MID-OHIO REGIONAL
MORPC
PLANNING COMMISSION

THE OHIO STATE UNIVERSITY
SUSTAINABILITY INSTITUTE

SECURING OUR ENERGY FUTURE:

EMERGING ENERGY TECHNOLOGIES AND FUTURE-PROOFING THE REGION

August 27, 2025

AUGUST 27 AGENDA

1:00 | **Welcome** | *Jessica Kuenzli, MORPC*

1:05 | **OSU Energy Advancement & Innovation Center** | *Emma Osborn, OSU EAIC*

1:10 | **Energy Landscape for Meeting Tomorrow's Demand** | *Brian Filiatraut, MORPC*

1:20 | **Hydrogen as a Versatile Fuel** | *Caitlin Holley, Trillium H2 Power*

1:35 | **Nuclear as a Consistent and Carbon-Free Source** | *Randy Keefer, AEP (retired)*

1:50 | **Battery as Improving Reliability and Balancing Energy Generation** | *Dr. Jung-Hyun Kim, OSU Institute for Materials Research*

2:05 | **Orchestrating through Smart Grid Technologies** | *Chris Monacelli, Westerville Electric Division*

2:20 | **Panel Discussion**

2:35 | **Audience Q&A**

2:55 | **Wrap-Up** | *Brian Filiatraut, MORPC*

MORPC MEMBERS

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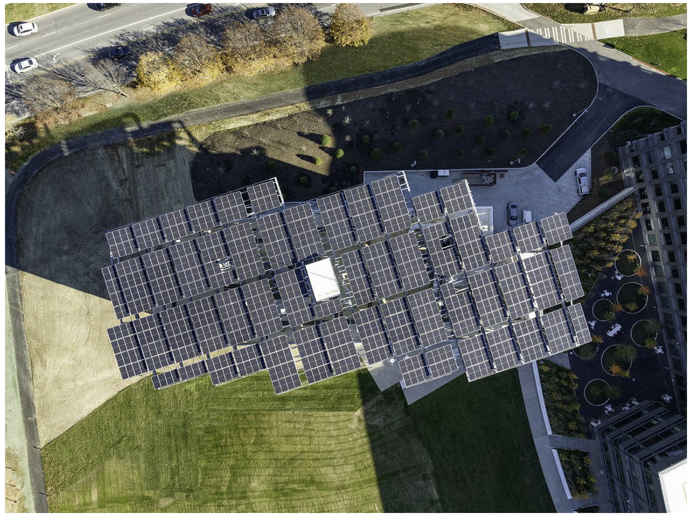


Energy Advancement and Innovation Center

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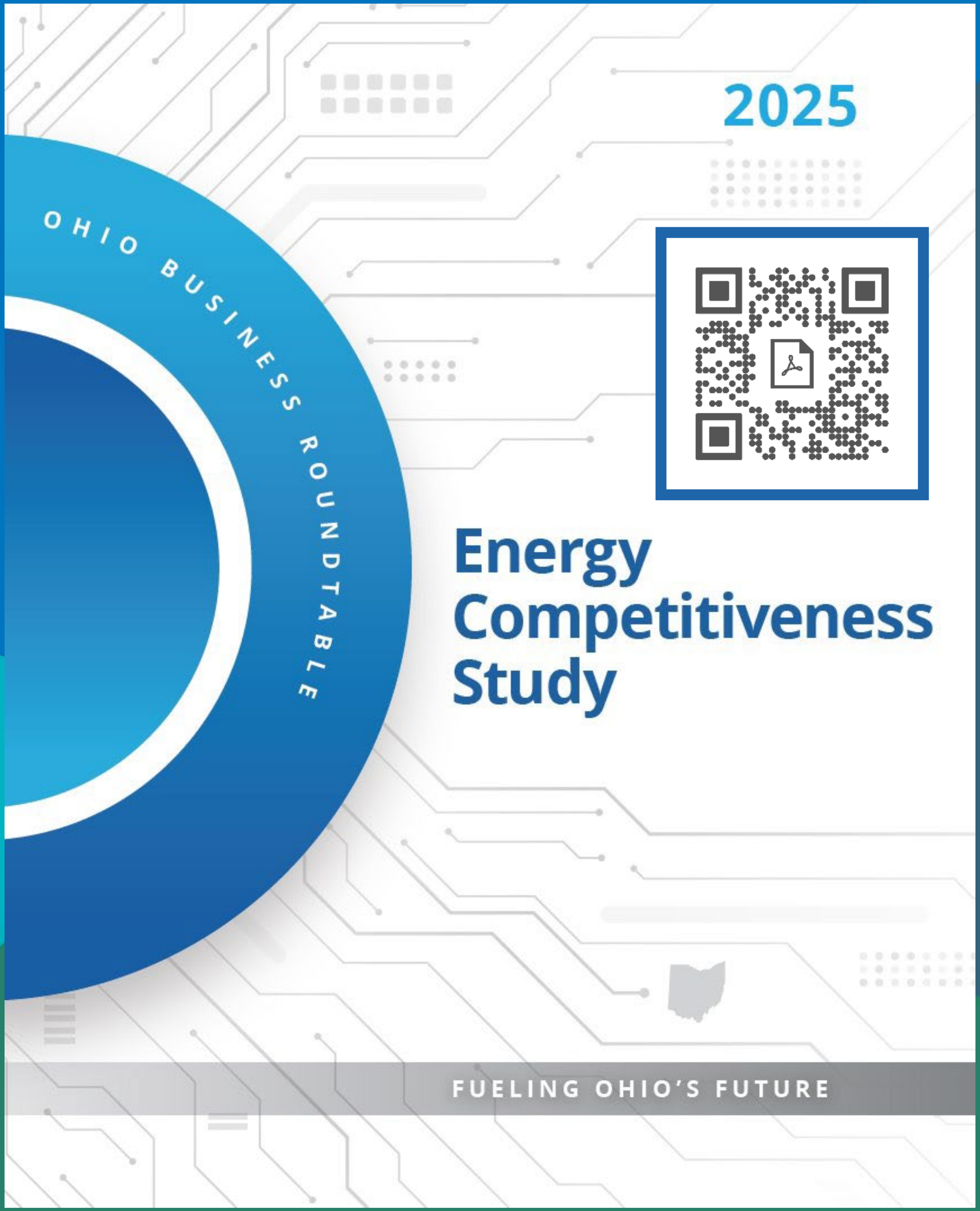
OHIO BUSINESS ROUNDTABLE (OBRT)

"The creation of this report was led by OBRT with the input and direction of 38 of its member companies."

“Since 2022, JobsOhio has won 1,016 economic development projects, with $74.27 billion in associated capital investment, demonstrating **Ohio is rapidly becoming a national hub for innovation, economic growth, and high-tech infrastructure**. However, the scale of this growth brings unprecedented **energy challenges**—aging infrastructure, the retirement of conventional power plants, and rising demand—all threatening to strain the very grid that fuels progress. To seize this moment of opportunity, **Ohio must take decisive action to modernize its energy infrastructure** and **ensure a resilient, affordable, and reliable power supply for both businesses and residents**.”

MORPC

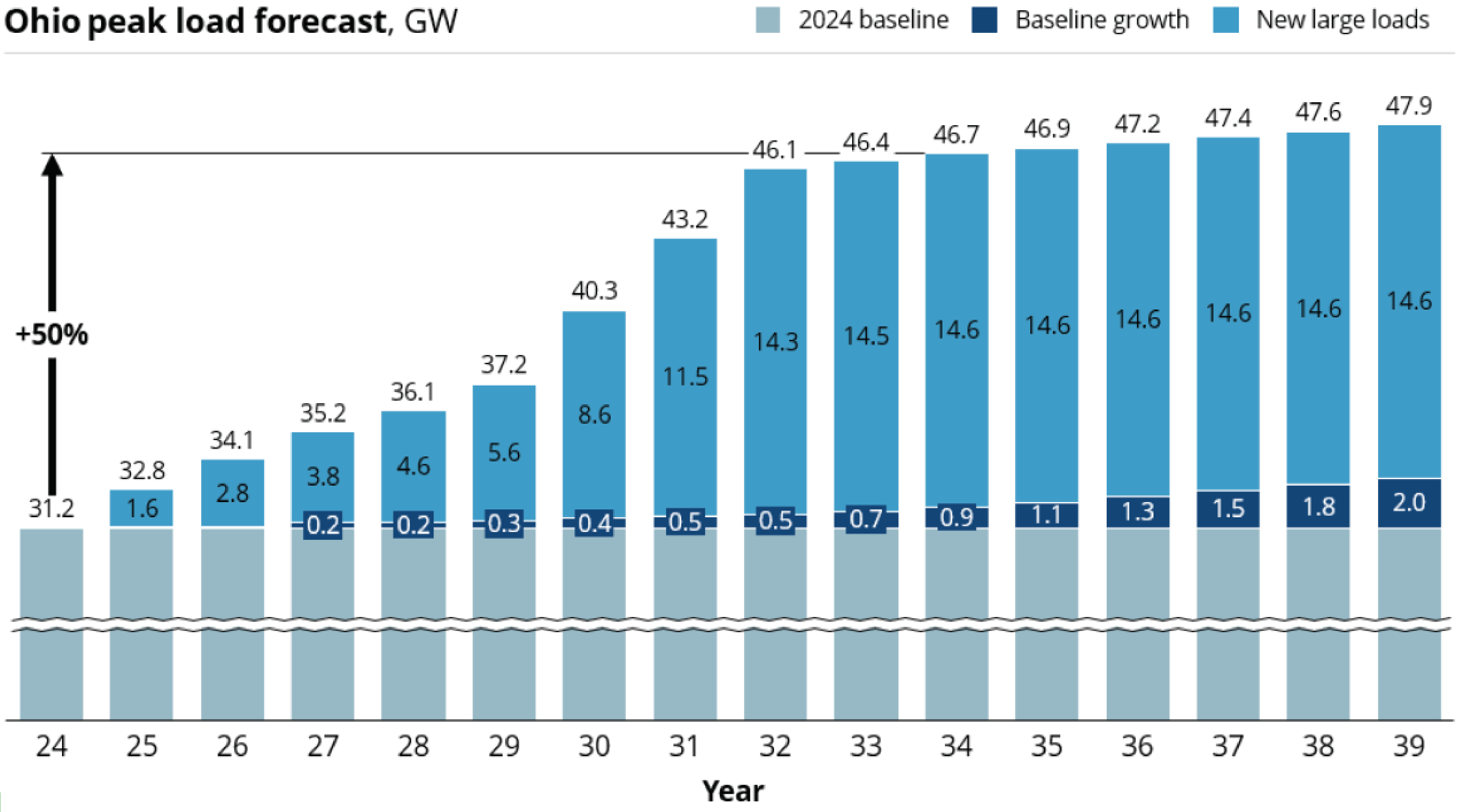


ENERGY COMPETITIVENESS STUDY

Ohio Business Roundtable (OBRT)

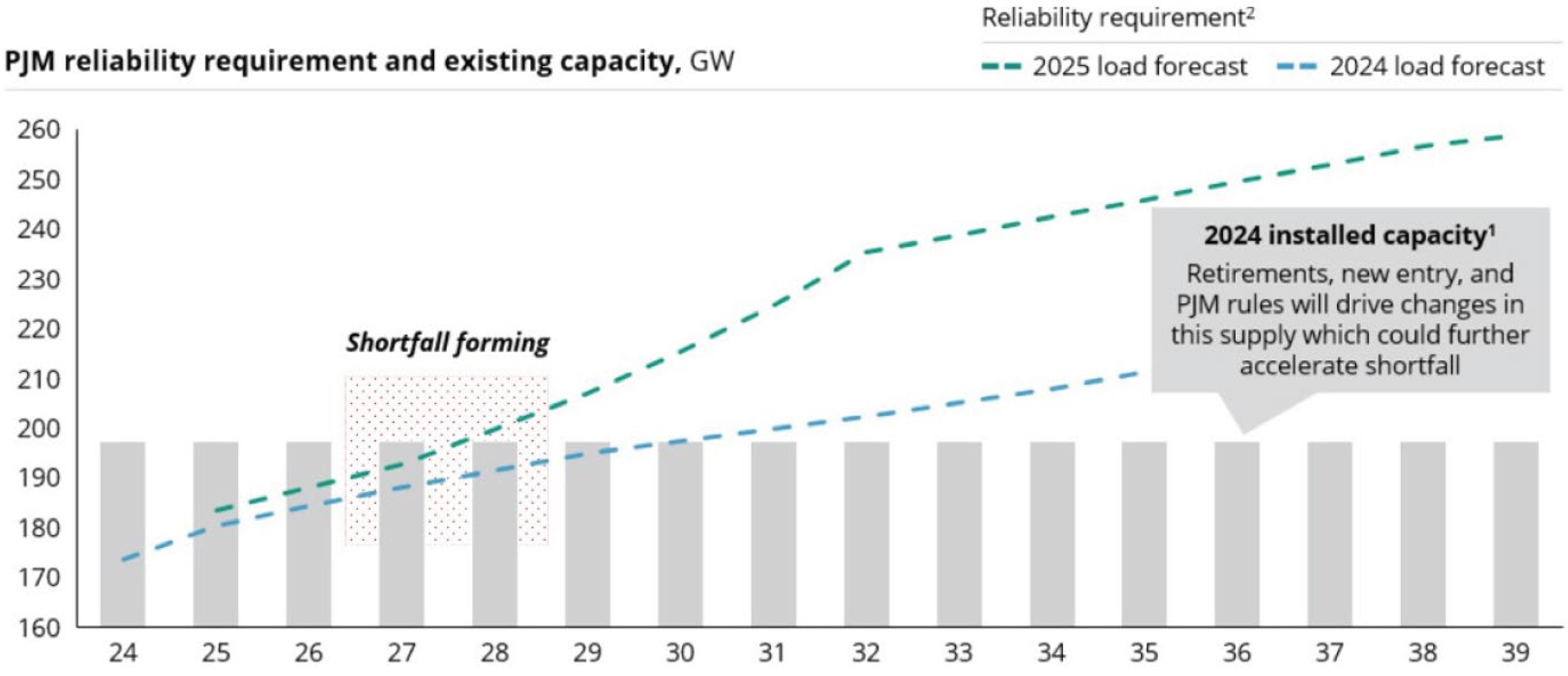
MORPC

The Demand for Electricity | Ohio Peak Load



Source: PJM 2024 load forecast hourly data; PJM 2024 load forecast supplement; PJM 2025 large load updates

The Demand for Electricity | PJM



1. Total PJM net summer capacity as of 9/30/2024, regardless of whether the capacity participated in the PJM capacity market
2. Reliability requirement indicates forecasted peak demand multiplied by the installed reserve margin (IRM) required to meet reliability standards. IRM of 14.8% used for 23-24 and 17.6% used for 25-39.

Source: Monitoring Analytics PJM State of the Market Reports; PJM 2024 load forecast report; PJM reserve requirement reports; PJM 2025 preliminary load forecast

JOIN US

SECURING OUR ENERGY FUTURE

Informational and Workshop Forum Series

WHAT – A series of **informational webinars and workshops** featuring energy, regulatory, and economic development experts in Central Ohio.

WHO – These sessions will help **local government and community leaders** plan for a more secure, resilient, and affordable energy future for their communities.

- **MAY 15** | **Landscape of Energy Planning**
- **JUNE 5** | **Planning Energy Resilience for a High-Demand Future**
- **JULY 10** | **Funding and Resource Opportunities to Build Your Energy Stack**
- **AUGUST 27** | **Emerging Energy Technologies and Future-Proofing the Region**

Securing Our Energy Future: Landscape of Energy Planning

MAY 15 | 12:30 – 2:30 PM | MORPC

SESSION #1

ALEX DENNEY
VP of Government Relations & Communications
Ohio Business Roundtable

KAMRAN ALI
SVP of Transmission Grid Planning & Engineering
American Electric Power

KENNY MCDONALD
President & CEO
One Columbus

WILLIAM MURDOCK
Executive Director
MORPC

Securing Our Energy Future:
Planning Energy Resilience for a High-Demand Future

JUNE 5 | 9:00 AM – 1:00 PM | MORPC

SESSION #2

JON-PAUL D'AVERSA
Principal
UNPREDICTABLEcity

DALE ARNOLD
Director of Energy, Utility, and Local Government Policy
Ohio Farm Bureau Federation

MIKE JACOBY
Director of Economic Development
Bricker Graydon

DYLAN BORCHERS
Partner
Bricker Graydon

HOLLY MATTEI
President
Crossroads Community Planning

Securing Our Energy Future:

Funding and Resource Opportunities to Build Your Energy Stack

JULY 10 | 1:00 – 3:00 PM | MORPC

SESSION #3

JOHN FLIS
Associate Attorney
Bricker Graydon

GABE LORENZ
Program Administrator
Ohio Air Quality Development Authority

EMMA MULVANEY
Senior Associate
Frost Brown Todd

JACKIE KEMBLE
Director of Operations
Columbus Region Green Fund

Securing Our Energy Future:

Emerging Energy Technologies and Future-Proofing the Region

AUGUST 27 | 1:00 – 3:00 PM | OSU Energy Advancement & Innovation Center

TODAY'S PANELISTS

CAITLIN HOLLEY
Vice President
Trillium H2 Power

RANDY KEEFER
New Nuclear / SMR Engineering Manager (Retired)
AEP

DR. JUNG-HYUN KIM
Associate Professor
The Ohio State University, Institute for Materials Research

CHRIS MONACELLI
Electric Utility Manager
City of Westerville, Westerville Electric Division

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Hydrogen: A Versatile Fuel for a Future-Proof Energy Mix

An Introduction to Hydrogen in Local & Regional Energy

Caitlin Holley

Vice President
Trillium H2 Power| https://th2power.com/
(614) 357-2566 | cholley@th2power.com

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Introduction to Hydrogen – Part of Ohio's Energy Future

OUTLINE

- ❑ Framing the Challenge - *Growing Demand Meets Energy Transition*
- ❑ Understanding Hydrogen - *From Molecule to Market*
- ❑ Hydrogen's Versatility - *A Multi-Sector Energy Tool*
- ❑ Ohio & Midwest Examples - *Hydrogen in Action, Close to Home*
- ❑ Call to Action - *Positioning Central Ohio to Lead*

Framing the Challenge

Growing Demand Meets Energy Transition

https://www.brickergraydon.com/insights/publications/h-b-15-proposes-largescale-changes-to-ohios-energy-landscape
https://puco.ohio.gov/news/puco-orders-aep-ohio-to-create-data-center-specific-tariff
https://www.whitehouse.gov/presidential-actions/2025/01/unleashing-american-energy/
https://www.utilitydive.com/news/pjm-interconnection-capacity-auction-prices/753798/

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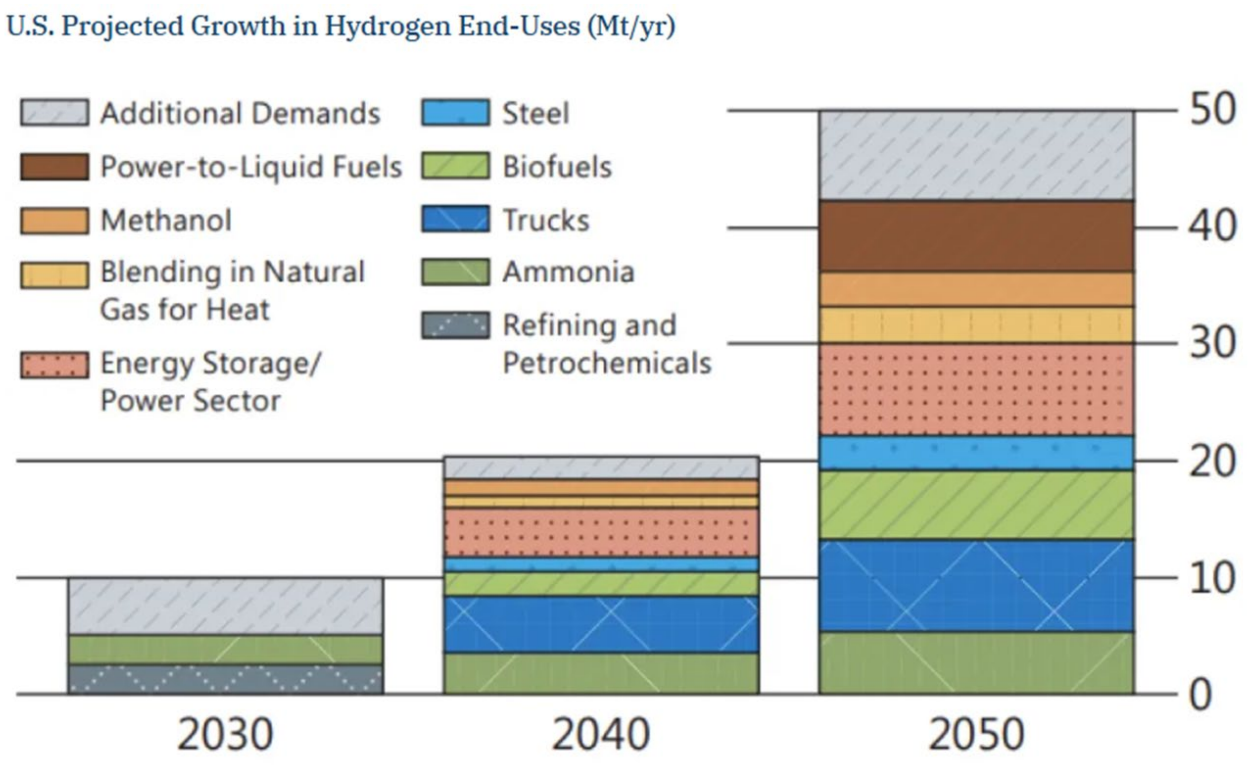
Why Hydrogen? Why Now?

- At the same time as we're experiencing an energy crunch, worldwide, federal, state, and local policies as pushing in the direction to transition toward lower-carbon sources.
- Hydrogen is one of the very few tools that can address both needs at once: supplementing heavy electrical load and offering a flexible, storable, carbon-managed fuel.
- Position hydrogen as part of the portfolio, not a silver bullet, but alongside SMRs, batteries, renewables, and demand-side management.



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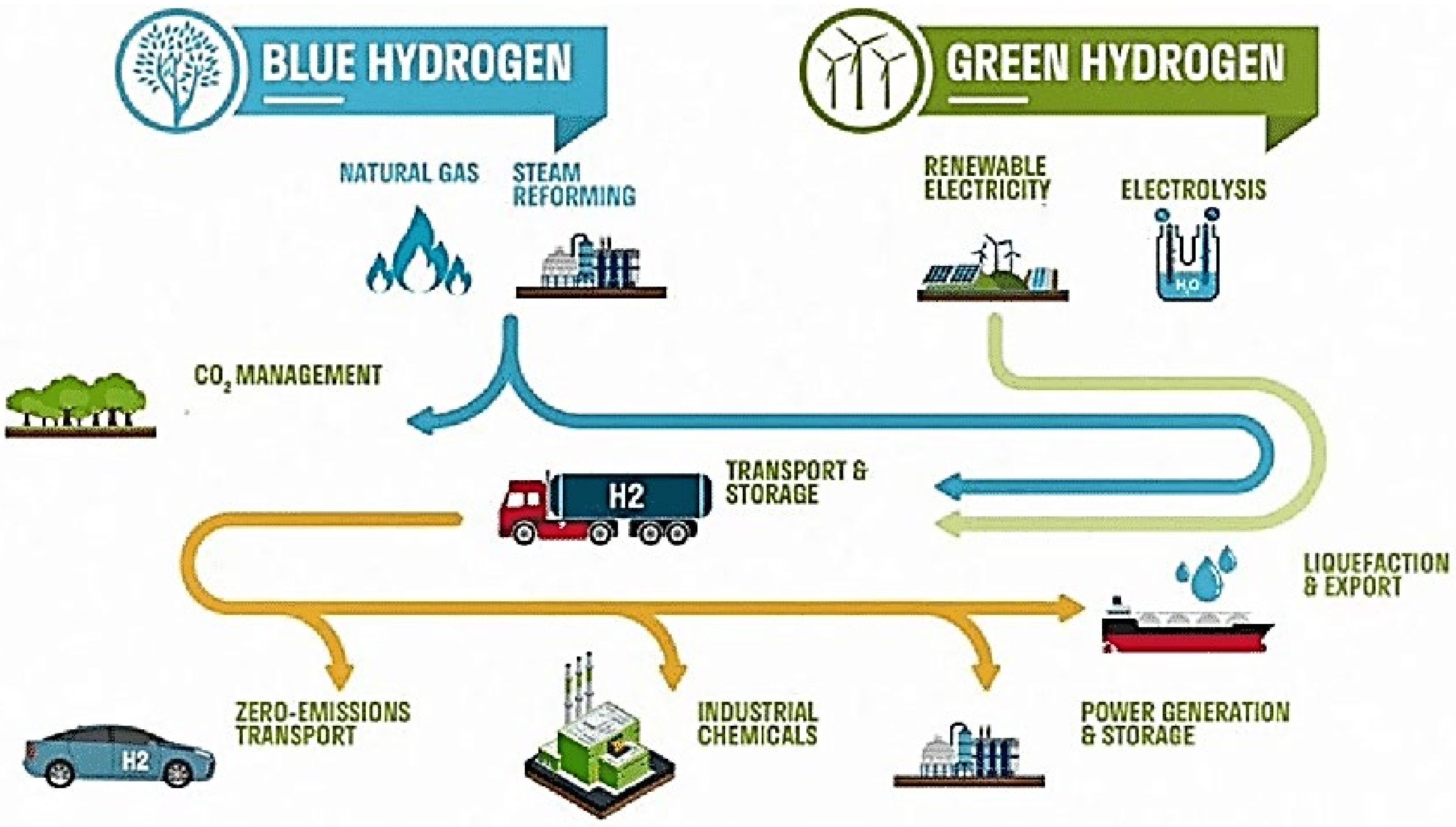
https://css.umich.edu/publications/factsheets/energy/hydrogen-factsheet

UNDERSTANDING HYDROGEN

From Molecule to Market



https://www.researchgate.net/figure/Blue-and-green-hydrogen-production_fig1_352598749

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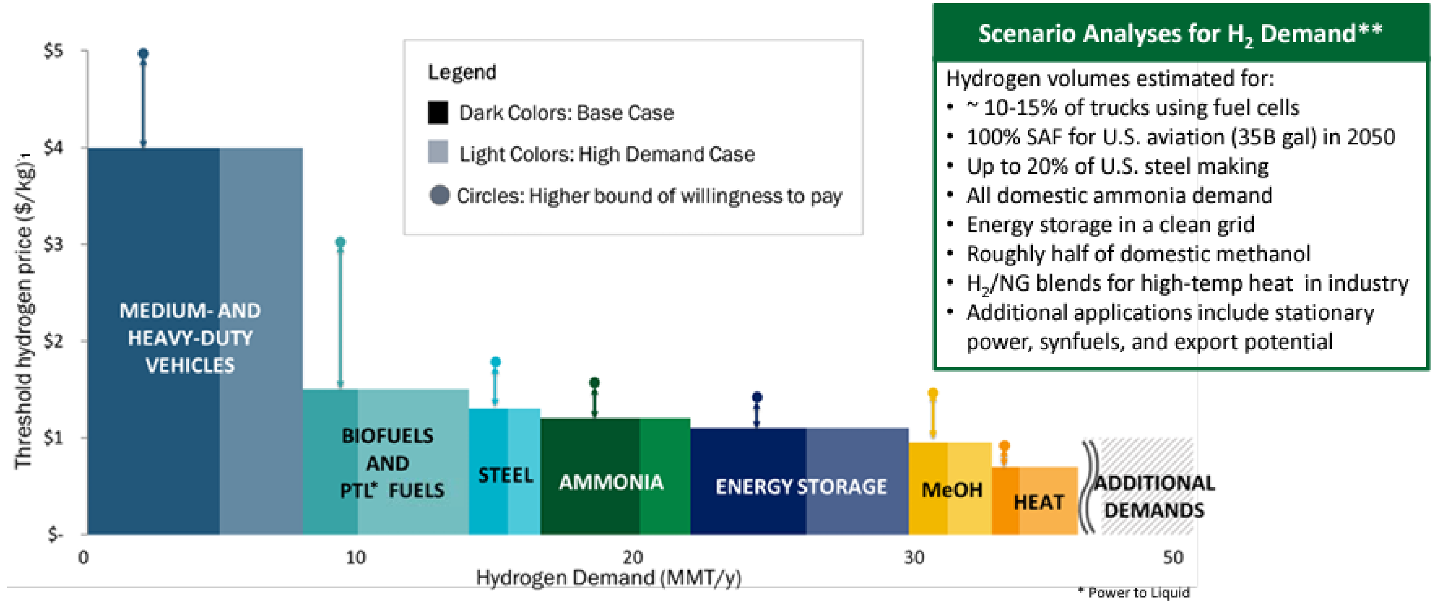
Introduction to the Current Landscape

- It is a clean-burning fuel, and when combined with oxygen in a fuel cell, hydrogen produces heat and electricity with only water vapor as a by-product.[1]
- Hydrogen fuel can be produced through several methods. The most common methods today are natural gas reforming (a thermal process), and electrolysis.[2]
- The U.S. Dept. of Energy is heavily investing in the development of clean hydrogen technologies to accelerate breakthroughs of more abundant, affordable, and reliable clean energy solutions within the decade.[3]

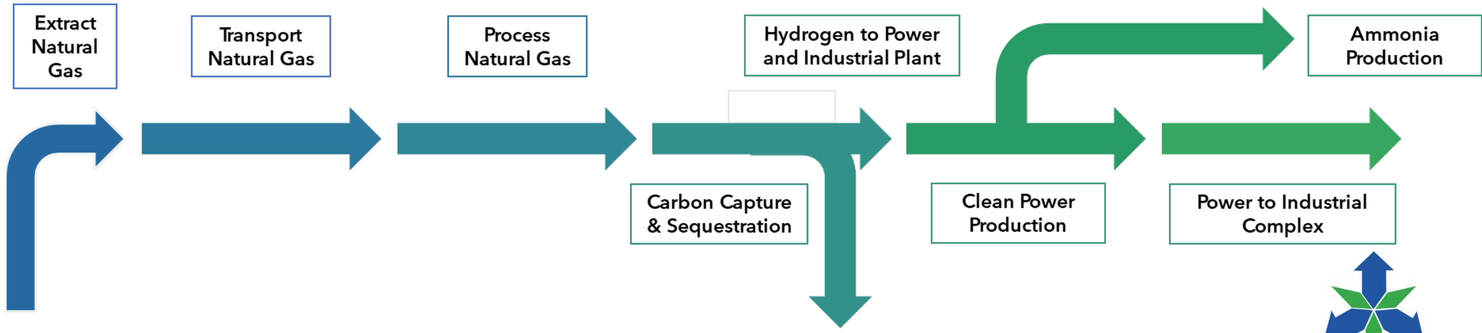
Clean Hydrogen Demand and Costs for Market Penetration



¹Costs include production, delivery, dispensing to the point of use (e.g., high-pressure fueling for vehicle applications)

* Power to Liquid

** Volumes dependent on multiple variables



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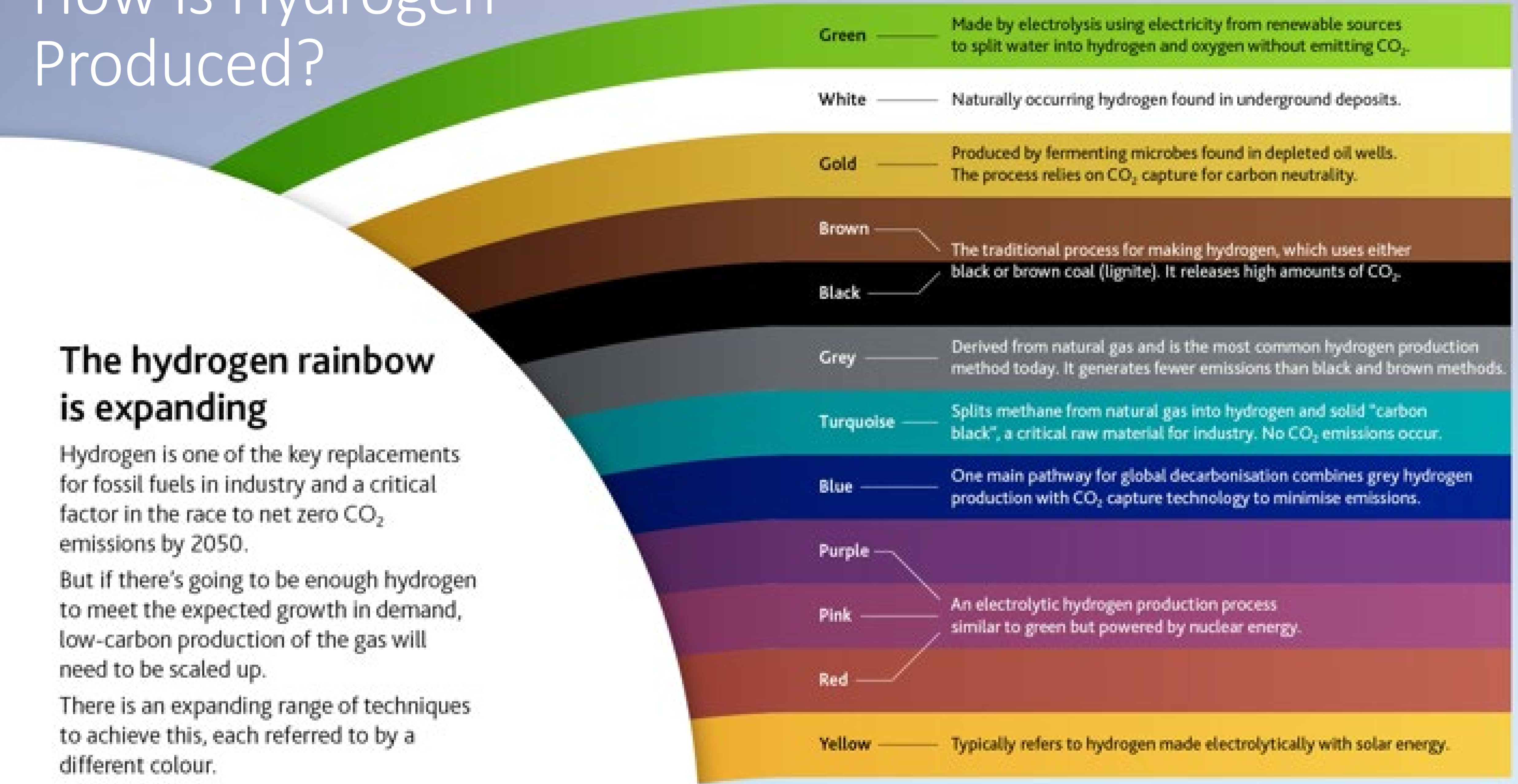
How is Hydrogen Produced?

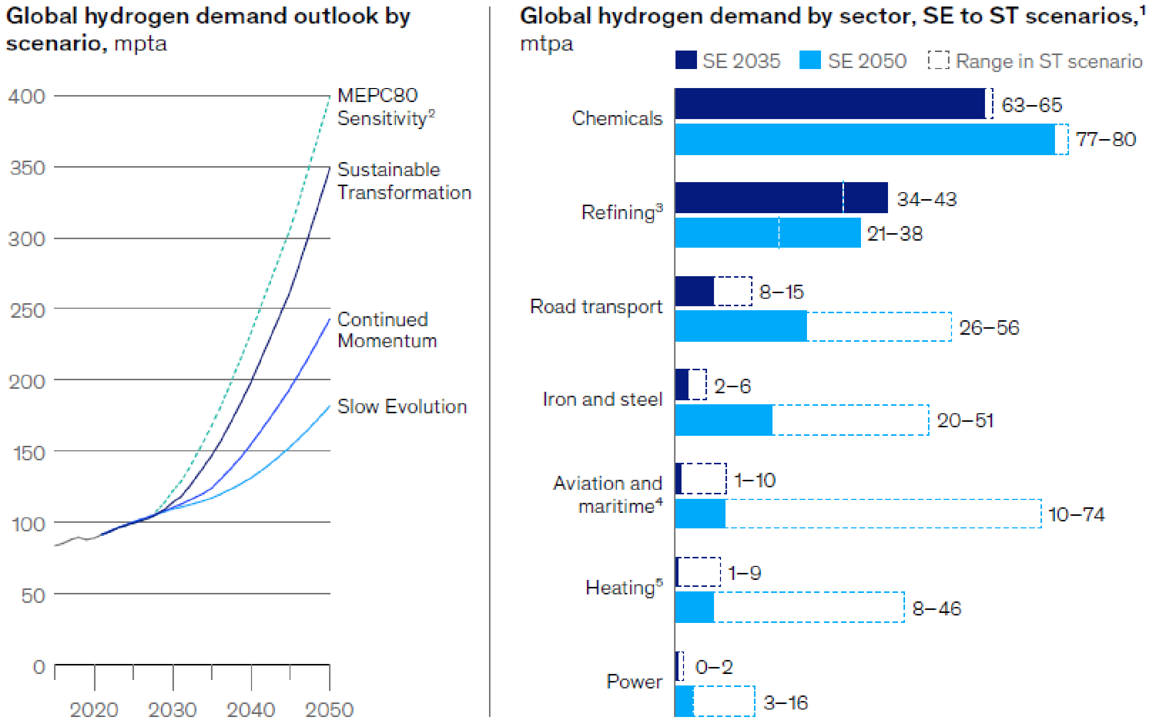


https://www.trafigura.com/news-and-insights/insights/energy-transition-and-esg/chasing-rainbows/

Global & National & Regional Investment

- DOE Hubs: 7 regions, \$8B for clean H_2 deployment[1]
- U.S. strategy: hydrogen in power, transport, industry – a note that hydrogen support is bipartisan[1], however the focus on different production pathways and results are different under each administration
- EU & Asia investing heavily in H_2 infrastructure
- U.S. Midwest positioned as hydrogen leader given its leadership in early-stage projects in multiple industrial sectors

Demand for clean hydrogen is projected to grow two to four times by 2050[15]



[1]SE = Slow Evolution; ST = Sustainable Transformation. [2]MEPC80 Sensitivity includes the implications of the 2023 adoption of IMO Greenhouse Gas Strategy. [3]Refining is the only sector where demand in 2035 and 2050 in the ST scenario is lower than in the SE scenario. Includes conventional fuels refining and biofuels hydrogenation and refining. [4]Aviation and maritime include the direct use of hydrogen and hydrogen-derived synfuels including kerosene, diesel, methanol, gasoline, and ammonia. The category also includes some hydrogen-derived synfuels in road transport. Maritime in Sustainable Transformation includes MEPC72. [5]Includes hydrogen demand for heating in other industry and buildings.

[15] Including green hydrogen (hydrogen produced by the electrolysis of water using RES) and blue hydrogen (hydrogen produced from natural gas with carbon capture and storage).

https://www.mckinsey.com/industries/energy-and-materials/our-insights/global-energy-perspective#/

[1]https://www.dailyclimate.org/trump-administration-steers-hydrogen-funding-to-fossil-fuel-projects-sidelining-clean-energy-hubs-2671877266.html

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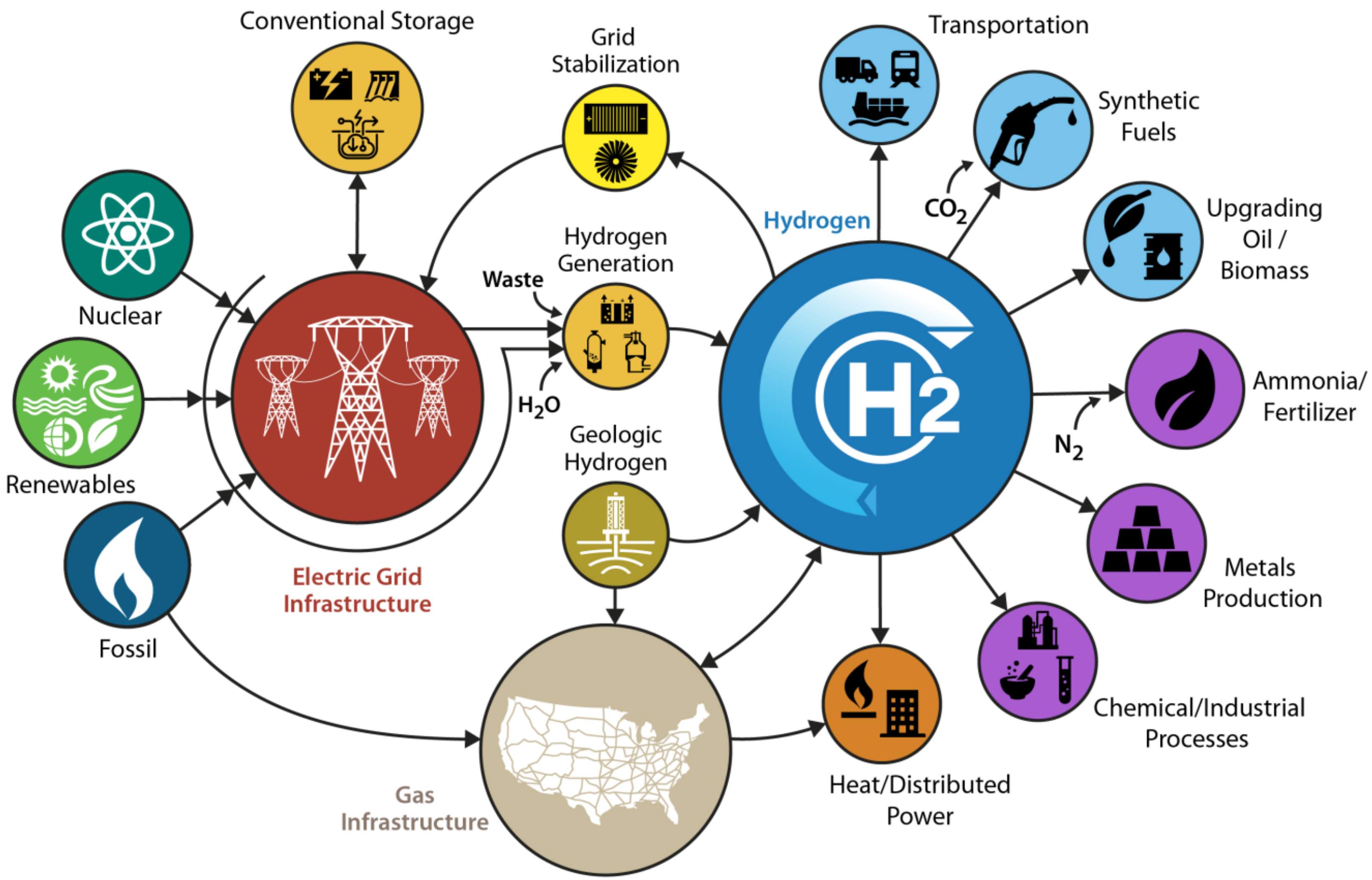
HYDROGEN'S VERSATILITY

A Multi-Sector Energy Tool



https://www.energy.gov/eere/fuelcells/h2scale

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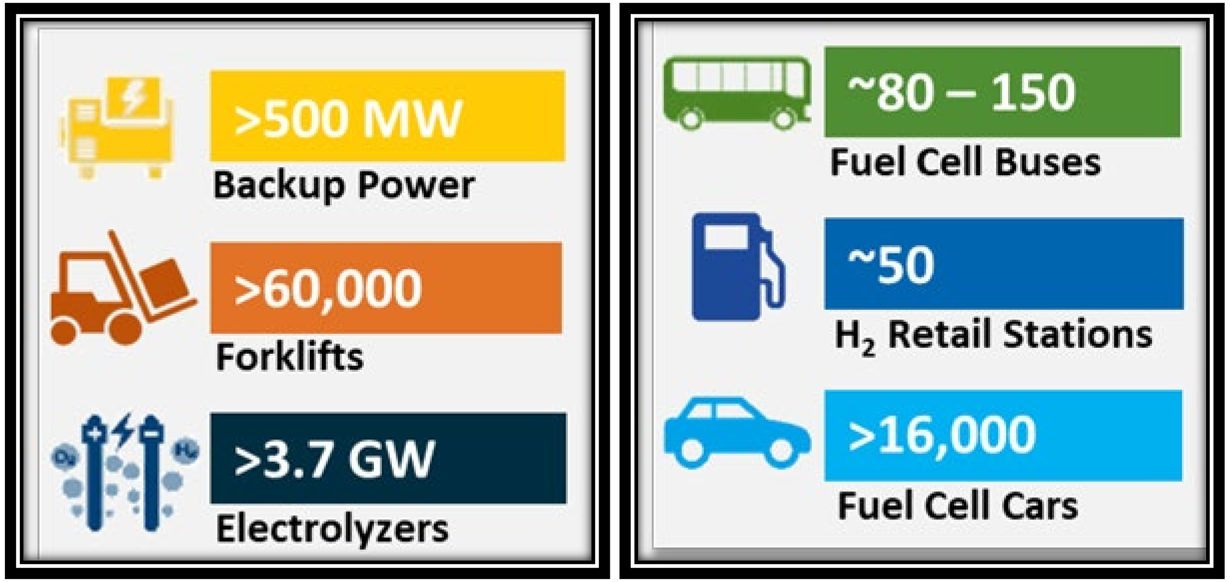
Transportation Uses

- Heavy-duty trucks, buses, trains, aviation
- Long range, fast refueling → fleet-friendly
- Proven in forklifts as a reliable alternative



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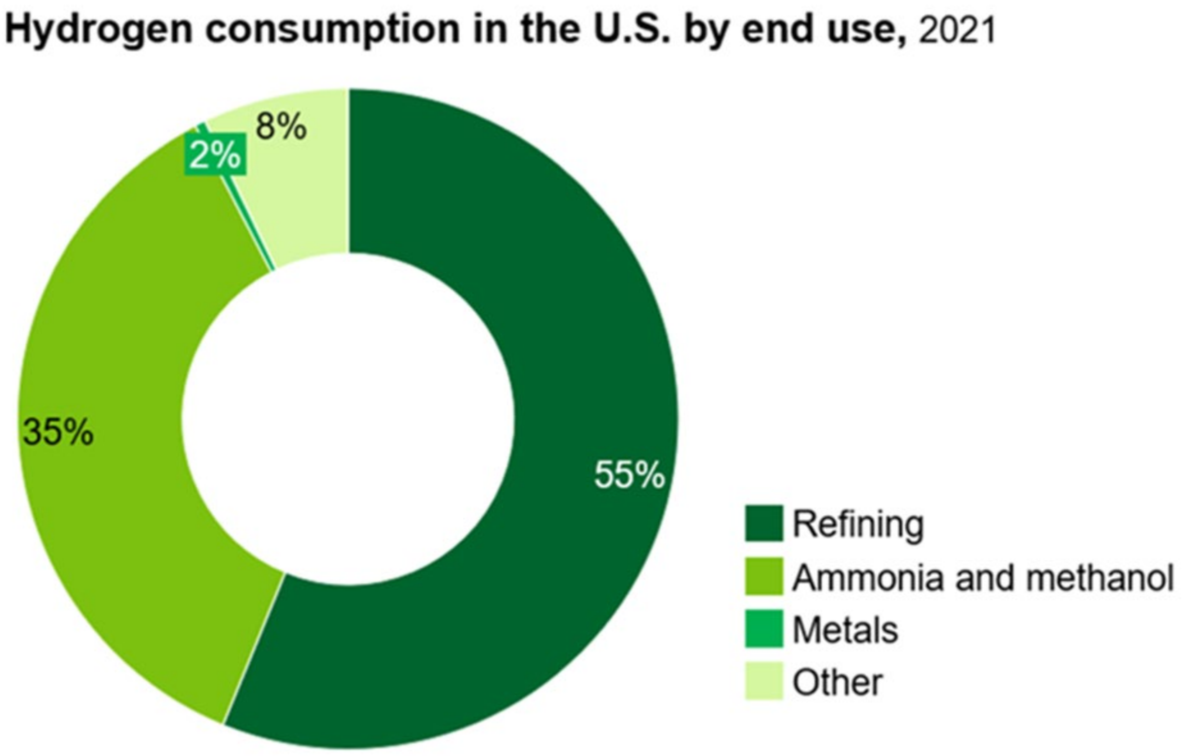
https://www.hydrogen.energy.gov/docs/hydrogenprogramlibraries/pdfs/us-national-clean-hydrogen-strategy-roadmap.pdf
https://www.plugpower.com/blog/hydrogen-fuel-cell-forklifts-the-impact-of-fuel-cells-in-material-handling/

Industry Uses

- Steelmaking: hydrogen replacing coal in reduction (direct iron reduction)
- Cement & glass: high-temp heat from H_2
- Feedstock: ammonia, methanol, refinery desulfurization

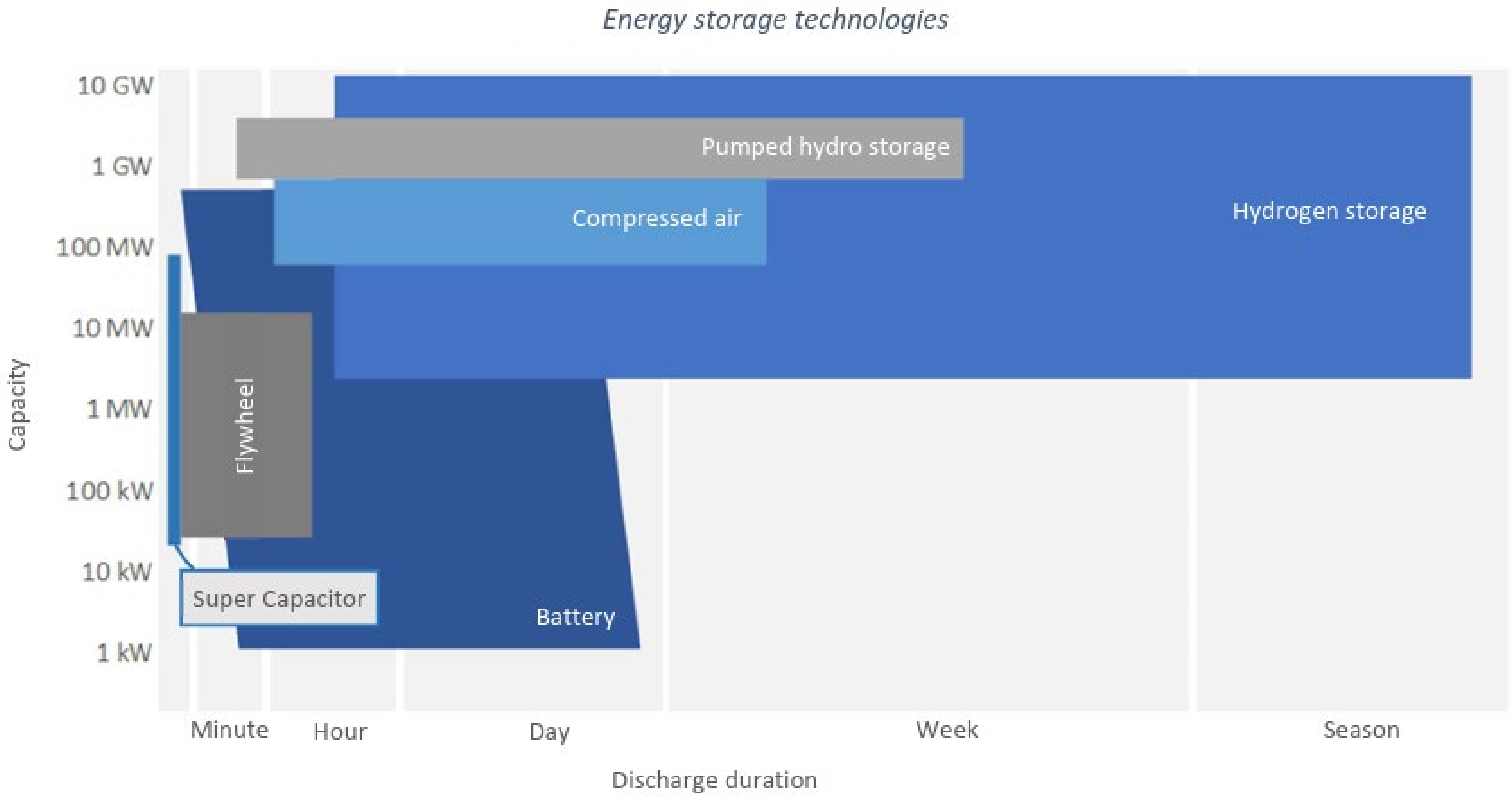


Consumption of hydrogen in the United States by end-use in 2021

https://www.hydrogen.energy.gov/docs/hydrogenprogramlibraries/pdfs/us-national-clean-hydrogen-strategy-roadmap.pdf

Power Storage

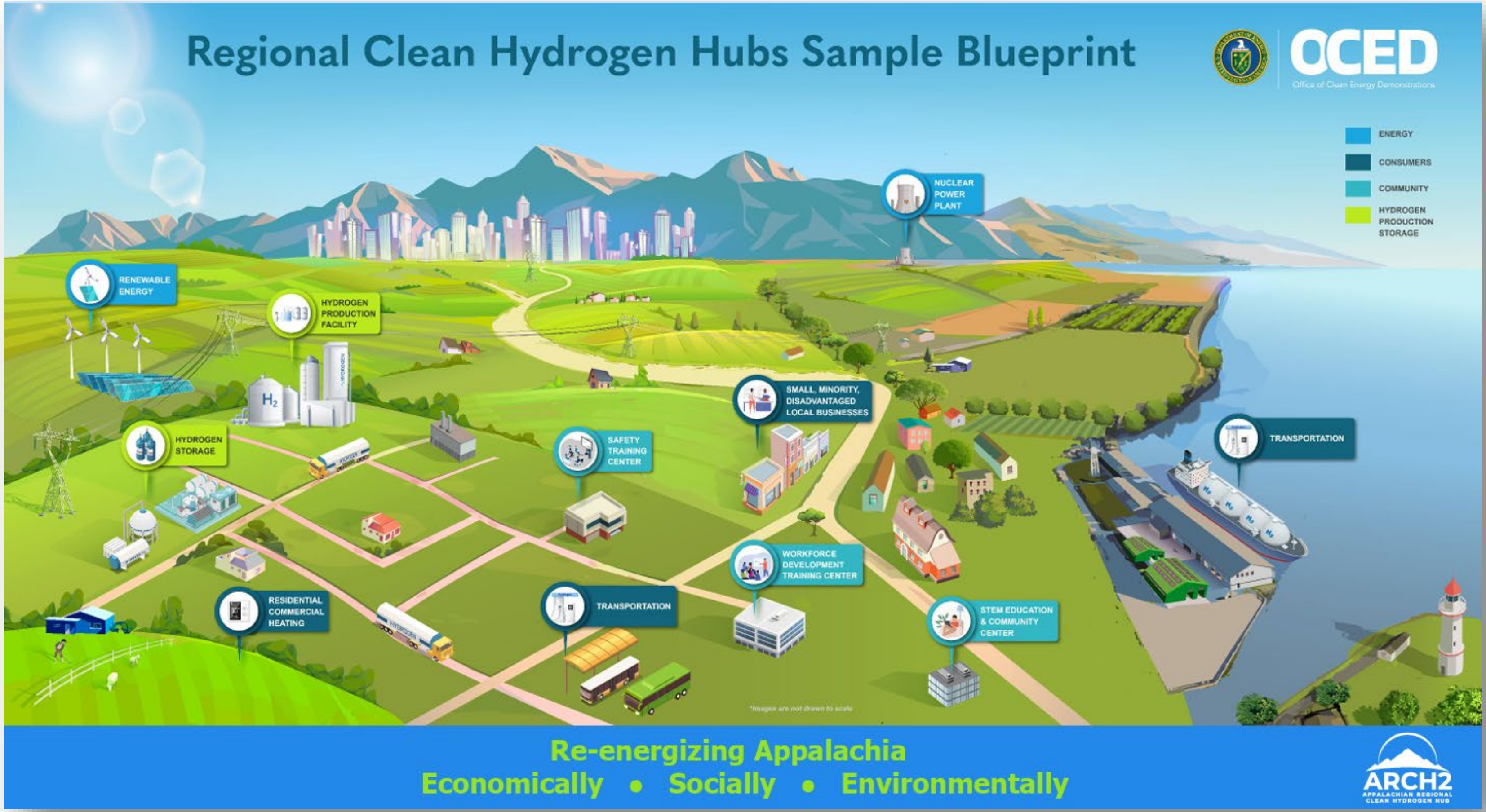
- Hydrogen-ready turbines → blend w/ natural gas
- Long-duration storage → weeks to months
- Backup fuel cells for critical facilities
- With batteries, creates a solid toolkit for grid reliability and backup



https://www.iaea.org/sites/default/files/hydrogen-production-with-operating-nuclear-power-plants.pdf

Ohio & Midwest Examples

Hydrogen in Action, Close to Home



https://www.kyoilgas.org/wp-content/uploads/2024/07/2-ARCH2-Overview-and-Update-emh2-FINAL-BRIEF-6-26-2024-Michael-Hines.pdf

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Stark Area Regional Transit Authority – Canton, Ohio

Early adopter: SARTA began transitioning to hydrogen fuel cell buses in 2016, launching one of the first publicly accessible hydrogen refueling stations in Ohio at its Canton headquarters.

Fleet performance from January 2019 to January 2020, six fuel cell buses:

- Averaged 2,446 miles/month.
- Used 0.19 kg H_2/mi.
- Avoided about 80,000 kg CO_2 (80 metric tons), compared to what six diesel buses would emit.

Nationwide impact estimate, FTA & DOT projections, indicate each hydrogen fuel cell bus could reduce up to:

- 100 tons CO_2/year
- 9,000 gallons of fuel/year
- $37,000/year in operating costs (versus diesel)

SARTA Ambitions - Fleet scale: As of early 2025, the agency is scaling up by planning a project to produce ~1 ton of H_2 per day, which could fuel 40 SARTA buses.

https://www.sartaonline.com/
https://www.midwesthydrogen.org/site/assets/files/1413/sarta_fuel_cell_bus_performance_final_report.pdf
https://rosap.ntl.bts.gov/view/dot/62742/dot_62742_DS1.pdf?utm_source=chatgpt.com
https://fuelcellsworks.com/2025/02/18/fuel-cells/ohio-transit-agency-to-switch-to-green-hydrogen-for-fuel-cell-buses

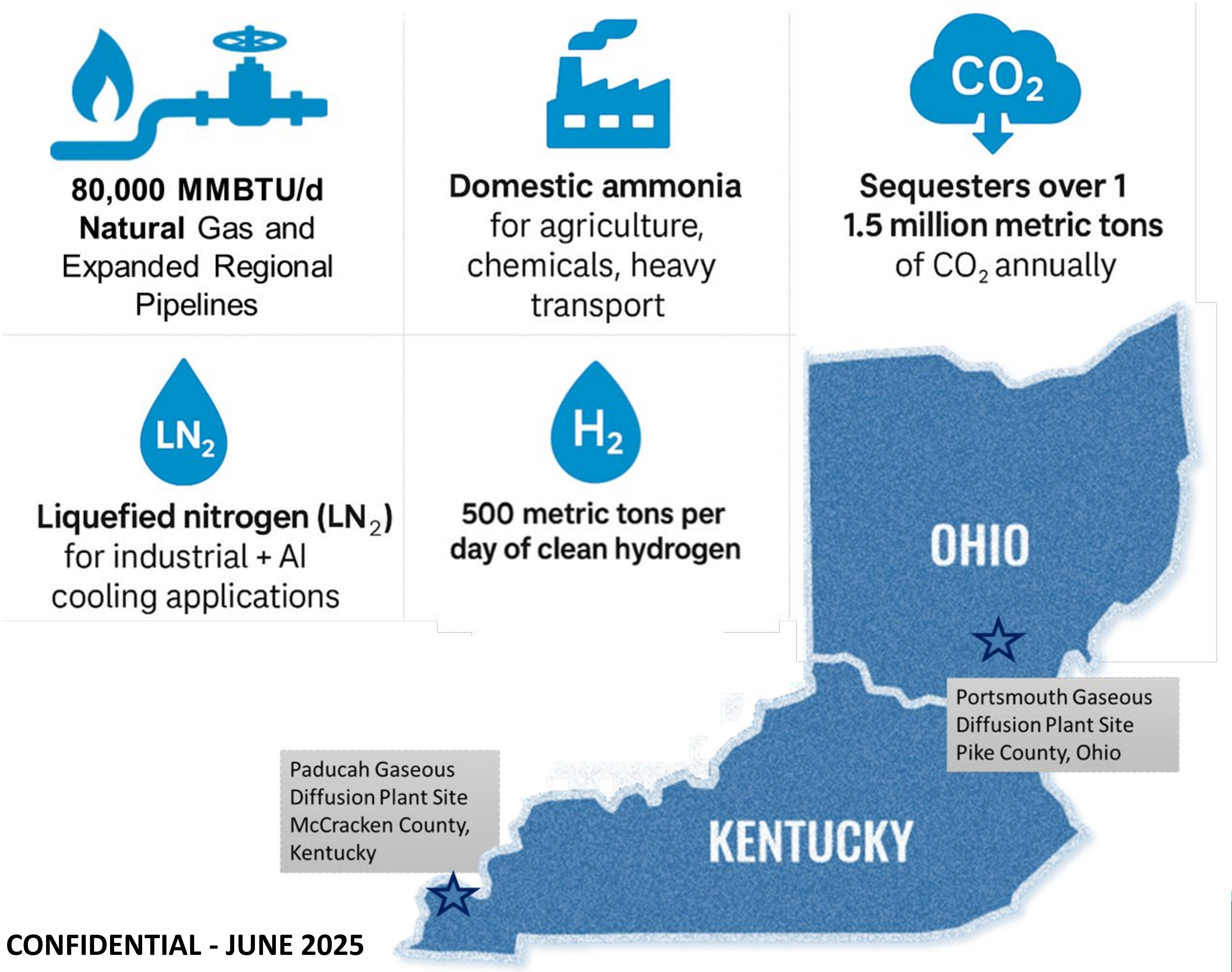
Trillium H_2 Power

Trillium H_2 Power is developing two large-scale clean energy facilities at former U.S. Department of Energy (DOE) sites in Ohio and Kentucky. These projects aim to turn previously industrial land into modern clean energy hubs, bringing back jobs and industry to communities that have long supported the DOE mission.

Each site will install an Integrated Clean Industrial Hub, providing:

- **Natural gas derived hydrogen** (H_2), a low-carbon fuel used for electricity, heavy trucks, fertilizer, and other **industries.**
- **Make ammonia** (NH_3) domestically, which is used in agriculture, energy, and manufacturing.
- **Capture carbon dioxide** (CO_2) emissions and permanently store them deep underground.
- **Generate electricity** on-site using hydrogen-powered turbines.
- **Produce liquefied nitrogen** (LN_2), which can help cool AI data centers and high-tech facilities.

Clean Hydrogen & AI Infrastructure – Advancing U.S. Energy Security, Economic Reshoring, and Technological Leadership



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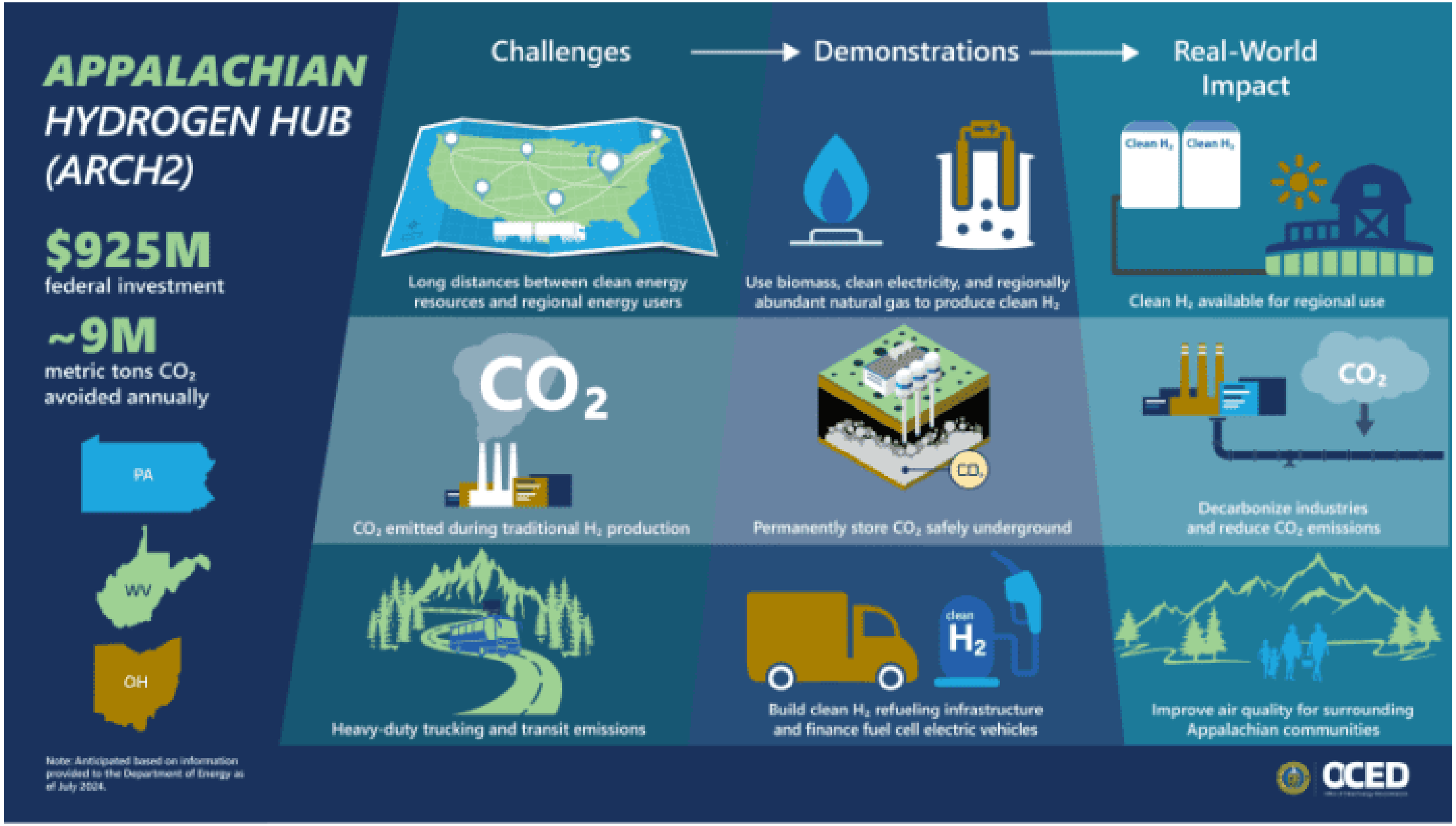
ARCH2 H_2 Hub – Ohio in a Regional Hydrogen Network

- $925M DOE award to Ohio/WV/PA/KY
- Multi-sector projects: power, industrial, mobility
- Thousands of construction & operations jobs
- Workforce training & manufacturing supply chain



https://www.arch2hub.com/about/arch2-concept/

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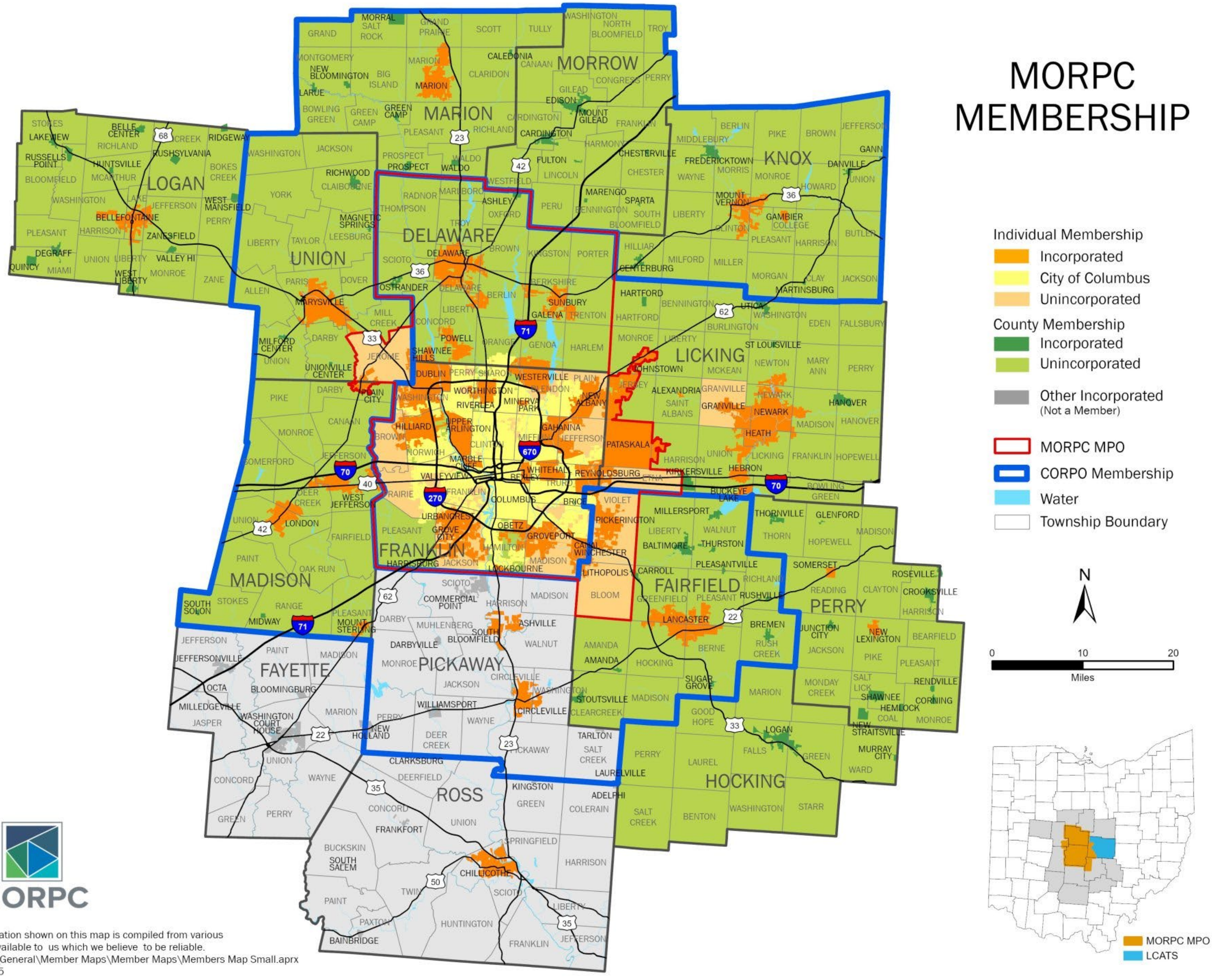
Call to Action

Positioning Central Ohio to Lead



https://www.morpc.org/about-morpc/

By Industry – The Hydrogen Advantage

Data Centers

- Data centers are the largest new load in Central Ohio.
- Hydrogen turbines and fuel cells can: Provide behind-the-meter baseload. Offer clean backup power without diesel. Enable dual-use: power now, ammonia/fertilizer/transport fuel later.
- This directly aligns with regional and local goals, ensuring infrastructure keeps pace with digital growth.

Logistics & Transport

- Columbus is the #1 logistics hub in the Midwest.
- Hydrogen trucks, buses, and material-handling equipment (forklifts, airport ground vehicles) are already commercial. SARTA (Canton) shows hydrogen buses work here in Ohio.
- Planning hydrogen fueling corridors on I-70 and I-71 (and a future I-73) makes Central Ohio a freight-friendly clean corridor.

Industry & Manufacturing

- Industrial heat accounts for 30% of U.S. energy use. Batteries can't supply this at scale.
- Hydrogen can replace natural gas in: food processing (steam, heat). cement and steel (direct reduction). chemicals & fertilizers.
- Central Ohio industries (food, chemicals, materials) could gain competitive edge by adopting low-carbon hydrogen early.

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https://news.microsoft.com/source/features/sustainability/hydrogen-fuel-cells-could-provide-emission-free-backup-power-at-datacenters-microsoft-says/
https://www.rolandberger.com/en/Insights/Publications/Is-solid-state-storage-the-missing-ingredient-in-hydrogen-transport.html
https://www.hydrogen-expo.com/industry-news/masdar-emirates-create-partnership-over-development-hydrogen-based-steel-production-project

The Regional Playbook

Steps Community Leaders Can Take Now	**Awareness:** Educate local governments on hydrogen's role.
	Zoning: Begin including hydrogen in comprehensive plans.
	Workforce: Partner with unions, colleges, and governmental agencies on training and grant opportunities to expand capabilities.
	Pilots: Support small-scale projects (fueling stations, municipal fleets).
	Partnerships: Engage leaders of local and regional projects (ARCH2, Trillium, SARTA, etc.), utilities, industrial power users.

Central Ohio Can Lead – Call to Action

Unique Assets, Unique Opportunity

- With leadership from MORPC and community stakeholders, Ohio can set national example for regional hydroge integration.
- Central Ohio is at the intersection of growth and innovation.
- Central Ohio can lead the Midwest in energy resilience by acting now.

Hydrogen isn't a buzzword - it's a tool for resilience, jobs, and competitiveness. The question for Central Ohio is not if hydrogen will matter - it's how fast we integrate it.

Assets

- Existing industry & workforce.
- Data center / logistics boom.
- Proximity to hydrogen hub and many regional projects

Ohio leaders, planners, and industry must…

…Stay informed

…Start planning

…Build partnerships

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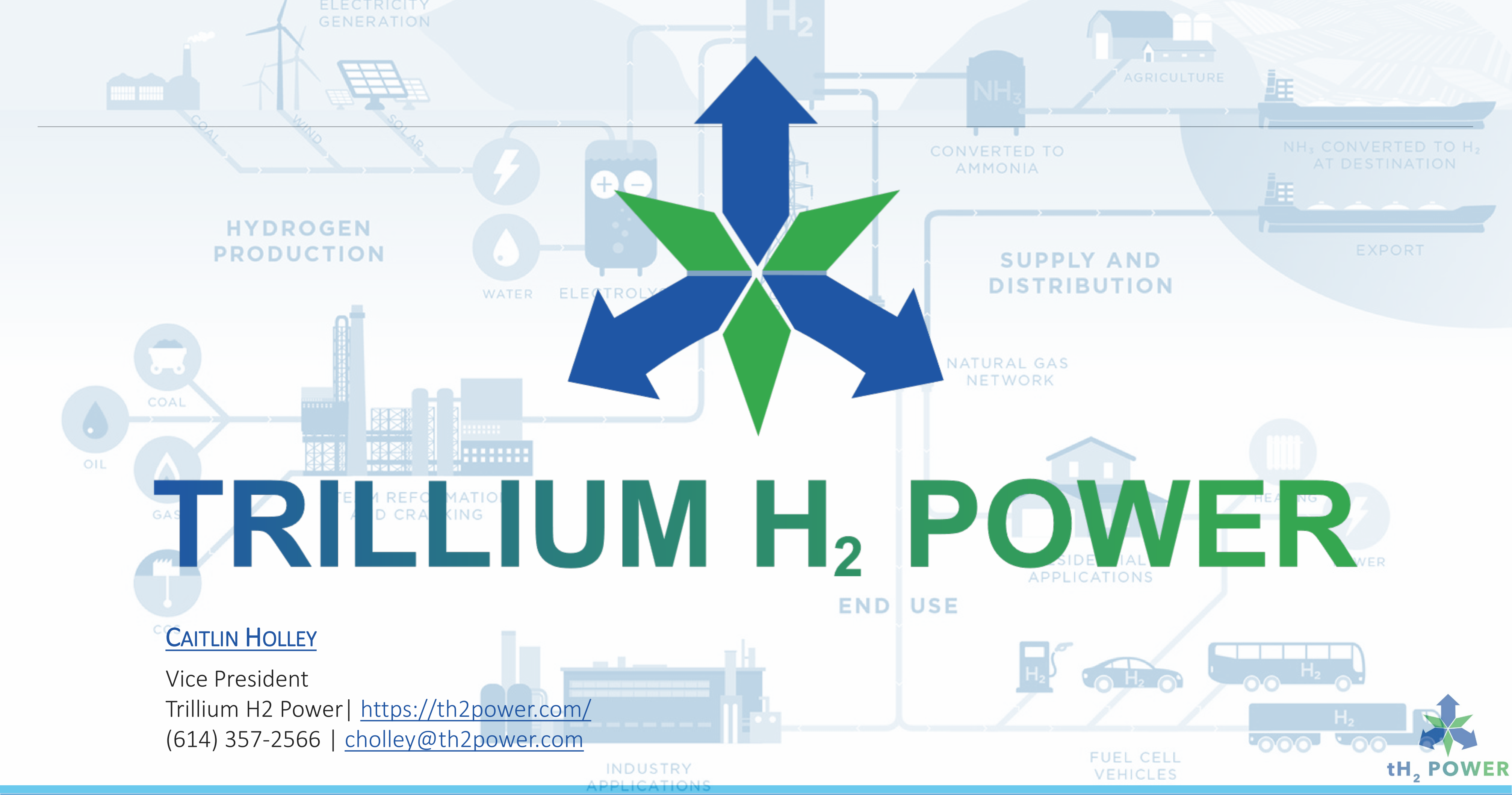

TRILLIUM H_2 POWER

CAITLIN HOLLEY

Vice President
Trillium H2 Power| https://th2power.com/
(614) 357-2566 | cholley@th2power.com

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https://view.ceros.com/hsf/decarbonisation-infographic-4/p/1

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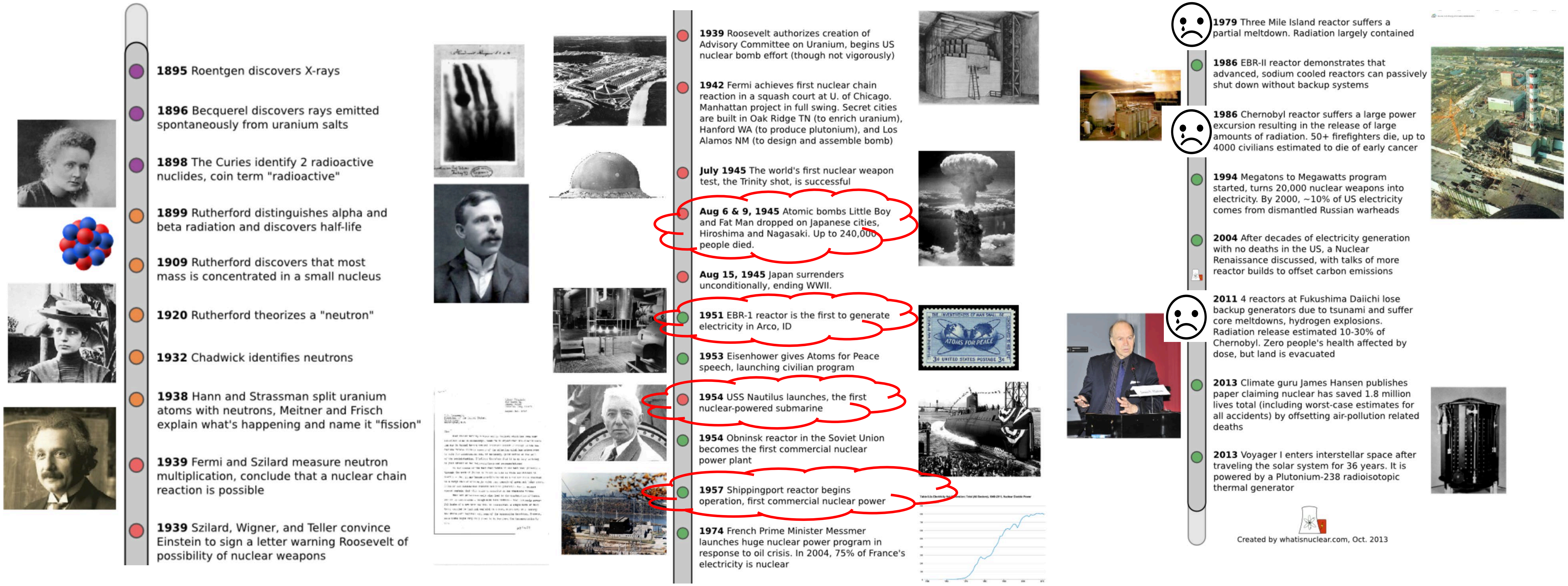
NUCLEAR AS A CONSISTENT AND CARBON-FREE SOURCE

Randy Keefer
New Nuclear / SMR Engineer *(Retired)*
AEP

AGENDA

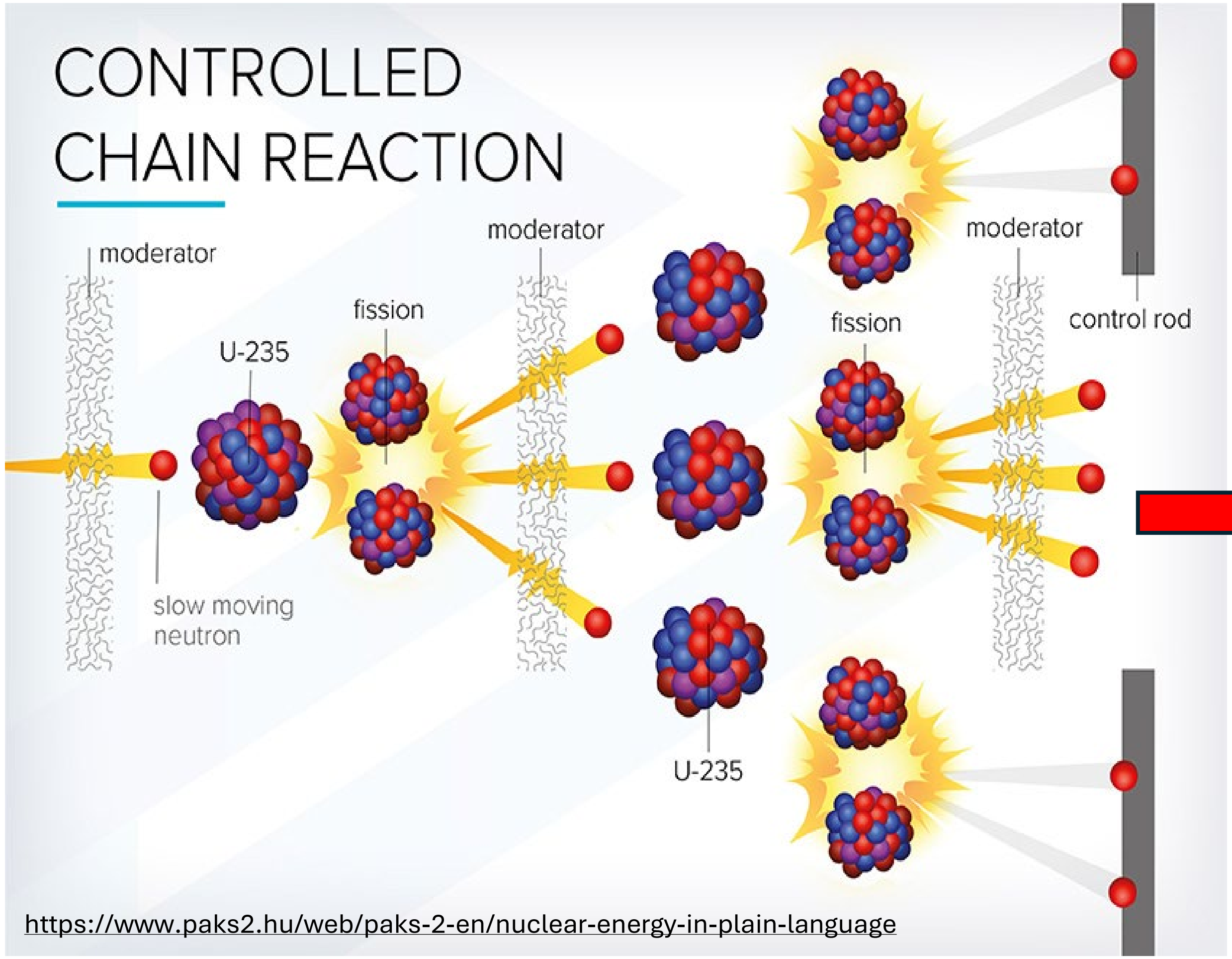
- The Development of Nuclear Power Reactors
- What is a Nuclear Power Reactor?
- Evolution of Nuclear Reactor Technology
- U.S. Commercial Nuclear Power, at a Glance
- Why Nuclear?
- Why Now?
- What's in a Name?
- Site Selection Process
- Regulatory Licensing Process
- Leading U.S. SMR Vendor / Reactor Designs

THE DEVELOPMENT OF NUCLEAR POWER REACTORS

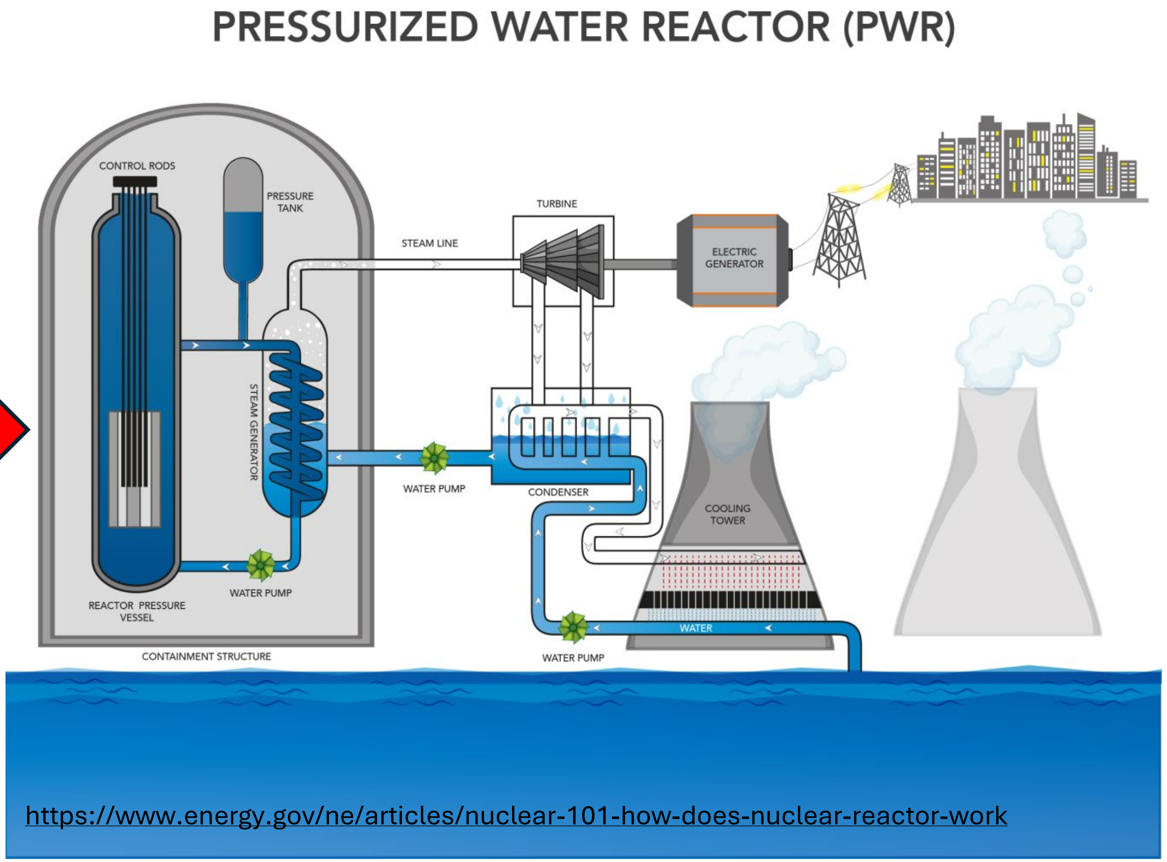


Source(s): https://whatisnuclear.com/nuclear-timeline.html

WHAT IS A NUCLEAR POWER REACTOR?

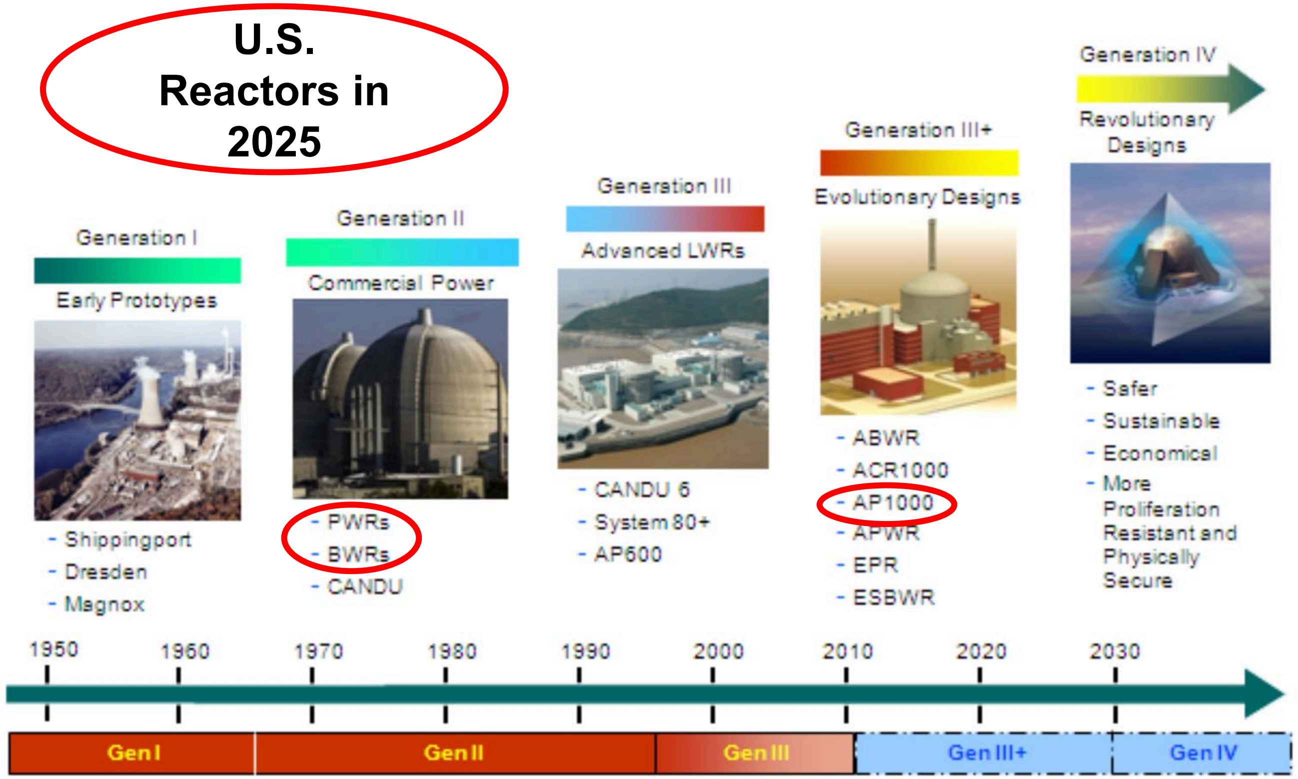


https://www.paks2.hu/web/paks-2-en/nuclear-energy-in-plain-language



https://www.energy.gov/ne/articles/nuclear-101-how-does-nuclear-reactor-work

EVOLUTION OF NUCLEAR REACTOR TECHNOLOGY

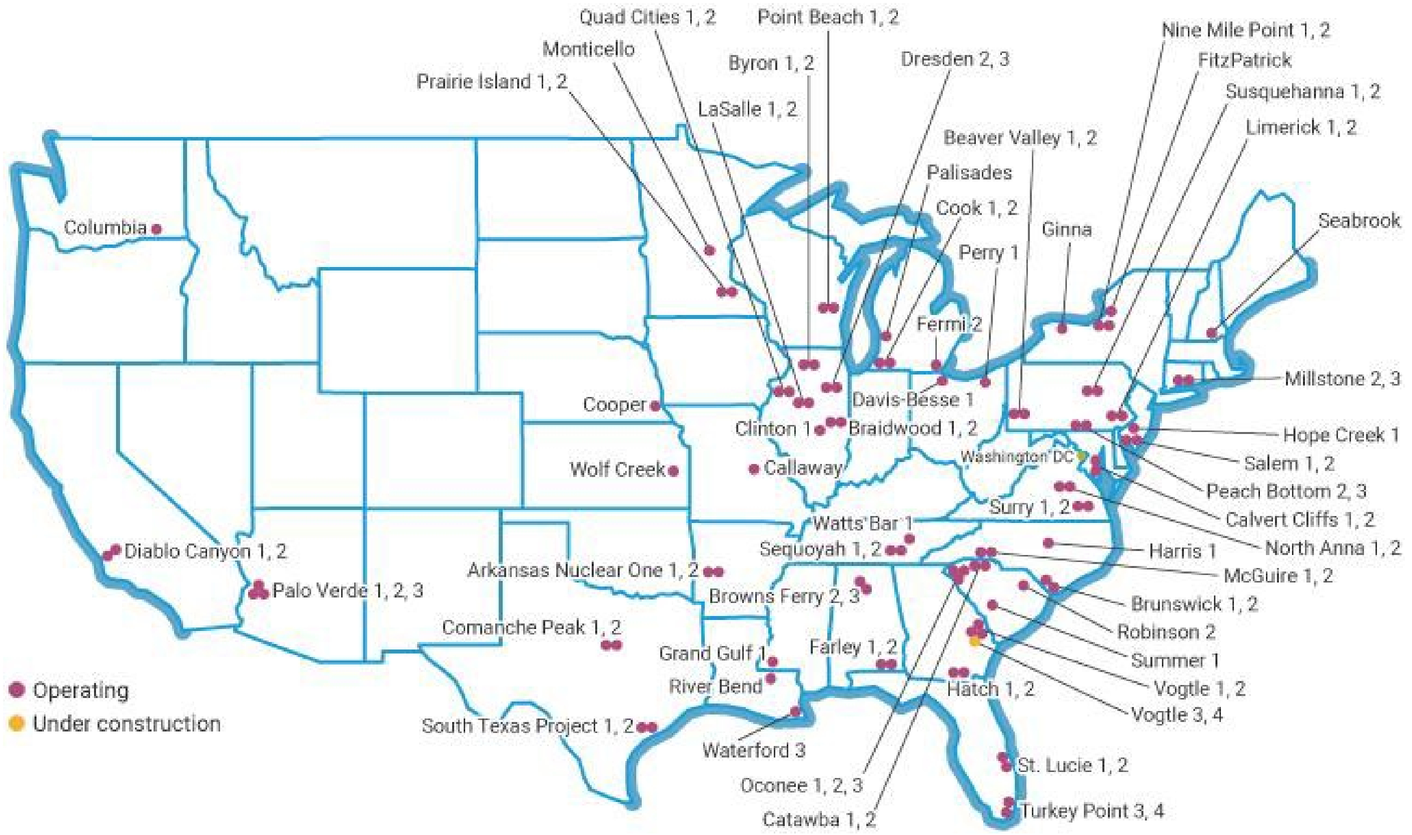


Why Light Water Reactors (LWRs) Dominate Nuclear Power

Historical legacy	First to be developed and commercialized
Engineering simplicity	Uses ordinary water as coolant and moderator
Regulatory ease	NRC and others already know LWRs well
Economic feasibility	Mature supply chain, fuel infrastructure
Operational safety record	Long track record with continual improvements

Source(s): https://www.realscience.org.uk/generation-IV-nuclear-reactors.html
https://www.eia.gov/todayinenergy/detail.php?id=65104

U.S. COMMERCIAL NUCLEAR POWER, AT A GLANCE



- U.S. is the **world's largest producer of nuclear power**, accounting for ~ 30% of worldwide generation of nuclear electricity
- U.S. operates **94 commercial reactors across 54 facilities**
  - Net generating capacity **~97 GW**
  - **~19%** of the nation's electricity
  - **Top Source of Carbon-Free Electricity** (~55%)
- Until 2013, there had been no new construction starts since 1977
- No new plants are under construction
- Almost all of U.S. nuclear generating capacity comes from reactors built between 1967 and 1990 → Average Age = 42 years

Source(s): https://world-nuclear.org/information-library/country-profiles/countries-t-z/usa-nuclear-power
https://www.eia.gov/tools/faqs/faq.php?id=228&t=3

WHY NUCLEAR?

- **Nuclear is Carbon-Free.**
  - It is the largest source of carbon-free electricity in the United States
  - And protects our air quality by generating electricity without other harmful pollutants like NOx, SOx, PM, or mercury.
- **Nuclear is Reliable.**
  - Nuclear plants are the most efficient source of electricity, operating 24/7 at a 93% average capacity factor.
  - Nuclear power does not suffer from the variability that affects solar and wind energy, providing a constant energy output that can be pivotal during periods of high demand or low renewable generation.
- **Nuclear is Powerful.**
  - One uranium fuel pellet—about the size of a gummy bear—creates as much energy as one ton of coal, 149 gallons of oil or 17,000 cubic feet of natural gas.
- **It's Complicated.**
  - While renewable energy sources are crucial to the transition towards a sustainable energy future, *nuclear power remains economically competitive in scenarios requiring high reliability, energy security, and low-carbon emissions*.

    → The decision to opt for nuclear over other fuels should be based on a comprehensive analysis of local energy needs, grid capabilities, economic incentives, and environmental goals.

Source(s): https://www.nei.org/fundamentals/nuclear-provides-carbon-free-energy#:~:text=In%20fact%2C%20America's%2094%20nuclear,the%20wind%20isn't%20blowing.
https://www.damona.co/the-economic-viability-of-nuclear-energy-in-renewable-dominated-markets/#:~:text=While%20renewable%20energy%20sources%20are,economic%20incentives%2C%20and%20environmental%20goals.

WHY NOW?

- **Climate Goals**:
  - Net-zero emissions and clean energy targets
- **Energy Security**
  - Reduce dependence on fossil fuels
- **Technology Advancements**
  - SMRs and advanced reactor designs
- **Growing Public & Political Support** (Bipartisan)
- **Aging Fleet Replacements & Life Extension**
- **Decarbonizing Industry and the Grid**

Source(s):

WHAT'S IN A NAME?

SMALL

- SMRs are advanced nuclear reactors (Gen III+/Gen IV)
- Have power capacity of several MW(e) → 350MW(e) per unit.
- SMRs are ~1/3 of the generating capacity of traditional, commercial nuclear power reactors.
- Given their smaller footprint (<30-50 acres/unit), SMRs can be sited on locations not suitable for larger nuclear plants.

MODULAR

- Prefabricated units of SMRs can be manufactured, and then shipped and installed on site
- Makes them more affordable to build than large power reactors, which are often custom designed for a particular location with significant risk of construction delays.

REACTOR

- Designs span various nuclear technologies, from newer generation, light water reactor (LWR) technologies (PWR and BWR), to technologies that use different nuclear fuels and heat transfer mechanisms that have existed in non-commercial form since the 1950s.

THE PROMISE OF SMRs

FLEXIBILITY

- Greater load-following capabilities and thermal output use in non-electric industrial applications

SITING

- Strong safety cases potentially justify an emergency planning zone (EPZ) that only extends as far as the site boundary (e.g. 35 acres (as opposed to 10 miles for current U.S. plants)
- This allows for SMRs to be sited in closer proximity to population centers, and to repower retiring coal stations using existing transmission lines.

COST

- The promise of significant cost reductions through modularized fabrication and construction which should further improve the construction schedule and reduce costs.
- Currently, SMRs are estimated to cost about $5,000/kW compared to >$6,500/kW for a 1,000MW current Light Water Reactor plant design.
- Additionally, once produced in numbers the relative cost is expected to drop.

SITING SELECTION PROCESS

PERHAPS THE MOST CRITICAL STEP IN A NEW NUCLEAR PROJECT

- Wetlands, streams and other waterbodies
- Soils and geology
- Historic and cultural resources
- Environmental and social justice
- Water quality and availability
- Local land use
- Wildlife and species impacts
- Flood risk
- Workforce availability
- Existing infrastructure such as power lines, roads, railroads, pipelines
- Transmission considerations
- Emergency services and response times

Source(s): https://appalachianpowersmr.com/resources

REGULATORY LICENSING PROCESS

PHASE	HISTORICAL TIMELINE	ACCELERATED TIMELINE (with reforms)
Pre-application & Docketing	1–3 years	~Months to 1 year
Application Review (NRC)	3–4+ years	**~18–25 months** (Part 52/COL)
Environmental / Hearing	Add-on years	Included or expedited via GEIS, written hearings
Construction	3–4 years	Similar (unless limited work authorization granted earlier)
Startup & Commissioning	6–12 months	Same
TOTAL (Pre-app to Operation)	**8–10+ years**	**Potentially 6–8 years** or less (depending on site and design)

Source(s): https://appalachianpowersmr.com/resources

LEADING U.S. SMR VENDOR / REACTOR DESIGNS

VENDOR	DESIGN	TECHNOLOGY	DEVELOPMENT STATUS
GE Hitachi	BWRX-300	BWR, Gen III+ LWR	• OPG's Darlington site in Canada • TVA Clinch River Project: U.S.NRC Construction Permit Application (CPA) filed early 2025
Holtec	SMR-300	PWR, Gen III+ LWR	• Palisades Nuclear Plant (Michigan)--Two SMR-300 units planned adjacent to the existing reactor (restarting in late 2025 after DOE loan approvals) • Pre-application activities with the NRC
Westinghouse	AP300	PWR, Gen III+ LWR	• Pre-application activities with the NRC • Intend to pursue NRC Design Certification (absent any project to deploy)
NuScale	VOYGR	PWR, Gen III+ LWR	• Only design approved by the U.S.NRC • Utah Associated Municipal Power Systems (UAMPS) "Carbon Free Power Project" (Idaho National Lab) cancelled Nov-2023
X-energy	Xe-100	High temperature, gas-cooled reactor (HTGR)	• CPA Submitted--Dow Long Mott Generating Station at Seadrift Operations manufacturing site on the Texas Gulf Coast.
TerraPower	Natrium	Sodium metal-cooled, fast fission reactor	• CPA Submitted--Kemmerer, WY Project
Kairos Power	KP-FHR	Fluoride salt-cooled, high temperature reactor (FHR)	• CPA Approved--Hermes demonstration reactor under construction near Oak Ridge, TN • Power Purchase Agreement (PPA) with TVA

THANK YOU

Randy Keefer, PE, PMP
Retired, New Nuclear Program Engineering Manager
AEP
keefer.Randall@yahoo.com

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Battery as Improving Reliability and Balancing Energy Generation

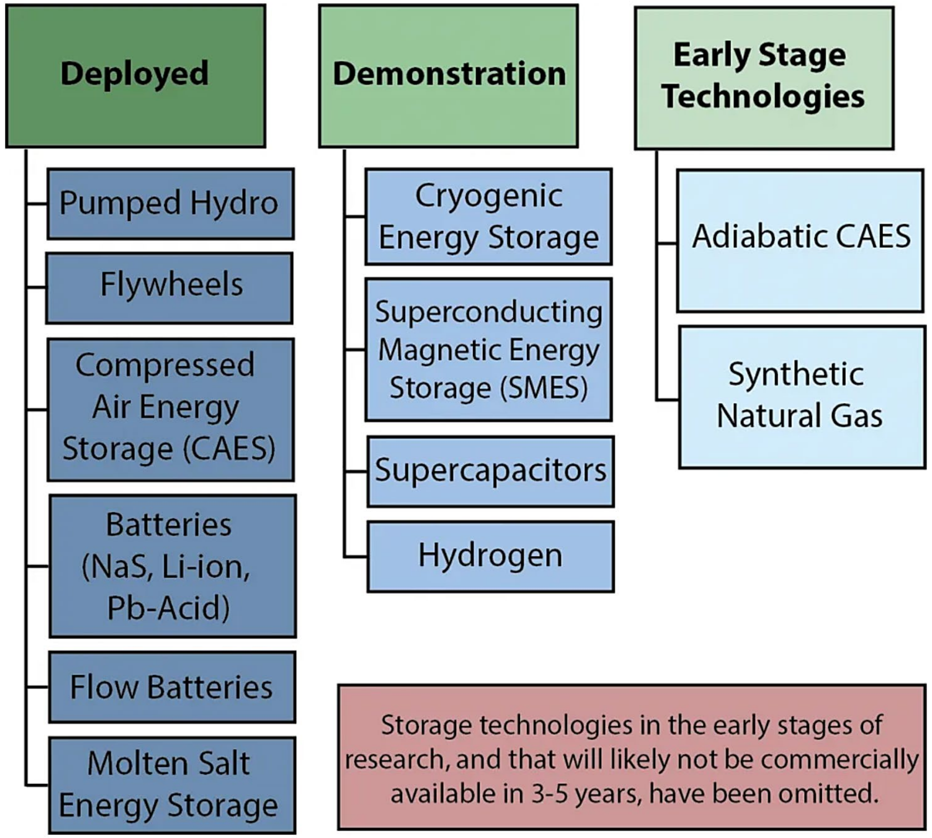
Jung-Hyun Kim
Mechanical and Aerospace Engineering

Outline

- ❑ Long-duration Grid-scale Storage Challenge
- ❑ Pumped Storage Hydropower (PSH)
- ❑ Batteries Energy Storage System (BESS)
- ❑ Redox Flow Batteries for ESS
- ❑ Flywheel Energy Storage System
- ❑ Compressed Air Energy Storage (CAES)
- ❑ Hybrid Energy Storage Systems: Case Study
- ❑ Summary

Long-duration Grid-scale Storage Challenge

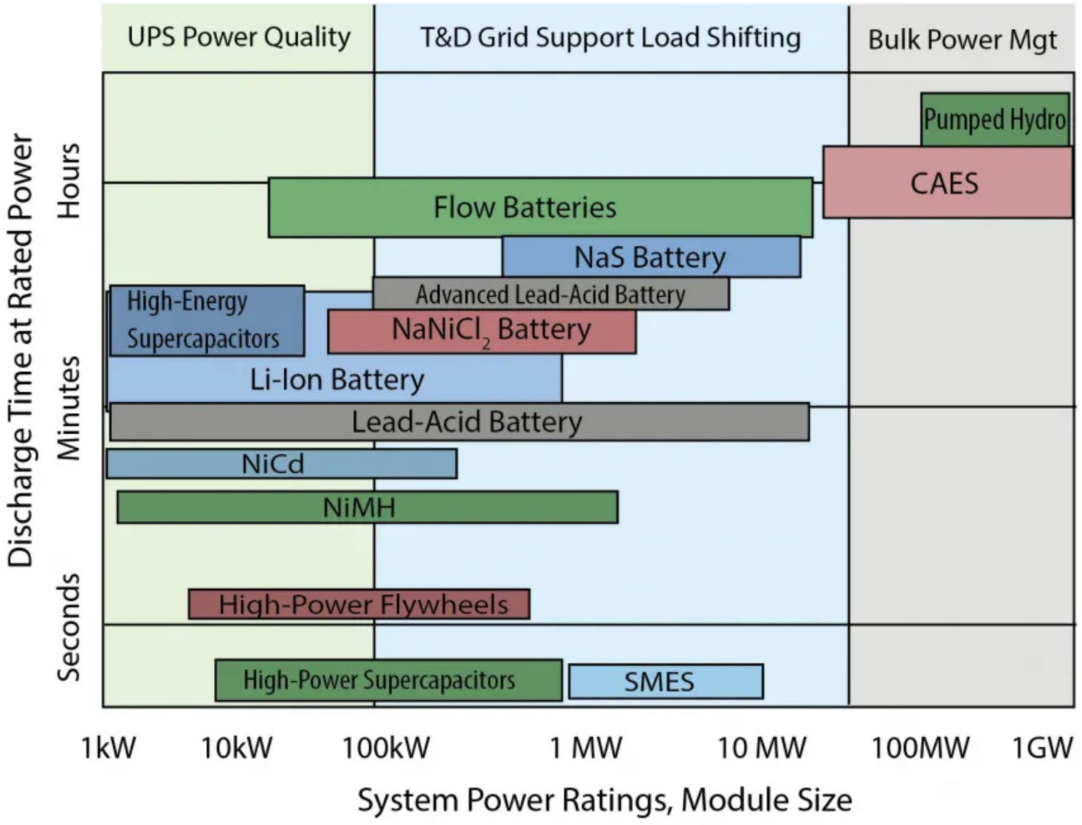
Maturity of energy storage technologies



CAES: Compressed Air Energy Storage

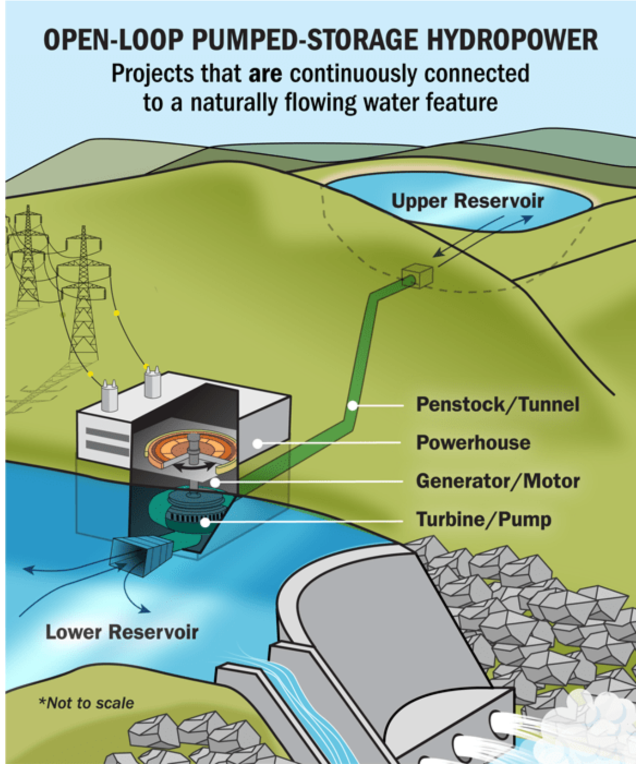
Source: World Energy Council (2020) Five Steps To Energy Storage.

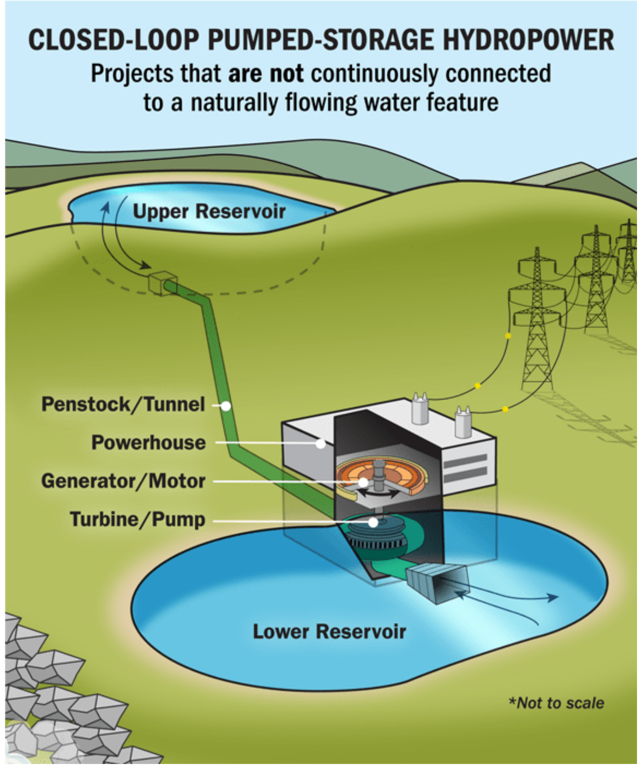
Characteristics of energy storage technologies



Source: SNL (2015) DOE/EPRI Electricity Storage Handbook in Collaboration with NRECA.

Pumped Storage Hydropower (PSH)





Source: Pumped Storage Hydropower | Department of Energy

- As electricity generated by power plant cannot follow the normal hourly demands, surplus power is used to pump water up to the reservoir
- Only practicable and economically viable way to store electrical energy in very large quantity
- As of 2021, PSH accounts for 93% of US energy storage.
- The round-trip energy efficiency (RTE) of PSH: 70%–87%
- Disadvantage: Geographic limitation, capital cost

World Map of PSH (Current/Future)

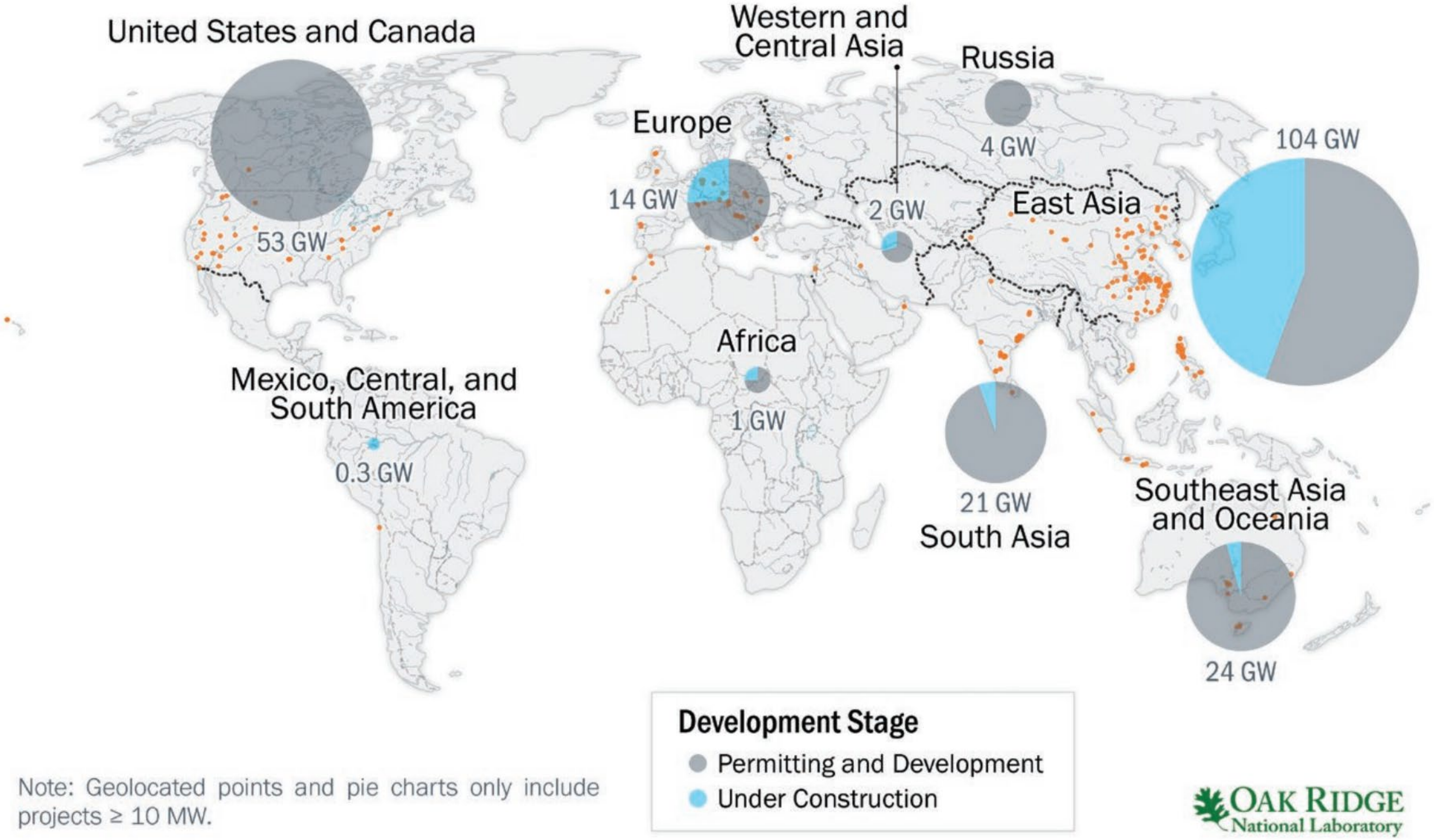


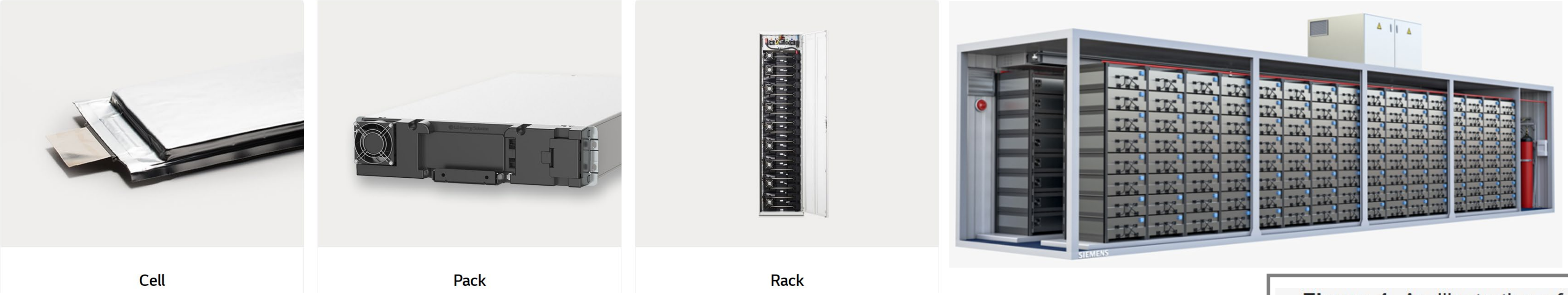
Figure ES-9. Map of PSH project development pipeline by region and development stage

Source: IIR, FERC

Note: Each point represents and individual project. The "under construction" category includes projects that have completed the permitting process and secured financing but have not yet broken ground.

As of 2024, PSH (> 180 GW) accounts for 68% of all active tracked storage installations worldwide (LIBs: 85 GW)

Li-Ion Batteries for Energy Storage System (BESS)



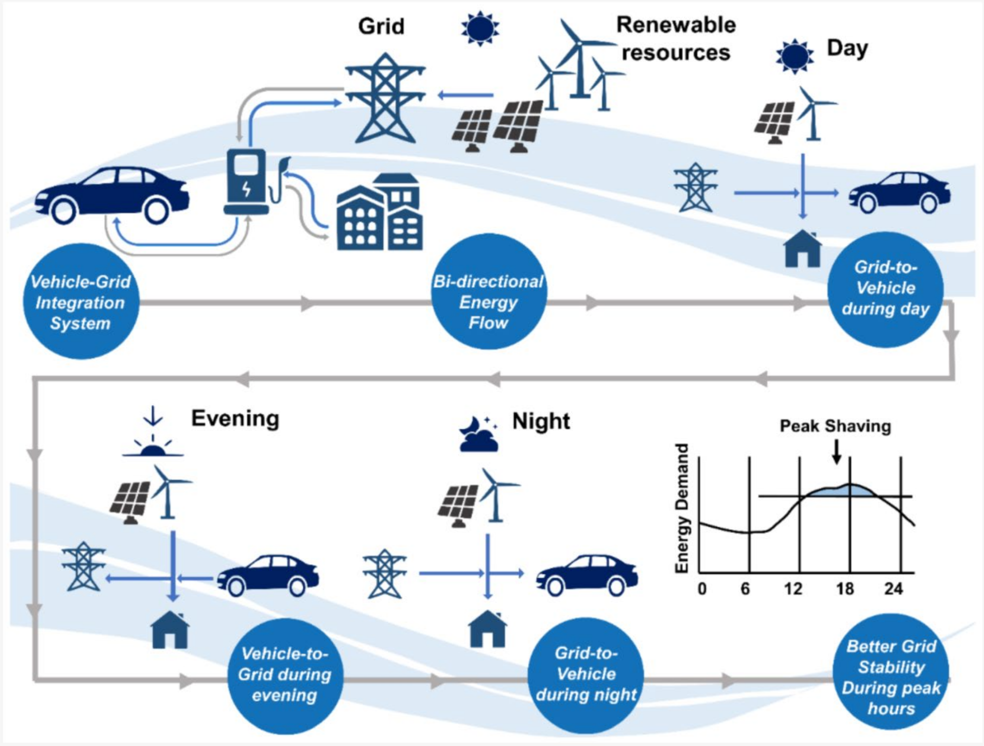
Source: ESS Battery / LG Energy Solution (lgensol.com)

Advantage: (1) fast response time, charging/discharging fast; (2) market-proven battery technology (sharing with EV); high RTE (85-95%)
Disadvantage: (1) elevated temperature degrade life-span; (2) thermal safety concern; (3) high cost ($2/kg Fe) and mediocre life span (~ 10 yr)

Vehicle-grid integration (VGI or V2G)

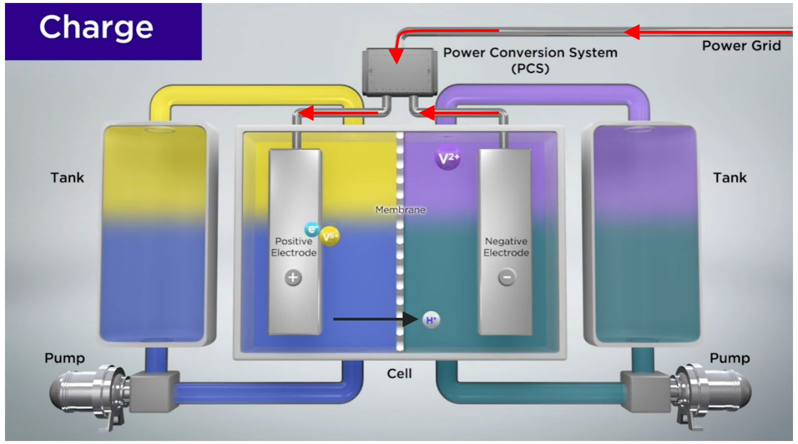
Concept: V2G technology is smart charging tech that allows to use car batteries as back up storage for electrical grid. Bidirectional charging stations to push and pull energy to and from connected electric vehicles (EVs) based on the demand for electricity at any given time.
Current challenges: (1) Most EVs and charging stations are unidirectional, and converting to bidirectional will take significant investment. (2) No consensus and regulations yet, which makes customer benefits not clear.

Figure 1. An illustration of the V2G concept during different times of the day. The graph shown in the figure is only for illustrative purposes (redrawn from [7]).



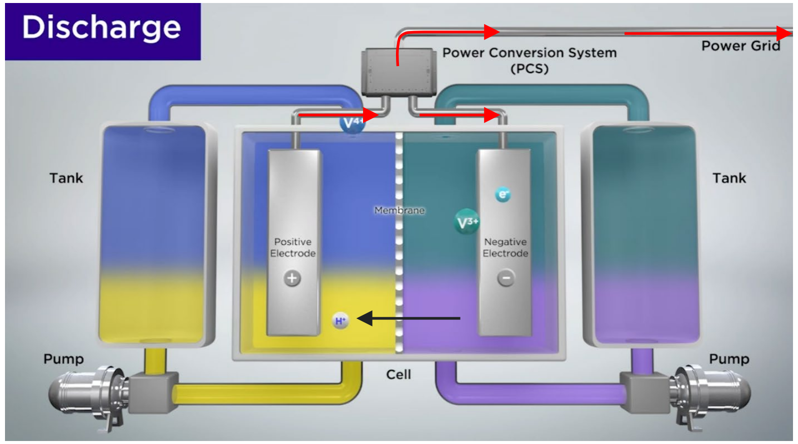
Source: Energies 2022, 15(2), 589

Redox Flow Batteries for ESS

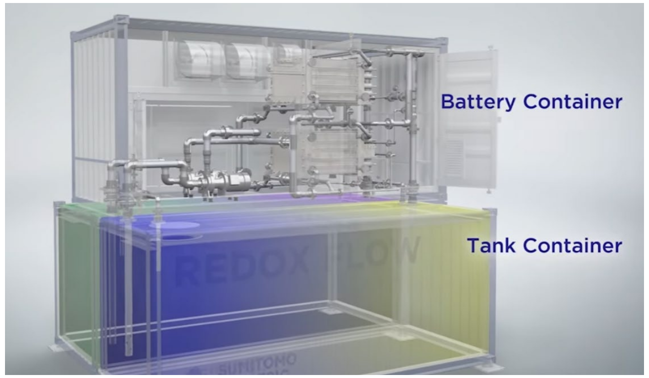


$$VO^{2+} \underset{\text{Discharge}}{\overset{\text{Charge}}{\rightleftarrows}} VO_2^{+} \qquad V^{2+} \underset{\text{Charge}}{\overset{\text{Discharge}}{\rightleftarrows}} V^{3+}$$

1 $V_{vs.SHE}$ -0.25 $V_{vs.SHE}$



Source: *sumitomoelectric.com*



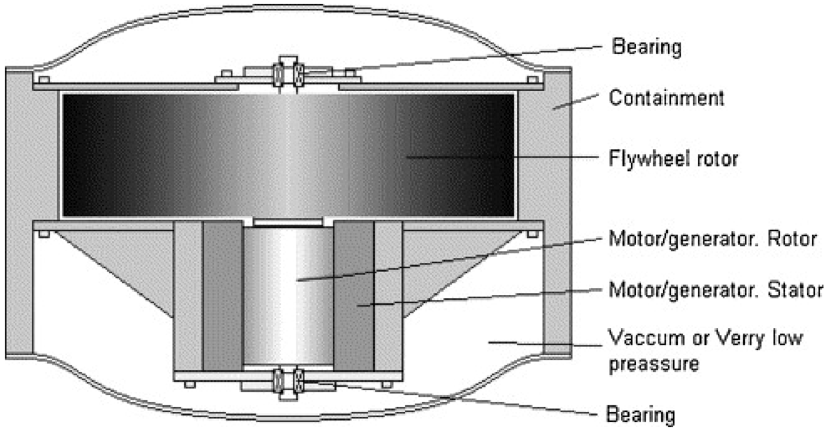
Energy ~ tank size / Power ~ stack #

Advantage: (1) easy to scale up; number of stack determines power; volume of tank determines capacity; (2) Thermal safety (aqueous electrolyte); (3) low cost ($2/kg Fe); (4) Long life span (> 20 yr with 10,000 cycles); (5) recyclable electrolyte

Disadvantage: (1) Low vol. energy density (20 – 40 Wh/L) vs. LIB (400-600 Wh/L); (2) low round-trip efficiency (65 – 80 %) vs. LIB (85-95%); (3) slow response time; (4) auxiliary components (pumps & valves) require a regular maintenance; (5) Hydrogen evolution at negative electrode ($H^+ + e^- \rightarrow \frac{1}{2} H_{2(g)}$) at 0 V that lowers efficiency

Application: long-duration (e.g., > 2 h) and mild power demanding applications, stationary grid storage

Flywheel Energy Storage System



Source: B.Bolundetal, Renewable and Sustainable Energy Reviews 11 (2007) 235

Source: Key Energy

Source: www.adaptive-balancing.de

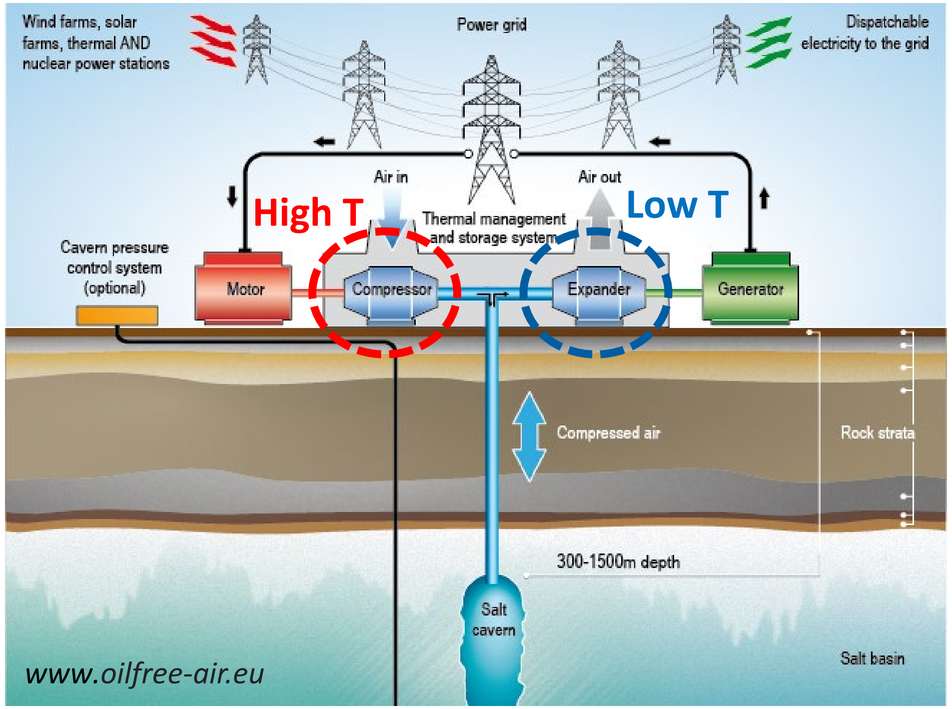
Operation: Store kinetic energy from spinning flywheel rotor (motor) / discharge energy by converting to AC (generator)

Advantage: (1) high power (kW to MW scales); (2) fast response (ms) due to 50k rpm; (3) long lifetime (20+ years)

Disadvantage: (1) low energy density (5-30 Wh/kg); (2) high self-discharge (5-20% loss per day); (3) capital cost for installation; (4) safety (mechanical failure)

Potential application: good for short-duration, high-power applications (frequency regulation, UPS, transit), with superior cycle life and response time compared to batteries.

Compressed Air Energy Storage (CAES)



World's first 300 MW CAES in Hubei, China
1.5 GWh, storage volume=24.7M ft^3

Source: www.globaltimes.cn/page/202501/1326611.shtml

Operation: Store energy as a form of compressed air inside salt and mined rock caverns / discharge energy by releasing compressed air, which is heated and expand through turbines.

Advantage: (1) longer discharge duration (hours – day); (2) lower price with larger scale; (3) long lifespan (+50 years)

Disadvantage: (1) low round-trip efficiency (RTE) of 50-70% (heating needed for expansion); (2) geographical constraints (salt caverns or depleted wells); (3) high upfront capital cost; (4) slow response time.

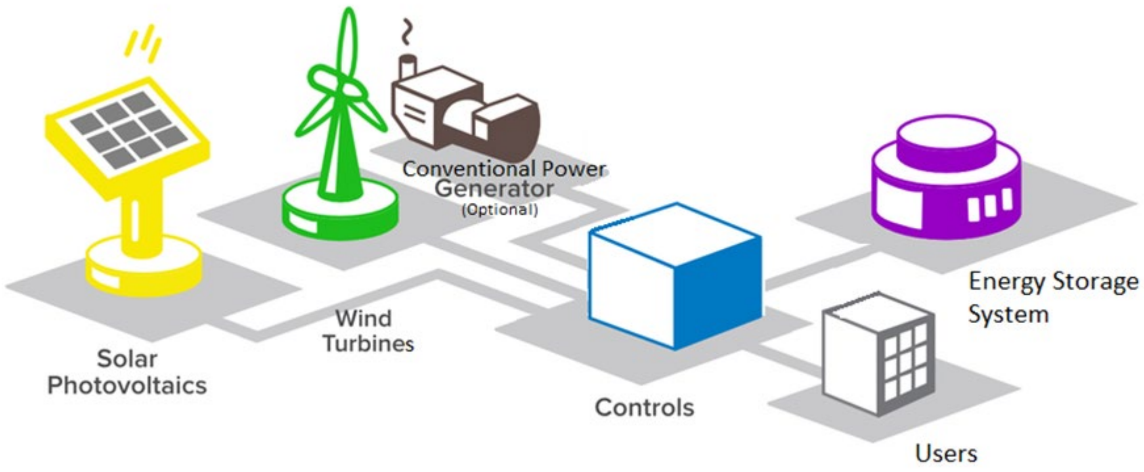
Potential application: good for long-term duration, such as energy storage for renewable energy and grid stability service, industry & remote grids.

Hybrid Energy Storage Systems (HESS)

Obtain optimal performance using multiple energy storage technologies

Advantage: (1) Leverages complementary strengths (power + energy); (2) extend battery lifetime (reduce high-rate cycling); (3) more efficient asset utilization

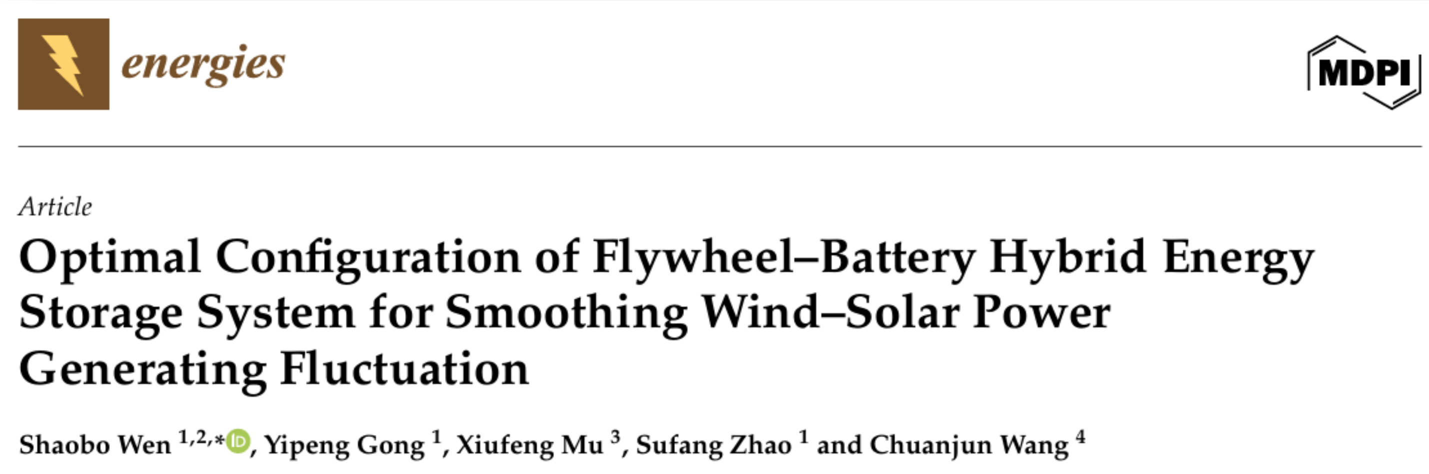
Disadvantage: (1) Require complex system integration and control; (2) potentially higher cost



Hybrid Microgrids

Source: stellaeenergy.com

HESS: Flywheel + Battery ESS



Reports

- Less power fluctuation (3.2% in 1-min interval);
- 45% cost reduction compared to single BESS solution

[Construction Begins on China's First Independent Flywheel + Lithium Battery Hybrid Energy Storage Power Station — China Energy Storage Alliance]

Reports

- 200 MW / 100 MWh capacity
- $LiFePO_4$ LIBs + flywheel
- Goal: peak-shaving with fast frequency response (flywheel) with sustained power (LIB)

HESS: Redox Flow Battery + Li-Ion Battery ESS

NEWS

Project with world's largest lithium-vanadium hybrid BESS officially launched in Oxford, UK

By Cameron Murray

July 5, 2022

Europe | Grid Scale, Connected Technologies | Business, Technology

LinkedIn Twitter Reddit Facebook Email

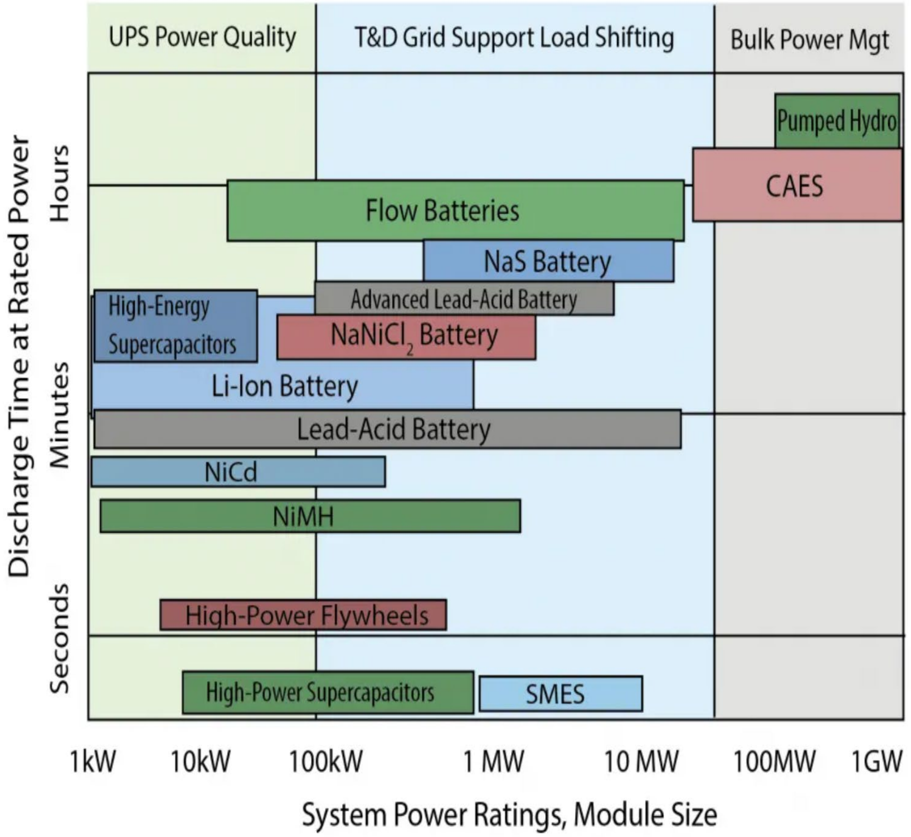
An aerial view of the Energy Superhub Oxford BESS. Image: Pivot Power.

Reports

- EV fast charging infrastructure
- Redox flow battery (2 MW/5 MWh) + LIB (50 MW/50 MWh)
- Li-ion does fast, high-power tasks but experience fast life degradation
- RFB does not degrade much
- Examine future HESS strategy to extend LIB life by implementing RFB

energysuperhuboxford.org

Summary – HESS Strategies



- ❑ The market is still in the learning phase regarding Hybrid Energy Storage Systems (HESS) for various applications.
- ❑ Lithium-ion batteries (LIBs) remain a costly but reliable option, driven by the expanding electric vehicle (EV) market and the availability of second-life batteries.
- ❑ AI/ML will shorten the learning curve to design, dispatch, and monetize HESS

Thank you

Jung-Hyun Kim
Email: Kim.6776@osu.edu

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CITY OF WESTERVILLE

The Westerville Electric Division

Safe, Reliable, and Affordable since 1898

Chris Monacelli
Electric Utility Manager

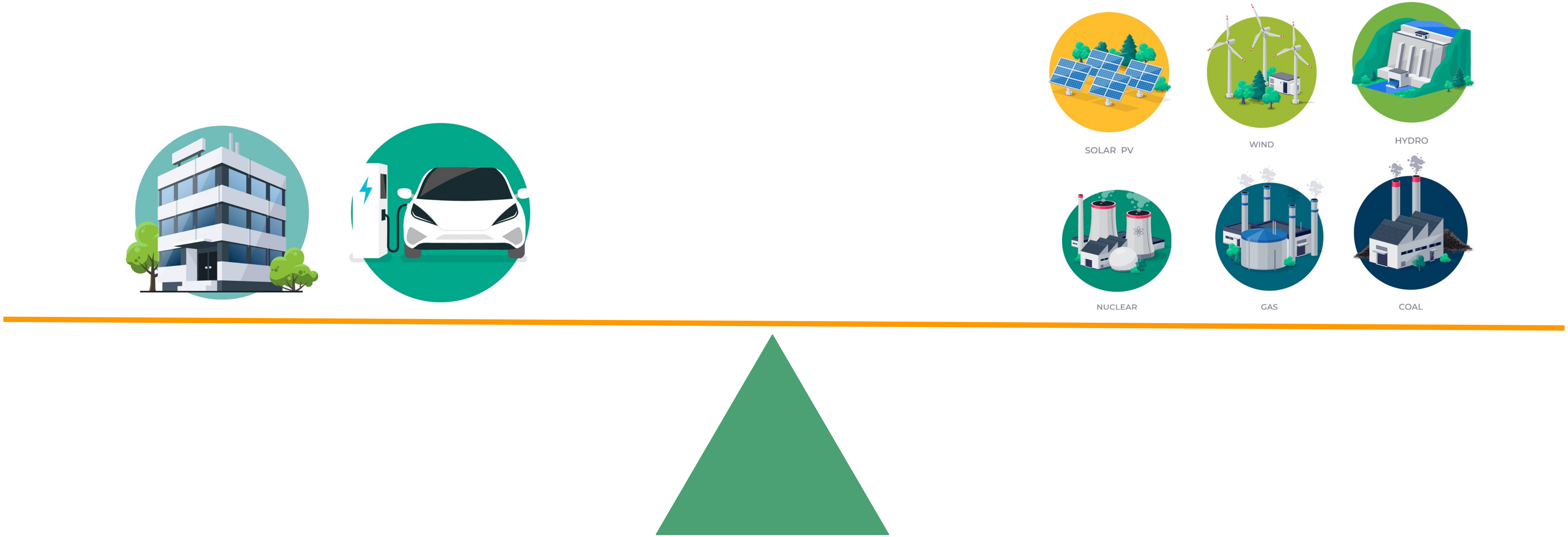
WESTERVILLE

CITY OF WESTERVILLE

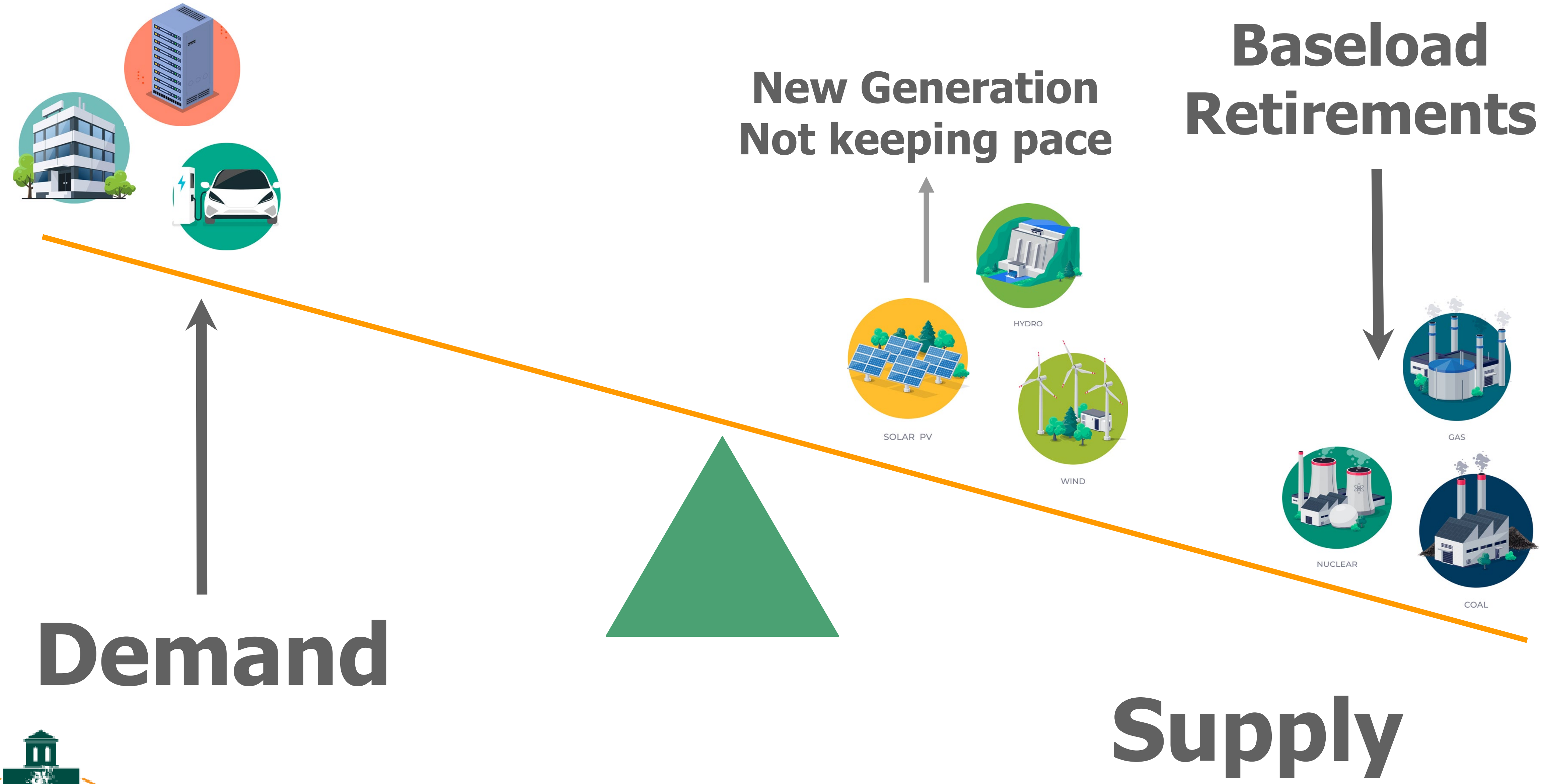
About Westerville

- Established **1898**
- **39,000** residents
- **18,000** meters
- **440M** kilowatt-hours
- Over **100** megawatt peak

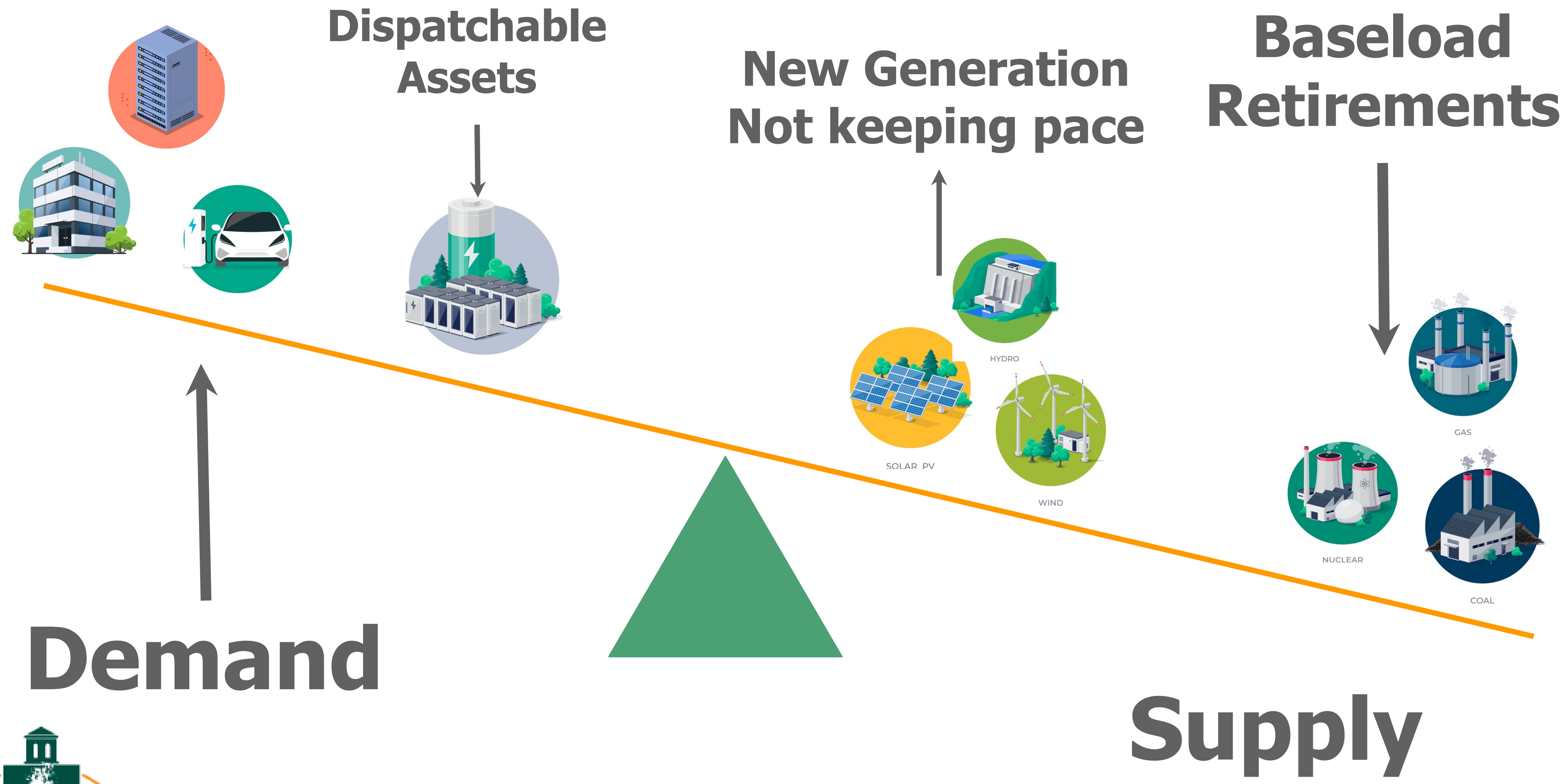
WESTERVILLE



Demand = Supply



WESTERVILLE



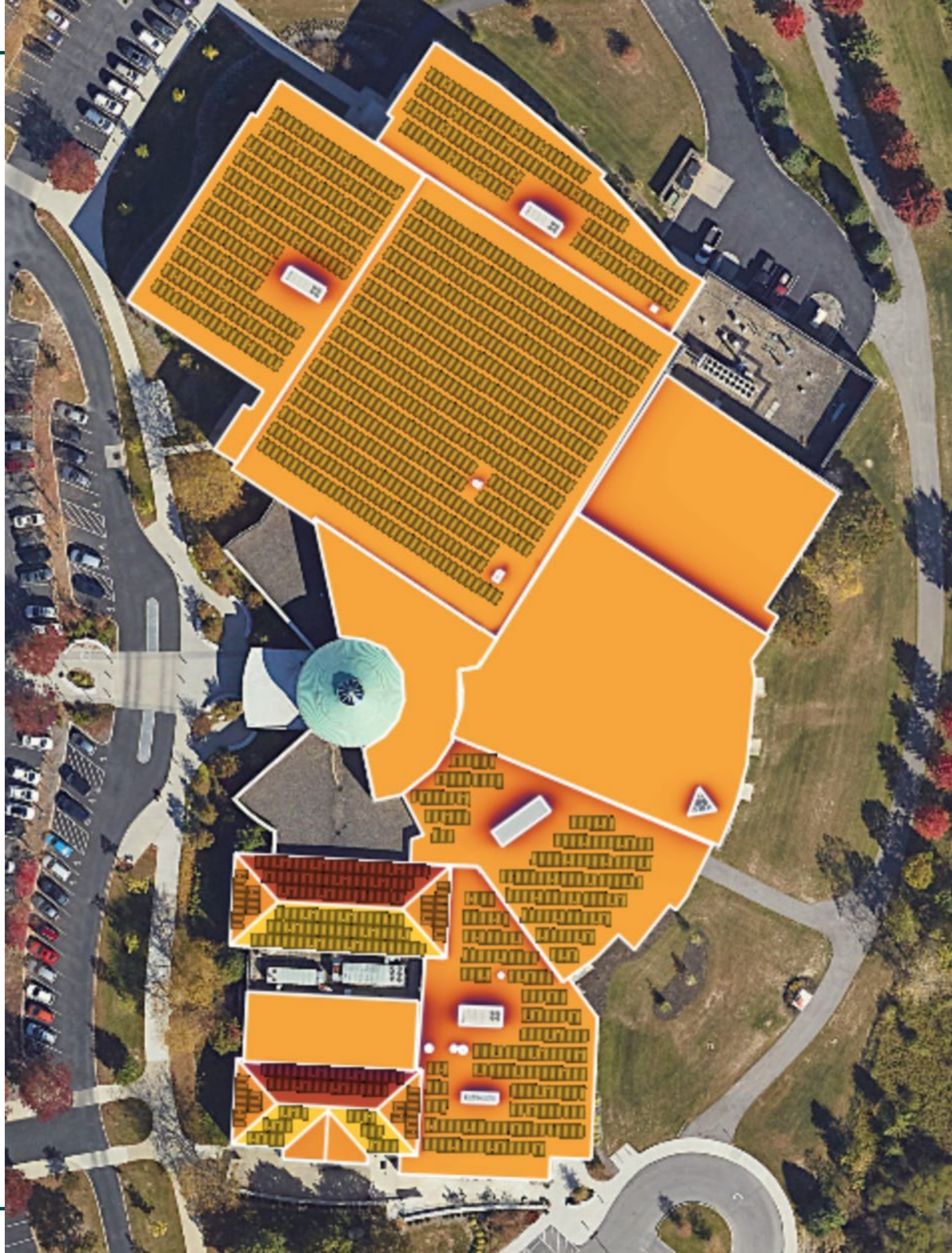
WESTERVILLE

Solar Power Purchase Agreement

→ 10 MW, 20 year PPA, Westerville Buildings

- Local and visible

COLUMBUS PARTNERSHIP

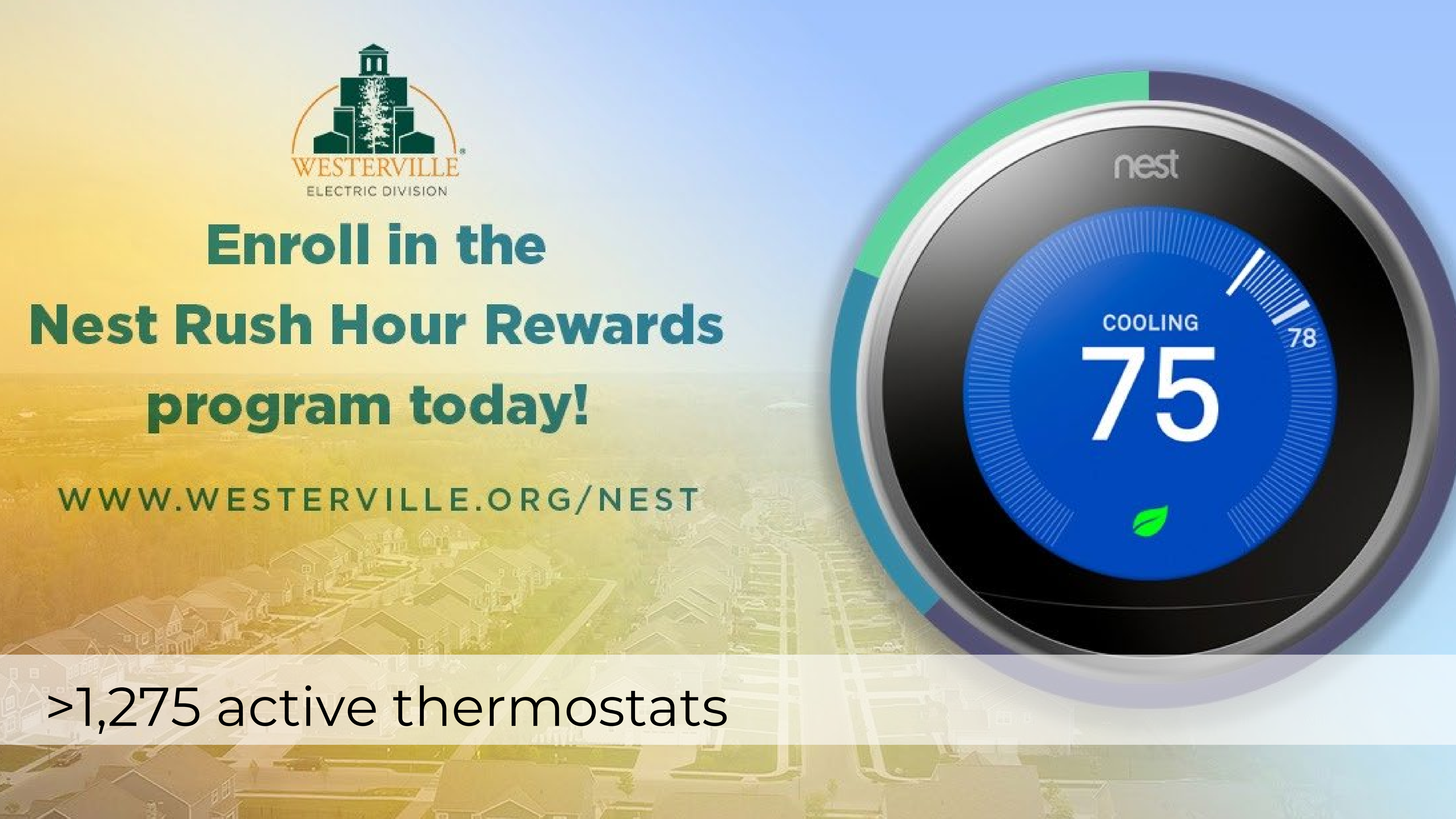


WESTERVILLE

RESIDENTIAL ELECTRIC VEHICLE **OFF-PEAK CHARGING PROGRAM**
powerup

ELECTRIC VEHICLE SUPPLY EQUIPMENT **REBATE PROGRAM**
powerup

+



>1,275 active thermostats

Utility Scale Battery Storage

WESTERVILLE

WESTERVILLE®

ELECTRIC DIVISION

Chris Monacelli
Electric Utility Manager

chris.monacelli@westerville.org

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2:05 | **Orchestrating through Smart Grid Technologies |** *Chris Monacelli, Westerville Electric Division*

2:20 | **Panel Discussion**

2:35 | **Audience Q&A**

2:55 | **Wrap-Up** | *Brian Filiatraut, MORPC*

Securing Our Energy Future:

Emerging Energy Technologies and Future-Proofing the Region

AUGUST 27 | 1:00 – 3:00 PM | OSU Energy Advancement & Innovation Center

TODAY'S PANELISTS

CAITLIN HOLLEY
Vice President
Trillium H2 Power

RANDY KEEFER
New Nuclear / SMR Engineering Manager (Retired)
AEP

DR. JUNG-HYUN KIM
Associate Professor
The Ohio State University, Institute for Materials Research

CHRIS MONACELLI
Electric Utility Manager
City of Westerville, Westerville Electric Division

AUGUST 27 AGENDA

1:00 | **Welcome** | *Jessica Kuenzli, MORPC*

1:05 | **OSU Energy Advancement & Innovation Center** | *Emma Osborn, OSU EAIC*

1:10 | **Energy Landscape for Meeting Tomorrow's Demand** | *Brian Filiatraut, MORPC*

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Central Ohio Climate Action Plan

A HEALTHY AND JUST FUTURE FOR CENTRAL OHIO

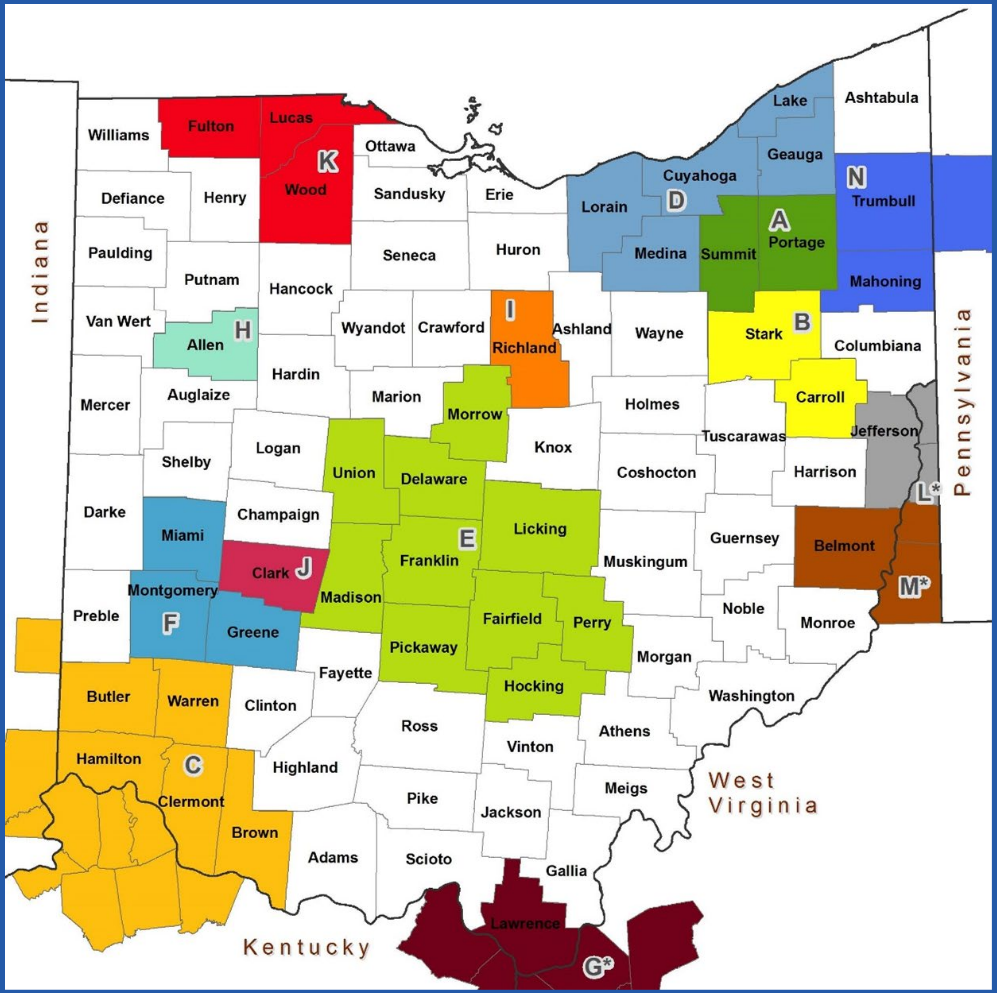
VISIT THE WEBSITE

50%

GHG REDUCTION BY 2035

100%

GHG REDUCTION BY 2050



Power A Clean Future Ohio — LOCAL COMMUNITIES LEADING THE WAY

MID-OHIO REGIONAL PLANNING COMMISSION MORPC

IMPACT Community Action — Serving Columbus and Franklin County

THE OHIO STATE UNIVERSITY COLLEGE OF PUBLIC HEALTH

SUSTAINABLE COLUMBUS — ANDREW J. GINTHER, MAYOR


REGISTER NOW
LOCAL ROOTS.
LASTING IMPACTS.
SUMMIT ON SUSTAINABILITY 2025
Tuesday, September 30 | 8:00 AM - 4:30 PM
Hilton Columbus Downtown
(401 North High Street | Columbus, OH 43215)

JOIN US

Energy and Air Quality Working Group

Wednesday, November 19 | 1:00 – 2:30 PM
Hybrid Meeting
Online / MORPC Office

MID-OHIO REGIONAL
MORPC
PLANNING COMMISSION

THANK YOU

BRIAN FILIATRAUT

Senior Program Manager, Energy and Sustainability
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Columbus, OH 43215