Grid Needs to Support EV Charging and Other Load Growth

PREPARING FOR RISING DEMAND

PRESENTED BY

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PRESENTED TO

LSI Electric Vehicle Charging Infrastructure Conference

JUNE 20, 2024

Brattle

Agenda

- EVs and Other Drivers of Future Demand Growth
- Infrastructure Needs for Rising Demand

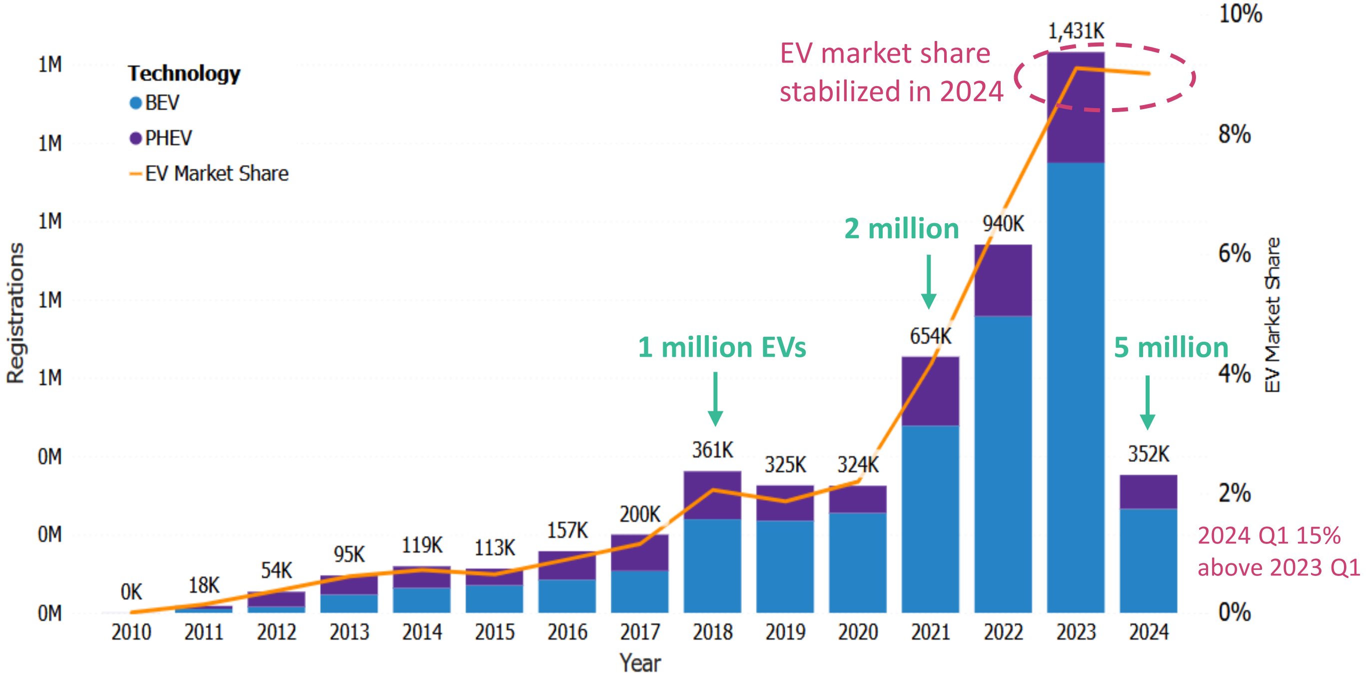
EVs and Other Drivers of Future Demand Growth

Over 5 Million EVs Sold in the U.S. through Q2 2024

EV sales increased by 4.4x from 2020 to 2023, rising from 2% of vehicle sales to 9%

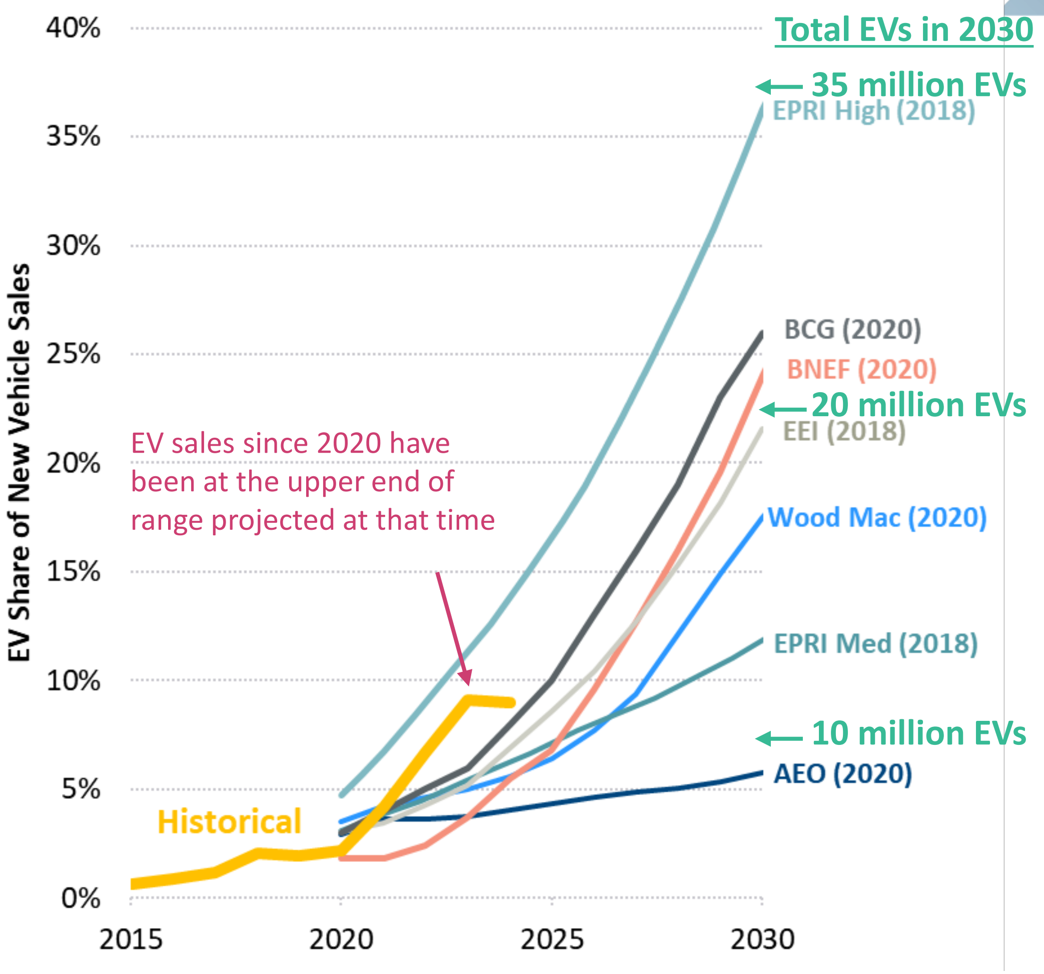
- 2024 sales indicate flattening demand, resulting in many recent articles on “decreasing demand”
- PHEV have remained about 20-25% of EV market

Annual U.S. EV Sales



Source: Atlas EV Hub

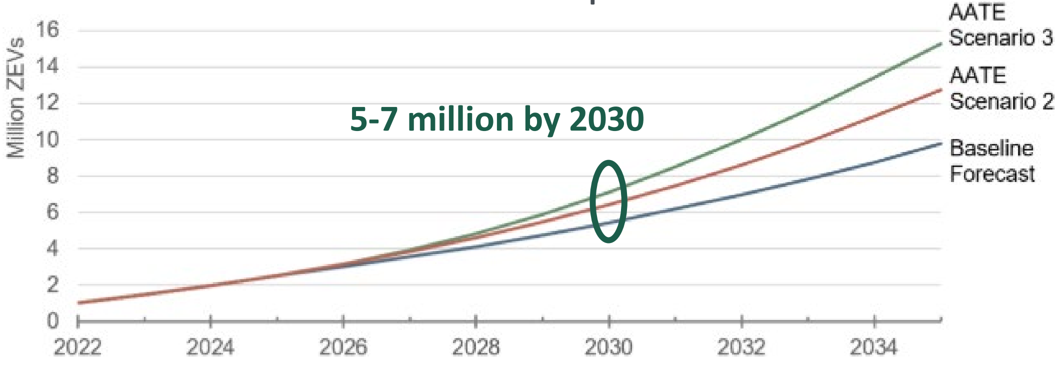
2020 Projections of U.S. EV Sales vs. Actual



System Planners are Projecting Rising EV Adoption

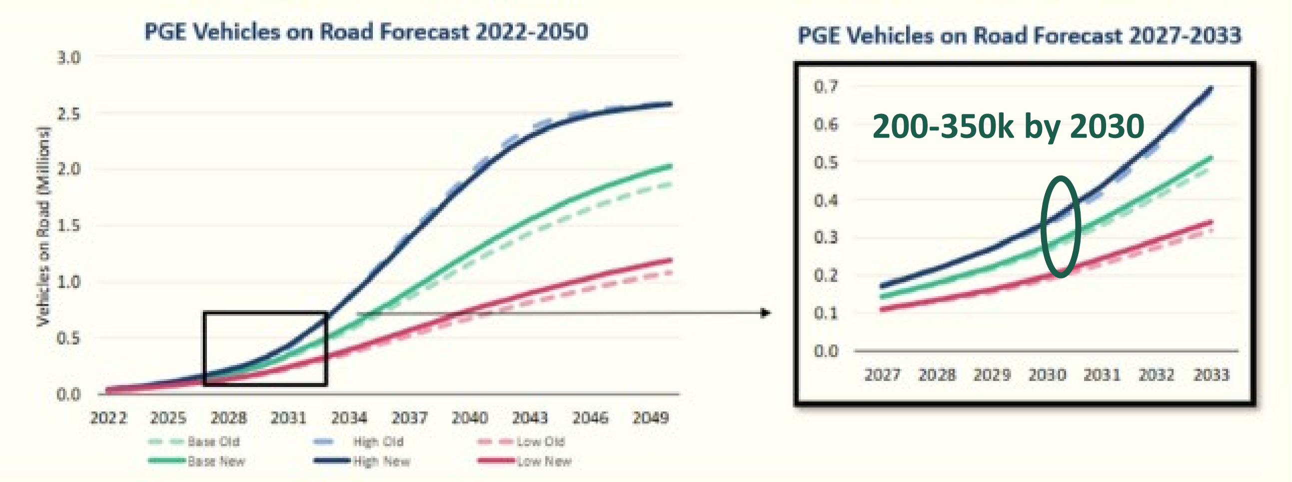
System planners incorporate EV adoption projections into their modeling to identify the necessary generation and transmission infrastructure required to support EV charging

California EV Adoption Forecast



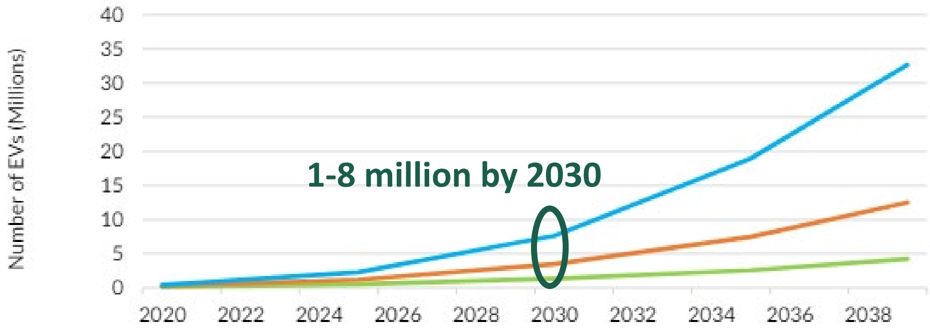
Source: CEC, Final 2022 IEPR Update, February 2023

Brattle PGE EV Adoption Forecast



Source: Portland General Electric, Load and DER Forecasting

MISO EV Adoption Forecast

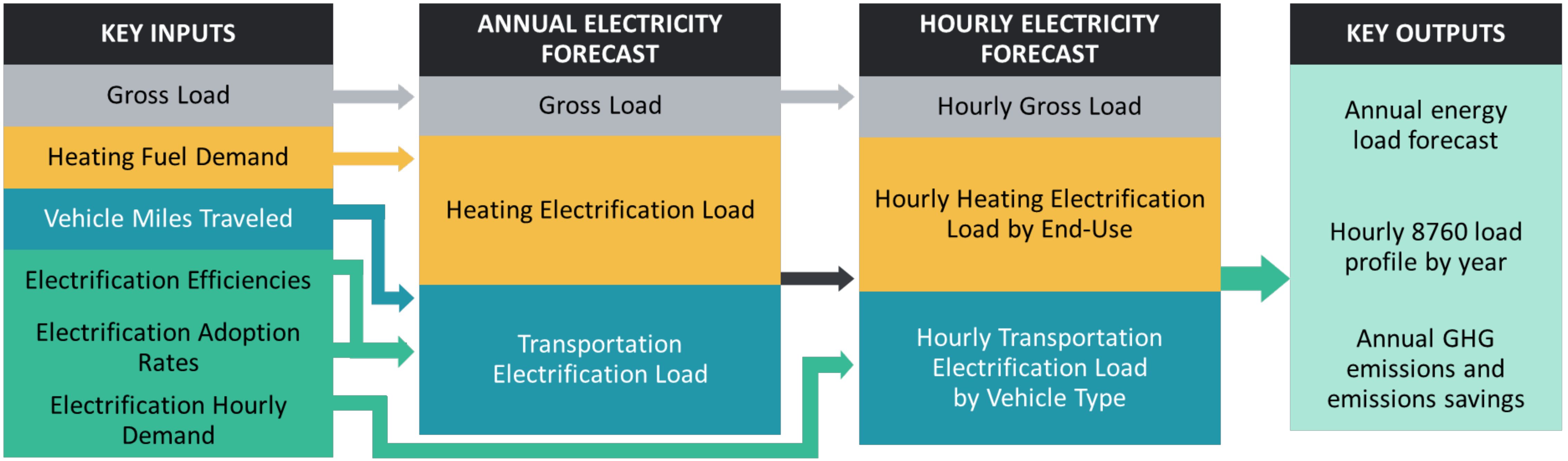


	2020	2025	2030	2035	2039
Future 1	0.135	0.53	1.33	2.57	4.19
Future 2	0.26	1.205	3.47	7.455	12.49
Future 3	0.416	2.272	7.598	18.91	32.686

Source: MISO Futures Report Series 1A, November 2023.

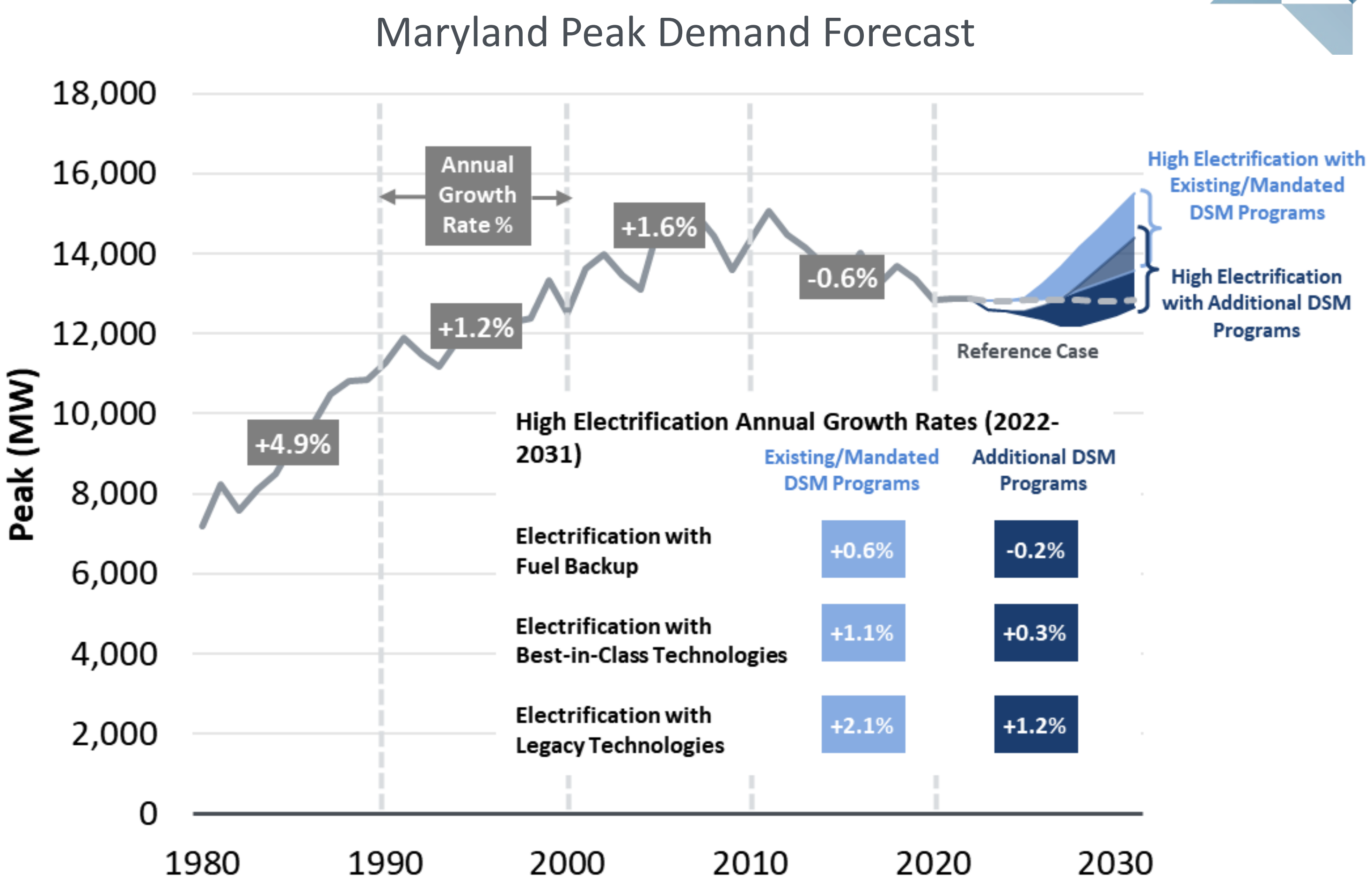
Approach to Electrification Load Modeling

At Brattle, we utilize our internal Decarbonization, Electrification, & Economic Planning ("DEEP") Model to conduct analyses of electric and gas load impacts across scenarios



Peak Demand: Maryland Electrification Load Forecast

- Peak demand growth projected to increase through the early 2030s due to electrification in most scenarios
- Majority of load growth driven by heating electrification with some contribution of EV demand
- Load growth mitigated by expanding demand-side load flexibility programs, such as EV managed charging

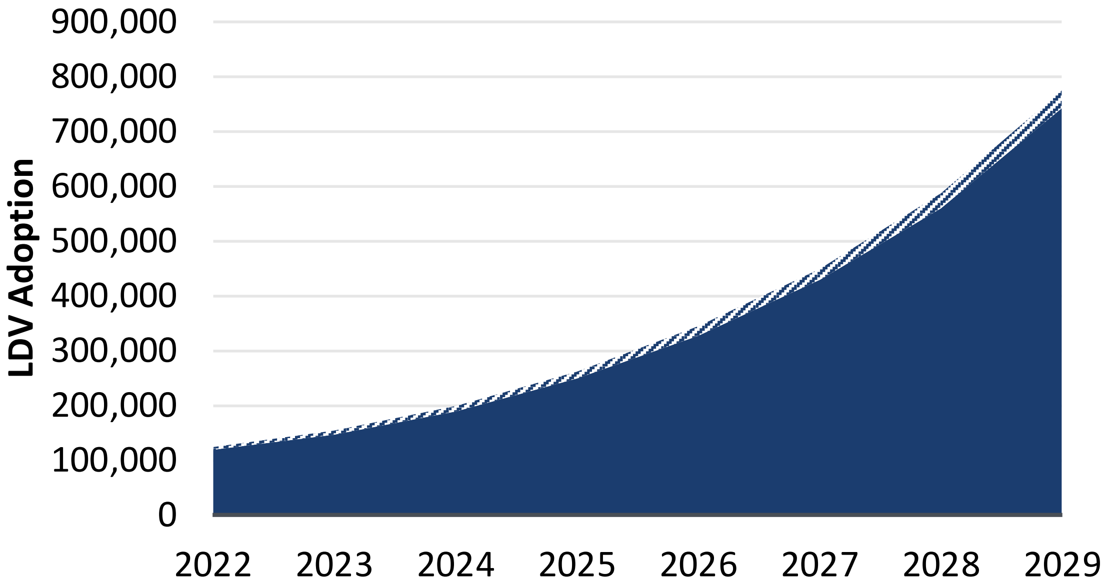


Source: The Brattle Group, et al., An Assessment of Electrification Impacts on the Maryland Electric Grid, December 2023.

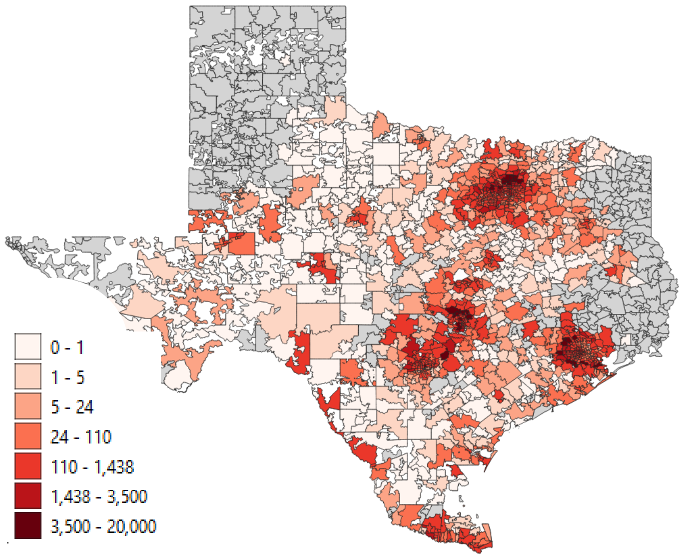
Spatial Distribution: LDV Electrification Load in ERCOT

- For ERCOT, analyzed several drivers of LDV EV adoption to develop a “propensity” score by zip code
  - Drivers included: Historical EV adoption rates, population density, and income levels
- Allocation concentrates adoption primarily in urban and suburban zip codes surrounding major cities
- The highest adoption zip codes in 2029 all started out with relatively high adoption in 2022

Texas-Wide EV Adoption



2029 LDV Allocation by Zip Code

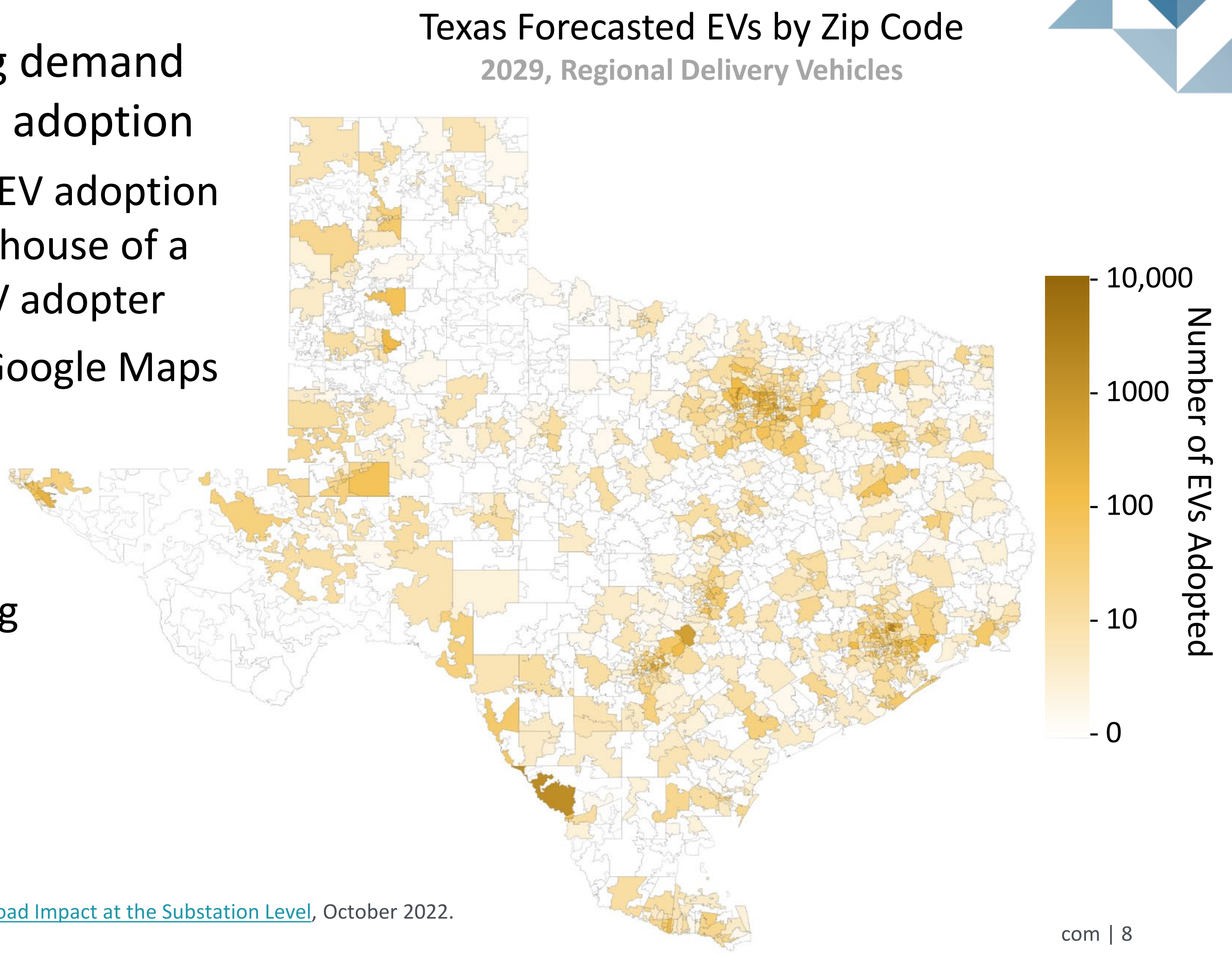


Source: The Brattle Group, ERCOT EV Allocation Study: Methodology for Determining EV Load Impact at the Substation Level, October 2022.

Spatial Distribution: ERCOT MHDV Electrification Load

Projecting distribution of MHDV charging demand requires taking a vehicle-specific view on adoption

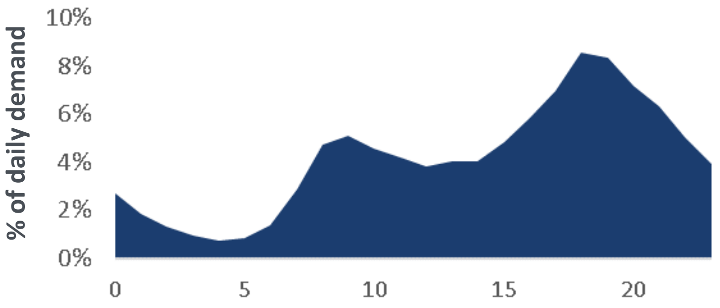
- For regional delivery trucks, we projected EV adoption based on whether the zip code has a warehouse of a major company expected to be an early EV adopter
- Identified warehouses coordinates using Google Maps
- Mapped coordinates to zip codes using Census zip code locations
- Electric regional delivery vehicle adoption is projected around city outskirts and along major highways



Source: The Brattle Group, ERCOT EV Allocation Study: Methodology for Determining EV Load Impact at the Substation Level, October 2022.

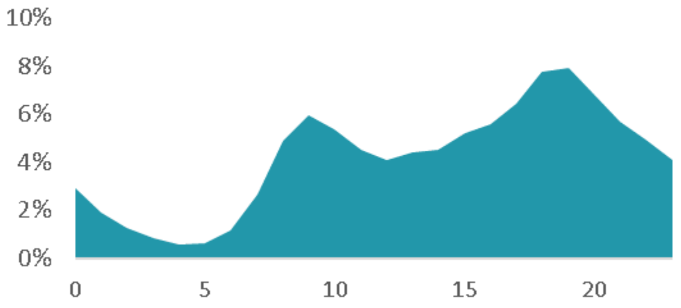
Temporal Distribution: Electric Vehicle Load Shapes

LDV-BEV



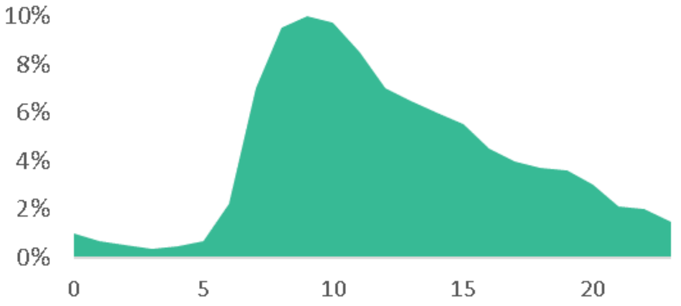
Source: EVI Pro-Lite

LDV-PHEV



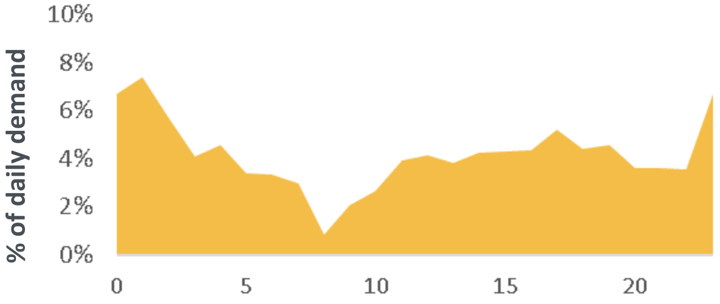
Source: EVI Pro-Lite

Class 2b-3



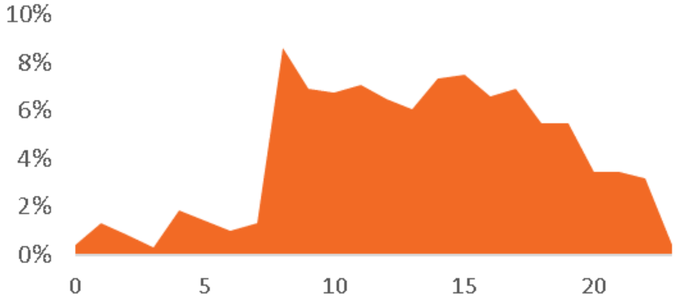
Source: California Load Shapes Report
Notes: We assume the commercial LDV load shape is representative of this vehicle class.

Class 4-8 Truck



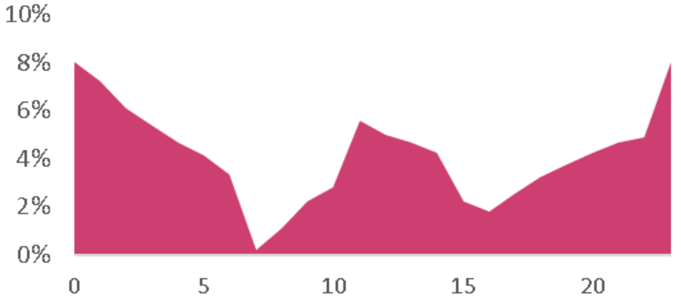
Source: 2023 ICCT Report
Notes: The profile is an aggregated profile of all class 4-8 trucks. The ICCT report utilized the HEVI-LOAD tool which is the same tool used in the California reports.

Class 7-8 Tractor Trailer



Source: 2021 California Report
Notes: Specifically, the tractor-trailer load shape is used for this category.

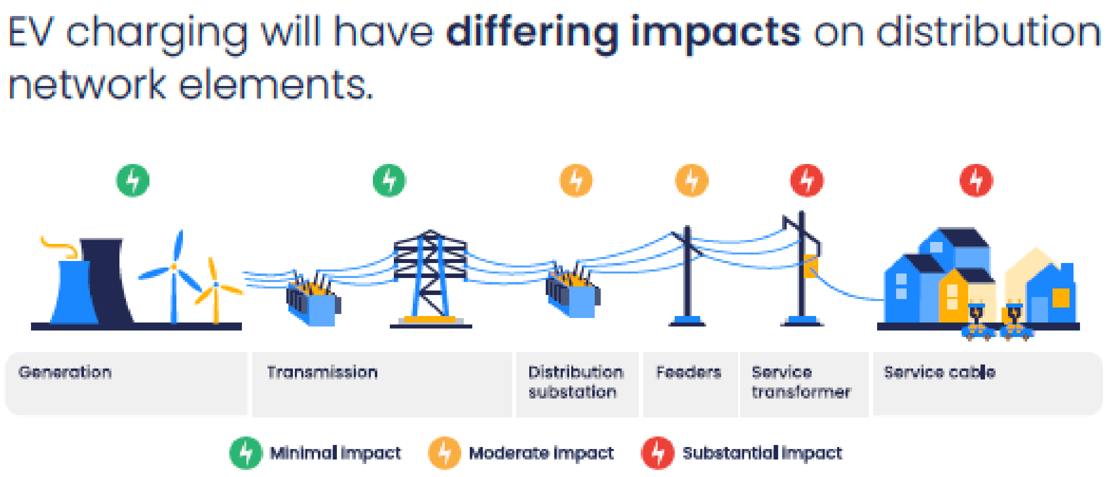
School Bus



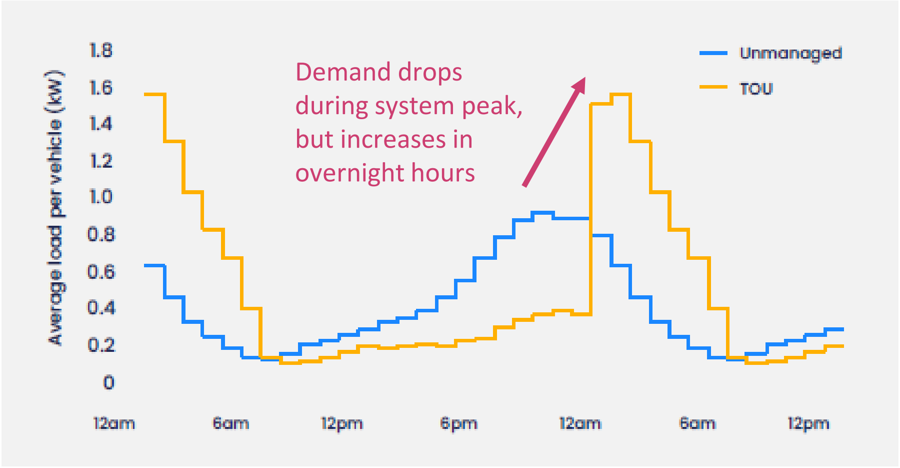
Source: 2021 California Report
Notes: Specifically, the school bus load shape is utilized.

Profiles show natural charging profiles, without any utility TOU or programs to incentivize off peak charging.

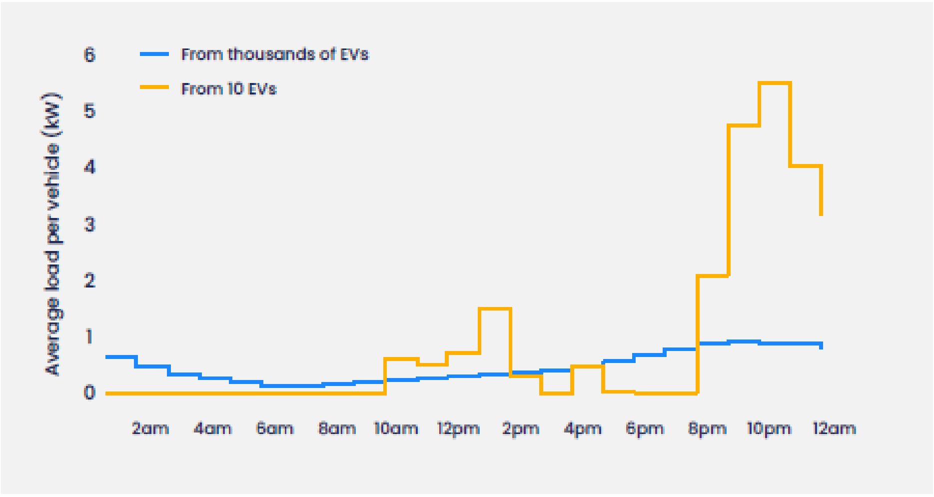
Temporal Distribution: Managed Charging Mitigates Upgrades

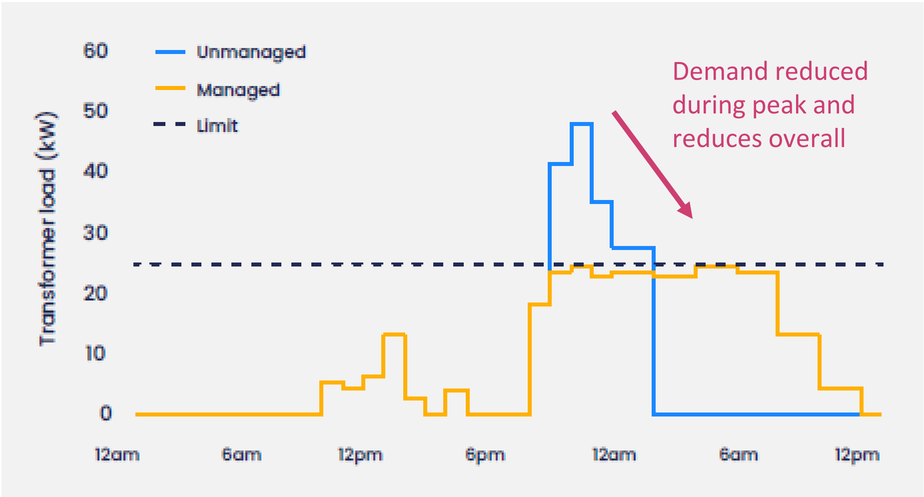


TOU Rates Shift EV Demand to Off-Peak Hours



EV Charging Diversification Reduces Peak Demand





Source: Energy Hub, From obstacle to opportunity: How managed charging can mitigate the distribution impacts of EV charging, 2023.

Substantial Load Growth Projected from Multiple Sources

Load growth from data centers, cypto mining, and industrial, transportation, and building electrification is projected to add more than 75 GW of load over the next 6 years.

- Transportation and building electrification account for about 20% of projected load growth
- Transmission vs. T&D investments for load
- Added demand for clean-energy generation will require additional transmission

DATA CENTERS

Data centers underpin the online economy technology sector and support the growth of artificial intelligence.

Current capacity: ~19 GW
Estimated electricity demand increase by 2030: +16 GW

ONSHORING & INDUSTRIAL ELECTRIFICATION

Electrification of the industrial sector is a major pathway to reduce emissions. New sources of electric demand are triggered by the onshoring of manufacturing activity, hydrogen production (e.g., electrolyzers), indoor agriculture, and carbon dioxide removal.

Current capacity: ~116 GW
Estimated electricity demand increase by 2030: +36 GW

CRYPTOCURRENCY MINING

Cryptocurrency mining is the process by which networks of computers generate and release new currencies and verify new transactions. Load from cryptocurrency mining is challenging to estimate because of its unique operational characteristics.

Current capacity: ~10–17 GW
Estimated electricity demand increase by 2030: +8–15 GW

TRANSPORTATION ELECTRIFICATION

A growing number of customers purchase electric passenger vehicles as a more climate-friendly alternative to gas vehicles; medium- and heavy-duty vehicles, motorcycles, and ferries can all operate on electricity.

Current capacity: ~7 GW (electric vehicles)
Estimated electricity demand increase by 2030: +8 GW

BUILDING ELECTRIFICATION

Electrification is a major pathway to decarbonize buildings and can include space heating (e.g., heat pumps), water heating (e.g., heat pump water heaters), and cooking (e.g., electric/induction cook stoves).

Current capacity: ~50 GW
Estimated electricity demand increase by 2030: +7 GW

Source: The Brattle Group, Electricity Demand Growth and Forecasting in a Time of Change, May 2024

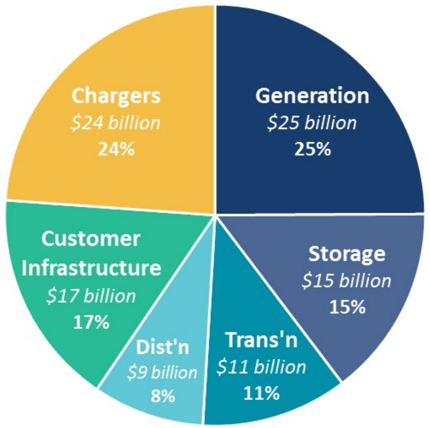
Infrastructure Needs for Rising Demand

20 million EVs Require $75-125B of Investment by 2030

Investment will come from different market participants across the supply chain, including utilities, merchant developers, competitive suppliers, and EV owners

- **$30-50 billion** for Generation & Storage to meet higher energy demand & peak loads (assuming renewables supply 50% of EV energy demand)
- **$15-25 billion** for T&D upgrades to serve peak demand, access renewables, and connect to charging infrastructure
- **$30-50 billion** for Chargers & Customer-Side Infrastructure to provide sufficient home, workplace, and public chargers

Electric Sector Investment Costs

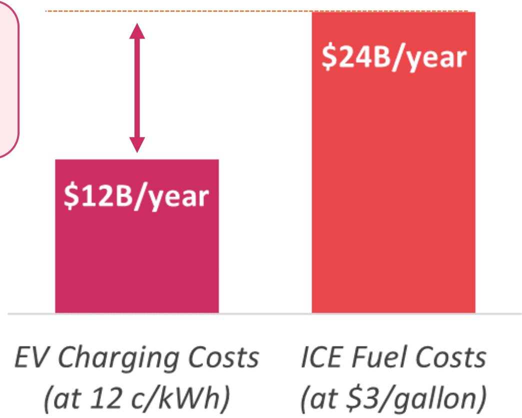


Mid Case = $101 billion
(about $9 billion per year or $450 per EV per year)

$12 billion per year of fuel savings
($600 per EV per year)

Payback for electric sector investments: 8.6 years

Annual Vehicle Fueling Costs



Payback time is 7.2 years if avoided GHG emissions (46 MMT/year) included

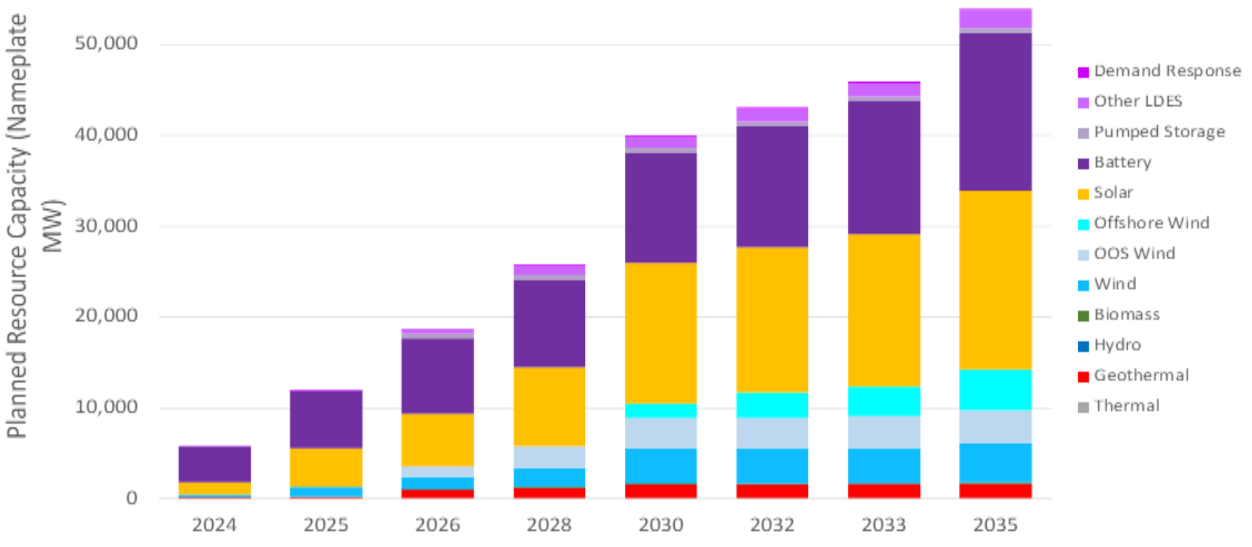
Source: The Brattle Group, Getting to 20 Million EVs by 2030: Opportunities for the Electricity Industry in Preparing for an EV Future, 2020.

Projected Resources Needs Rising Across the Western U.S.

California will need to add 52 GW of new clean energy resources through 2035, about 4.3 GW per year

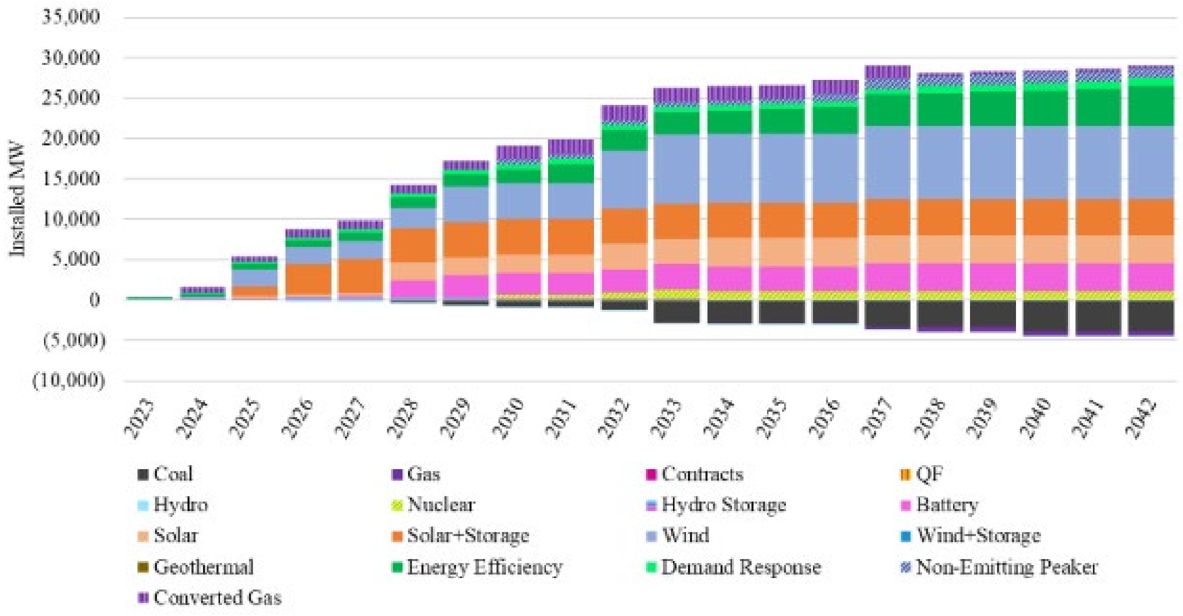
PacifiCorp is projecting a need for 25 GW of new resources by 2033, about 2.5 GW per year

CPUC Planned Resource Additions through 2035



Source: CPUC, [Integrated Resource Planning (IRP) Proposed 2023 Preferred System Plan (PSP) and 2024-2025 Transmission Planning Process Portfolios Analysis](), October 2023.

PacifiCorp Planned Resource Additions through 2042

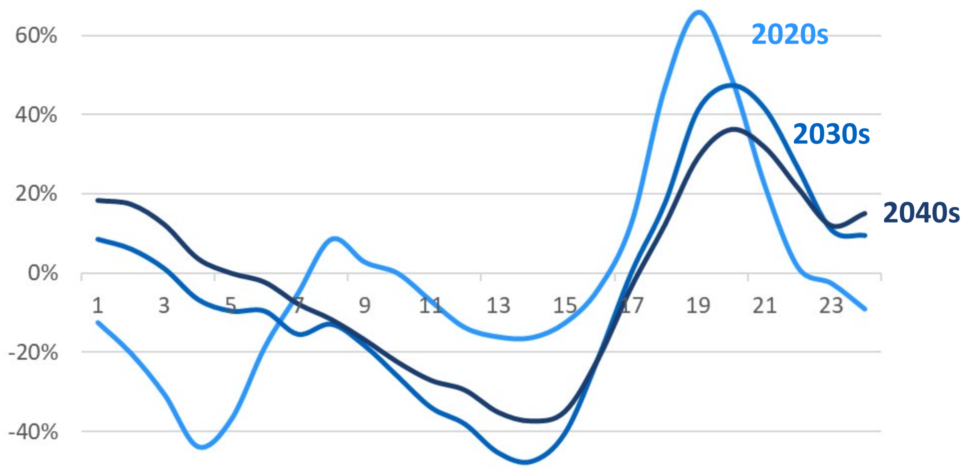


Role of Shorter and Longer Duration Storage

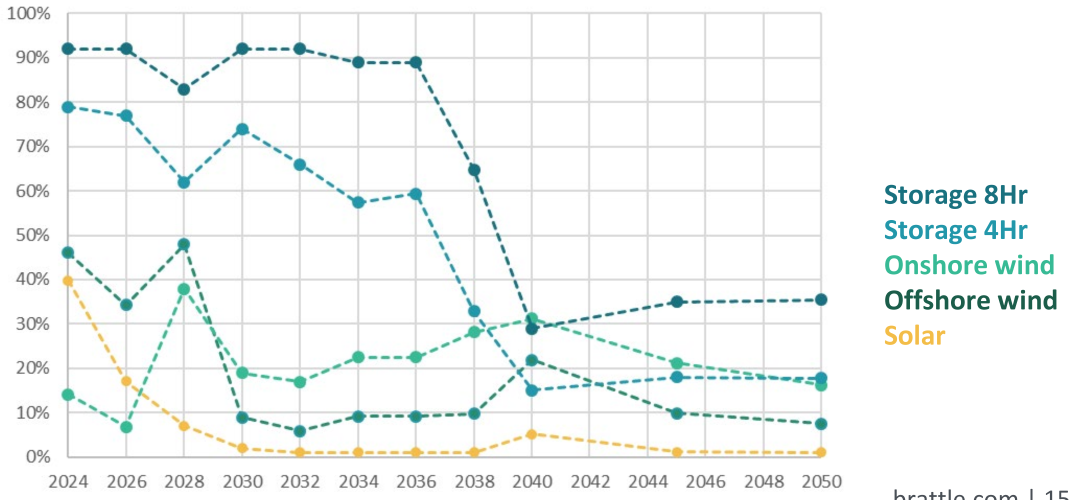
Role of storage will shift as the power system decarbonizes and relies on clean resources to balance hourly generation and demand

- **Near-term (2020s):** Provides fast-responding AS and meets evening peak demand; best met by shorter-duration (1-4 hour) storage
- **Mid-term (2030s):** Balances hourly generation and meets longer evening peak hours; requires mid-duration (4-8 hour) storage
- **Long-term (2040s):** Generate daily for **10+ hours** to balance generation with demand and for 20-100 consecutive hours to maintain reliability in highly decarbonized system

4-hr Storage Hourly Average Charge and Discharge Profile



Marginal Capacity Value of Renewables and Storage



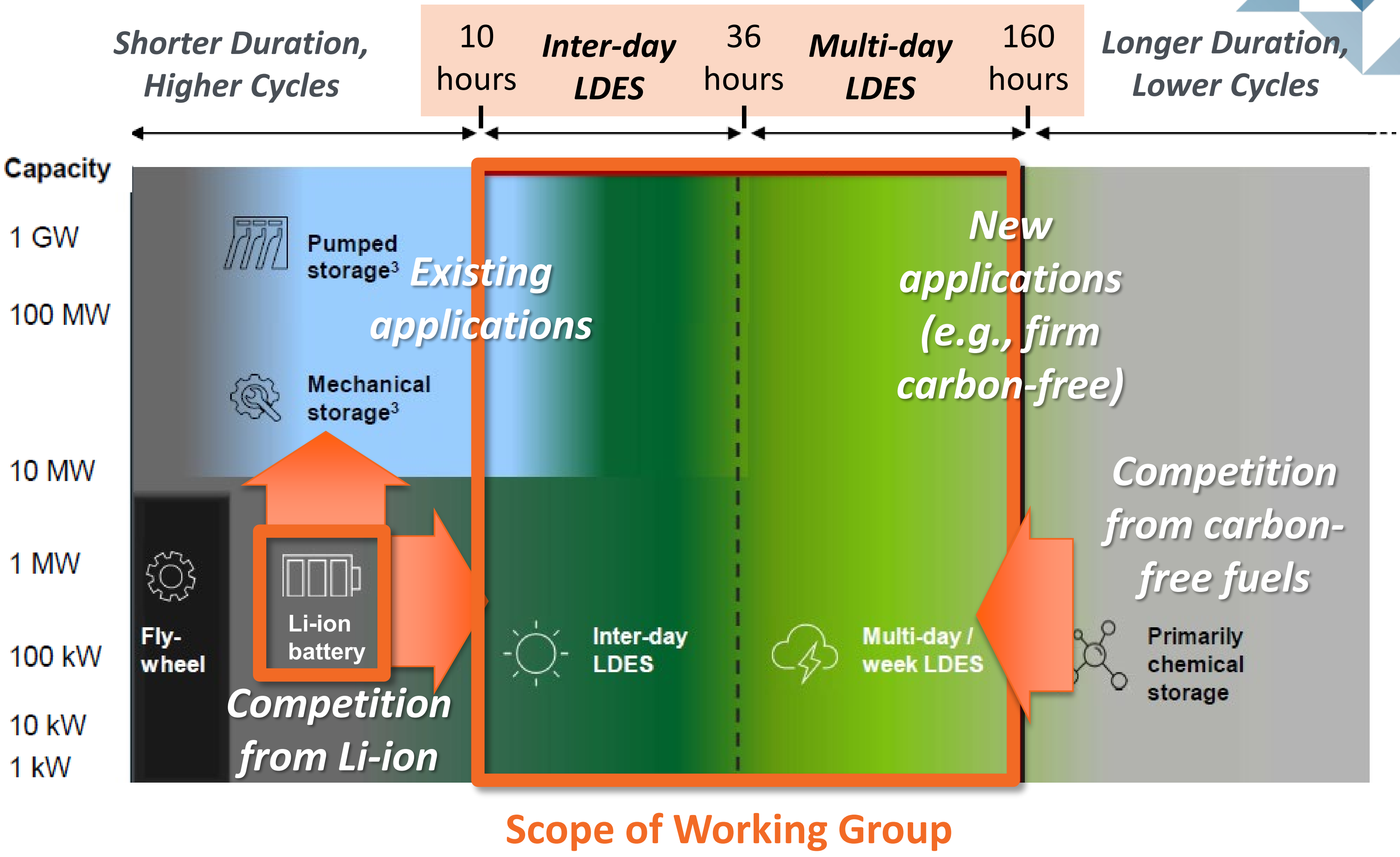
LDES will Compete with Other Clean Resources to Meet Long-Term Needs

LDES encompasses a wide range of durations that can be split into two buckets:

- **Inter-day LDES: 10-36 hrs**
- **Multi-day LDES: 36-160 hrs**

LDES faces competition from other clean energy technologies to meet future system needs at least cost

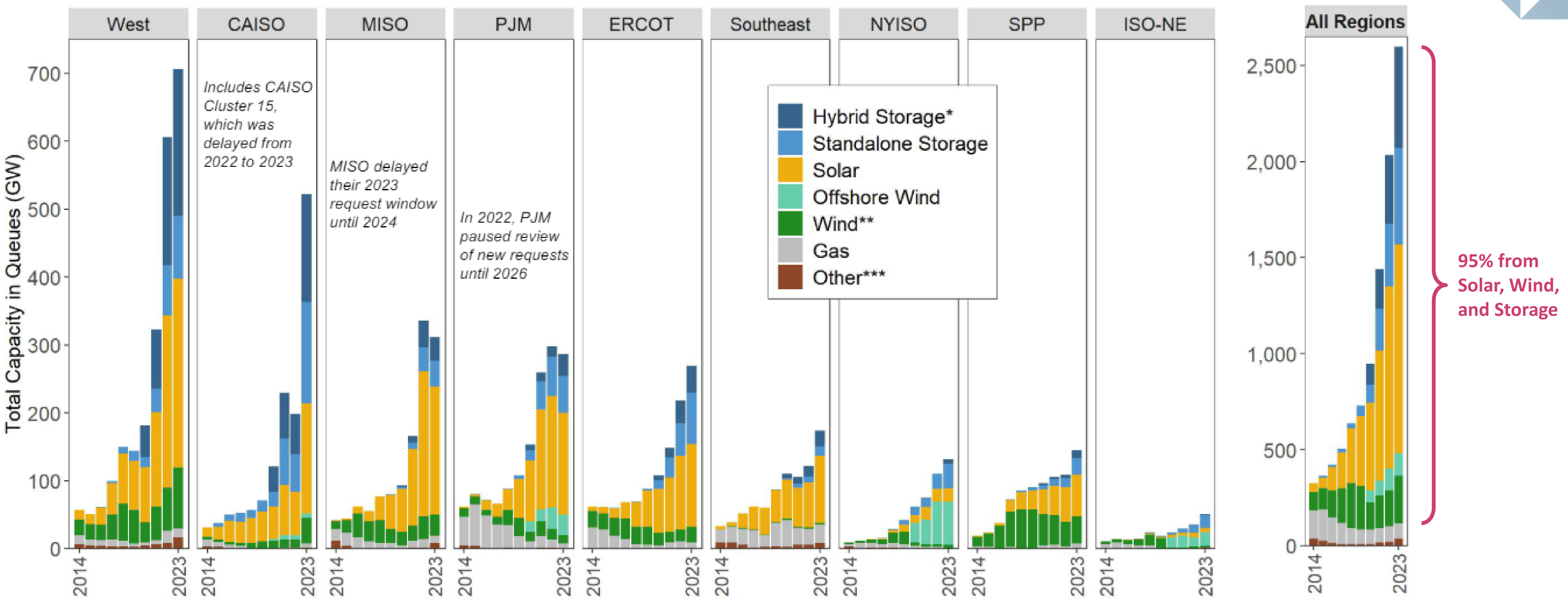
- **Inter-day LDES will compete with shorter duration Li-ion**
- **Multi-day LDES will compete with dispatchable clean resources**



Source: Adapted from U.S. Department of Energy, Pathways to Commercial Liftoff: Long Duration Energy Storage, 2023.

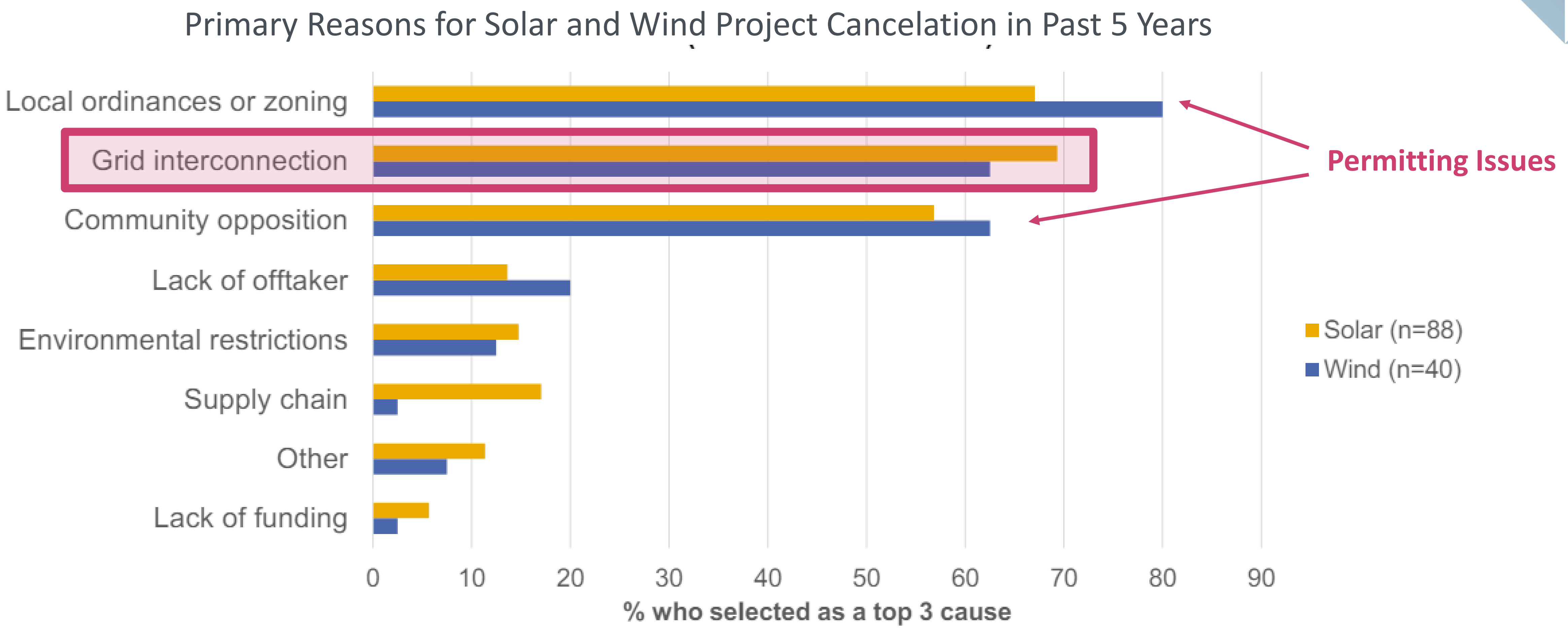
Generation Development Has Increased by Nearly 10x in Decade

Total Active Capacity in Interconnection Queues across the U.S.



Source: LBNL, Queued Up: 2024 Edition: Characteristics of Power Plants Seeking Transmission Interconnection As of the End of 2023, April 2024.

Interconnection and Permitting are Barriers to Development

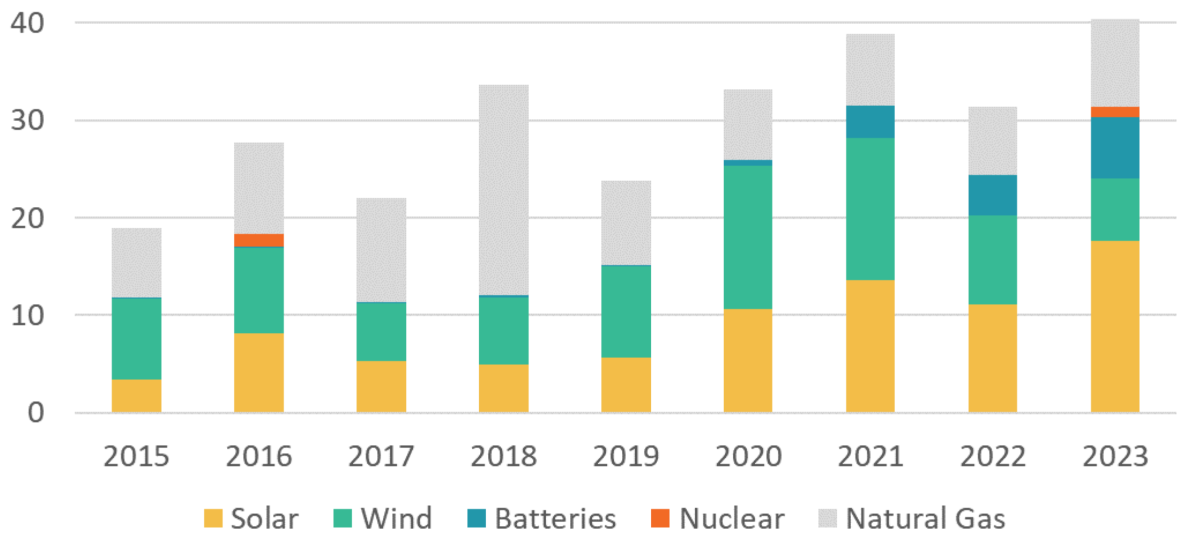


Interconnection Rates Have Stalled in Many Regions

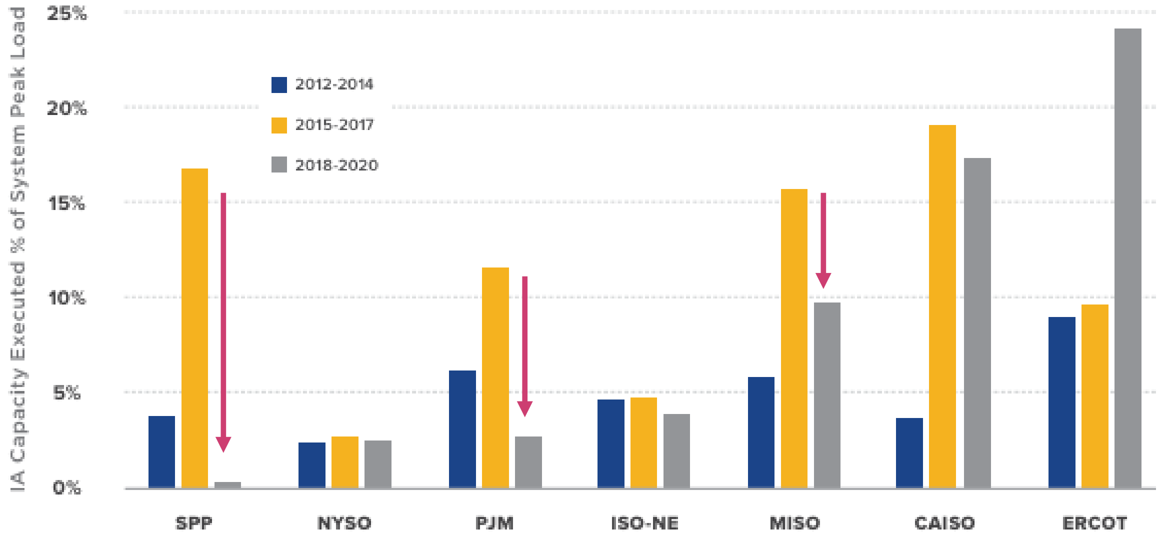
Despite growing capacity being developed, annual capacity additions have remained relatively flat, ranging from 30 – 40 GW per year over the past six years

- Generation interconnection processes have been overwhelmed by surging requests for interconnection and stalled processes in CAISO, PJM, MISO and SPP

U.S. Generation Additions by Year and Type (GW)



Rates of Interconnection Agreements by Region (% of Load)

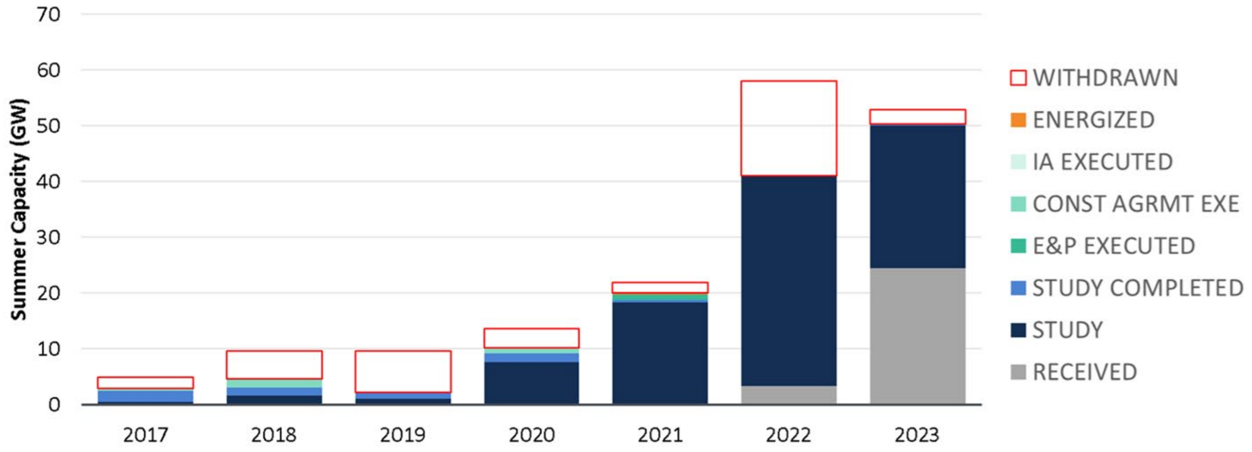


Queue Analysis: Bonneville Power Authority

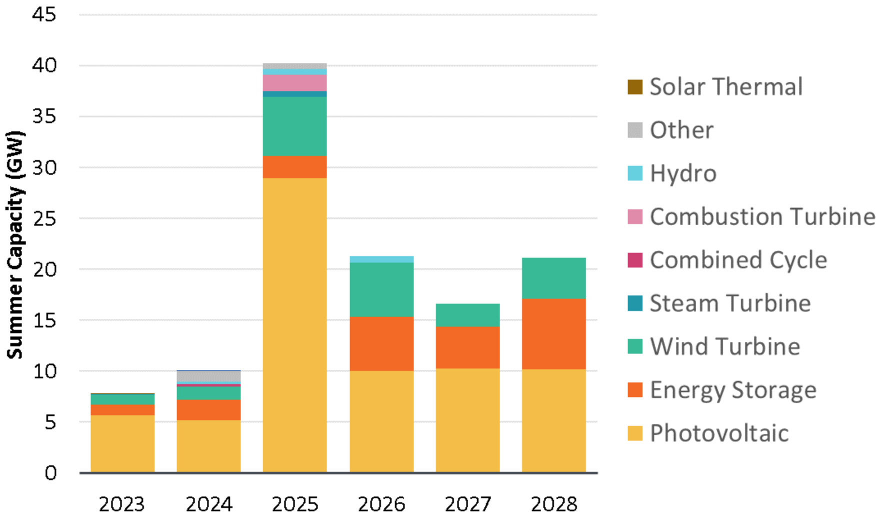
BPA has experienced a huge surge in applications, most of which are in the study phase and only a small percentage have come into service.

- Currently, 138.7 GW of active requests in the queue with 111 GW submitted since 2021
- BPA received 48 GW of Generator Interconnection requests in 2022 alone

BPA Project Request Phase by Queue Entry Date



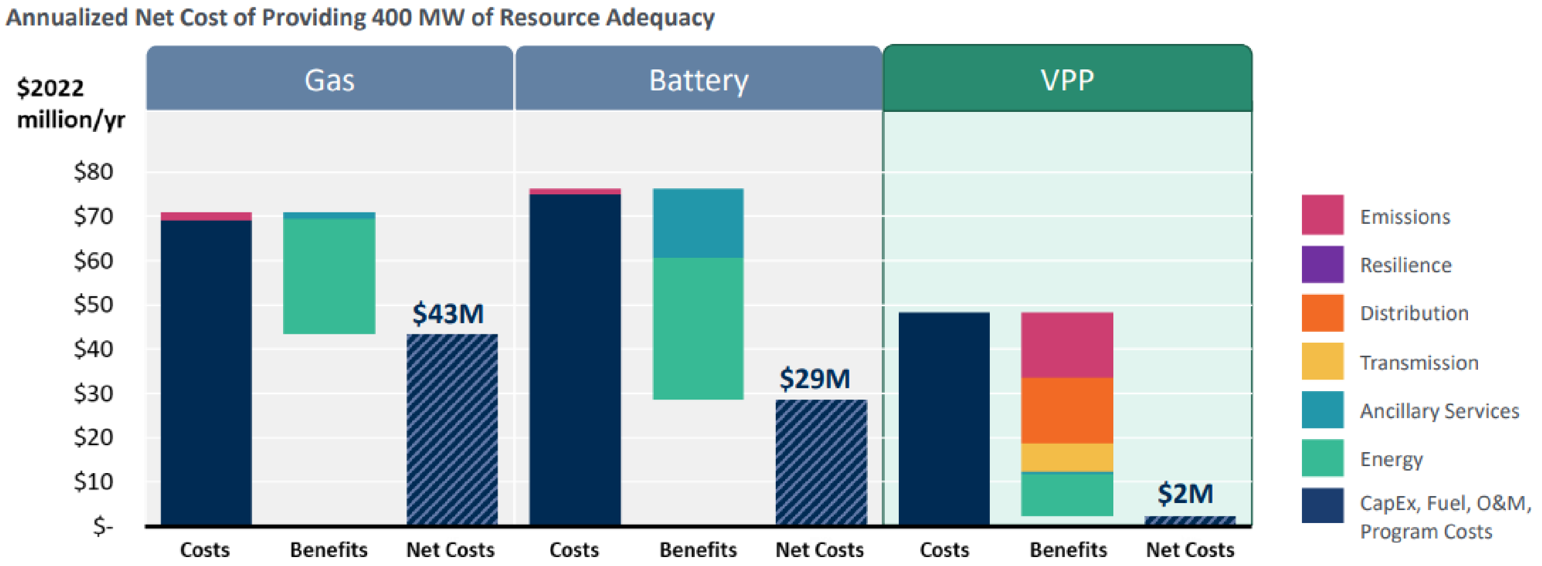
Active BPA Requests by Year and Technology



Demand Flexibility and Virtual Power Plants (VPPs)

Quickly increasing electricity demand and system peak loads also offers substantially increased opportunities to more cost-effectively meet system needs

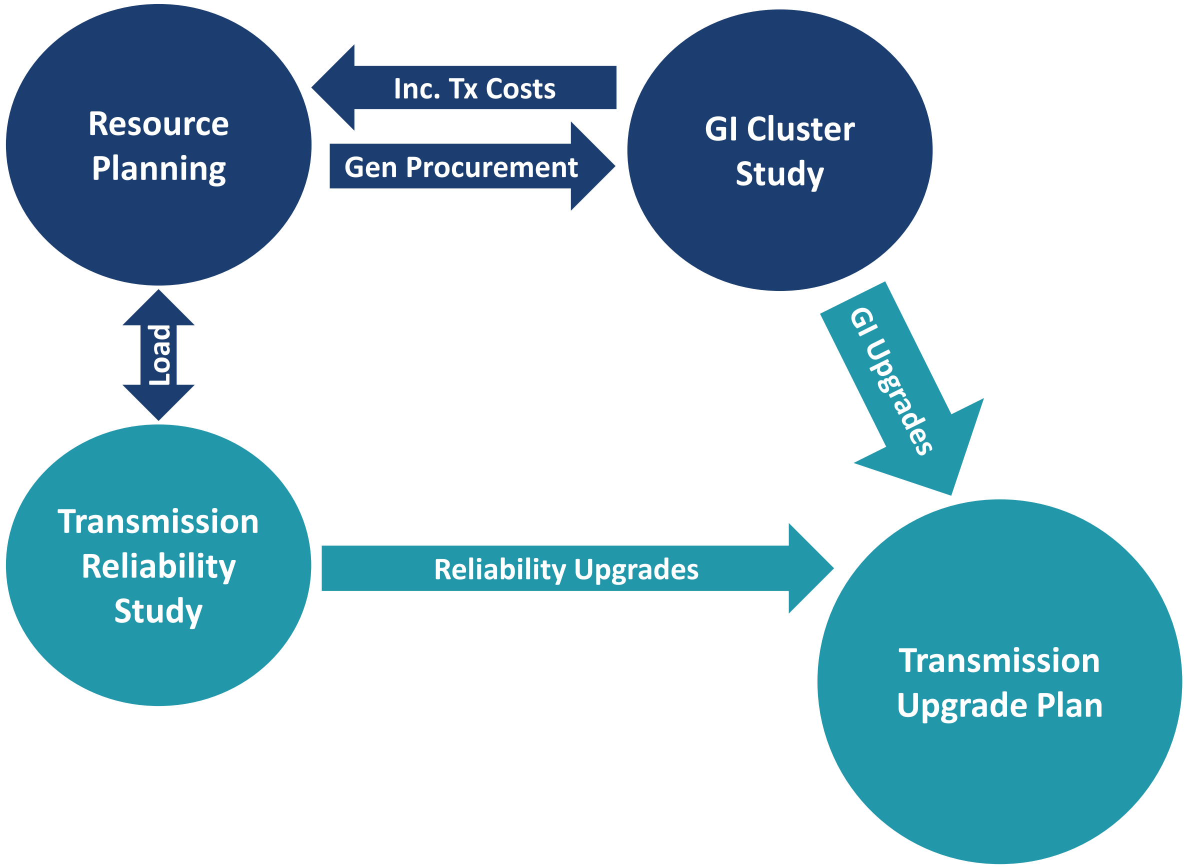
- Most electrification demand is flexible
  - Examples: Electric Vehicle (including V2G), building HVAC, thermal storage, solar+storage
- Many electrification loads and distributed energy resources (DERs) are highly controllable
  - RMI: 60 GW of dispatchable VPPs can be developed by 2030 to provide RA and flexibility/operational reliability
  - VPPs offer resource adequacy at (1) significantly lower cost and (2) without delays in generation interconnection



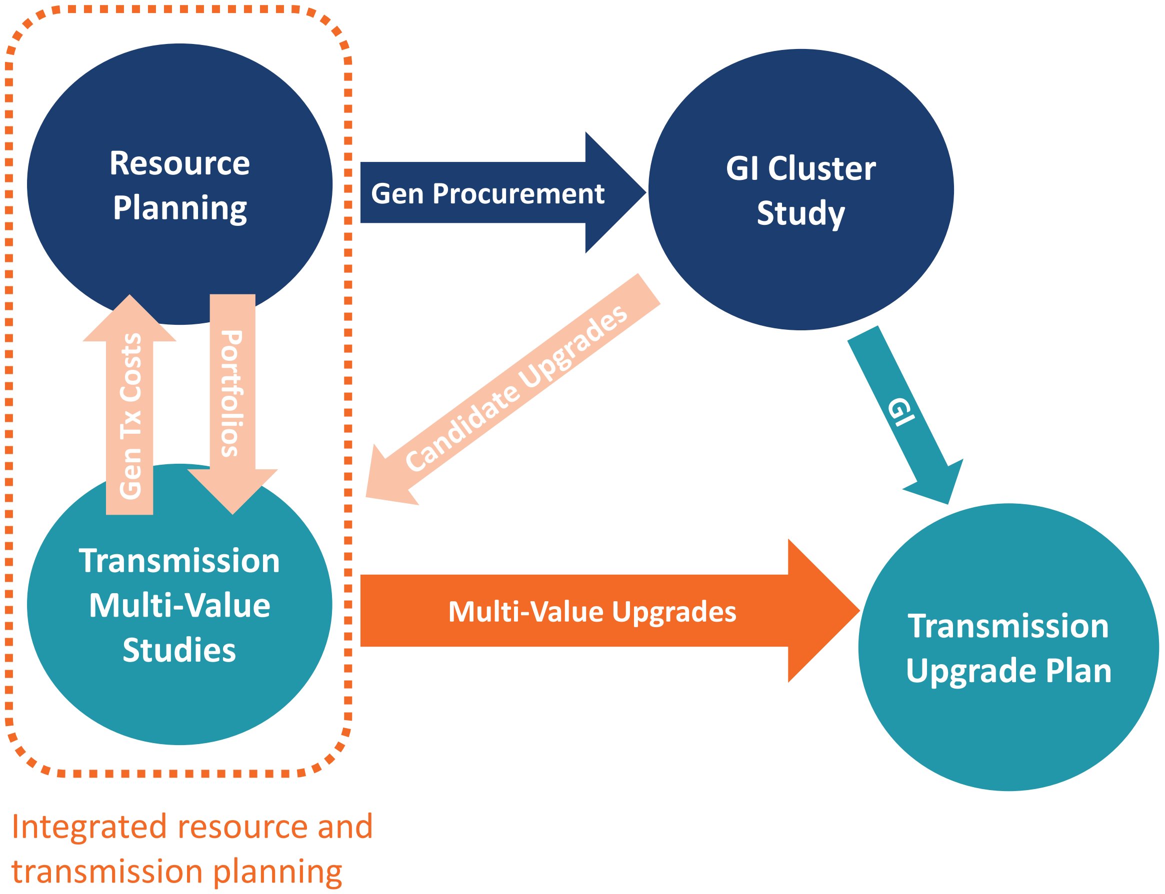
Source: The Brattle Group, Real Reliability: The Value of Virtual Power, May 2023.

Proactive Transmission Planning is Key to Reducing Costs

Current Process without Proactive Transmission Planning

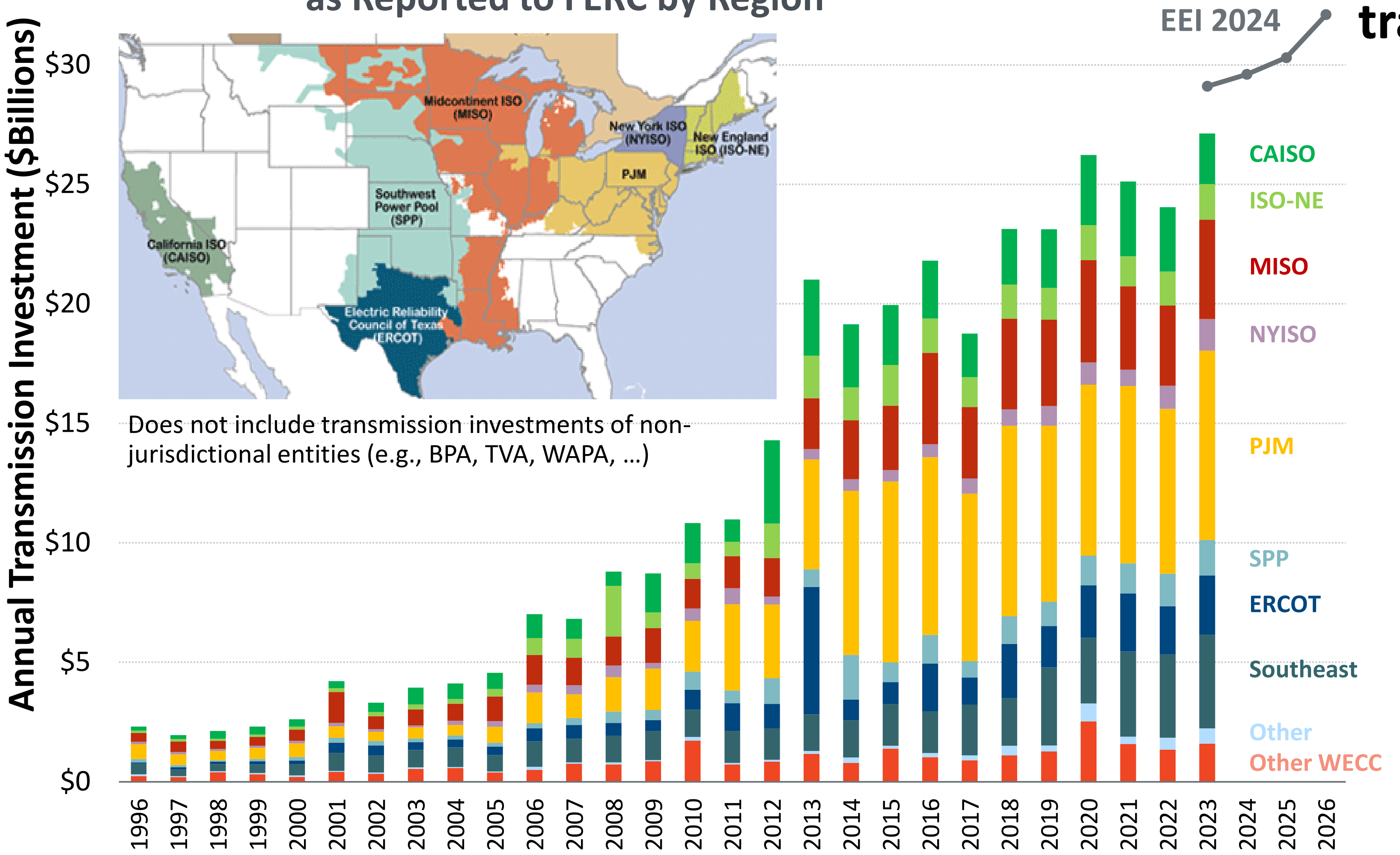


Updated Process with Proactive Transmission Planning



Annual U.S. Transmission Investments 1996-2023

Annual Transmission Investment as Reported to FERC by Region



Sources: The Brattle Group analysis of FERC Form 1 Data; EEI "Historical and Projected Transmission Investment" report.

$25+ billion in annual U.S. transmission investments, but:

- More than 90% of it justified solely based on reliability needs without benefit-cost analysis
  - About 50% solely based on "local" utility criteria (without going through regional planning processes)
  - The rest justified by regional reliability and generation interconnection needs
- While significant experience with transmission benefit-cost analyses exists, few projects justified based on economics to yield cost savings
- FERC Order 1920 may change that

Western U.S. Transmission Projects are Being Built

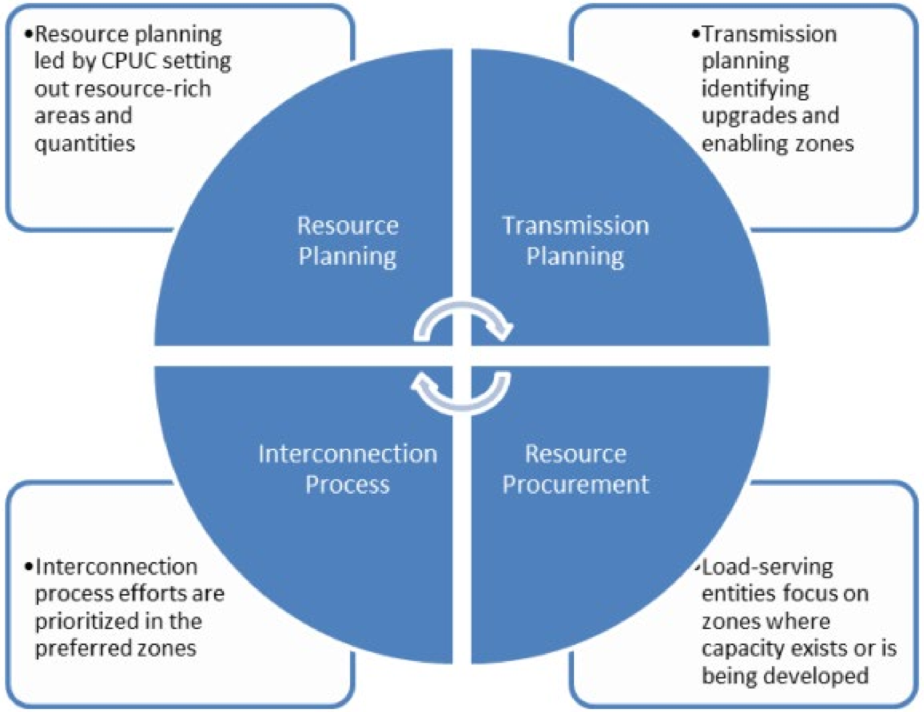
$26B in major regional and interregional transmission projects towards construction in the Western U.S., including:

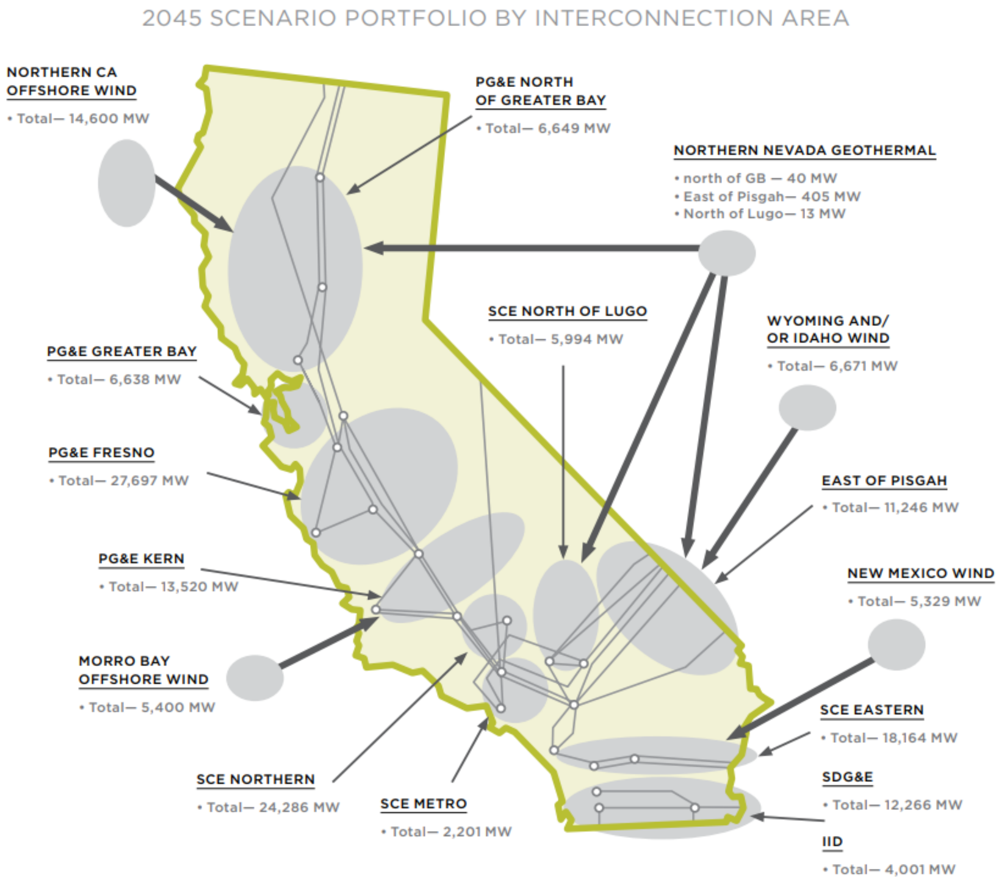
- Gateway West and South ($8B)
- CAISO 22-23 Policy Projects ($5.5B)
- TransWest Express ($3B)
- NVE Greenlink Nevada ($2.5B)
- BPA East-West Cluster Upgrades ($2B)
- SunZia ($1.5B)
- SWIP-North ($1B)
- Cross Tie ($0.8B)
- Southline ($0.8B)
- Ten West Link ($0.6B)

California's Transmission Planning Process (TPP)

California's TPP combines (1) scenario-based, zonal resource development outlooks prepared by agencies with (2) planning and procurement of transmission solutions by CAISO

- See overview and board-approved 2022-2023 Plan
- Improved generator interconnection process (link) offers substantial headroom



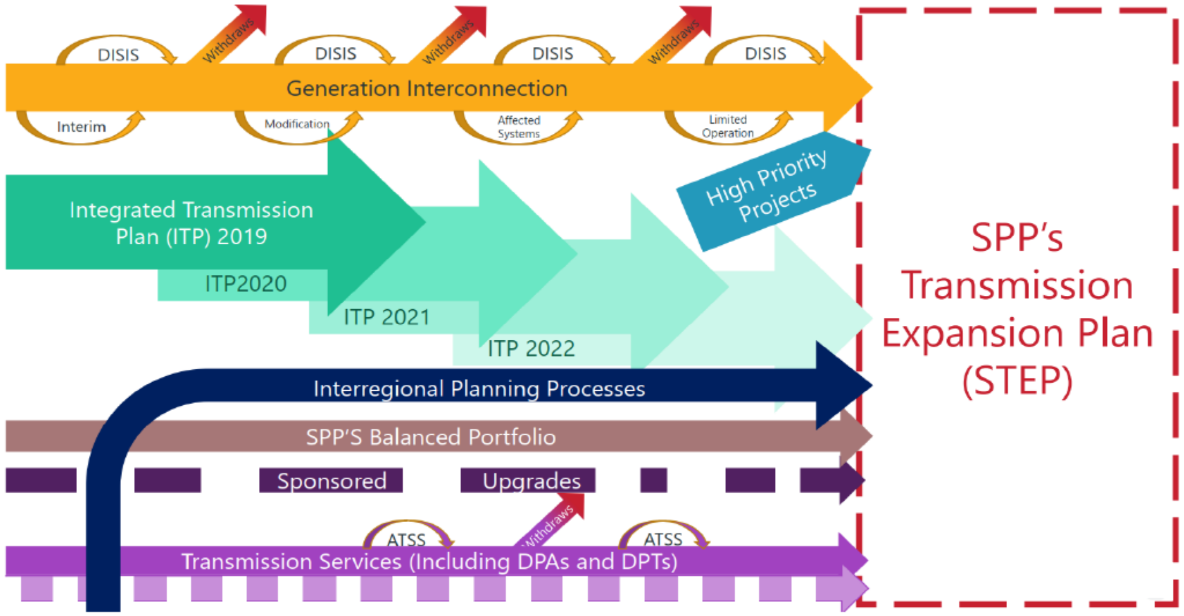


Source: CEERT summary of CA transmission planning

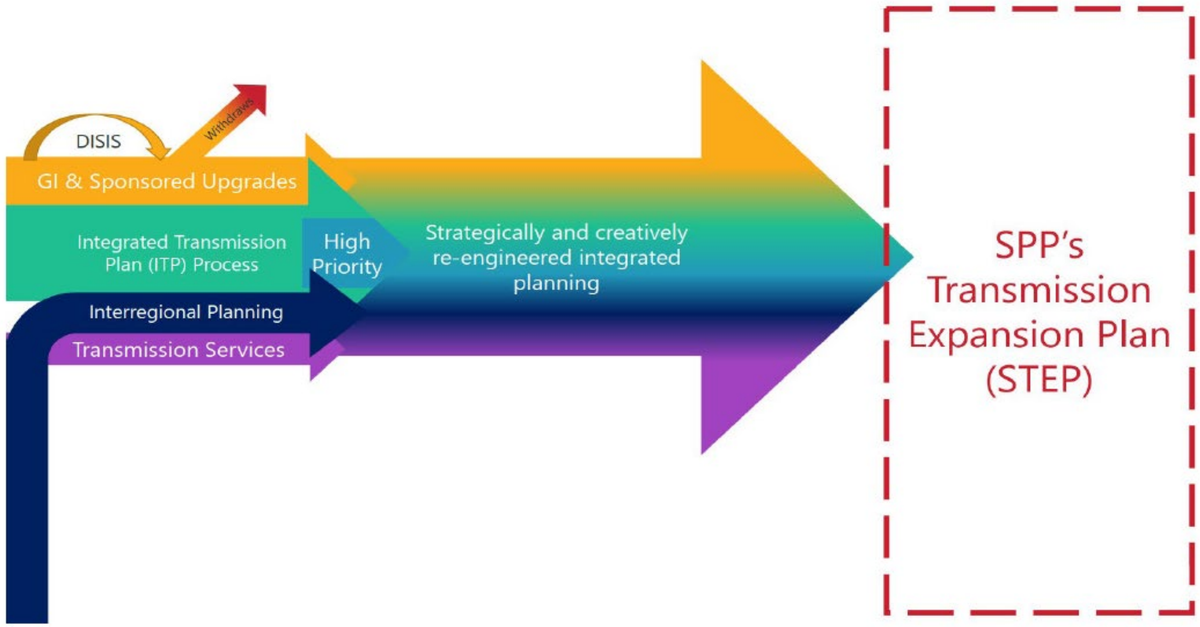
SPP's Proposed Consolidated Planning Process (CPP)

Southwest Power Pool (SPP) is consolidating its siloed planning processes (e.g., for generator interconnection, integrated regional transmission, transmission service requests and interregional) into a single holistic process

Current Planning Process



Proposed Consolidated Planning Process



Source: SPP, Strategic and Creative Re-Engineering of Integrated Planning Team (SCRIPT), CPP Task Force, Dec 13, 2021

MISO Long-Term Transmission Planning (LRTP)

Scenario-based LRTP ➔ Several tranches of "least regrets" portfolios of multi-value transmission projects (MVPs)

MISO 2022 LRTP results

- Tranche 1: $10 billion portfolio of proposed new 345 kV projects for its Midwestern footprint
- **Supports interconnection of 53,000 MW of renewable resources**
- **Reduces other costs by $37-70 billion**
- Portfolio of beneficial projects designed to benefit each zone within MISO's Midwest Subregion
- Postage-stamp cost allocation within MISO's Midwest Subregion

MISO is currently in the process of finalizing $23 billion of Tranche 2 projects (link)

MISO 2022 LRTP, Tranche 1 Projects

Source: 3-29-22 LRTP Presentation (misoenergy.org)

Speaker Information

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11 years of experience in utility and electric power industry planning and regulatory analysis, including utility resource planning, transmission planning, and generation interconnection processes

His expertise includes long-term generation and storage resource planning, transmission planning and development, and electrification of transportation and heating. Mr. Hagerty has experience working on matters related to electric vehicle adoption and system impact analysis; renewable resource, generation, and storage asset valuation; decarbonization policies; and transmission benefit-cost analysis.

Clarity in the face of complexity

Brattle