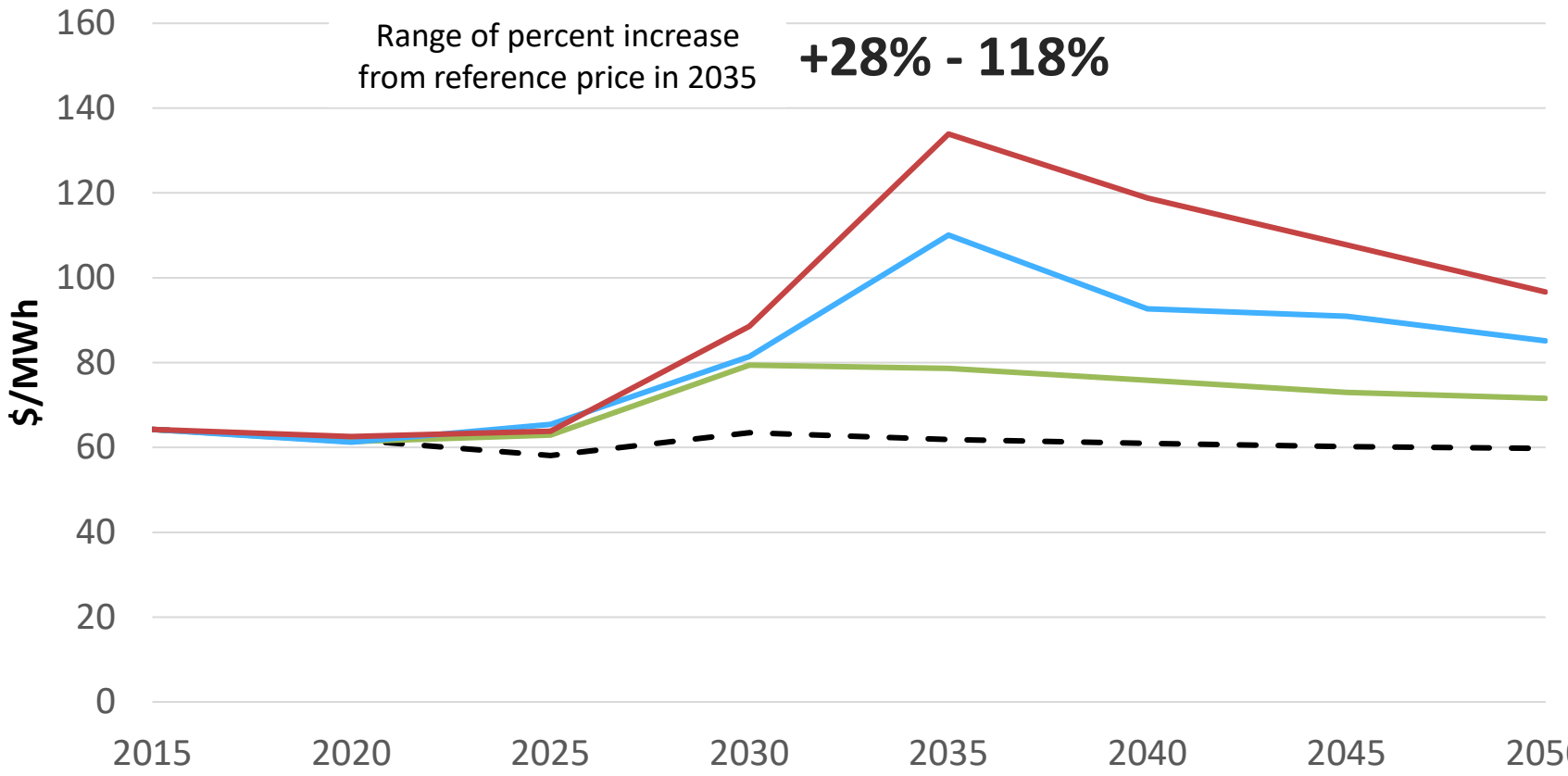
Energy Storage & Demand Response



CAPACITY

Net Zero vs. Carbon Free vs. 100% Renewable

U.S. Average Generation Price



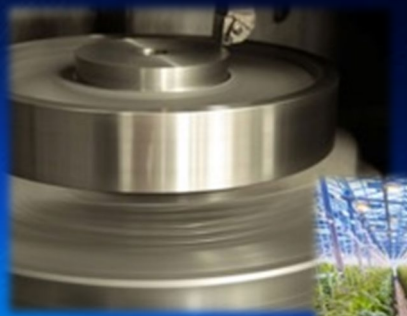
Restricting technology options significantly increases cost of electric sector decarbonization

Cleaner Electricity That is Reliable and Affordable Leads to Efficient Electrification

Mobility

Heating and Cooling

New Applications



EPRI ELECTRIC POWER RESEARCH INSTITUTE

Affordability *Benefits of Switching to EVs**

BEFORE

Total Energy Bill: $4,528

CO_2 Emissions: 18 tons

AFTER

Total Energy Bill: $3,571 ↓ 21%

CO_2 Emissions: 12 tons ↓ 34%

*Based on 2015 data for an average U.S. household. With rapidly declining purchase prices, EVs are projected to be a lower total cost option for most households in the early 2020s.

Key to Lower Carbon: Expanded Charging Infrastructure to Support EV Adoption

160,000 gas stations

The Utility's Role

- Charge-ready grid infrastructure and charging stations
- Rates to incentivize EV smart charging
- Energy storage infrastructure for fast charging

Level 2 Stations (Workplace and Public)

2018: 50,000

2030*: 1,000,000 – 3,000,000

Fast Charging Stations

2018: 10,000

2030*: 50,000 – 80,000

**Projections based on U.S. DOE Alternative Fuels Data Center EVI-Pro Lite tool and EPRI USNEA Progressive scenario*

2018-2030 Estimated installation cost of public and workplace charging infrastructure:

$4B-$30B

Key to Lower Carbon: An Integrated Grid Efficiently Linking Resources and Active Demands

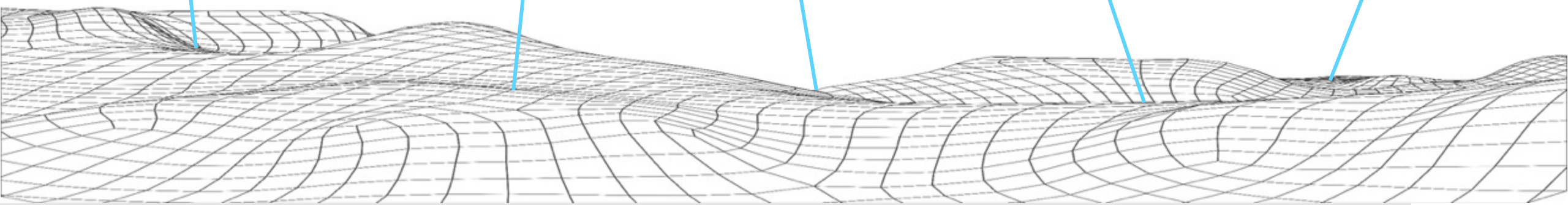
Smart and Fast Charging of EV

Enabling Higher Penetration of EV/Solar/DER

Grid-Integrated Energy Storage

Vehicle-to-Grid System Resource

Connected, Smart Demand-Responsive Load



Beyond 2030 – Hydrogen/Clean Electricity Production

H_2 Production

Advanced Nuclear

Next-Gen Electrolysis

Existing Clean Generation

Natural Gas CCS

H_2 Delivery

Utilizing Existing Natural Gas Pipelines Through Blending

Shipping and Trucking

H_2 End-Use

Boiler

Heavy Duty Transportation

Electric Generation

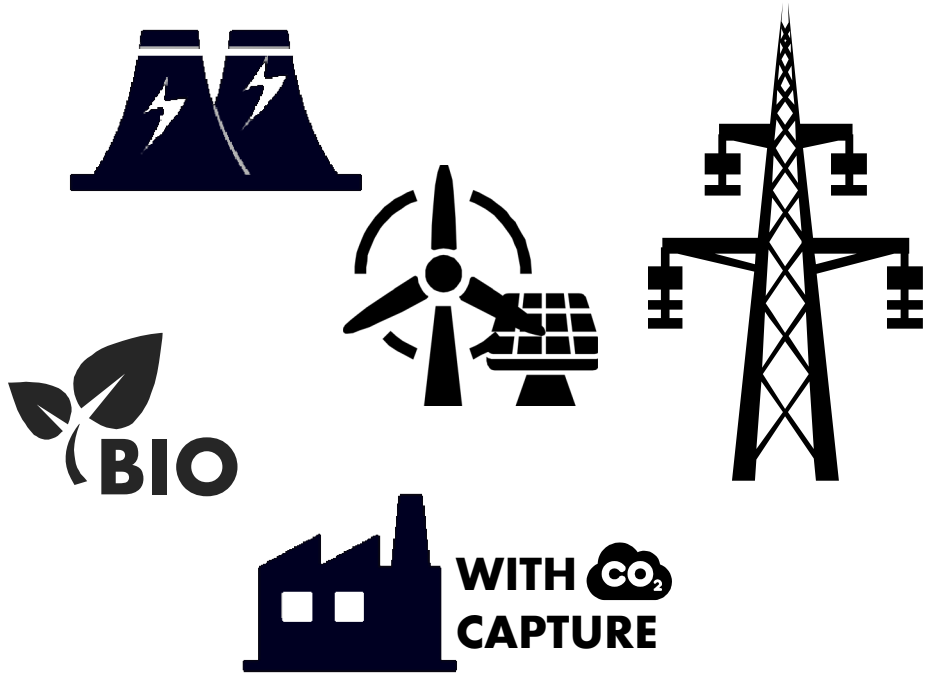
Advanced Fuel Cell

Large Industry

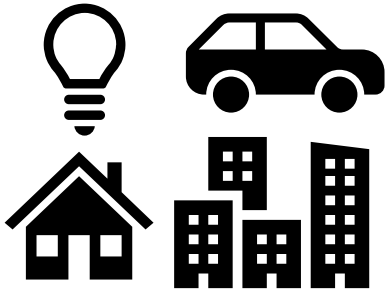
Chemical Process

Low-Carbon Fuels Pathway from the Electric Sector

Low-Carbon Generation, Transmission & Distribution

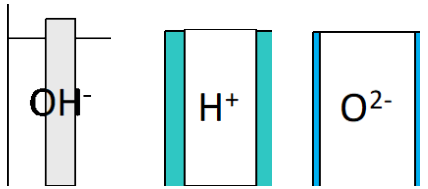


→ **Direct Electrification** →



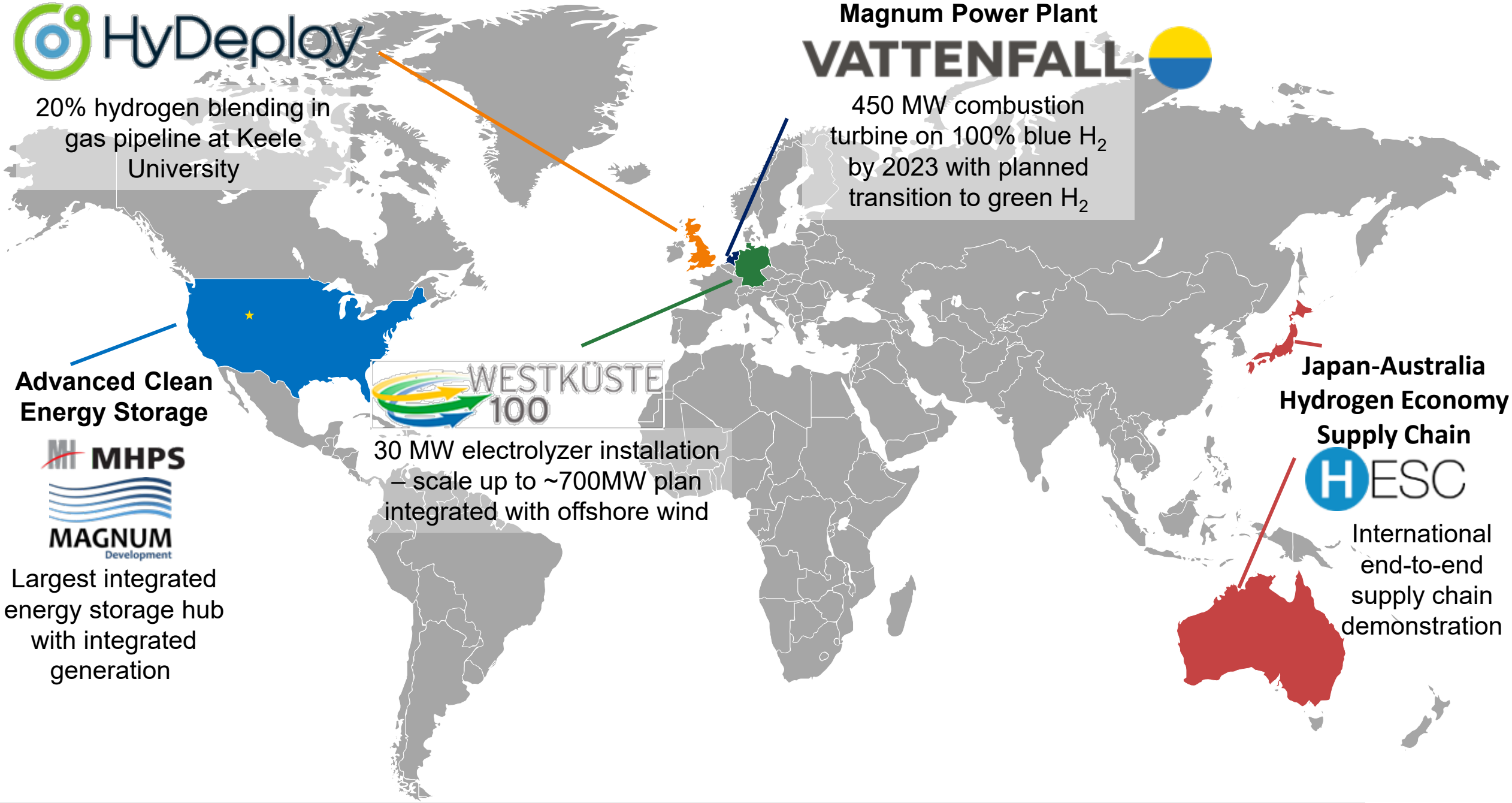
→ **Indirect Electrification** → **Low-Carbon Fuels***

Electrolysis →



- **Hydrogen**
- **Ammonia**
- **Synthetic Hydrocarbons**

**Representative of one of several pathways*



A five-year initiative to advance low-carbon resources

LCRI
LOW-CARBON
RESOURCES INITIATIVE

IOU

Alliant Energy
Ameren
American Electric Power
aps
Atmos Energy
CenterPoint Energy
ConEdison
Consumers Energy
Dominion Energy
DTE
Duke Energy
Exelon
FirstEnergy
Hawaiian Electric
Intermountain Gas Company
National Fuel
MiSource
NW Natural
Portland General Electric
PPL
Southern California Edison
SoCalGas
Southern Company
WEC Energy Group
Xcel Energy

Public Power

CPS Energy
SRP
LES
TVA Tennessee Valley Authority
LA DWP Los Angeles Department of Water & Power
Missouri River Energy Services
Nebraska Public Power District
New York State of Opportunity. NY Power Authority
OPPD Omaha Public Power District

Co-op

East Kentucky Power Cooperative
OglethorpePower
PowerSouth Energy Cooperative
Tri-State

INTL

Fortis Inc.
nationalgrid
NOMAC
TEPCO

OEMs

GE
Mitsubishi Power

EPC

Babcock & Wilcox
Black & Veatch

EPRI