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Smart. Focused. Done Right.®

Energy: A Sector in Transformation

EUCI Leadership Conference for Women in Energy

June 28, 2023

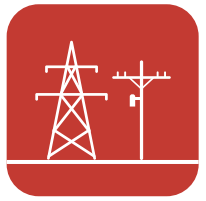
Energy Is Who We Are

ScottMadden is a management consulting firm with 40 years of deep, hands-on experience. We deliver a broad array of consulting services—from strategic planning through implementation—across the energy utility ecosystem.

Our energy practice covers the following areas:

GENERATION

RATES & REGULATION



TRANSMISSION & DISTRIBUTION

NATURAL GAS

GRID EDGE

ENERGY CORPORATE SERVICES

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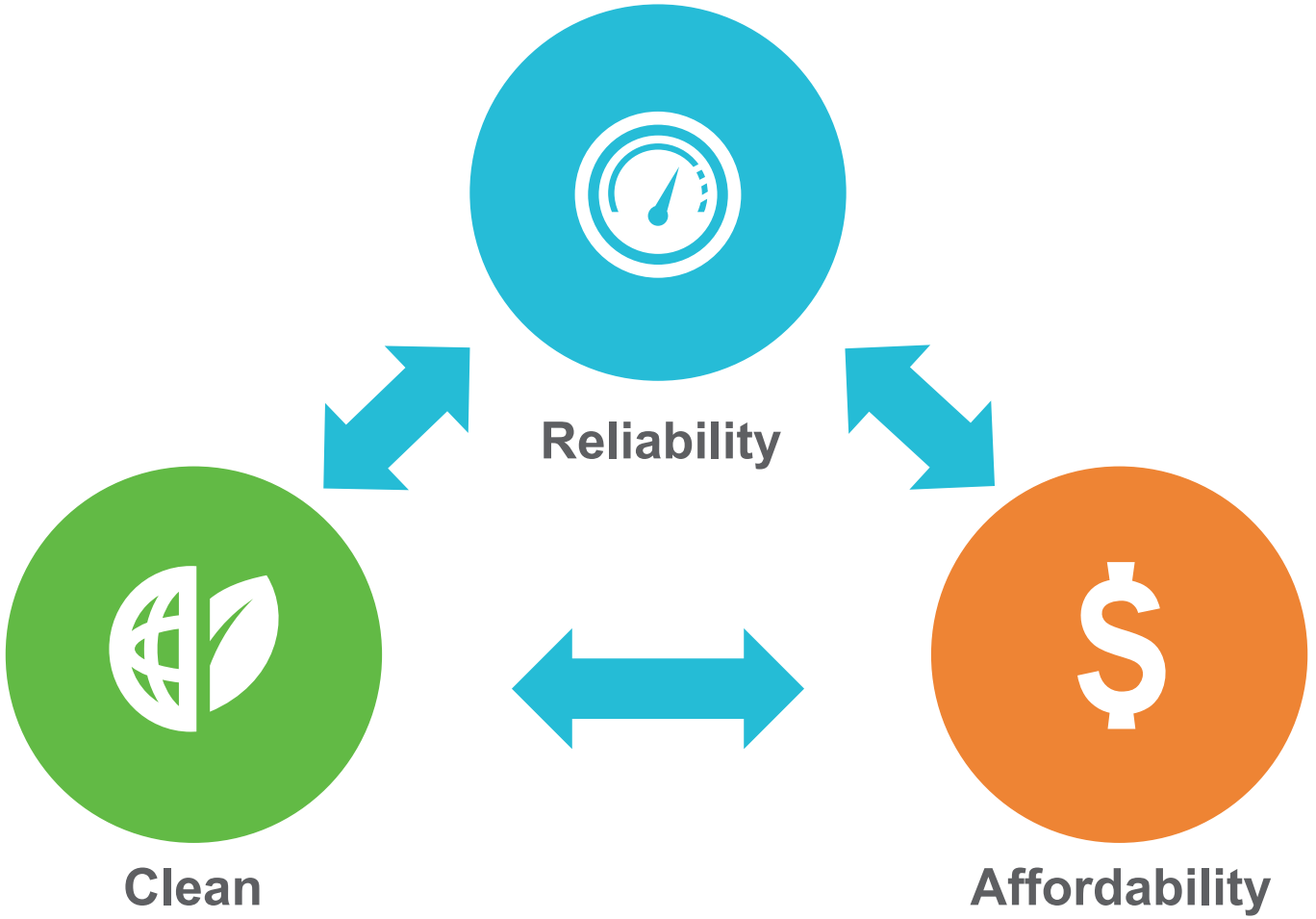
The Changing Electric System

Balancing Objectives



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Reliability

Resource Adequacy and Reliability Defined

Defined

Resource Adequacy: "The ability of the electricity system to **supply the aggregate electric power and energy requirements of the electricity consumers at all times**, taking into account scheduled and reasonably expected unscheduled outages of system components." (NERC)

Operating Reliability: "The ability of the Bulk-Power System to **withstand sudden disturbances**, such as electric short circuits or the unanticipated loss of system elements from credible contingencies, while avoiding uncontrolled cascading blackouts or damage to equipment" (NERC)

What's Changing

- Energy adequacy vs. capacity at peak
- Late summer duck-curve impacts
- Risks during shoulder months
- Pace of transition, higher penetration of variable resources
- More inverter-based and distributed resources
- Extreme weather events
- Gas-power interdependence (not changing but a continuing issue)

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Source: NERC

What the Industry is Saying

NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

…a **significant portion of the U.S. faces risks of electricity supply shortfalls** during periods of more extreme summer conditions.

- NERC 2023 Summer Reliability Assessment

pjm

While electricity demand continues to rise, **more than 20% of PJM's generators (~40 GW) are expected to retire by 2030**. At the same time, the **new renewable generation resources** expected to replace them are successfully completing the PJM interconnection process but **are not being built**.

- PJM, "Ensuring a Reliable Energy Transition"

FERC

The U.S. electric power system is headed for "potentially catastrophic consequences" as dispatchable generating **resources are retiring "far too quickly" and in quantities that "threaten our ability to keep the lights on**."

- FERC Commissioner Christie to the House Subcommittee on Energy, Climate and Grid Security

New York ISO
Independent System Operator

"New York's public policies are increasingly prioritizing clean energy production and a rapid transition away from fossil fuels… …it is **imperative that during this time of rapid change we maintain adequate supply** necessary to meet a growing demand for electricity."

- Rich Dewey, CEO of NYISO

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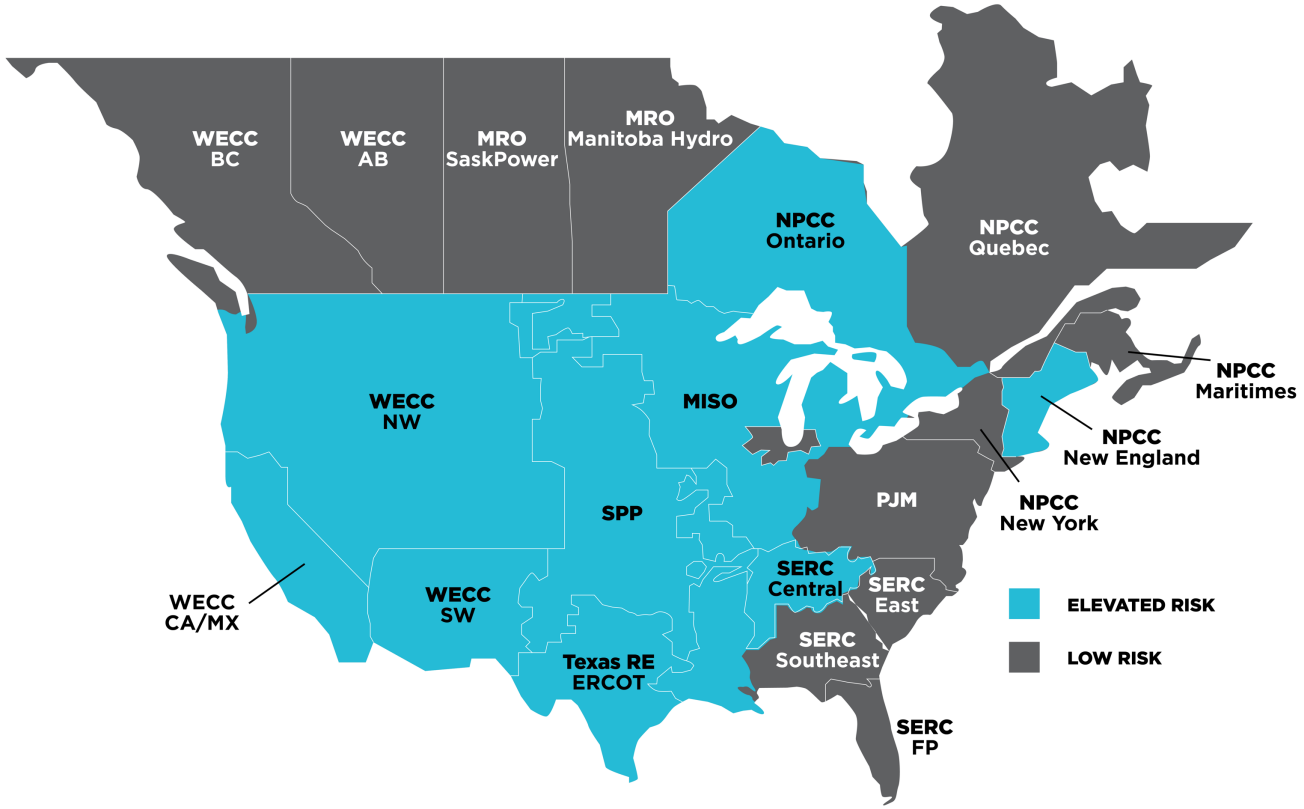
Sources: NERC, PJM, FERC, NYISO

NERC Summer Reliability Assessment



Seasonal Risk Assessment Summary	
HIGH	Potential for insufficient operating reserves in normal peak conditions
ELEVATED	Potential for insufficient operating reserves in above-normal conditions
LOW	Sufficient operating reserves expected

According to NERC's Summer Reliability Assessment, around 2/3rds of the country is at elevated risk of having insufficient operating reserves this summer.

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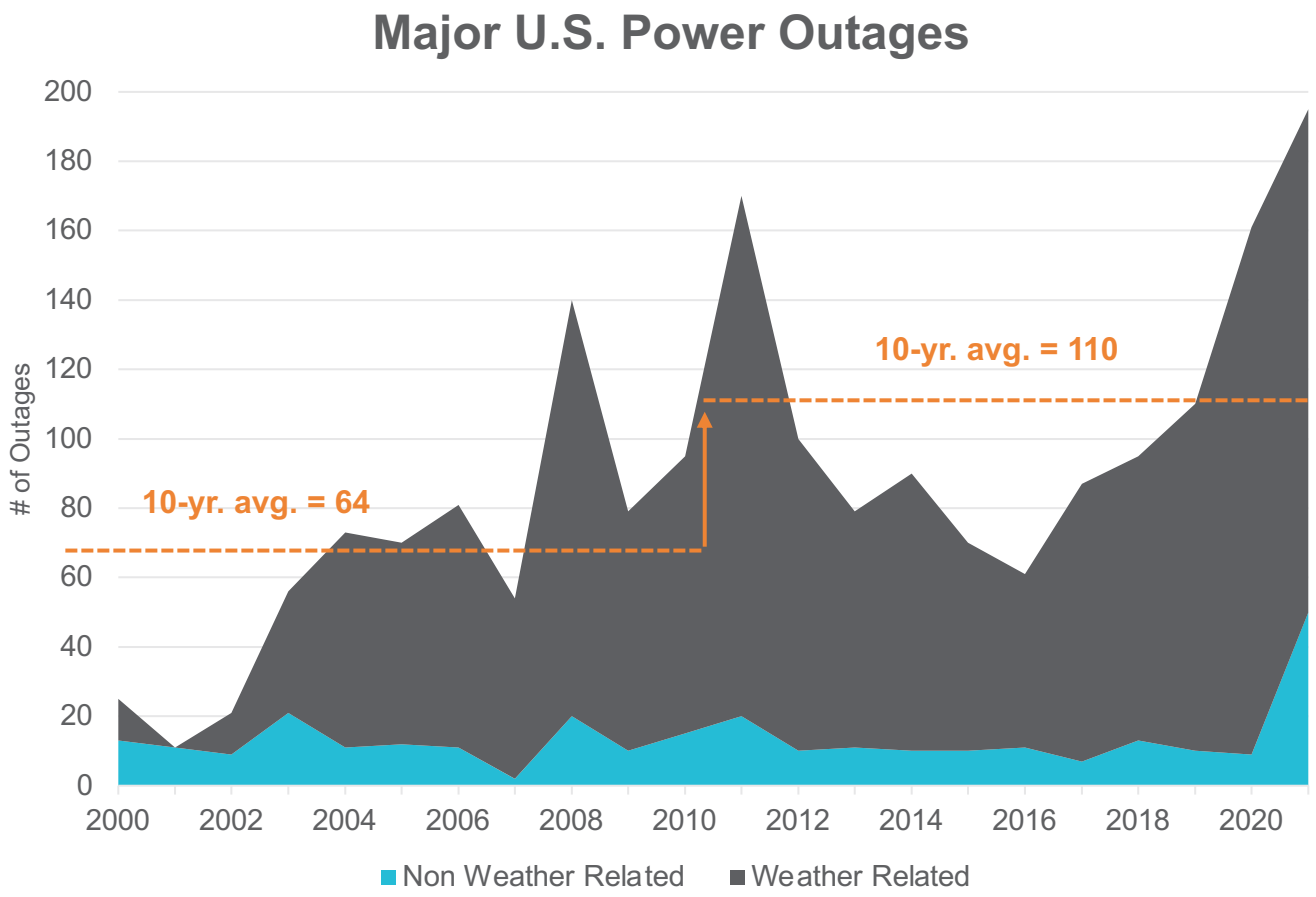
Source: NERC Summer Reliability Assessment

Driver of change – Severe Weather



Average annual weather-related power outages increased by 78% during 2011-2021, compared to 2000-2010

Major power outage – Outage reported by an electric utility during which at least 50,000 customers lost power (FERC OE-417)

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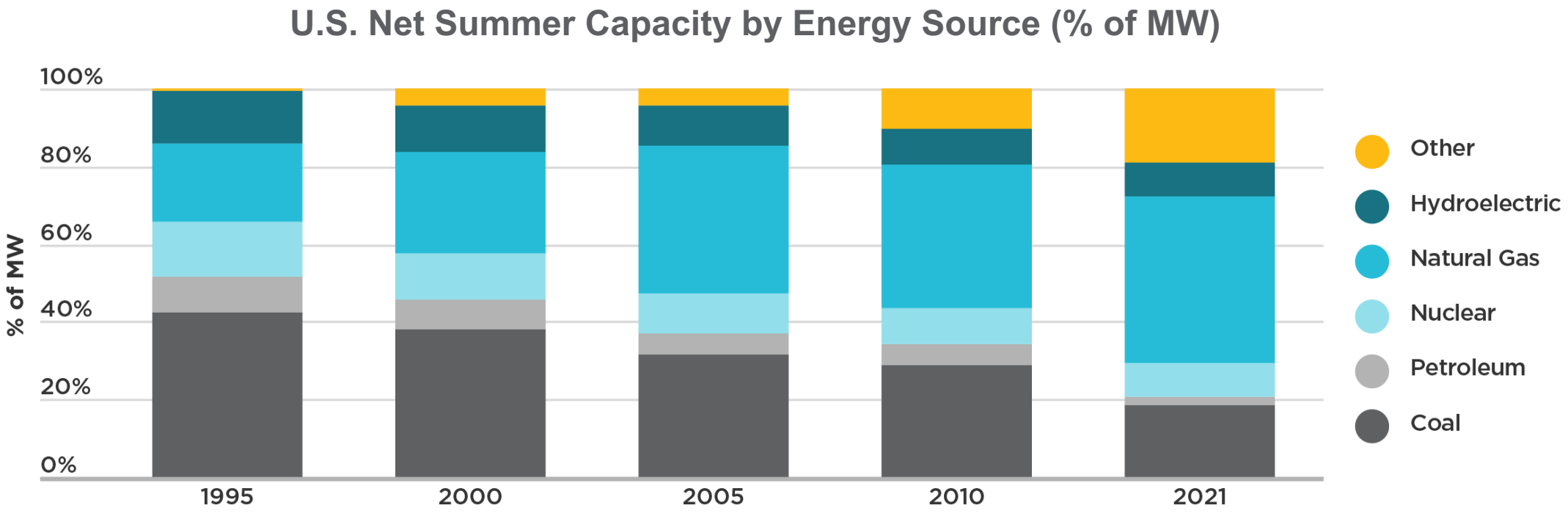
Source: Climate Matters "Surging Weather-Related Power Outages" (2022)

Changing Resource Mix



U.S. renewable, hydro, and natural gas generating capacity has gone from about 1/3 of total capacity in 1995 to more than 2/3 as of 2021.

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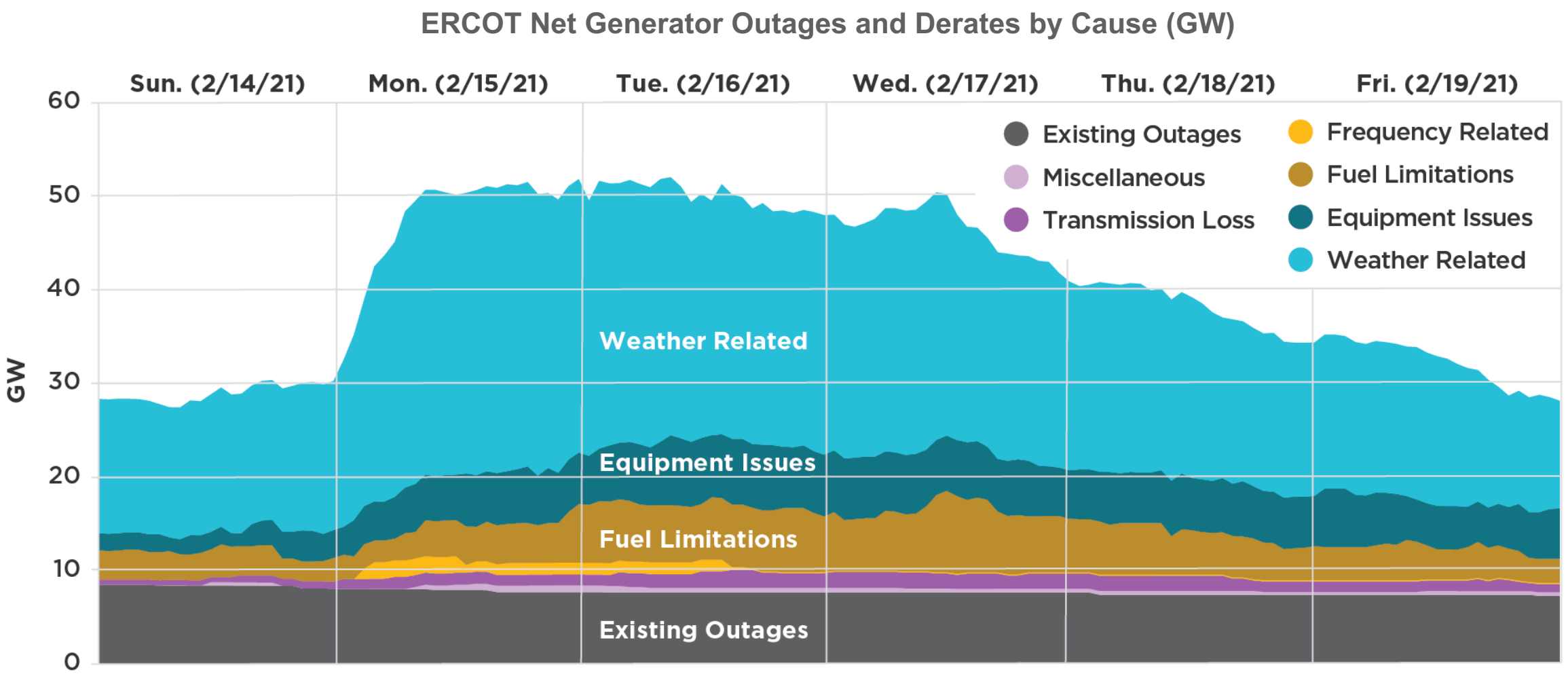
Source: EIA

Extreme Weather – February 2021 Winter Storm Uri



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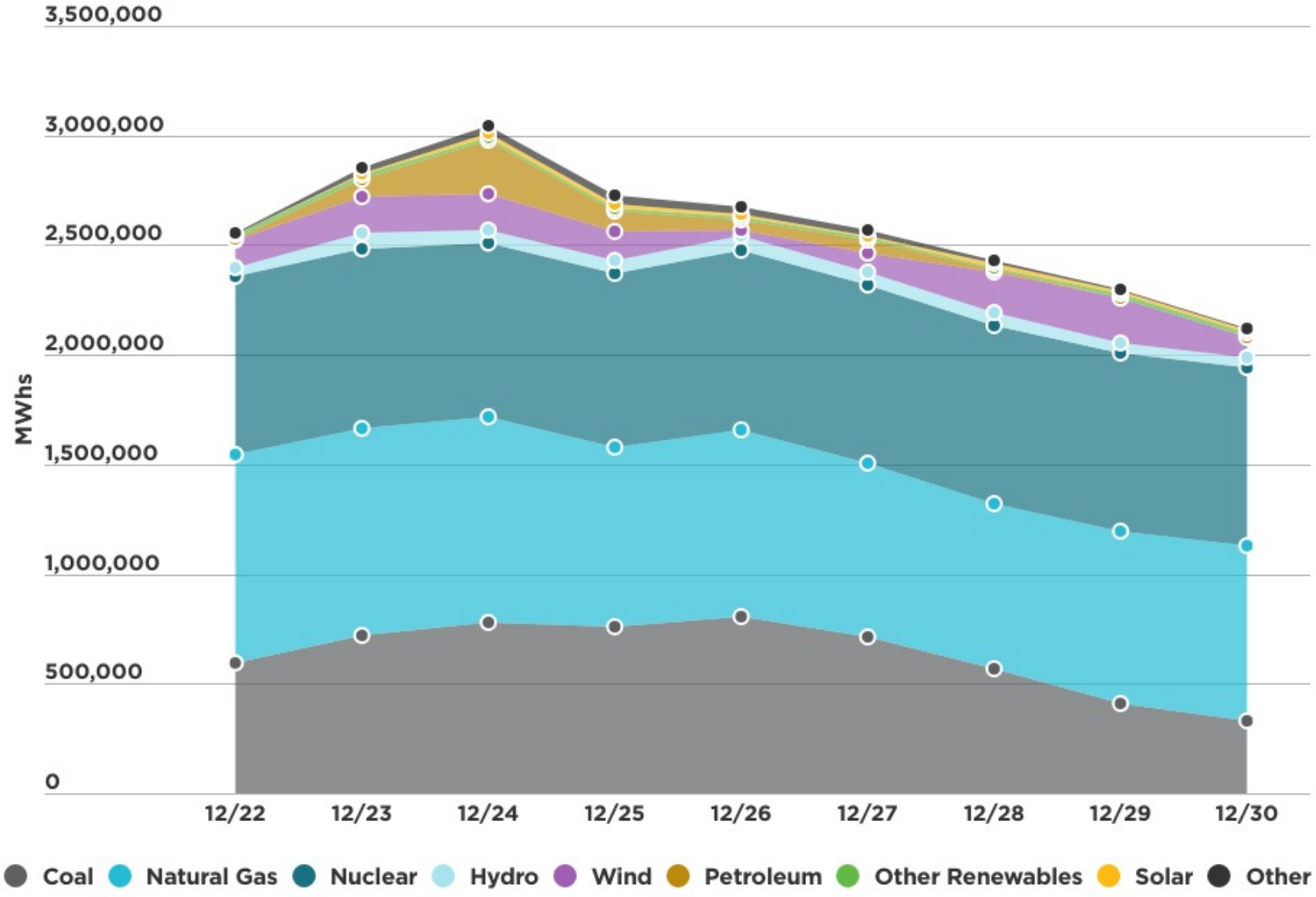
Source: ERCOT

Extreme Weather – December 2022 Winter Storm Elliott – PJM



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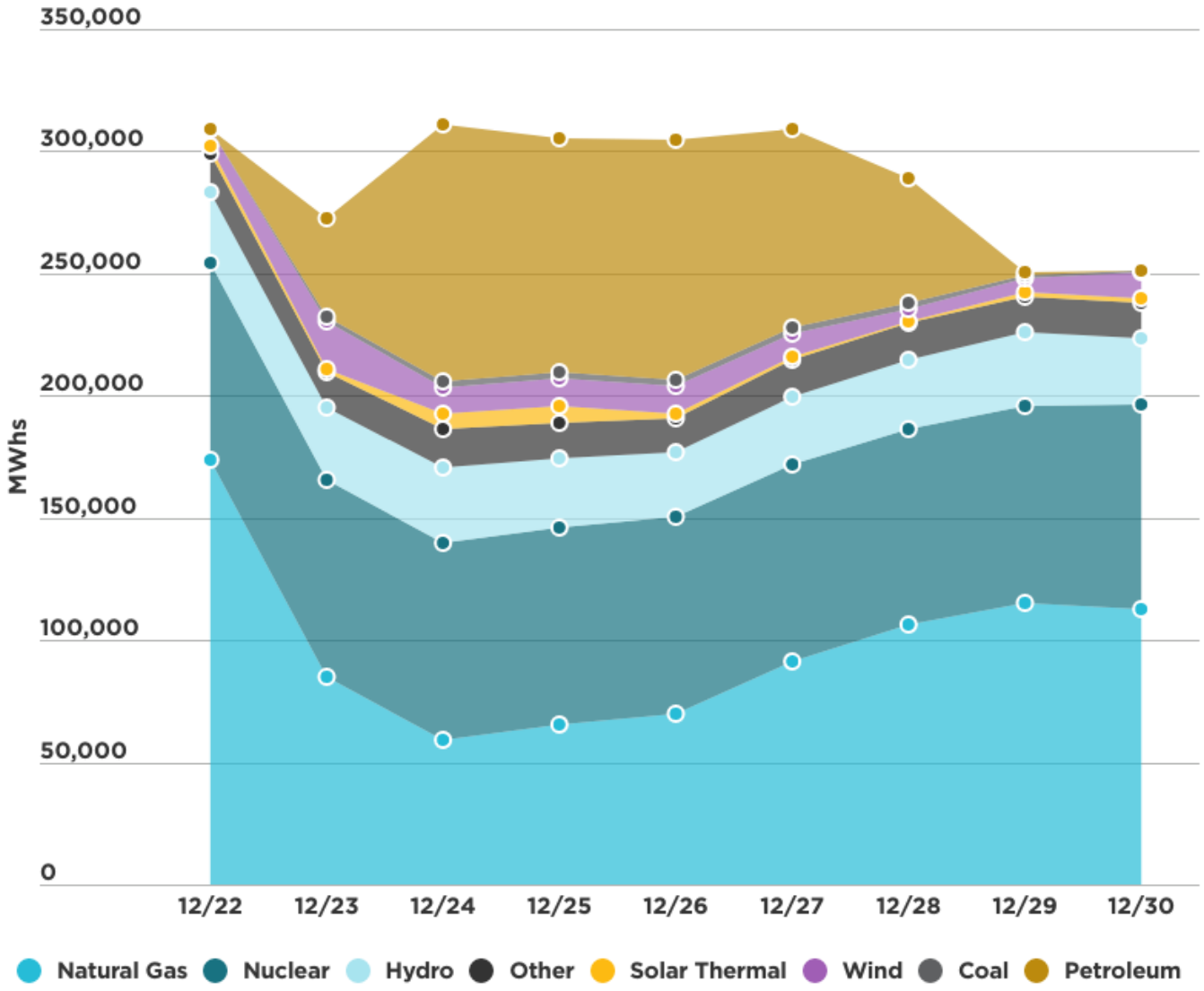
Sources: EIA, RTO data

Extreme Weather – December 2022 Winter Storm Elliott – ISO NE



Sources: EIA, RTO data

Electric/Gas Coordination

	2011 EVENT	2014 EVENT	2015 EVENT	2016 EVENT	2017 EVENT
Significant levels of incremental unplanned electric generating unit losses with top causes found to be mechanical/electrical, freezing, and fuel issues	✓	✓	✓	✓	✓
Significant natural gas production decreases occurred, with some areas of the country more severely affected.	✓			✓	✓
Short-range forecasts of peak electricity demands were less than actual demands for some BAs in event area.	✓		✓	✓	✓

Winter Storm Elliott highlighted the failings of current electric and gas coordination.

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Source: NERC

Electric/Gas Coordination Cont'd

2011 Report

- Utilize pre-operational warming prior to severe cold weather
- Perform adequate/timely inspection of generating unit freeze protection measures; inspect / maintain heat trace and insulation
- Ensure winterization supplies/equipment are in place, and ensure adequate staffing for cold weather events

2014 Polar Vortex Report

- Review and update generating unit weatherization based on lessons learned, and conduct reviews of generating unit winter readiness

2021 Winter Storm Uri Report

- Add/modify Reliability Standards regarding generating unit freeze protection measures
- Require natural gas facilities to implement cold weather preparedness plans; implement measures to protect natural gas infrastructure from freezing; adopt minimum uniform standards for winterization of natural gas production and processing facilities
- Establish a forum to improve reliability of natural gas infrastructure to support the Bulk Electric System
- Protect critical natural gas infrastructure loads from demand response and load shedding

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Source: NERC

Key Takeaways

Industry Change

The **nature of bulk power resources has changed** over the past decade.

Extreme Weather

Recent summer and winter weather **events have tested power supply availability**—both for renewable and gas-fired generation.

Need for New Measures

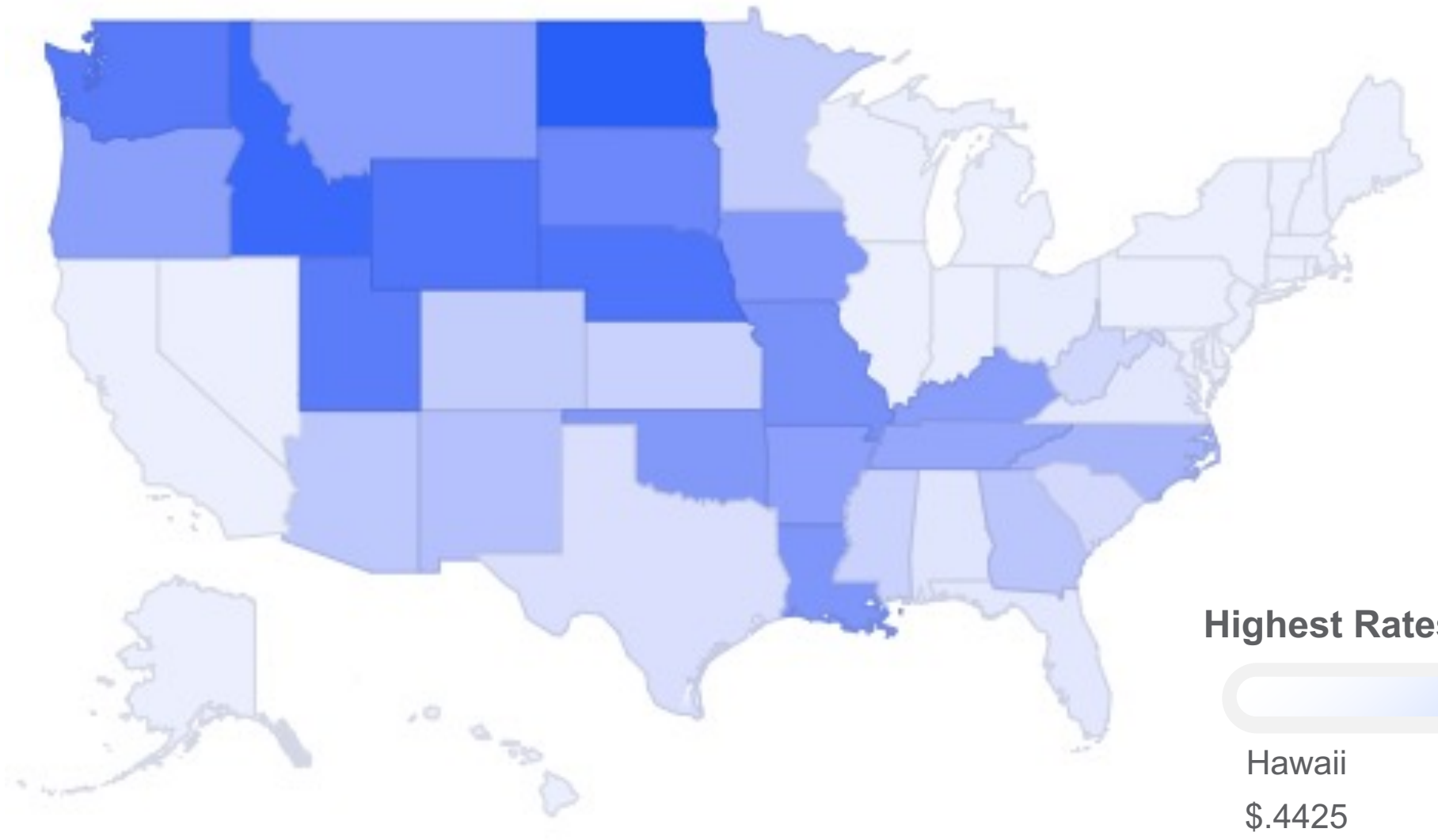
Resource adequacy analysis is adapting to account for different supply composition and the needs for energy adequacy through multi-hour and multi-day events.

Electric / Gas Interdependence

The interdependence of gas and power systems **continues to be an area of vulnerability**, particularly in winter. Gas demand for power is growing for heating demand and to back up renewables.

Affordability

Residential Electricity Cost per KWh by State



Highest Rates

Hawaii

$.4425

Lowest Rates

N Dakota

$.0972

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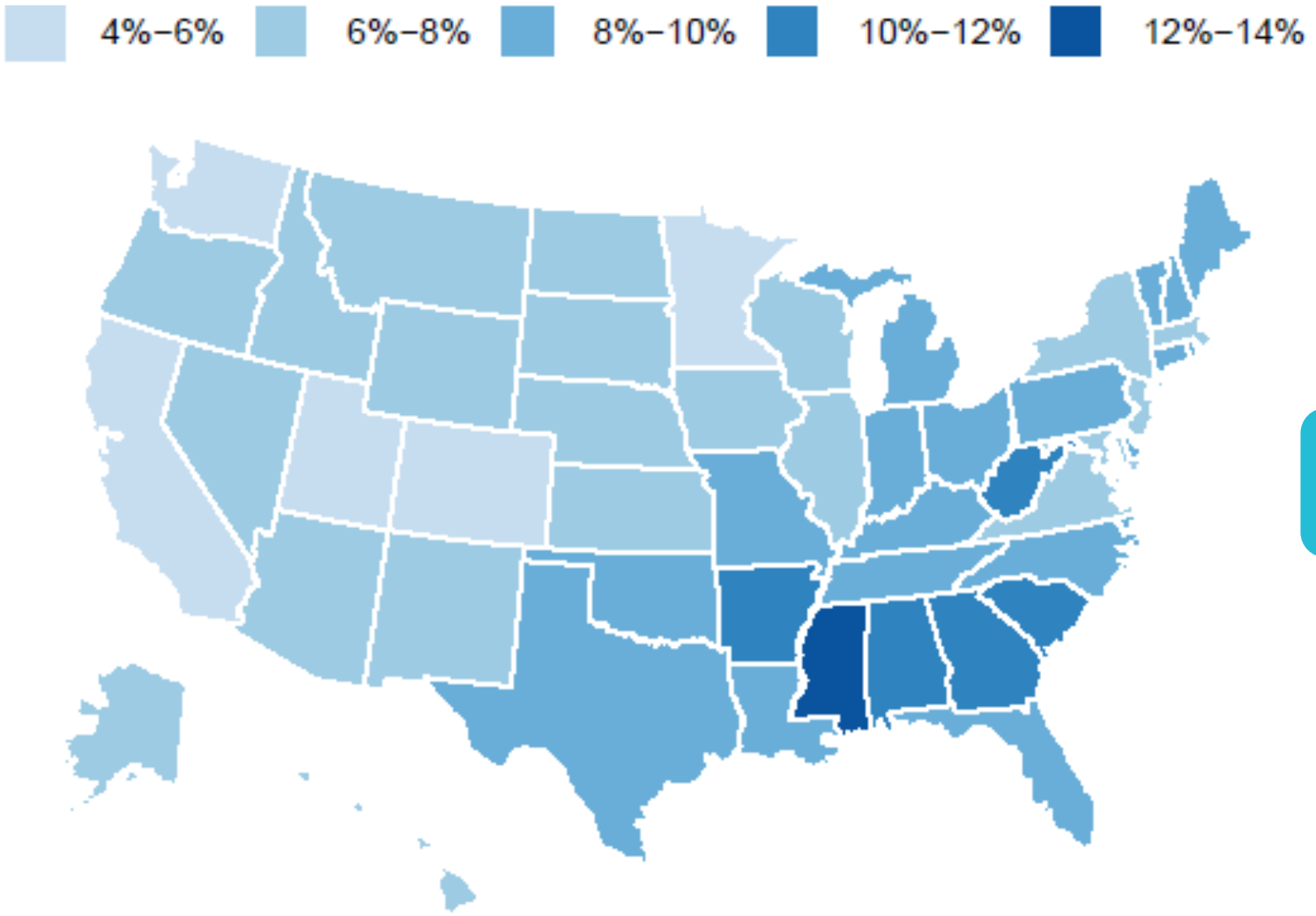
Source: Energybot

Low-Income Energy Burden (% of Income)



Average energy burden for low income customers is 8.6%; for non-low income is 3%

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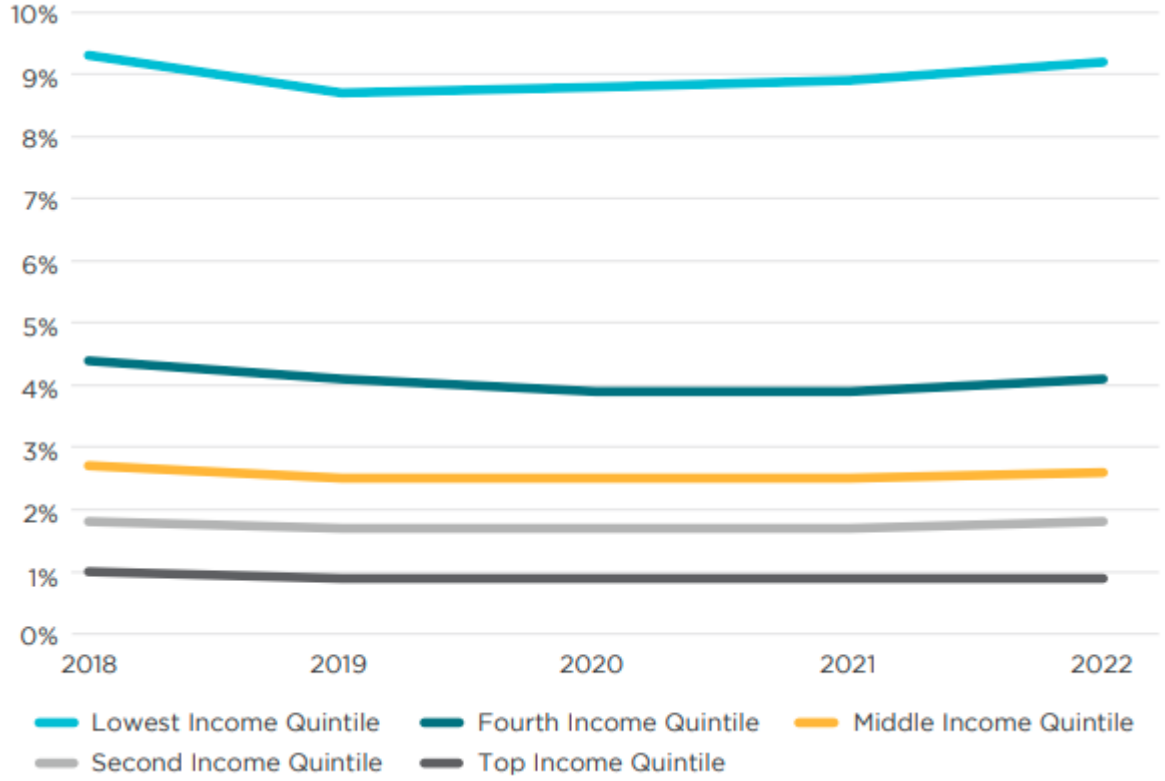
Affordability Metrics

U.S. Household Percentage of Income Spent on Electricity by Income Tier (2021–22 Estimated)



California's Recently Implemented Approach to Affordability Metrics

Affordability Ratio (AR)

$ essential services bill

$ household income – non-discretionary expenses (housing and other utilities)

= AR

Hours at Minimum Wage (HM)

\# Hours of earned employment at the local minimum wage needed to pay for essential services

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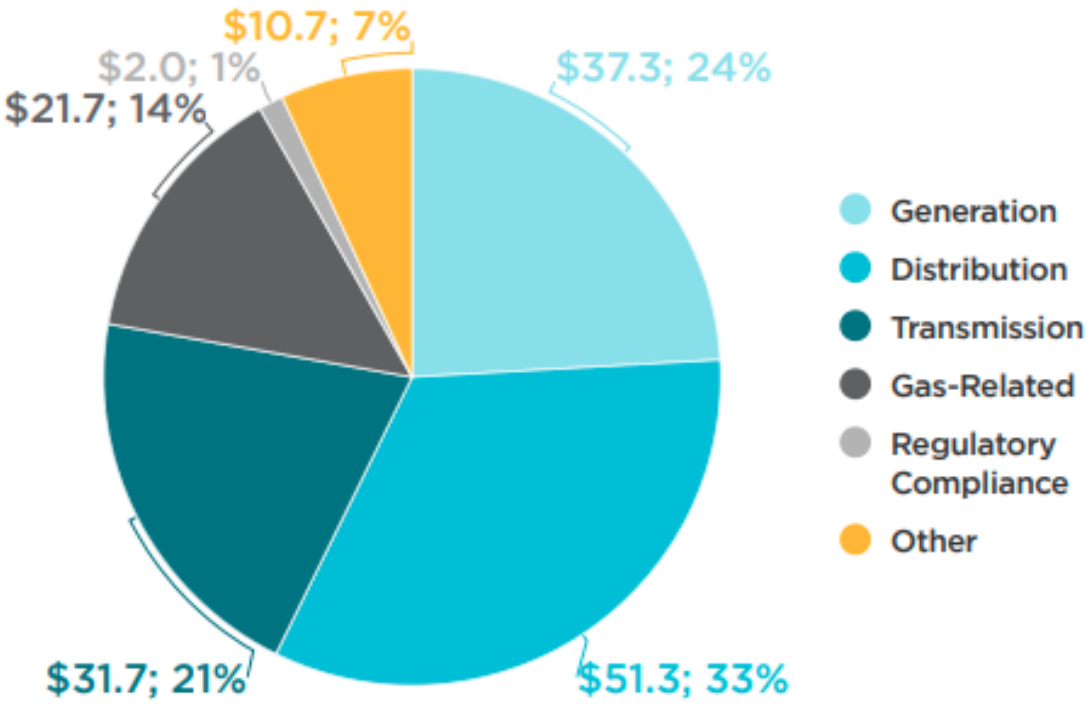
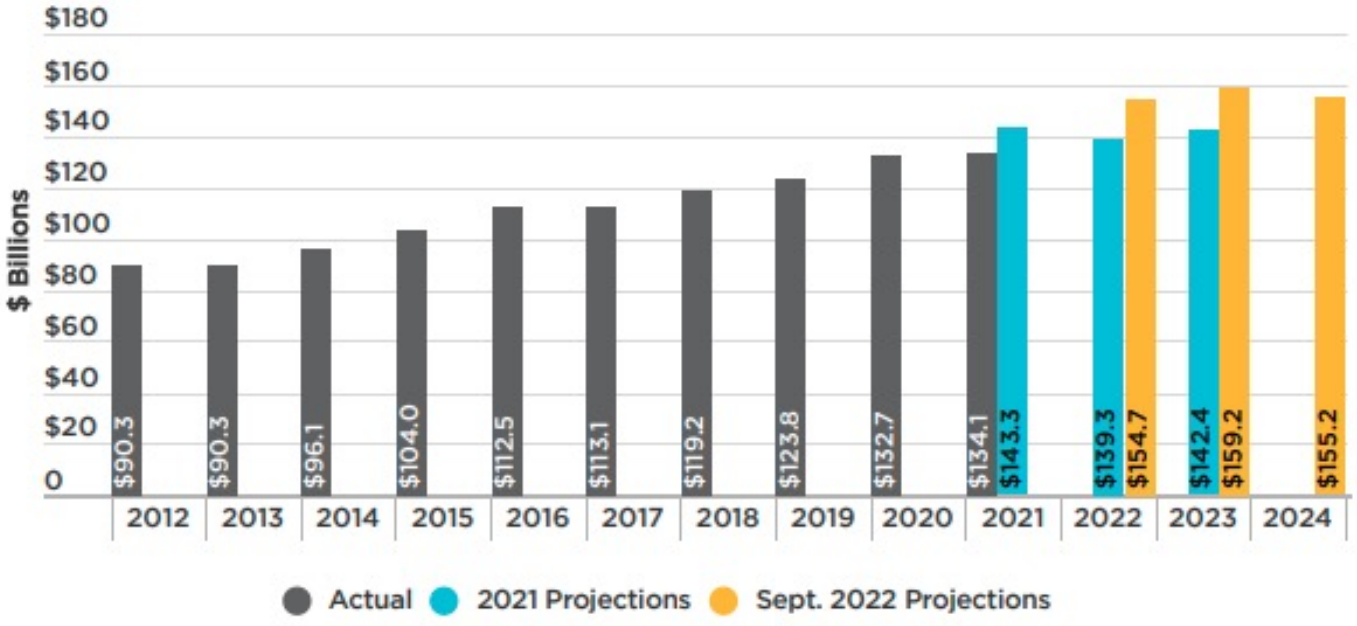
Source: National Energy Assistance Directors Association, CPUC

Utility Capex

Investor-Owned Electric Utilities Estimated Functional Capital Expenditures (2022) ($ Billions)



Actual and Projected Capital Expenditures for Investor-Owned Electric Utilities (2012–2024) ($ Billions)



Utility spending is expected to continue to rise, putting additional upward pressure on electricity prices

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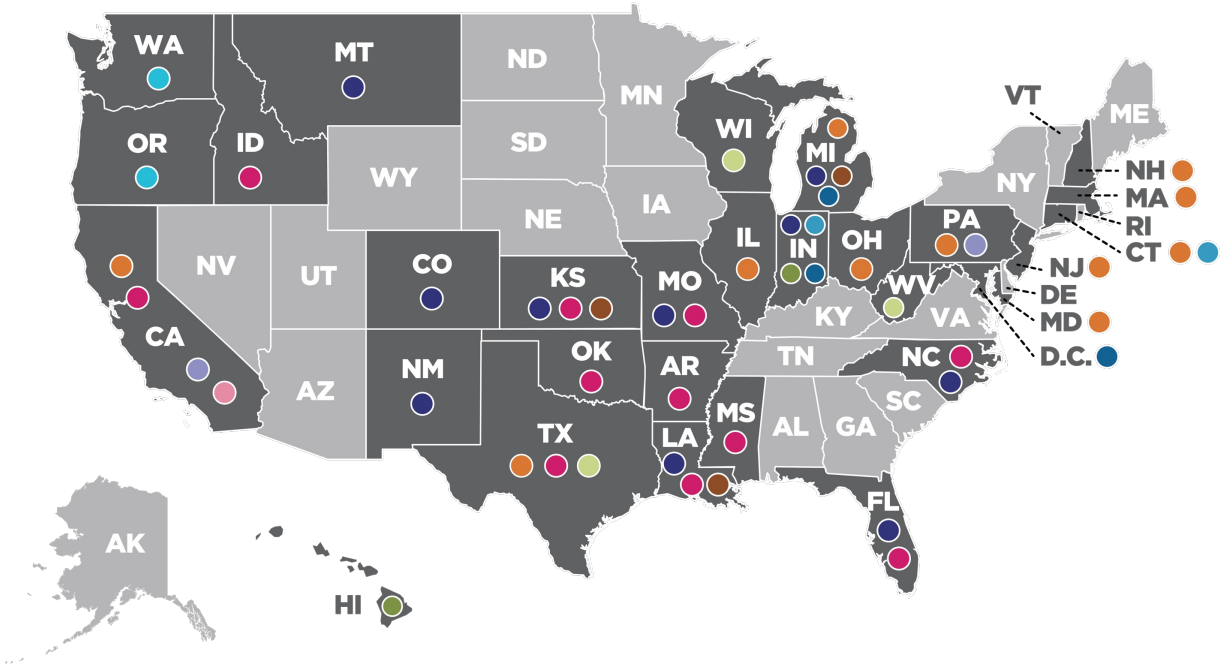
Source: EEI

Regulatory Assets

32 jurisdictions allow by statute or rule utilities to seek securitization of costs



Incremental regulatory assets may include storm costs, COVID costs, non-rate case asks (EE, single issue projects), riders and trackers

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Source: S&P Capital IQ Pro

Key Takeaways

Customer Bills and Affordability

Electricity rates will continue to rise, as will customer bills. Utilities and their regulators will be well served to consider ways to temper rate hikes and enhance programs that assist in ensuring energy affordability.

Increasing Investment

Aggregate **power system investment is increasing** as utilities modernize their grids, replace aging infrastructure, incorporate new resources, and accommodate increasing electrification.

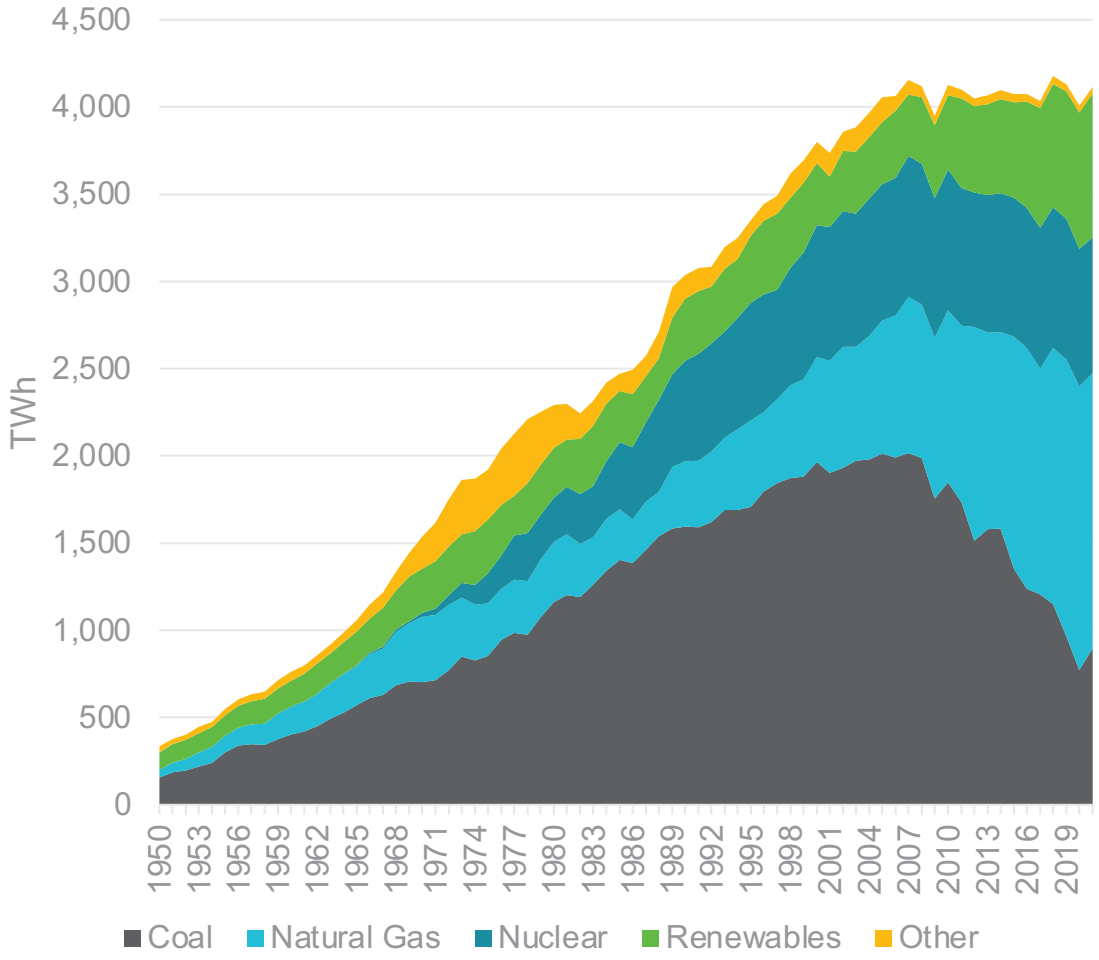
Amortizing Extraordinary Expenses

System shocks – from pandemic-related costs, extraordinary weather events, potential stranded costs (early retirement of some assets) – **remain concerns for utilities**.

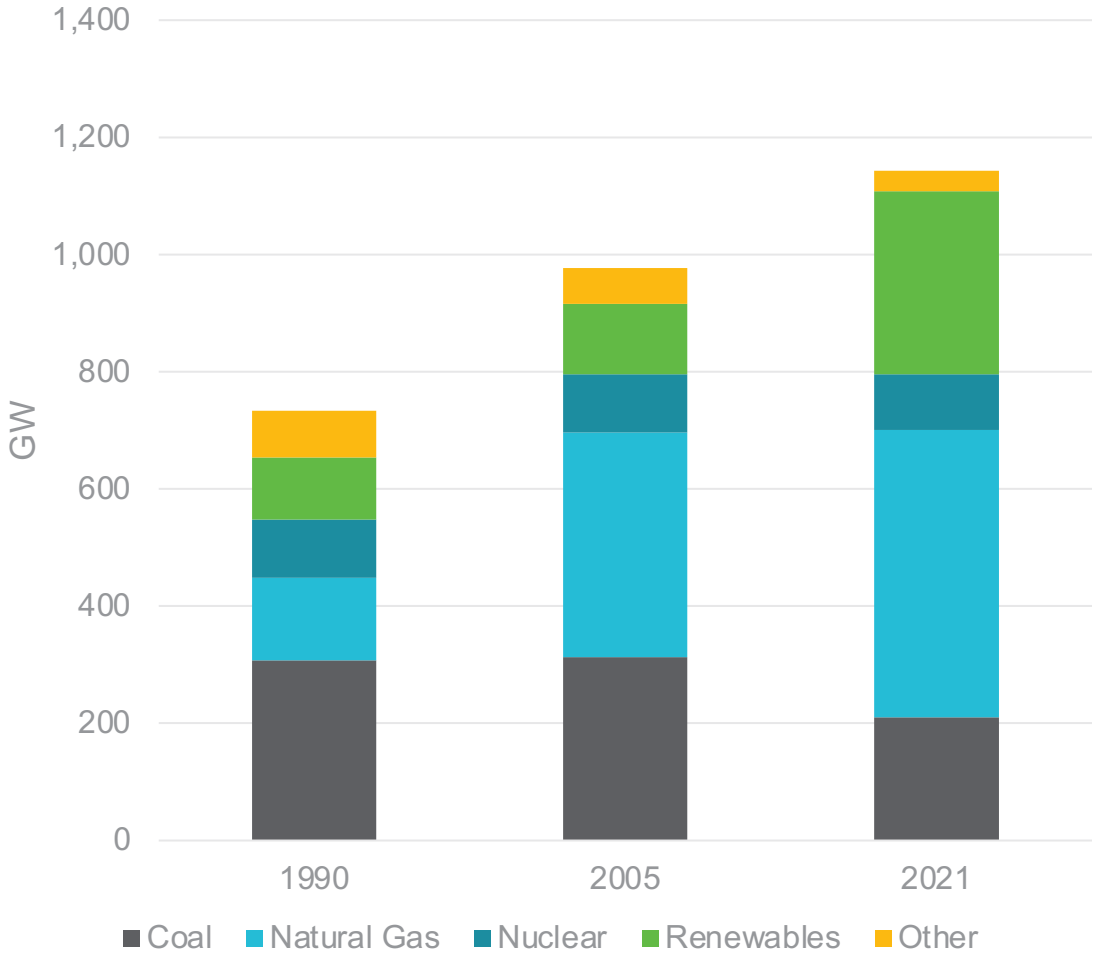
Clean

Changing Generation Mix

U.S. Generation Mix by Year (1950-2021) (TWh)



U.S. Capacity by Major Energy Source (GW)



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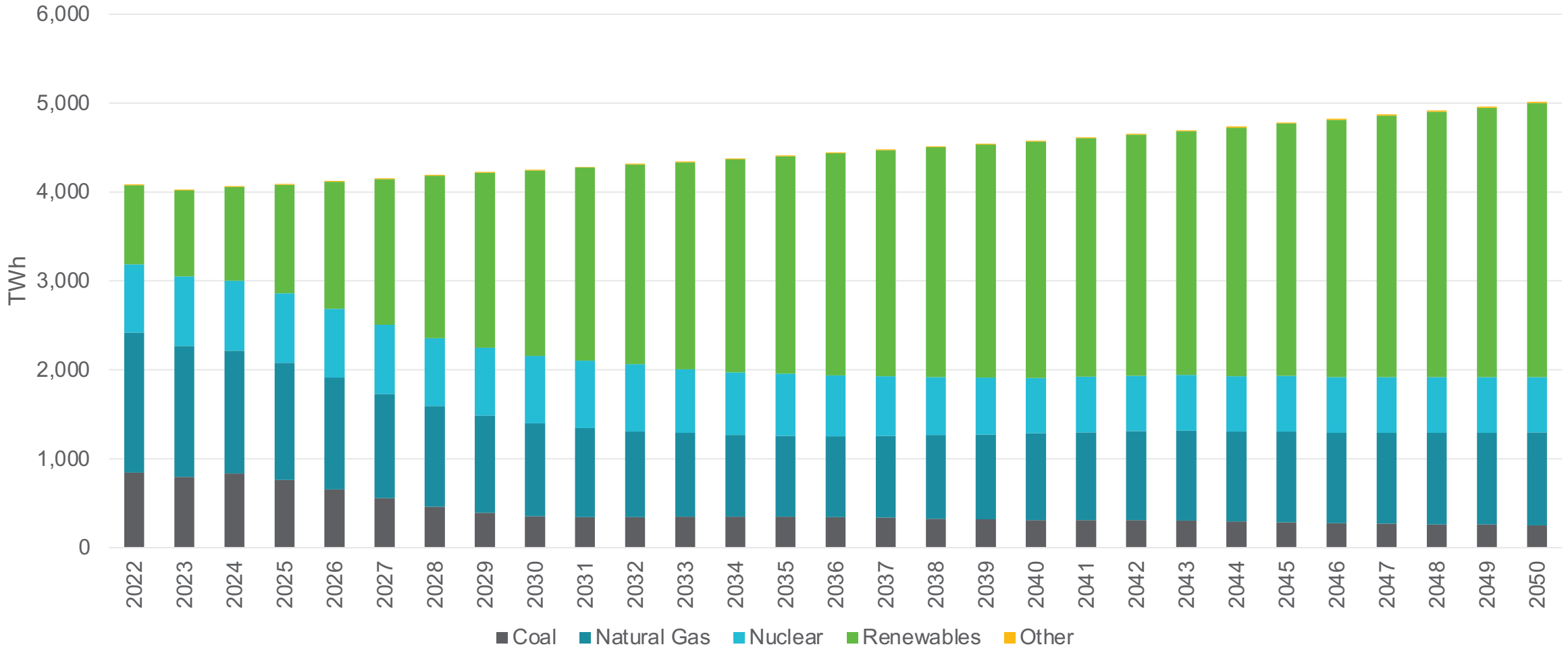
A New Energy Landscape

Projected U.S. Electricity Generation by Fuel Type (2022-2050) (TWh)



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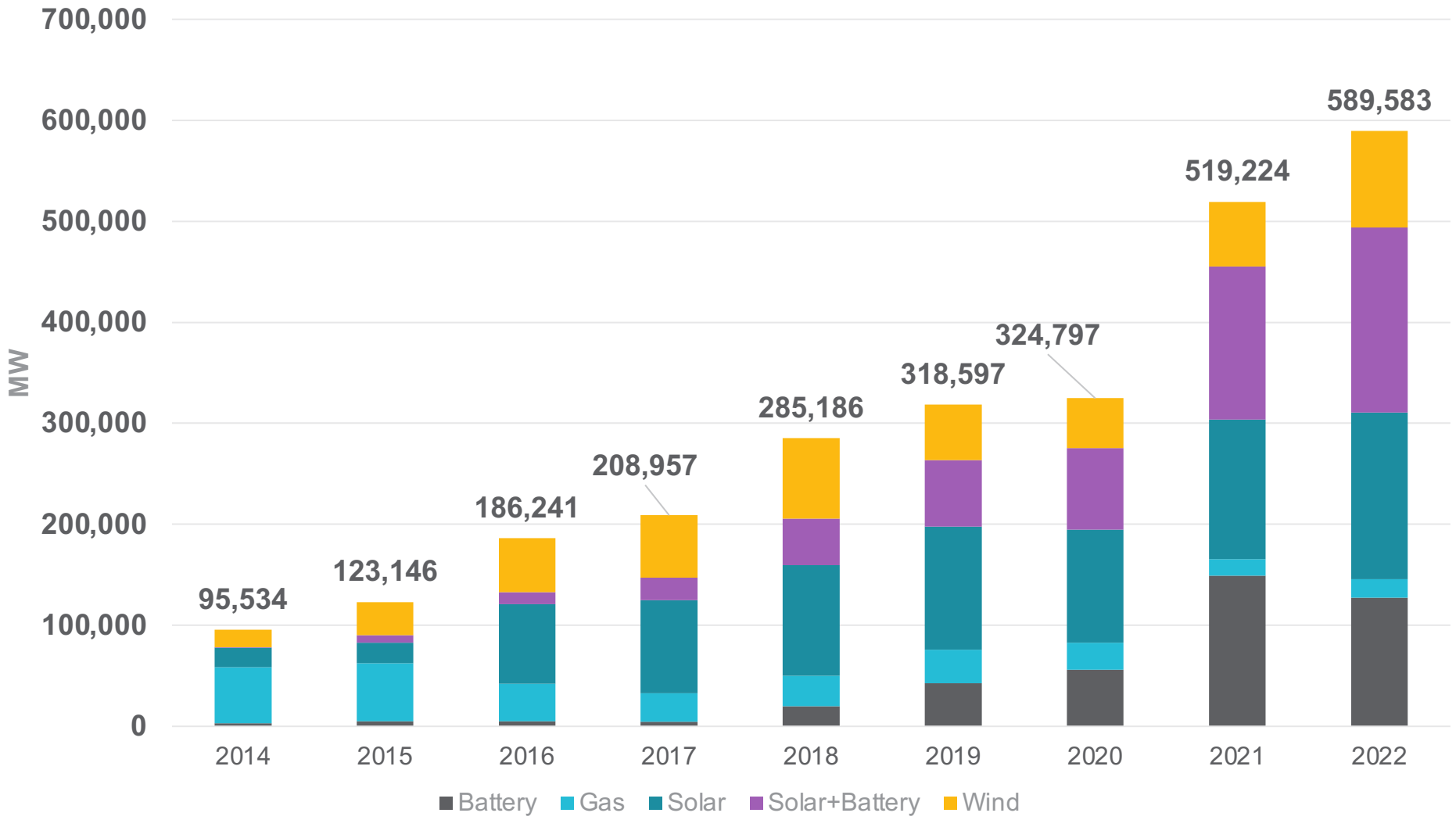
Source: EIA Annual Energy Outlook 2023

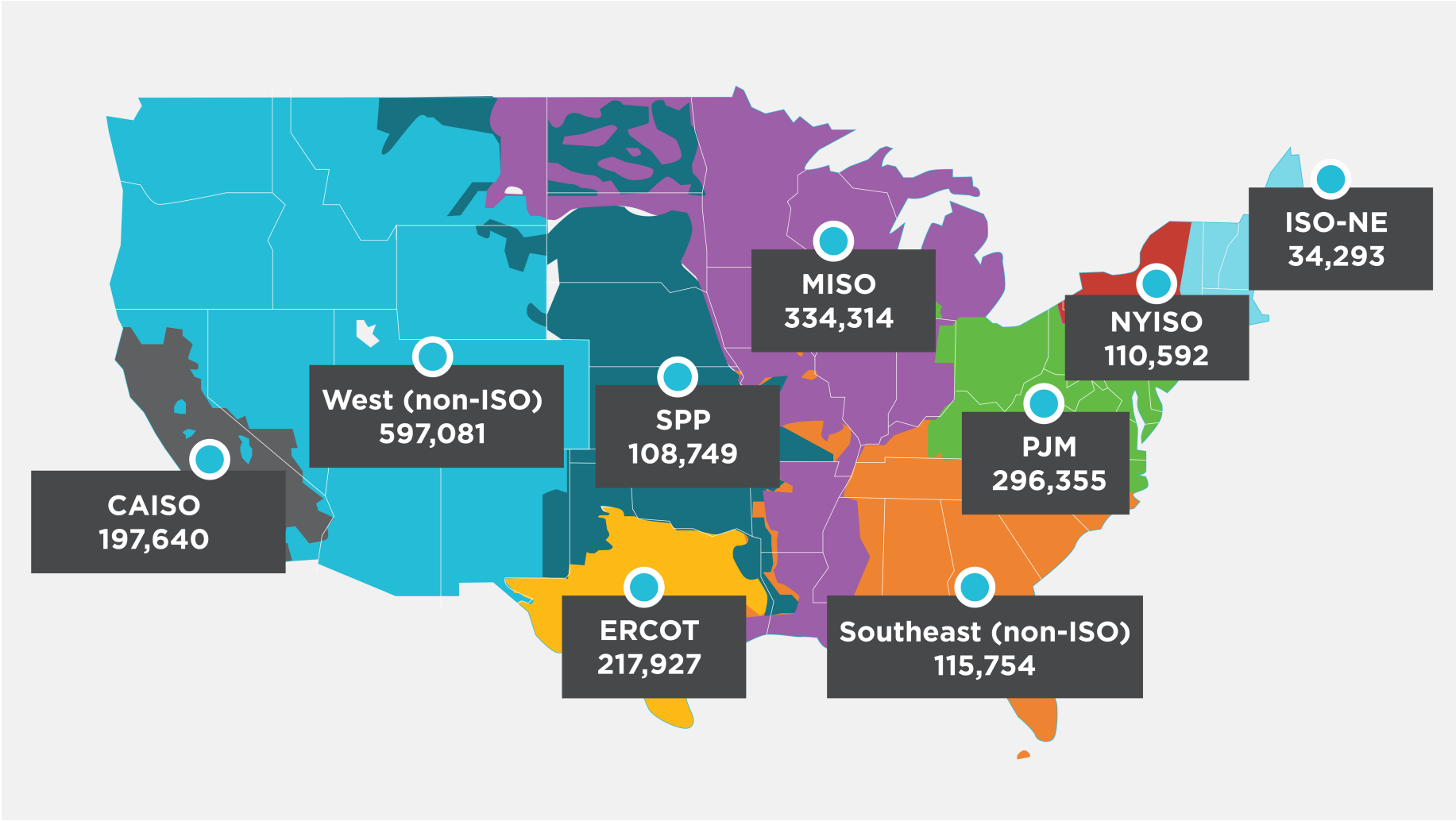
Interconnection Queues – Generation in Queue by Year and Capacity



Source: Lawrence Berkely National Lab

Note: Data for both graphics is through the end of 2022.

Interconnection Queues – Cumulative MW in Regional Queues

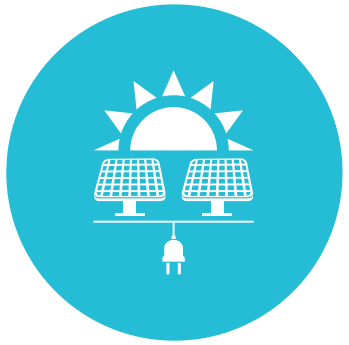


Source: Lawrence Berkely National Lab

Note: Data for both graphics is through the end of 2022.

New Technologies as Potential Game Changers?

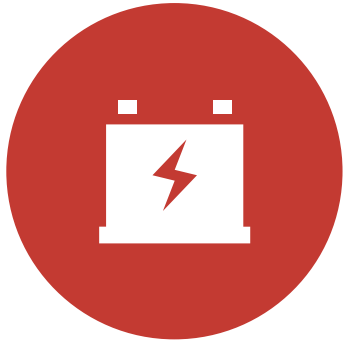
Advanced Nuclear (SMRs)



Distributed Generation

Hydrogen

Carbon Capture and Storage (CCS)



Long-Duration Storage

Offshore Wind

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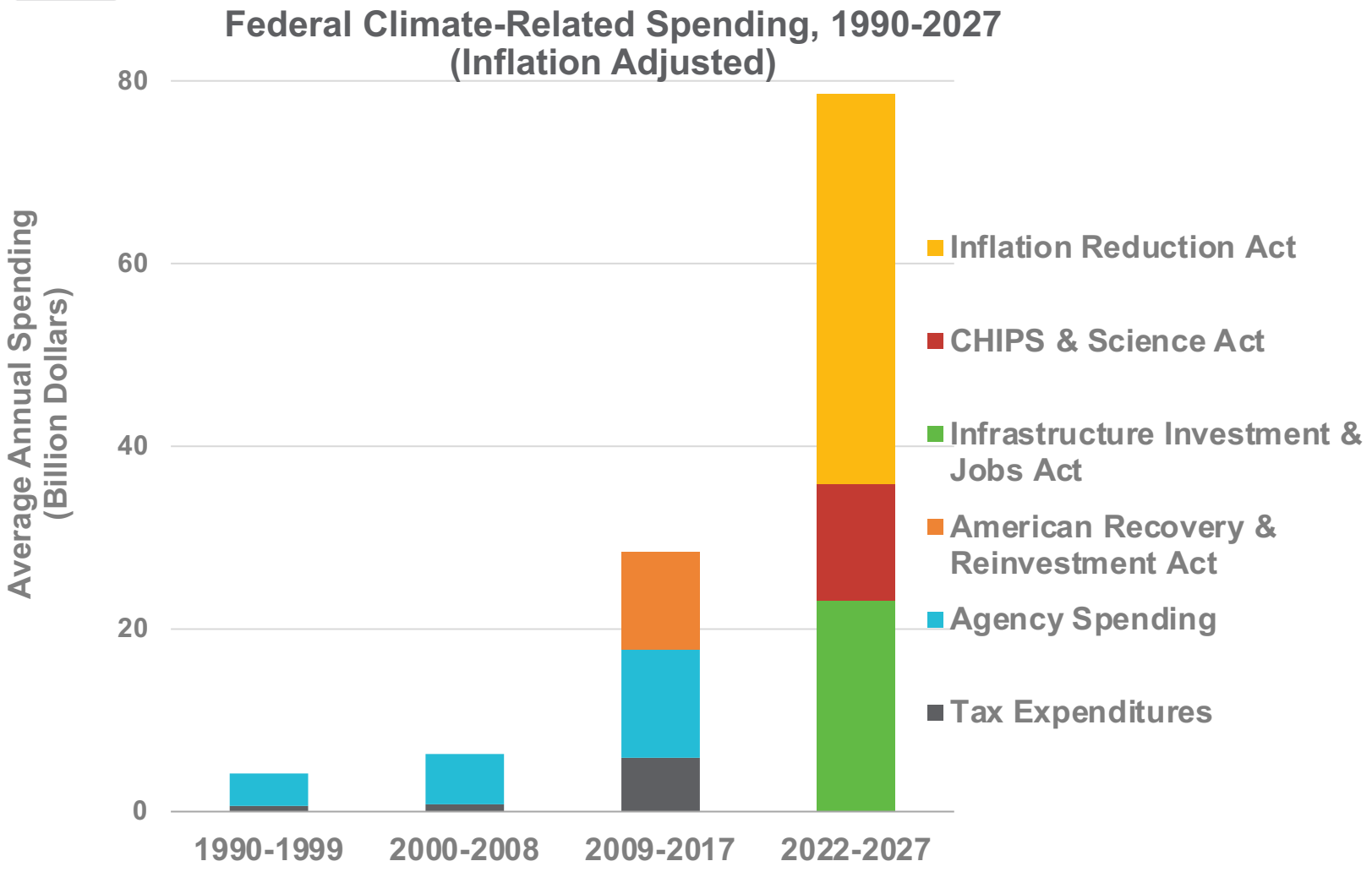
Federal Spending Bolsters Transition



IRA
Sweeping in Scope & Scale

- Cost
- Carbon
- Jobs

Sources: Rocky Mountain Institute; ScottMadden analysis of IRA

Key Takeaways

Pace of Change

Policy mandates and federal subsidies are **driving money into the sector** and the generation mix is shifting rapidly.

Transmission and Interconnection

There are significant resources awaiting interconnection across the US. There is **increasing focus on transmission as an enabler** of the clean energy transition.

Nascent Technologies

The industry is making **big bets on technologies** that are in relatively early stages of development. Projections for some of these resources may prove optimistic (both deployment timelines and cost).

IRA Effects

The IRA will help these nascent technologies come to market; however, it may also drive investment in **resources that don't contribute to reliability** in a meaningful way.

What Can be Done?

Integrated System Planning

The energy transition is creating additional complexity in operating and planning for utility systems.

DRIVERS FOR PLANNING INTEGRATION
Generation and Transmission

- Common mode failure analysis
- Interconnection queue challenges
- FERC Notice of Proposed Rulemaking on regional planning
- Resources that span functions (energy storage)

DRIVERS FOR PLANNING INTEGRATION
Transmission and Distribution

- Wholesale demand response management
- FERC Order 2222
- Distributed energy resources located at sub-transmission
- Interconnection cost allocation
- Real time operations
- Optimized solutions across T&D

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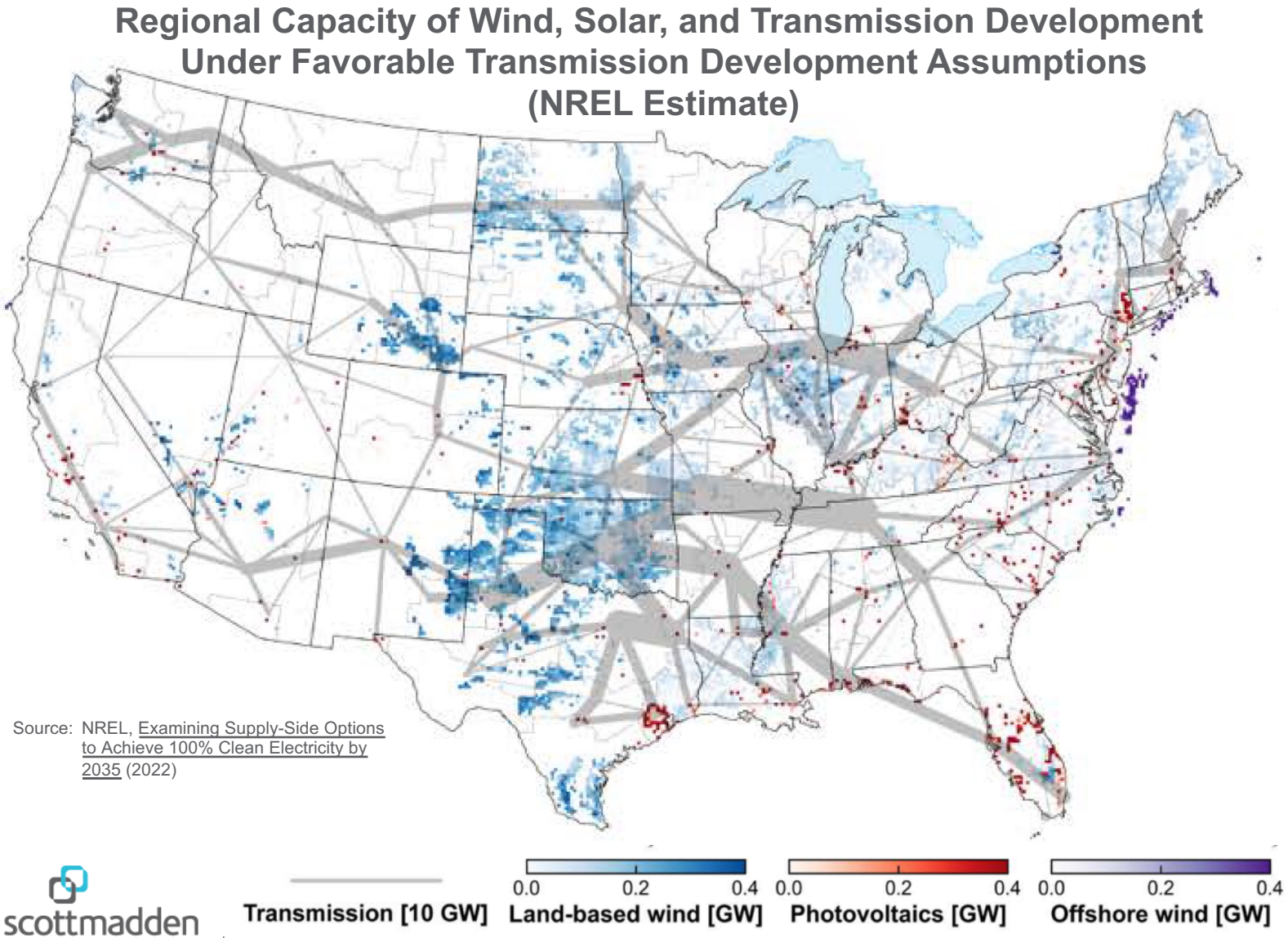
Integrated System Planning

Integrating (or re-integrating) planning processes can help address growing complexity:

- **Better management of increasing penetrations of DERs**
- **Achievement of aggressive net-zero/carbon-emission reduction targets**
- **Optimization of investments at the system level (for effectiveness and lowest cost)**
- **Fairly and accurately accounting for the full value of non-wires alternatives**
- **Sharing data required to transition from deterministic to probabilistic forecasting**
- **Better supporting system scenario planning**

There is no Transition Without Transmission



Source: NREL, Examining Supply-Side Options to Achieve 100% Clean Electricity by 2035 (2022)

- Transmission is a key to reduce cost and reliability issues while accessing renewable energy distant from load centers
- Permitting reform is critical to developing the transmission needed for transition (see chart at left)

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Education About Tradeoffs

Policymakers and Regulators

- Required investment (T, D, G, and DR)
- Performance and cost profile of new mix
- Marginal cost of reliability
- Prudency and new technology
- Time to transition
- Alternative rate designs

Stakeholders

- Potential bill impacts to avoid rate shock
- Drivers of cost, especially reliability
- Focus on affordability
- Efficiency and other customer-side options and mitigation strategies

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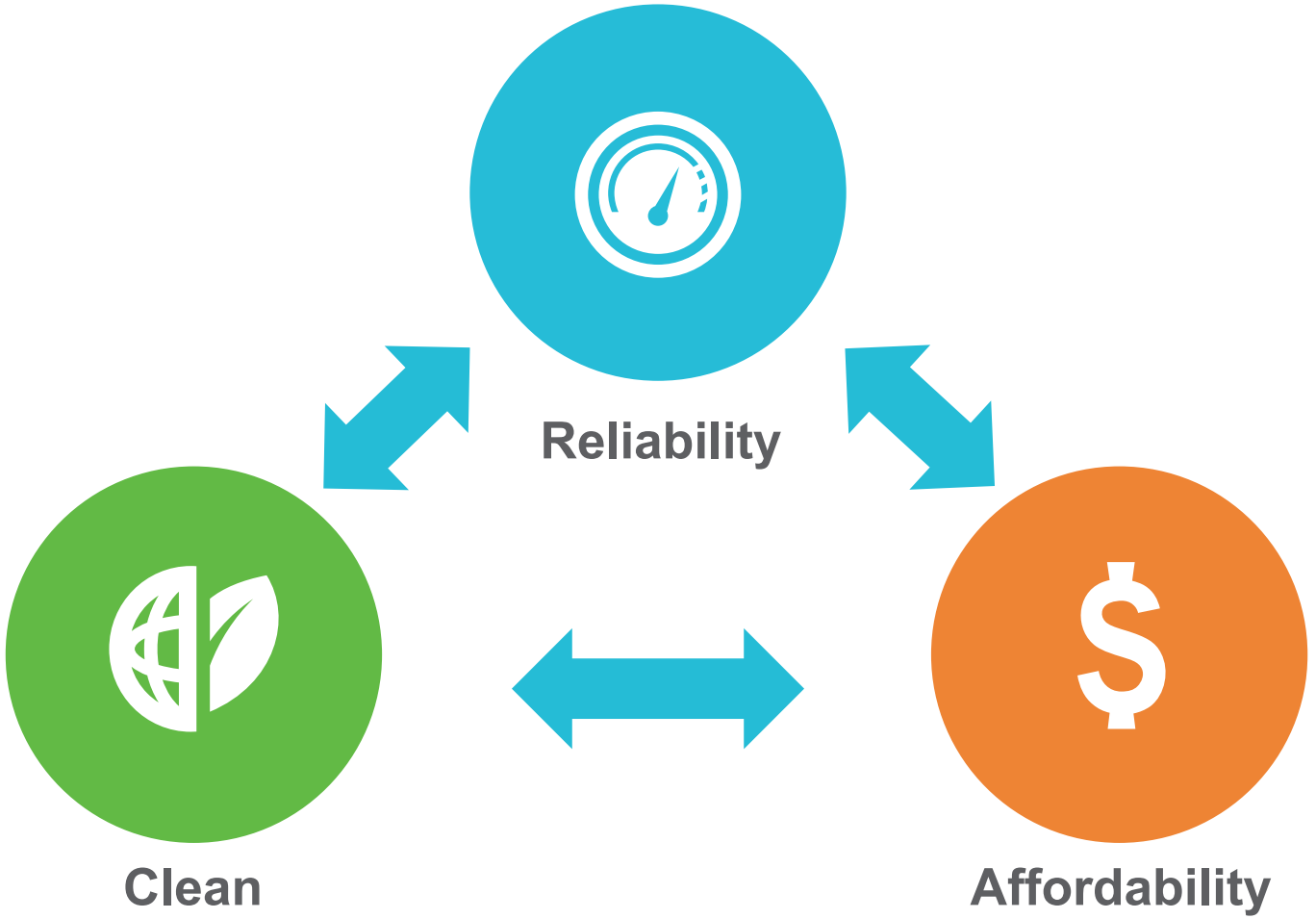
Balancing Objectives

An informed conversation about the necessary trade offs across these objectives is critical to achieving all three



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