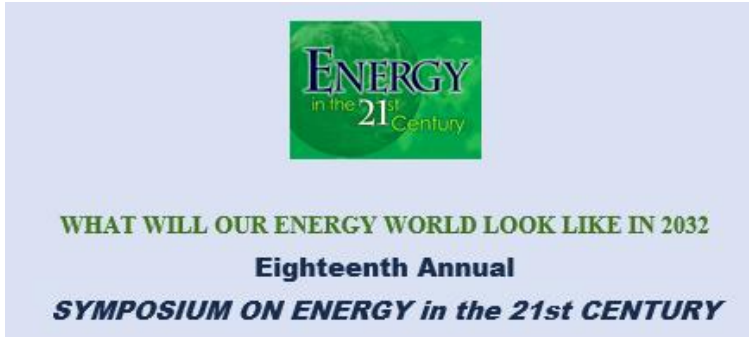
NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Walt Musial Slides

Offshore Wind Outlook for the Next Decade

Walt Musial | National Renewable Energy Laboratory | Offshore Wind Lead

April 8, 2022



NREL Science Drives Innovation

Renewable Power

Solar

Wind

Water

Geothermal

Sustainable Transportation

Bioenergy

Vehicle Technologies

Hydrogen

Energy Efficiency

Buildings

Advanced Manufacturing

Government Energy Management

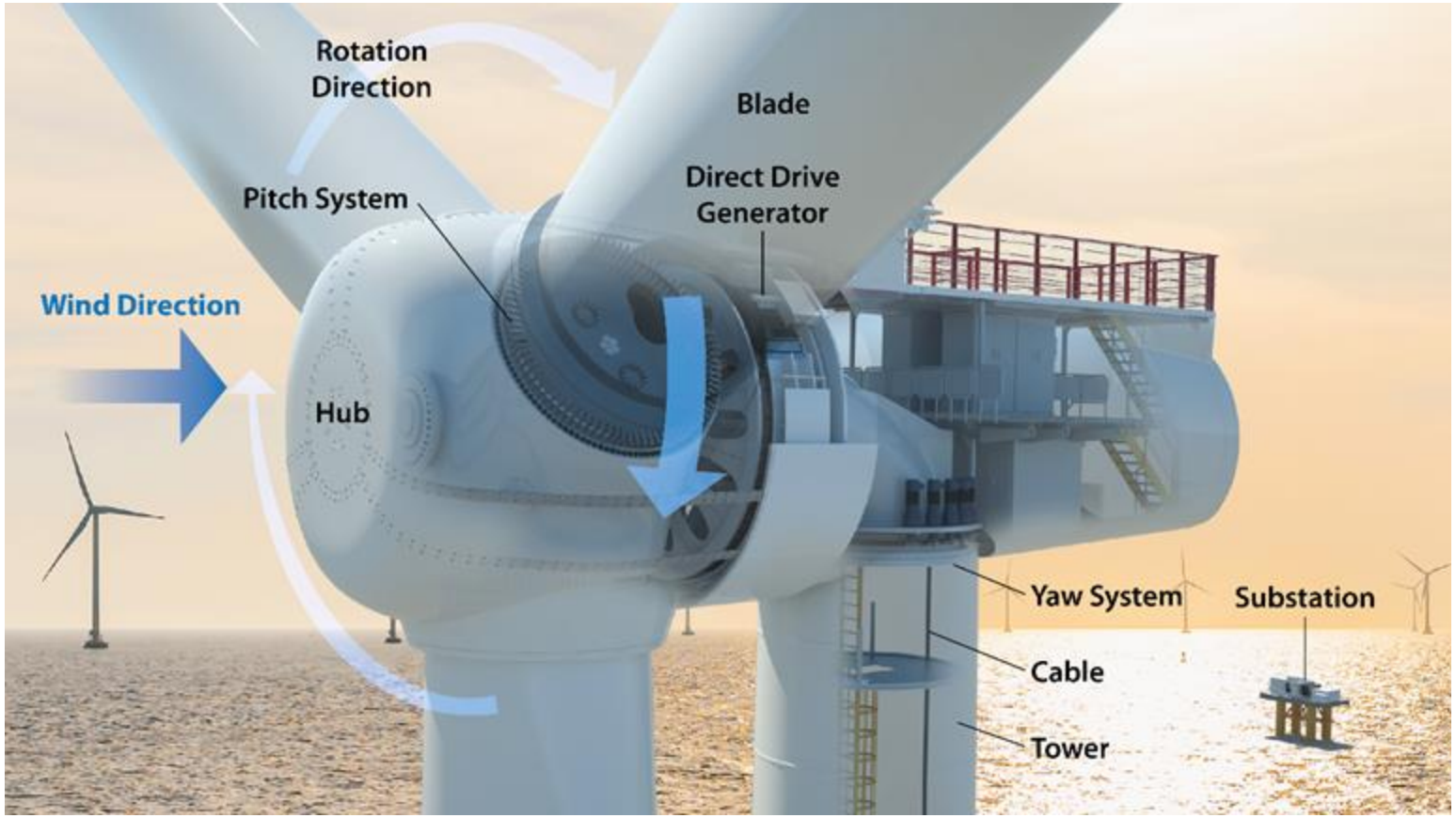
Energy Systems Integration

Grid Integration

Hybrid Systems

Security and Resilience

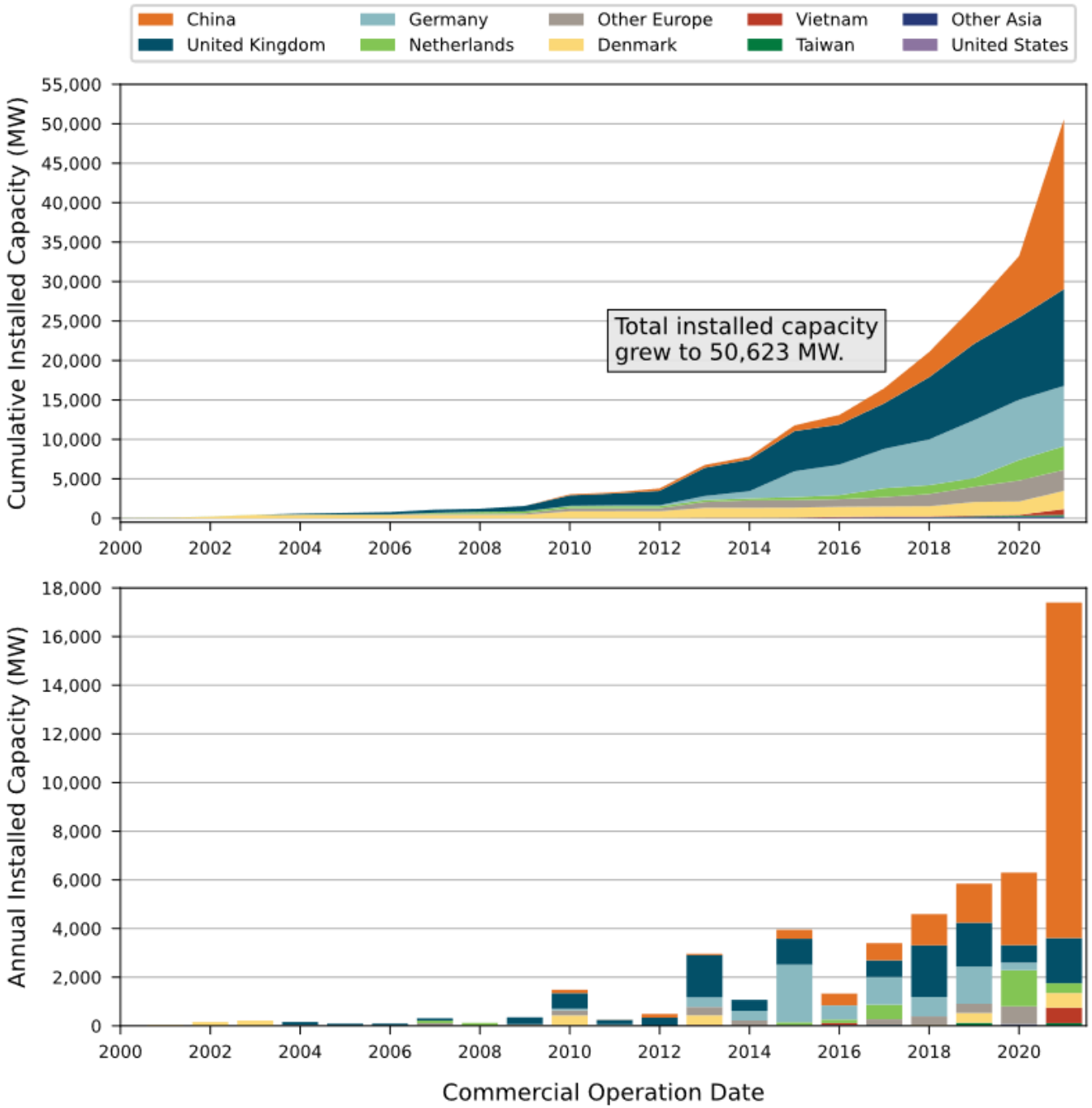
Offshore Wind Power Plant



Graphic by Joshua Bauer, NREL

- The rotor (hub + blades) converts kinetic energy of the wind to create torque (rotational force) that spins a generator that produces electricity.
- Multiple turbines are connected to a substation that connects a high-voltage cable to the land-based grid.
- Offshore wind plants are growing beyond 1,000 MW in size.
- Peak energy output is comparable to large coal, natural gas, or nuclear power plants.
- One 12-MW offshore wind turbine can power 4,500 U.S. residences.

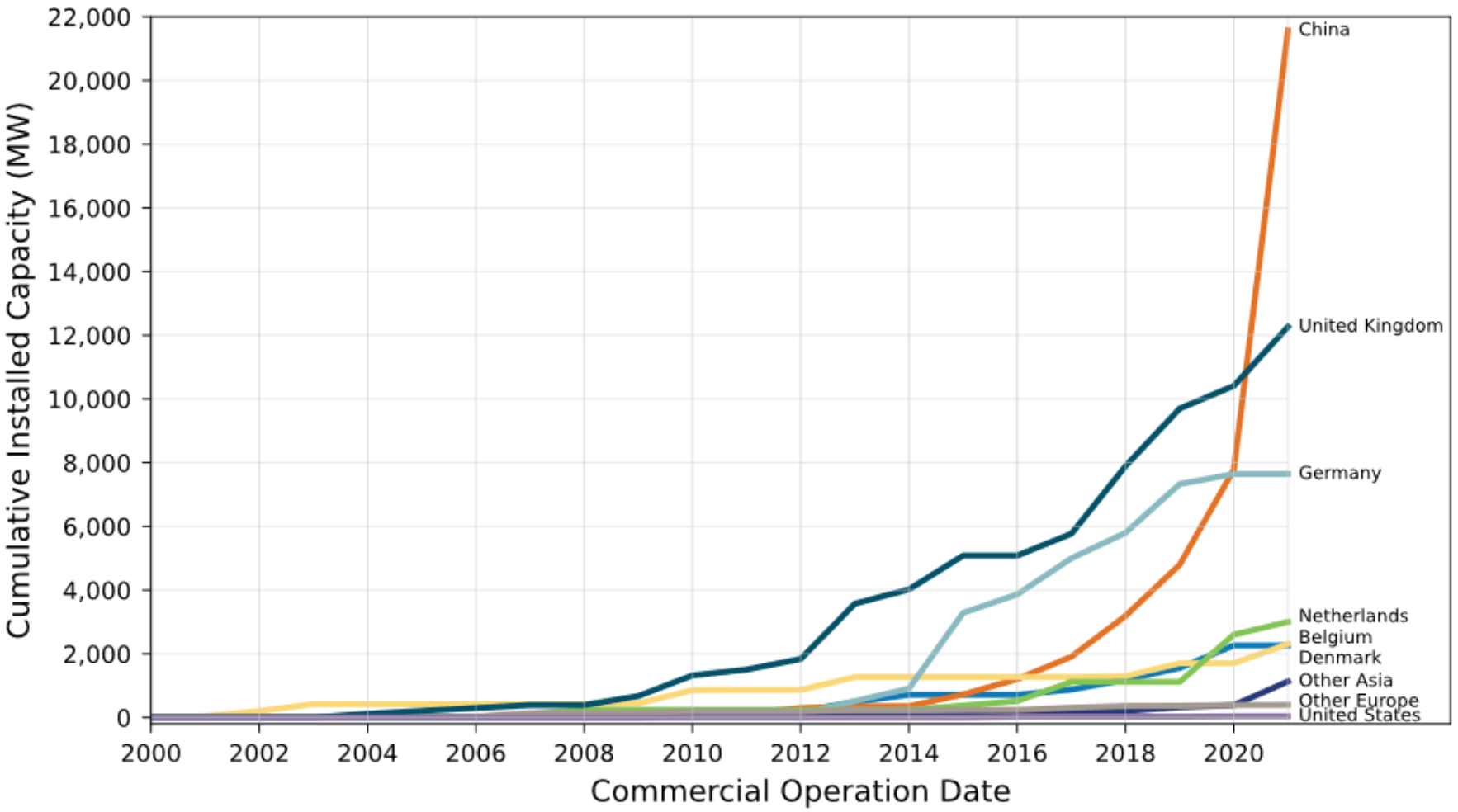
Offshore Wind Growth by Country to Date



- Over 17 GW of new capacity added to global offshore wind supply in 2021.
- This industry deployment record was spurred by Chinese development.
- 50,623 MW of offshore wind is now operating worldwide.

Data Source: NREL - data are subject to change but are current as of December 31, 2021

Offshore Wind Growth by Country



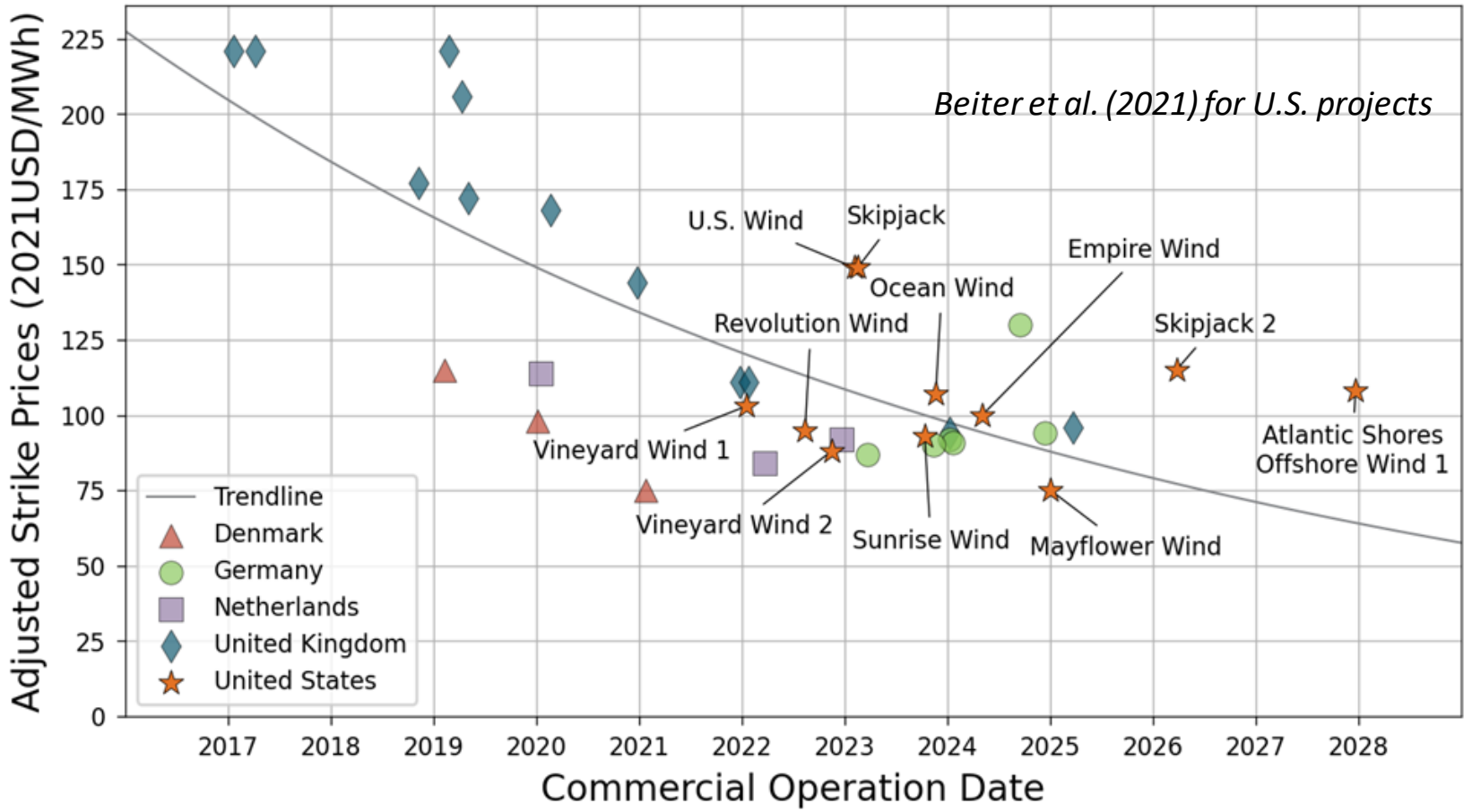
- China has now become the leading offshore wind country in terms of capacity deployed.
- Large growth in 2021 was due in part to the elimination of Chinese feed-in tariffs at the end of 2021

Data Source: NREL - data are subject to change but are current as of December 31, 2021

Adjusted Strike Prices from U.S. and European Offshore Wind Procurements

Cost Drivers

- Advancing technology (e.g., larger turbines)
- Increasing competition
- Maturing supply chains
- Lower risk

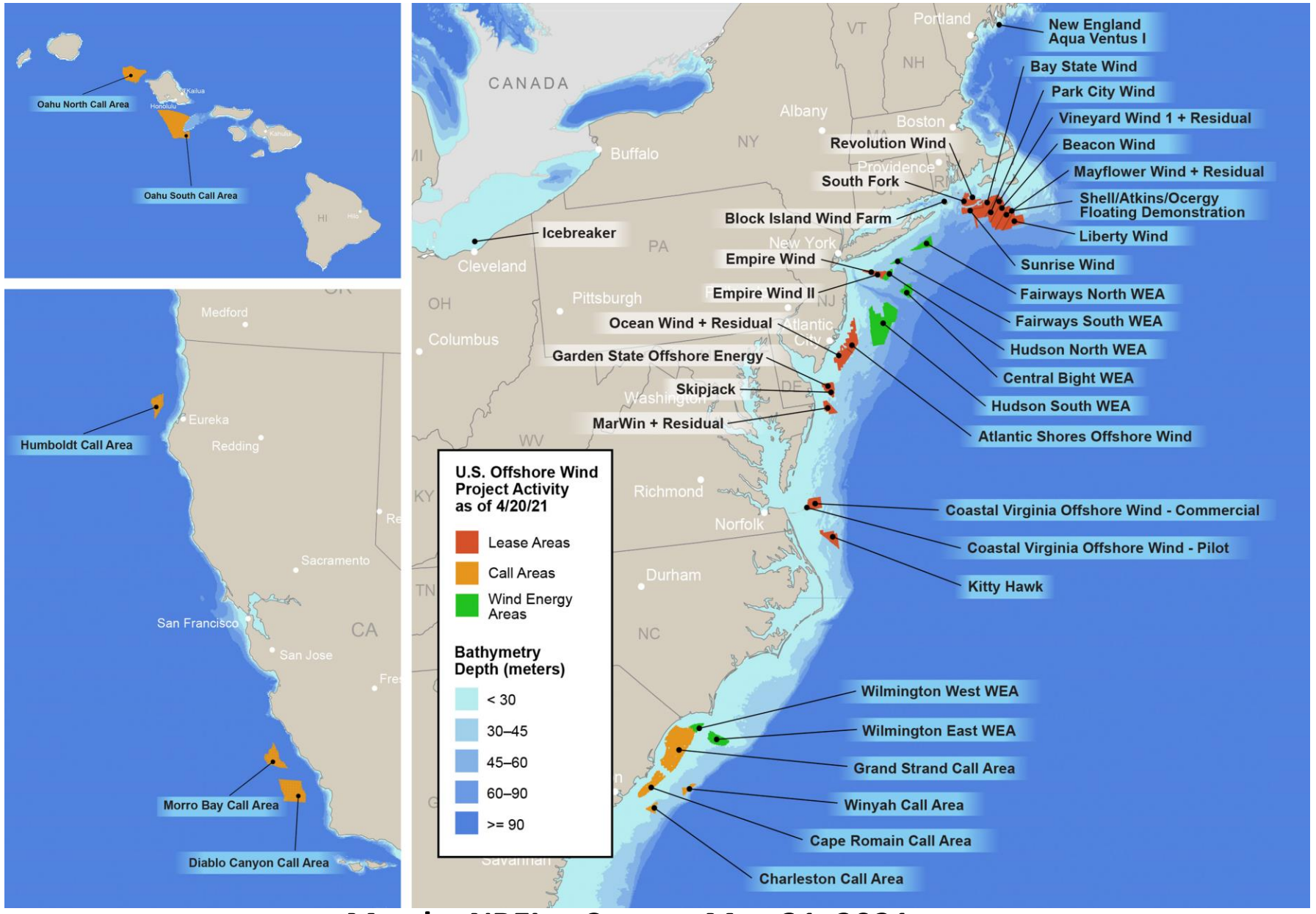


Data Source: NREL - data are subject to change but are current as of December 31, 2021

Decreasing costs for offshore wind are motivating U.S. state policy

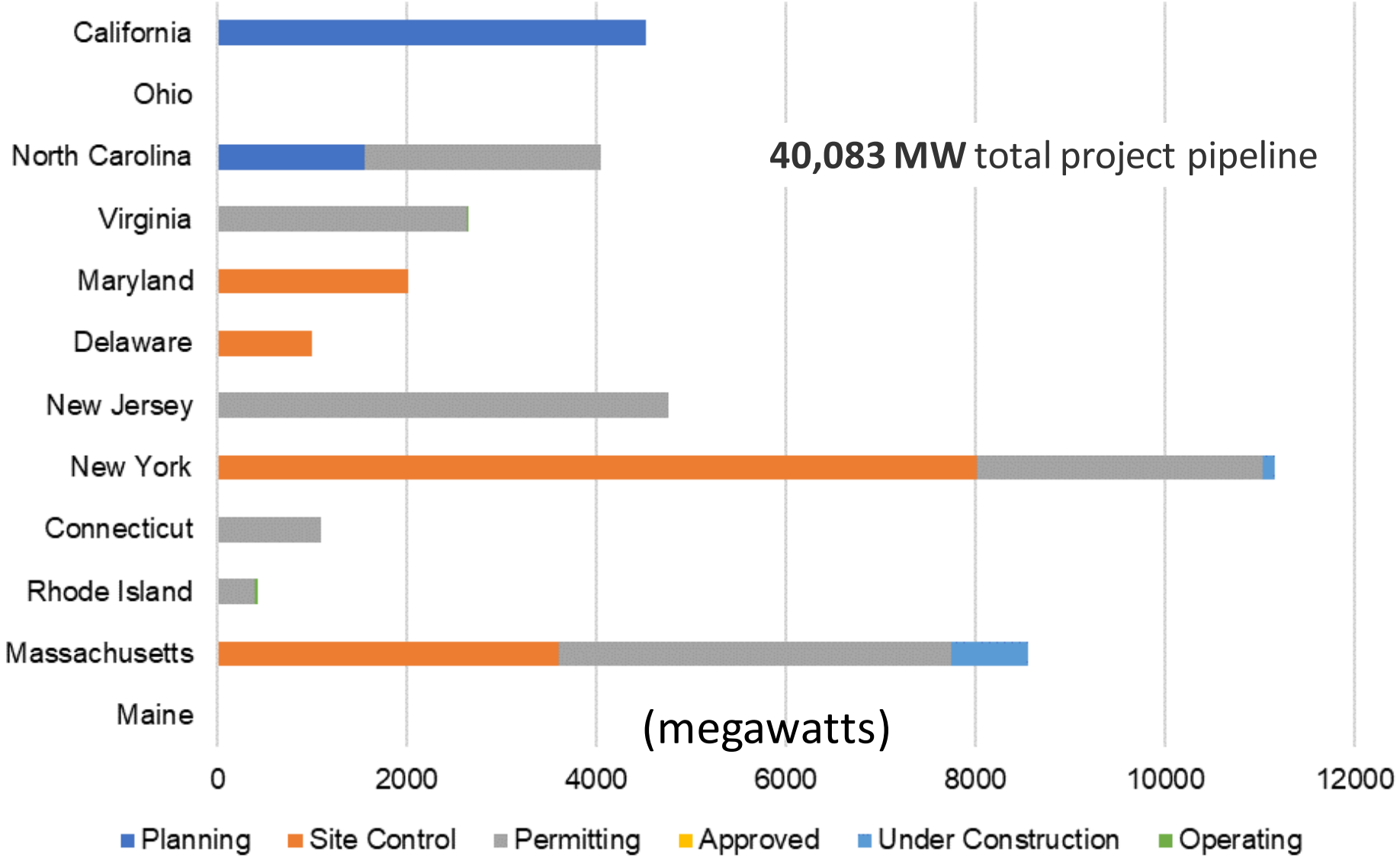
Snapshot of Emerging U.S. Offshore Wind Industry

- U.S. Offshore Wind Target for **30 GW by 2030.**
- **39,322 MW** of policy commitments from eight eastern states
- **40,083 MW** in project regulatory pipeline
- **42 MW** installed
- **932 MW** under construction (Vineyard Wind and Skipjack)
- **24** offtake agreements for **17,597 MW**
- **18,581 MW** in advanced permitting



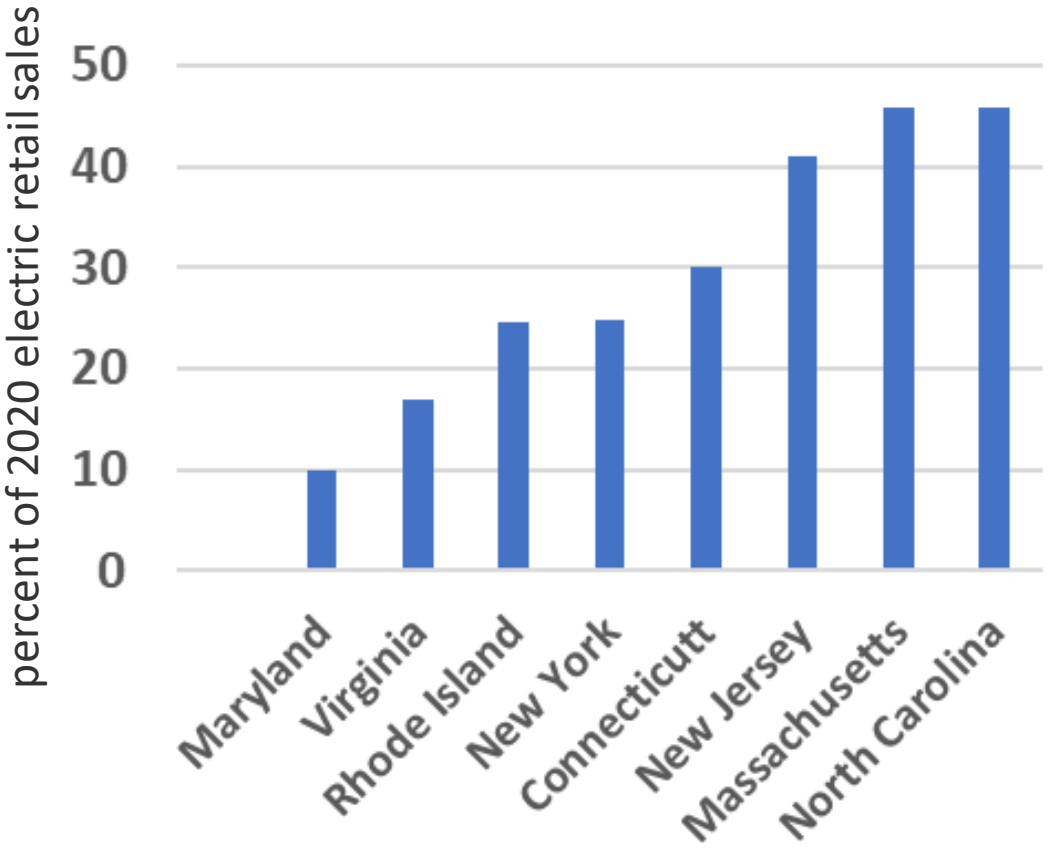
Map by NREL – Current May 31, 2021

Data Source NREL – Preliminary data as of March 2022



State Policy Drives Major Offshore Penetration in Northeast

State Offshore Wind Percentages of 2020 Electric Retail Sales



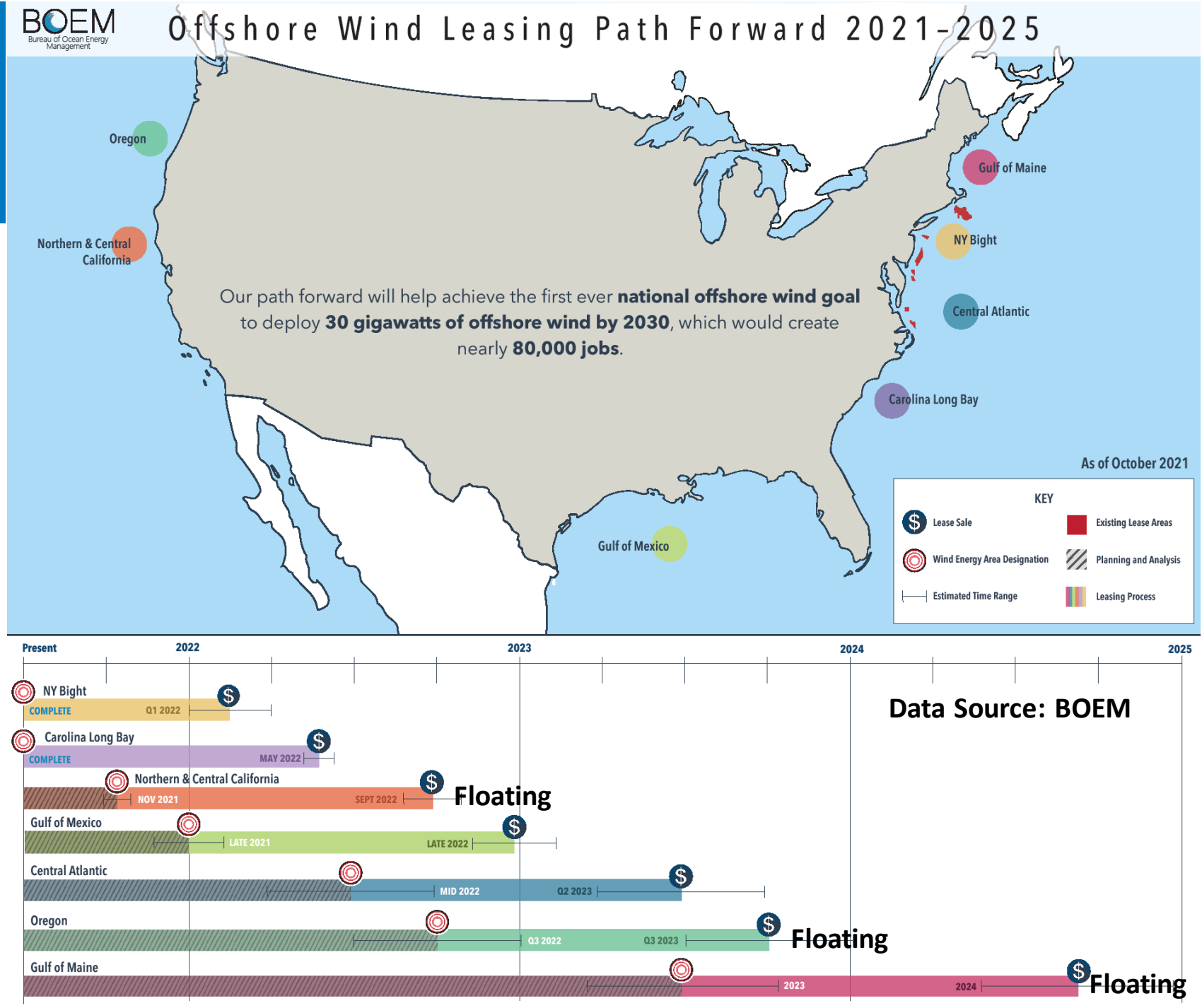
State	State OSW Policy MW	Retail Energy Sales (2020) MWh	Net Capacity Factor	Offshore Wind Energy MWh	Percent Retail
Maryland	1,568	60,720,658	0.44	6,043,699	10
Virginia	5,200	118,435,380	0.44	20,042,880	17
Rhode Island	430	7,349,915	0.48	1,808,064	25
New York	9,000	145,600,345	0.46	36,266,400	25
Connecticutt	2,000	27,899,996	0.48	8,409,600	30
New Jersey	7,500	73,916,704	0.46	30,222,000	41
Massachusetts	5,600	51,336,598	0.48	23,546,880	46
North Carolina	8,000	136,435,531	0.42	29,433,600	46
Totals	39,298				

Retail Energy Sales based on EIA data November 2020
https://www.eia.gov/electricity/state/

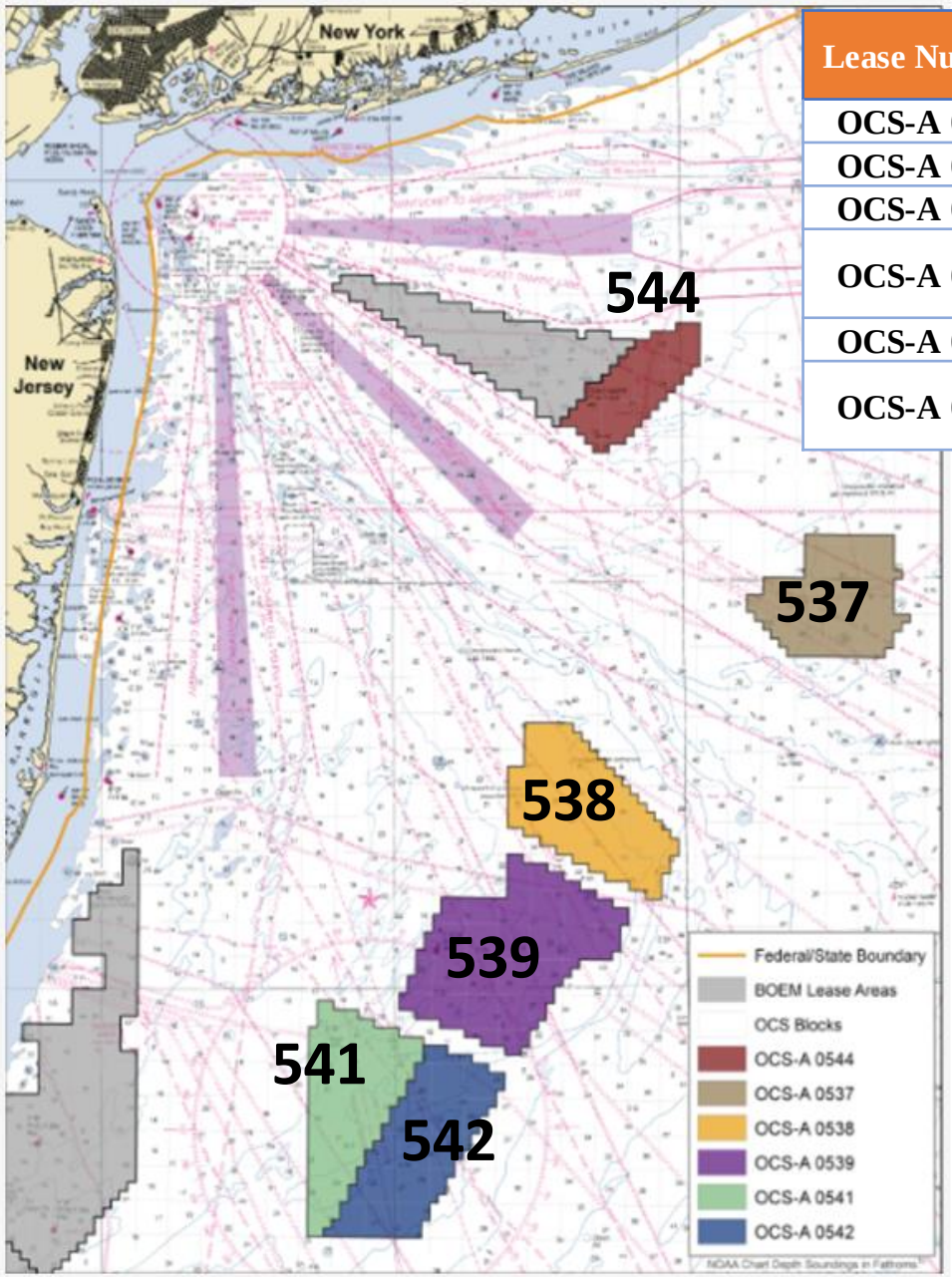
Data Source: NREL, EIA

2025 Offshore Wind Leasing Plan Announced

- Secretary Haaland outlined an offshore wind leasing strategy on Oct 13, 2021.
- Seven new offshore lease sales by 2025. (Three will be for floating wind.)
- Major technology issues:
  - Floating wind commercialization
  - Hurricane resilience
  - Great Lakes conditions
- Major competing use issues
  - Fishing
  - Military



New York Bight Lease Sales



Lease Number	Purchaser	Developer	Area (km2)	Capacity (MW)	Price
OCS-A 0544	Mid-Atlantic Offshore Wind LLC	CIP	174	523	$285,000,000
OCS-A 0537	OW Ocean Winds East LLC	EDPR & Engie	289	868	$765,000,000
OCS-A 0538	Attentive Energy LLC	Total Energies	321	964	$795,000,000
OCS-A 0539	Bight Wind Holdings LLC	RWE & National Grid	462	1,387	$1,100,000,000
OCS-A 0541	Atlantic Shores Offshore Wind Bight LLC	Shell & EDF	308	924	$780,000,000
OCS-A 0542	Invenergy Wind Offshore Wind LCC	Invenergy & EnergyRE	311	934	$645,000,000

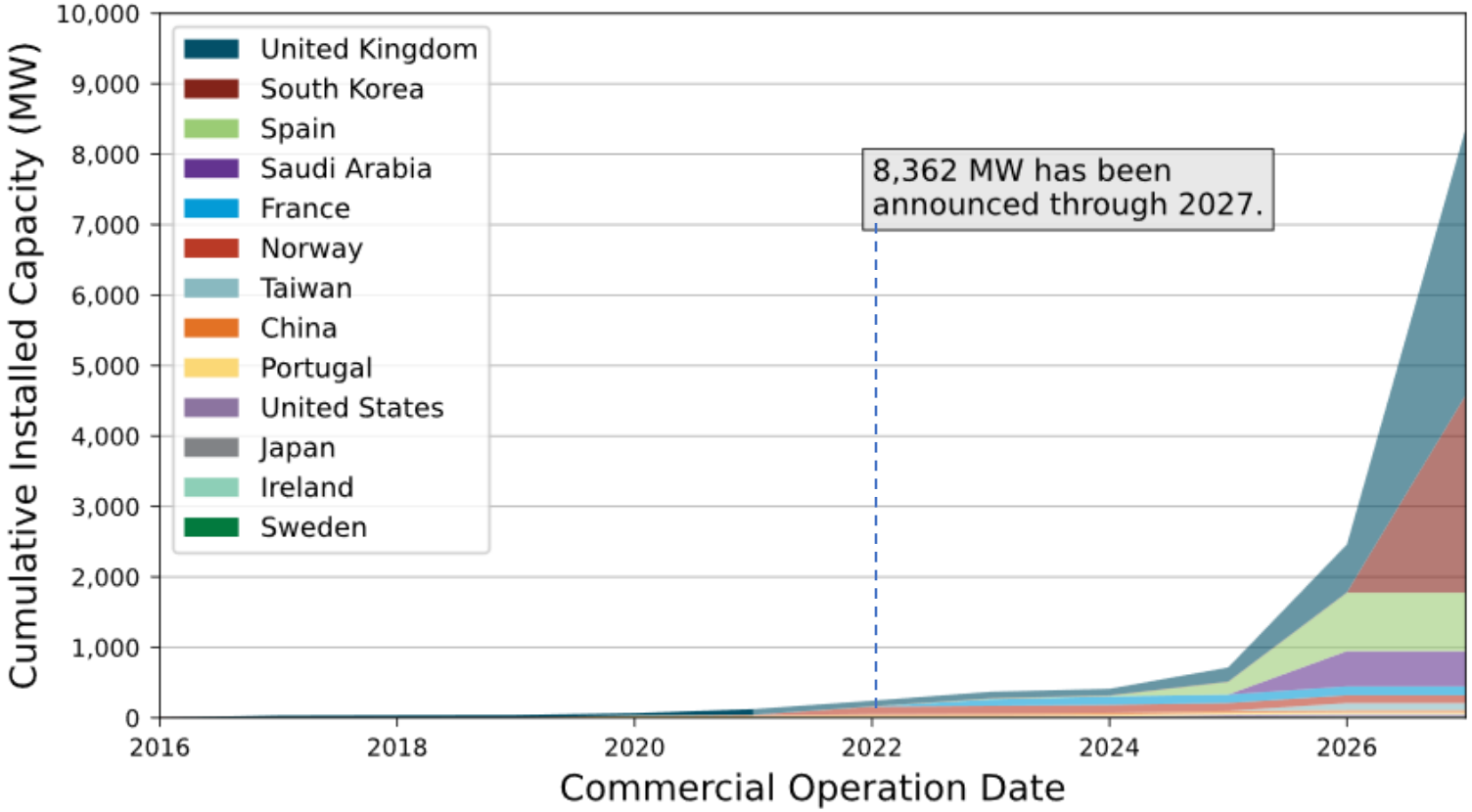
- Total Lease Sales $4.37 Billion
- $763/kW average lease sale (20% of the cost of building a wind project)
- 5,600 MW capacity can power about 3 million NY residences

Data Source: BOEM

Floating Offshore Wind Growth Based on Developer Announcements

Floating Drivers

- Site scarcity in shallow water
- Potential for reduced costs
- Fewer conflicts
- Stronger and more abundant winds



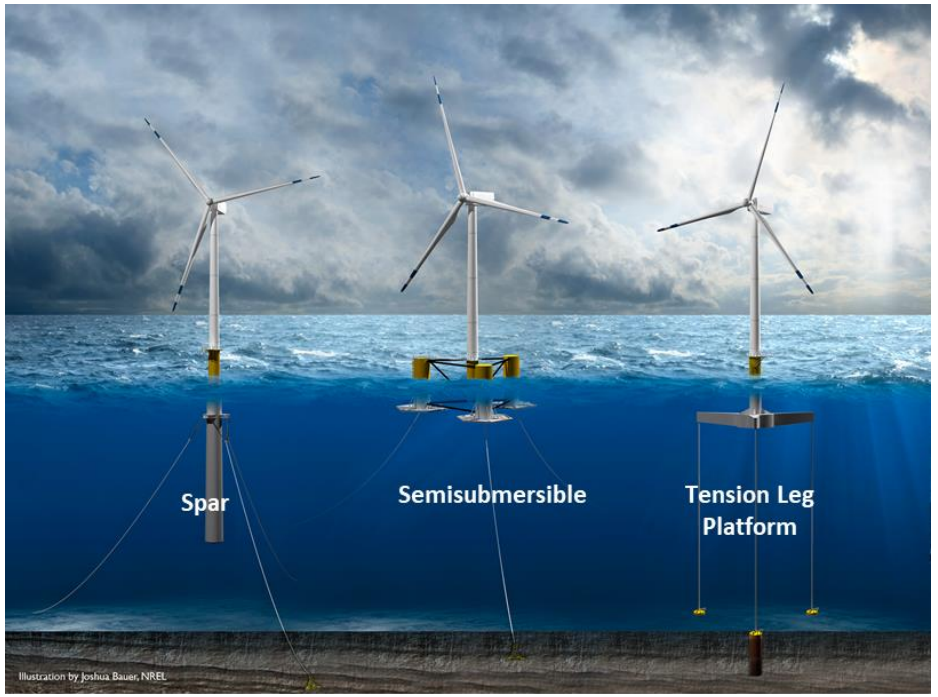


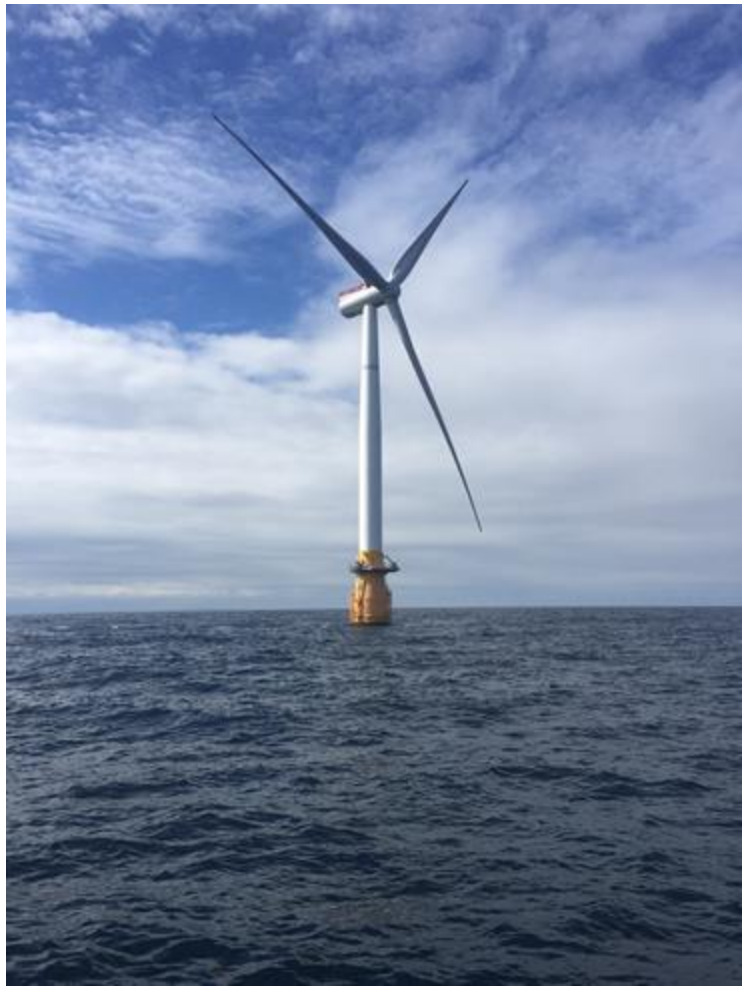
Figure credit: NREL

Primary Substructure Types

Data Source: NREL - data are subject to change but are current as of December 31, 2021

Surface View of Floating and Fixed-Bottom Wind Turbines

Principle Power 2.0-MW floating wind turbine in Portugal; 2011
WindFloat semisubmersible substructure.
Photo by Walt Musial, NREL

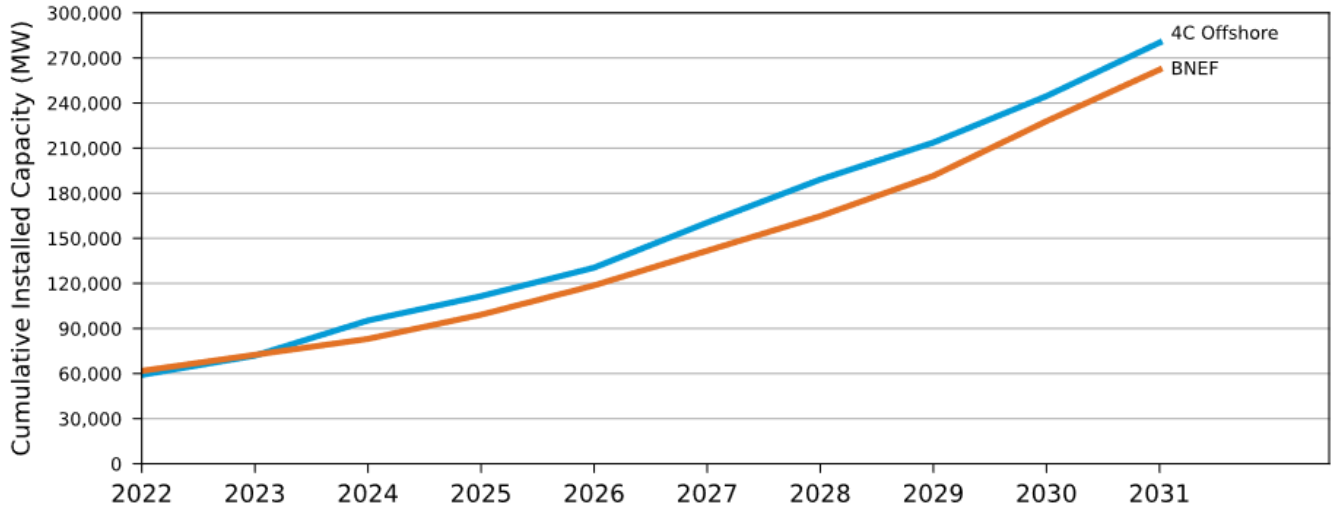


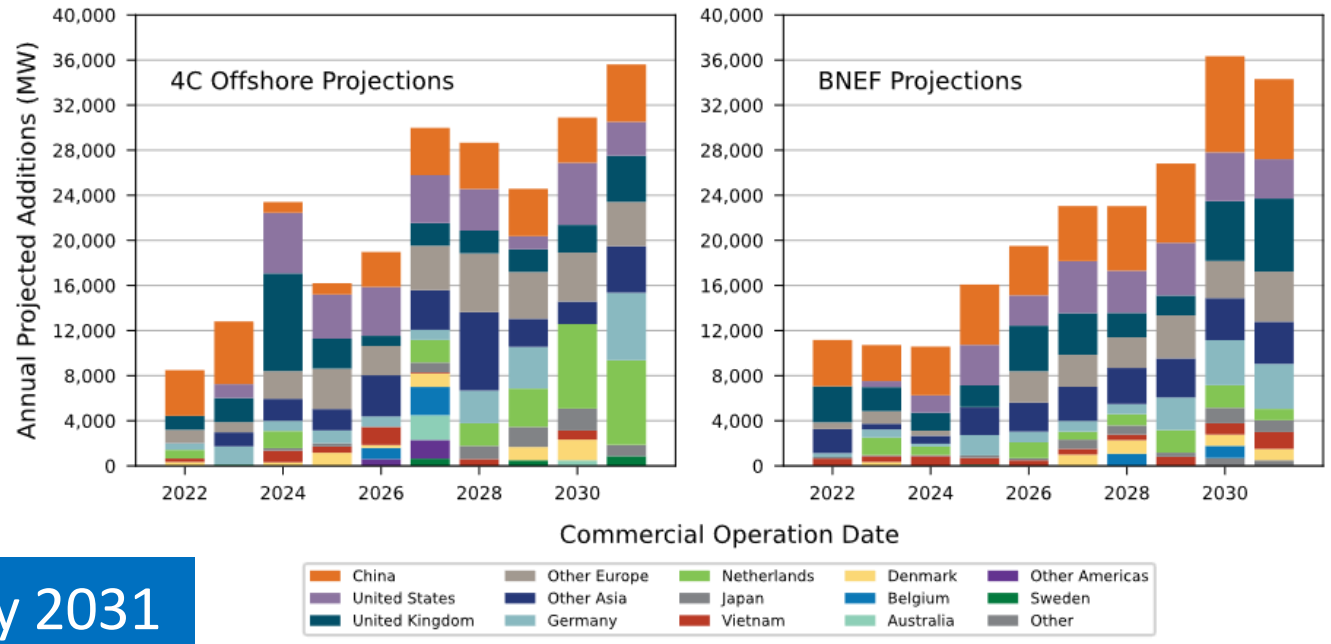
Equinor 6-MW Siemens floating wind turbine in Scotland; 2017
Hywind-2 spar substructure.
Photo by Walt Musial, NREL

Baltic-1 2.3-MW Siemens fixed-bottom wind turbine in Germany; 2010
monopile substructure.
Photo by Walt Musial

Future Drivers for U.S. Offshore Wind - 2032

- **Climate action and decarbonization**
- **Cost reduction**
- **Technology advancement**
- **Transmission access**
- **Regulatory efficiency**
- **Port development**
- **Vessel development**
- **Domestic supply chain development**
- **Jobs and economy – $12 B+/year**





Global Offshore Wind may reach 275 GW by 2031

Thank you for your attention!

Walt Musial
Offshore Wind Research Platform Lead
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David Lovelady Slides

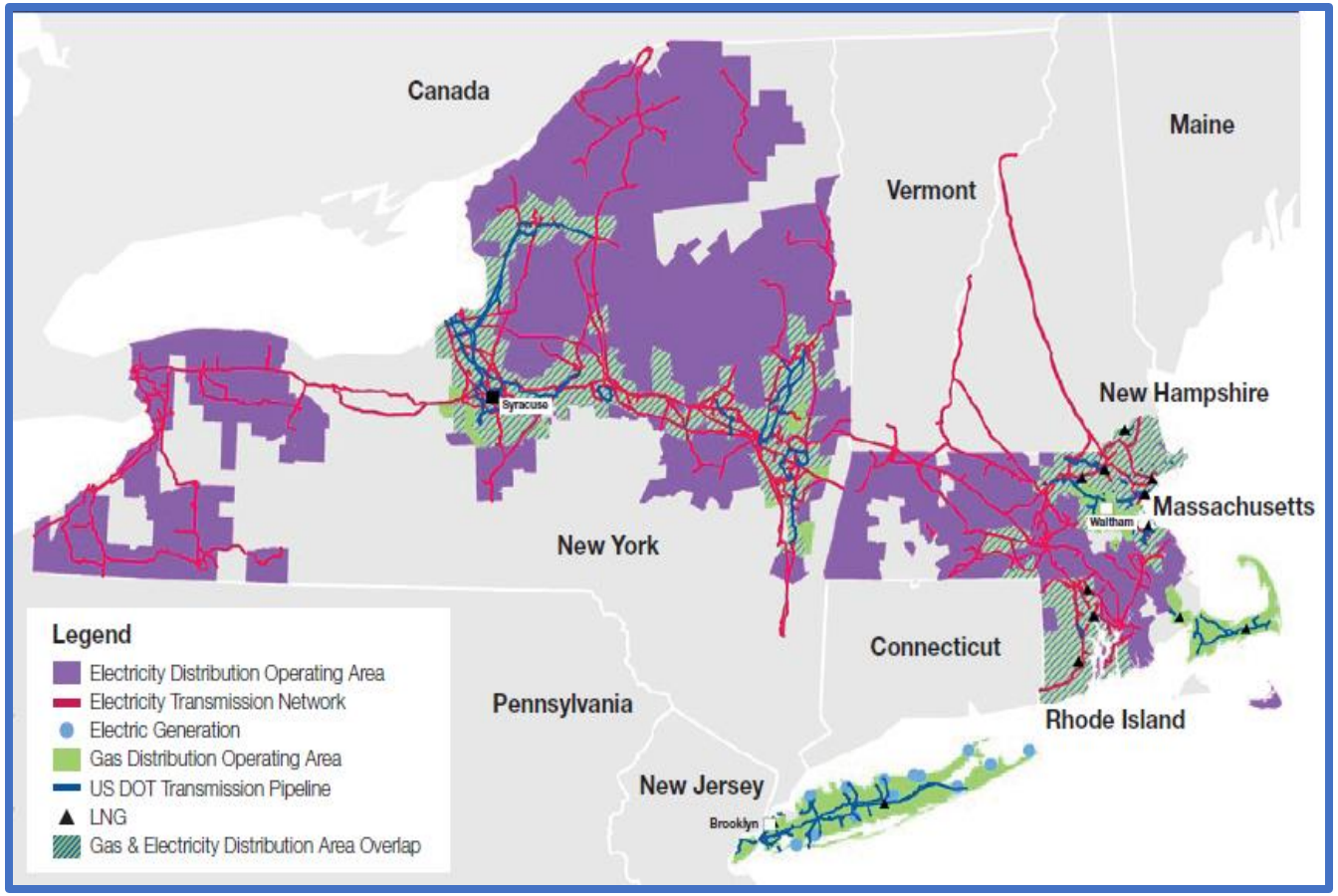
Connecting and Delivering Renewable Energy to New York Homes & Businesses in 2032 – A Distribution Focus

David Lovelady – Director of Distributed System Operations

April 8, 2022

nationalgrid

National Grid USA Serves More Than 20 Million People Across NY, MA and RI; We Share Our Customers' Vision to Reach Net Zero Emissions by 2050



National Grid also manages the UK Transmission System and recently acquired the WPD utility

National Grid's USA Electric System Statistics

30,000	Square miles
9,000+	Transmission miles
5,000+	Sub-transmission miles
70,000+	Distribution miles
1,125+	Substations

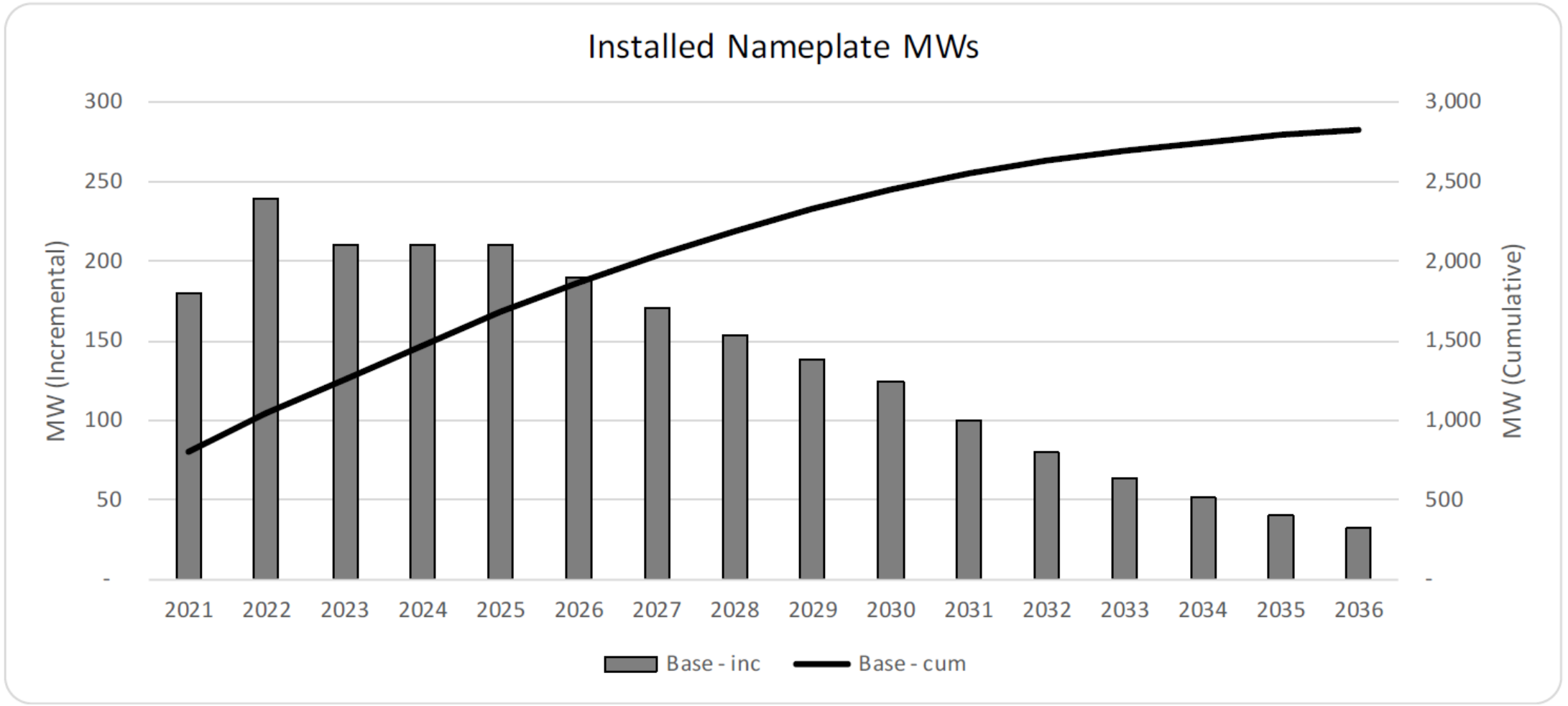
National Grid USA Stats on Distribution Connected Solar:

- Interconnected **107,850** projects totaling **3.6 GW**
- In-queue projects that will add **another 6 GW**
- A **Goal of 8.5 GW** to be installed by 2025

National Grid has connected the **second largest amount of non-residential distribution solar installations** in the nation (behind PG&E)

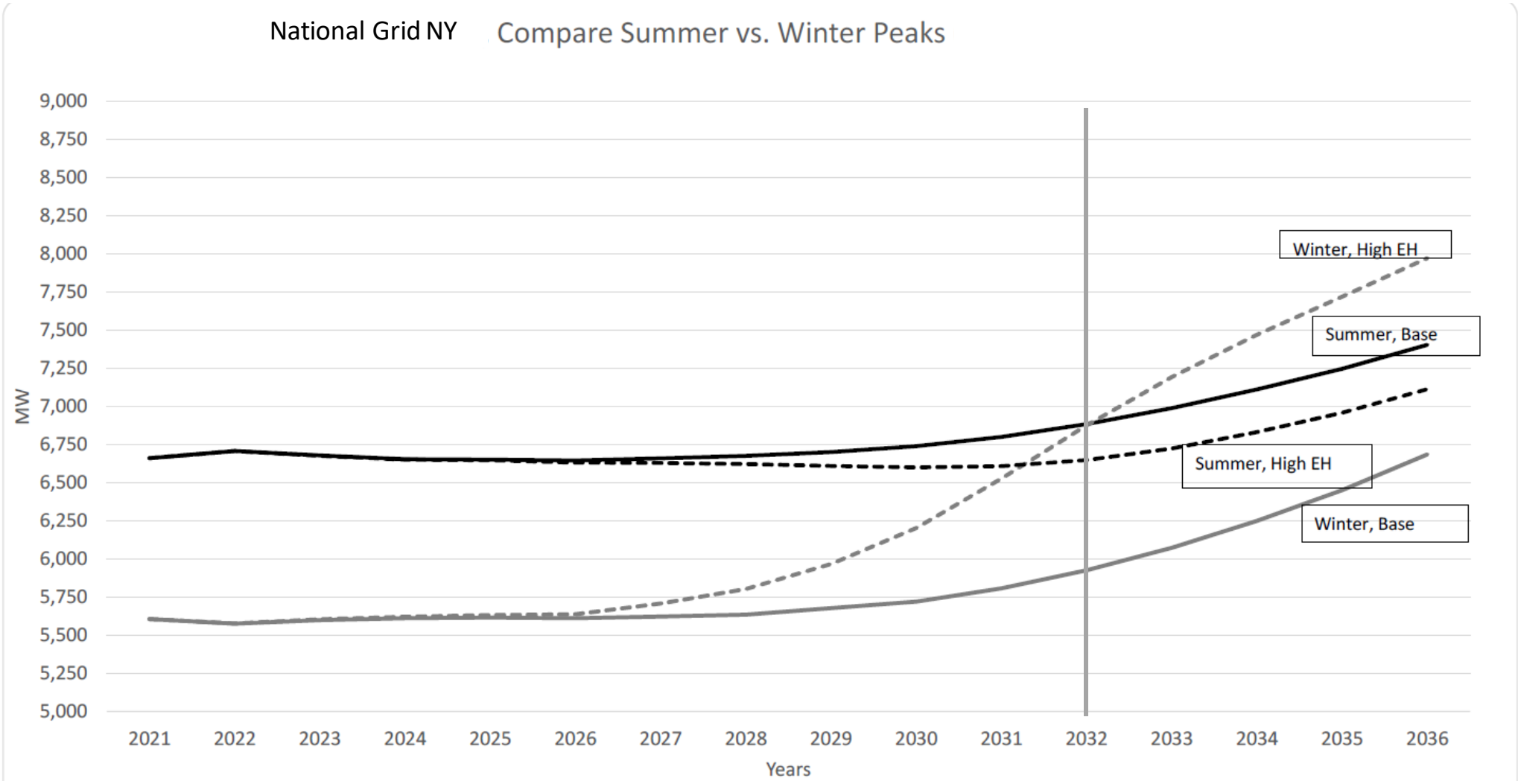
Forecasted to see Continued Growth in Distribution Grid Connected Solar, with Some Saturation Expected in 2026+

National Grid NY Solar PV



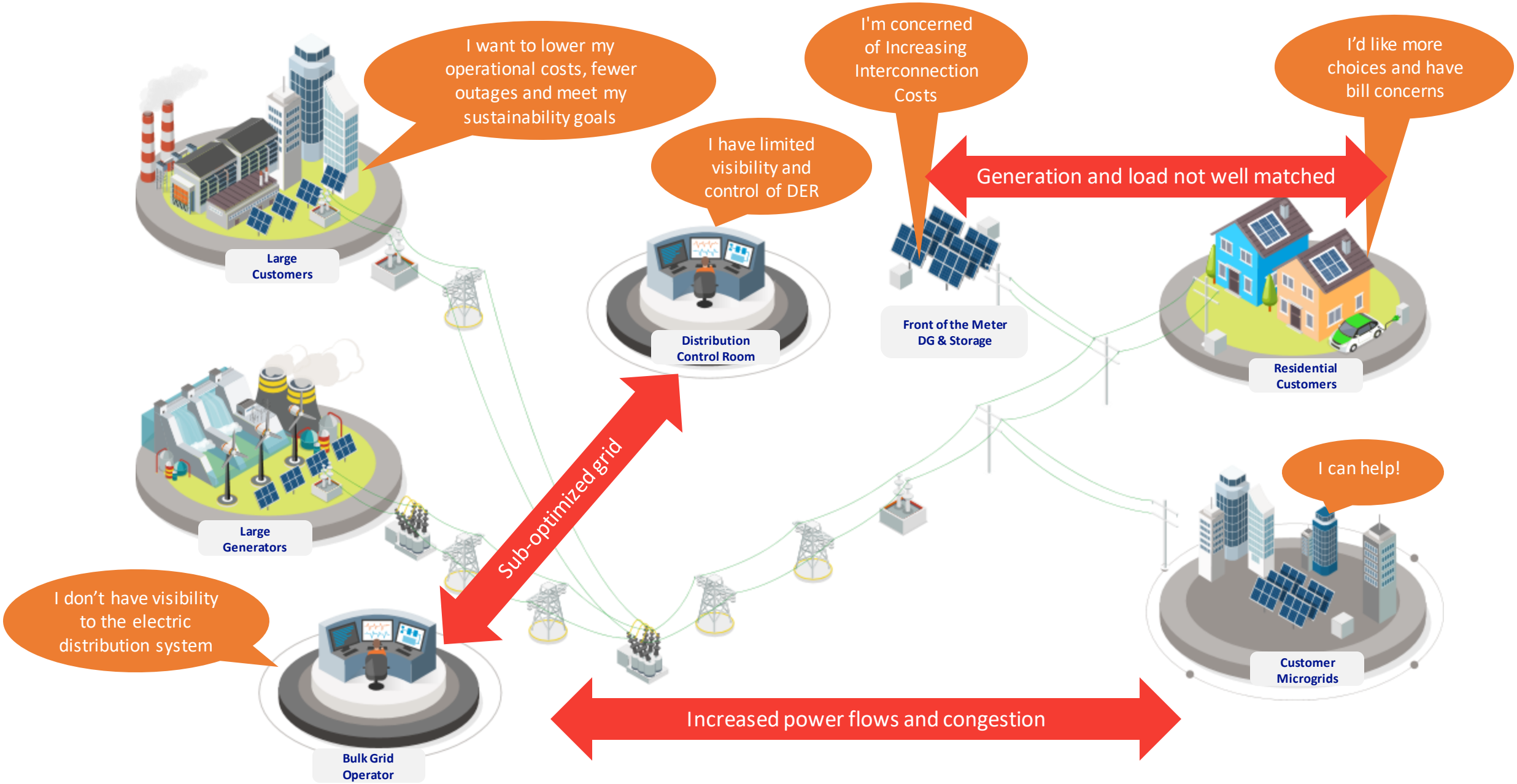
We are seeing grid constraints occurring in the Spring and Fall noon-time periods

Around 2032 Things Start to Get Really Interesting When Electrification of Heat (EH) Could Start to Drive Summer to Winter Peak Load Transition



We start to see grid constraints occurring in the morning and evening Winter periods beyond 2032

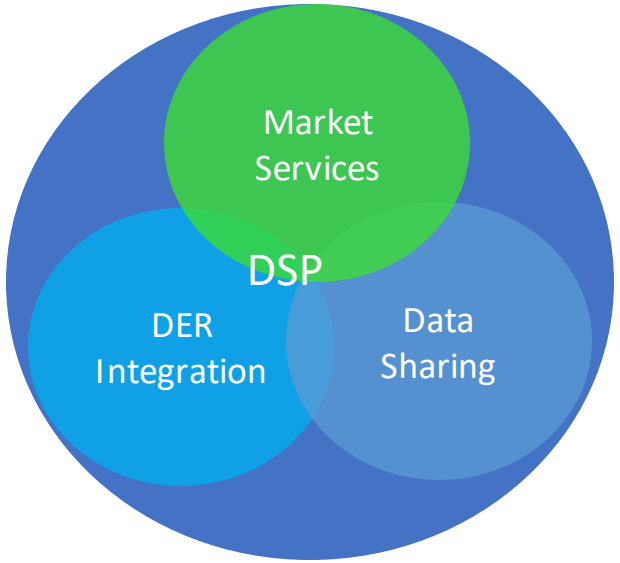
What Challenges & Opportunities Lie Ahead for the Electric Grid and Customers?



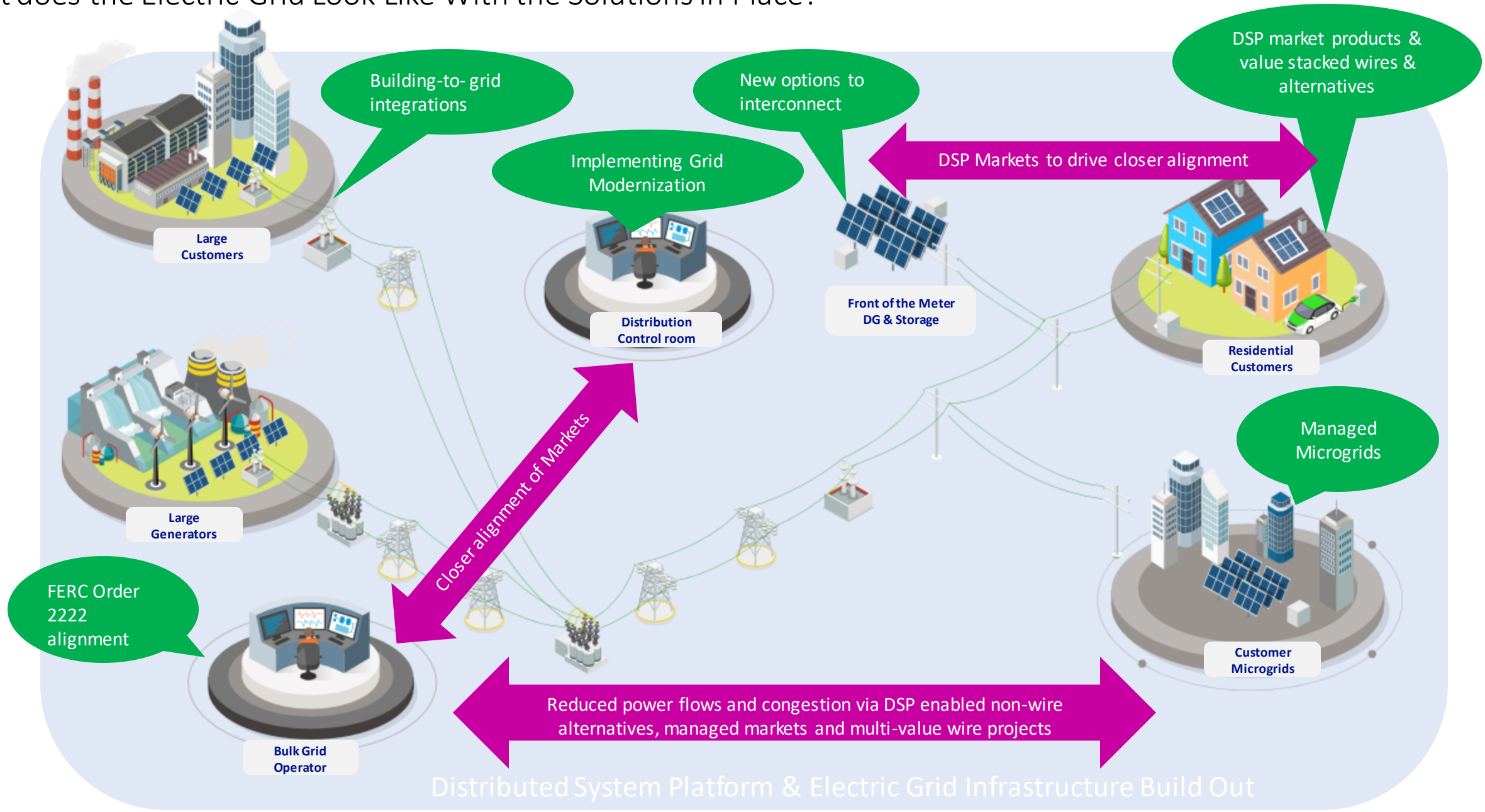
How is National Grid Planning to Solve These Challenges – by Becoming a Trusted Enabler of a More Electric Clean Energy Future by Delivering a Customer-centric and Modernized Network Infrastructure

Strategy to Achieve Future Goals:

1. Build grid infrastructure to drive multi-value projects, *e.g.*, solutions that increase hosting capacity and simultaneously improve reliability and resiliency.
2. Enable and optimize Distributed Energy Resources (DER) through an evolving role as the Distributed System Platform (DSP) provider and associated grid modernization technologies.
3. Pivot quickly to industry changes and implement capabilities in an agile manner to deliver value early.
4. Work closely with all stakeholders to achieve goals.



What does the Electric Grid Look Like With the Solutions in Place?



What Steps is National Grid Taking to Implement these Solutions?

Today	Tomorrow	Future
Roadmaps	Kick-start Roadmap Implementation	Roadmap Implementation
Innovation Projects Planning	Innovation Projects Implementation	Scale Up Innovation Projects
Station and Feeder Monitoring and Control Implementation	Wholesale and Retail Market Integration First Steps	Drive Toward Whole System Market Optimization
3rd Party Non-Wire Alternative Contracts	3rd Party Non-Wire Alternatives Construction	Scale Up Non-Wire Alternative Solutions
Multi-Value Wire Planning	Multi-Value Wire Projects Implementation	Grid Ready for 2030+ Goals
System Data Sharing Portal	Smart Meters, Advanced Distribution & DER Management Technologies Initial Implementation Phases	Fully Advacned Grid Modernization and Management Technologies
	Statewide Data Platform Planning	System Data Platform Go Live

Track sign-posts, take agile approach and continue to engage all stakeholder along the way

David Mooney's Slides

NREL's Strategy

Achieving Our Vision Today and into the Future

Dave Mooney, Ph.D.
April 8, 2022

NREL's Vision and Mission are More Important Than Ever

Climate change, economic recovery, environmental justice, and the ambitious goals of our nation are an urgent call to us as a national laboratory.

Through our Strategy we can answer this call and be the most impactful organization we can be.

Megatrends

Climate Change

Economic Development

Urbanization

Electrification

Resource Competition

Cyberthreats

Climate Change

- Globally, we are off-track to meet Paris Agreement
- Many nations have ambitious carbon-neutral pledges that require energy transitions
- Adaption and resilience efforts must be scaled.

Economic Development

- Uneven distribution of benefits of globalization
- Income

Urbanization

- Over 70% of global population expected to live in cities by 2050
- $4.9 Billion people in cities

Electrification

- Transportation electrification
- Industrial electrification

Resource Competition

- Increased pressure on agriculture, water, and power systems
- Access to critical

Cyberthreats

- Hyperconnectivity through internet and social media
- Increasingly distributed

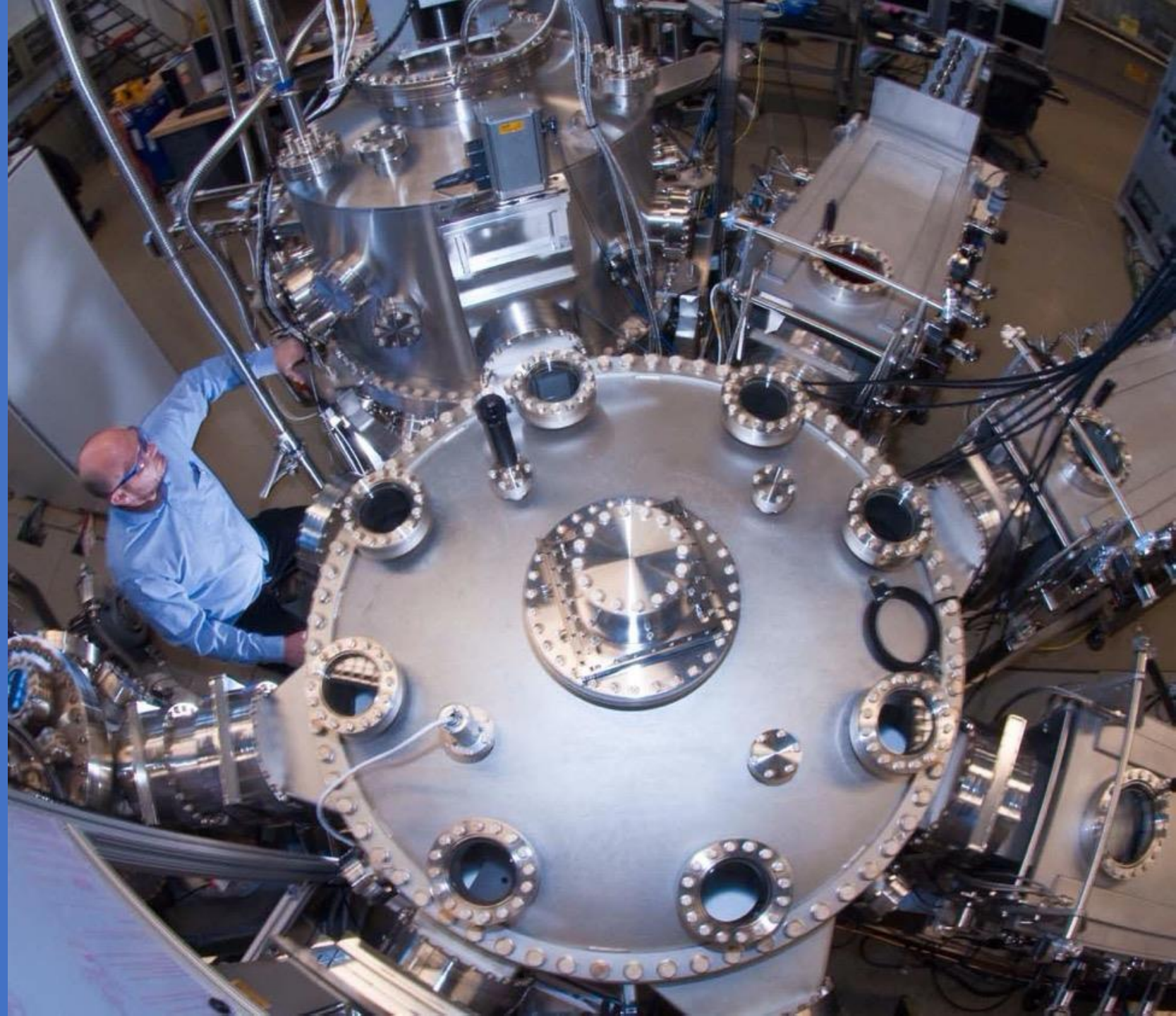
NREL's Strategy Responds to These Trends

Our Vision is

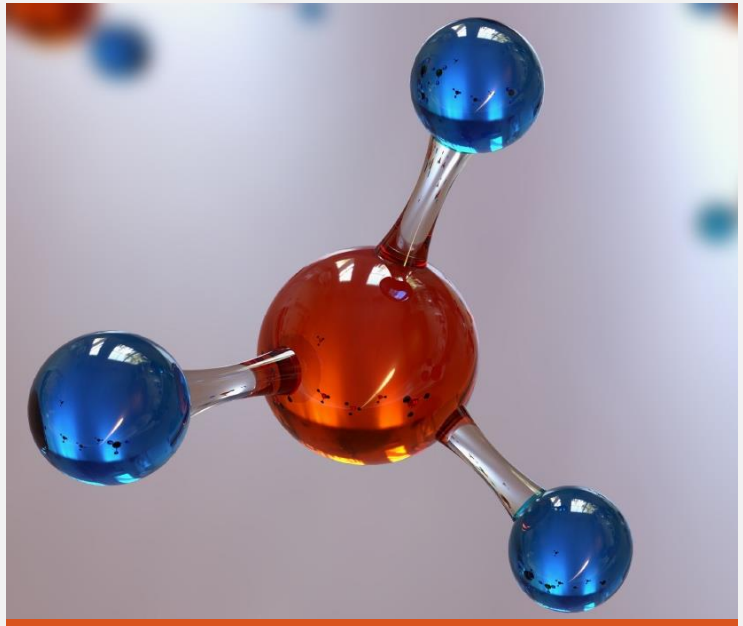
A **Clean Energy Future** for the World

Our Mission

NREL leads research, innovation, and strategic partnerships to deliver solutions for a clean energy economy.



Integrated Energy Pathways



Electrons to Molecules

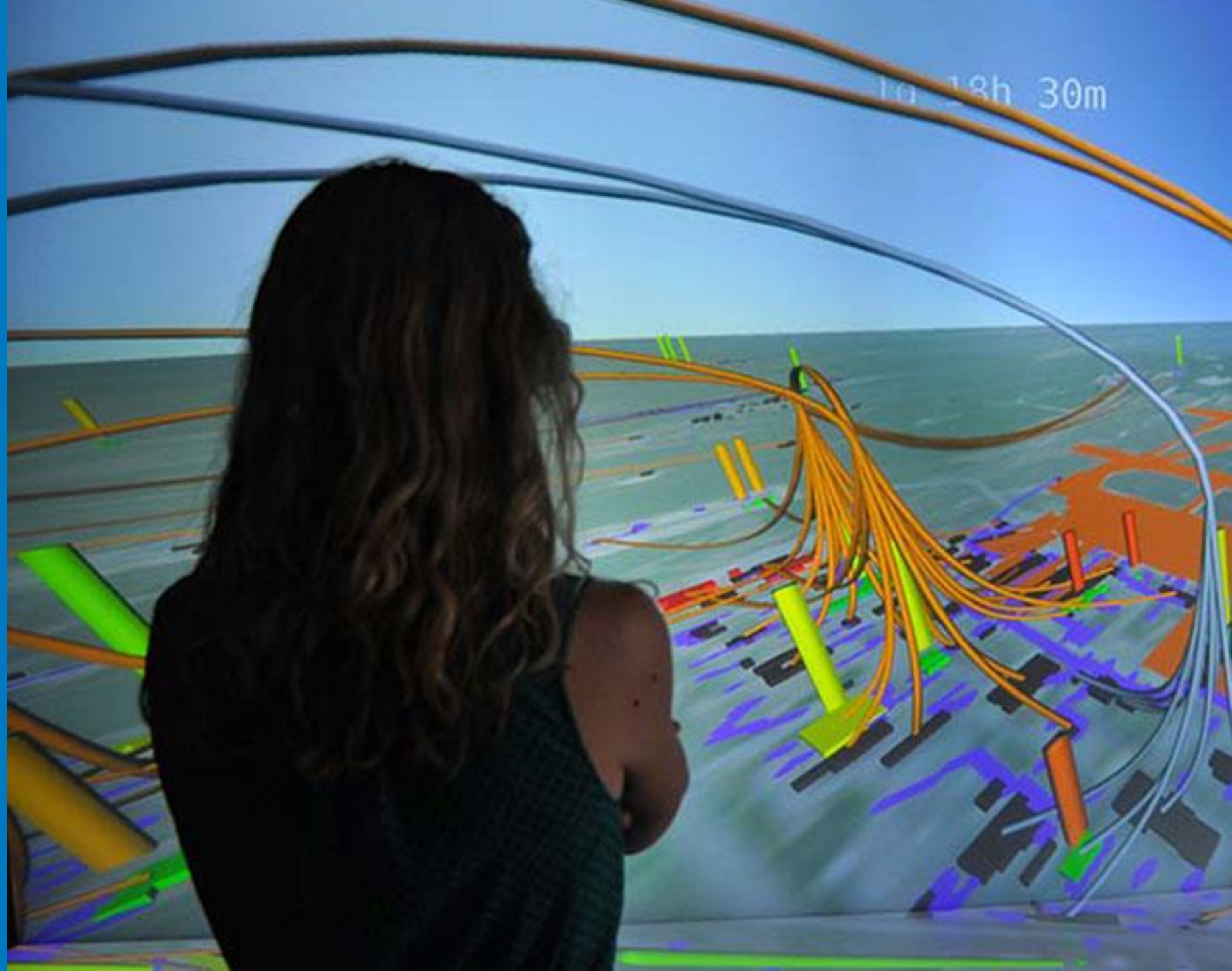
Circular Economy for Energy Materials

NREL's Critical Objectives

Our Critical Objectives describe critical areas where we need to grow, scale, and invest to achieve our vision.

Integrated Energy Pathways

- Modernizing our grid to support a high level of renewable energy integration,
- Using storage and advanced technologies and controls,
- Expanding transportation electrification
- Maintaining grid reliability and security.



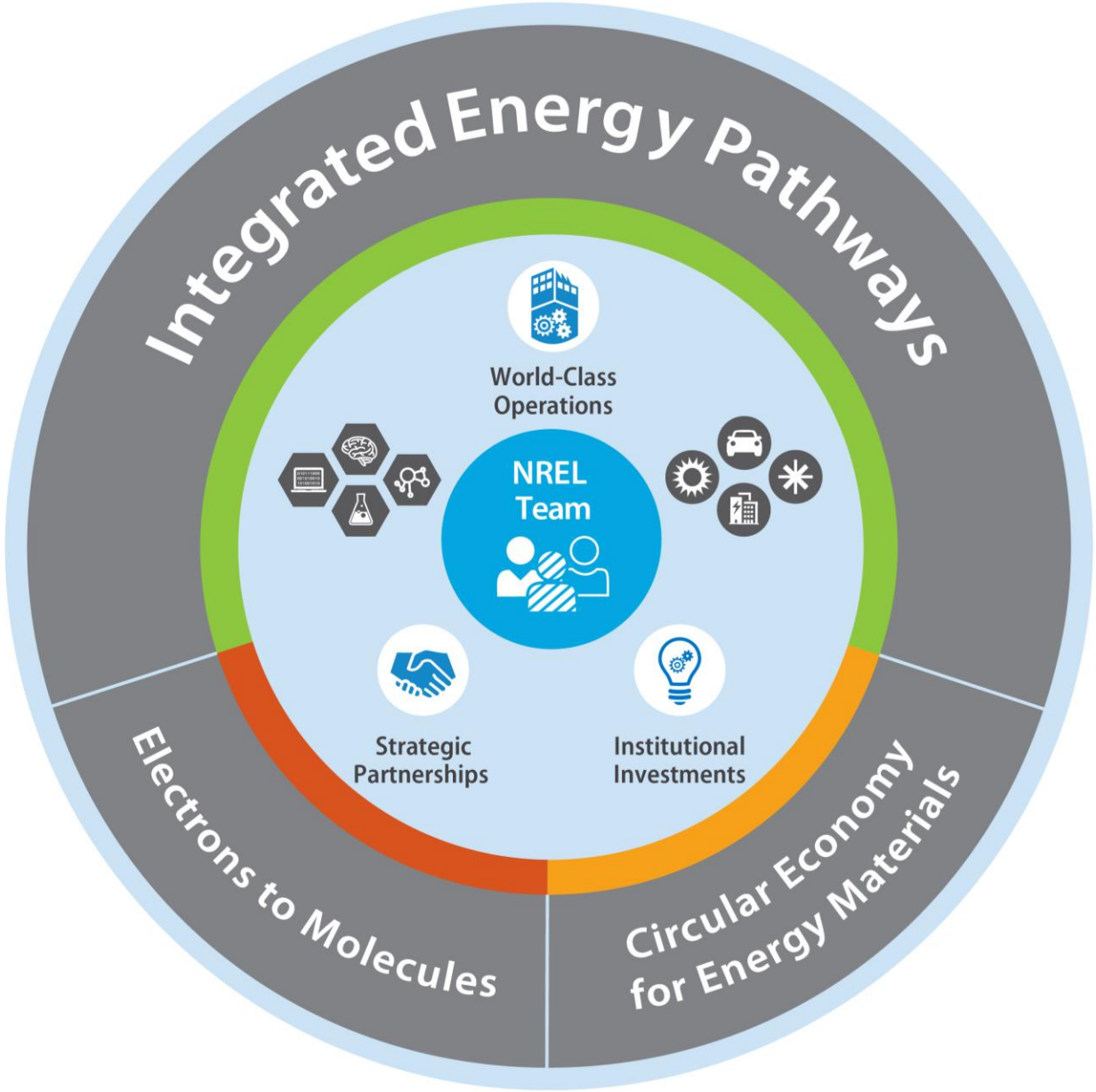
Electrons to Molecules

- Advance deep decarbonization of transportation and industrial sectors through
- Development of cost-competitive, carbon-free hydrogen
- Generation of 10 billion gallons/year of energy-dense fuels produced from renewable electricity, water, CO_2, biomass and/or waste
- Electrification of a wide range of industrial processes for chemicals, materials, and other products.

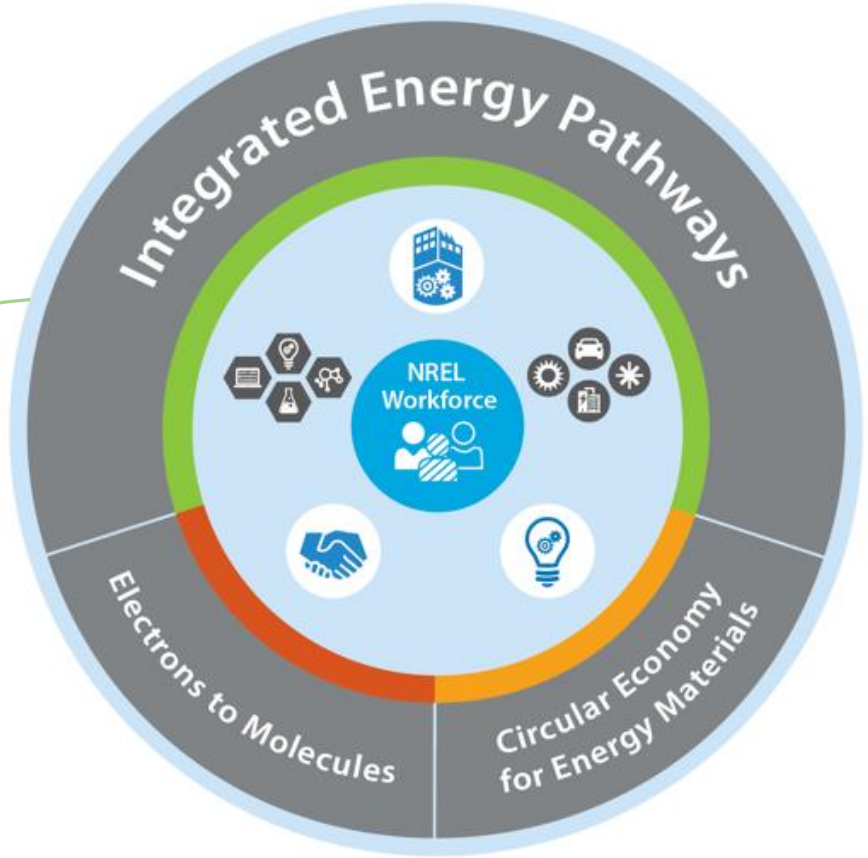
Circular Economy of Energy Materials

- Enable resource sustainability
- Ensure critical supply chains for energy systems
- Polymer upcycling

NREL's Vision:
A Clean Energy Future for the World



Our **Critical Objectives** remain at the center of our strategy



A **Clean Energy Future** for the World

Thank You

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Albert Gore Slides

Albert Gore

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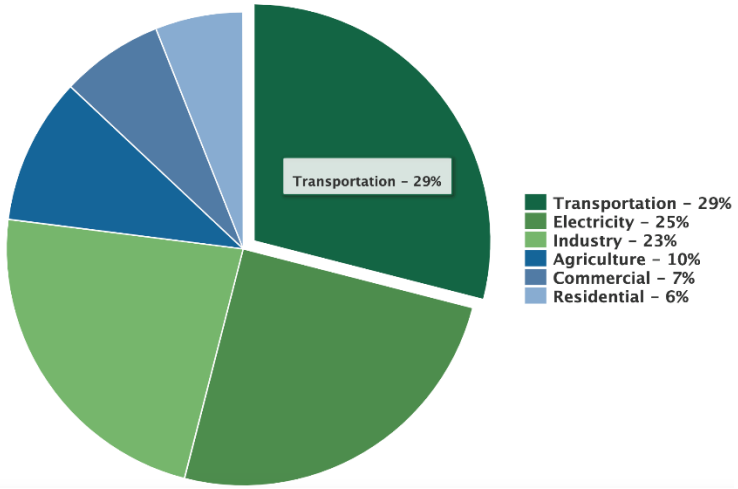
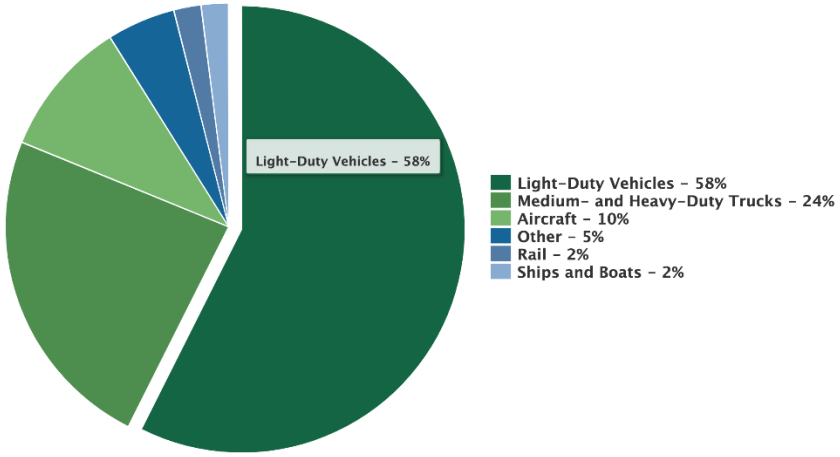
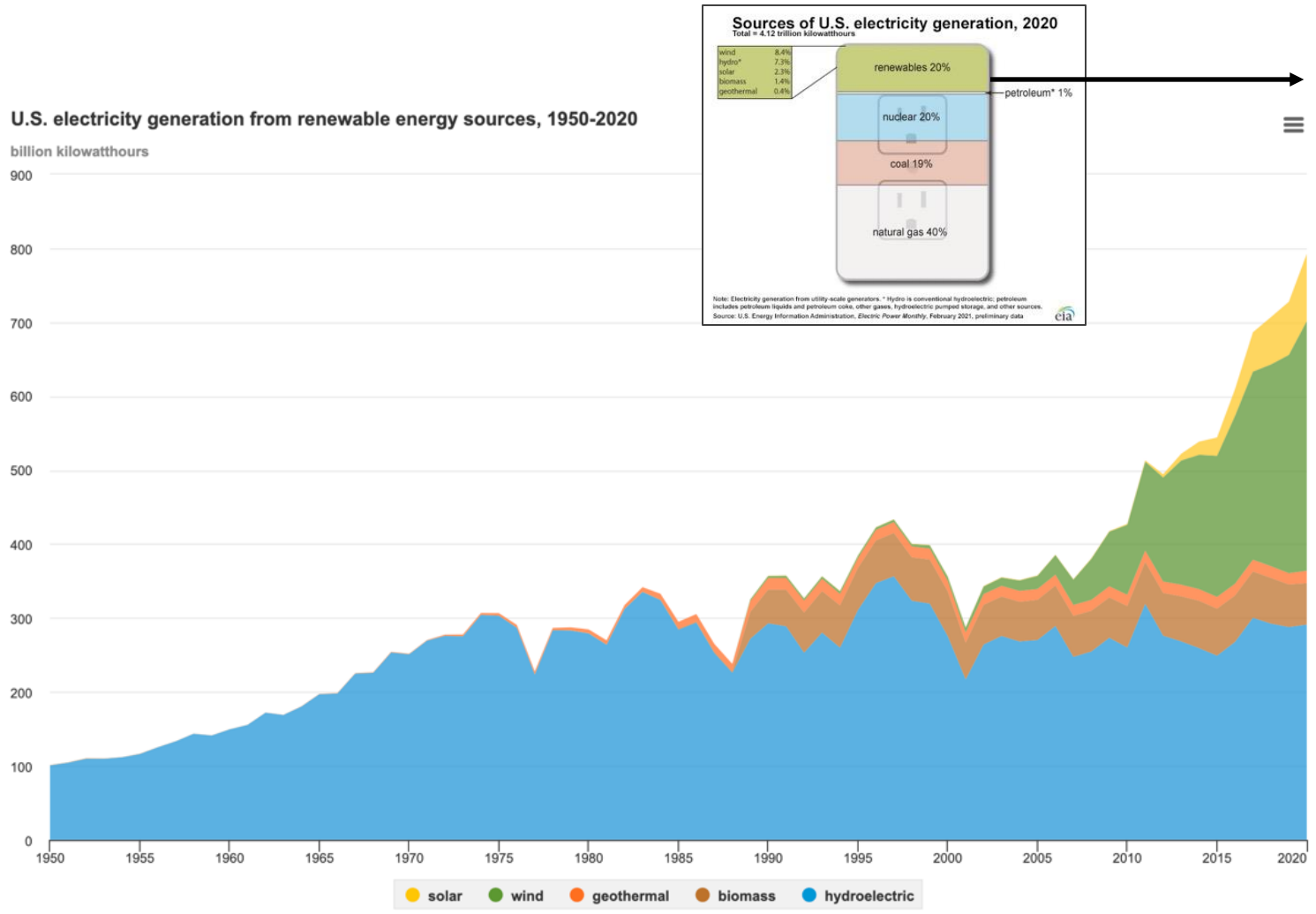
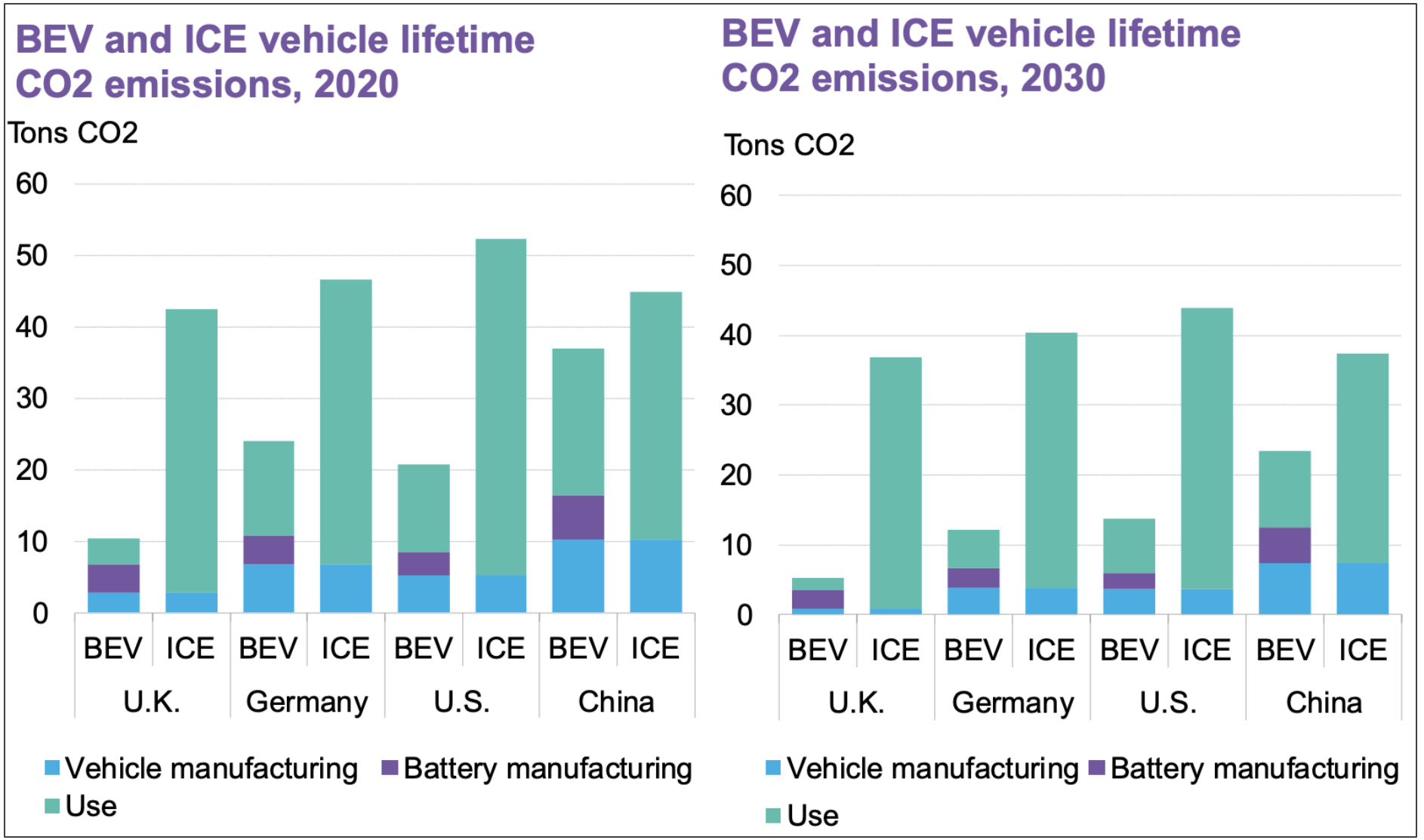
2019 U.S. GHG Emissions by Sector



2019 U.S. Transportation Sector GHG Emissions by Source

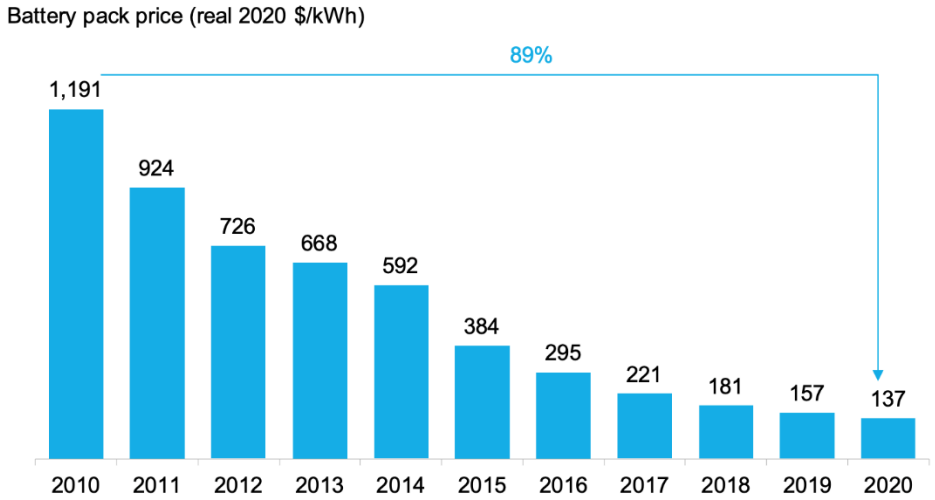






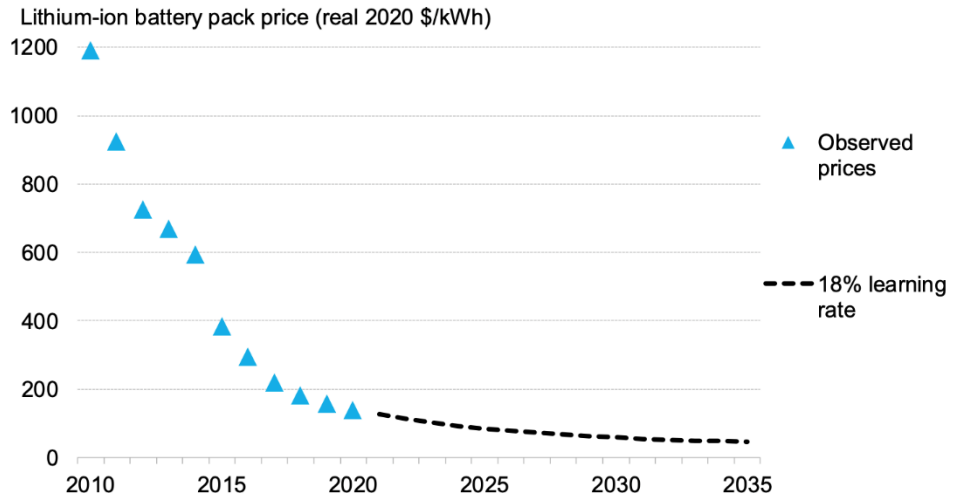
Source: BNEF, ICCT. Note: for European countries we assume that the raw materials and the battery cells are manufactured in Germany and the pack in the country where the vehicle is used; for the U.S. and China the materials, cells and pack are manufactured domestically; the battery size of medium BEV is 71 kWh.

Lithium-ion battery pack price



Source: BloombergNEF.

Lithium-ion battery pack price outlook

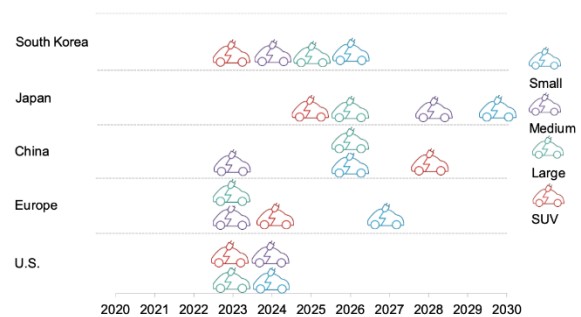


Source: BloombergNEF.

Market drivers

BEVs will soon be cost-competitive to make and buy, on an unsubsidized basis

Year of expected upfront price parity for BEVs vs. ICEs



Falling battery prices will soon start to bring the upfront cost of BEVs to parity with equivalent ICEs.

A battery price of $100/kWh is the point at which we expect EVs will start to reach price parity with internal combustion engine vehicles on an upfront cost basis. (EVs can already compete with ICEs on total cost of ownership in many cases.)

The exact crossover point depends on the region of sale and vehicle segment. For example, medium-sized BEVs are competitive in China and Europe as soon as 2023, while small BEVs are not competitive until 2026 and 2027 in those same regions respectively.

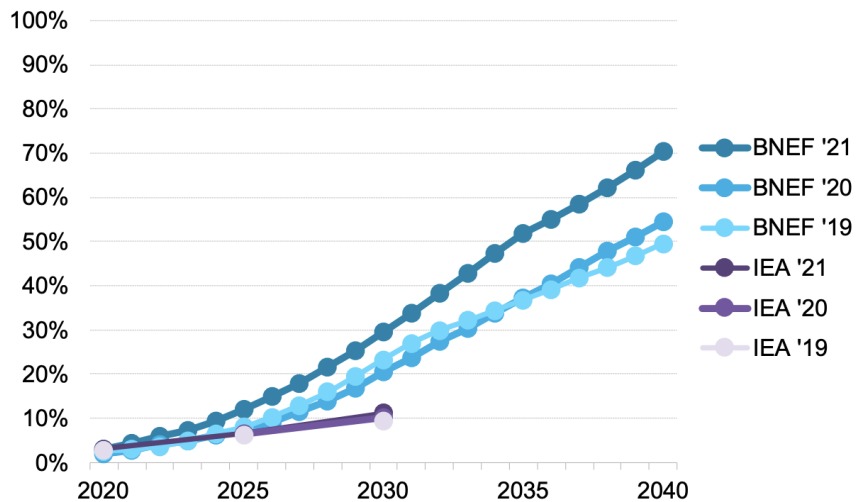
For all vehicle classes, we expect that BEVs can be cost-competitive with ICEs before the end of the decade.

Some vehicle segments, in some countries, can reach price parity very soon.

We estimate SUVs in the U.S. can reach price parity as soon as 2023, while in Europe this won't happen until 2024. In contrast, Europe will see large cars reach parity in 2023.

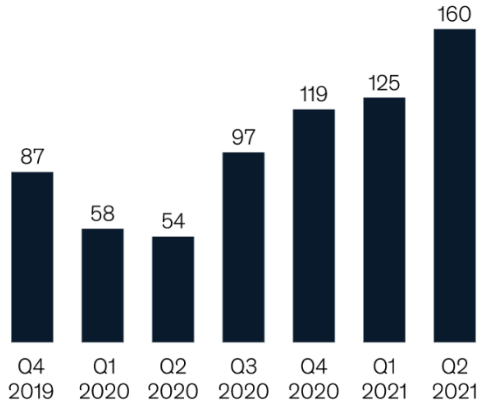
Source: BloombergNEF. Note: Includes direct manufacturing cost and additional cost. Tax not included. Might vary by country depending on local policy.

Global ZEV share of passenger vehicle sales, various outlooks

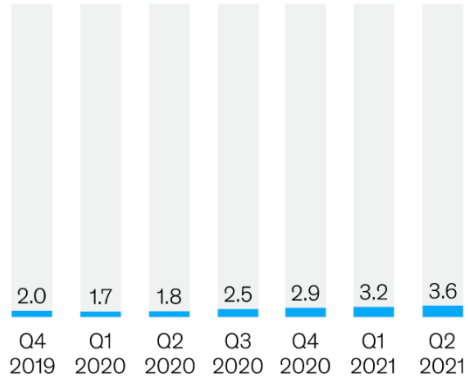


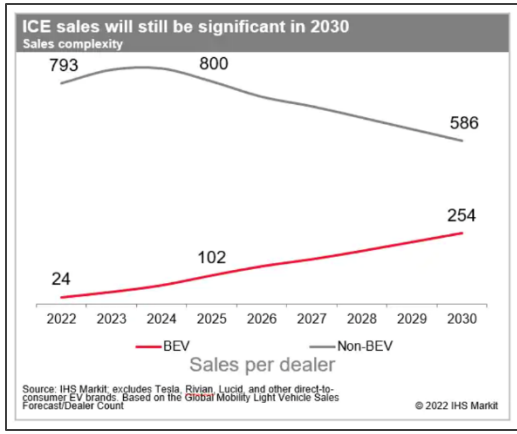
In Q2 2021, US electric-vehicle sales reached 3.6 percent of total car sales.

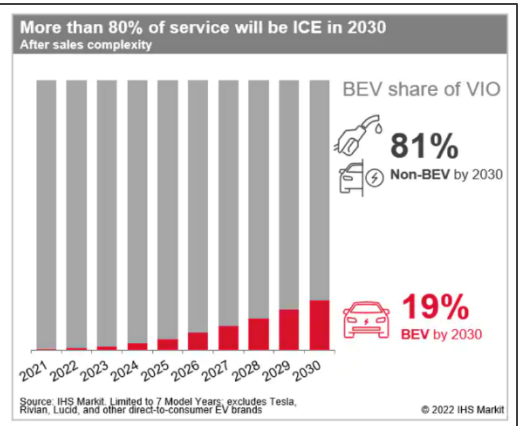
US electric-vehicle sales, thousands



US electric-vehicle sales as share of total vehicle sales, %

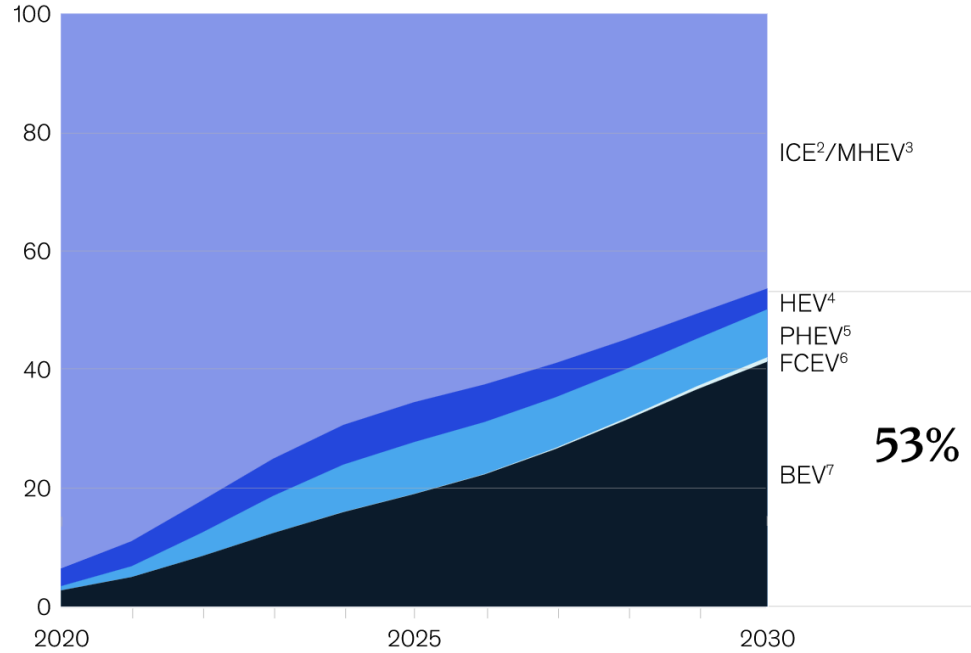






If electric-vehicle adoption continues to accelerate, EVs are likely to account for more than half of all US passenger car sales by 2030.

US new light-vehicle sales,[1] % of total sales



Note: Numbers may not sum to total, because of rounding.
[1]Expected case. Electric-vehicle-scenario assumptions include battery-pack prices of $125 per kilowatt hour (kWh) for 2020, $94/kWH for 2025, and $87/kWh for 2030. Assumed fuel-consumption targets are 47 miles per gallon (mpg) for 2020, 50 mpg for 2025, and 63 mpg for 2030. [2]Internal combustion engine. [3]Mild hybrid electric vehicles. [4]Hybrid electric vehicles. [5]Plug-in hybrid electric vehicles. [6]Fuel cell electric vehicles. [7]Battery-electric vehicles.
Source: EV-volumes.com; HIS Markit; International Council on Clean Transportation; literature search; McKinsey Center for Future Mobility; McKinsey Electrification Model

McKinsey & Company

President Barack Obama greets Ford President and CEO of Ford Alan Mulally and other auto industry executives following his remarks on fuel efficiency standards for 2017-2025 model year cars and light-duty trucks during an event at the Washington Convention Center in Washington, D.C., July 29, 2011. (Official White House Photo by Pete Souza)

Administrator Scott Pruitt and the CEOs of the National Automobile Dealers Association, Alliance of Automobile Manufacturers, and the Association of Global Automakers, smiling as the administration announces its plan to roll back the 2022-2025 vehicle emissions standards (EPA).

IN THE UNITED STATES COURT OF APPEALS
FOR THE DISTRICT OF COLUMBIA CIRCUIT

STATE OF TEXAS, *et al.*, *Petitioners*, v. UNITED STATES ENVIRONMENTAL PROTECTION AGENCY, *et al.*, *Respondents*.	No. 22-1031 (consolidated with Nos. 22-1032, 22-1033, 22-1034, 22-1035, 2-1036, 22-1038)

MOTION OF THE ALLIANCE FOR AUTOMOTIVE INNOVATION TO INTERVENE IN SUPPORT OF RESPONDENTS

Pursuant to Federal Rules of Appellate Procedure 15(d) and 27 and Circuit Rules 15(b) and 27, the Alliance for Automotive Innovation ("Auto Innovators")[1] respectfully moves for leave to intervene in the above-captioned consolidated

[1] Formed in 2020, the Alliance for Automotive Innovation is the singular, authoritative, and respected voice of the automotive industry. Focused on creating a safe and transformative path for sustainable industry growth, the Alliance for Automotive Innovation represents the manufacturers producing nearly 98 percent of cars and light trucks sold in the U.S. The organization is involved in regulatory and policy matters impacting the light-duty vehicle market across the country. Members include U.S. operations of international motor vehicle manufacturers, original equipment suppliers, technology, and other automotive-related companies and trade associations. The Alliance for Automotive Innovation is headquartered in Washington, DC, with offices in Detroit, MI, and Sacramento, CA. For more information see http://www.autosinnovate.org.