

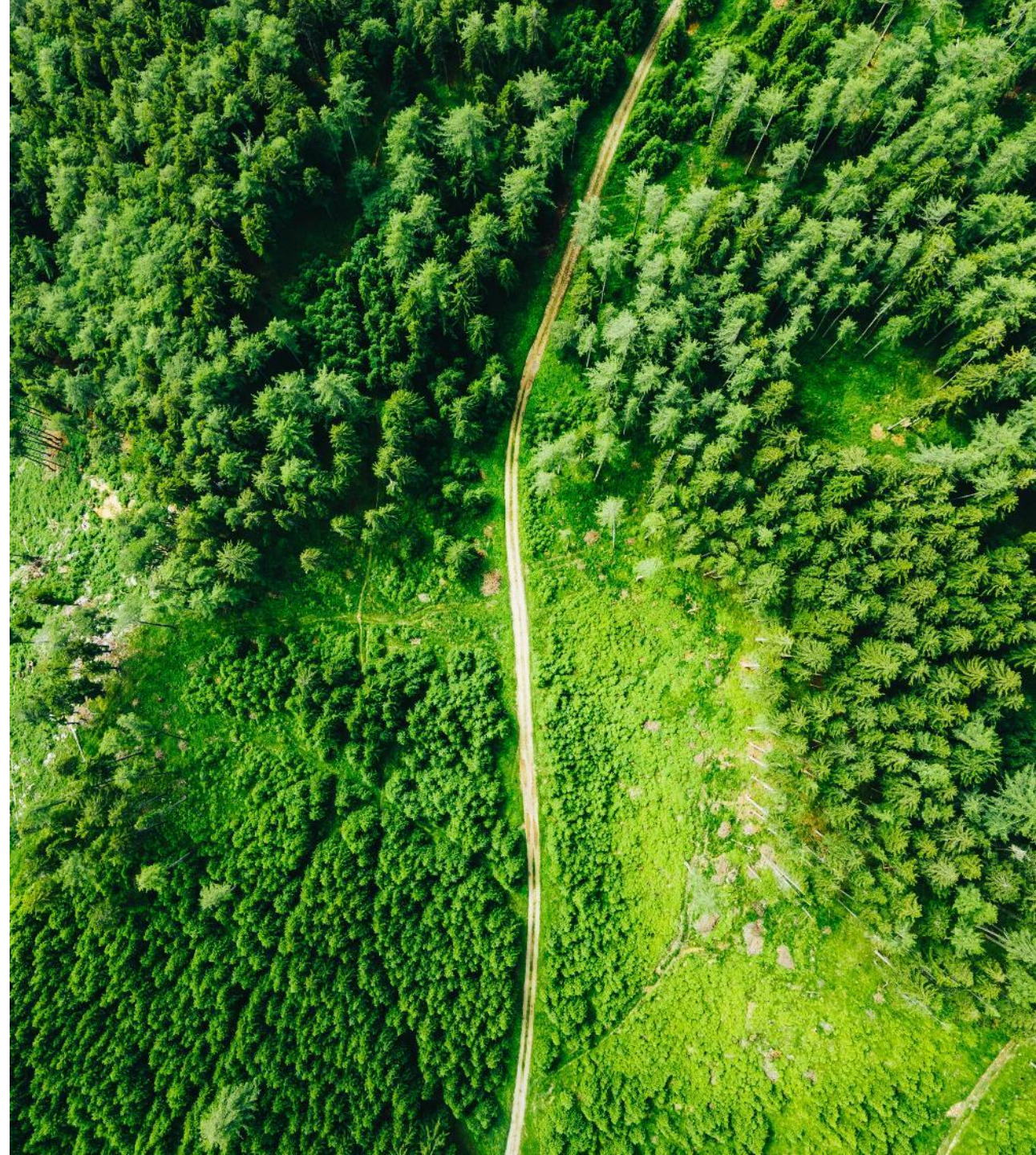


Tackling Climate Change

Luke Wentlent, Ph.D., Principal R&D Engineer, Hydrogen Storage & Refueling, Chief Technology Office

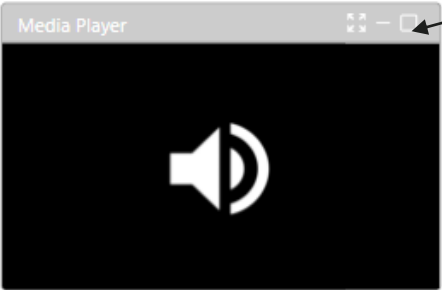
6.28.23

Copyright 2021, Plug Power Inc.



Console tour

Speaker



Ask Question

Ask Question

Enter your question

Submit

Related Content

- Hydrogen Basics: Fuel of the Future Explained
- Plug's 15TPD Green Hydrogen Plant Update
- Shattering Hydrogen Myths in 'Glass Onion: A Knives Out Mystery'

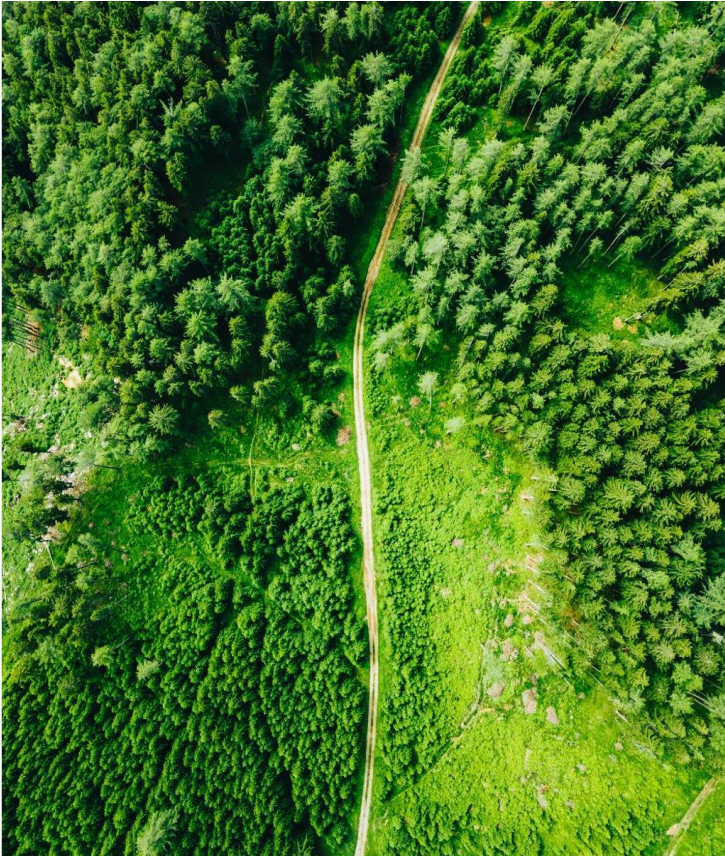
Slides



Tackling Climate Change

Luke Wentlent, Ph.D., Principal R&D Engineer, Hydrogen Storage & Refueling, Chief Technology Office

6.28.23
Copyright 2021, Plug Power Inc.



Speaker bio

Speaker Bio



Luke Wentlent, Ph.D.
Principal R&D Engineer
Plug

Dr. Luke Wentlent is a Principal R&D Engineer at Plug where he is responsible for leading the technology roadmap development for all units and products related to Hydrogen Storage and Hydrogen Refueling infrastructure. His focus is on high-density methods of hydrogen storage, small-scale hydrogen liquefaction, cryogenic turbomachinery.

Take Survey

Post-Event Survey

1. How would you rate today's webinar (1 to 10, with 10 being the best)

Select a Choice

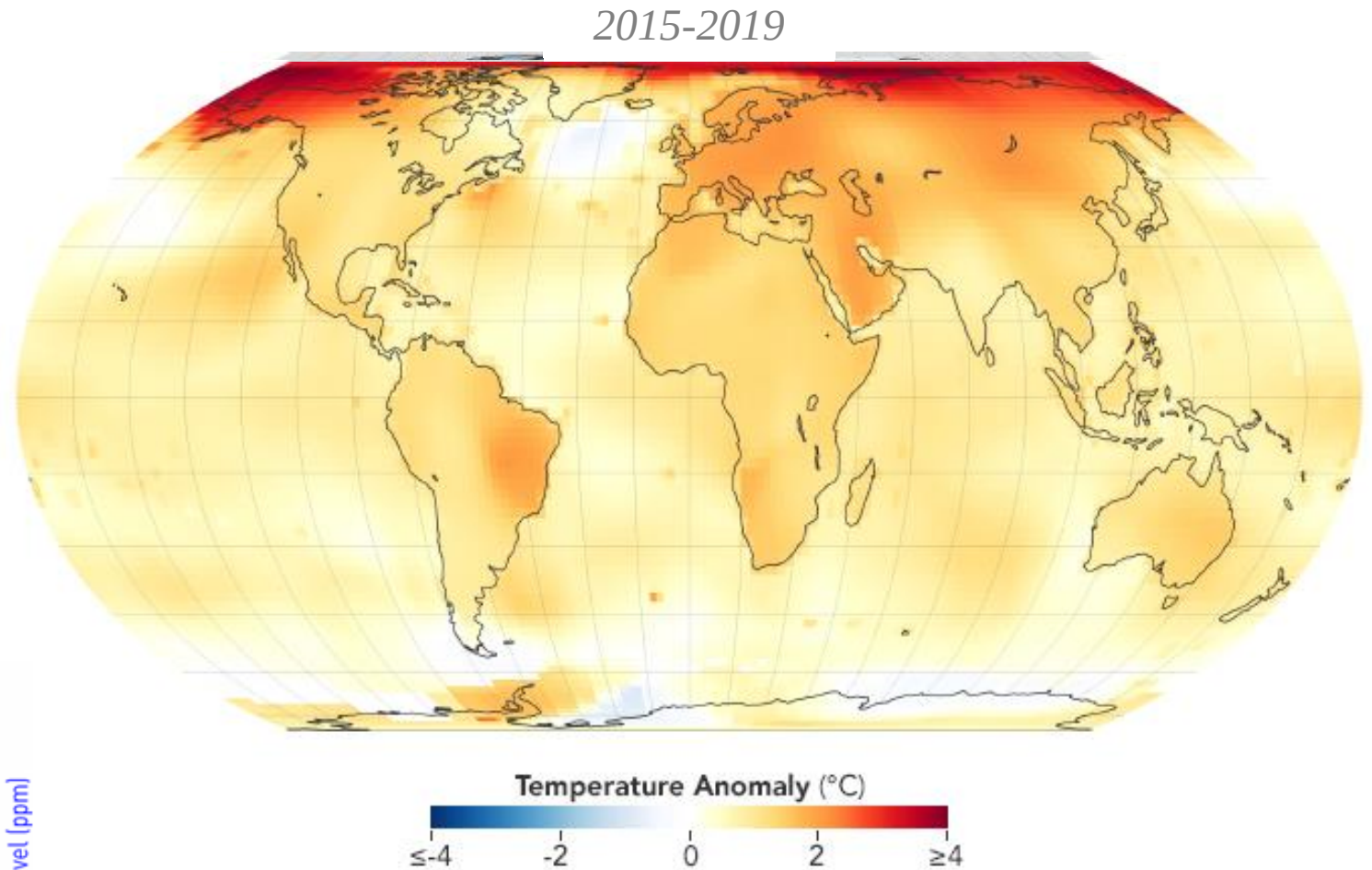
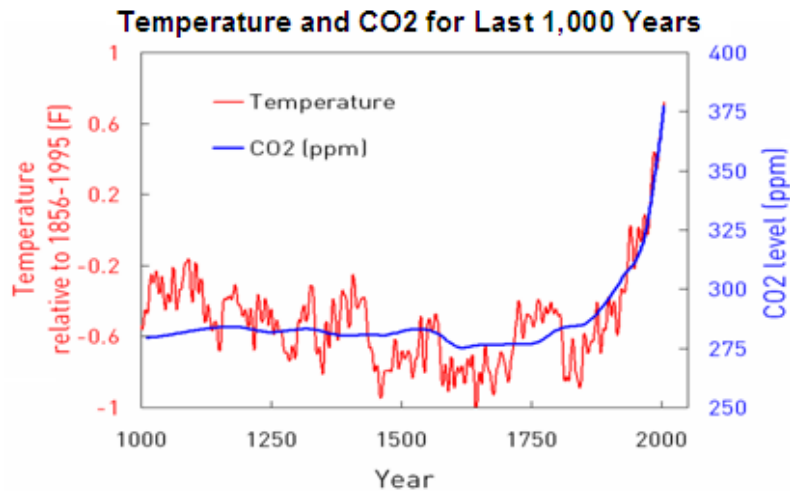
2. Would you recommend this webinar to a colleague?

Select a Choice

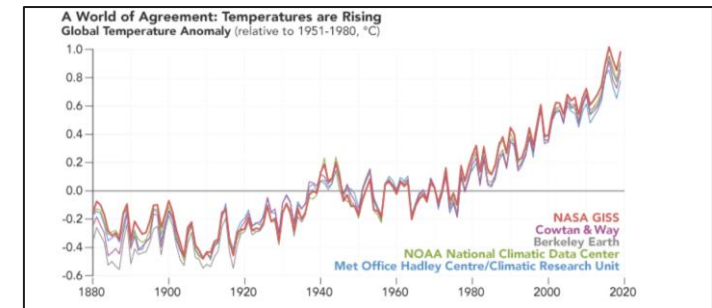
Other useful information

Let us know your feedback!

There is strong evidence and scientific agreement showing that the world has been on an accelerating warming trend for the past century...



This warming trend can be tied to clear increases in GreenHouse Gas (GHG) emissions associated with fossil fuel combustion in the modern Industrial Era.



Graphics reconstructed using data published by NASA's Goddard Institute for Space Studies

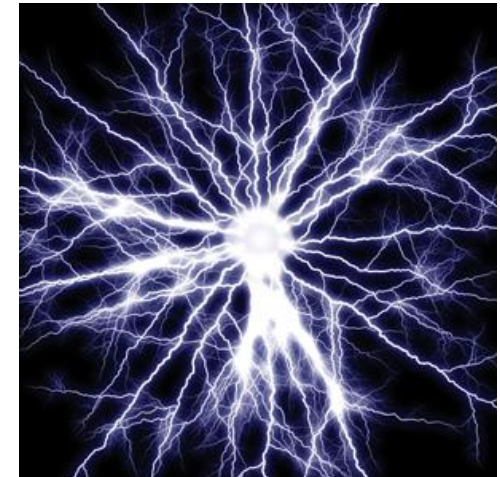
How do we address this?

There is a clear need to transition away from the fossil fuel dependency and in order to do this, we must understand the role (and scope) that they play in our society

Fossil fuels are energy vectors. Highly efficient ways of moving and storing energy from one place to another.



Energy

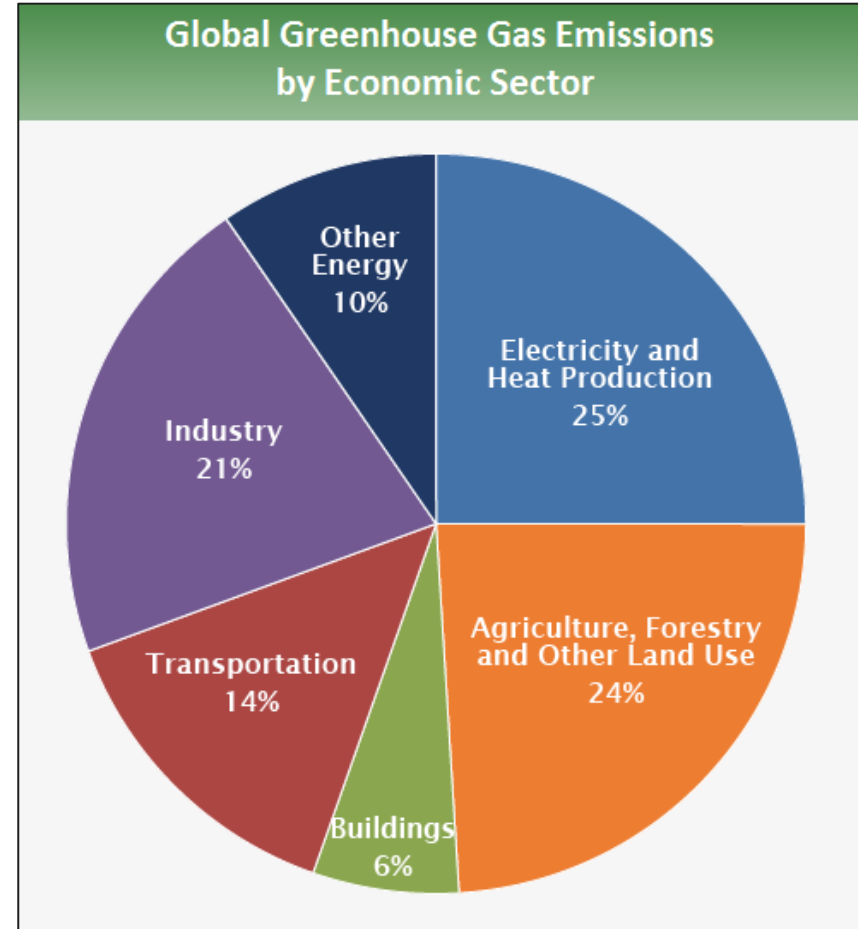


In 2018, the United States total energy expenditure totaled over \$1.3 trillion (~3x that of the global semiconductor market).

When fossil fuels are burned, they release large amounts of greenhouse gas into the air

Some sector examples include:

- Passenger vehicles
- Public transportation
- Ships
- Airplanes
- Manufacturing/industrial operations
- Logistics
- Coal power plants
- Electricity usage
- ... and more



Source: Intergovernmental Panel on Climate Change Report. Based upon 2010 emissions data.

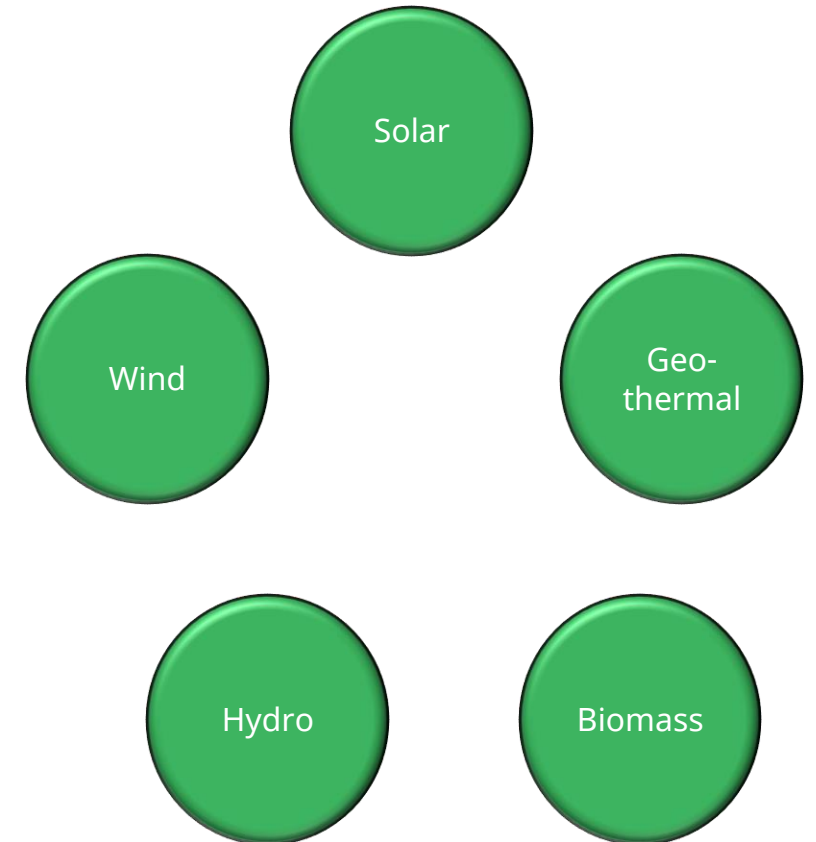
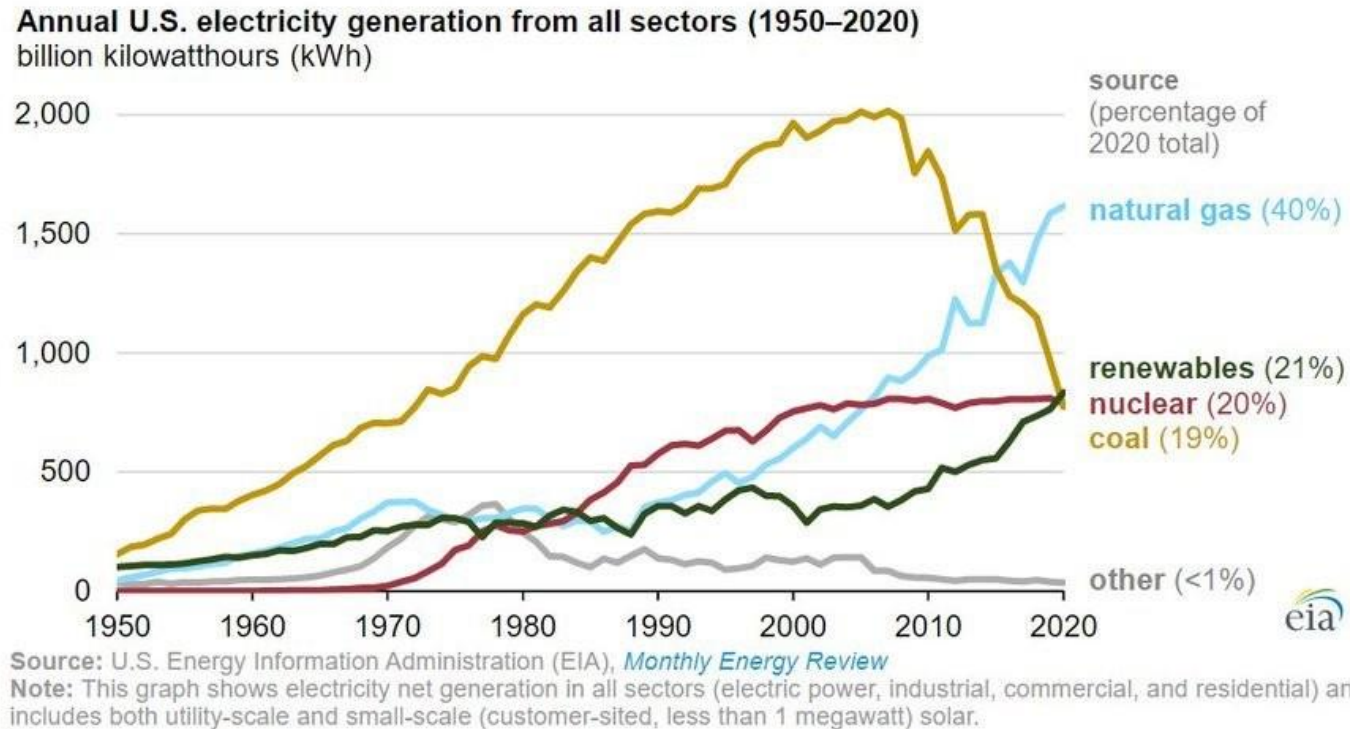
But we need heat and electricity,
transportation, agriculture, etc.

So, how can we decarbonize these
critical industries?



Part of the answer lies in renewable power deployment

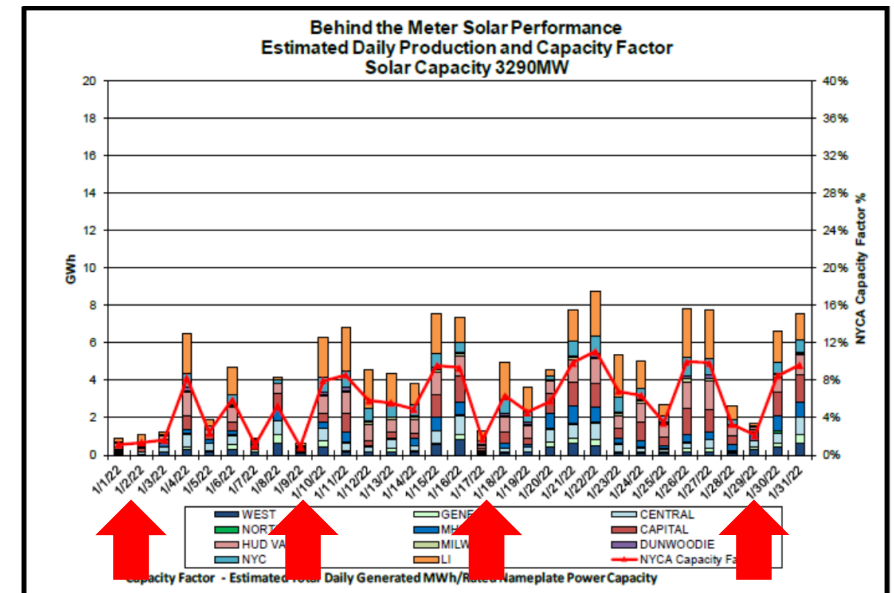
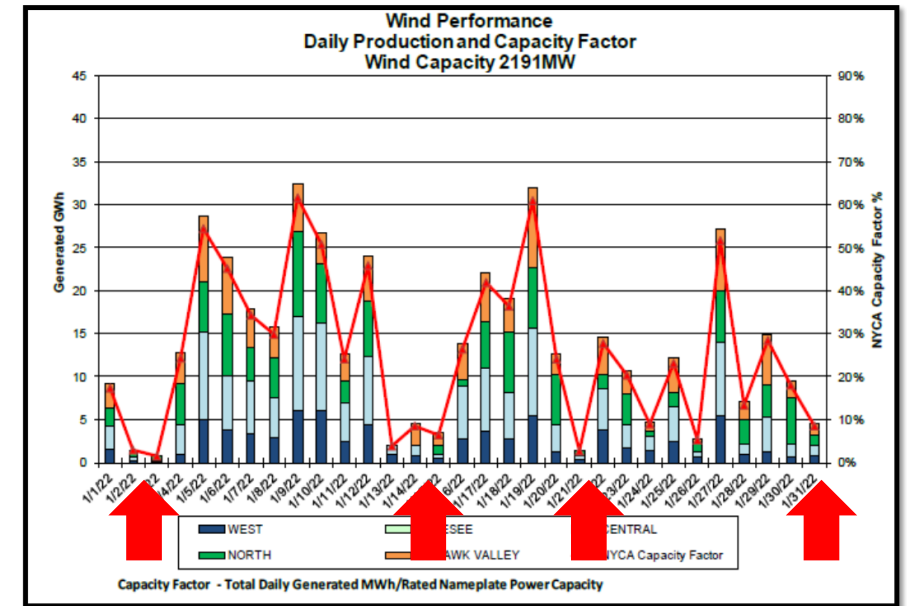
The clean energy industry has begun to accelerate over the past decade, particularly as technology has matured and financial incentives have been deployed.



Renewable energy challenges

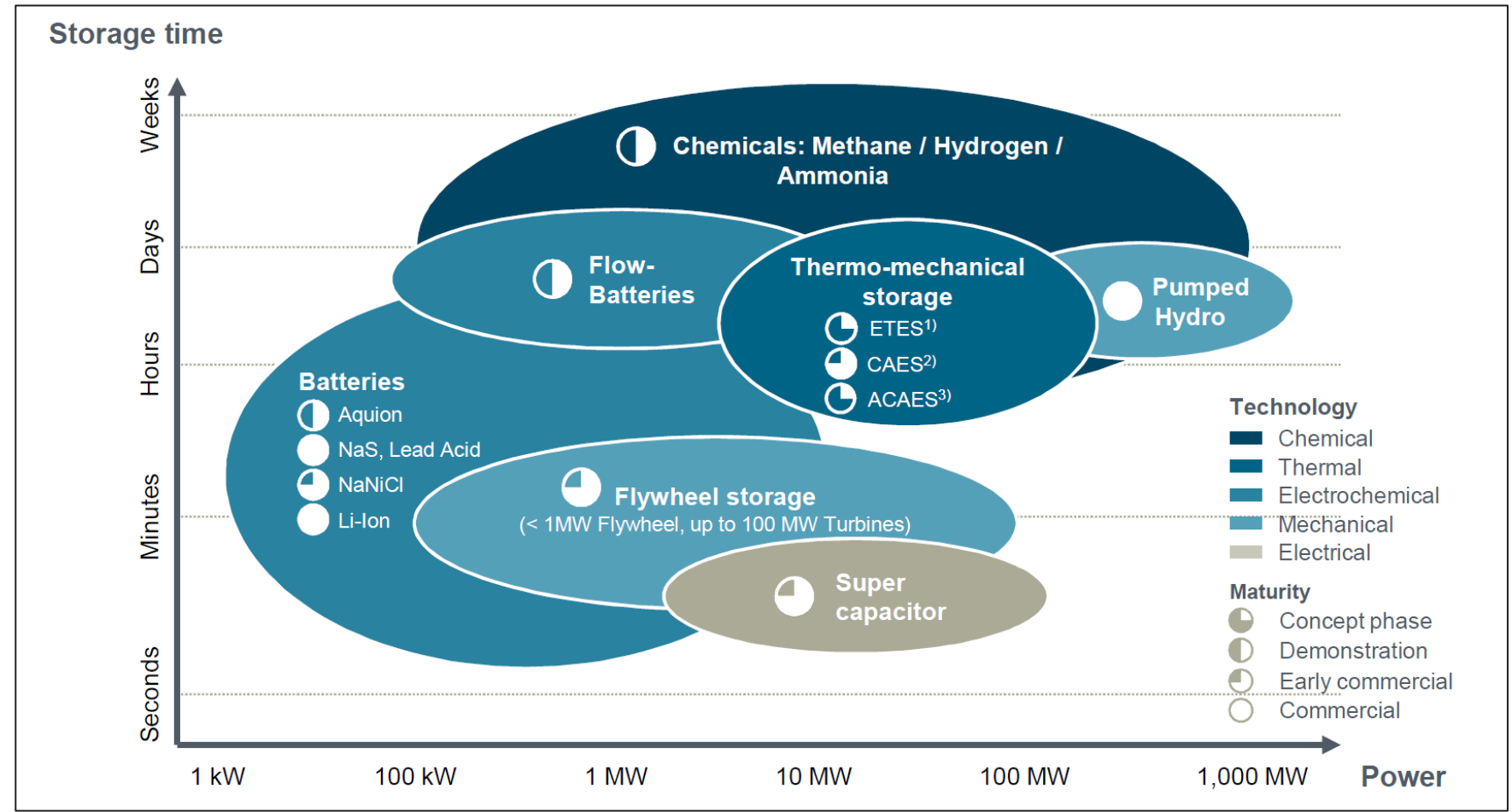
- Intermittency – we cannot control the wind, sun, etc.
- In January 2022, New York State saw ~25% of the month produce below 20% of the name plate capacity
- Location – where the renewable source is vs. where the energy needs to be used
- Renewable energy sources are purely generating raw energy. They must be used in a different form
- Asset utilization

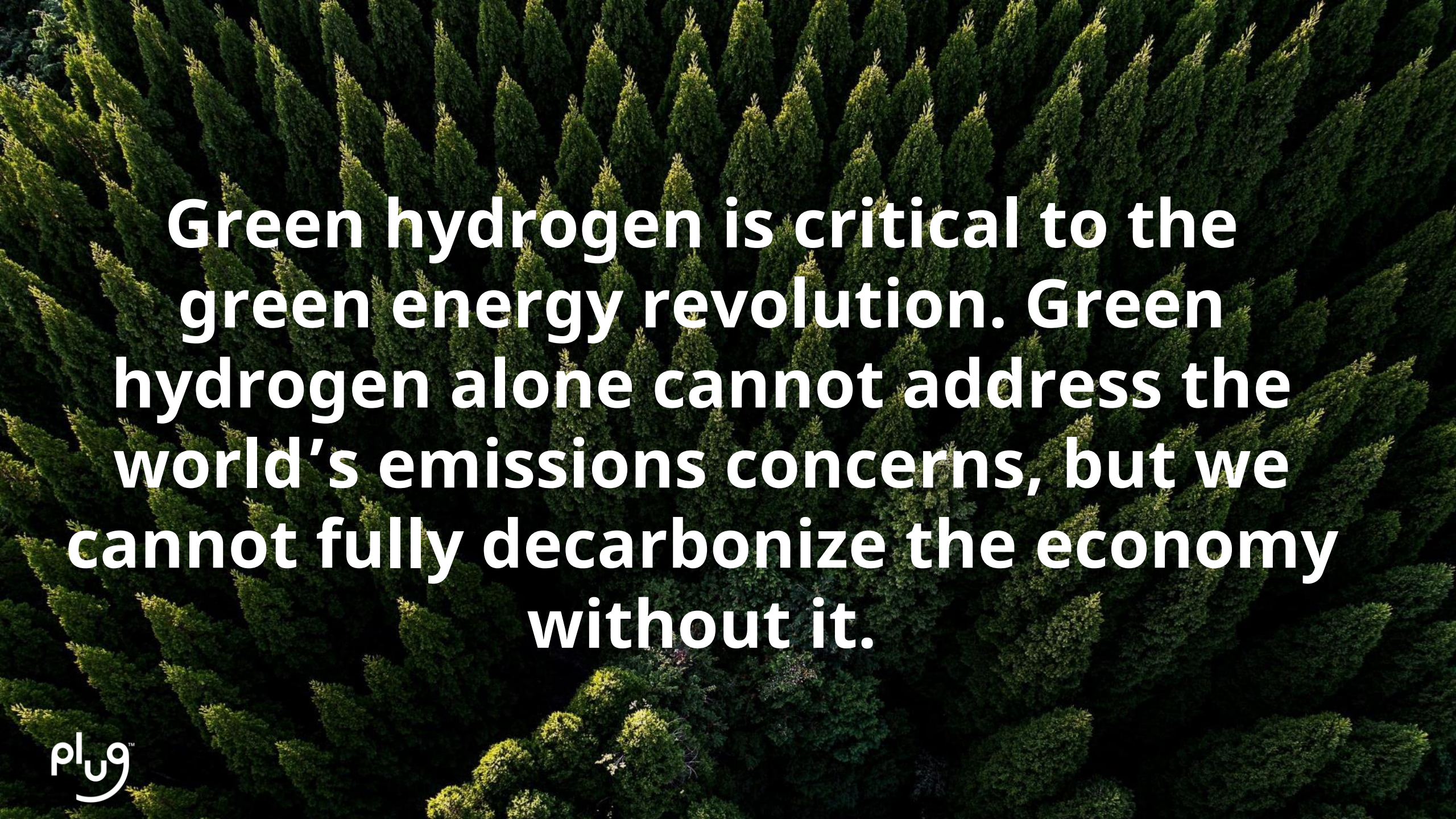
How do we do this?



Renewable deployment needs to be supported with clean ways to store energy...

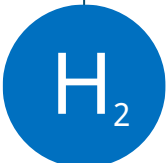
- The storage of energy is equally as important as deploying
- There is no one size fits all technology that will satisfy energy storage demands
- Hydrogen and batteries are the two most widely viable (and both have advantages and disadvantages)



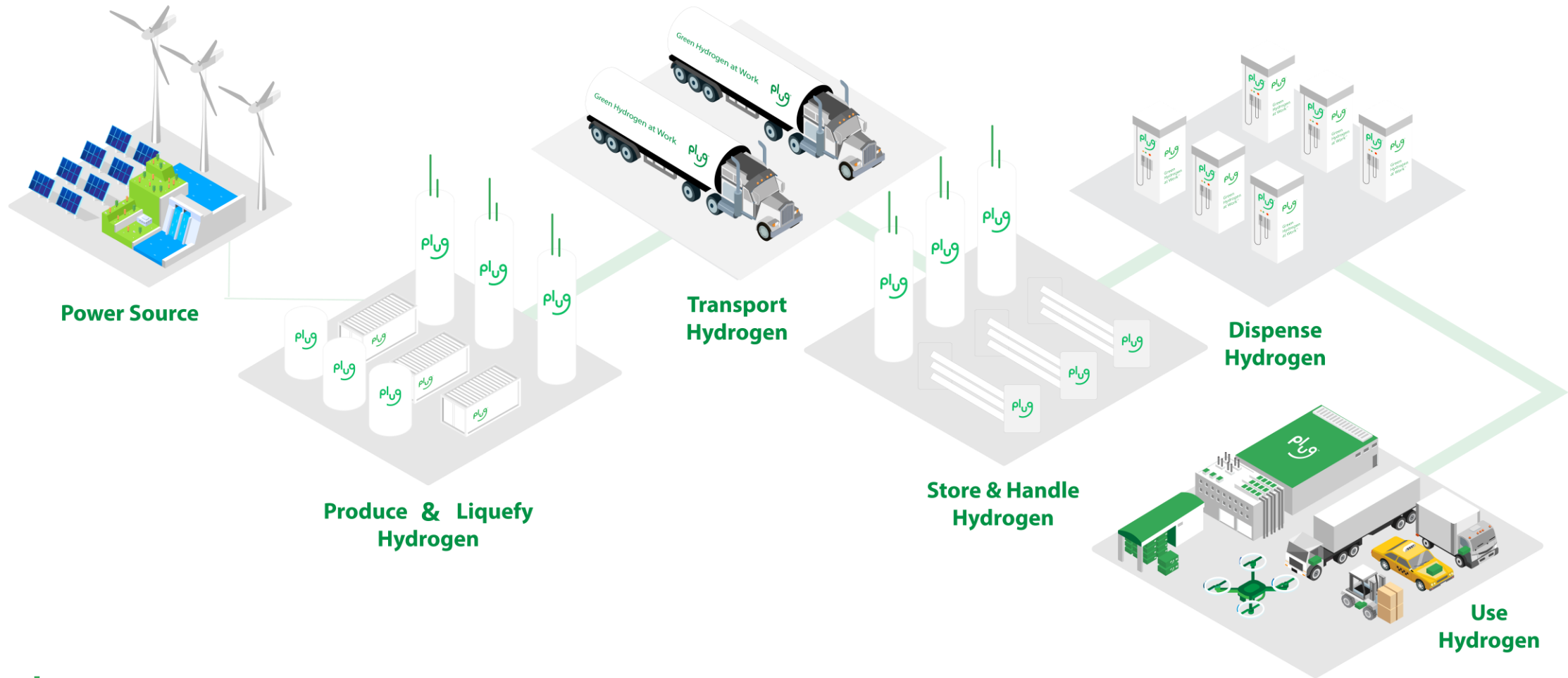
An aerial photograph of a dense forest of evergreen trees, likely spruce or fir, with their pointed tops creating a repeating pattern across the frame. The lighting is bright, casting shadows that emphasize the texture of the foliage.

Green hydrogen is critical to the green energy revolution. Green hydrogen alone cannot address the world's emissions concerns, but we cannot fully decarbonize the economy without it.

What makes hydrogen green?

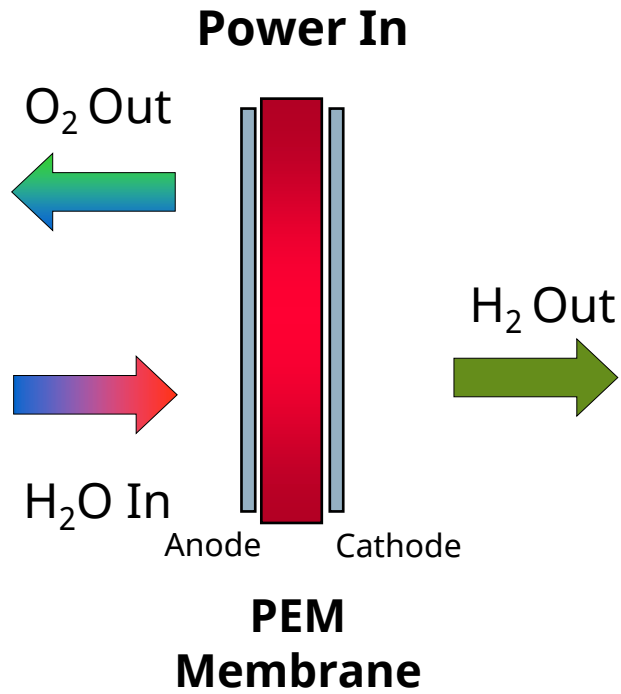
	Transformed Molecule	Process	Emissions
	Coal	Gasification	NOx, SOx, Black Carbon or Particulate Matter
	Natural Gas (CH4)	Steam-Methane-Reforming	NOx, SOx, Black Carbon or Particulate Matter
	Natural Gas (CH4)	Steam-Methane-Reforming	CO2 that is captured
 	Green H2O	Electrolysis through Renewables	Oxygen

Plug's green hydrogen ecosystem



Zero Emissions Power: Electrolyzers

Hydrogen is generated via an electrochemical process using electricity to capture hydrogen from water.



ROBUST & DEPENDABLE

Based on more than 47 years of experience in design, production and sales of electrolyzer stacks and integrated products. Providing industry-leading performance for a variety of diverse applications including heavy industry, e-mobility, renewable energy and energy storage needs.

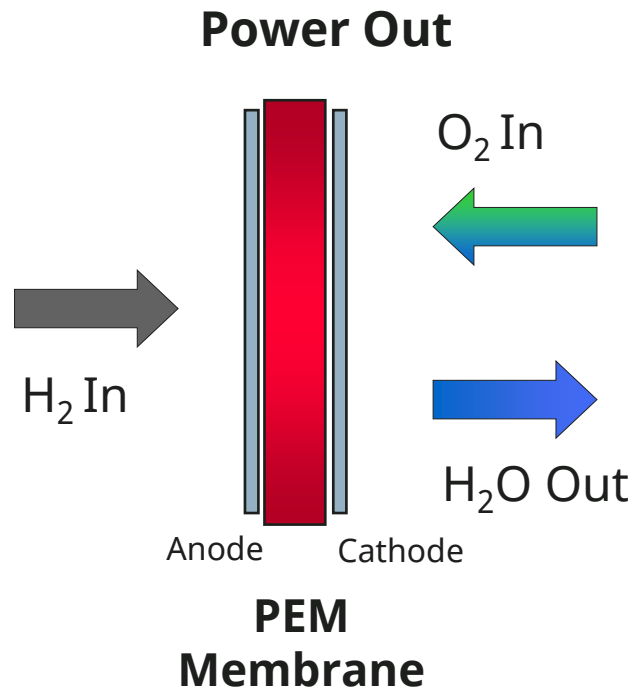


ADAPTABLE & MODULAR

Electrolyzer solutions support industry expansion – flexible and scalable to meet a wide array of performance requirements. Simplified BOP and reduced stack and system cost make these products cutting edge. PEM technology allows us to have immediate response time the moment that renewable electricity is available to turn it into hydrogen.

Zero Emissions Power: Fuel Cells

Power is generated via an electrochemical process using hydrogen and oxygen with water as the byproduct.



ZERO-EMISSION POWER

Hydrogen fuel cells (HFCs) produce no harmful emissions, the only by-products are heat and water, making our products a zero-emission, sustainable power source.



ROBUST RELIABILITY

Proven technology in tough conditions, including cold environments as low as -40 degrees F/C, weather environments like hurricanes, deserts, and winter storms, and even the hard-working business environments of material handling warehouses



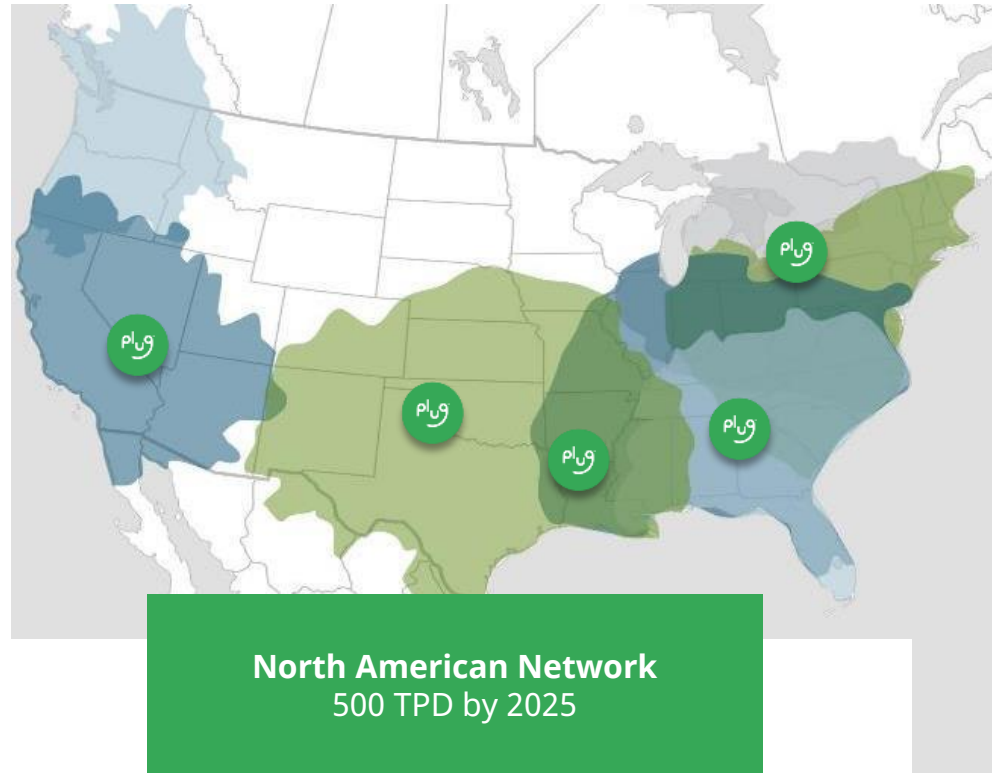
IMPROVED EFFICIENCY

Hydrogen fuel cells are generally between 40-60% energy efficient. This range compares to the typical internal combustion engine of a car which is about 25% energy efficient



Plug is building a global green hydrogen network

- 13 North American plants with Green Hydrogen generation of 500-tons per day by 2025
- Announced Green Hydrogen plant locations at California, Georgia, Louisiana, New York and Texas
- Announced 30TPD Green Hydrogen plant location at Port of Antwerp-Bruges in Belgium



EU and Global Network
1,000 TPD Globally by 2028
100+ TPD in Europe by 2028



Green hydrogen supports multiple applications

Hydrogen technology can power non-stop forklifts, trucks, planes, data centers.



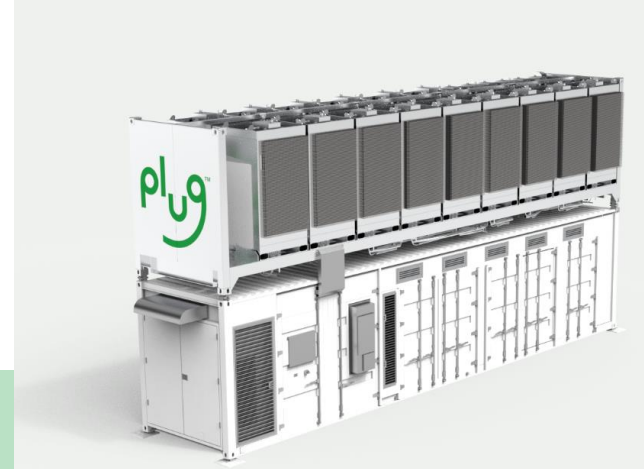
Forklifts & GSE

All class forklifts
GSE trucks
Yard and Port trucks



Commercial Fleet Vehicles

Class 3 - 8
Last Mile
Middle Mile
Long Haul



Stationary Power

Megawatt Scale
Critical Backup
Power
Power Generation



Aerospace

Short Range
Cargo/Commuter
Regional Passenger
UAV/Drones

Companies running on green hydrogen with Plug



Mercedes-Benz

AIRBUS



HONDA



Plug is leading the hydrogen revolution across the globe



*World's first PEM technology
Gigafactory in Rochester, NY*



Vista Tech Facility, Slingerlands NY



45 TPD plant, Woodbine, GA



*45 TPD Plant, Project Gateway, WNY STAMP,
Genesee County, NY*

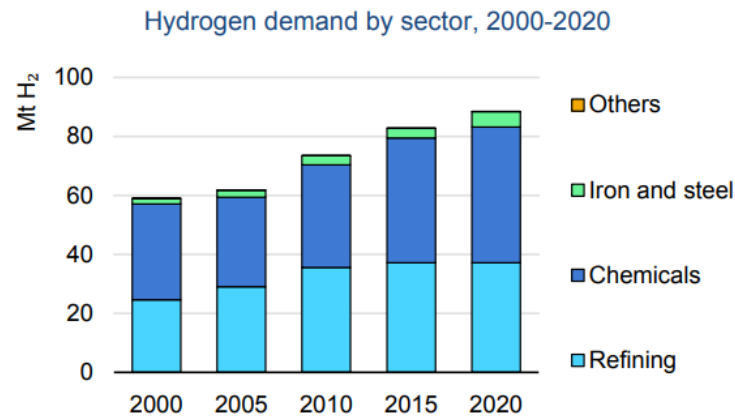


35 TPD Plant, Port of Antwerp-Bruges, Europe



Hydrogen's potential

- Hydrogen is an increasingly important piece of the net zero emissions by 2050 puzzle
- Ability to avoid up to 60 Gt CO₂ emissions in 2021-2050
- Can decarbonize a variety of sectors: industry (steel, ammonia, fertilizer), long-range trucking, maritime shipping and aviation building heating and can be used for long-term storage

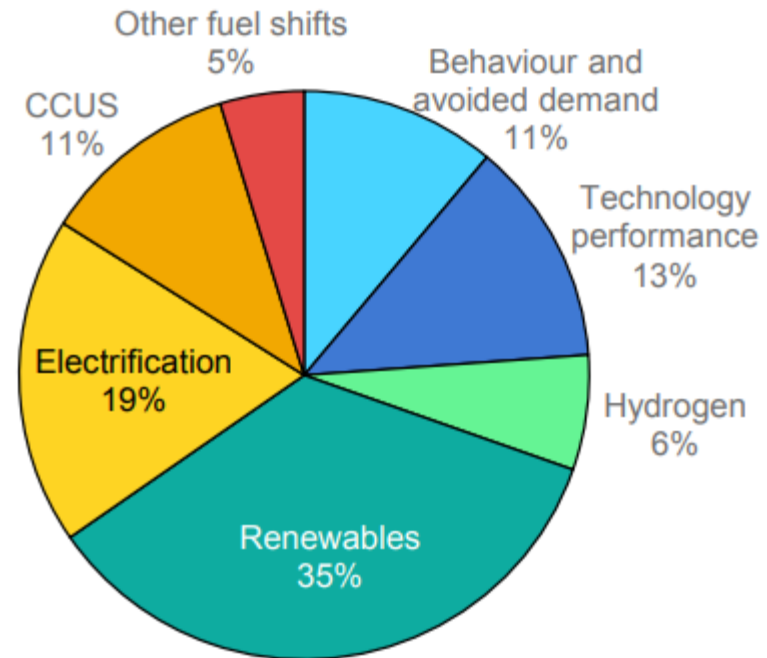


IEA. All rights reserved.



Source: IEA (2021), Net zero by 2050.

Cumulative emissions reduction by mitigation measure in the NZE, 2021-2050





Green Hydrogen at WorkTM