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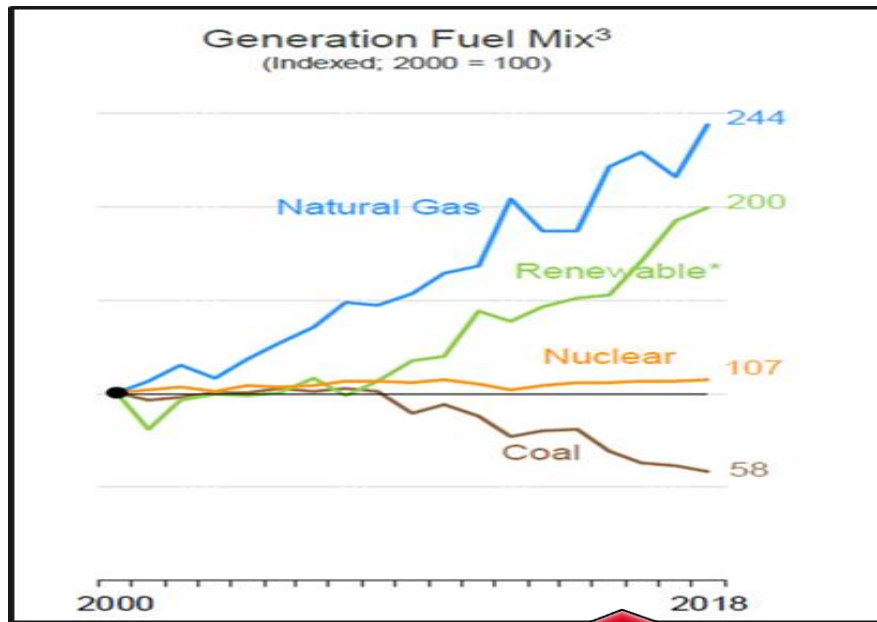
CHANGE IN POWER

DOE NETL University Turbine Systems Research Meeting – November 5, 2019

Paul Browning
President and CEO

Americas Market Dynamics

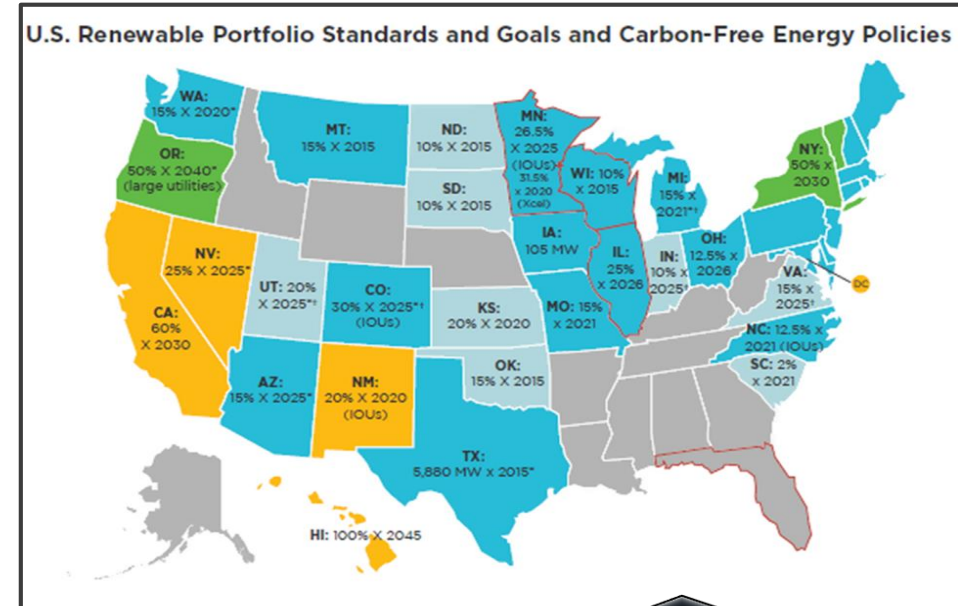
The future is natural gas, renewables, and storage in the Americas



Natural Gas Generation

Natural gas supplies baseload power as coal and nuclear are retired

9.1 GW /yr HDGT in Americas

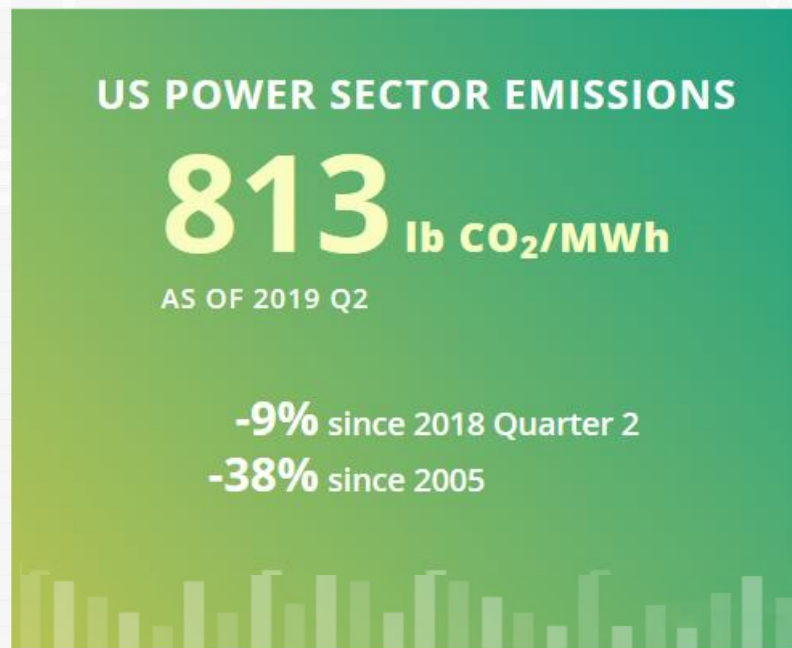


Renewable Generation

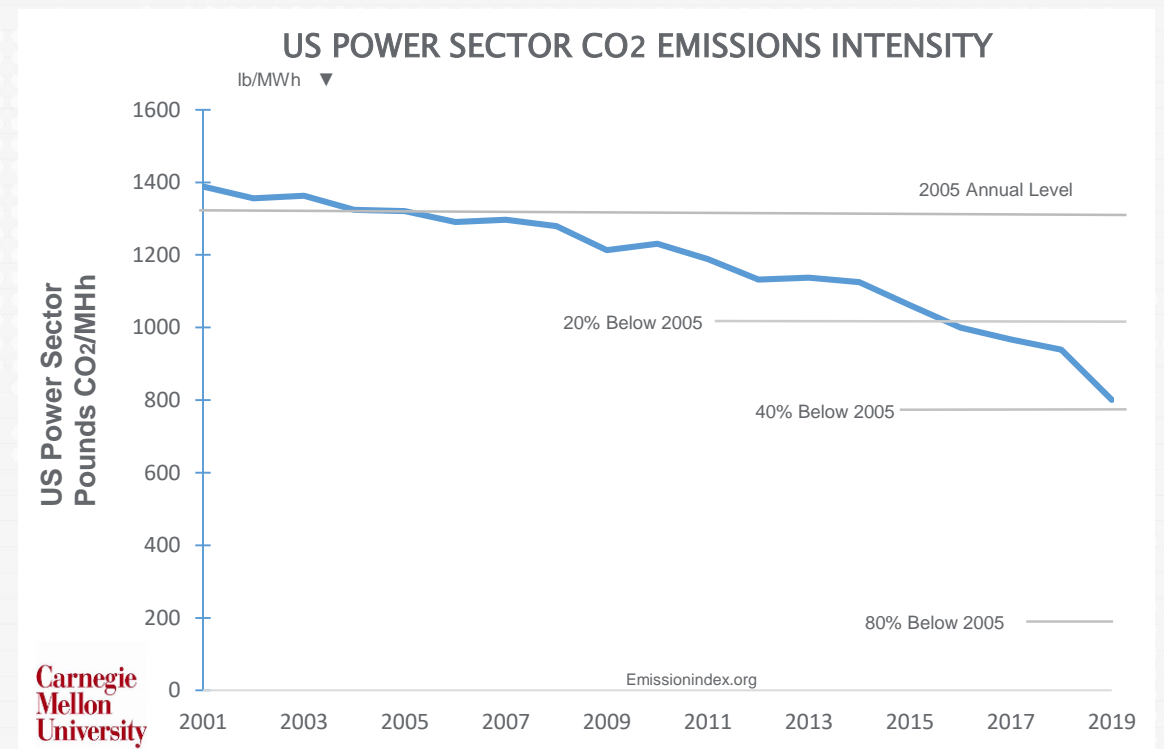
Economics, subsidies, and policy drive renewable installations for the foreseeable future

POWER SECTOR CARBON INDEX

Created By The
Carnegie Mellon University
Scott Institute for Energy Innovation

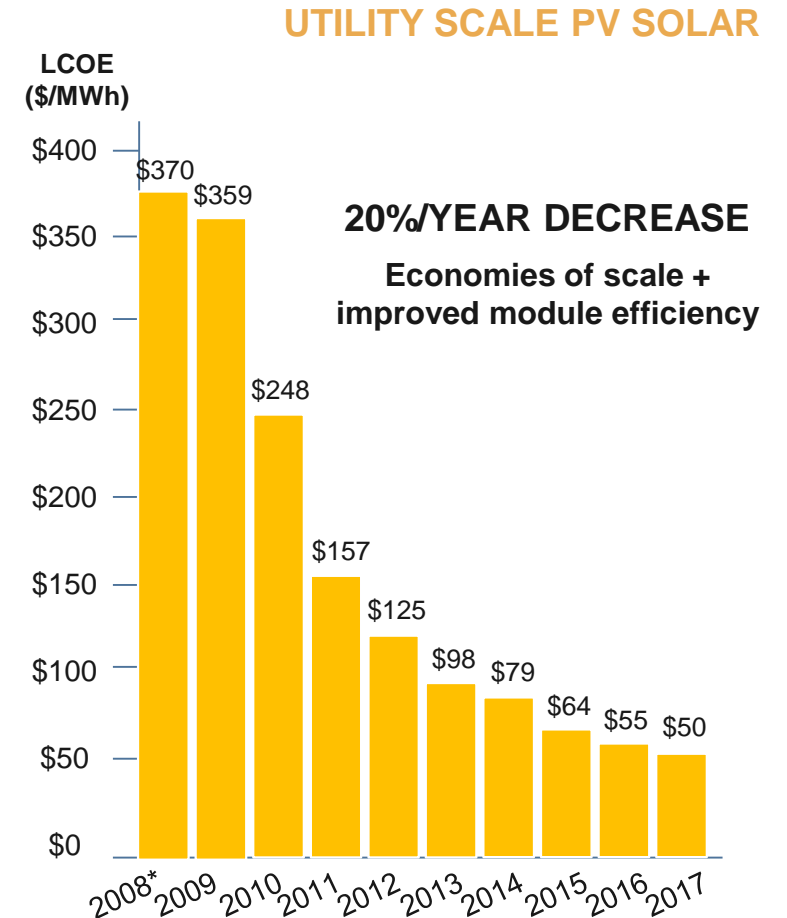
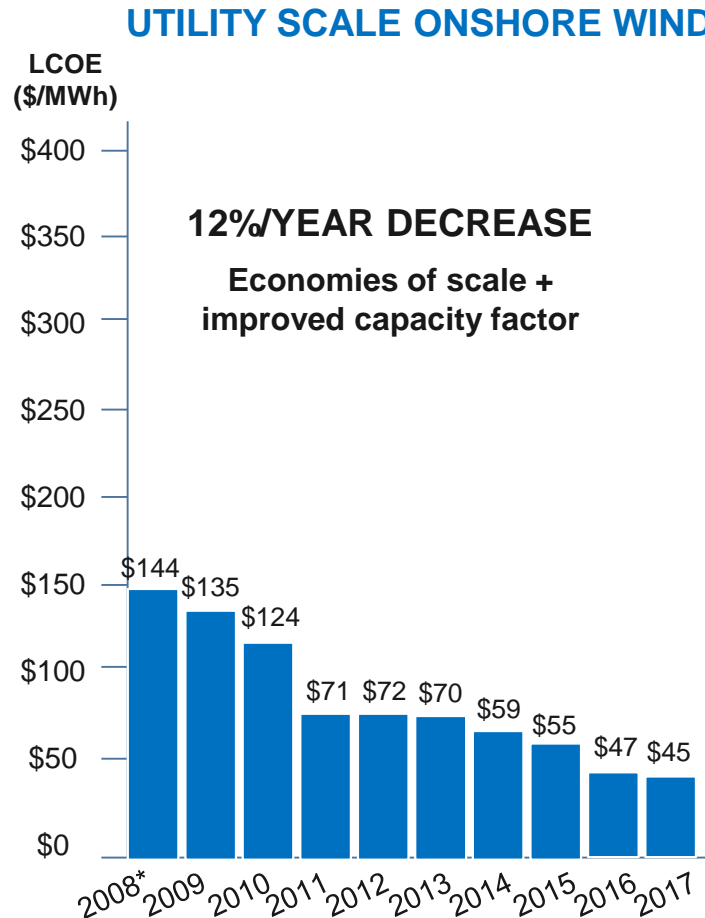
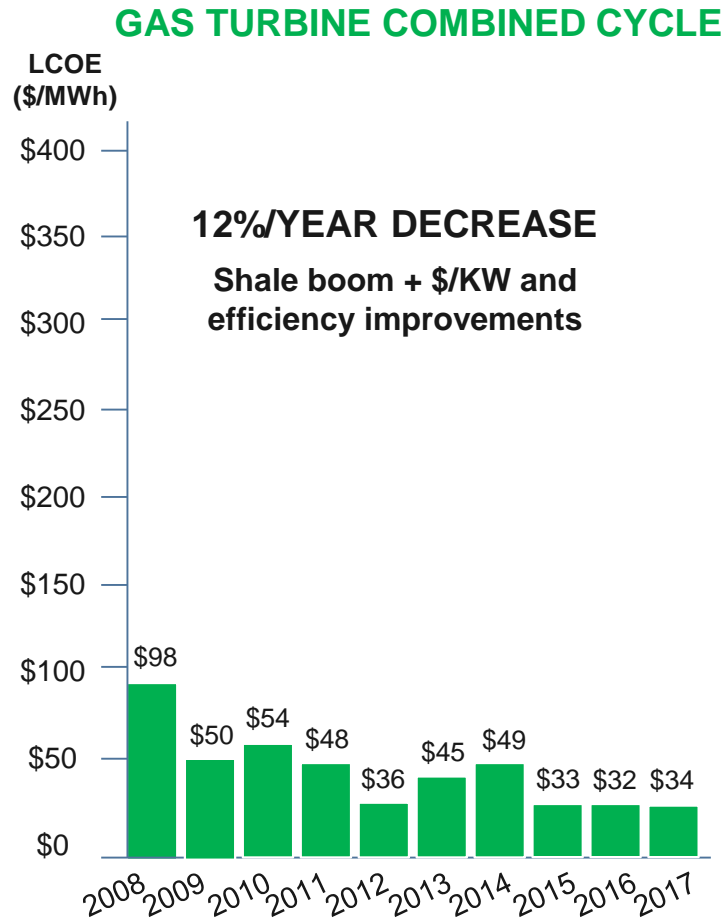


Sponsored by  **MHPS**



"The switch from coal to natural gas, and a 75% increase in renewables generation, are the two largest factors contributing to the reduction in emissions intensity"

Gas, Wind, and Solar Costs Continue to Decline

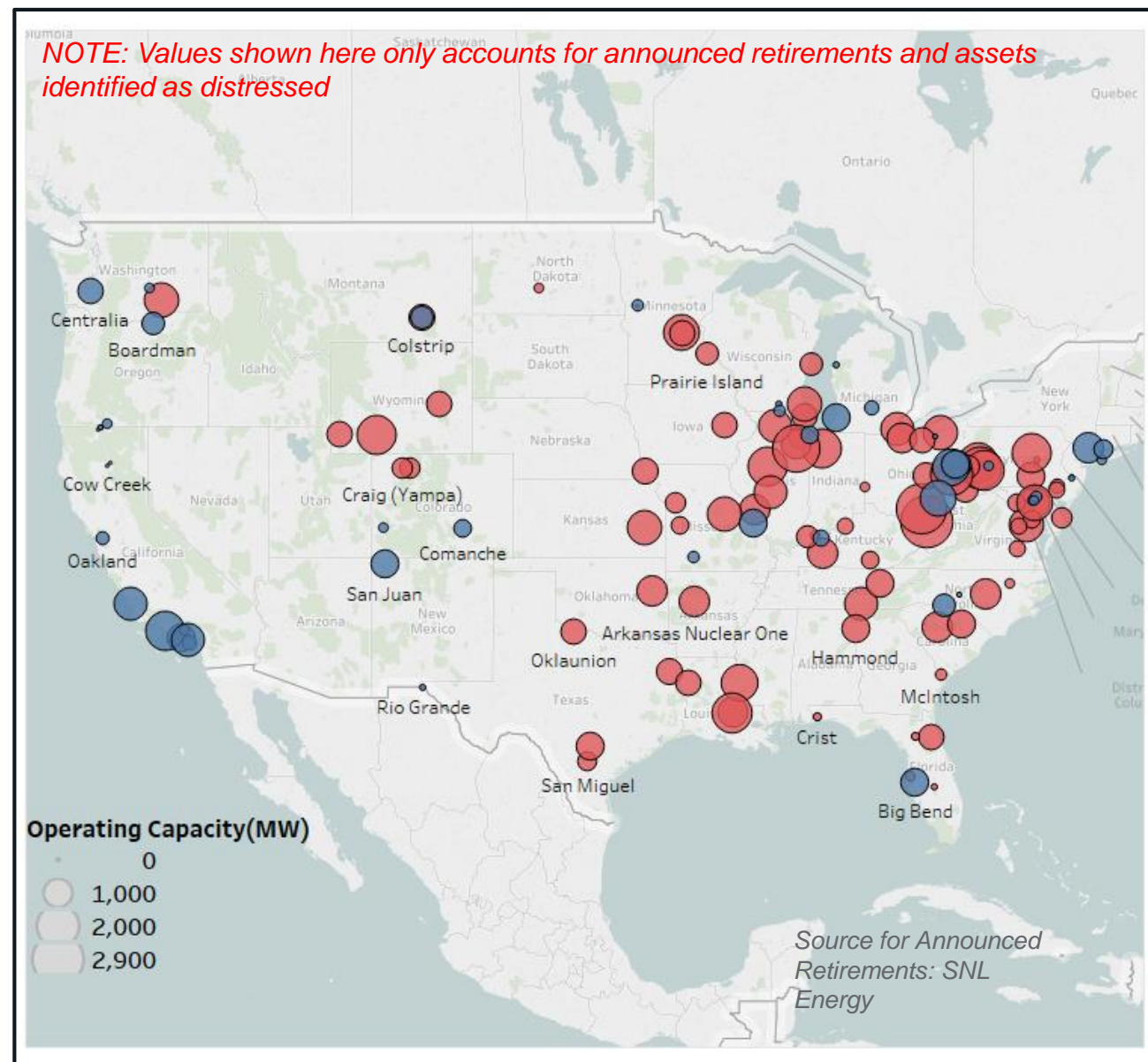


LCOE is now \$41/MWh for a 50/25/25 split of gas, wind & solar

Source: Lazard's Levelized Cost of Energy Analysis v11.0; MHPS Market Analysis; *Estimated

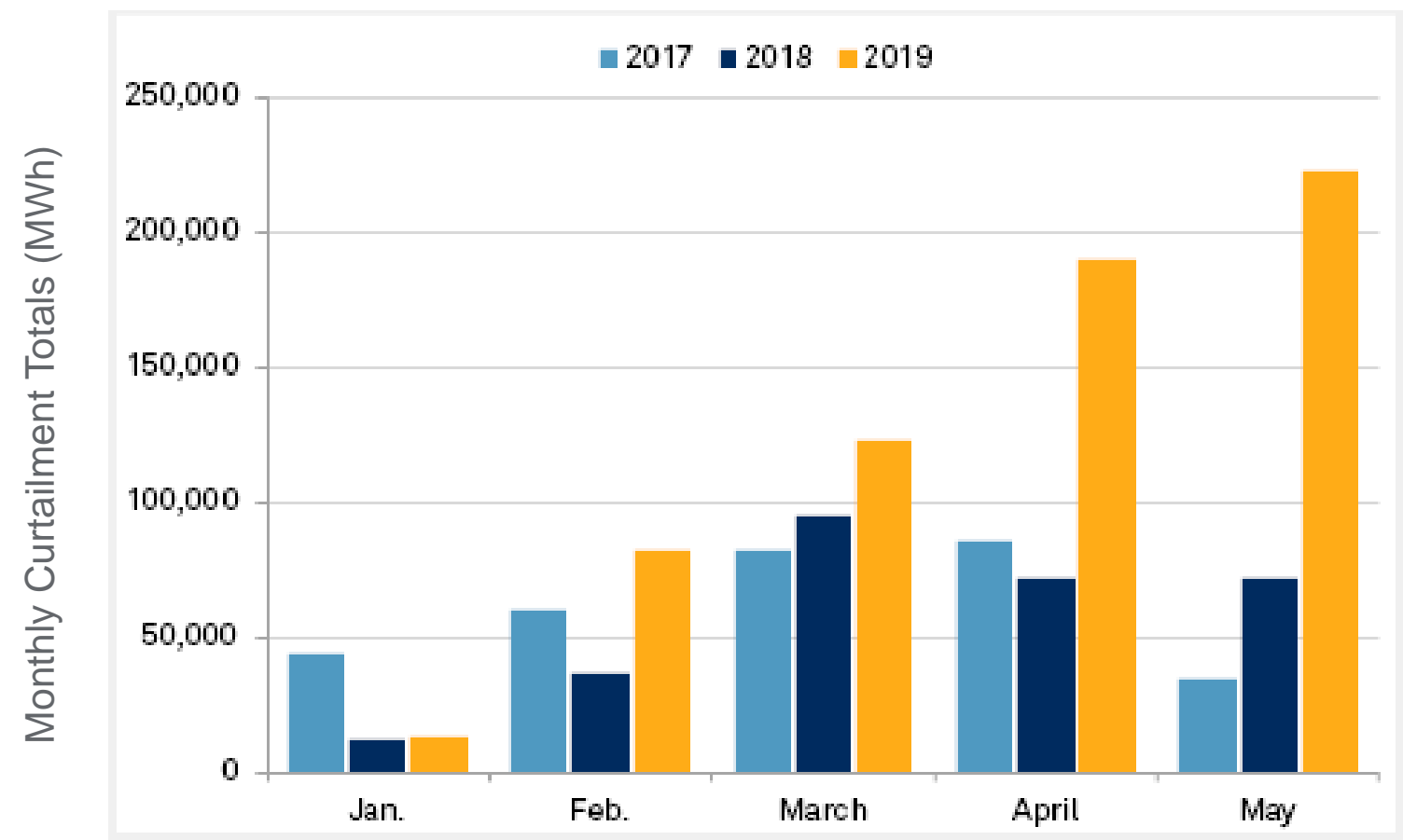
Announced Retirements and Distressed Assets

- Western US has retired most of their coal plants
- Eastern and mid-continent US still has a lot of coal to retire
- 19.1 GW of announced retirements
- 73.3 GW of distressed assets



Curtailments and Negative Pricing Signal the Need for More Storage

CAISO wind and solar curtailments hit record high in May 2019



Source: CAISO
Data compiled June 6, 2019

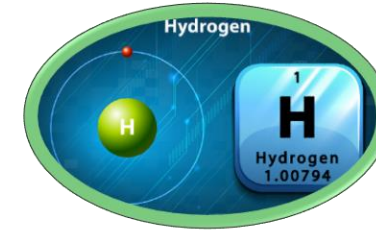
Energy Storage Technologies



Lithium Ion

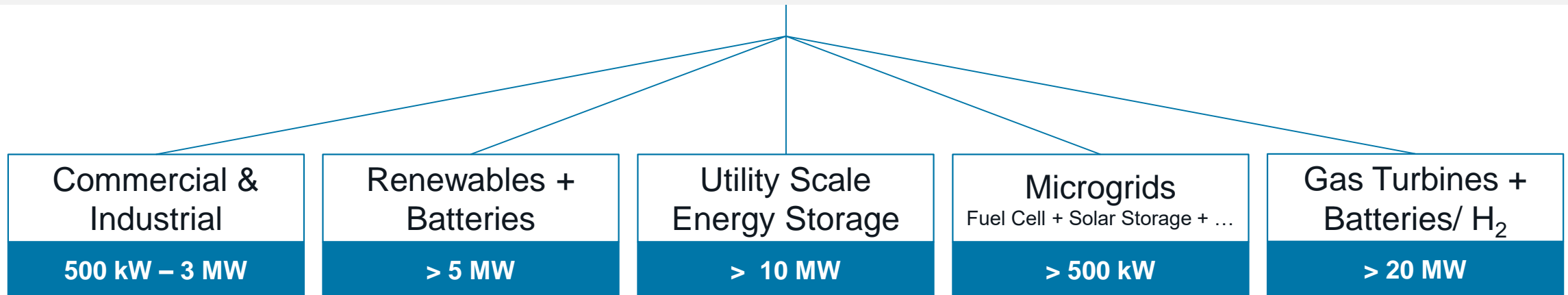


Flow



Renewable
Hydrogen

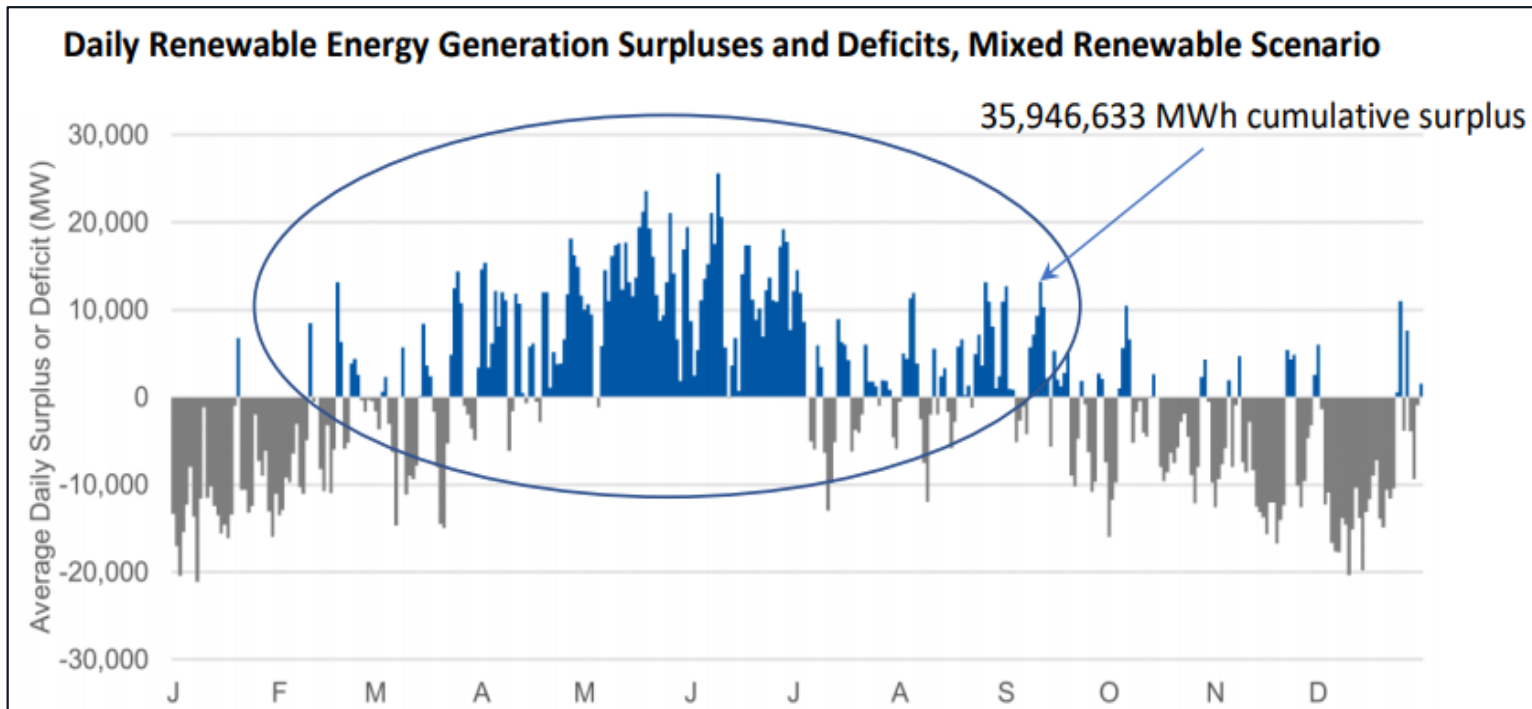
Flexible Technologies For Multiple Uses



Li-Ion Limitations: Capturing Maximum surplus becomes Cost prohibitive

California surplus and deficit patterns under a 100% renewable energy scenario

Accumulated surplus during the year equals 35.9 Million MWh, or roughly 14% of the California's annual electric usage.

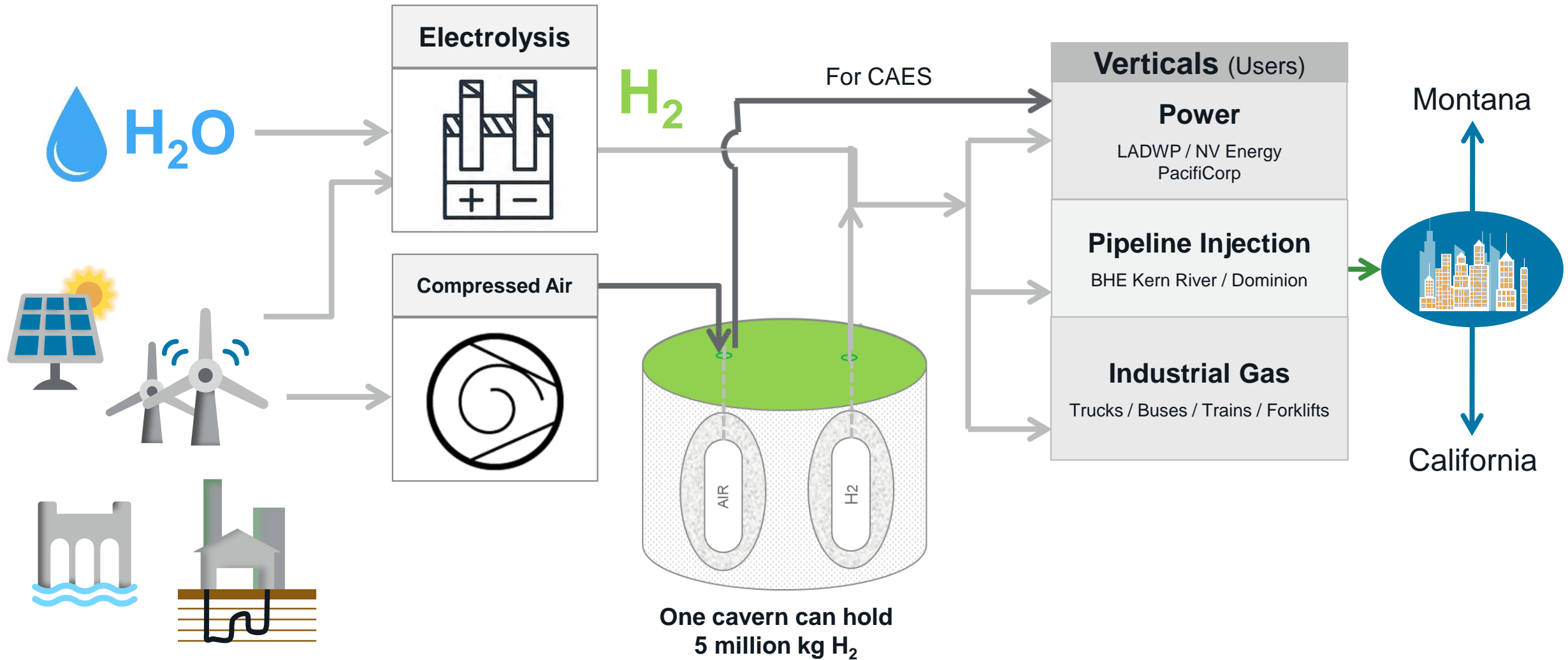


To contain that much energy at peak storage time :

- A peak storage system equivalent in instantaneous capacity larger than the generating capacity of the entire US electric grid
- Assuming \$80/kwh (80% lower than where it is today) - the total cost of such a battery storage system would be \$2.9 trillion
- California's annual GDP is \$2.7 trillion.

Source: Armond-Cohen (Clean Air Task Force) Testimony: Building Americas Clean Future

Advanced Clean Energy Storage (ACES) Project Delivers a Complete Solution



Large scale centralized storage for total grid stabilization

The Evolutionary Path to 65%+ Combine Cycle Efficiency

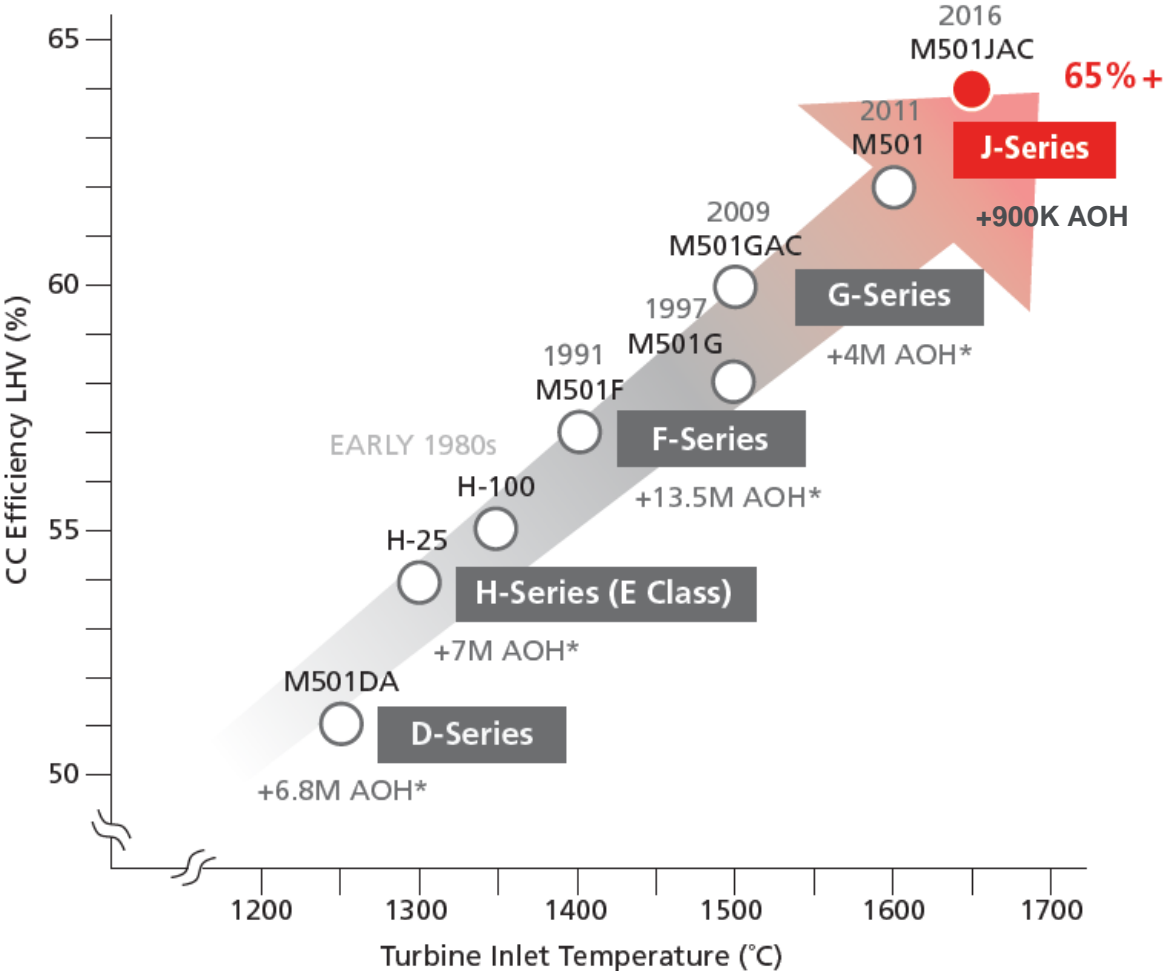


T-Point 1 1997 (G) / 2011 (J) COD



MHPs TOMONI Point 2020 COD

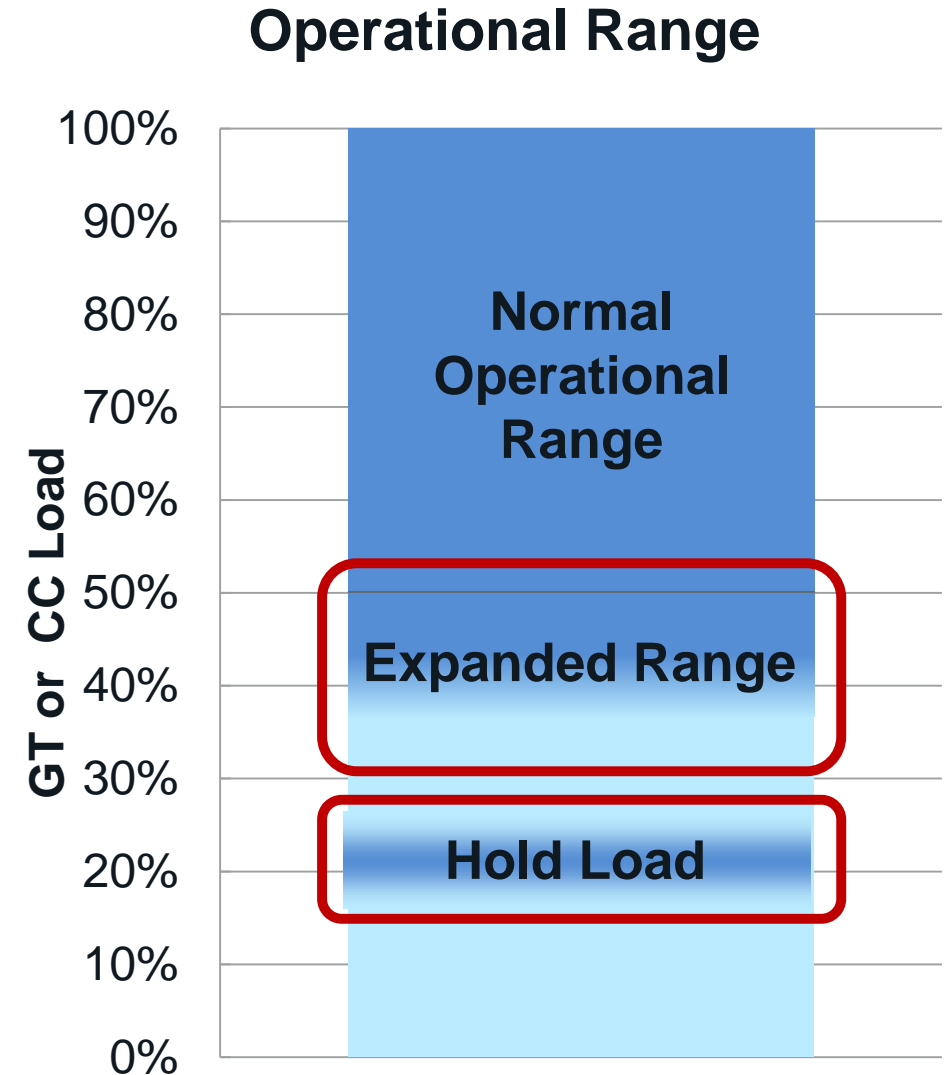
July 2019



*Actual Operating Hours (AOH) as of November 2019

Larger Operating Range with High Efficiency Gas Turbines

- Increased flexibility reduces fuel costs and avoids starts / stops when integrating with renewables
- Normal operational range is from 100% to MECL (Minimum Emissions Compliant Load)
- MECL is typically 50% GT Load
- MHPS-TOMONI Very Low Load (VLL):
 - Expanded range: emissions compliant continuous ramping ~ 40%-100% load
 - Very low operational point @ ~20% GT load and emissions compliant



US Patent number : 9,399,927, Dated Jul. 26, 2016

MHPS Renewable Hydrogen Fueled Turbine

100% Hydrogen Fuel =
Zero CO₂ Emissions

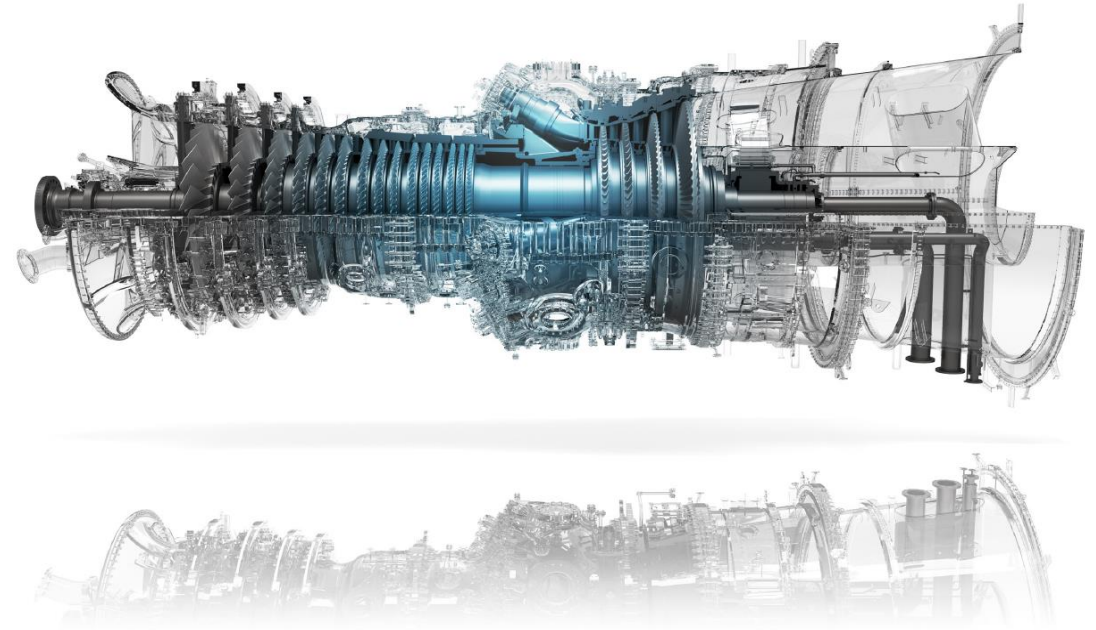


Powering the Next Generation,
with Renewable Hydrogen

Extensive
EXPERIENCE
with hydrogen fuel mix

Over
3 MILLION
hours of operation

100% renewable
hydrogen by 2024



Thank You