The Future of Clean Energy in the U.S.

DRIVERS, INNOVATIONS, AND CHALLENGES

PRESENTED BY
Sam Newell

PRESENTED FOR
Morgan Stanley Equity Research

OCTOBER 7, 2020

Brattle

Disclaimer

PLEASE NOTE

This presentation shall not be intended to serve as a substitute for your own analysis or for the exercise of your own business judgment in any decisions you might make, nor shall it constitute investment advice under any circumstances.

The Brattle Group does not accept liability under any theory for losses suffered, whether direct or consequential, arising from any party's reliance on our analyses or from the failure of assets to have at any point or points in time any specific economic value, and cannot be held responsible for any conclusion drawn from this presentation should it prove to be inaccurate.

Any recipient of this presentation, whether in electronic, hard copy, visual, or oral form, proposing to engage in commercial activity or make commercial decisions in relation to energy markets and/or energy prices anywhere in the world should apply dedicated, specialist analysis to the specific legal and business challenges spanning the activities/decisions in question. This presentation in no way offers to substitute for such analysis.

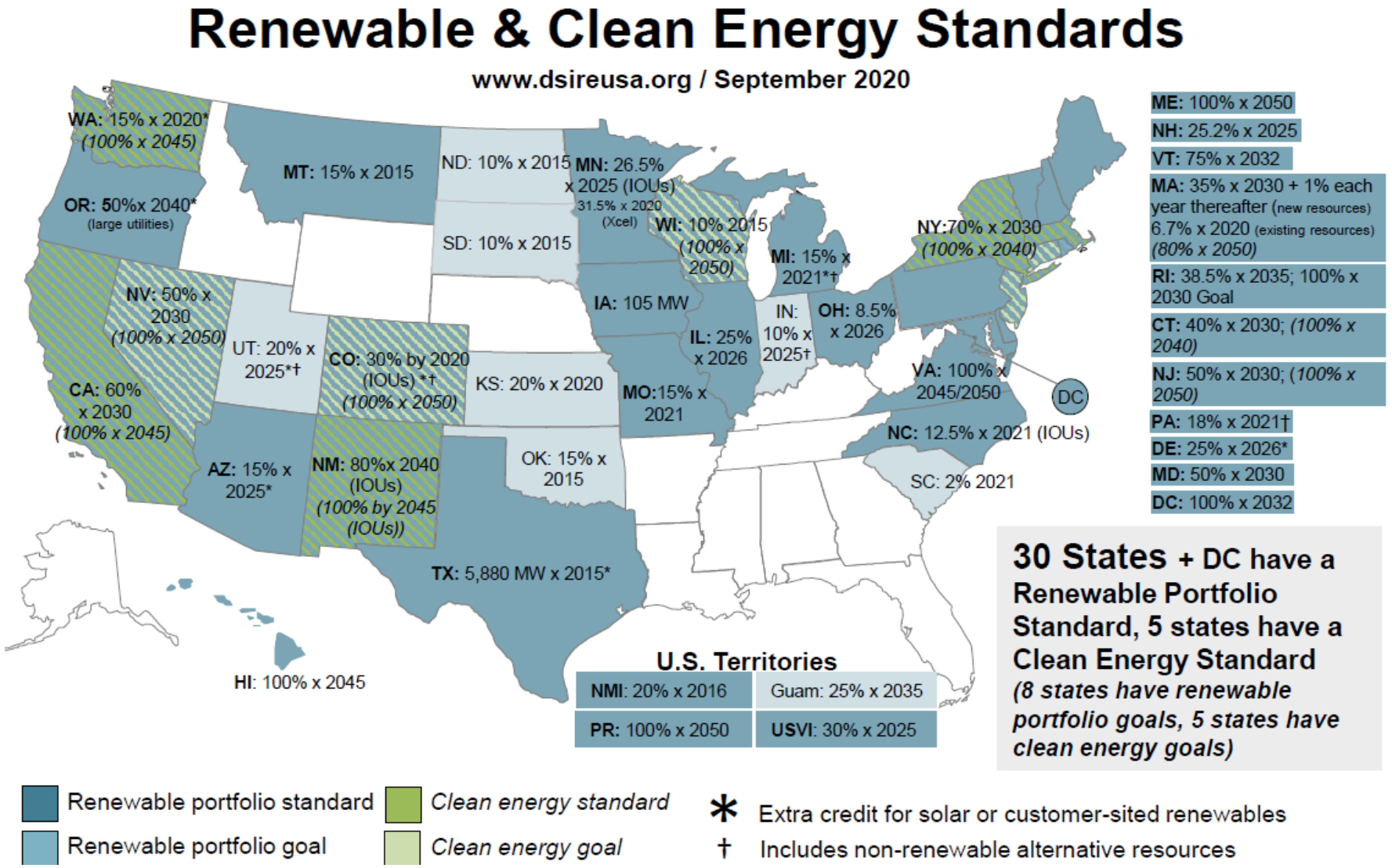
Agenda

I. Drivers of Clean Energy Investment

II. Innovations to Watch

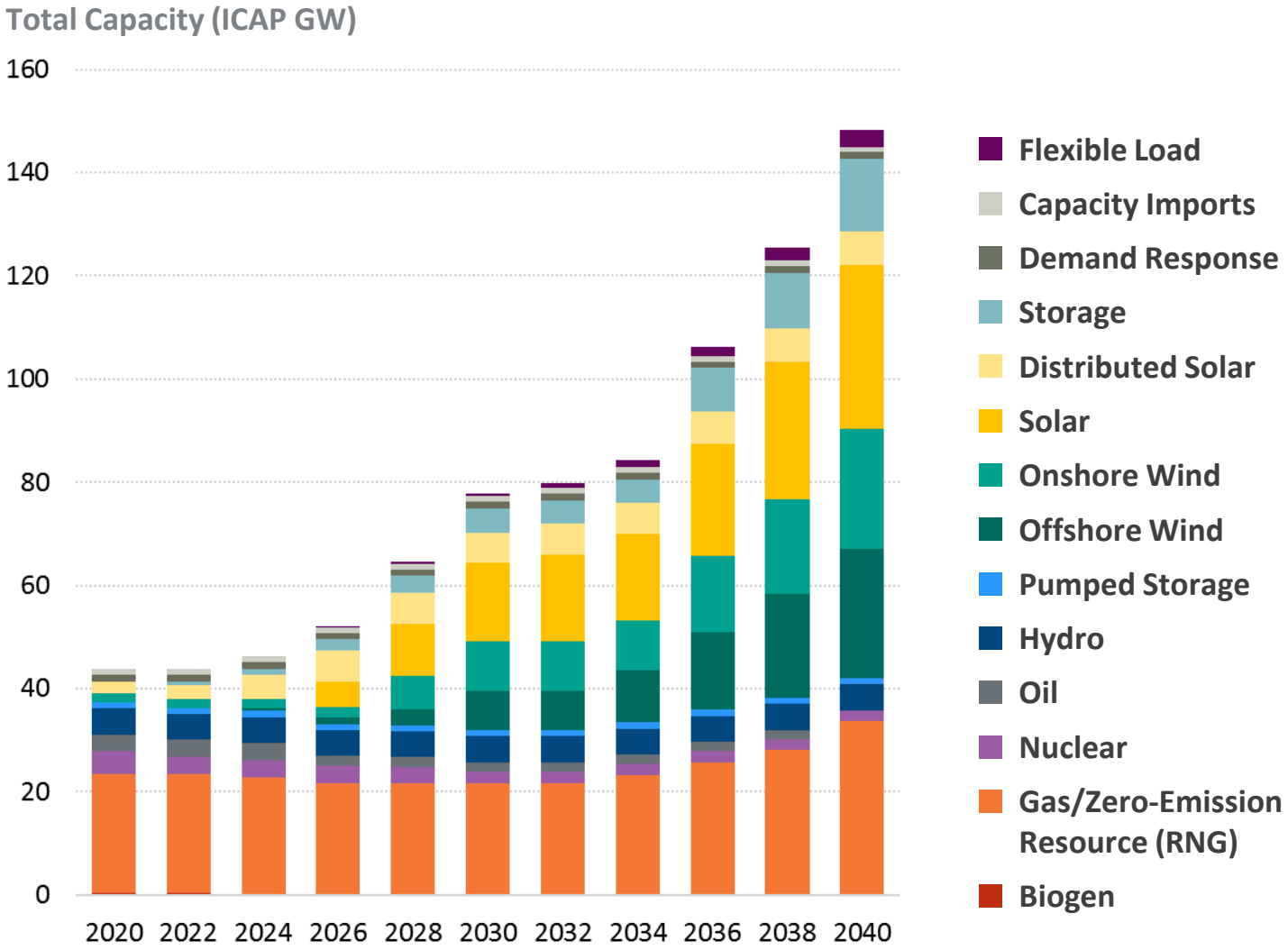
III. Long-term Challenges

State Clean Energy Mandates



Source: https://s3.amazonaws.com/ncsolarcen-prod/wp-content/uploads/2020/09/RPS-CES-Sept2020.pdf

New York Needs +35 GW Renewables by 2030, 80 GW by 2040



Resources that **grow in capacity**

- Renewables to meet zero-emissions mandate
- Storage and flexible load for short-term balancing (+5 GW storage by 2030; 14 GW storage + 3 GW flex load by 2030)
- Dispatchable generation: gas-fired generators switch to zero-carbon fuel (RNG) in 2040, for long-term balancing

Resources that **maintain their capacity**

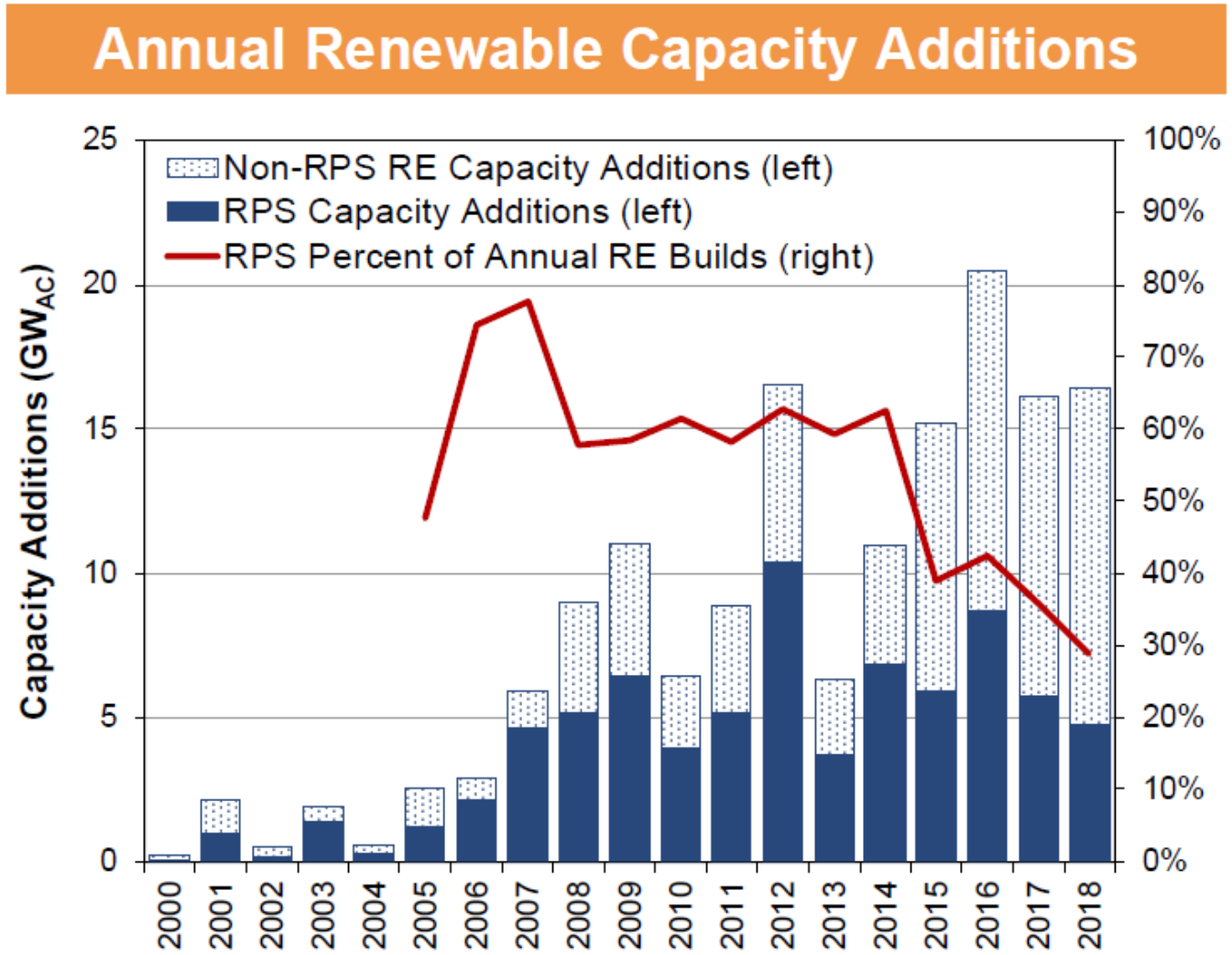
- Pumped storage for short-term balancing
- Hydro continues to provide clean power

Resources that **shrink in capacity**

- Portion of nuclear fleet retires by 2030 due to high refurbishment costs
- Oil-fired generation fully retires by 2040

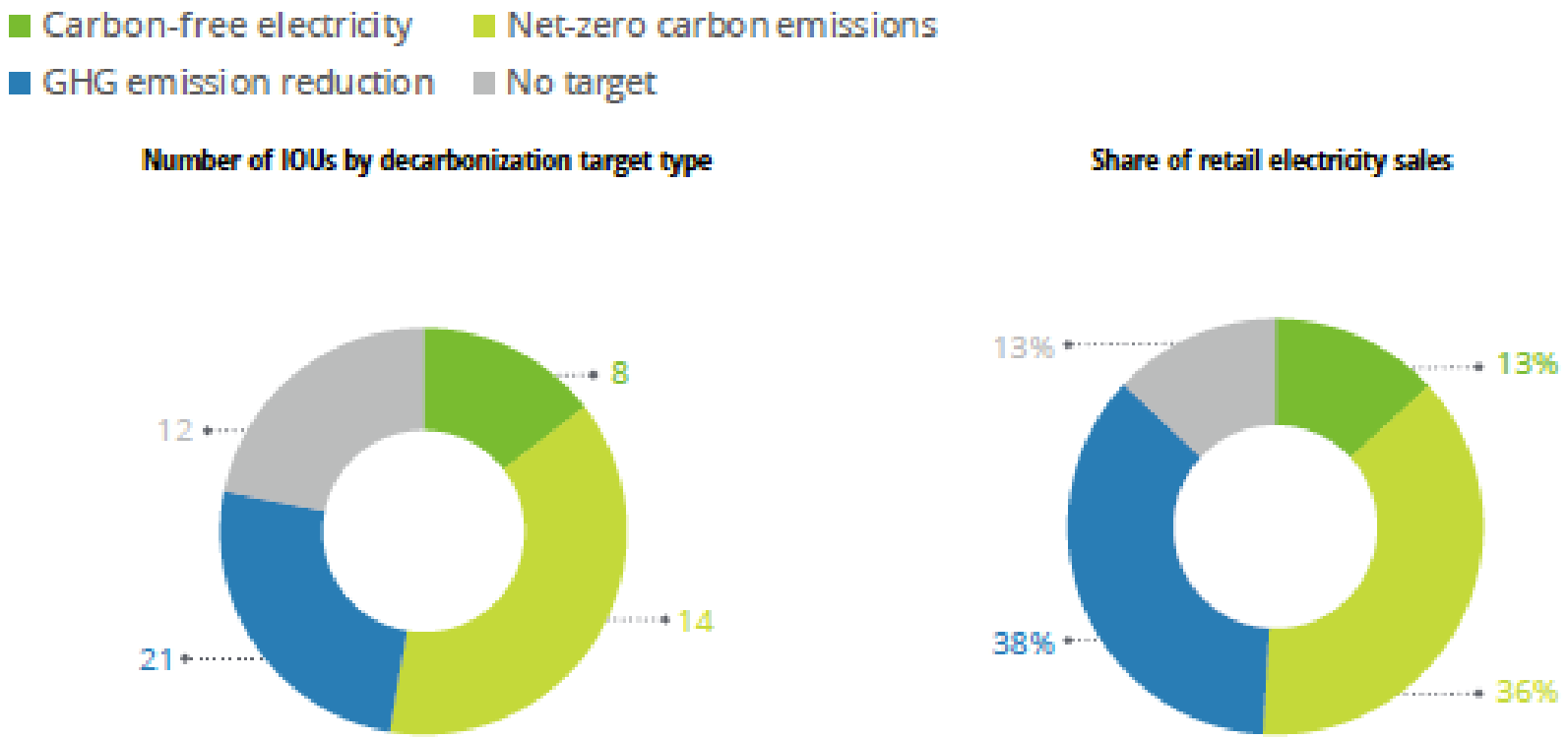
Source: The Brattle Group, New York's Evolution to a Zero Emission Power System, prepared for NYISO, June 22, 2020.

But State Mandates are Not the Only Driver



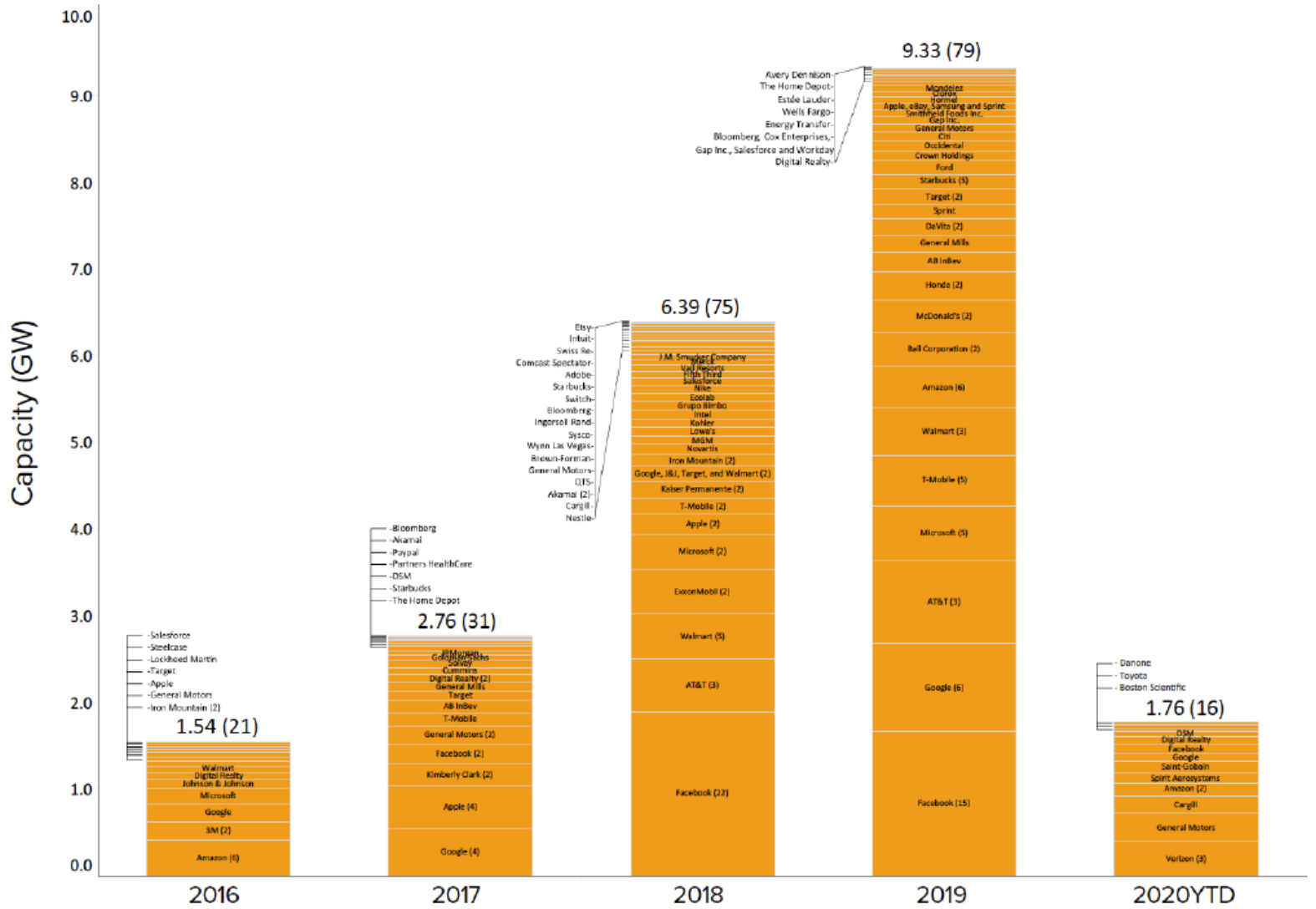
Source: G. Barbose, "U.S. Renewables Portfolio Standards—2019 Annual Status Update," Lawrence Berkeley National Lab, July 2019.

Many Utility Targets Exceed RPS, for Environmental & Economic Reasons



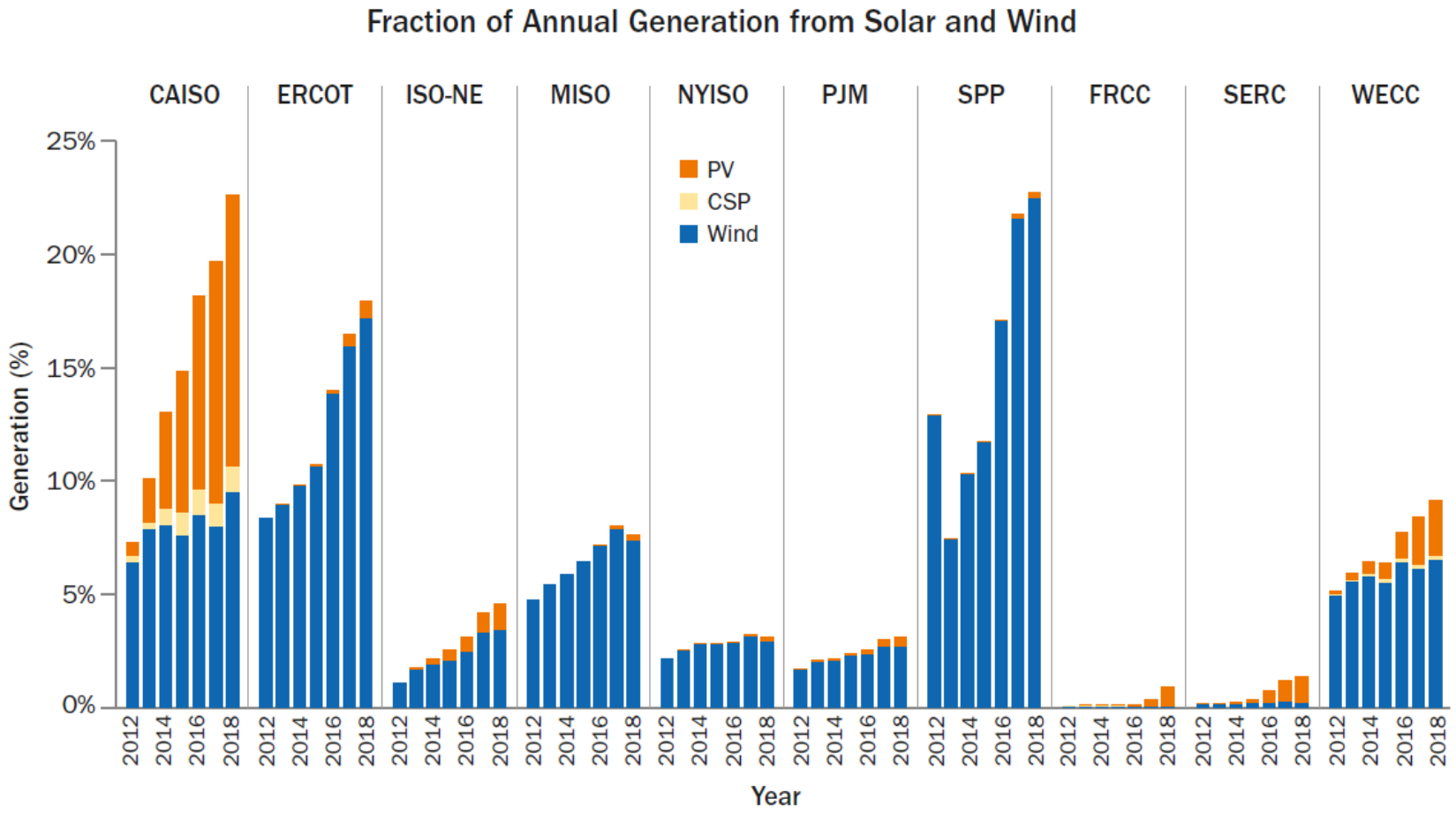
Source: Deloitte Insights, "Utility Decarbonization Strategies," September 2020, p. 4.

Corporate Renewable Purchases Are Growing



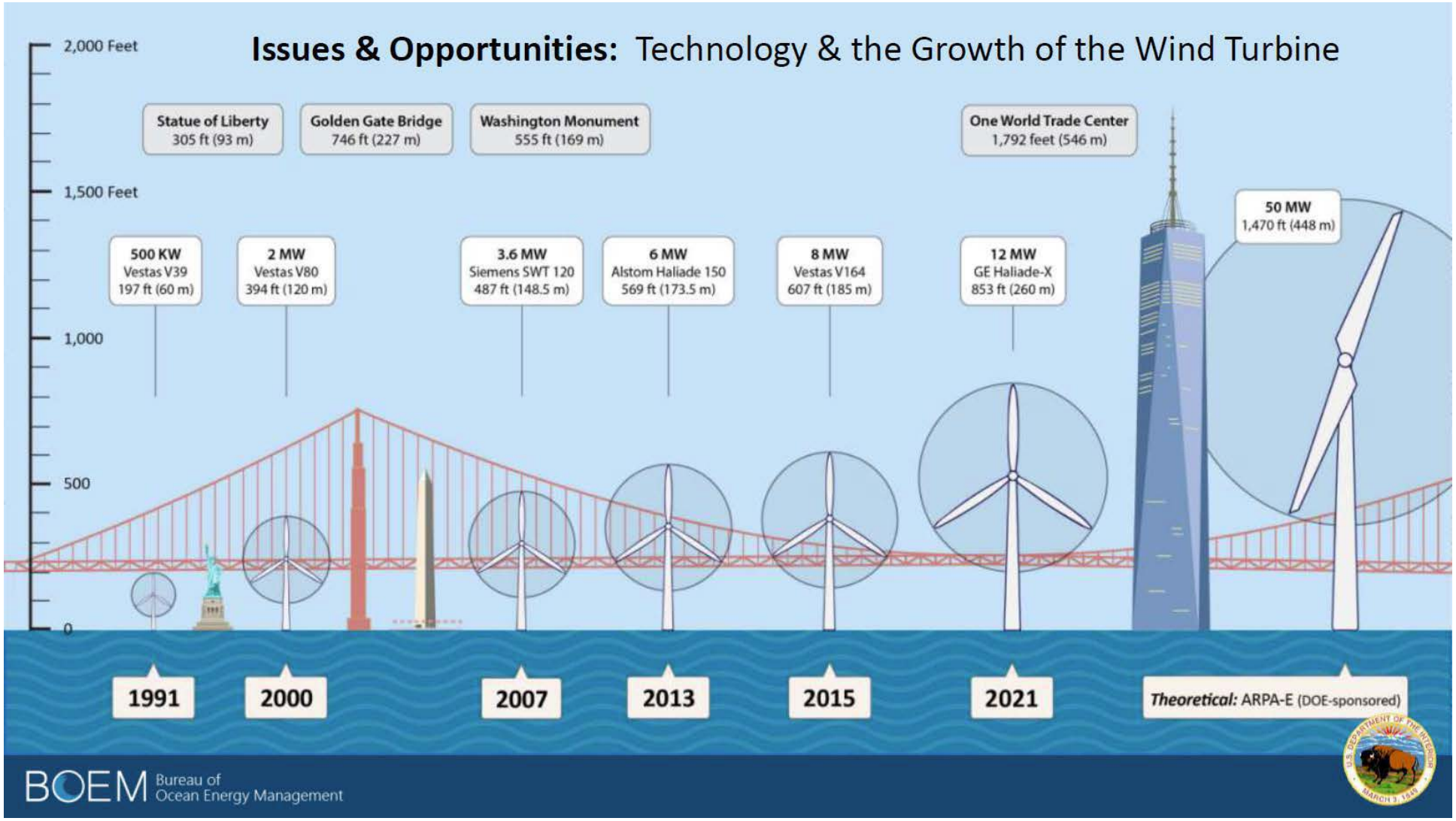
Source: Renewable Energy Buyers Alliance, accessed from https://rebuyers.org/deal-tracker/, Oct 1, 2020.

Renewable Energy Penetration So Far, By Region



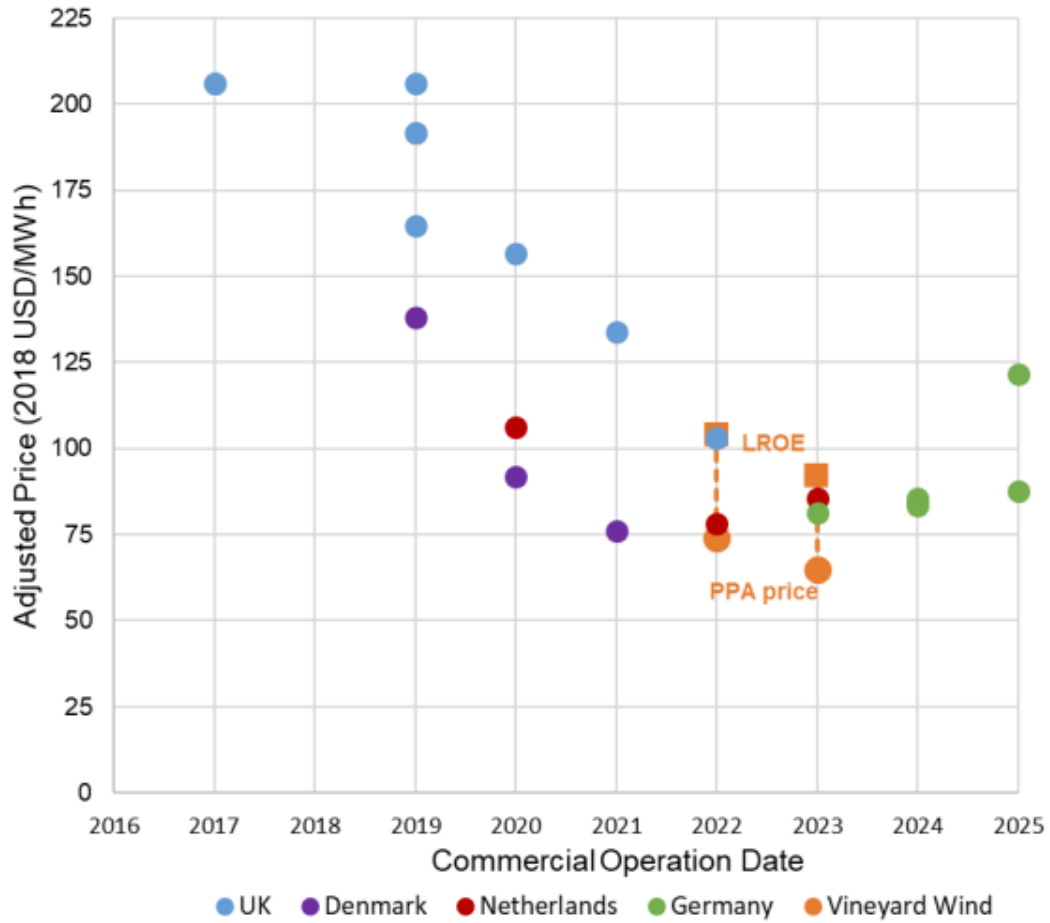
Source: *2018 Renewable Energy Grid Integration Data Book*, U.S. Department of Energy, National Renewable Energy Laboratory (NREL) and the Lawrence Berkeley National Laboratory (LBNL), March 2020.

Larger Turbines



Source: Bennett, J. U.S. Outer Continental Shelf Renewable Energy. Bureau of Ocean Energy Management. Presented at The Council of State Governments/Eastern Regional Conference. August 14, 2017.

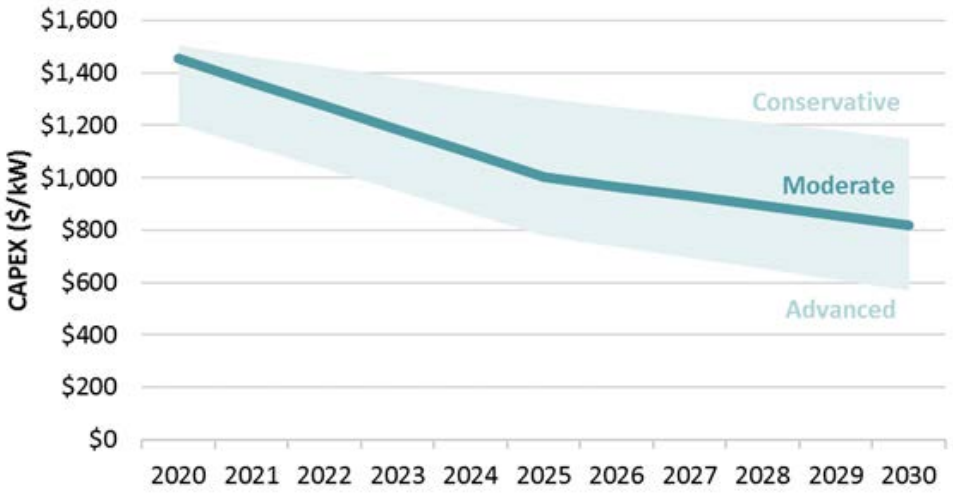
Cost Declines Exhibited in Offshore Wind PPAs



Source and notes: P. Beiter, "The Vineyard Wind Power Purchase Agreement: Insights for Estimating Costs of U.S. Offshore Wind Projects," National Renewable Energy Laboratory, February 2019. https://www.nrel.gov/docs/fy19osti/72981.pdf. "Adjusted Price" adds revenues exogenous to PPAs, including capacity and tax credits (Vineyard) and grid and development costs (D, NL, DK), in order to reflect the full economic cost.

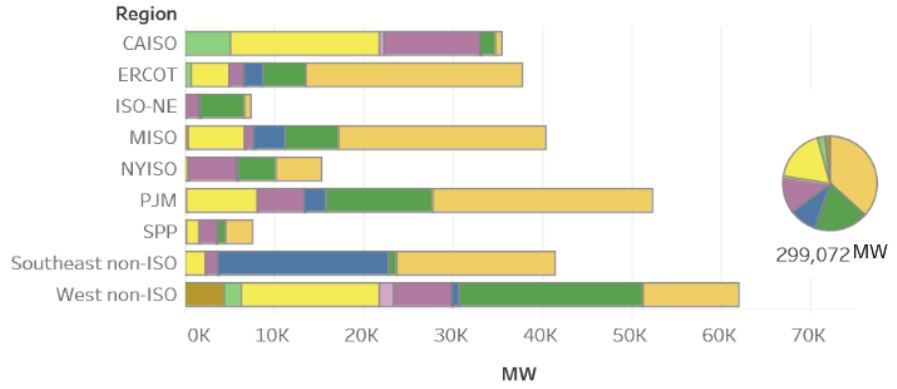
Ongoing Development & Implementation of Storage

Projected Installed Cost for 4-hr Li-ion Storage Systems

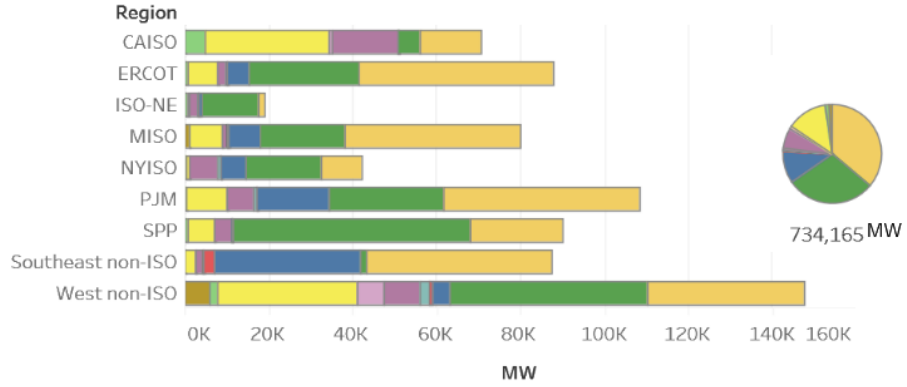


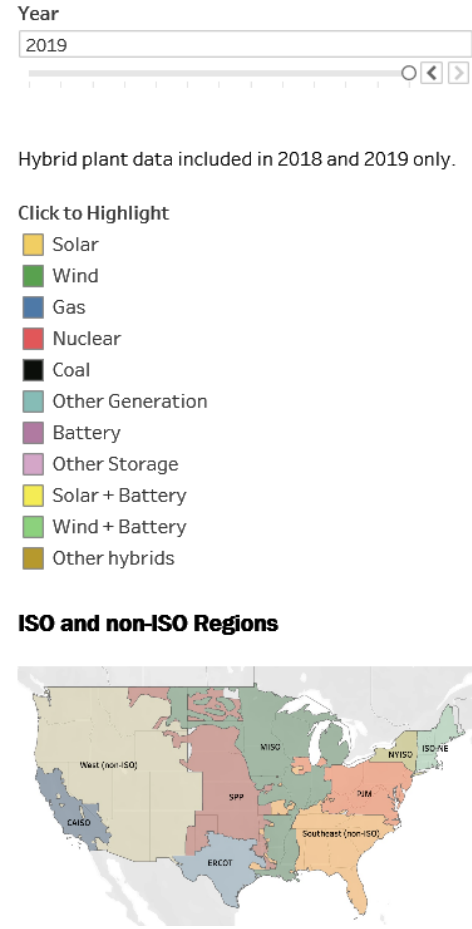
Source: NREL 2020 ATB https://atb.nrel.gov/electricity/2020/index.html?t=su

Capacity Entering the Queue During 2019



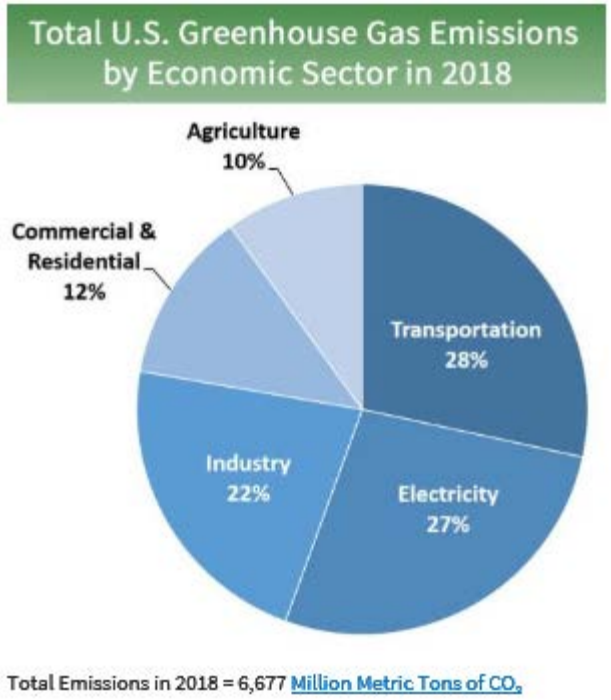
Total Capacity in Queue at End of 2019



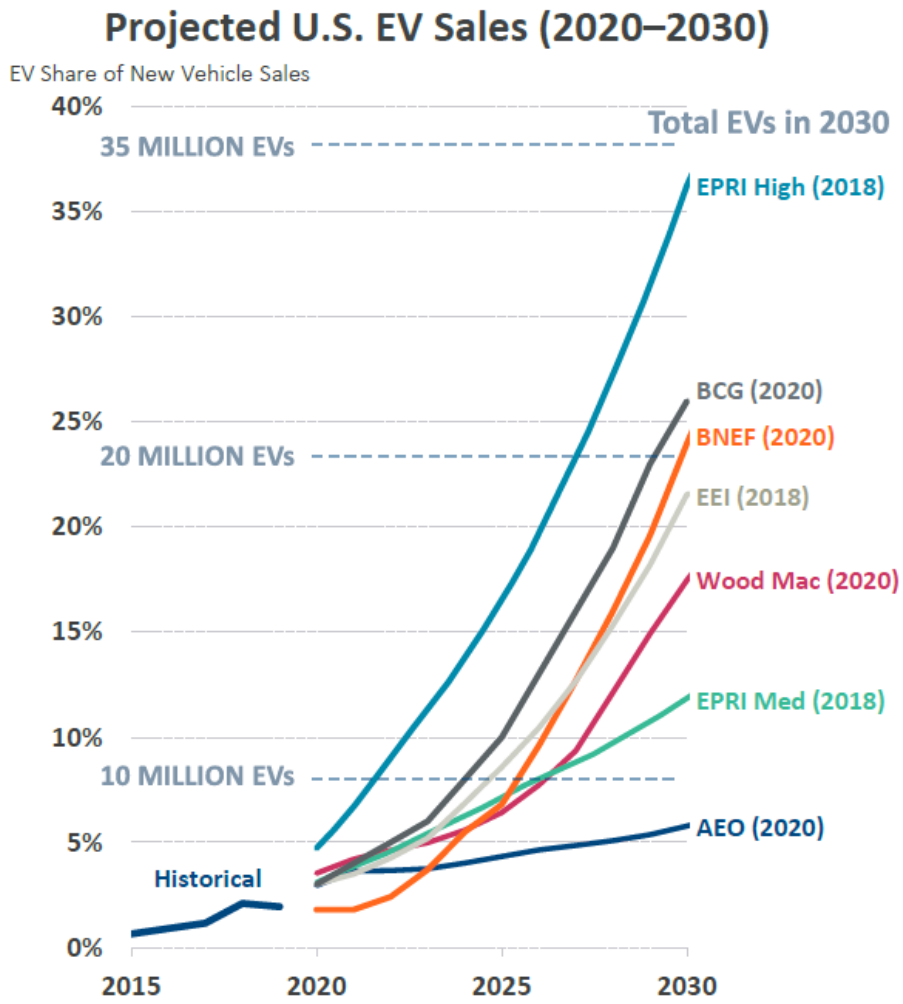


Source: https://emp.lbl.gov/generation-storage-and-hybrid-capacity

Electrification



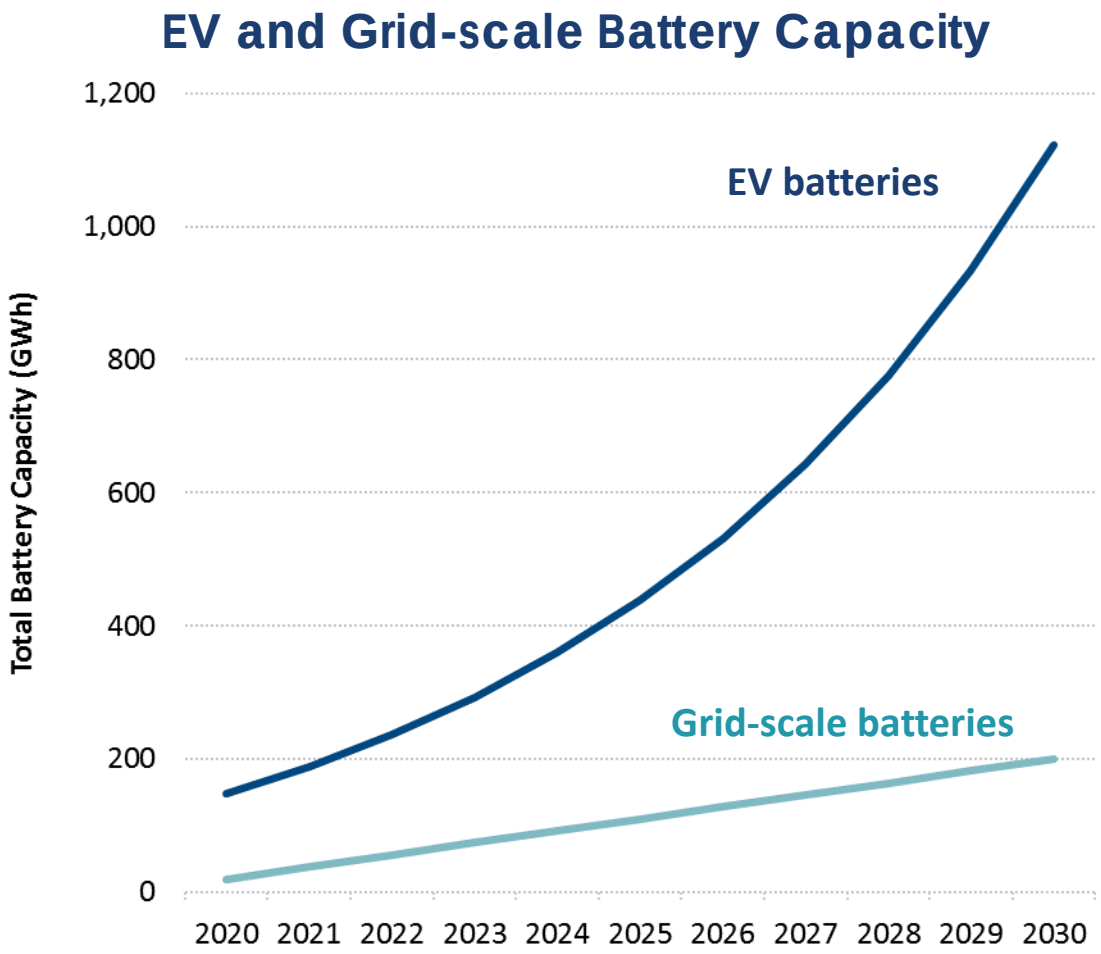
Source: https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions



Source (right): M. Hagerty et al., "Getting to 20 Million EVs by 2030Opportunities for the Electricity Industry in Preparing for an EV Future," The Brattle Group, June 2020.
EPRI, PEV Market Projection Assumptions: June 2018 Update, June 2018. (EPRI Low forecast not shown because its 2030 forecast is below the levels already obtained.); BCG, Who Will Drive Electric Cars to the Tipping Point?, January 2020.; BNEF, Electric Vehicle Outlook, 2020; IEI/EEI, Electric Vehicle Sales Forecast and the Charging Infrastructure Required through 2030, November 2018; Wood Mackenzie, Electric car forecast to 2040, accessed May 2020; EIA, Annual Energy Outlook: Light-duty vehicle sales by technology type and Census Division: United States, 2020.

See Disclaimer on Slide 2

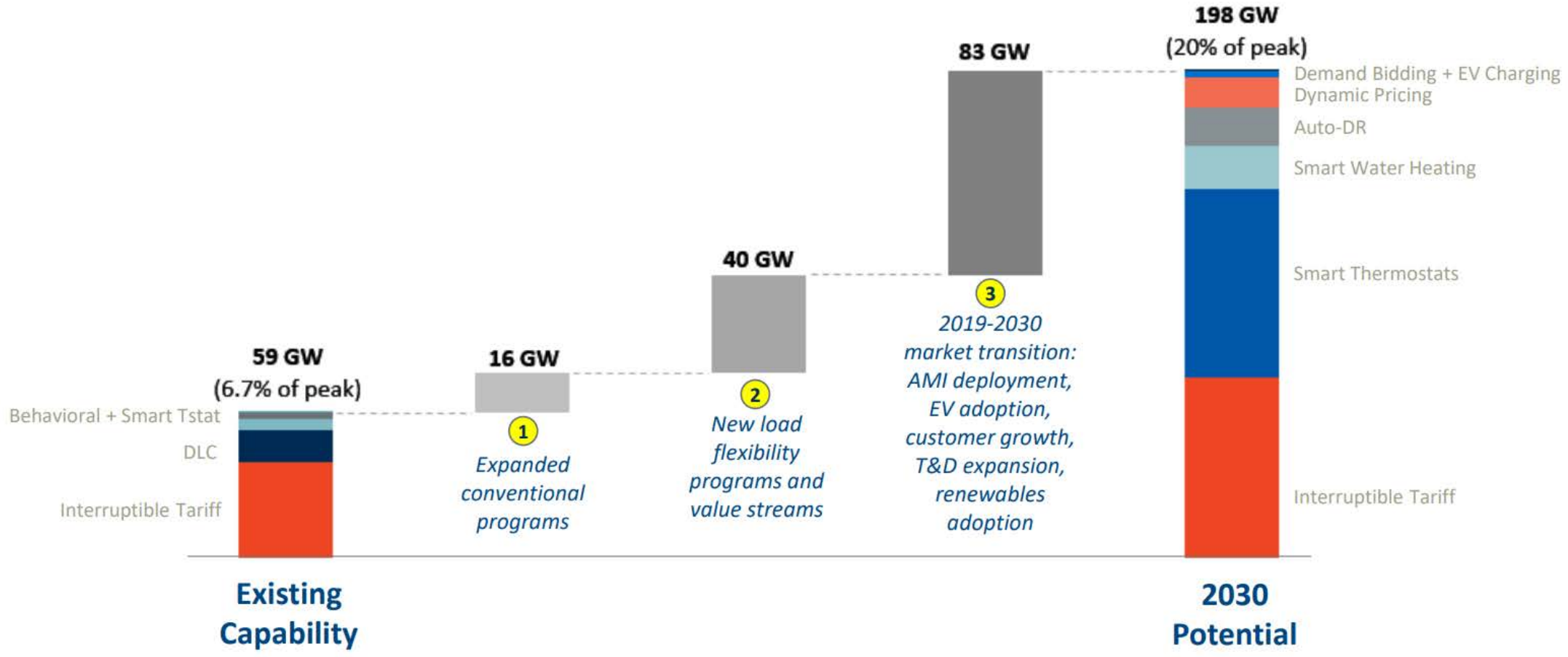
V2G?



Source: Brattle analysis

Load Flexibility

US Cost-Effective Load Flexibility Potential



See Disclaimer on Slide 2

Source: R. Hledik et al., "The National Potential for Load Flexibility," The Brattle Group, June 2019.

Where to Site to Many Wind and Solar Resources?

Brattle-NYISO Grid Evolution Study: *Modeled vs. Feasible Resources*

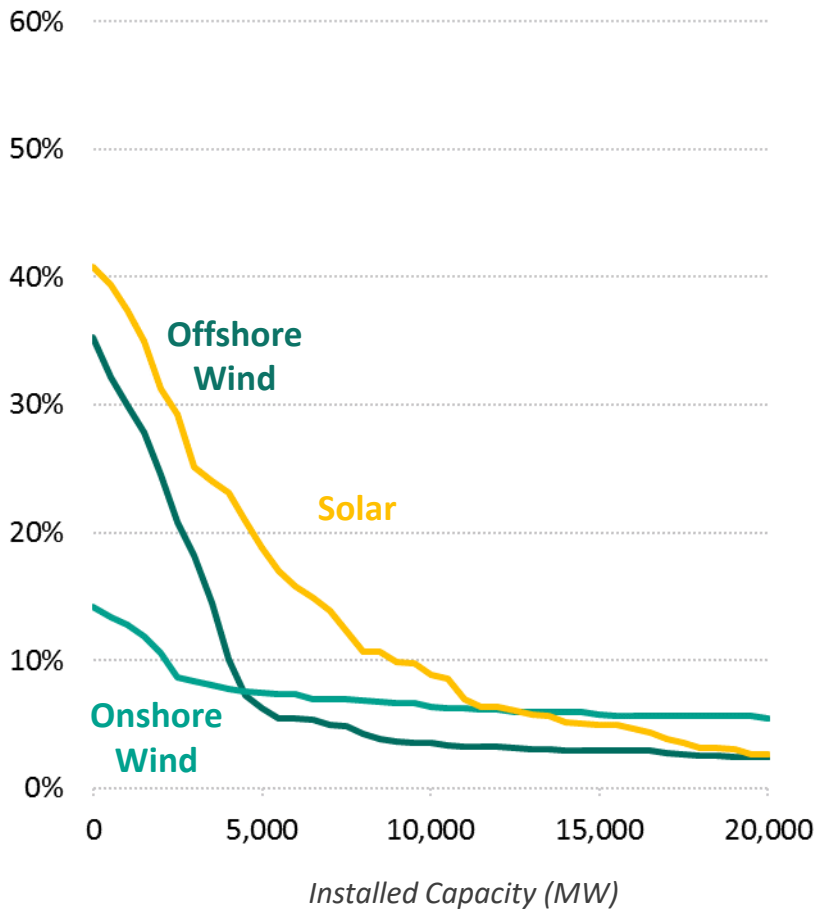
	Base Case Capacities		"Maximum Feasible" Capacity by 2030		Technical Potential
	2030	2040	DPS	NYSERDA	NREL
Onshore Wind	9.7 GW	23.3 GW	10 GW	8 GW	26 GW
Offshore Wind	7.6 GW	25.1 GW	10 GW	7 GW	146 GW
Solar	21.1 GW	38.1 GW	7 GW	48 GW	984 GW

Sources: The Brattle Group, New York's Evolution to a Zero Emission Power System, prepared for NYISO, June 22, 2020. Based on: NYSERDA (2014). Energy Efficiency and Renewable Energy Potential Study of New York State, Provides bounds on max annual energy production (GWh), which we convert to MW assuming capacity factors of 13%, 26%, and 42% for solar, onshore wind, and offshore wind respectively. DPS (2016). Clean Energy Standard White Paper – Cost Study. Quantities estimated as maximum value of 2030 supply curves; NREL (2012). U.S. Renewable Energy Technical Potentials: A GIS-Based Analysis.

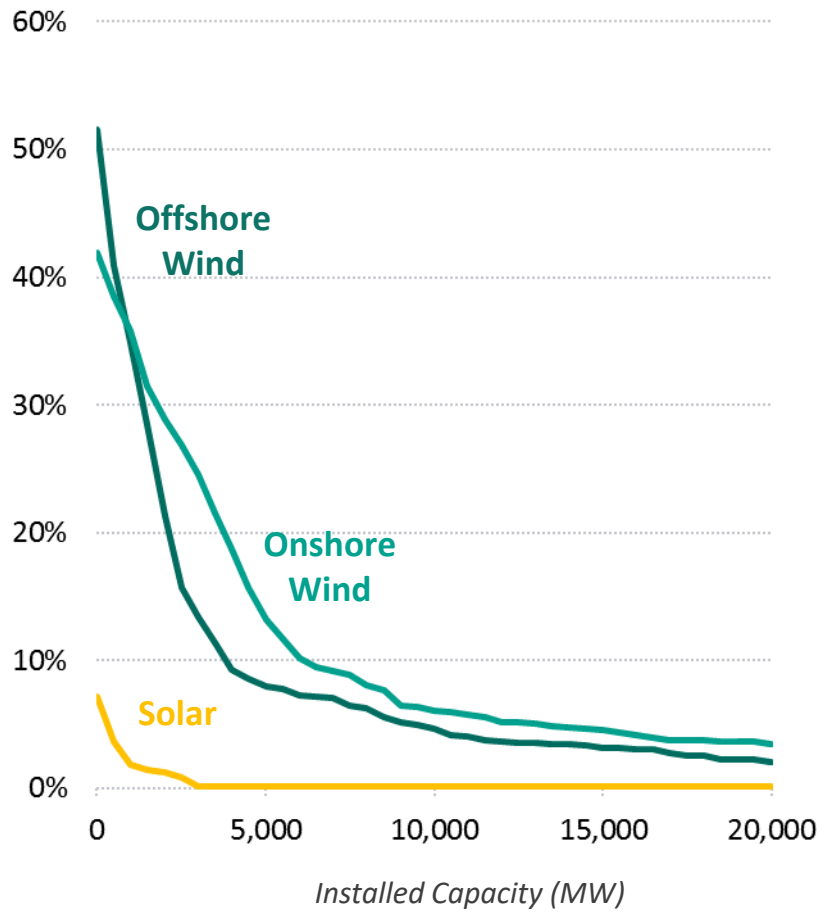
See Disclaimer on Slide 2

Declining Marginal Value

***Summer** Marginal Capacity Value*



***Winter** Marginal Capacity Value*

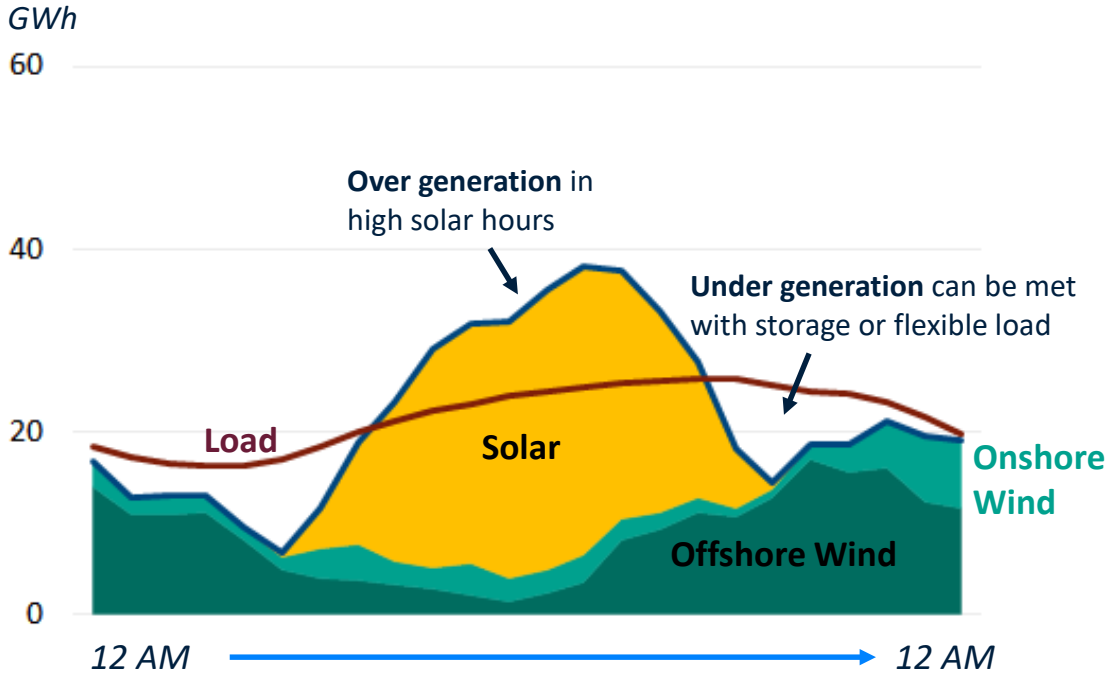


See Disclaimer on Slide 2

Source: The Brattle Group, New York's Evolution to a Zero Emission Power System, prepared for NYISO, June 22, 2020.

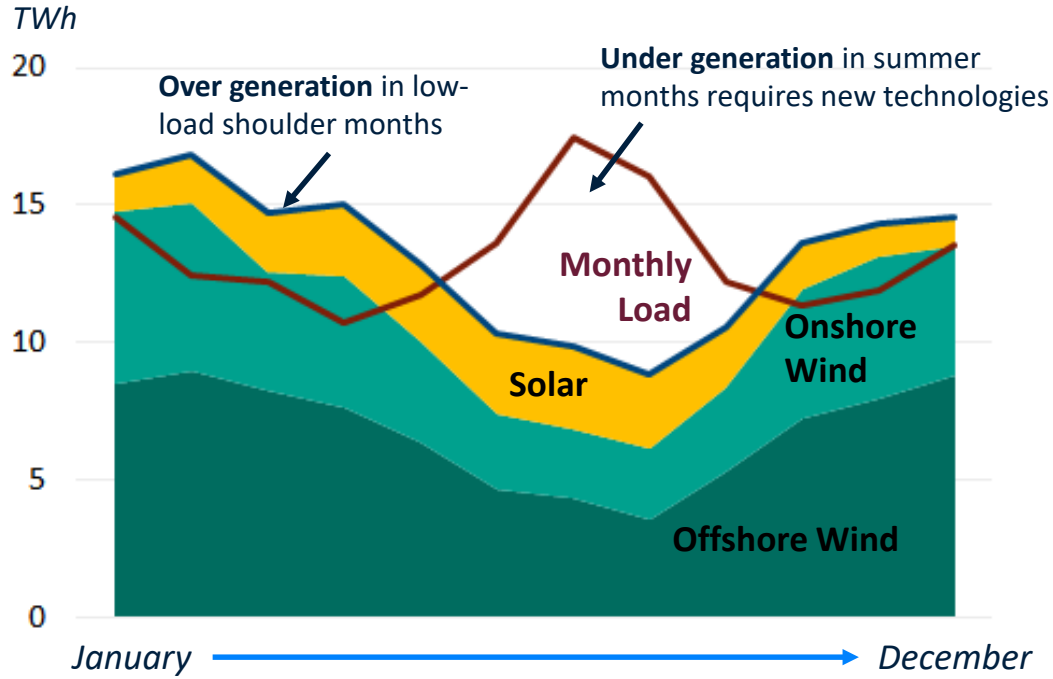
Supply Adequacy During Extended Low-Wind/Solar Periods

Hourly Balancing Challenge



Batteries and load flexibility can provide short-term balancing.

Seasonal Balancing Challenge

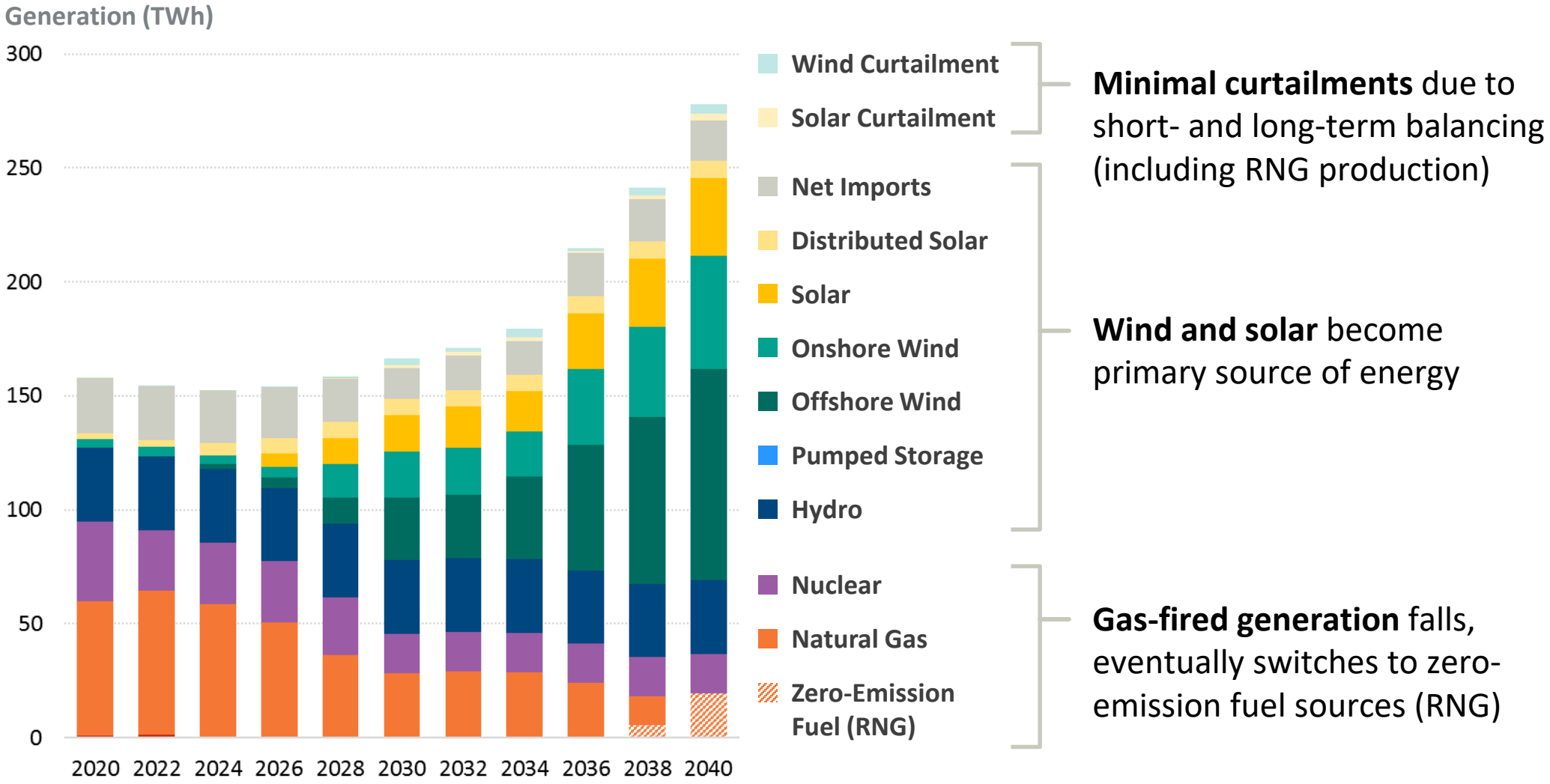


Seasonal balancing is the more difficult challenge, requiring new technologies such as seasonal storage or zero-emission dispatchable generation.

Source: The Brattle Group, New York's Evolution to a Zero Emission Power System, prepared for NYISO, June 22, 2020.

See Disclaimer on Slide 2

New Technologies Needed for Long-Term Storage…by 2040



Minimal curtailments due to short- and long-term balancing (including RNG production)

Wind and solar become primary source of energy

Gas-fired generation falls, eventually switches to zero-emission fuel sources (RNG)

Source: The Brattle Group, New York's Evolution to a Zero Emission Power System, prepared for NYISO, June 22, 2020.

See Disclaimer on Slide 2

Sam Newell

PRINCIPAL | BOSTON

Sam.Newell@brattle.com

+1.617.234.5725

Dr. Samuel Newell leads The Brattle Group's Electricity Practice.

He has 22 years of experience helping clients with wholesale market design, generation asset valuation, resource planning, and transmission planning. Much of his work addresses the industry's transition to clean energy. He frequently provides expert reports and testimony to ISOs, the FERC, state regulatory commissions, and the American Arbitration Association.

Dr. Newell earned a Ph.D. in Technology Management & Policy from the Massachusetts Institute of Technology, an M.S. in Materials Science & Engineering from Stanford University, and a B.A. in Chemistry & Physics from Harvard College.

Learn more about Sam

About Brattle

The Brattle Group answers complex economic, finance, and regulatory questions for corporations, law firms, and governments around the world. We are distinguished by the clarity of our insights and the credibility of our experts, which include leading international academics and industry specialists. Brattle has over 350 talented professionals across three continents. For more information, please visit **brattle.com**.

Our Services	Our People	Our Insights
Research and Consulting	Renowned Experts	Thoughtful Analysis
Litigation and Support	Global Teams	Exceptional Quality
Expert Testimony	Intellectual Rigor	Clear Communication

Our Practices and Industries

ENERGY & UTILITIES

- Competition & Market Manipulation
- Distributed Energy Resources
- Electric Transmission
- Electricity Market Modeling & Resource Planning
- Electrification & Growth Opportunities
- Energy Litigation
- Energy Storage
- Environmental Policy, Planning & Compliance
- Finance and Ratemaking
- Gas/Electric Coordination
- Market Design
- Natural Gas & Petroleum
- Nuclear
- Renewable & Alternative Energy

LITIGATION

- Accounting
- Alternative Investments
- Analysis of Market Manipulation
- Antitrust/Competition
- Bankruptcy & Restructuring
- Big Data & Document Analytics
- Commercial Damages
- Consumer Protection & False Advertising Disputes
- Cryptocurrency and Digital Assets
- Environmental Litigation & Regulation
- Intellectual Property
- International Arbitration
- International Trade
- Mergers & Acquisitions Litigation
- Product Liability
- Regulatory Investigations & Enforcement
- Securities Class Actions
- Tax Controversy & Transfer Pricing
- Valuation
- White Collar Investigations & Litigation

INDUSTRIES

- Electric Power
- Financial Institutions
- Infrastructure
- Natural Gas & Petroleum
- Pharmaceuticals & Medical Devices
- Telecommunications, Internet & Media
- Transportation
- Water

Our Offices


BOSTON


BRUSSELS


CHICAGO


LONDON


MADRID

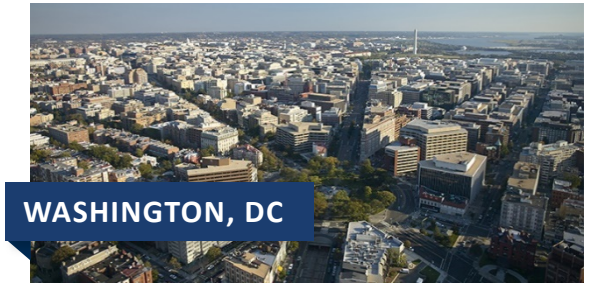

NEW YORK


ROME


SAN FRANCISCO


SYDNEY


TORONTO


WASHINGTON, DC

Clarity in the face of complexity

That's the Power of Economics™

Brattle