Renewable Energy Economics

UPDATE ON DEVELOPMENT FUNDAMENTALS

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INSTITUTE FOR ENERGY LAW 2024
RENEWABLES CONFERENCE

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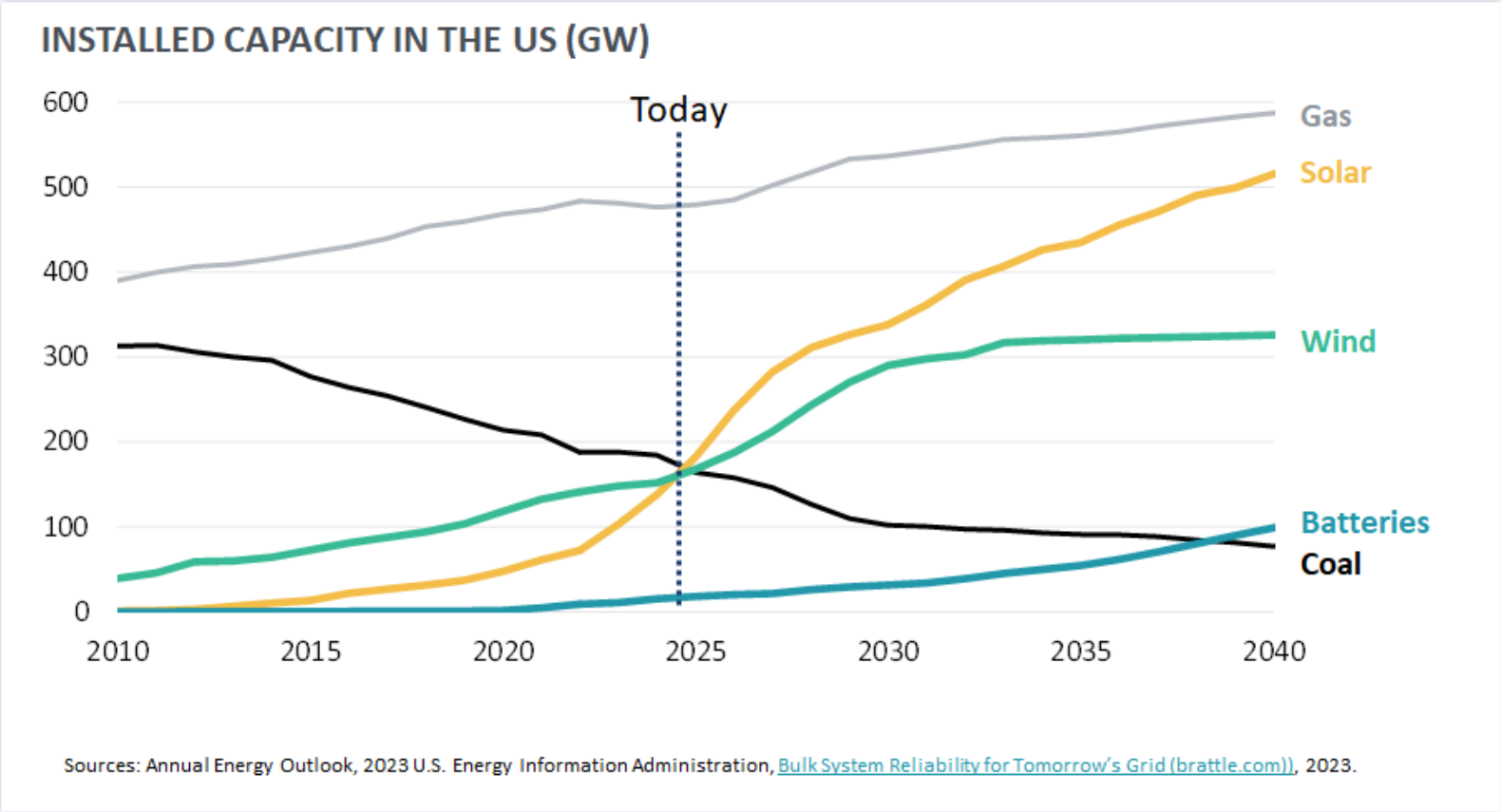
Brattle

Objective and Agenda

Objective: as helpful background for legal services you may be providing on transactions, regulations, or disputes in the electricity industry, I will discuss the economics, challenges, and opportunities surrounding renewable energy development.

- **Current Trends** in renewable energy development
- **Investment Drivers**: declining costs, IRA, state goals & corp demand, load growth
- **Challenges**: siting, transmission, supply chain, Diminishing returns, reliability
- **Hot topics**: new contract structures; what counts as “clean”
- **Implications** for your work

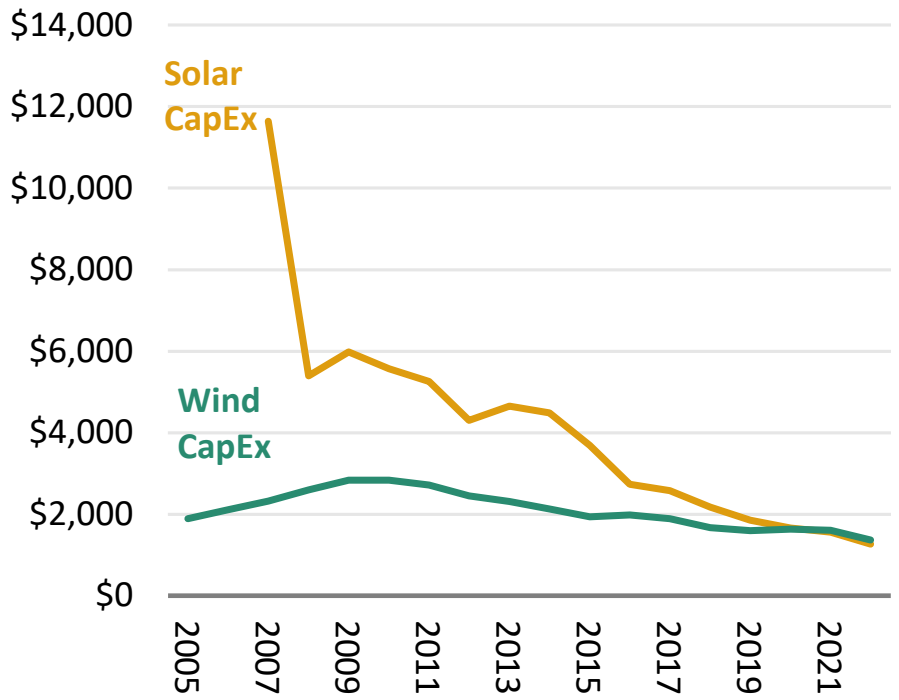
Investment in Renewables



Sources: Annual Energy Outlook, 2023 U.S. Energy Information Administration, Bulk System Reliability for Tomorrow's Grid (brattle.com)), 2023.

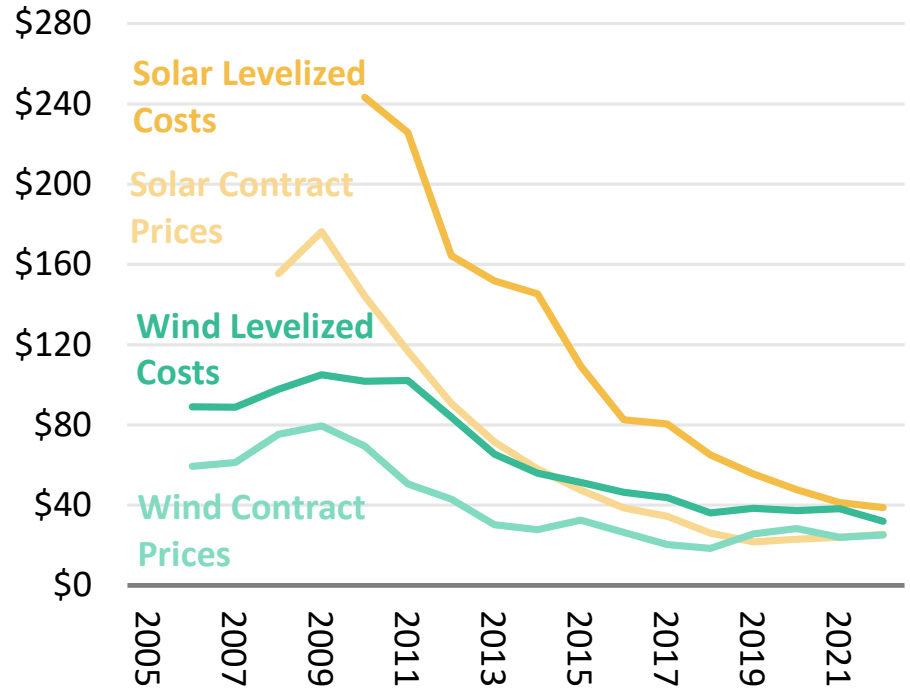
Cost Trends

CAPITAL COSTS (2022 $/kW-AC)



Sources: LBNL 2022 Land Based Wind Market Report, 2022 Utility Scale Solar Market Report, Bulk System Reliability for Tomorrow's Grid (brattle.com)), 2023

LEVELIZED COSTS AND CONTRACT PRICES (2022 $/MWh)

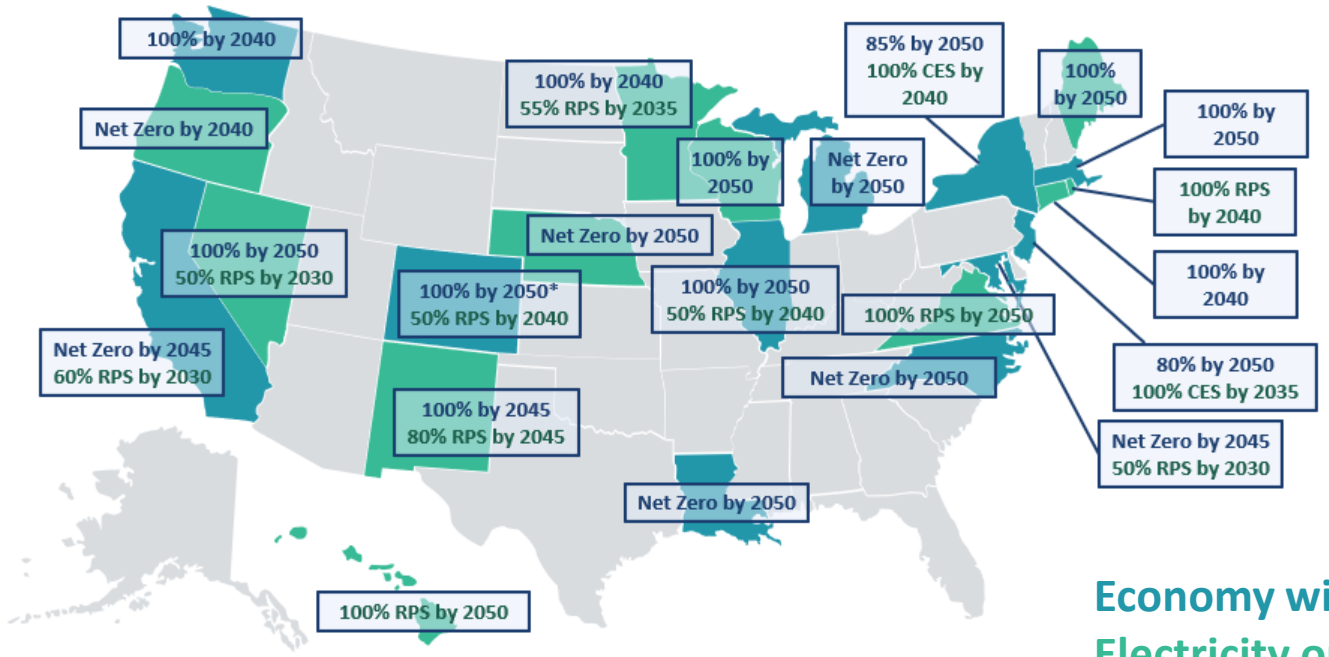


Sources: LBNL 2022 Scale Solar Market Report
Bulk System Reliability for Tomorrow's Grid (brattle.com)), 2023

Growing Demand for Renewable Energy

- Most development has been in windy high plains, the sunny southwest, and CA
- State RPS and other goals are broadening development

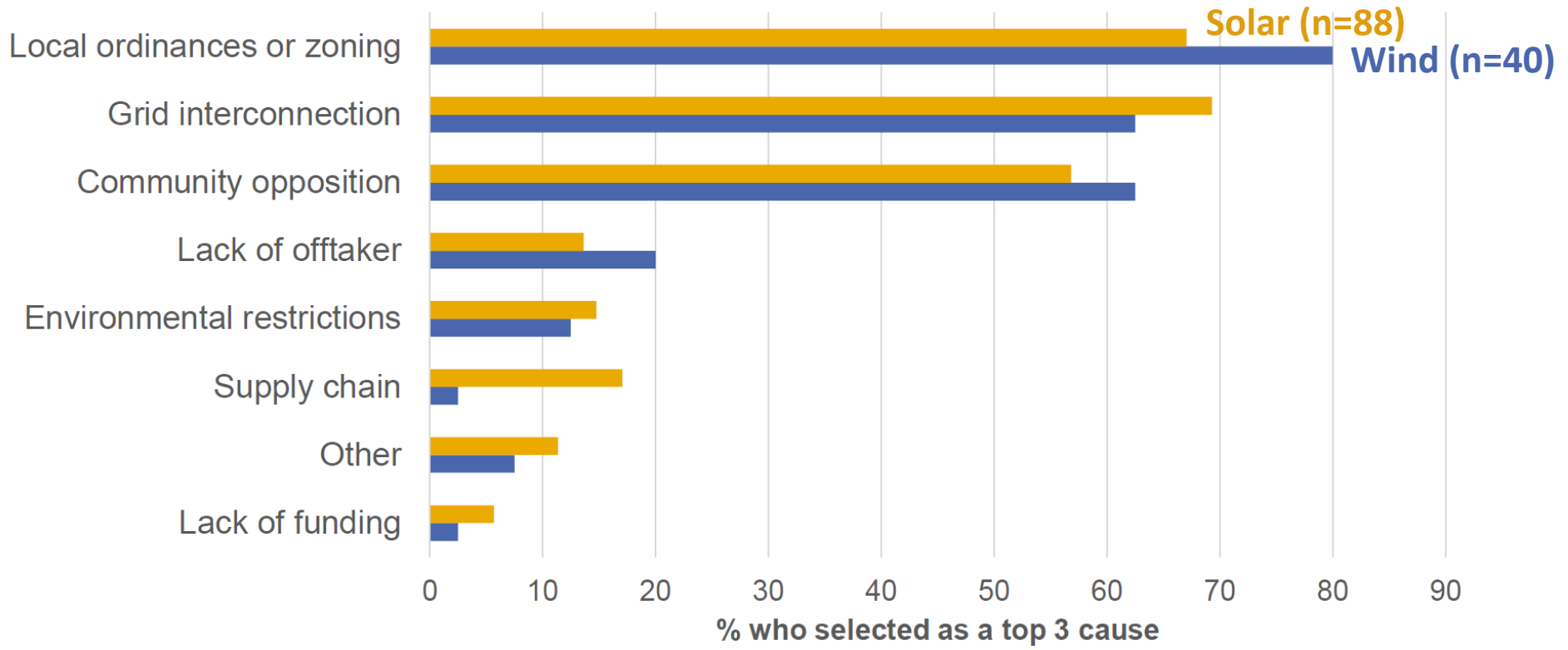
STATES WITH 100% CLEAN ENERGY GOALS/STANDARDS



Source: Adapted from Barbose, G, U.S. State Renewables Portfolio & Clean Electricity Standards: 2023 Status Update, Lawrence Berkeley Lab, June 2023

Development Challenges

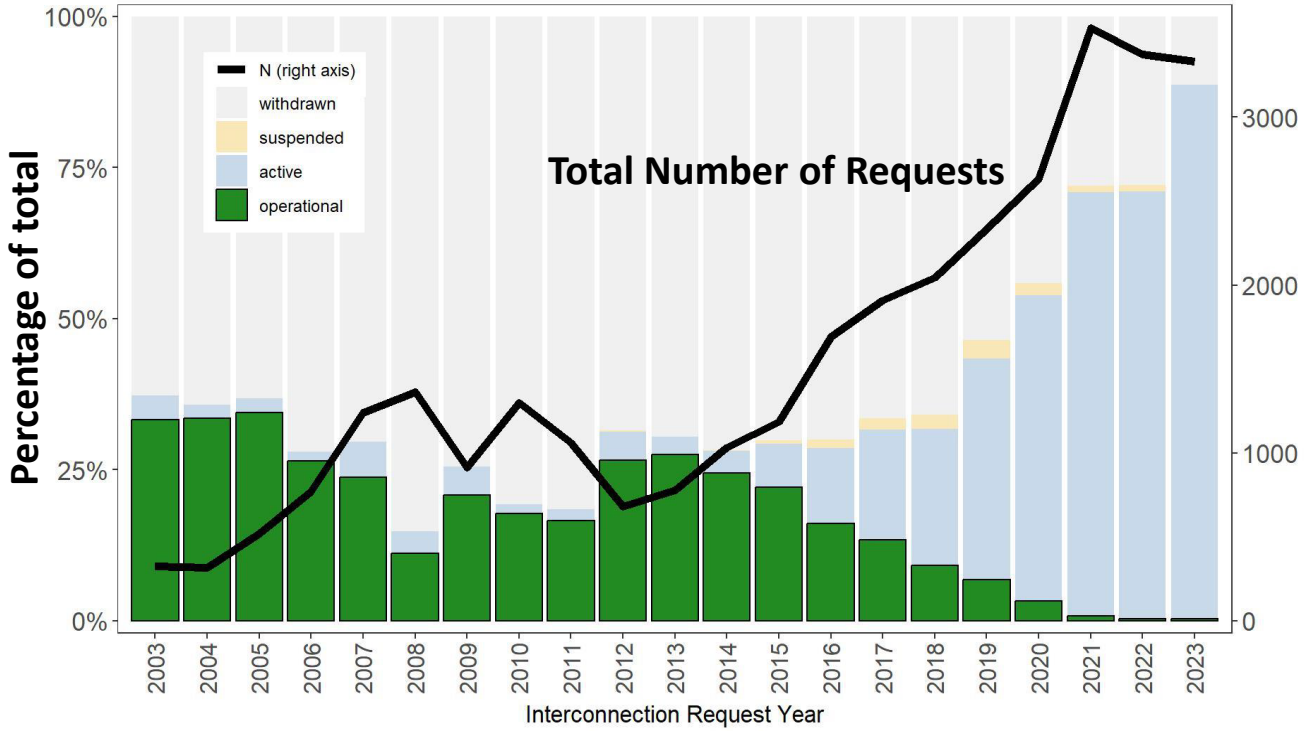
“Within the last five years, what has been the leading causes of project cancelation?”



Source: Robi Nilsen et al., Survey of Utility-Scale Wind and Solar Developers Report, Lawrence Berkeley Lab, January 2024

Grid Interconnection Bottlenecks

CHARACTERISTIC OF INTERCONNECTION QUEUES



Source: Joseph Rand et. al, Queued Up: 2024 Edition, Lawrence Berkeley Lab, 2024

Overall Scorecard Grade	
CAISO	B
ERCOT	B
ISO-NE	D+
MISO	C-
NYISO	C-
PJM	D-
SPP	C-

Source: Generator Interconnection Scorecard, 2024

Improvements in Interconnection Processes are underway, but further improvement will be needed, with streamlined studies, more fast-track access, and more proactive planning and use of grid-enhancing technologies

Supply Chains Growing Pains

Solar Energy Industries Association, March 9, 2023

Policy-Driven Supply Constraints Cause Steep Drop in Solar Installations in 2022

Tariff investigation, equipment detainments lead to 16% drop in new solar capacity last year

Renew Economy, November 6, 2023:

Ørsted blames lack of ships for New Jersey offshore wind failure and massive write downs

The Financial Times, July 30, 2023:

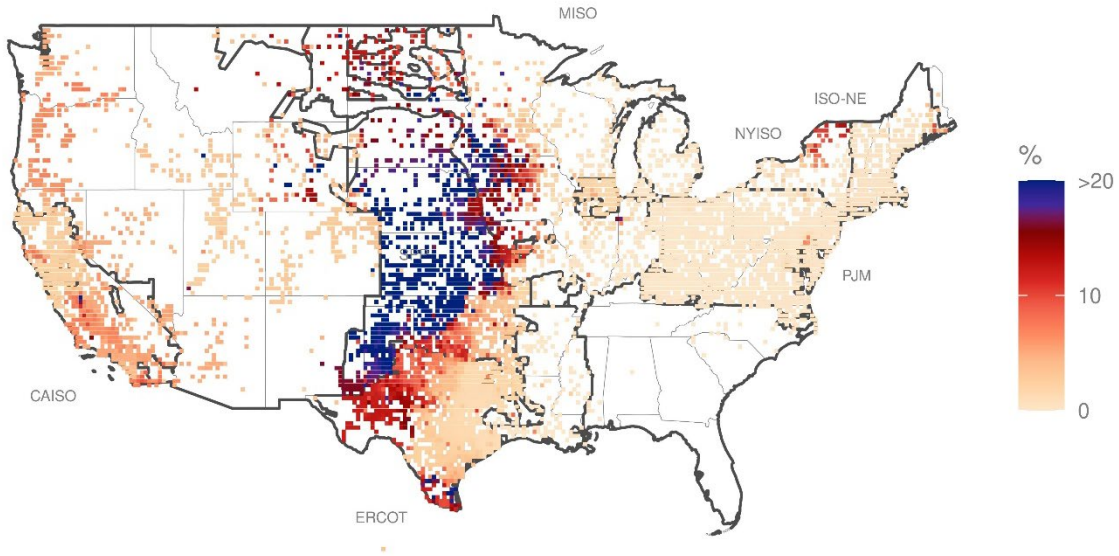
"[l]ead times for electricity parts have 'gone through the roof', with waits of three to four years for large power transformers… [and total delivery] times for HVDC converter stations have jumped to up to seven years"

Policy/Market Responses

- China dominates **solar supply chain** and has just massively increased; **tariff** issues
- **IRA** has helped **attract $100 billion investment** in U.S. solar manufacturing
- **State** help for OSW supply chain (plus steady stream of demand)

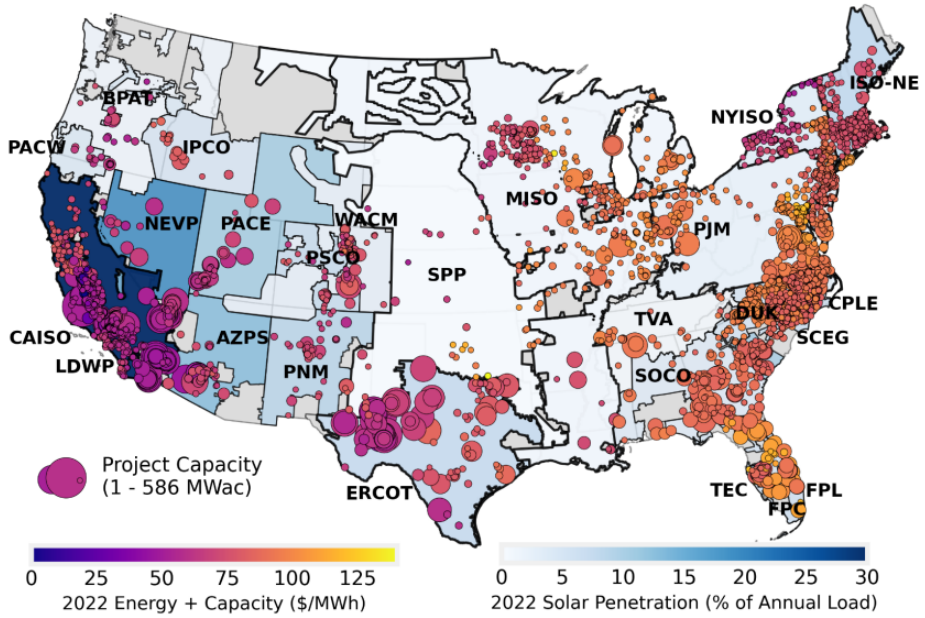
Diminishing Marginal Energy Value

NEGATIVE PRICING FREQUENCY (2022)



Source: [The Renewables and Wholesale Electricity Prices (ReWEP) Tool | Energy Markets & Policy (lbl.gov)](), Lawrence Berkeley Lab, 2023

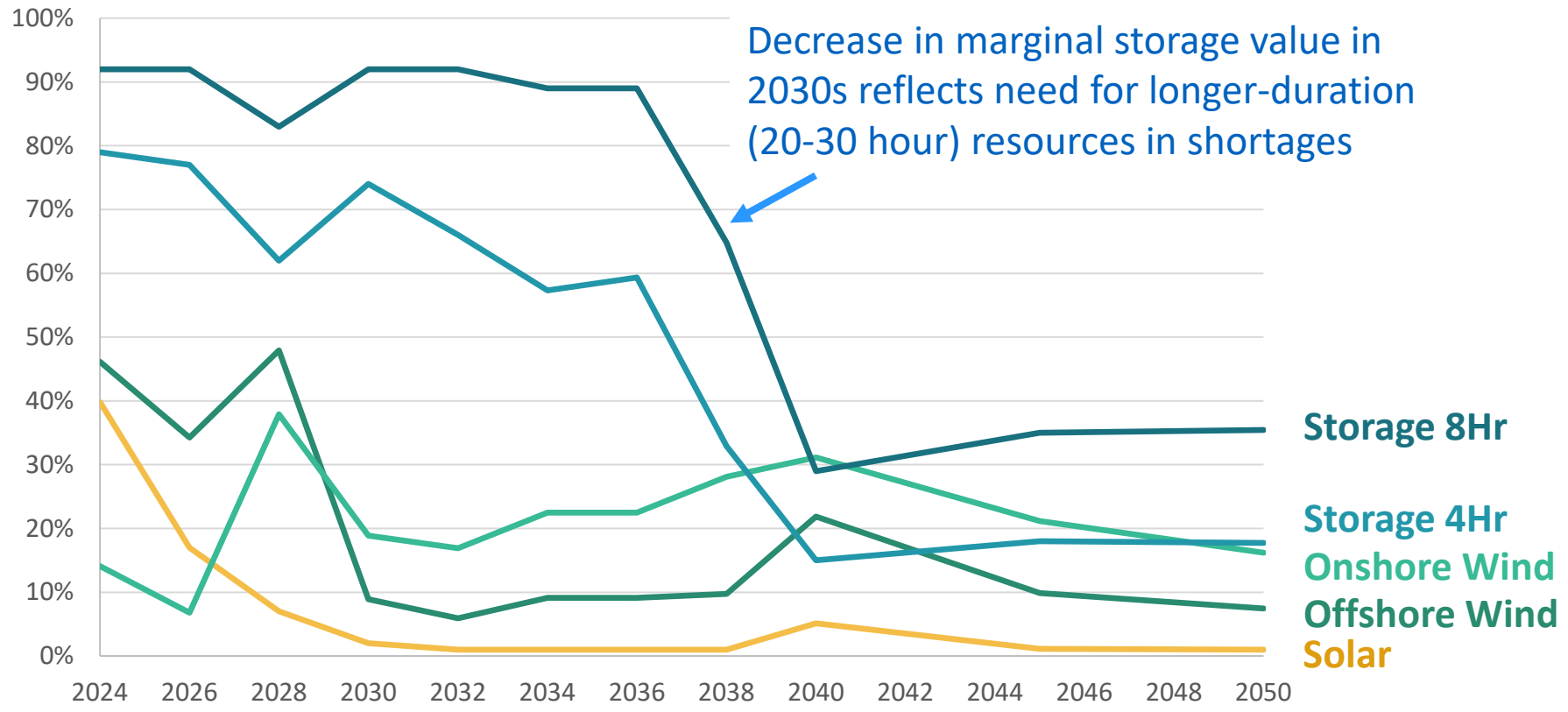
SOLAR VALUE FOR PROJECTS LARGER THAN 1MW (2022)



Source: [Utility-Scale Solar](), Lawrence Berkeley Lab, 2022

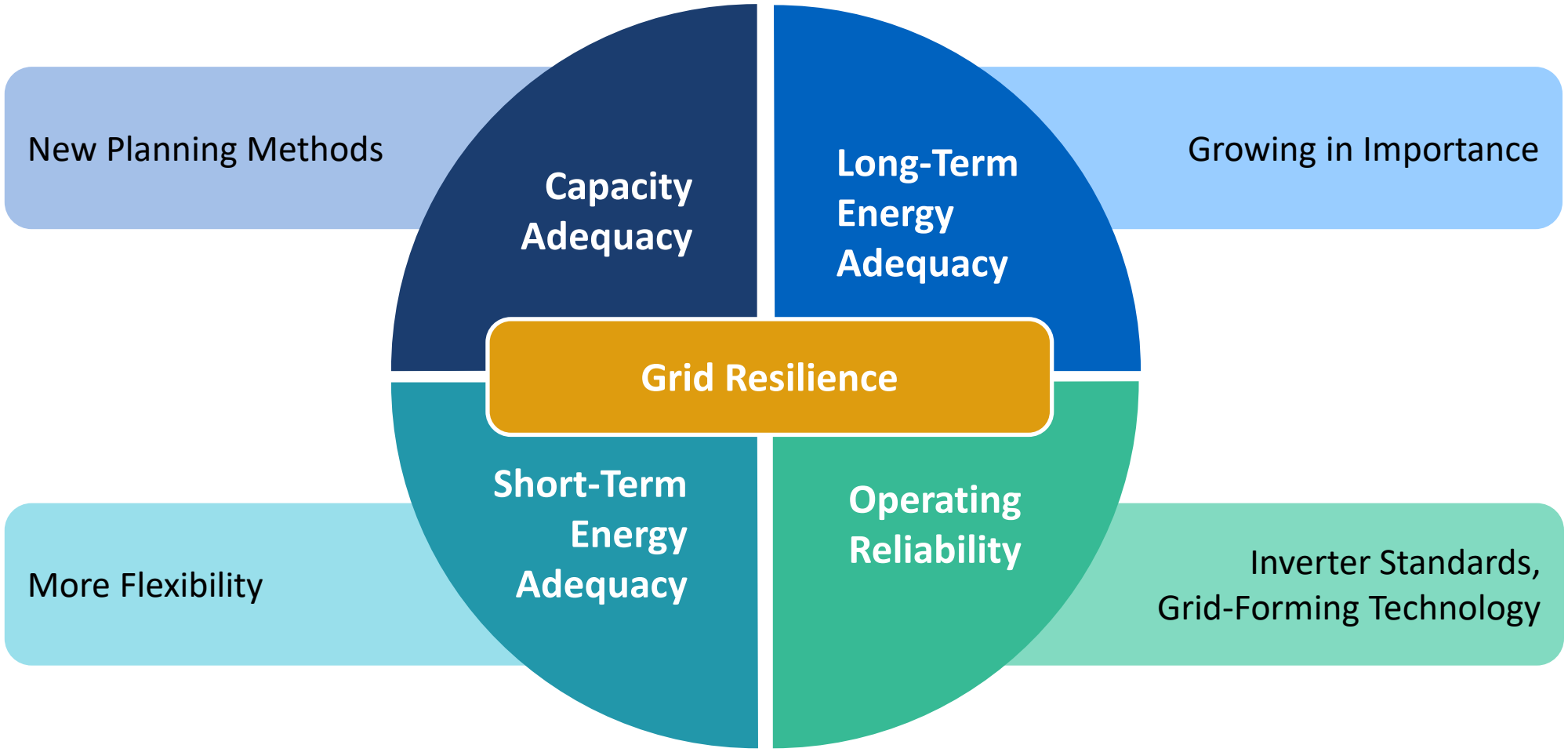
Diminishing Marginal Capacity Value

ILLUSTRATIVE MARGINAL CAPACITY VALUE OF RENEWABLES AND STORAGE



Source: The Brattle Group, New England Energy Storage Duration Study, December 2023

Reliability Management



Source: The Brattle Group, Bulk System Reliability for Tomorrow's Grid, 2023

New Indexed Contract Structures

	Optional?	From Bid to…	Index	Cap
New York Solar and Onshore Wind	Yes	Start of construction	75% PPI (25% fixed)	None
New York Offshore Wind	Yes	BOEM COP approval	30% labor, 25% fabrication, 10% steel, 10% diesel, 5% copper (20% fixed)	None
New Jersey Offshore Wind	No	BOEM COP approval	30% labor, 30% fabrication, 10% steel, 10% fuel (20% fixed)	+/- 15%
Massachusetts and Connecticut Offshore Wind	Yes	PPA approval or financial close	30% CPI, 12% steel, 6% copper, 7% fuel, 9% fab., 11% labor, (25% fixed) 0.67 * Δ10-yr T-rates	MA: +/- 15% CT: +/- 15%
Rhode Island Offshore Wind	Yes	PPA approval or financial close	RI: 100% CPI	RI: +16%

Source: from states' most recent offshore wind or Tier 1 REC RFPs

GHG and Clean Energy Accounting Approaches

1. Annual Matching	2. Hourly Matching	3. Three Pillars	4. LME	5. Flow-based
DEFINITION				
Procurement of carbon-free electricity matches their individual consumption on an **annual basis**	Procurement of carbon-free electricity matches their individual consumption on an **hourly basis** throughout the year	Electricity consumers require three criteria for clean energy purchases: **hourly matching**, **deliverability**, and **additionality**	Electricity consumers measure incremental **GHG emissions rate at a local level**; clean energy procurements seek to **maximize avoided GHG emissions**	Carbon emissions are traced from generators to loads as aligned with granular **physical power flow measurements**, and assigned based on consumption
PRIMARY ADVANTAGES				
Lower cost and simpler				**More accurate for some purposes**
KEY SUPPORTERS				
NEXTera ENERGY, ACORE	Google, Constellation.	European Commission, U.S. Department of the Treasury	Microsoft, REsurety	Singularity

Source: GHGP Summary of Responses from Scope 2 Guidance Stakeholder Survey

Conclusions

Investment in renewable energy projects will continue to increase due to economics and policies.

This will create value but will take effort, including yours, to address the challenges along the way.

- **Project development**
  - Siting/permitting
  - Supply chain management/contracting
  - Offtake contracting
  - Accessing transmission
  - Project financing
- **Enabling infrastructure/mechanisms**
  - Manufacturing and services
  - Transmission investment
  - Regulatory/market mechanisms for reliability
- **Surrounding opportunities** with new loads
- **Disputes**

Presented By

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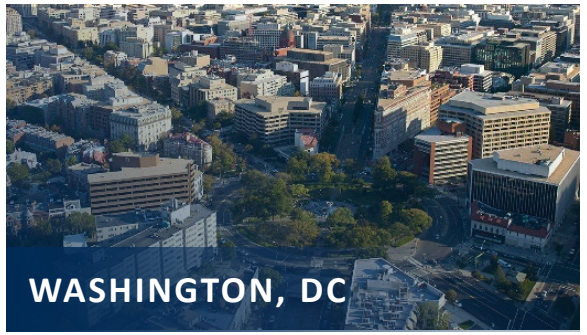
Dr. Newell leads Brattle's Electricity Practice of 60 consultants addressing the most challenging economic questions facing an industry transforming to clean energy.

His expertise centers on the analysis and design of wholesale electricity markets to provide necessary grid services through the energy transition; procurement of clean energy; valuation of generation and contracts; and enhanced planning and benefit/cost analysis of transmission.

He frequently provides testimony and expert reports to Independent System Operators (ISOs), the Federal Energy Regulatory Commission (FERC), state regulatory commissions and legislatures, state courts, and the American Arbitration Association.

A Global Firm



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