NREL
Transforming ENERGY

Better Planning for Future Adoption of Distributed Energy Resources (DERs)

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How do DERs fit into future power grids?

- Future power systems will have substantially more DERs
- Traditional utility planning does not consider DERs
- Better models needed for integrated distribution planning
- Distribution systems and transmission systems are linked

Historically, resource planning does not consider distributed energy resources.

Planning entities (e.g. utilities and commissions) conduct long-term planning to determine least-cost options for meeting changing demand and maintaining reliability.

Traditional frameworks forecast demand independently from supply and do not consider local resources or services.

A widespread transition to distributed energy is taking place.

- It began with solar and is spreading to transportation and other demand-side resources
- Customers want local resources and autonomy
- Local policymakers have set ambitious energy and climate goals
- Grid resiliency is a growing concern due to climate change and weather disasters
- More communities face high energy burdens

DERs offer unique technical, economic, and social benefits.

- Siting flexibility
- Reduced transmission congestion
- Increased resiliency
- Local economic and jobs impact
- More equitable participation in clean energy

But planning for DER technologies can be complex

Traditional planning methods consider distributed PV (DPV) and perhaps combined heat and power (CHP) growth.

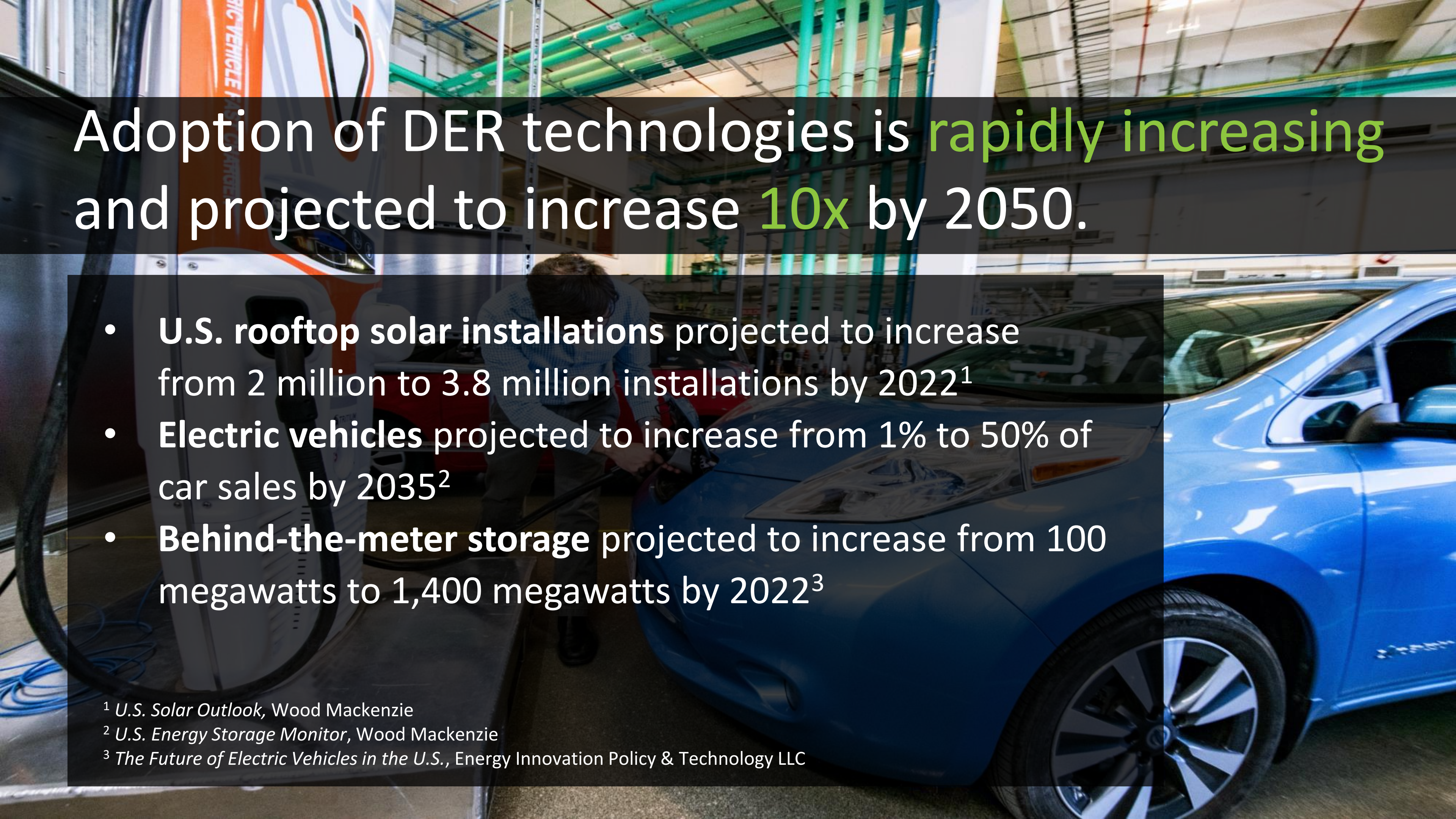
Emerging methods need to consider these and:

- Electric vehicles
- Energy storage
- Energy efficiency
- Demand response
- And others

Also:

Technology *co-adoption*

How technologies are *operated*

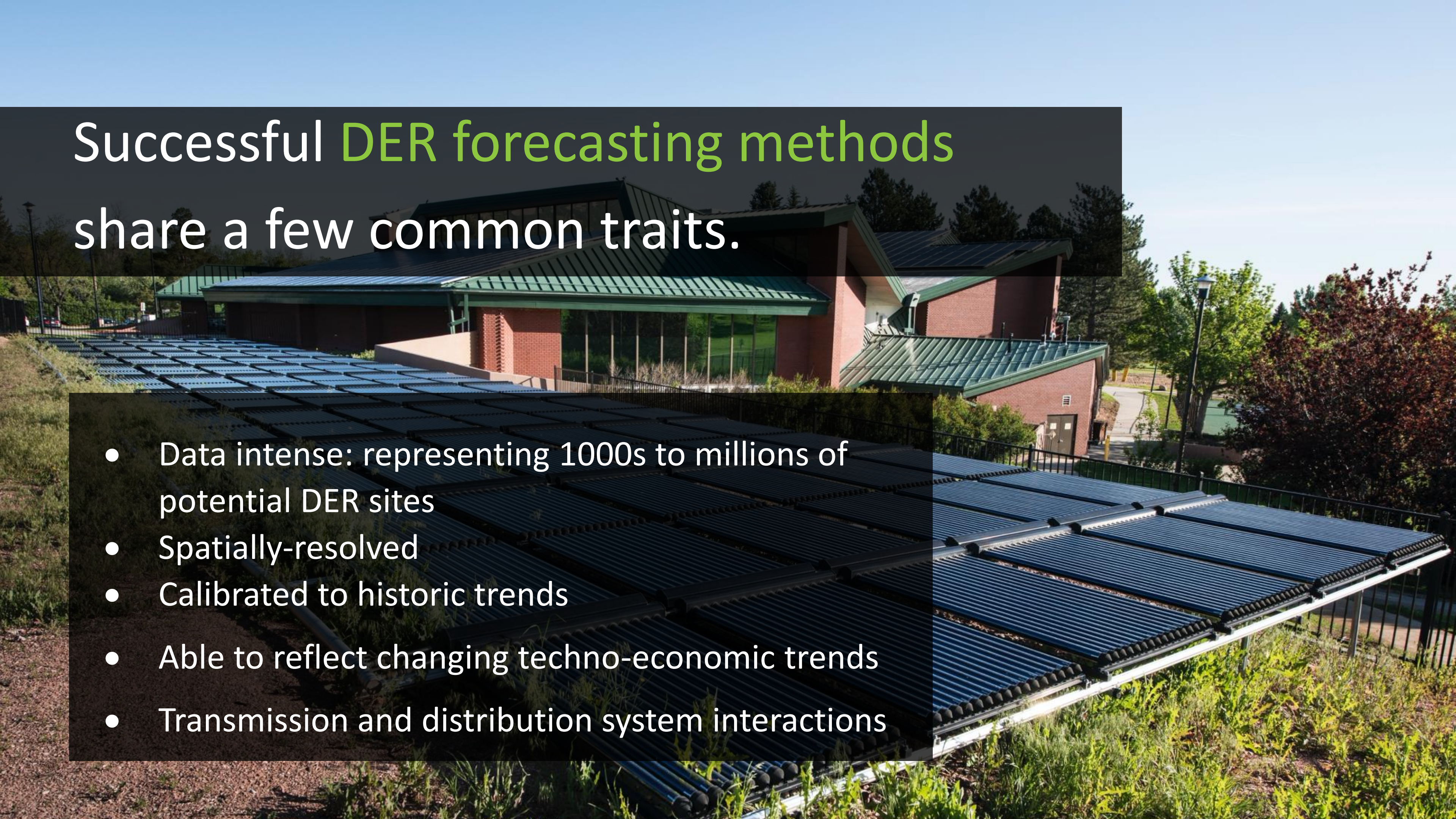


Adoption of DER technologies is rapidly increasing and projected to increase 10x by 2050.

- **U.S. rooftop solar installations** projected to increase from 2 million to 3.8 million installations by 2022[1]
- **Electric vehicles** projected to increase from 1% to 50% of car sales by 2035[2]
- **Behind-the-meter storage** projected to increase from 100 megawatts to 1,400 megawatts by 2022[3]

[1] *U.S. Solar Outlook*, Wood Mackenzie
[2] *U.S. Energy Storage Monitor*, Wood Mackenzie
[3] *The Future of Electric Vehicles in the U.S.*, Energy Innovation Policy & Technology LLC

Power system planners need tools to understand the opportunities and costs of changing resource and demand options.



Successful DER forecasting methods share a few common traits.

- Data intense: representing 1000s to millions of potential DER sites
- Spatially-resolved
- Calibrated to historic trends
- Able to reflect changing techno-economic trends
- Transmission and distribution system interactions

The costs of inaccurate DER adoption forecasting can be high.

Improved DPV forecasting alone saves $250,000/TWh of utility sales![1]

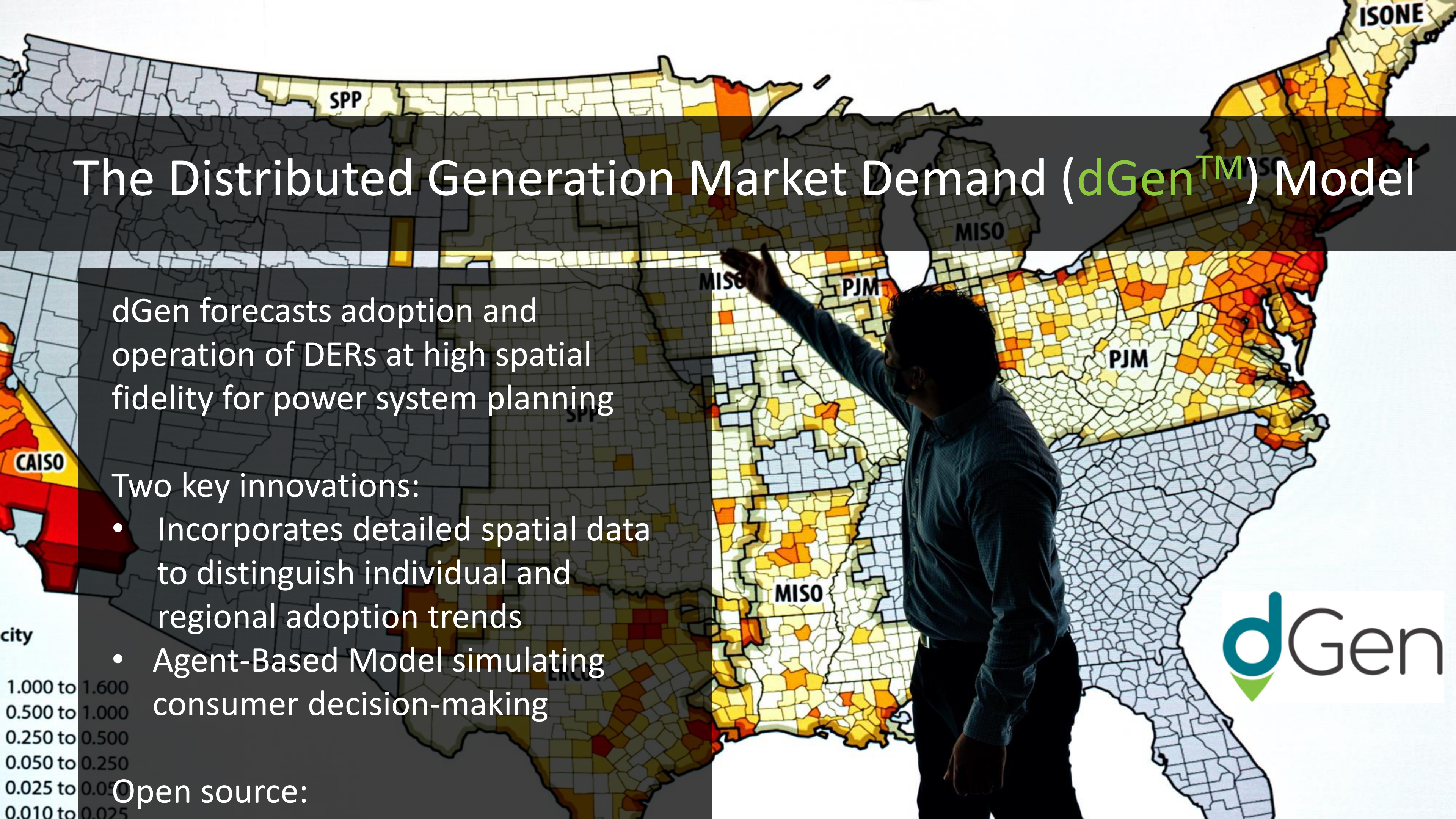
Under-forecasting: An overbuilt system with unused capacity

Over-forecasting: An underbuilt system without sufficient capacity and reliability issues.

[1] *Estimating the Value of Improved Distributed Photovoltaic Adoption Forecasts for Utility Resource Planning*, NREL Technical Report


More sophisticated models are needed to support integrated utility resource planning for future grids.

The Distributed Generation Market Demand (dGen™) Model



dGen forecasts adoption and operation of DERs at high spatial fidelity for power system planning

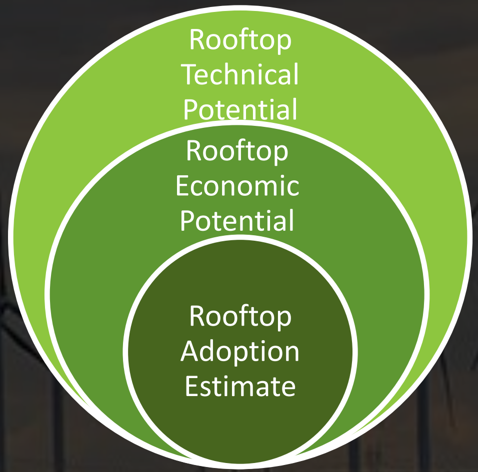
Two key innovations:

- Incorporates detailed spatial data to distinguish individual and regional adoption trends
- Agent-Based Model simulating consumer decision-making

Open source:

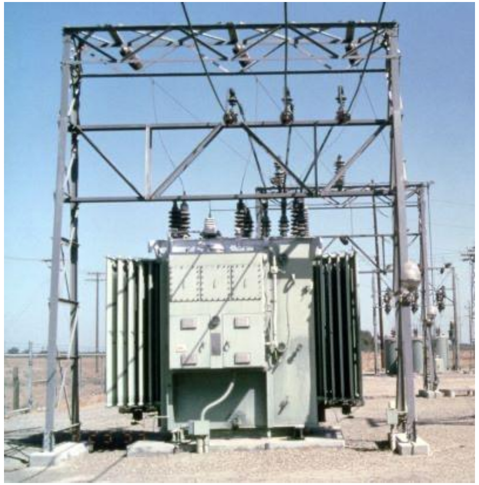
dGen

dGen™ uses a bottom-up, agent-based modeling approach.



- Starts at the bottom and forecasts up
- Agent decisions based on census data and peer effects
- Spatially resolved data factors in spatial and socioeconomic considerations
- Lidar scans assess roof suitability
- Customizable framework

Two types of methods are emerging



Transmission-level

- Focus is on predicting aggregate amount, e.g. state, county, or ISO-level
- Forecasts primarily affect generation and transmission resource plans

Distribution-level

- Focus is on predicting spatial pattern of adoption, e.g. feeder-level or household-level
- Forecasts primarily affect distribution resource plans

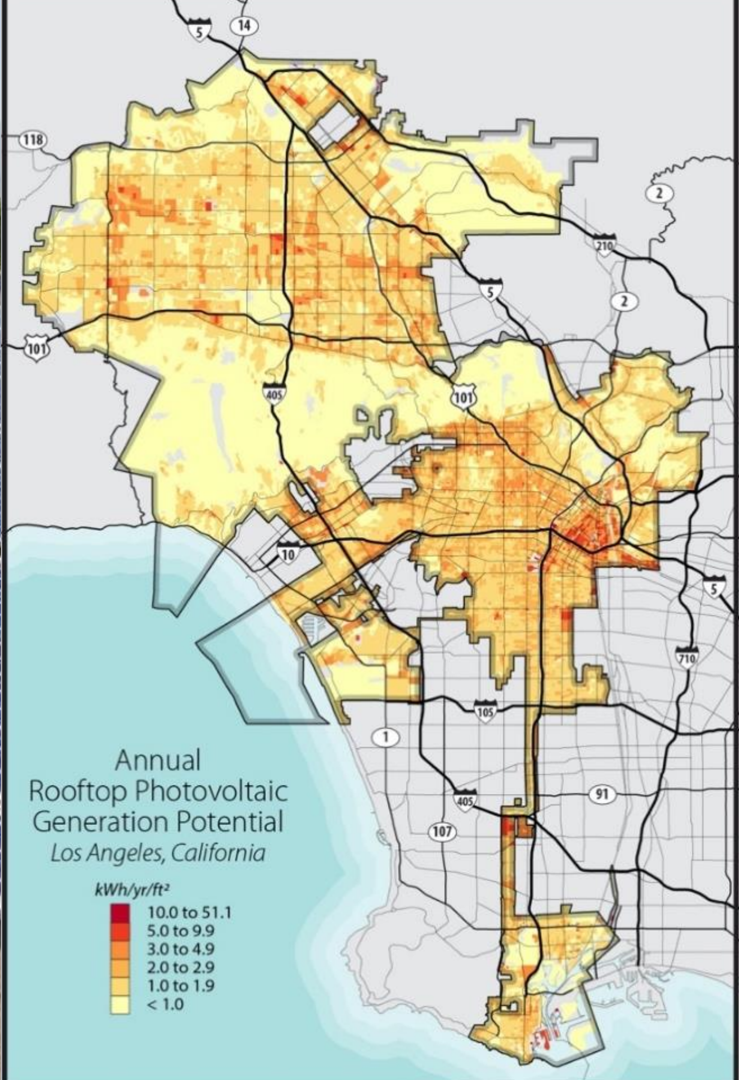
DER customer adoption forecasts help inform Los Angeles energy planning.

- LA100 Study: Los Angeles 100% Renewable Study
- NREL partnership with Los Angeles Department of Water and Power
- Rigorous, integrated engineering-economic analysis of LA's future grid with 100% renewable energy supply by 2045
- Modeled technical and economic potential for both customer-adopted and utility-procured DERs.

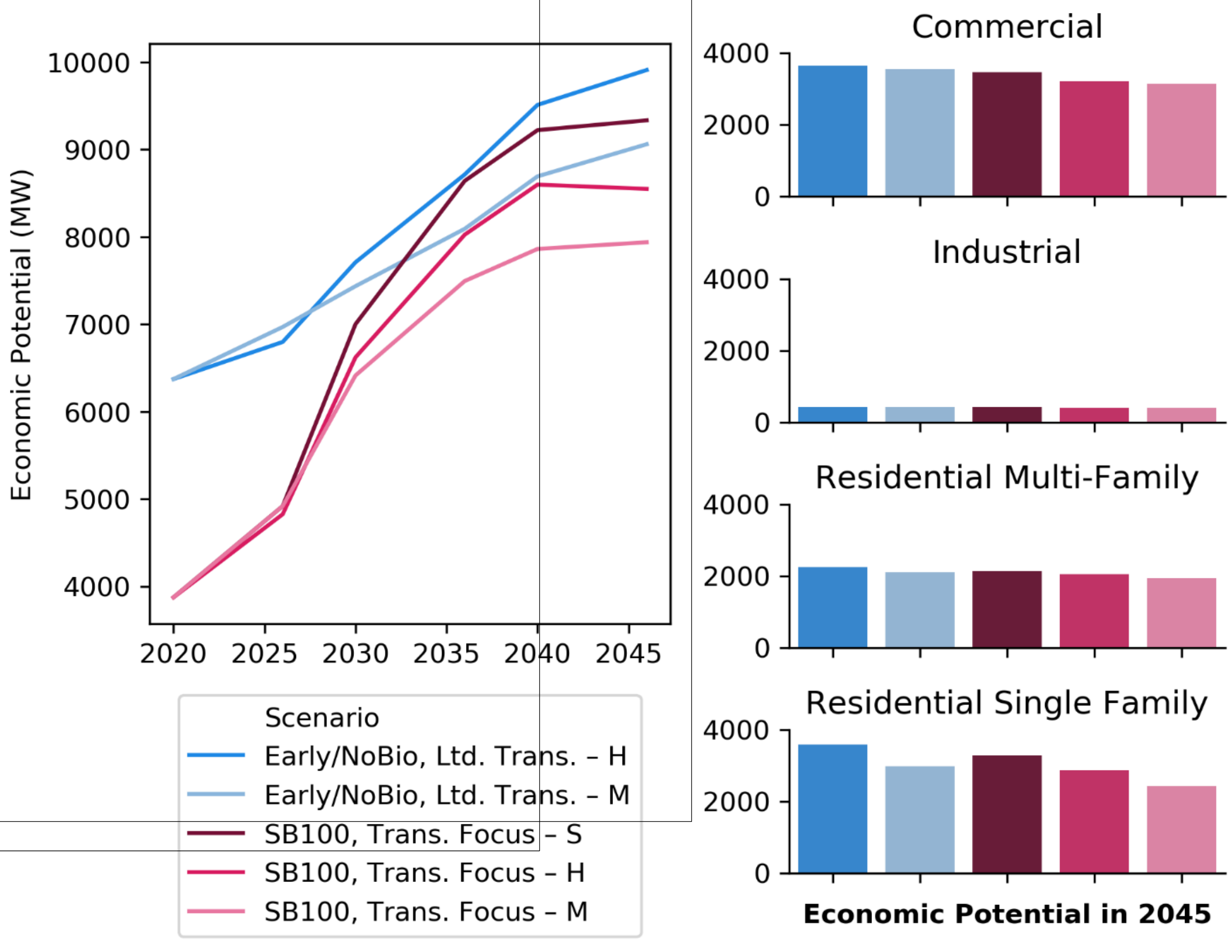
How much potential exists for customer-adopted DERs in LA?

Customer-adopted DER modeled for each building in LADWP service territory identifying *how much* is technically feasible, economically viable, and ultimately adopted.

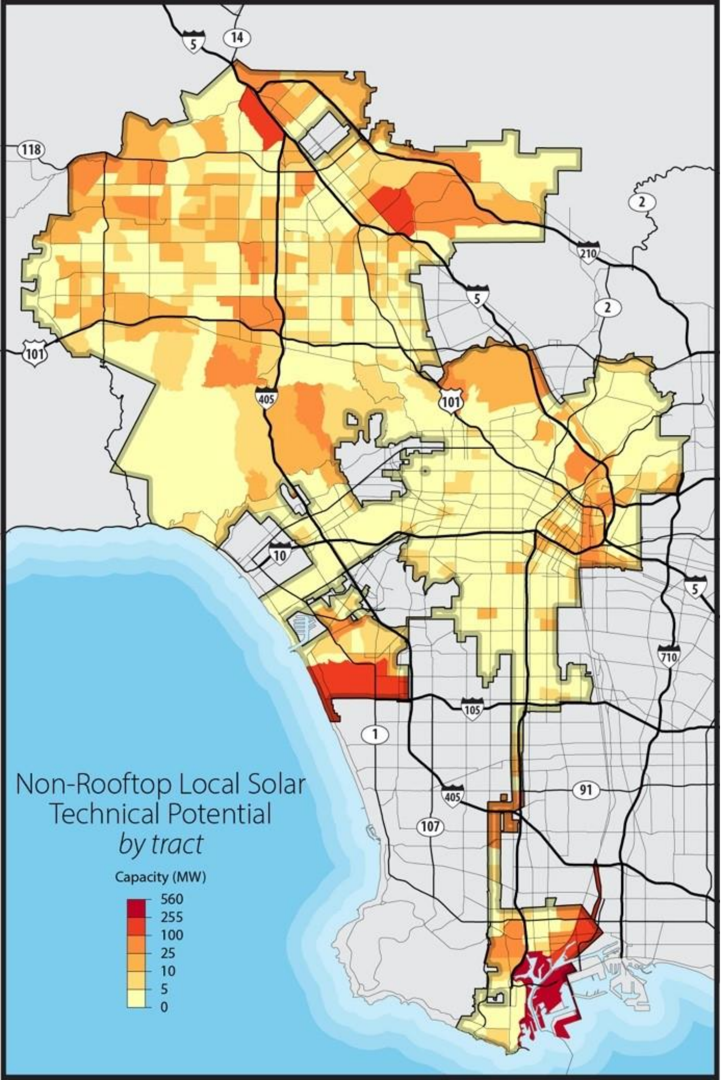
Each scenario is done in concert with bulk power capacity expansion and production cost models



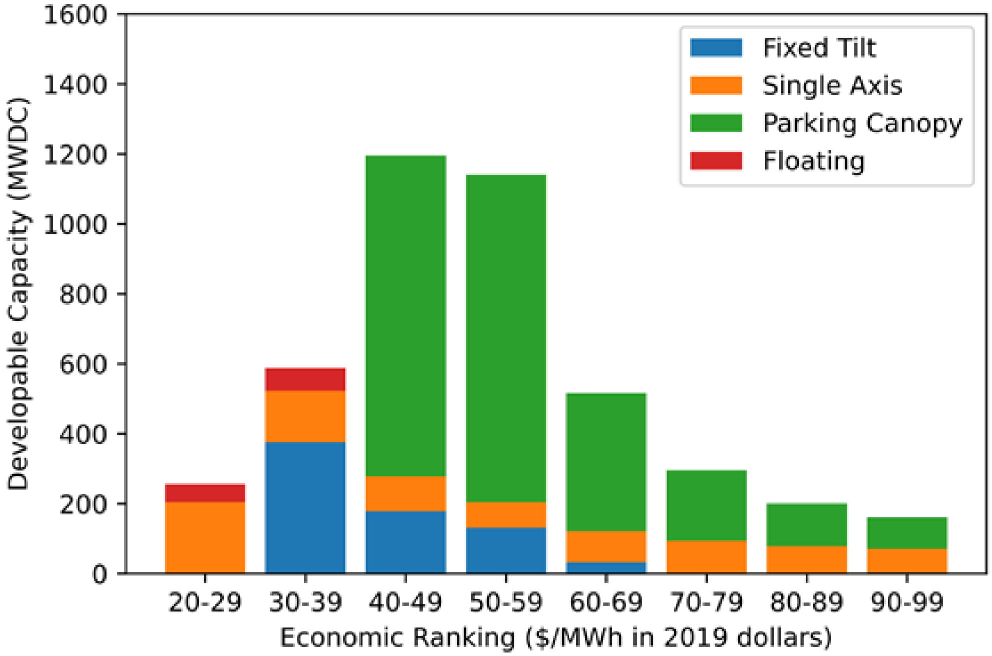
Sigrin et al. 2021. "Chapter 4: Customer-Adopted Rooftop Solar and Storage." In The Los Angeles 100% Renewable Energy Study, https://www.nrel.gov/docs/fy21osti/79444-4.pdf.



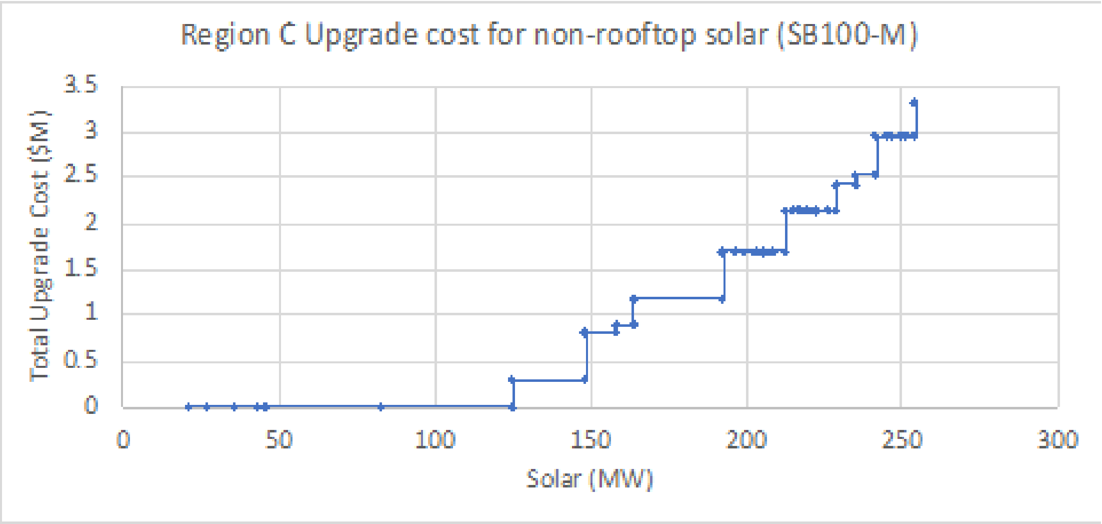
Result in detailed insights:
when, where,
and how much?

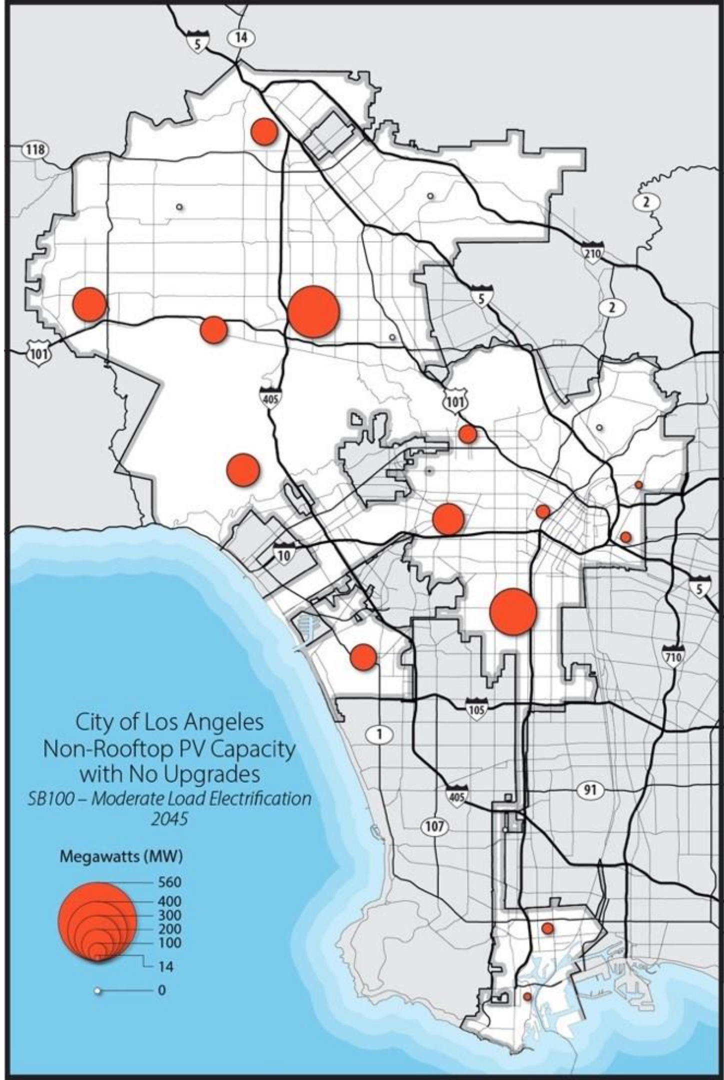


How much potential exists for non-customer solar in LA?



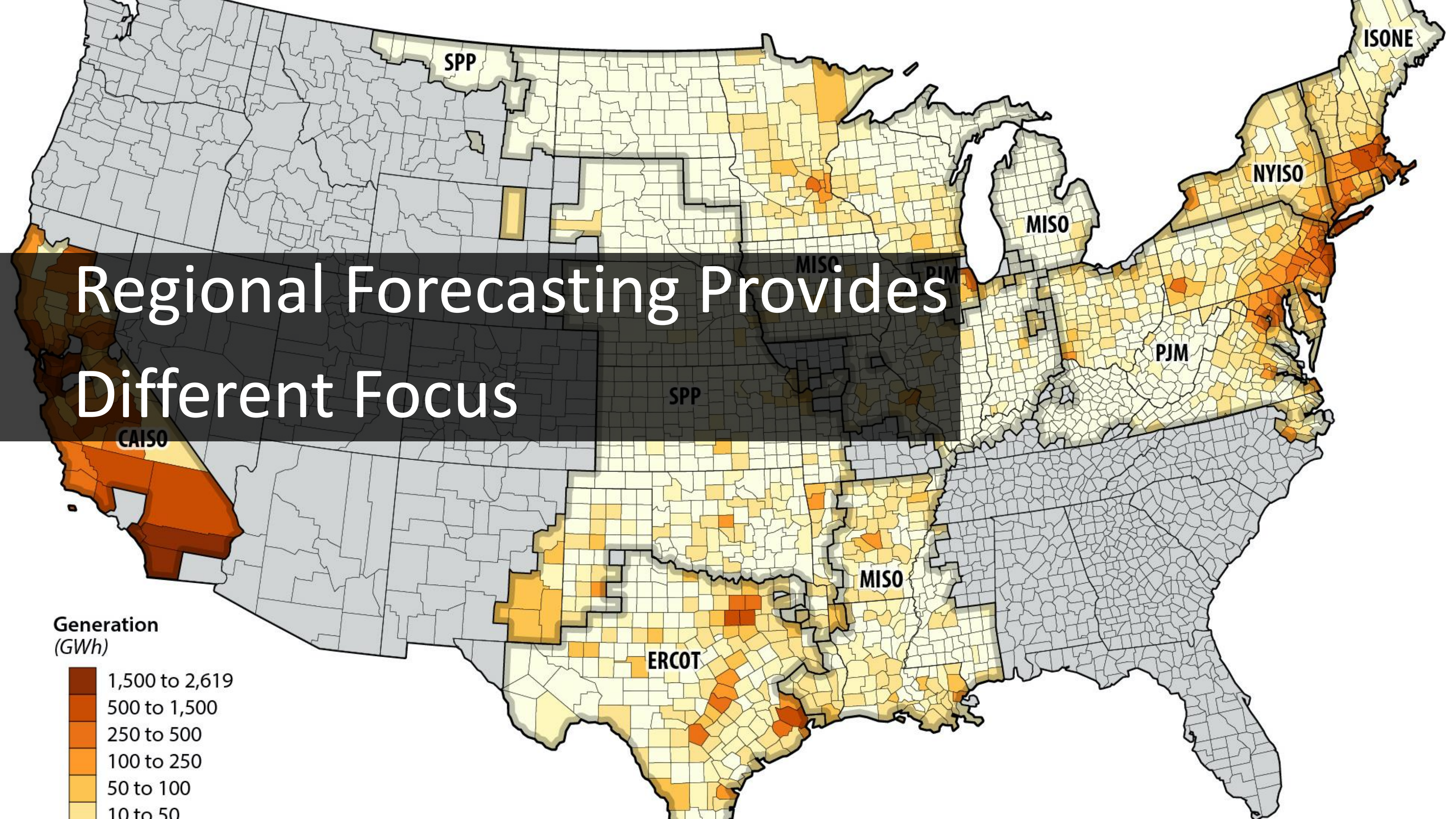
Pair with distribution models to find no-cost upgrade solutions





Mooney et al. 2021. "Chapter 5: Utility Options for Local Solar and Storage." In The Los Angeles 100% Renewable Energy Study https://www.nrel.gov/docs/fy21osti/79444-5.pdf.

Regional Forecasting Provides Different Focus

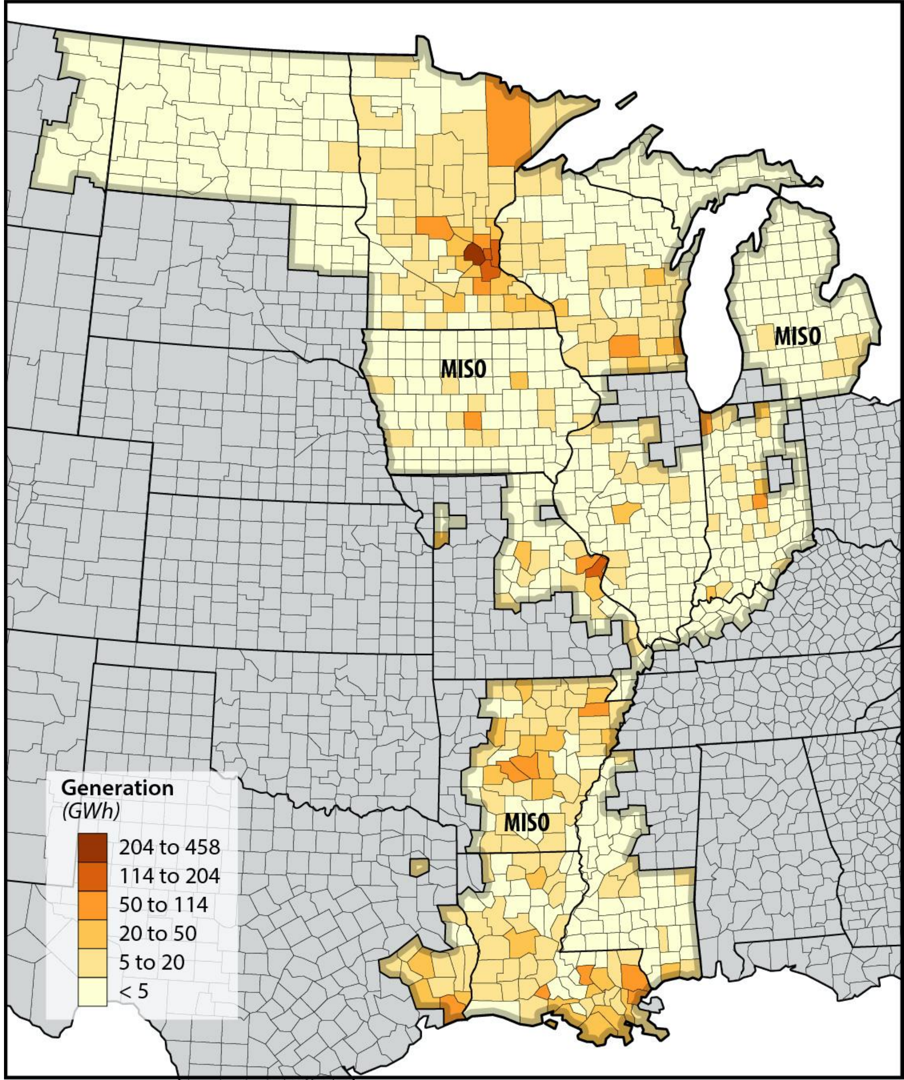


Transmission-level forecasts are traditionally used in IRPs, load forecasting, and other “big picture” studies

Less focus on predictive accuracy, instead understanding a range of outcomes or tipping points.

Often, the projections are highly dependent on policy assumptions

Helps to pinpoint expected growth and emphasizes intra-regional differences



Das et al. *Forecasting DER Deployment by ISO/RTO Territory. Under Review*

New and better models hint at a symbiotic relationship between utility-scale renewables and DERs.

Utility-scale renewables and distributed energy resources reduces stress on the bulk power system.

Utility-scale renewables and distributed energy resources reduces stress on the bulk power system.

- Distributed solar + storage can be deployed at peak times and reshape load—reduces system peaks by 16% by 2050
- Less bulk power is needed when local resources serve the distribution grid
- Co-optimization reduces capacity factors of thermal generators and peaker plants resulting in lower system costs
- Utility-scale renewables and distributed solar + storage totals **$88 billion in savings** by 2050

Why Local Solar For All Costs Less: A New Roadmap for the Lowest Cost Grid, Vibrant Clean Energy

Four Grand Challenges for Reaching DER Potential

Continued Cost Reduction

Fully Digitized System

Harmonized T. & D. systems

Pursue System Flexibility

Join the distribution planning community.

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Nrel.gov/dgen