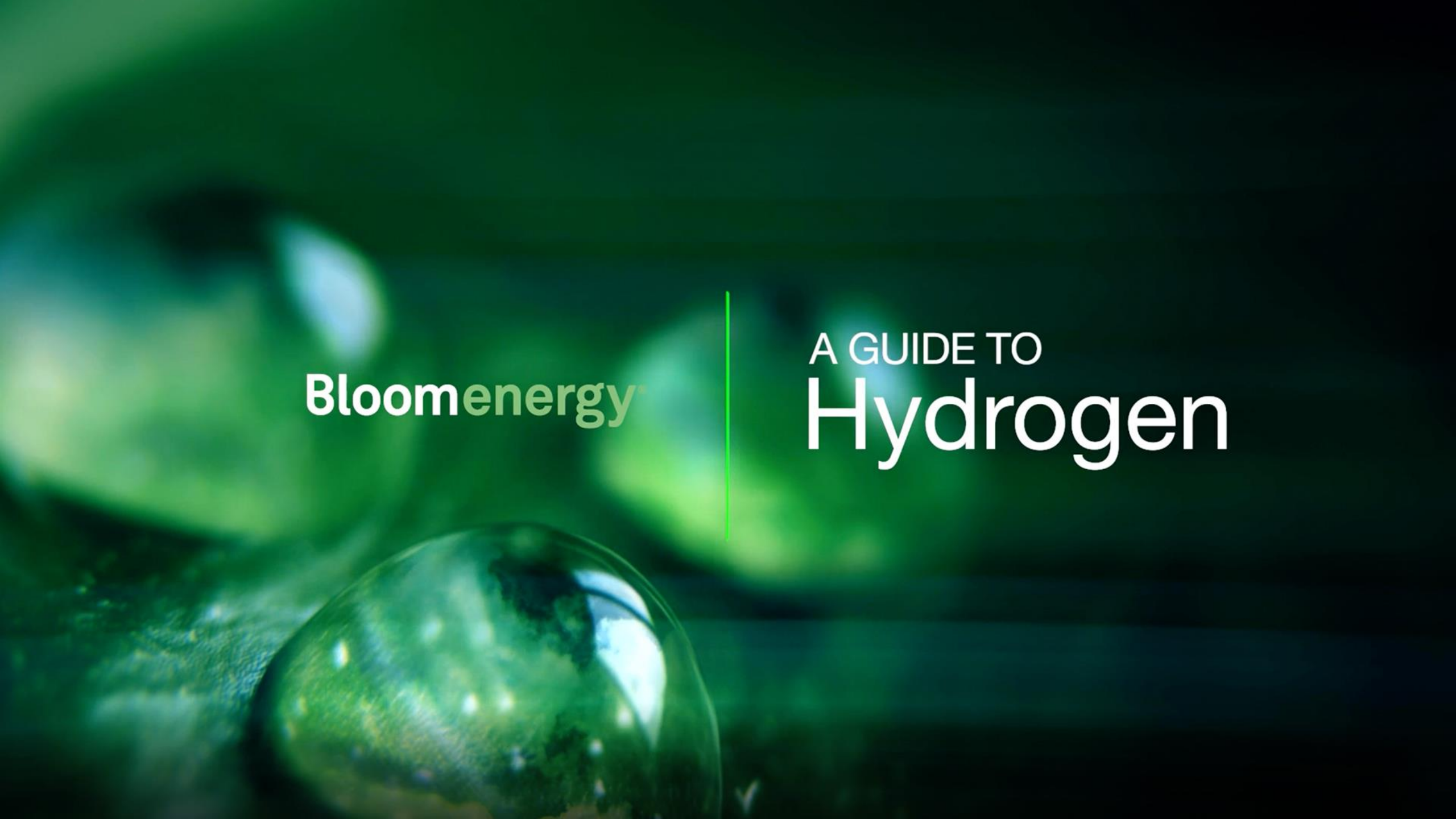
Bloomenergy

ACCELERATING NEW MARKETS FOR GREEN HYDROGEN

RENEWABLE ENERGY MARKETS '22


Bloomenergy
A GUIDE TO
Hydrogen

Topics Covered

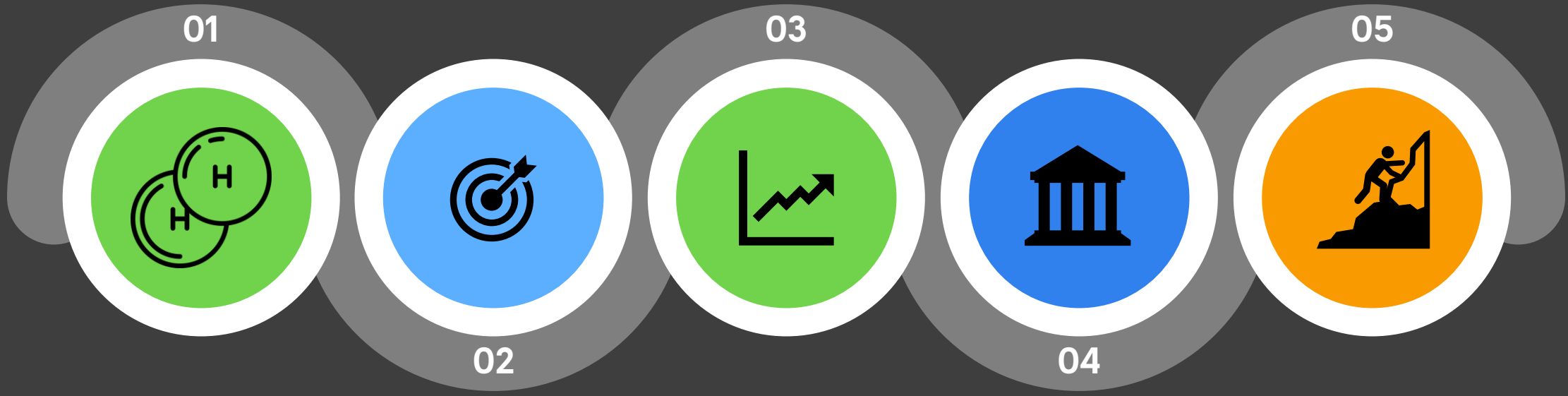
01 Green Hydrogen Fundamentals

02 Grid Challenges & Opportunities

03 Market Outlook

04 Policy Development

05 The Way Forward



FUEL CELL MICROGRIDS

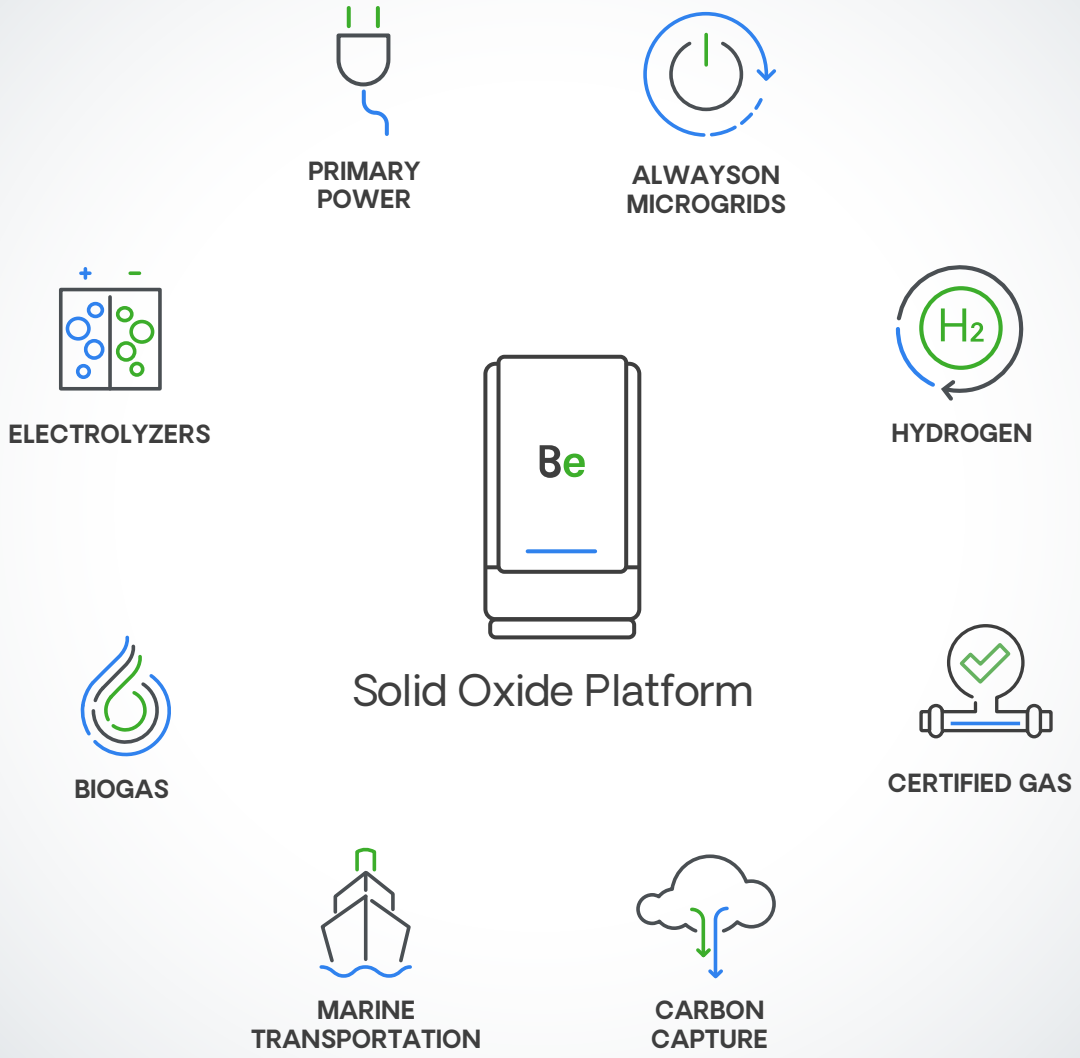
NASA DEVELOPED TECHNOLOGY IN REVERSE

In the 1990s, KR Sridhar and a small NASA team of university researchers created a fuel cell device that could use solar power to split Martian water into oxygen for breathing and hydrogen for use as fuel for vehicles. When their NASA project ended in 2001, Sridhar's team shifted focus to develop this Mars mission technology in reverse—**to create electricity from oxygen and fuel.**

Bloom Energy was born.

One Platform. Multiple Solutions.

Our future-proof energy platform unlocks multiple pathways to net-zero.

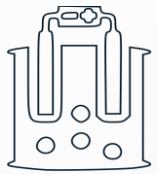


GREEN HYDROGEN FUNDAMENTALS

Not all hydrogen is created equal

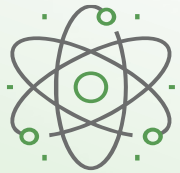
Multiple Inputs for Hydrogen Production

Renewable Electricity

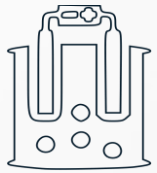


Electrolyzer

Green Hydrogen

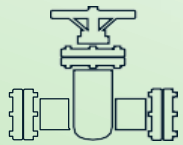


Nuclear Electricity

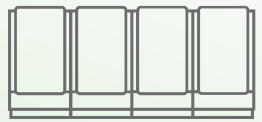


Electrolyzer

Pink Hydrogen



Natural Gas

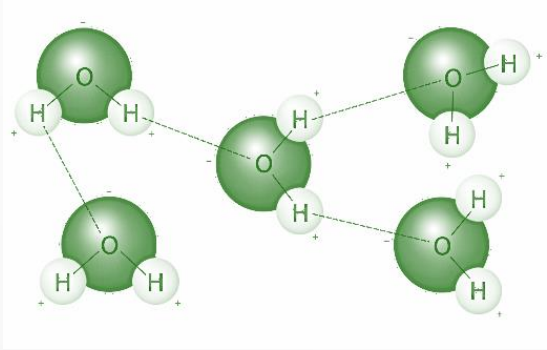


SOFC with CCUS

Blue Hydrogen

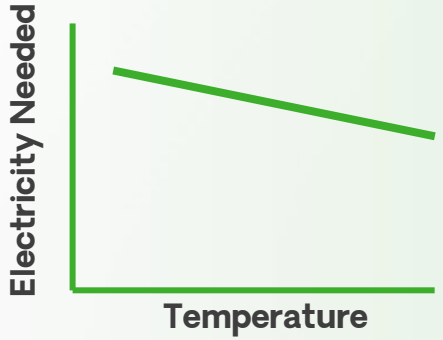
Hydrogen Production Using Electrolysis

An electric current drives a chemical reaction, converting water into hydrogen and oxygen



H_2O + Energy (kJ) = H_2, O_2

1 Mole of water into **1 Mole of H2** requires **286 kJ**

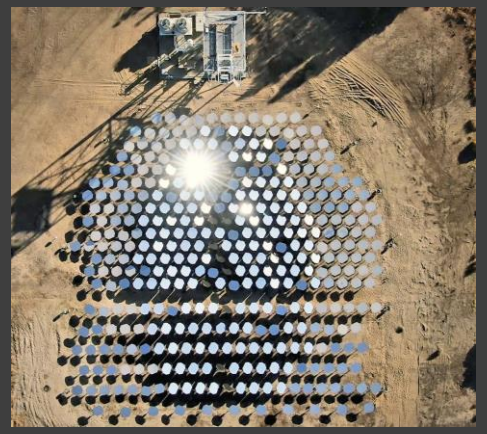


At high temperature, **less electrical energy** is required

Application Examples: CSP and Nuclear.

Concentrated Solar Power / Nuclear – Thermal Power

Carbon-free industrial heat
for use in electrolysis



Combining Heat and Electricity = Higher Efficiency

It is **easier and more efficient** to use existing heat to heat water, than convert solar energy into electric energy, and electric energy to heat energy.

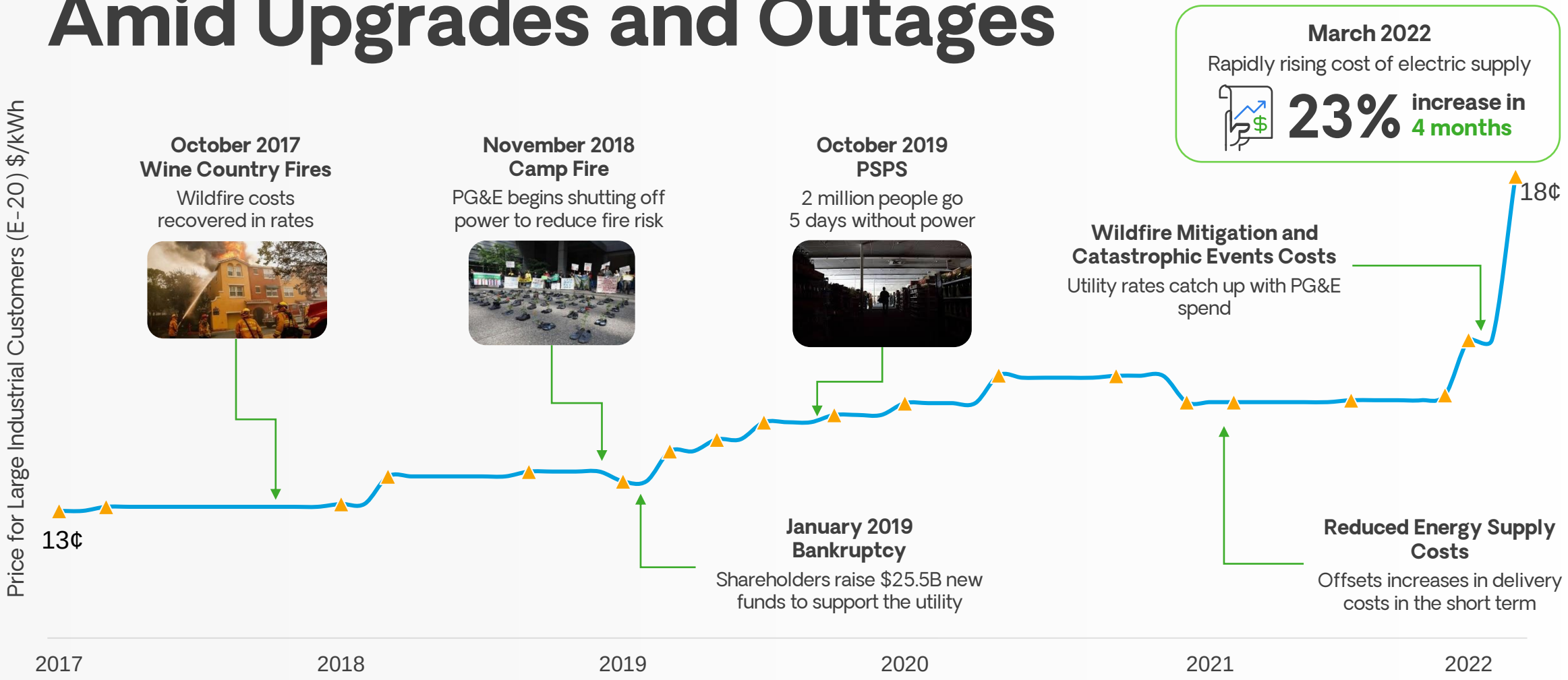
It's **more efficient and lower cost** to bring water temperature up to the highest point you can, minimizing electric energy.


GRID CHALLENGES

Extreme Weather is stressing critical infrastructure.

- U.S. grid outages have increased 70% over the past decade.
- Extreme weather is causing frequent damage to our electrical system
- Unexpected power outages can cause significant business disruptions

Utility Rates Continue to Increase Amid Upgrades and Outages



A PG&E Case Study

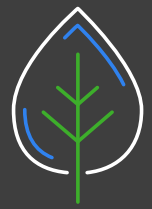
An energy solution should address all critical needs.

Predictable

- Gain certainty and a predictable cost pattern over the long term.
- Quick time to power
- Consistent power quality

Resilient

- Eliminate outage risk with energy independence
- Reliable architecture maximizes availability and uptime
- Ensure business continuity

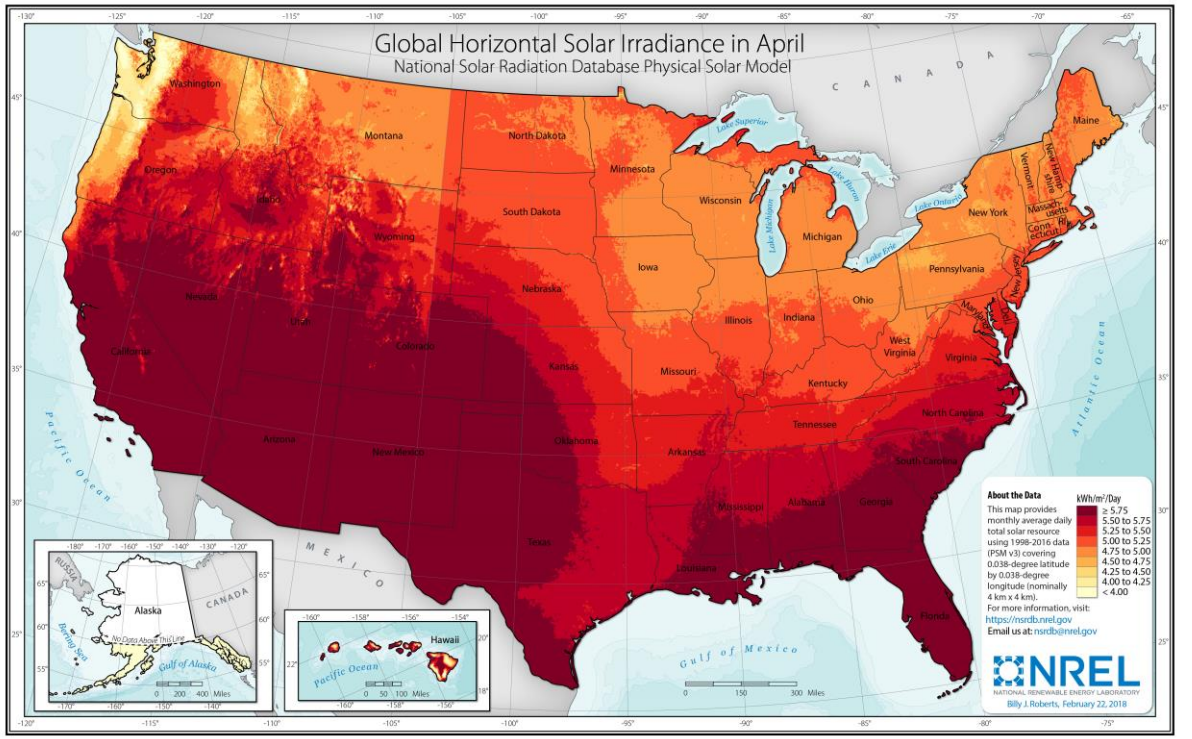


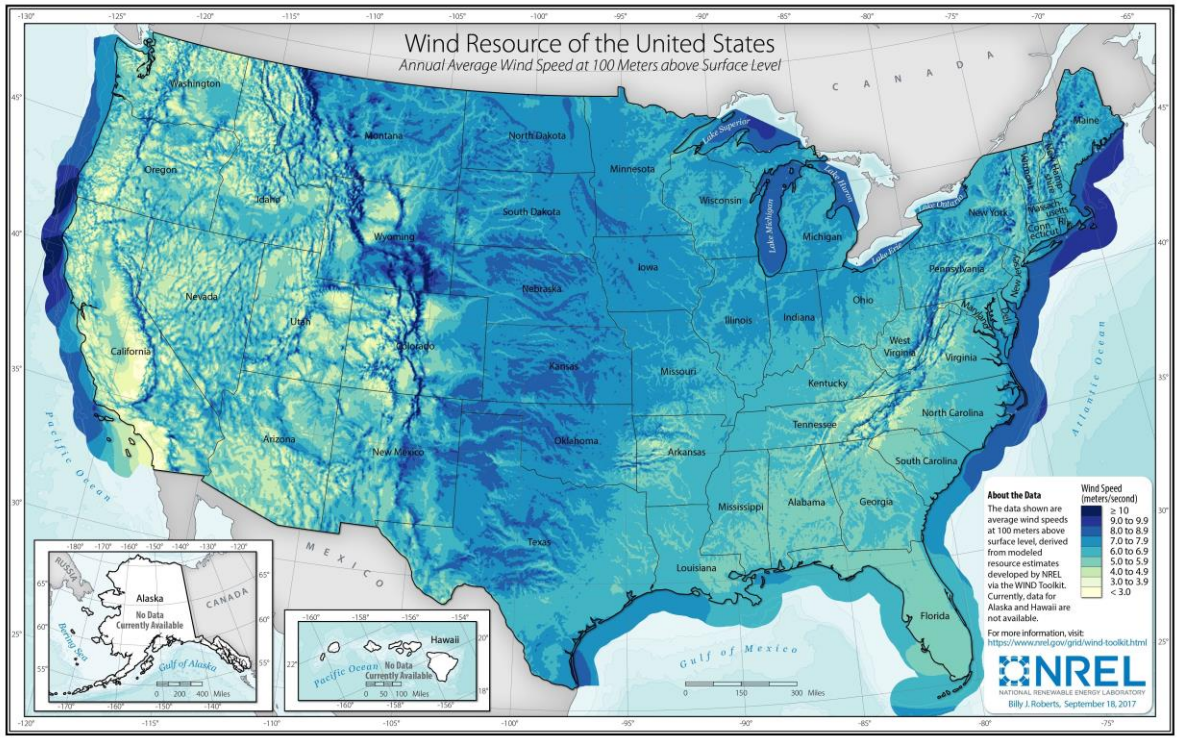
Sustainable

- Fuel-flexible, upgradeable, future proof
- Accelerate sustainability roadmap and decarbonization goals
- Address the causess and consequences of climate change

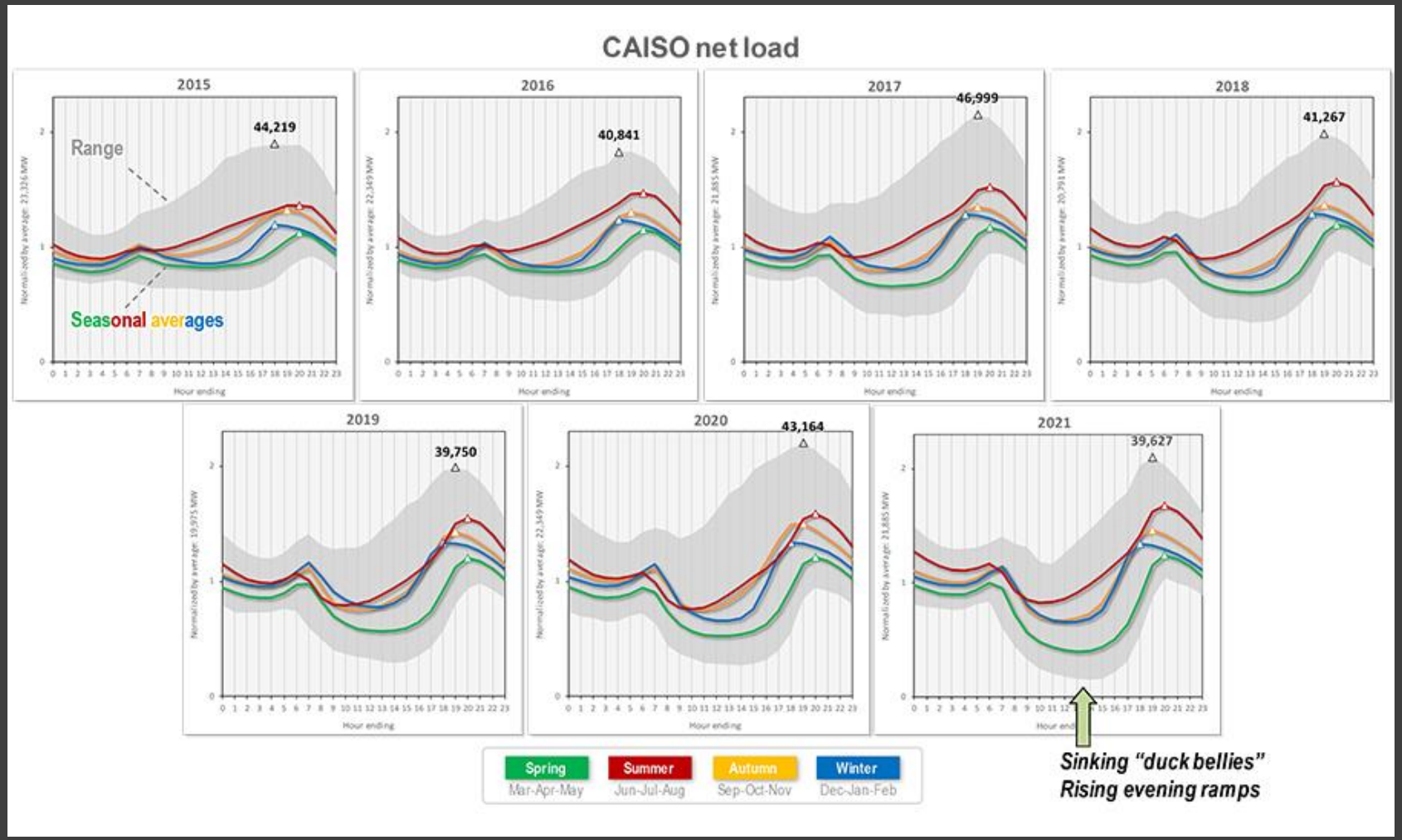

GRID OPPORTUNITIES

An Abundance of Renewable Resources

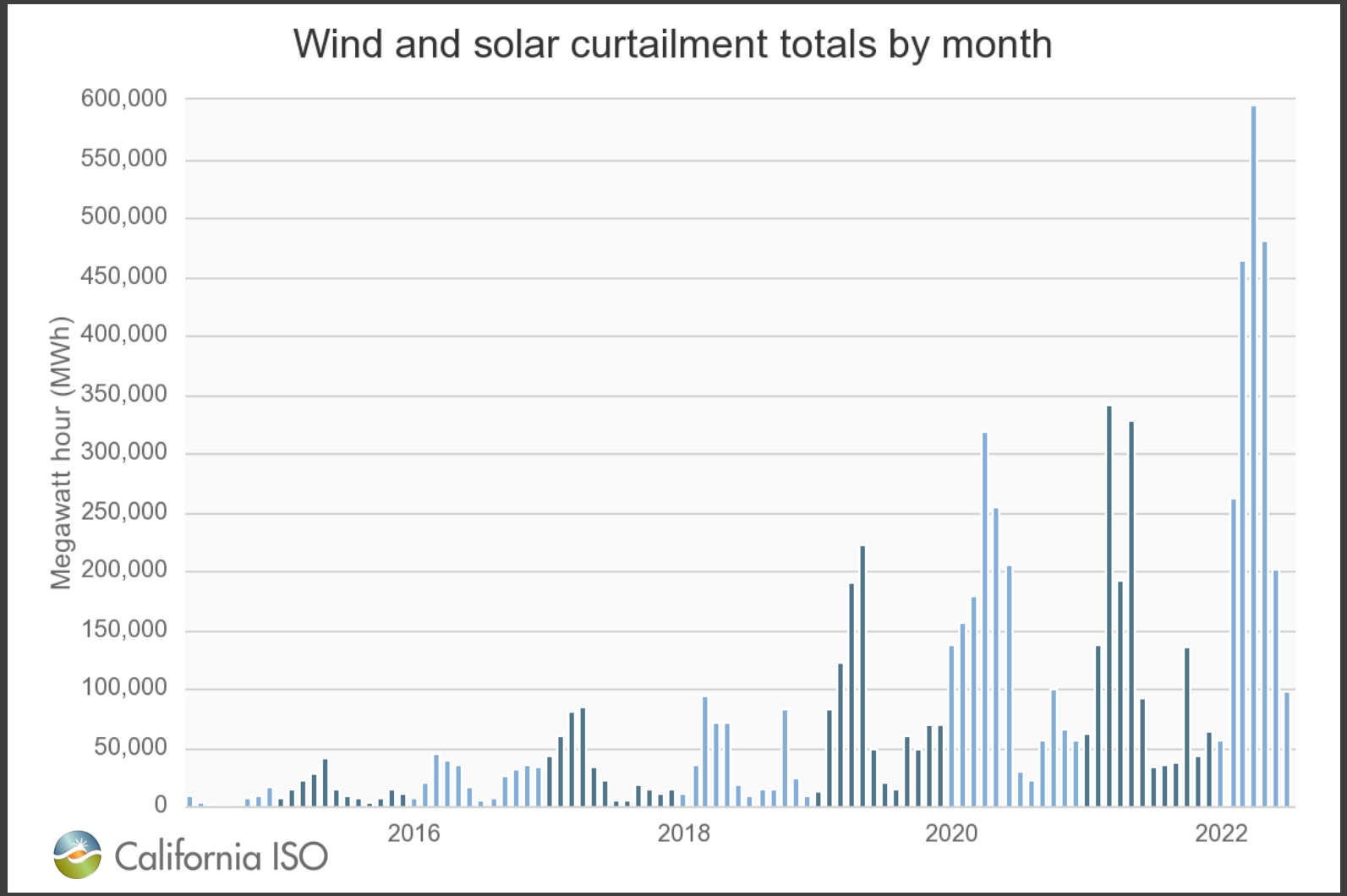




Precautionary Tale: Renewables in CAISO

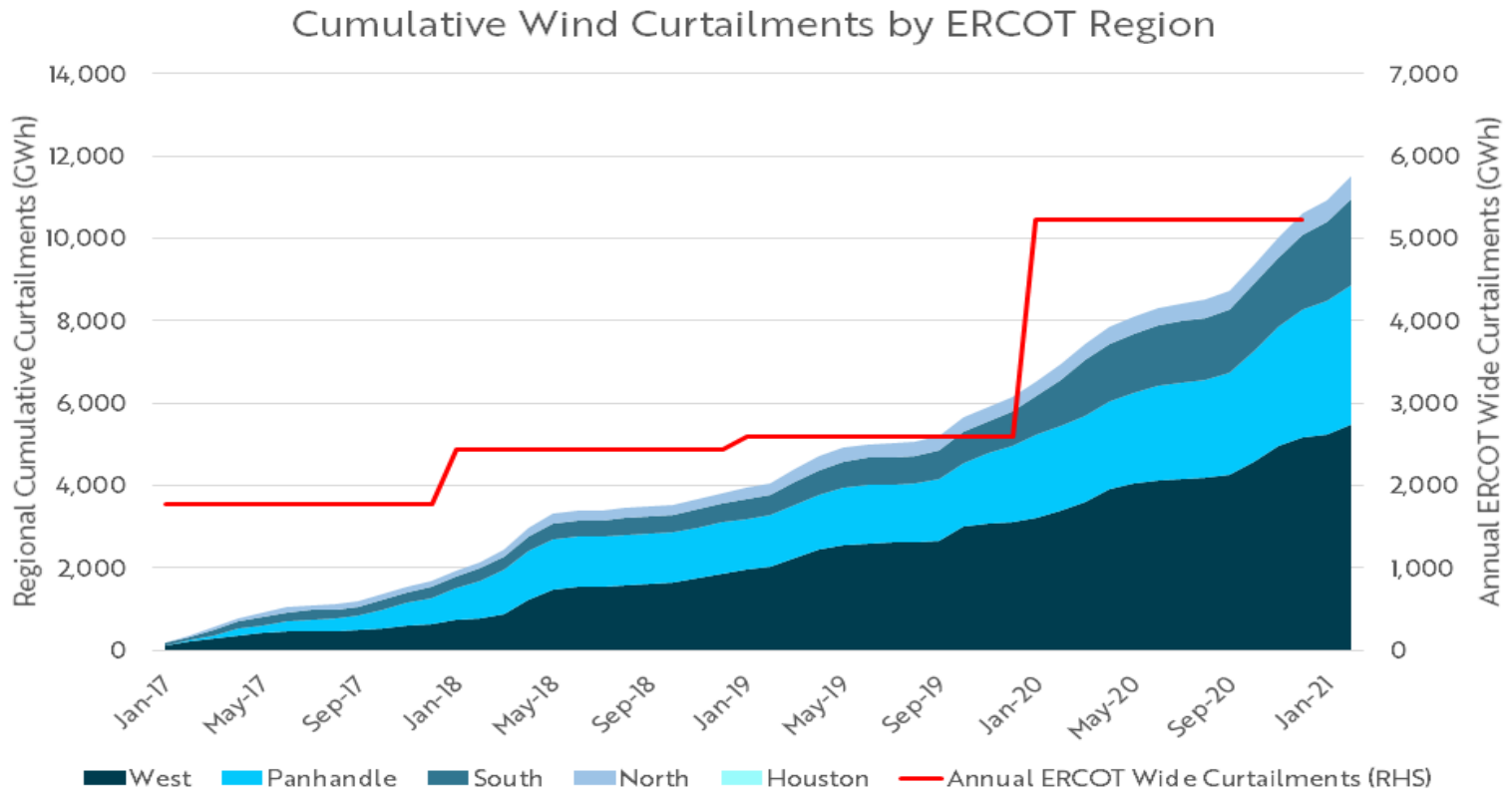


Higher RE Penetration = Higher Curtailments



Higher RE Penetration = Higher Curtailments

ERCOT wind curtailments more than doubled in 2020, with help from the South where curtailments grew from 300 GWh annually to about 1,000 GWh



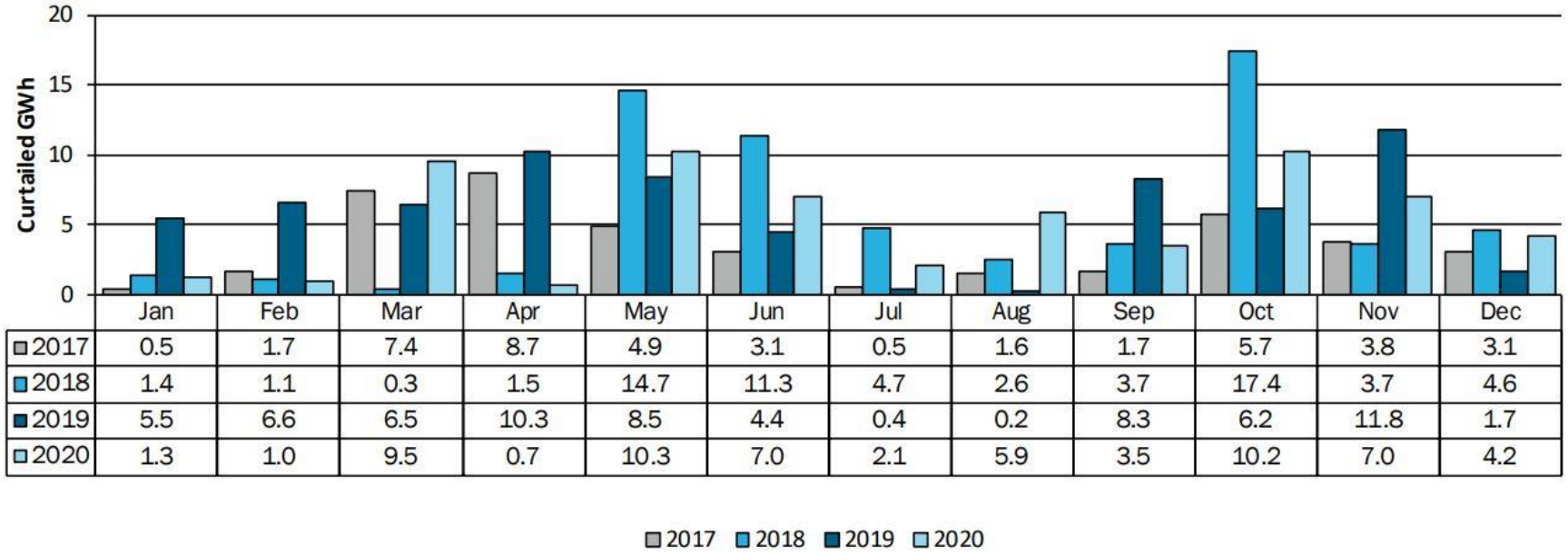
Source: BTU Analytics

Higher RE Penetration = Higher Curtailments

NY Economic Wind Curtailments

Total Annual Wind Curtailments (GWh)			
2017	2018	2019	2020
42.6	66.9	70.5	62.7

NYCA Wind Plants - Monthly Estimated Curtailed Energy



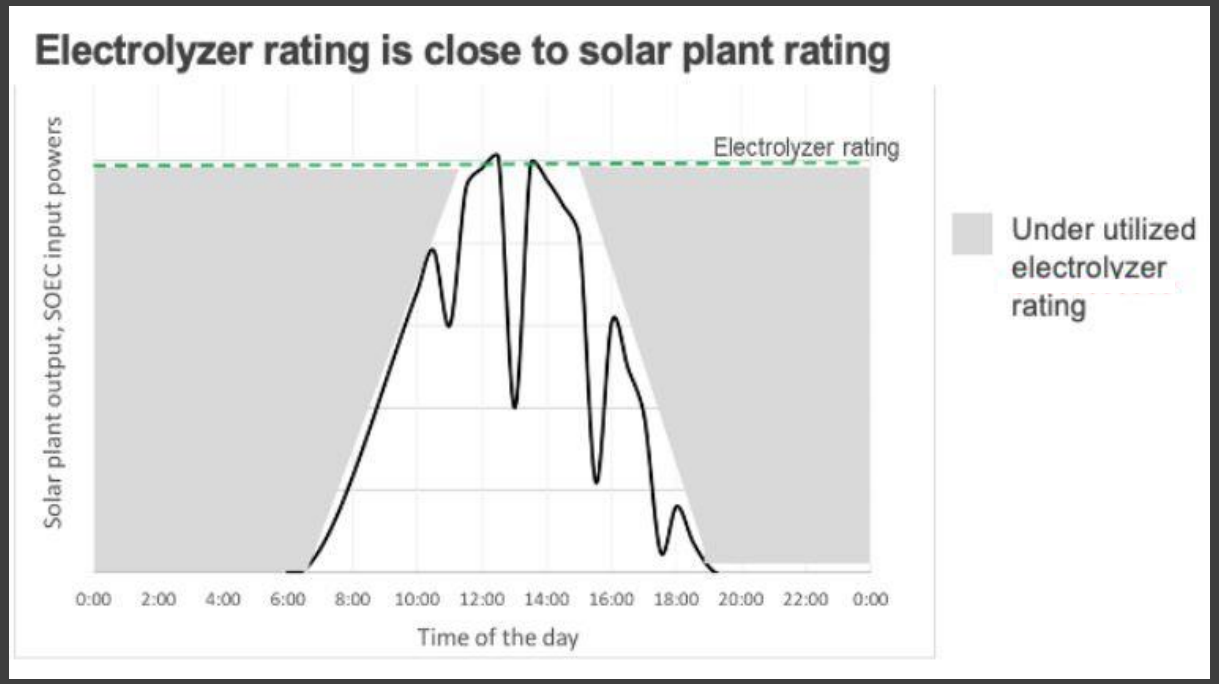
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2017	0.5	1.7	7.4	8.7	4.9	3.1	0.5	1.6	1.7	5.7	3.8	3.1
2018	1.4	1.1	0.3	1.5	14.7	11.3	4.7	2.6	3.7	17.4	3.7	4.6
2019	5.5	6.6	6.5	10.3	8.5	4.4	0.4	0.2	8.3	6.2	11.8	1.7
2020	1.3	1.0	9.5	0.7	10.3	7.0	2.1	5.9	3.5	10.2	7.0	4.2

DRAFT – FOR DISCUSSION PURPOSES ONLY

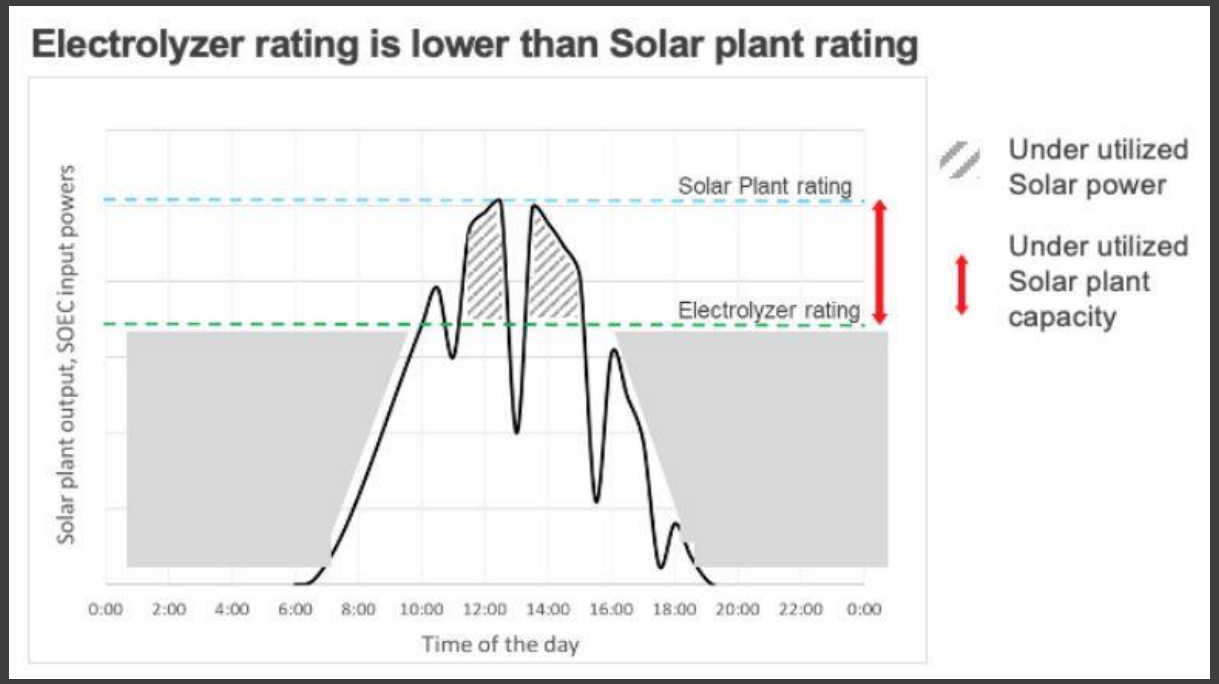
New York ISO

Green Hydrogen for Renewables Integration

"The Goldilocks Principle"



Too "Hot"

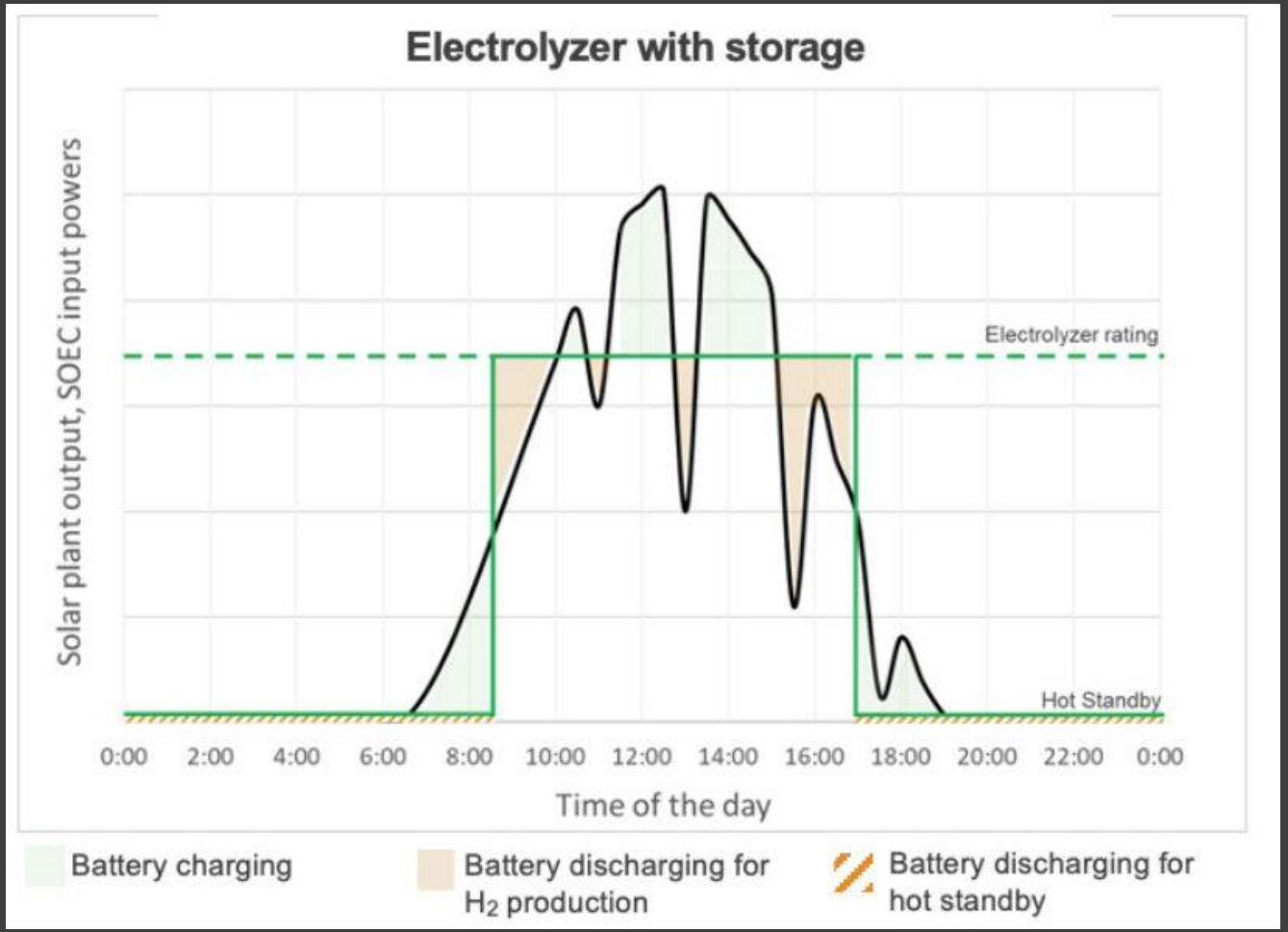


Too "Cold"

Green Hydrogen for Renewables Integration

Just Right

“The Goldilocks Principle”

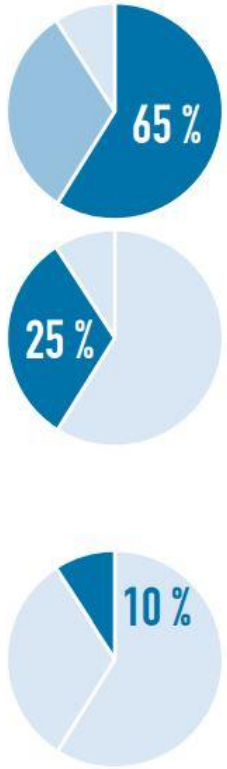


MARKET OUTLOOK

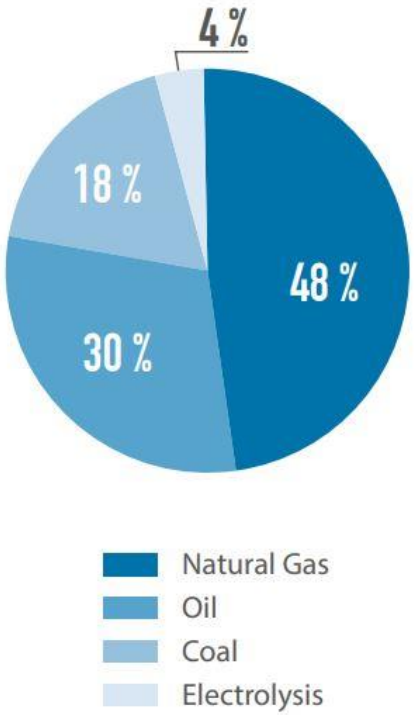
Current Hydrogen Production Sources

INDUSTRY SECTOR	KEY APPLICATIONS
CHEMICAL	• Ammonia • Polymers • Resins
REFINING	• Hydrocracking • Hydrotreating
IRON & STEEL	• Annealing • Blanketing gas • Forming gas
GENERAL INDUSTRY	• Semiconductor • Propellant fuel • Glass production • Hydrogenation of fats • Cooling of generators

PERCENTAGE OF GLOBAL H_2 DEMAND

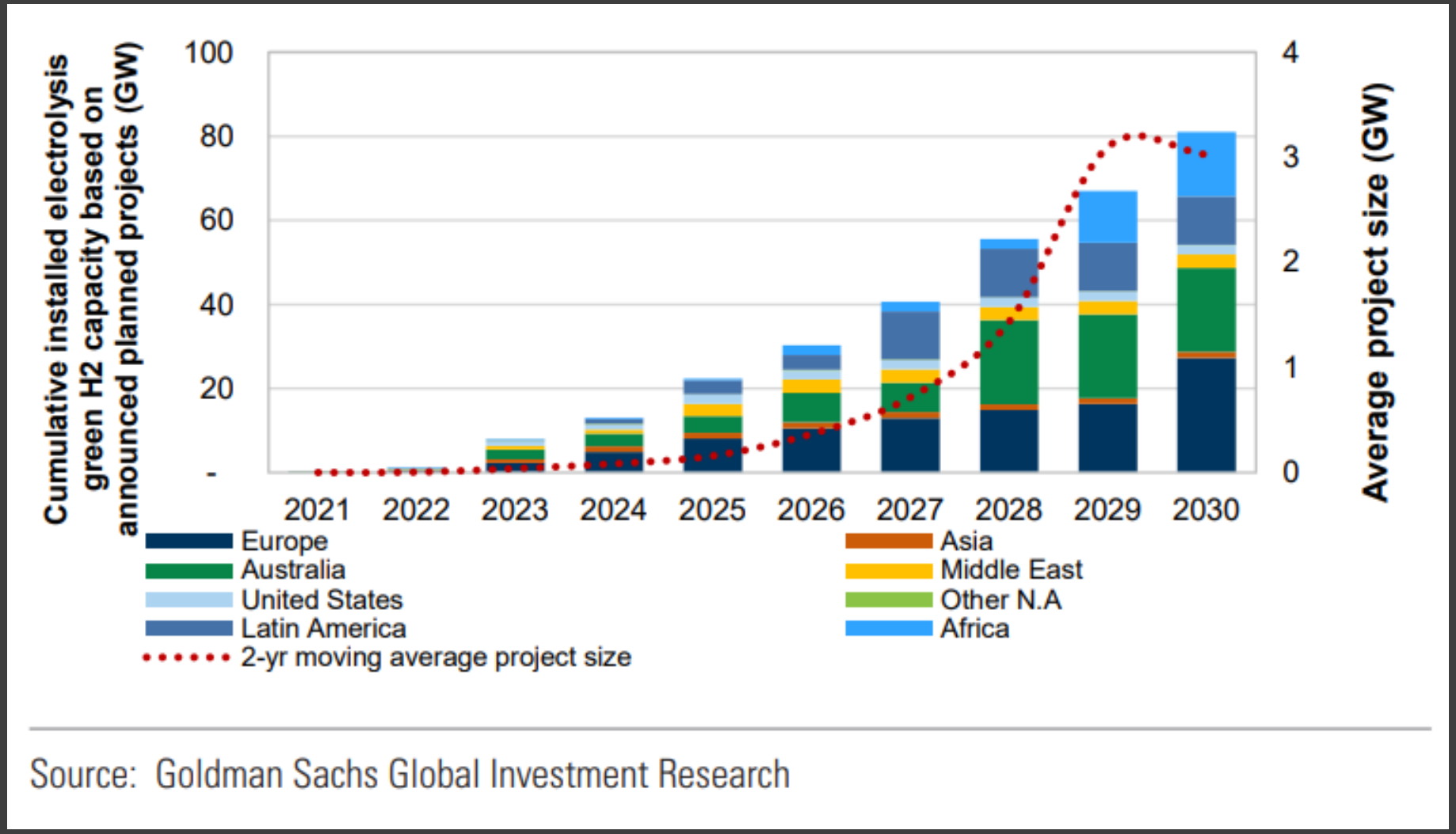


HYDROGEN SOURCES



Source: IRENA based on FCH JU (2016).[3]

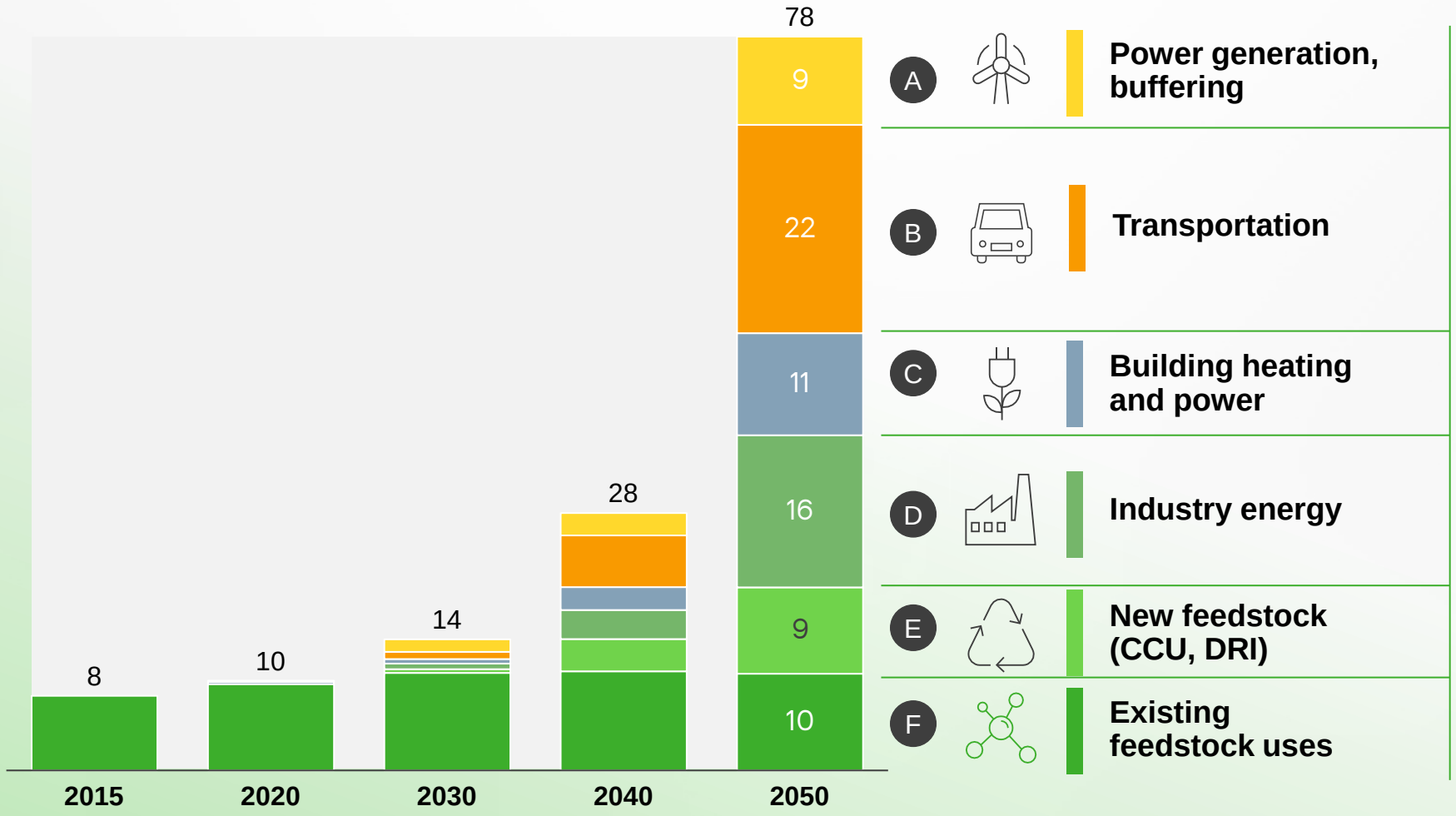
Green Hydrogen Project Pipeline



Source: Goldman Sachs Global Investment Research

Hydrogen Demand Could Grow 10x by 2050

Global energy demand supplied with hydrogen, (Exajoule (EJ))



18%
of final energy demand

6Gt
annual CO_2 abatement

$2.5tn
annual sales (hydrogen and equipment)

30m
jobs created

Source: Hydrogen Council: Scaling Up, McKinsey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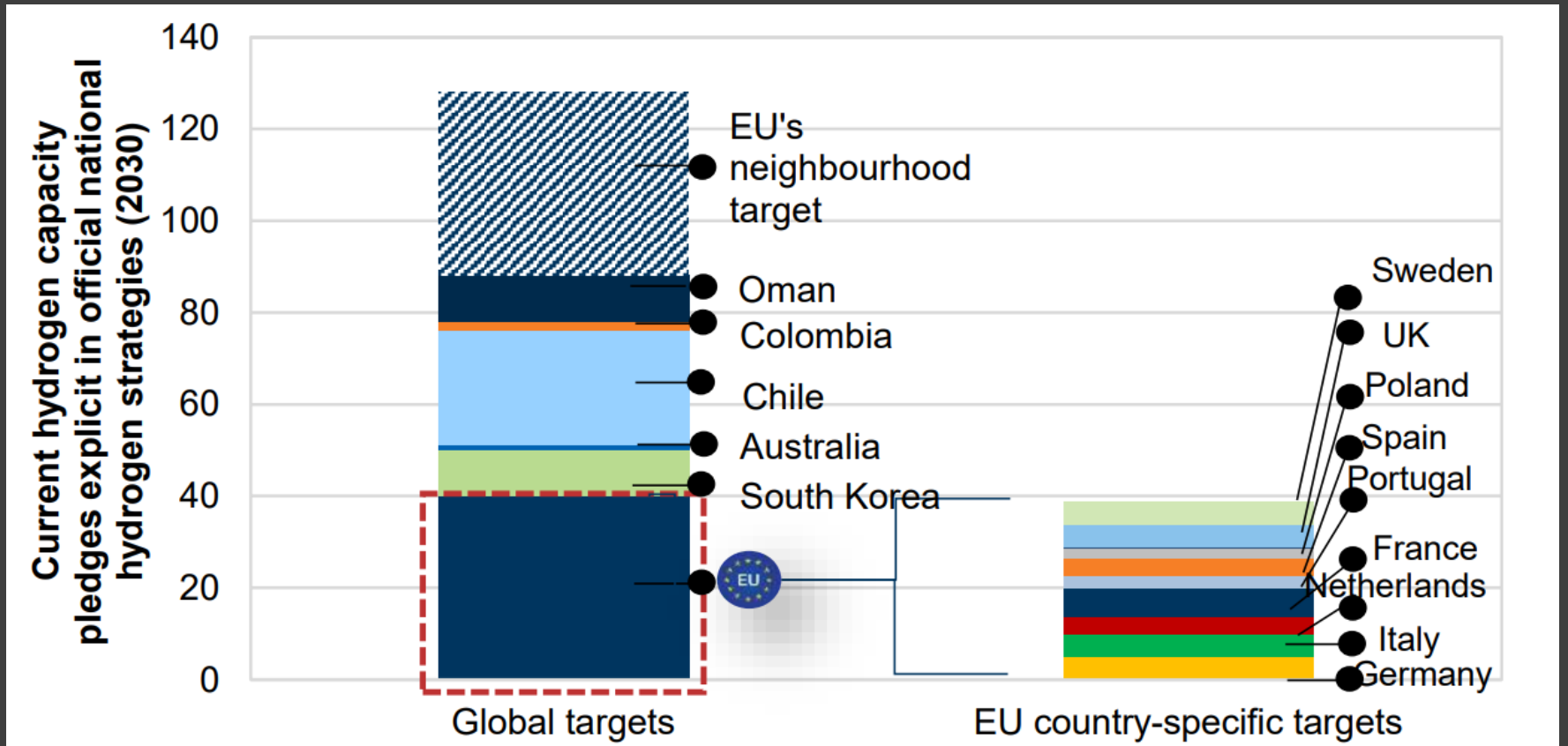
POLICY
DEVELOPMENT

Green Hydrogen – A Global Policy Priority



Source: European Commission, data compiled by Goldman Sachs Global Investment Research

US Federal Hydrogen Legislation

Bi-Partisan Infrastructure Bill

Regional Clean Hydrogen Hubs	- $8 Billion
Clean Hydrogen Electrolysis Program	- $1 Billion
Clean Hydrogen Manufacturing and Recycling Programs	- $500 Million
Grants for Charging & Fueling Infrastructure	- $2.5 Billion
Advanced Technology Vehicles Manufacturing	- $1.7 Billion
Port Infrastructure Development Program Grants	- $50 Million
Preventing Outages and Enhancing the Resilience of the Electric Grid Grants Program	- $5 Billion

Inflation Reduction Act

Sec. 48 ITC Extension

Sec. 45Q – Carbon Oxide Sequestration

Sec. 45V – Hydrogen Production Tax Credit

Energy Storage Credit

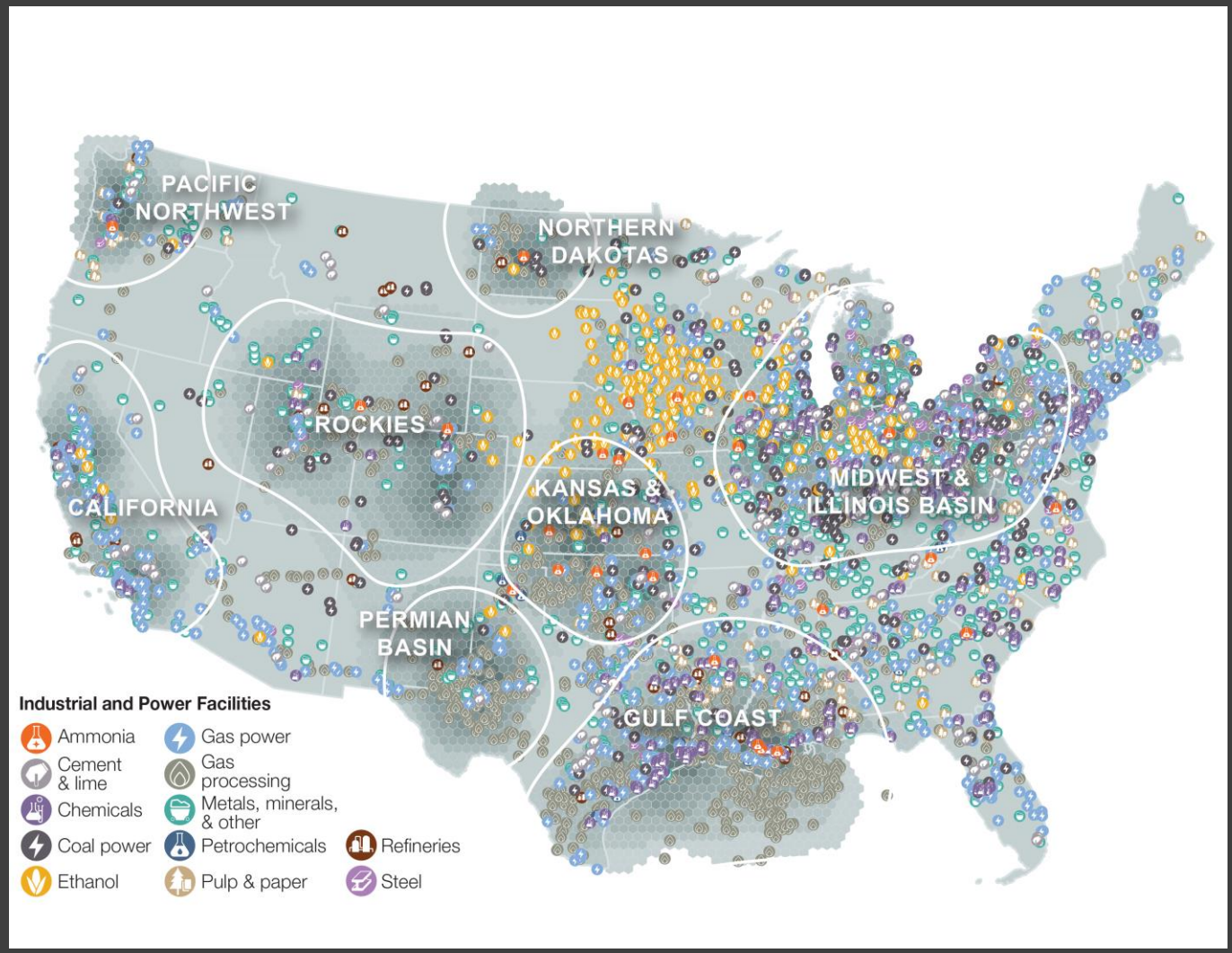
Alternative Fuel Refueling Property Credit

Advanced Energy Project Credit

Qualified Commercial Clean Vehicles Credit

Energy Infrastructure Reinvestment Financing - $5 Billion

US Federal Hydrogen Legislation



NY Climate Leadership and Community Protection Act

2019 Law Requires Massive Transformation of Grid

New York CLCPA: Key Milestones

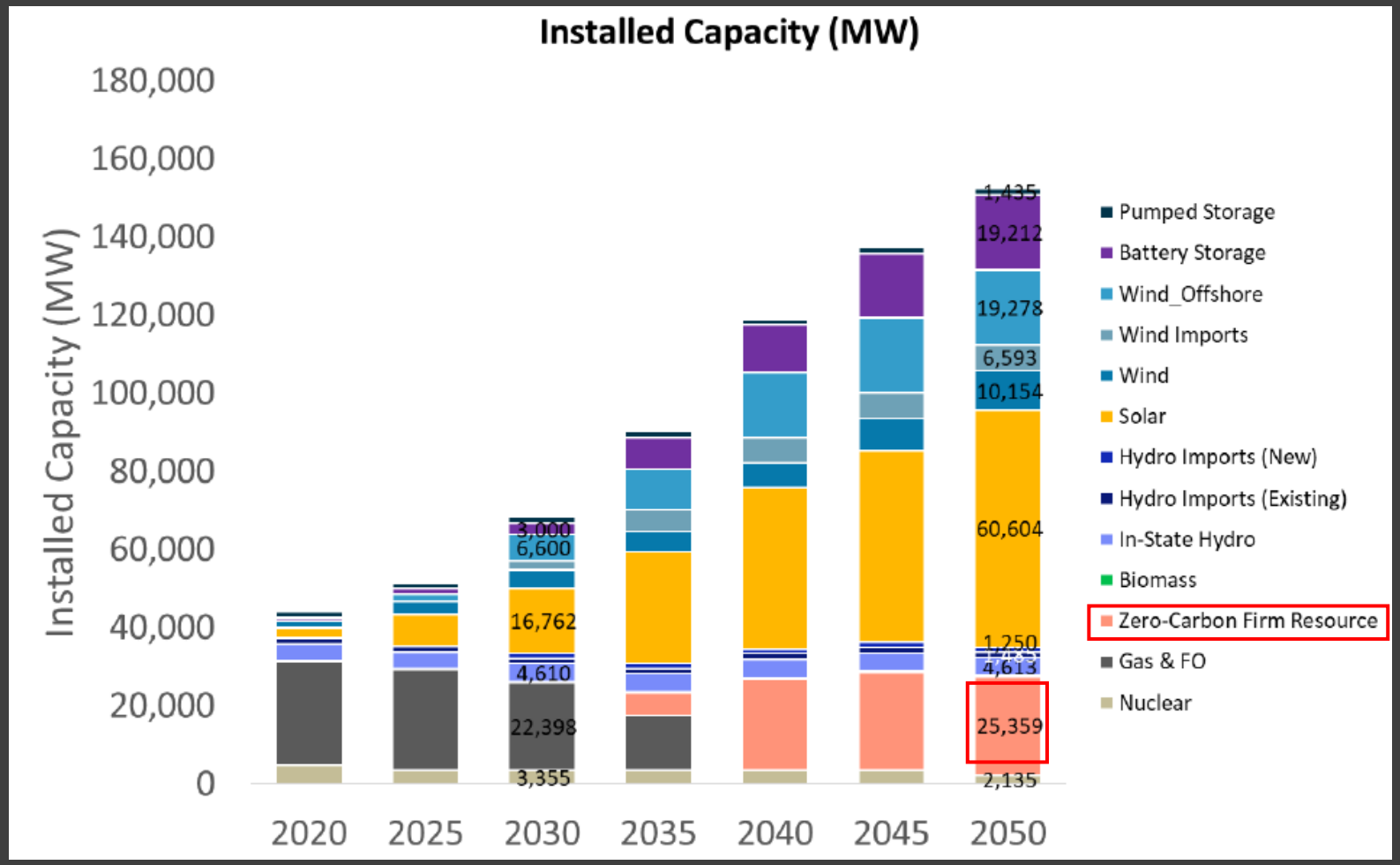
2025	2030	2035	2040
6,000 MW Solar capacity	**70%** of NY load served by renewable resources	**9,000 MW** Offshore wind capacity	**100%** Decarbonized economy

Significant new **generation capacity** needed to support addition of intermittent renewables

Massive transmission investment required, to move new generation to customers

Redundancy required to ensure grid stability

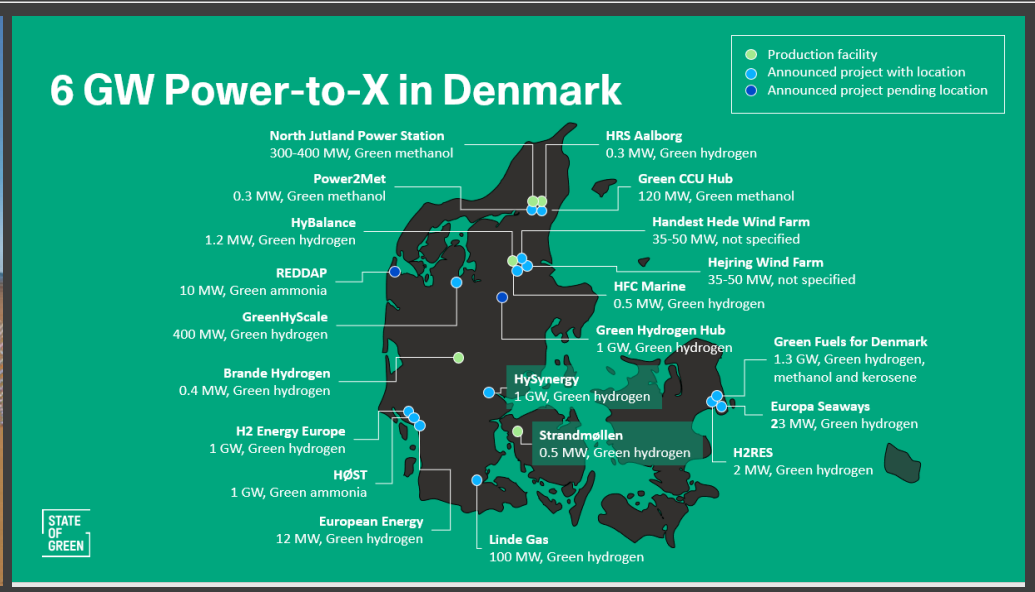
The Need for Green Hydrogen (NYISO)

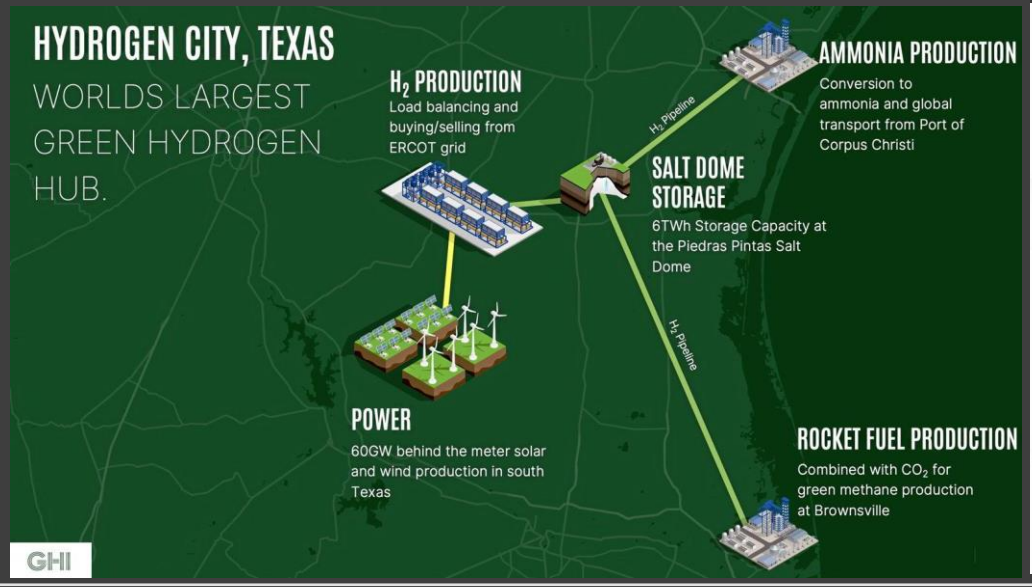


- In all modeled scenarios of the CAC Scoping Plan, NY will consume 100-225 Tbtu of green hydrogen by 2050.
- "Hydrogen effectively provides a form of storage to the system on the order of hundreds of hours and that a higher amount of 100-hour battery capacity is needed to meet the same reliability as hydrogen-based resources."


THE WAY
FORWARD

Collaborate!





Bloomenergy®

What Powers You

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