NARUC
National Association of Regulatory Utility Commissioners

NARUC Transportation Electrification Planning Workshop

Wednesday, November 15, 2023

1:00- 5:00 pm

www.naruc.org/cpi

NARUC would like to thank the Department of Energy (DOE) for their support.

Who is in the room today?

WELCOME & INTRODUCTIONS

DANIELLE SASS BYRNETT

NARUC CENTER FOR PARTNERSHIPS & INNOVATION (CPI)

Overview of the Day

Workshop Objectives:

- Identify lessons learned from practical examples of Transportation Electrification planning
- Develop promising approaches for active transportation electrification planning processes across states

Agenda Review

NARUC Transportation Electrification Planning Workshop

Wednesday, November 15, 2023, from 1:00 to 5:00 pm PT
Following NARUC 2023 Annual Meeting and Education Conference
La Quinta Resort and Club | La Quinta, California | Room Diego 2 & 3

Transportation electrification planning is critical for the nation's economy and electric grid. Electric vehicle charger availability and operations have been the focus of extensive attention and funding from state and federal agencies, utilities, public utility commissions, and other stakeholders. The grid infrastructure investment decisions needed for chargers to be powered are equally important and squarely within the purview of utilities and commissions. During this interactive workshop, attendees will hear and discuss lessons learned and develop initial thoughts about promising approaches to carry into increasingly active transportation electrification planning processes across states.

Workshop Agenda

1:00 - 1:20 pm: Welcome, Introductions, Building Blocks for Transportation Electrification Planning
Danielle Sass Byrnett, Senior Director, NARUC Center for Partnerships and Innovation

1:20 - 1:40 pm: Setting the Stage: Grid Planning for Vehicle Electrification
James Okullo, Energy Systems Integration Group

1:40 - 2:00 pm: Collective Wisdom: Positive Examples and Pressing Challenges
All Attendees, in small groups

2:00 - 2:25 pm: Understanding Future Scenarios for EV Growth
Moderator: Hon. Milt Doumit, Washington Utilities and Transportation Commission
Eric Wood, National Renewable Energy Laboratory
Jason Salmi Klotz, Portland General Electric

2:25 - 2:50 pm: Forecasting Charging Loads
Moderator: Hon. Katherine Peretick, Michigan Public Service Commission
Mark Esguerra, Southern California Edison
Matthew Cloud, Enterprise Holdings

2:50 - 3:05 pm: Break

3:05 - 3:30 pm: Understanding Grid Infrastructure Needs
Moderator: Hon. Milt Doumit, Washington Utilities and Transportation Commission
Stephen Martz, Xcel Energy
Bin Wang, Lawrence Berkeley National Laboratory

3:30 - 3:55 pm: Identifying and Evaluating Solutions to Meet Needs
Moderator: Hon. Katherine Peretick, Michigan Public Service Commission
Steve Nadel, American Council for an Energy-Efficient Economy
Ben Shapiro, RMI

3:55 - 5:00 pm: Promising Practices to Incorporate into Transportation Electrification Planning
All Attendees, in small groups

Framing: Building Blocks for Electricity System Planning

From NARUC-NASEO Task Force on Comprehensive Electricity Planning, 2021

www.naruc.org/taskforce/resources/

Standard Building Blocks of Electricity System Planning Processes

- Establish planning assumptions based on known future changes
- Develop load and supply forecasts based on current trends
- Describe target or desired trajectory incorporating policy goals
- Identify system needs to meet targets, forecasts, and requirements
- Collect and evaluate possible solutions to meet needs
- Apply criteria and select preferred solutions to meet needs
- Finalize and adopt plan containing preferred solutions

• Intended to frame planning processes in consistent terms

• Order may vary / can be iterative

Source: Aligning Integrated Resource Planning and Distribution Planning—Standard Building Blocks of Electricity Planning Processes, www.naruc.org/taskforce/resources/

Building Blocks for Today's Agenda

Establish planning assumptions based on known future changes

Develop load and supply forecasts based on current trends

Describe target or desired trajectory incorporating policy goals

Identify system needs to meet targets, forecasts, and requirements

Collect and evaluate possible solutions to meet needs

Two sessions:
Understanding Future Scenarios for EV Load Growth
Forecasting Charging Loads

Two sessions:
Understanding Grid Infrastructure Needs
Identifying & Evaluating Solutions

Group Activities:
Commission / Utility Planning Process Forums

Apply criteria and select preferred solutions to meet needs

Finalize and adopt plan containing preferred solutions

Generally beyond scope today

Setting the Stage: Grid Planning for Vehicle Electrification

- James Okullo, Energy Systems Integration Group

Grid Planning for Vehicle Electrification

Evolving Grid Planning Practices for Electric Vehicles

ESIG DER Working Group

NARUC Annual Meeting

November 15, 2023

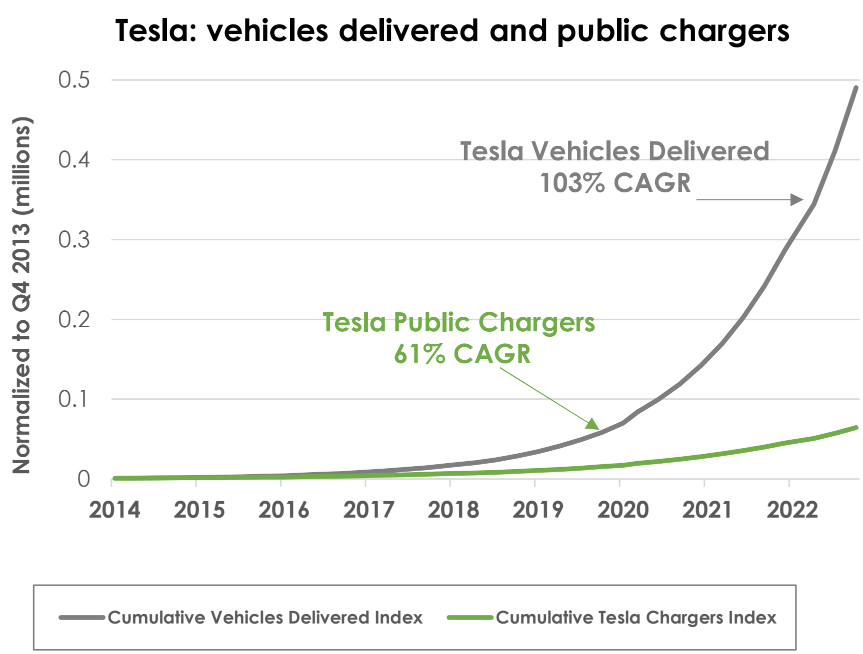
ESIG
ENERGY SYSTEMS INTEGRATION GROUP

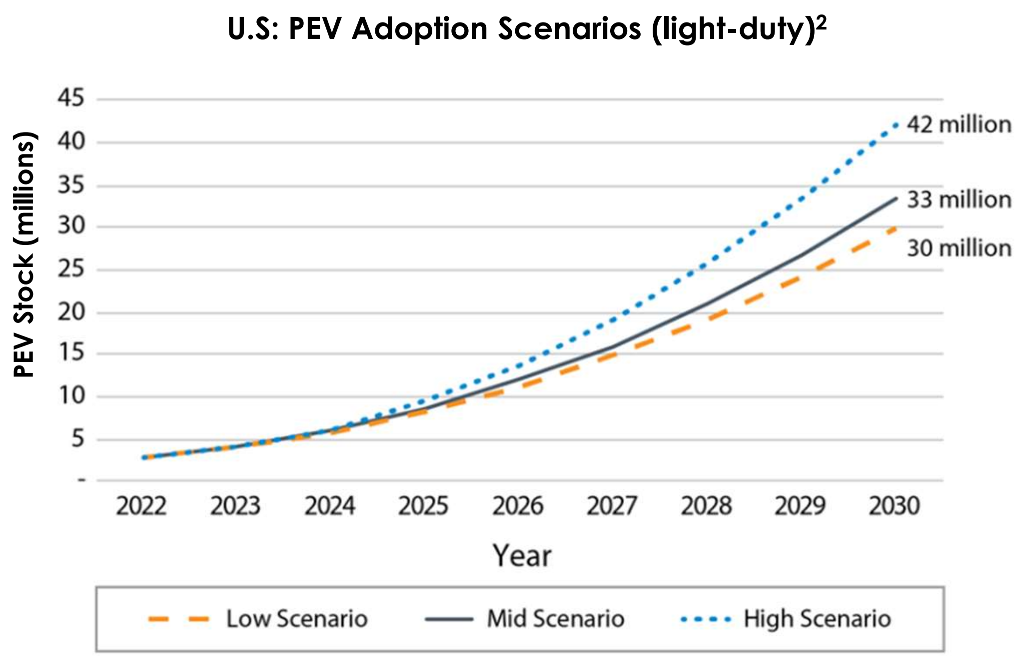
Presentation by

James Okullo, ESIG

Transportation electrification continues to accelerate

Drivers: customer demand, commitments from vehicle manufacturers, public policy targets and incentives

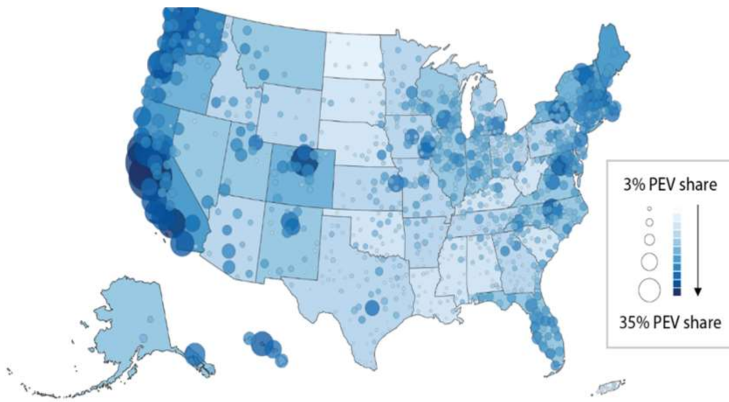




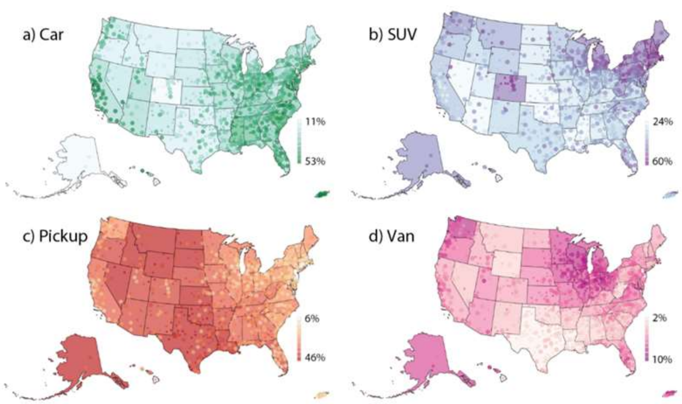
[1]Tesla
[2]NREL. 2023. *The 2030 National Charging Network*

Uncertainty abounds: Adoption, Geography, Location

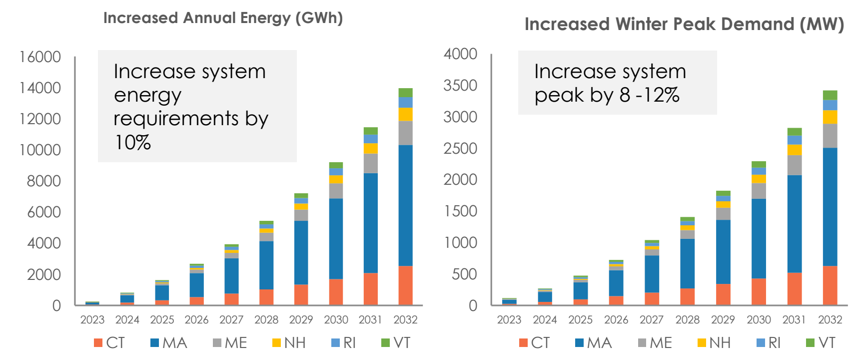
2030 PEV National Adoption[1]



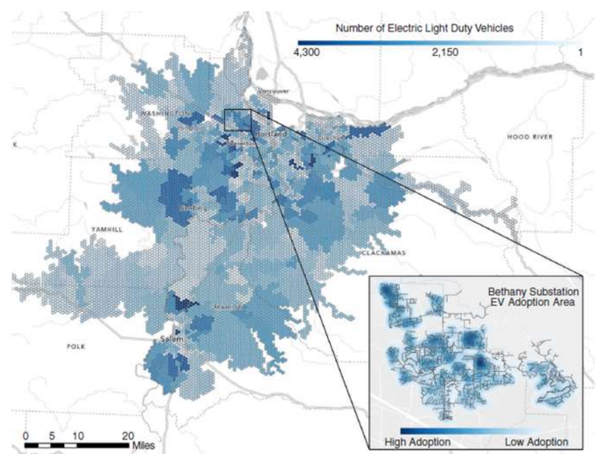
Chassis Mix – Current LDVs[1]



New England Load Changes By State[2]



Within a service territory: Portland, Oregon[3]

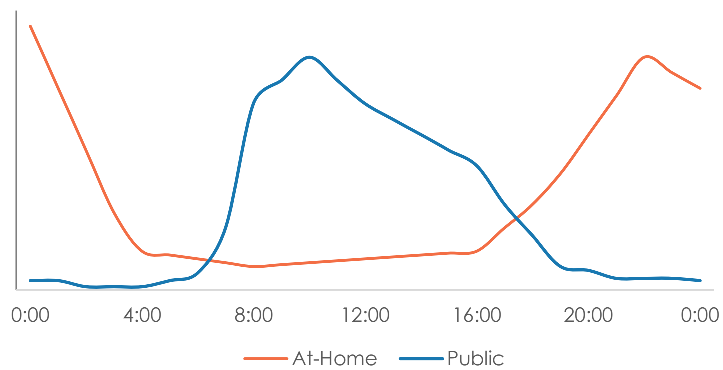


[1]NREL. 2023. *The 2030 National Charging Network*
[2]*ISONE. 2023. Final 2023 Transportation Electrification Forecast*

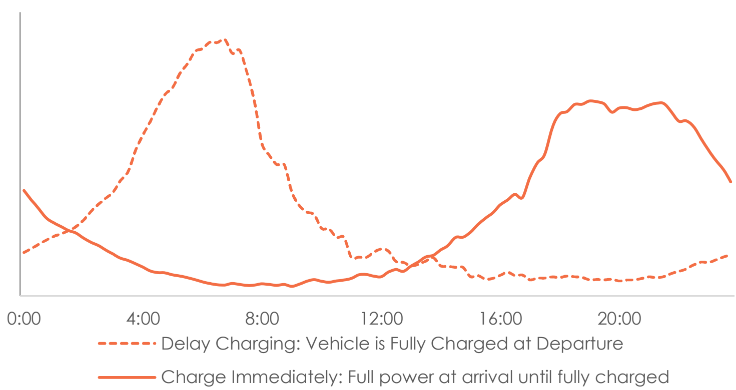
[3]IEEE. 2023. Utility Planning for Distribution-Optimized Electric Vehicle Charging: A Case Study in the United States Pacific Northwest

Uncertainty Abounds: Charging Location and Timing

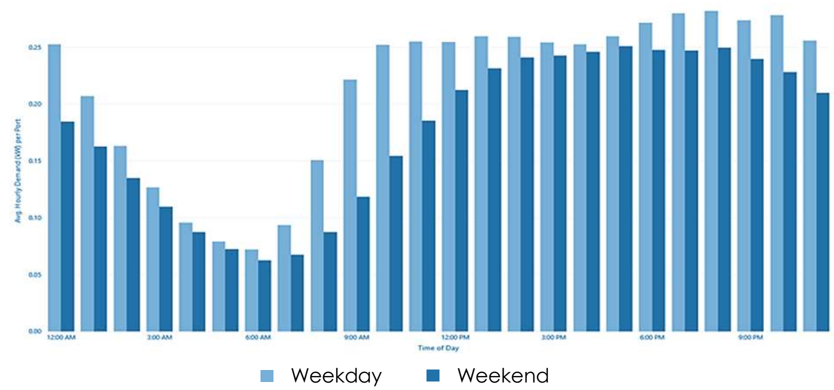
At Home Vs Public Charging[1]



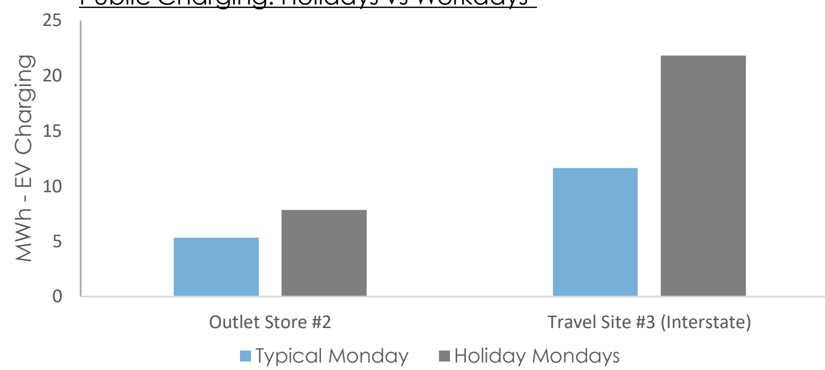
At Home Charging: Immediate vs Delayed[2]



Public Charging: Weekdays vs Weekends[3]



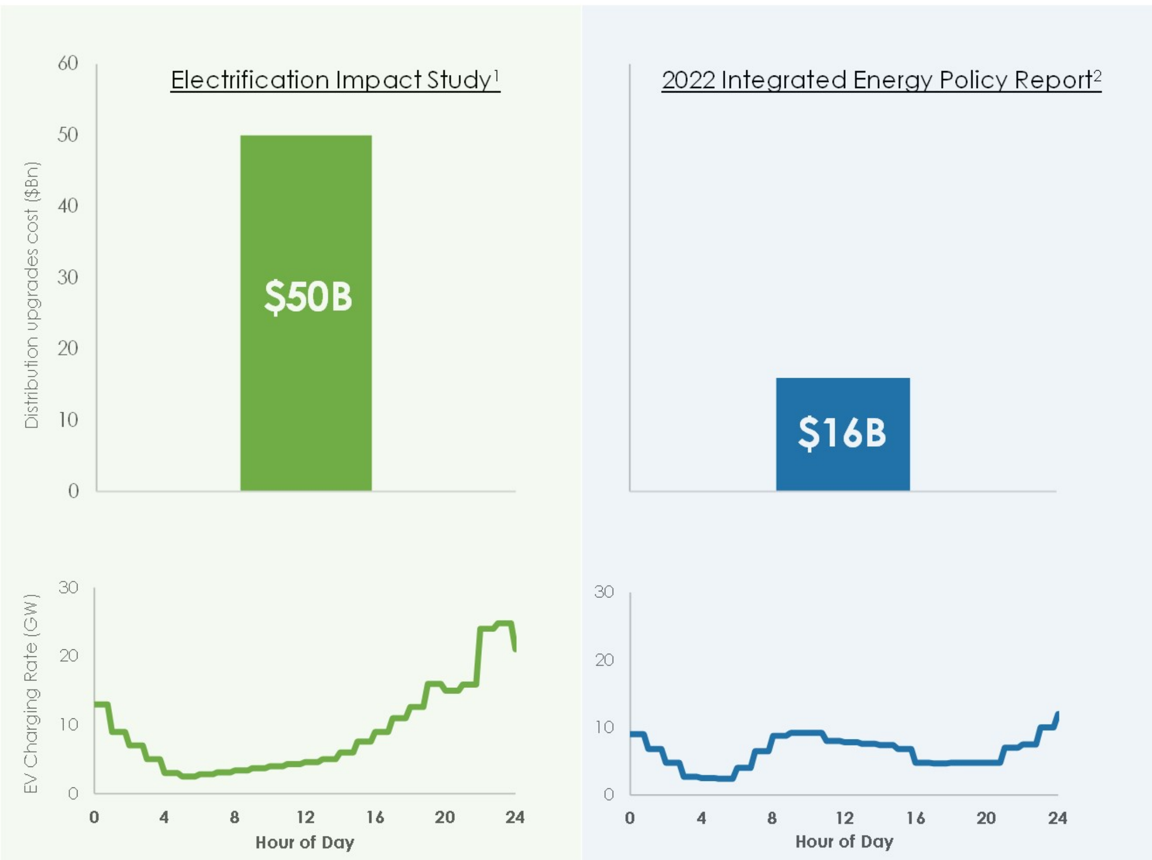
Public Charging: Holidays vs Workdays[4]



[1] Data: 2022. Powell, Cezar, & Rajagopal
[2] Data: EVI-lite-Pro
[3] Data: EVWatts
[4] Data: Telsa

Uncertainty abounds: Cost of upgrades

Two studies looking at California, vastly different costs…



1. Kevala, 2023. 2. Public Advocate's Office, 2023

Right-Sizing under High Uncertainty

Risks:

- Unreliable grid
- Stunted public interest in EVs
- Long waits for charger installs

Risks:

- Expensive underutilization
- Inequitable burden of costs

Priorities for effectively integrating vehicle electrification into grid planning

- **Improve forecasting** by considering multiple vehicle end uses, new vehicle technologies, and more data sources. Use of scenarios to capture the uncertainty of locational and temporal grid impacts .

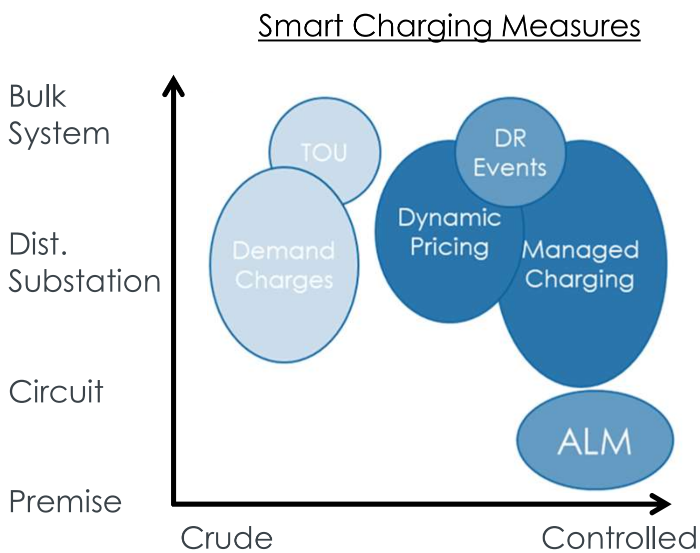
- **Embrace smart charging** options at every level of the grid from the premise to the bulk system. Targeted smart charging, operating limits, and strategically located storage can help bridge immediate load growth while long-term solutions are implemented.

- **Incorporate future-ready planning** to allow for upsizing of infrastructure or enable future upsizing whenever equipment is being replaced.

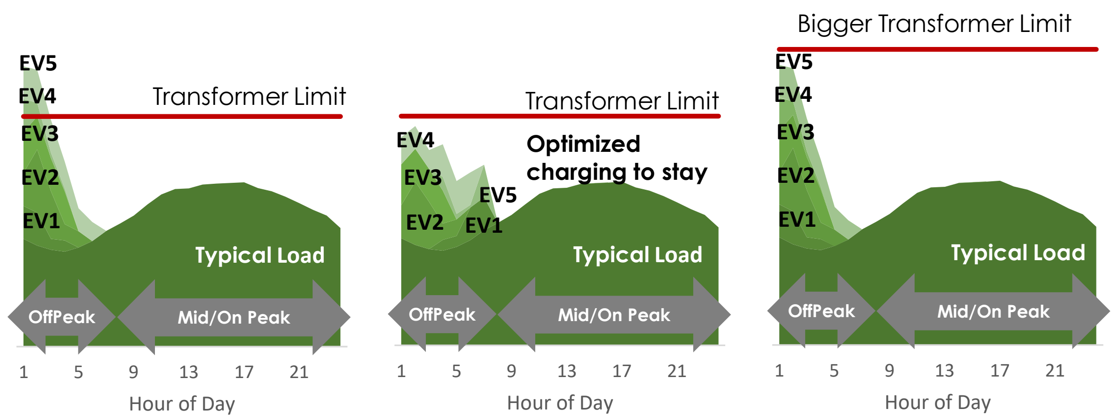
- **Prioritize proactive upgrades** identified by a multi-stakeholder group because EV adoption and charging needs can grow much faster than utility upgrades can be implemented.

Smart Charging is an important solution

Evaluate different smart charging measures against each other and alternatives, such as infrastructure improvements



Cost and ease to implement smart charging measures should be evaluated against alternatives, such as infrastructure



Inspiration for image right: PGE/Weavegrid.

Adapt/evolve processes:
Align the Grid Planning Process with the Need

ESIG

Managed Light-Duty Vehicles

Existing Processes
- Daily/routine charging
- L2 demand charging
- Elastic demand

Customer-Collaborative Processes
- Perceived charging deserts
- Service provider request

Proactive Processes
- Heavy deployment
- Existing grid heavily loaded
- Inflexible demand

Highways & Corridors

Existing Processes
- Minimal highway throughput

Customer-Collaborative Processes
- Private highways

Proactive Processes
- Grid capacity limited along highways
- Regional EV growth
- MHD vehicles

Fleets

Existing Processes
- Small fleets
- Sufficient highway charging

Customer-Collaborative Processes
- Perceived charging deserts
- Service provider request

Proactive Processes
- Multiple fleets competing for capacity
- Limited land availability

Underserved Communities

Existing Processes
- Planning processes include equity layer
- EV & smart charging incentives

Customer-Collaborative Processes
- Multi-family housing developers

Proactive Processes
- Avoid charging paradox
- Heavy industry adjacent

THANK YOU

James Okullo

james@esig.energy

Collective Wisdom: Positive Examples and Pressing Challenges

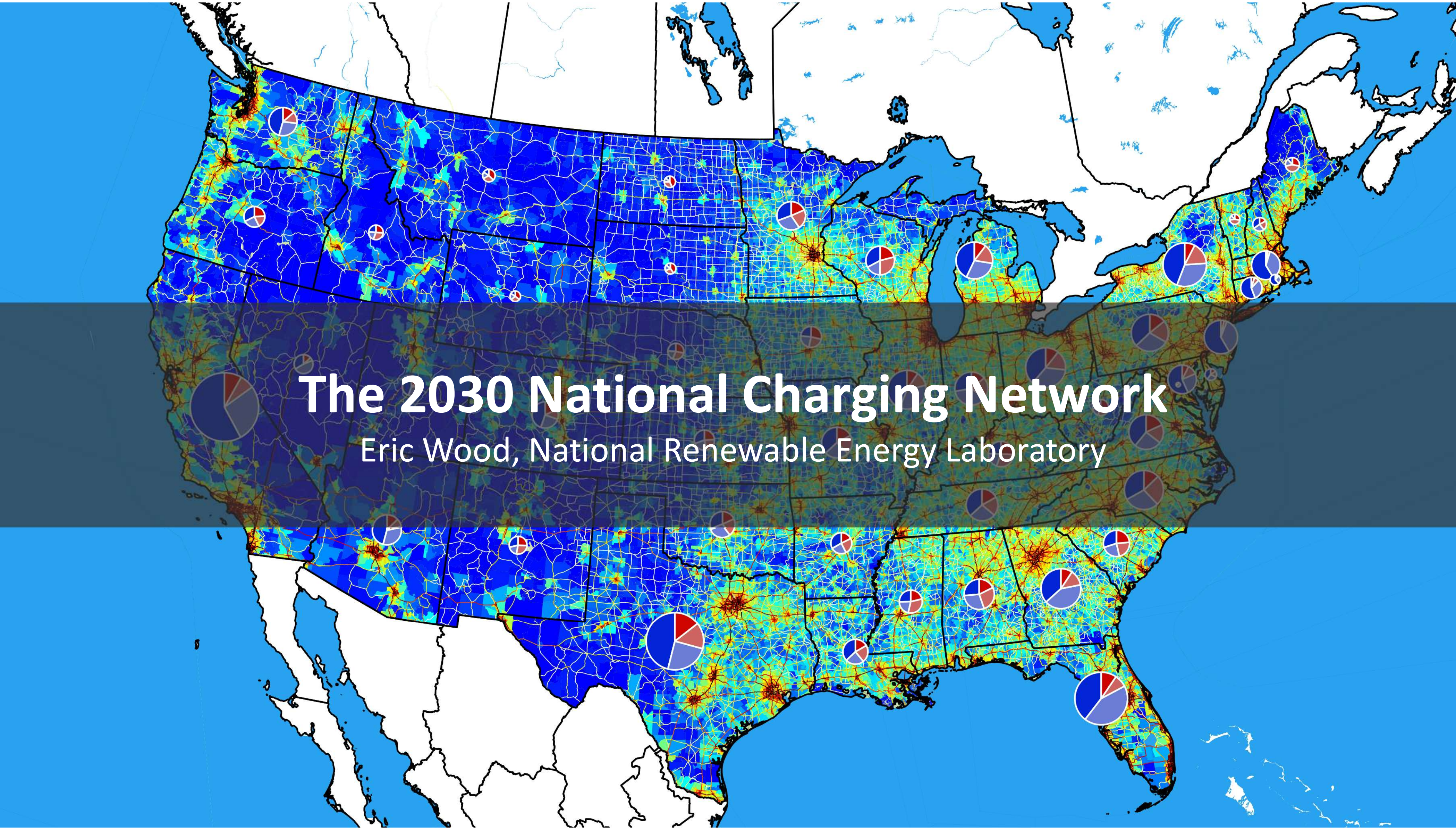
- Elevate and share top-of-mind examples at your table
  - One sticky note per idea

1. What are your **positive examples** of promising approaches to transportation electrification planning? Where are they happening?
2. What are you concerned about? What are the **pressing challenges** to T.E. planning?

Understanding Future Scenarios for EV Growth

Moderator:
Hon. Milt Doumit, Washington Utilities and Transportation Commission

- Eric Wood, National Renewable Energy Laboratory
- Jason Salmi Klotz, Portland General Electric

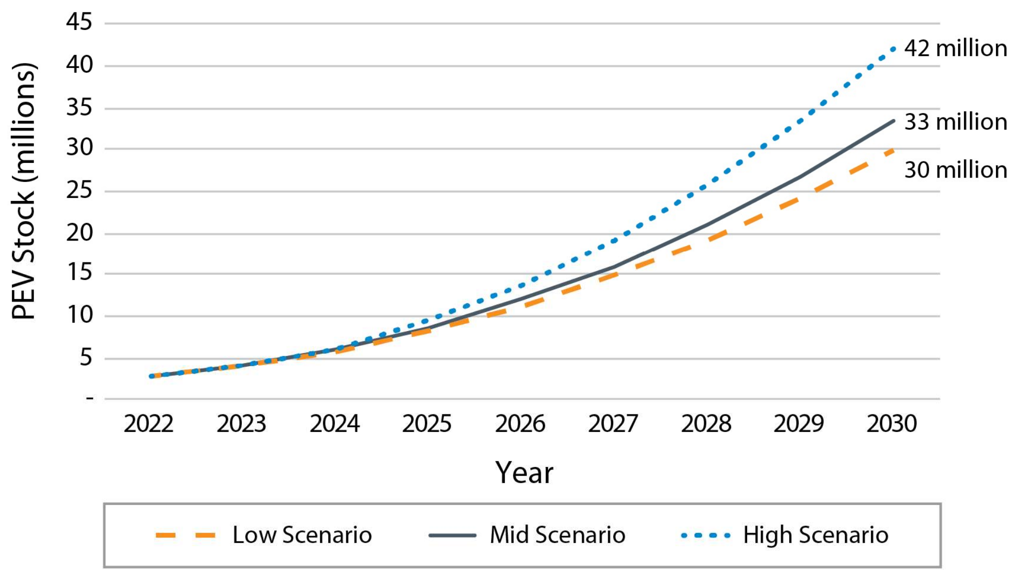


The 2030 National Charging Network

Eric Wood, National Renewable Energy Laboratory

The Road to 2030

U.S. PEV Adoption Scenarios (light-duty)



Scenarios derived from NREL's TEMPO model.

PEV = plug-in electric vehicle
LDV = light-duty vehicle
Y/Y = year over year
ZEV = zero emission vehicle
ARB = Air Resources Board

U.S. climate goals necessitate rapid decarbonization and PEVs are well-positioned in the light-duty segment

PEV adoption is accelerating (2022 LDV Sales Share and Y/Y Growth)

- U.S. = 8% +55%
- California = 19% +38%
- China = 29% +80%
- Europe = 21% +15%
- Global = 14% +55%

U.S. Executive Order, 2021 = 50% (U.S. LDV ZEV Sales by 2030)
California ARB, 2022 = 100% (CA LDV ZEV Sales by 2035)

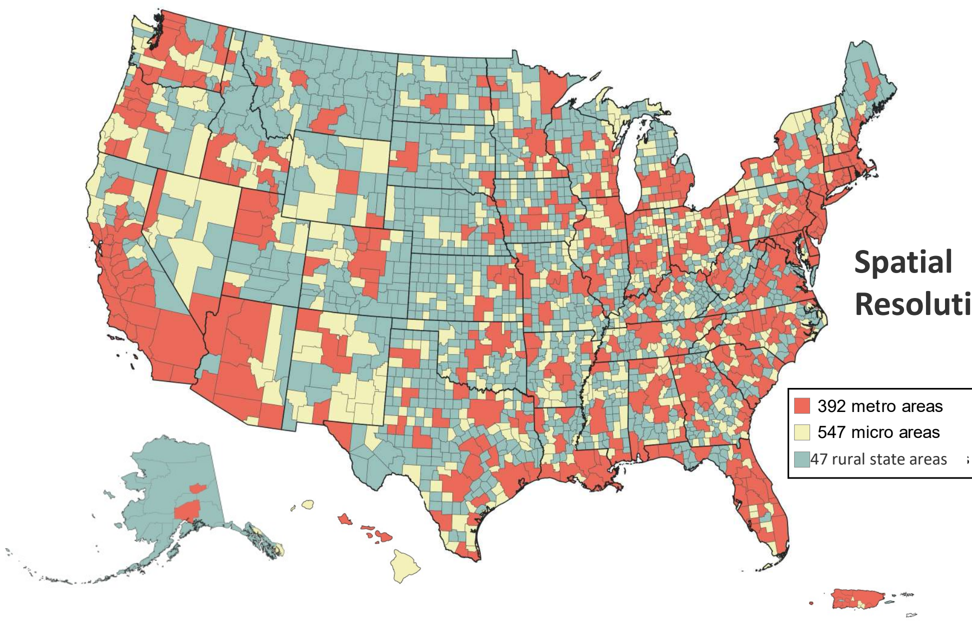
BIL & IRA provide significant incentives

Auto industry 100% ZEV ambitions

- Tesla = 2003
- Audi, Fiat, Volvo, Mercedes-Benz = 2030
- General Motors = 2035
- Honda = 2040

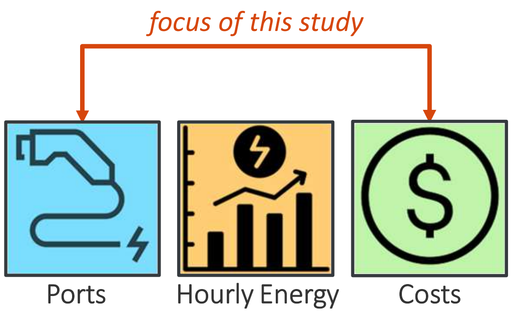
Scope of Modeling

Outputs:	EVSE port counts and costs
Vehicle Segment:	Personally-owned light-duty vehicles
Timeframe:	2022 - 2030
Spatial Resolution:	986 CBSAs/rural-state areas (see below)
EVSE Types:	(see EVSE Taxonomy table)



Spatial Resolution

Outputs:



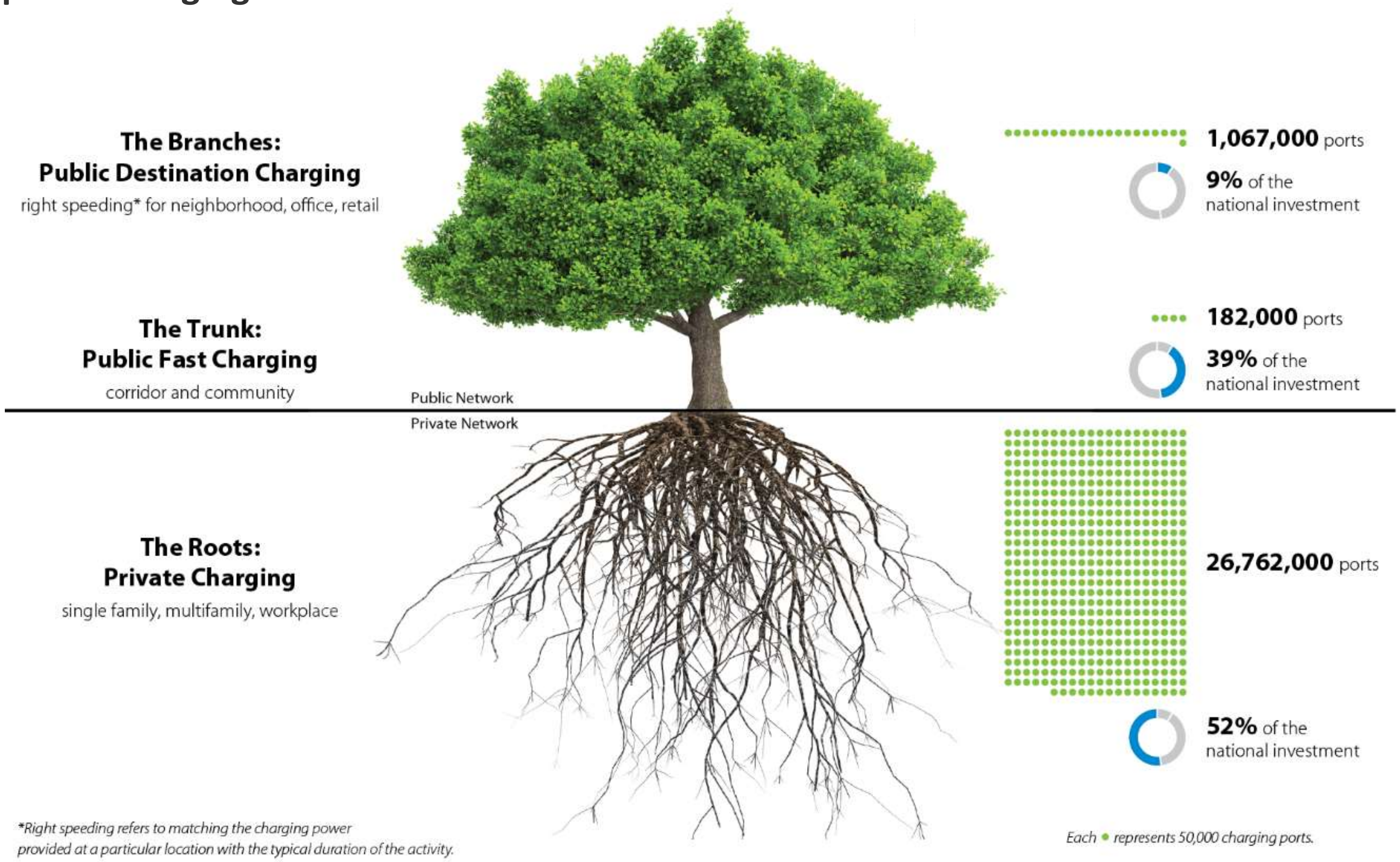
by...

EVSE Taxonomy

Access Type	Public	Private
Location Type	Home: SFH Home: MFH Neighborhood Workplace Office Retail	Recreational Healthcare School Community Center Transit Hub
EVSE Type	Level 1 Level 2 DC 50 kW	DC 150 kW DC 250 kW DC 350+ kW

Key Findings (1/5)

Convenient and affordable charging at/near home is core to the ecosystem but must be complemented by reliable public charging:



Key Findings (4/5)

The public DC fast charging network will serve multiple use cases:

- The majority (**65%**) of demand is in support of **daily travel (community charging)**, particularly for those without reliable home or workplace charging.
- **21%** of demand from **ride-hail** EVs, a disproportionate share compared to other LDVs.
- **14%** of demand from **long-distance travel (corridor charging)**, though these stations are critical for providing comprehensive national coverage (reducing ”range anxiety”).

Table 10. State-Level Port Count Summary for the Simulated 2030 Public DC Network

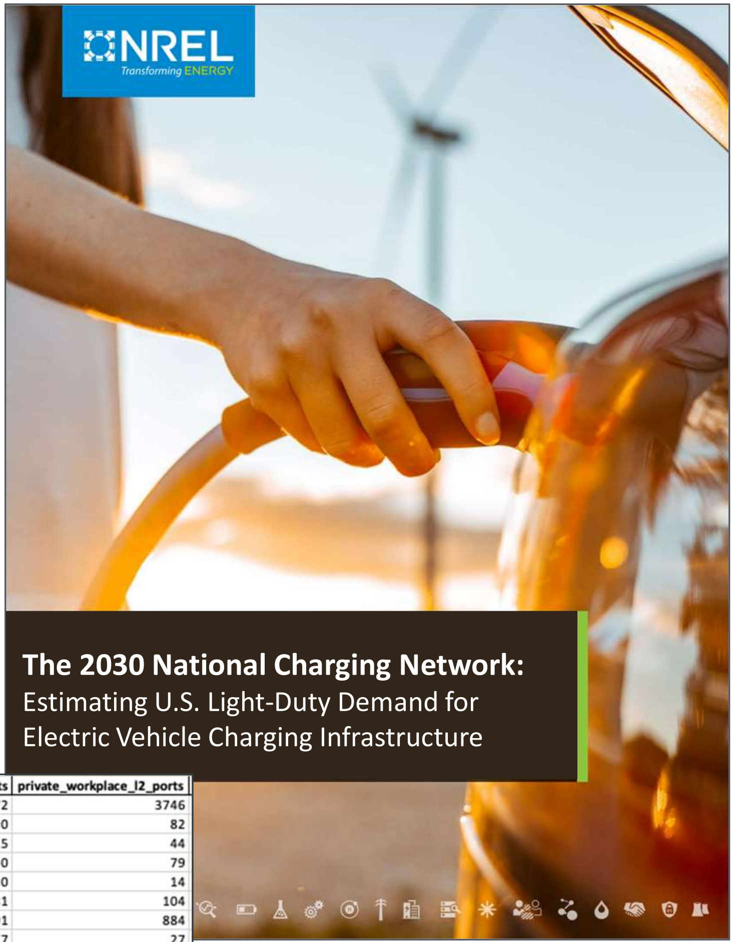
State	PEVs	DC150	DC250	DC350+	Total
AK	60,000	200	200	300	700
AL	310,000	900	900	700	2,500
AR	190,000	800	900	700	2,400
AZ	780,000	1,200	1,100	1,500	3,800
CA	7,330,000	10,700	7,500	10,900	29,100
CO	790,000	1,500	1,200	1,500	4,200
CT	340,000	600	400	500	1,500
DC	70,000	100	100	100	300
DE	100,000	100	100	100	300
FL	1,900,000	2,800	2,600	2,400	7,800
GA	810,000	1,800	1,800	1,500	5,100
HI	170,000	300	200	200	700
IA	270,000	900	1,000	900	2,800
ID	210,000	600	500	700	1,800
IL	1,100,000	2,000	2,000	1,700	5,700
IN	500,000	1,100	1,100	1,000	3,200
KS	230,000	800	800	900	2,500
KY	300,000	800	900	900	2,600
LA	230,000	600	700	600	1,900
MA	810,000	1,300	1,100	1,100	3,500
MD	680,000	1,100	800	900	2,800
ME	160,000	400	300	400	1,100
MI	720,000	1,700	1,500	1,400	4,600
MN	560,000	1,500	1,200	1,500	4,200
MO	450,000	1,200	1,300	1,100	3,600
MS	150,000	600	700	600	1,900
MT	100,000	600	500	700	1,800
NC	890,000	1,700	1,600	1,600	4,900
ND	50,000	400	300	400	1,100
NE	160,000	600	600	700	1,900
NH	170,000	300	200	300	800
NJ	820,000	1,200	900	1,000	3,100
NM	200,000	500	600	1,200	2,300
NV	320,000	600	600	1,100	2,300
NY	1,420,000	2,500	1,800	2,000	6,300
OH	860,000	1,700	1,700	1,600	5,000
OK	240,000	600	800	800	2,200
OR	720,000	1,200	900	1,500	3,600
PA	1,060,000	1,900	1,600	1,900	5,400
PR	90,000	200	100	200	500
RI	100,000	200	100	100	400
SC	380,000	700	700	600	2,000
SD	70,000	400	300	400	1,100
TN	530,000	1,100	1,200	1,000	3,300
TX	2,230,000	3,900	4,400	5,000	13,300
UT	380,000	700	700	1,200	2,600
VA	950,000	1,800	1,500	1,700	5,000
VT	100,000	300	200	300	800
WA	1,340,000	2,100	1,400	2,100	5,600
WI	530,000	1,300	1,100	1,100	3,500
WV	120,000	400	400	500	1,300
WY	50,000	200	200	400	800

Report Available Now!

https://www.nrel.gov/docs/fy23osti/85654.pdf

Also includes:

- Detailed results and discussion for baseline and 11 sensitivity scenarios.
- Downloadable data files containing detailed results (PEVs and port counts) at the state- or CBSA-level for all scenarios (2025 and 2030).



Example data file (2030 baseline – Alabama)

region_type	region_id	region_name	year	pevs	bevs	phevs	private_sfh_l2_ports	private_sfh_l1_ports	private_mud_l2_ports	private_workplace_l2_ports
State	1	Alabama	2030	312143	279339	32804	193417	72854	872	3746
Micropolitan Statistical Area	10700	Albertville, AL Micropolitan Statistical Area	2030	6232	5576	656	3858	1454	0	82
Micropolitan Statistical Area	10760	Alexander City, AL Micropolitan Statistical Area	2030	3390	3028	362	2120	800	5	44
Metropolitan Statistical Area	11500	Anniston-Oxford, AL Metropolitan Statistical Area	2030	6716	6000	716	4204	1586	0	79
Micropolitan Statistical Area	12120	Atmore, AL Micropolitan Statistical Area	2030	1591	1427	164	1011	380	0	14
Metropolitan Statistical Area	12220	Auburn-Opelika, AL Metropolitan Statistical Area	2030	10726	9588	1138	6692	2523	31	104
Metropolitan Statistical Area	13820	Birmingham-Hoover, AL Metropolitan Statistical Area	2030	70337	62978	7359	43589	16404	391	884
Metropolitan Statistical Area	17980	Columbus, GA-AL Metropolitan Statistical Area	2030	2892	2591	301	1779	669	7	27
Micropolitan Statistical Area	18980	Cullman, AL Micropolitan Statistical Area	2030	5618	5039	579	3523	1325	0	69
Metropolitan Statistical Area	19300	Daphne-Fairhope-Foley, AL Metropolitan Statistical Area	2030	20243	18065	2178	12258	4625	150	237
Metropolitan Statistical Area	19460	Decatur, AL Metropolitan Statistical Area	2030	9333	8334	999	5824	2200	16	110
Metropolitan Statistical Area	20020	Dothan, AL Metropolitan Statistical Area	2030	9394	8395	999	5848	2207	6	117
Micropolitan Statistical Area	21460	Enterprise, AL Micropolitan Statistical Area	2030	3698	3308	390	2309	870	0	44
Micropolitan Statistical Area	21640	Eufaula, AL-GA Micropolitan Statistical Area	2030	1165	1038	127	735	278	2	9
Metropolitan Statistical Area	22520	Florence-Muscle Shoals, AL Metropolitan Statistical Area	2030	8935	7992	943	5629	2122	3	97
Micropolitan Statistical Area	22840	Fort Payne, AL Micropolitan Statistical Area	2030	4405	3945	460	2799	1053	0	50

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Photo from iStock-627281636

Collective Wisdom: Positive Examples and Pressing Challenges

Goal: This session aims to elevate and share top-of-mind examples among attendees.

- 5 minutes for table participants to quietly write sticky notes with their examples/concerns.
- 10 minutes for peer discussion at your table and placing sticky notes on the flip chart in the correct columns.
- 5 minutes for room-wide "popcorn" style report from participants.

Group Questions

1. What are your great examples of promising approaches to transportation electrification planning? Where are they happening?
2. What are you concerned about? What are the pressing challenges to T.E. planning?

NARUC 2023 Connecting the Dots – PGE DER Modeling

Jason Salmi Klotz – Senior Manager Distributed Resource Planning & Engagement

November 2023

PGE

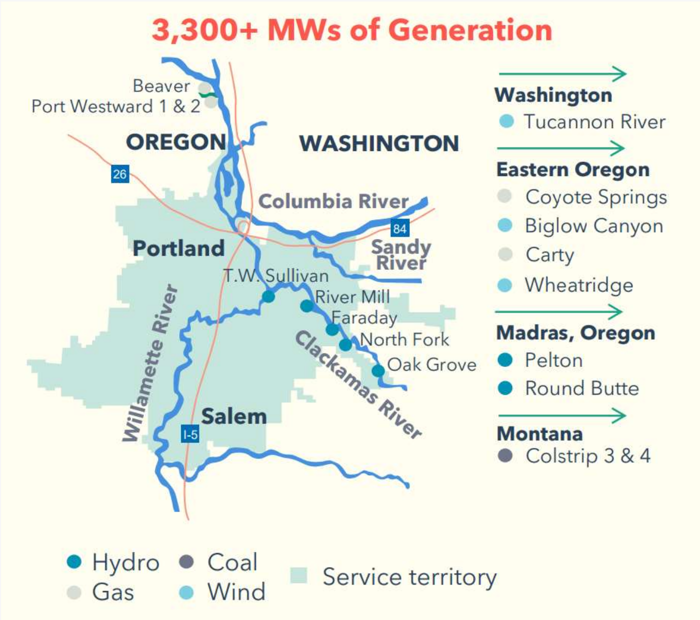
PGE at a glance

Quick facts

- Vertically integrated electric utility encompassing generation, transmission and distribution
- 900,000 retail customers within a service area of 2 million residents
- 46 percent of Oregon's population lives within PGE service area, encompassing 51 incorporated cities entirely within the State of Oregon
- 75 percent of Oregon's commercial and industrial activity occurs in PGE service area

Leading the way to a clean energy future for Oregon

- With PGE support, Oregon legislature recently approved HB2021, requiring utilities to achieve an 80% reduction in greenhouse gas emissions by 2030 and 100% clean electricity by 2040.



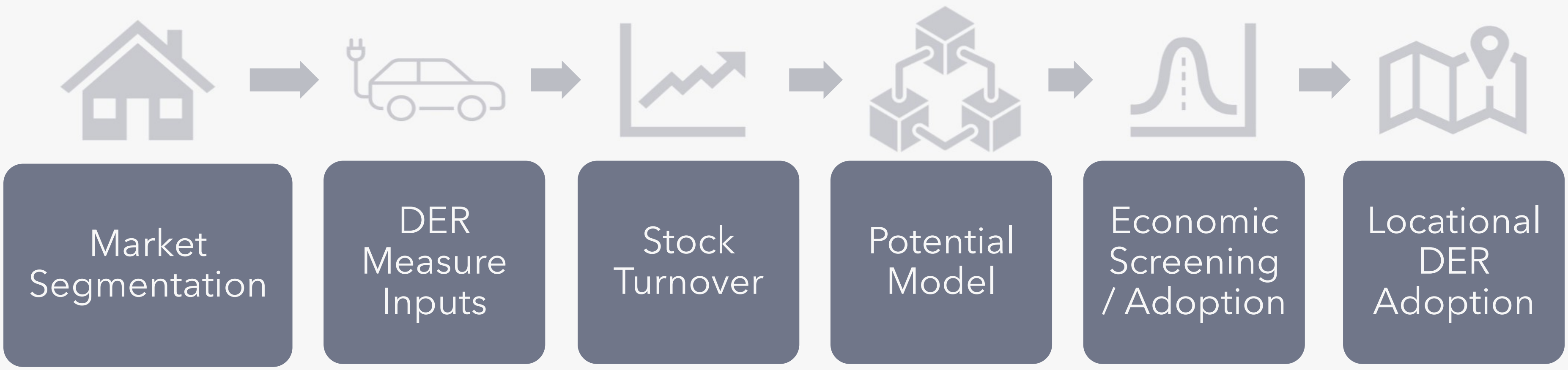
PGE uses a model called AdopDER. We created AdopDER in collaboration with Cadeo with assistance from Brattle Group.

AdopDER is a site-level simulation model that estimates locational, 8760-hour load impacts from the co-adoption of 40+ distributed energy resources

PGE uses AdopDER to inform multiple OPUC filings
Integrated Resource Plan
Distribution System Plan
Clean Energy Plan

It has also won national recognition – 2023 AESP Energy Award for Innovation

AdopDER Simplified Workflow



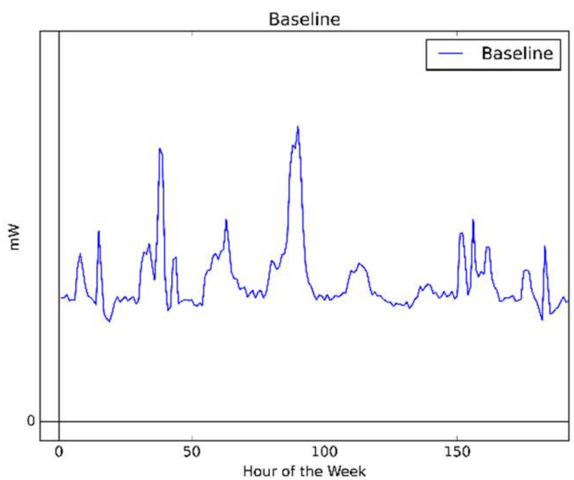
DER Measure Inputs

- **Solar and Storage**
  - Solar PV
  - Battery Energy Storage
  - Single-site microgrid
  - Campus microgrid
- **Electric Vehicles**
  - Light-Duty Vehicles
  - Medium-Duty Vehicles
  - Heavy-Duty Vehicles
- **Basic EVSE**
  - Res L2
  - Non-res L2
  - Non-res DCQC
- **Smart Charging**
  - Res Smart EVSE
  - Non-res Smart EVSE
- **Smart Water Heating**
  - ERWH retrofit switch
  - ERWH smart controls
  - Smart ERWH
  - HPWH smart controls
- **Smart HVAC**
  - Res smart tstat controls
  - Res line voltage tstat
  - Res DHP controls
- **C&I DR**
  - Commercial smart tstat
  - Irrigation load control
  - Large C&I tariff
  - Cold thermal storage
- **Non-firm DR**
  - Peak Time Rebates (PTR)
  - Time of Use (TOU) rates
  - EV-TOU

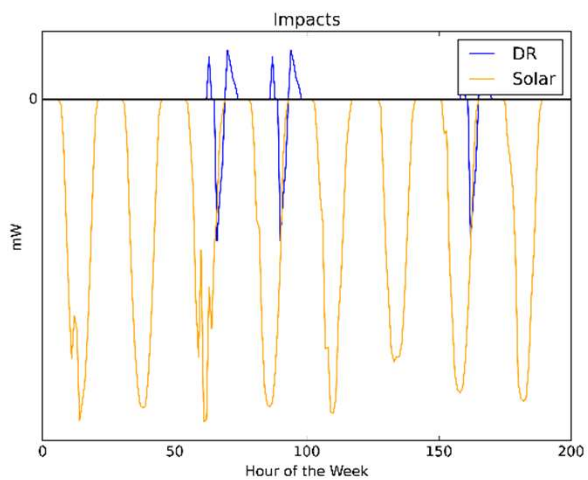
We apply DER load impacts to baseline to build a load forecast

Feeder-Level load, no DER adoption → Apply load impacts for each DER measure → Feeder-level load with DER adoption

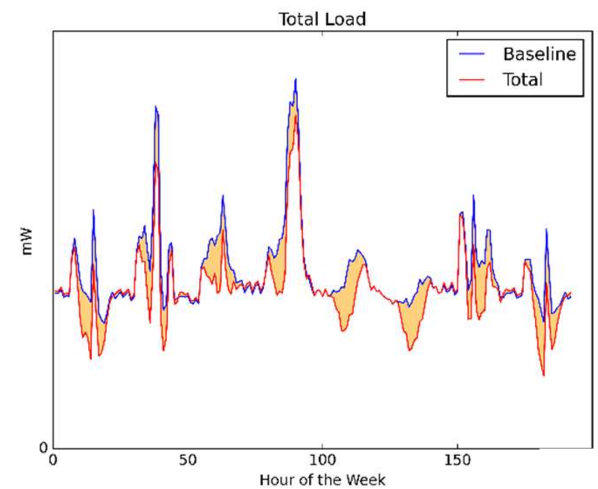
Predicted Hourly Feeder Load (MW, Aug 2030)



Predicted DER Load Impacts (MW, Aug 2030)



Predicted Hourly Feeder Load (MW, Aug 2030)



Site-level DER adoption simulates the customer journey.

Hypothetical Example of DER Adoption

Year 2015

- Start with known characteristics
- ICE vehicle in the garage

Year 2017

- Replace ICE with BEV
- Keep that L1 EVSE around
- Now eligible for Smart L2 EVSE

Year 2019

- Purchase a Smart L2 EVSE
- Now eligible for EVSE DLC

Year 2022

- Enroll in ESVE DLC program

Step 1: Adoption

Planning for Heavy Duty Charging

PGE partners with fleet customers providing fleet electrification analysis at no cost and gaining insights into fleet customers' plans

***Early* engagement with the utility** is critical, especially for heavy duty charging sites

Challenges to rapid deployment:

- Some fleet sites will require significant electrical upgrades on site and on the distribution system
- Supply chain delays for vehicles, chargers, electrical infrastructure

State and federal funding can help build public heavy-duty charging; West Coast Clean Transit Corridor Initiative provides a framework

PGE Fleet Partner:
A turnkey solution for fleet electrification

- Free planning and technical services for fleet customers
- Installation of make-ready infrastructure with custom cost incentives
- Rebates for qualified Level 2 chargers
- Fleet Partner Phase 1 reserved all funding, hoping to expand January 2024

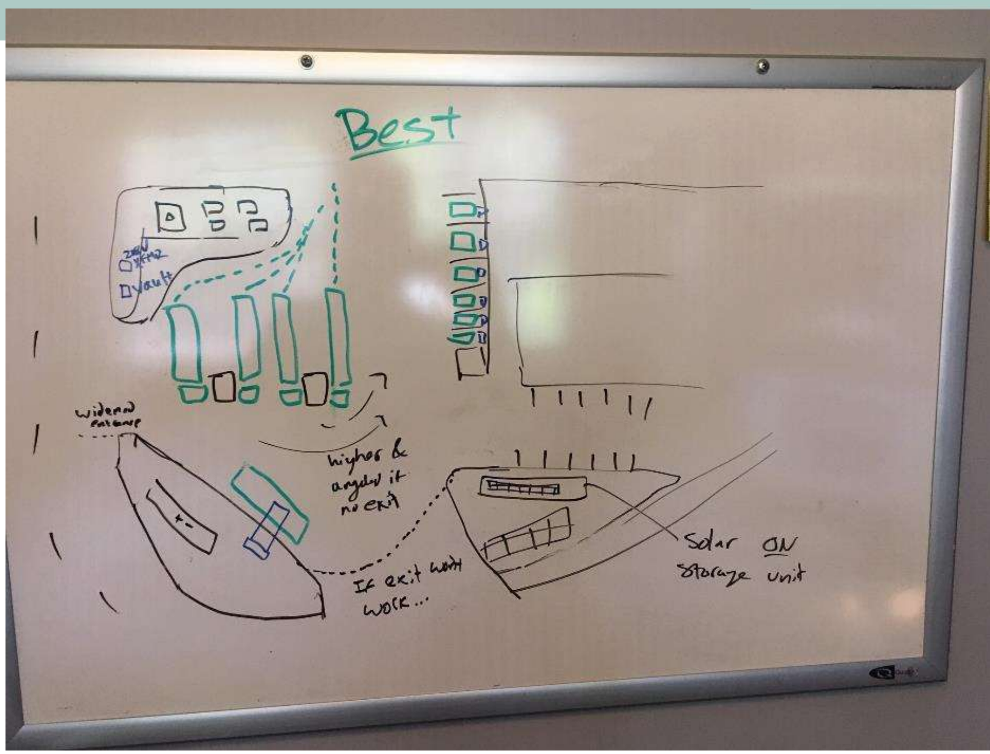
Reduces cost and complexity associated with transitioning to electric fuel

- Commercial
- Municipal
- School
- Non-profit
- Transit fleets

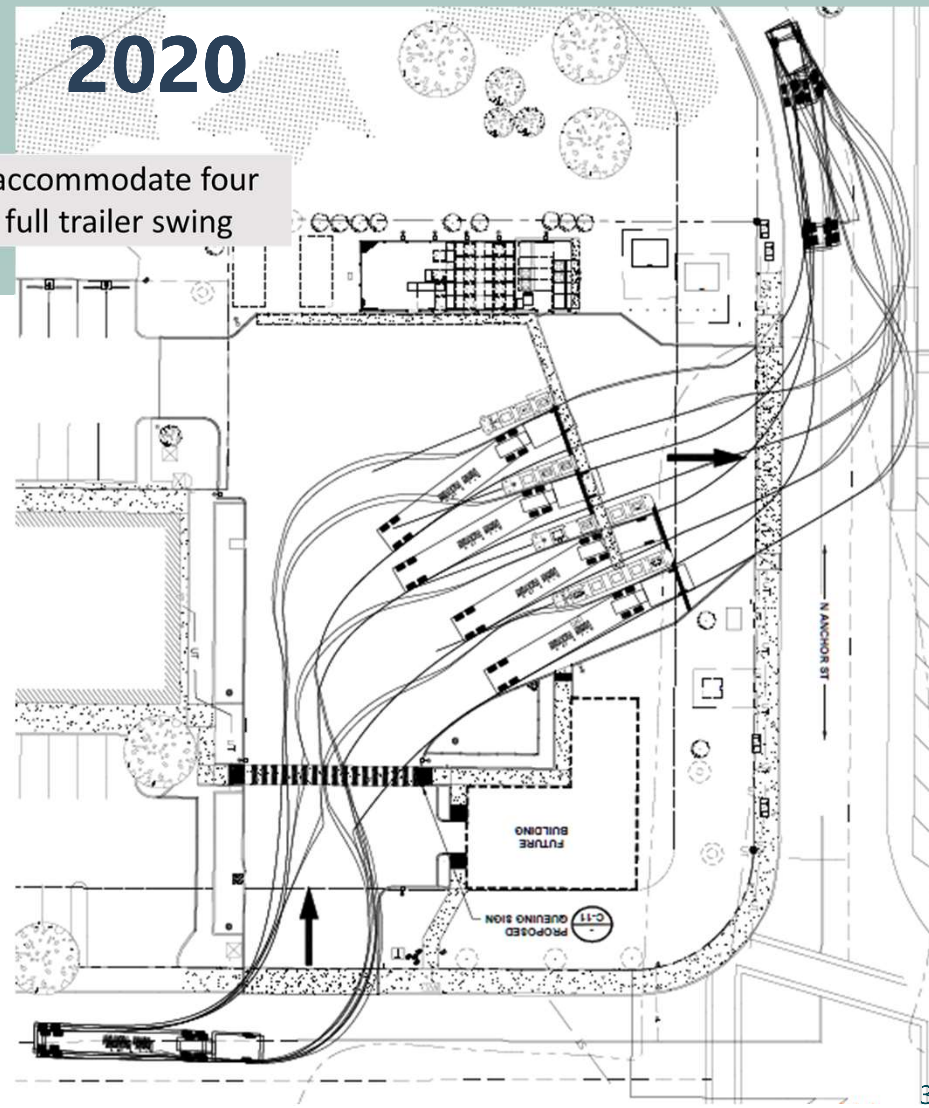
Site Design

2020

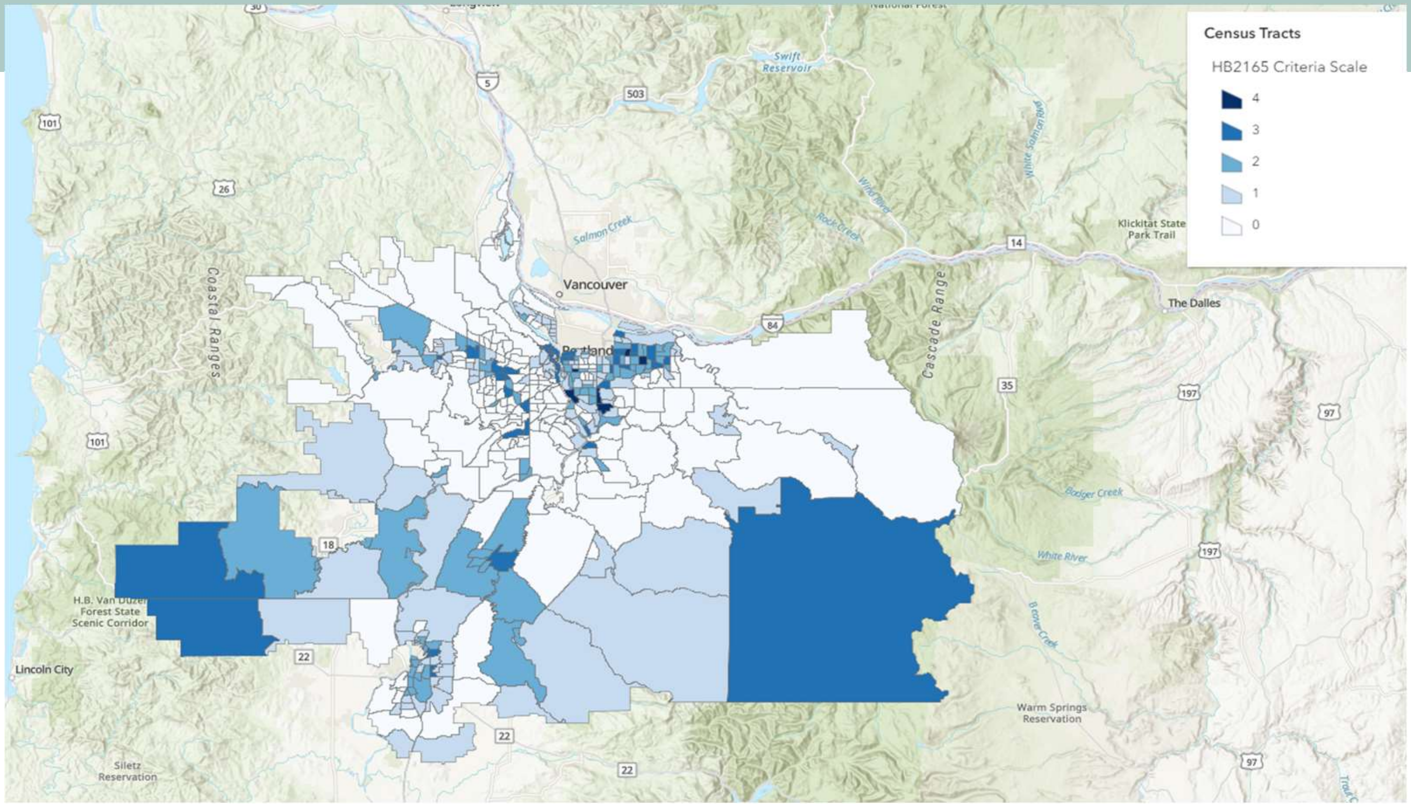
Facility designed to accommodate four Class 8 trucks with full trailer swing



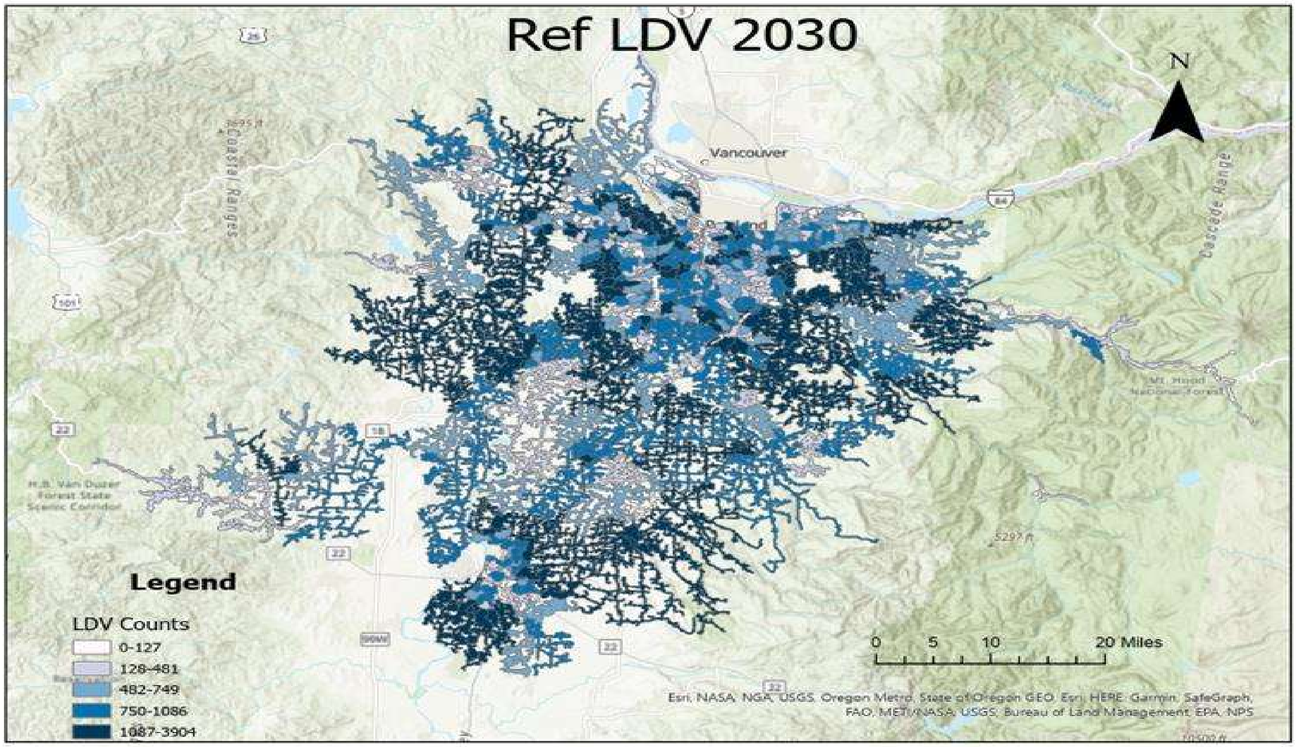
2019



PGE Underserved Communities under HB2165 Criteria

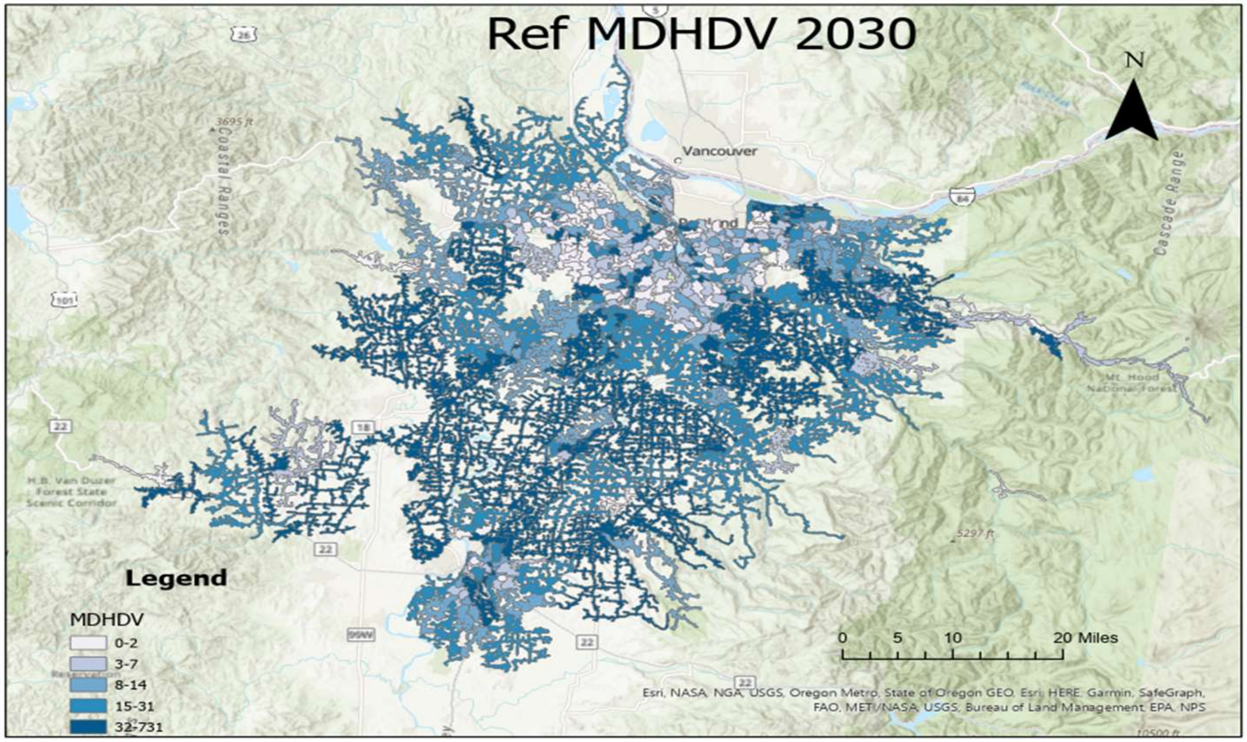


Reference Case LDV Adoption at Feeder Level in 2030



Source: PGE analysis, DSP Part II, Ch 3

Reference Case MDHDV Adoption at Feeder Level in 2030



Source: PGE analysis, DSP Part II, Ch 3

Lessons Learned Broadly

Valuation matters they drive decisions – there are several flavors of valuation

- Business values, Customer values, System values – Including locational , Regulatory such as cost effectiveness and Community Benefit Indicators

Tariffs and Rates matter – TE is a new business sector and should be managed as such – Programmatic approach will last and reach on so far.

Who and how to serve underserved communities, what is the utility long term obligation. How is charging cost parody obtained in multi-family dwellings.

Should a utility own chargers?

How does the utility create EVSE build partnerships to assure insight and some level of control over siting EVSE and how to manage EVSE load?

PGE's Strategy is to Plan, Serve and Manager TE Load – What is best mix of rates, tariff and programs to meet all concerns in the market while manage total cost to customers and the system.

Let's meet the future together.

Forecasting Charging Loads

Moderator:

Hon. Katherine Peretick, Michigan Public Service Commission

- Mark Esguerra, Southern California Edison
- Matthew Cloud, Enterprise Holdings

COUNTDOWN TO 2045

REALIZING CALIFORNIA'S PATHWAY TO NET ZERO

NARUC TRANSPORTATION ELECTRIFICATION PLANNING WORKSHOP
NOVEMBER 15, 2023

EDISON INTERNATIONAL®

Southern California Edison (SCE) is one of the nation's largest electric utilities

15 MILLION RESIDENTS

5 MILLION CUSTOMER ACCOUNTS

50,000 SQUARE-MILE SERVICE AREA

1.4 MILLION POWER POLES

724,000 TRANSFORMERS

1,360 MW ENERGY STORAGE CONTRACTS

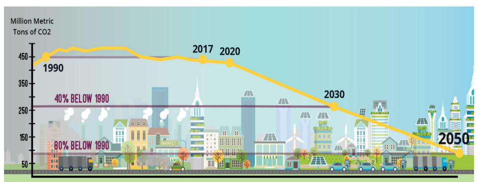
3,500 MILES OF OVERHEAD POWER LINES REPLACED WITH INSULATED WIRE

118,000 MILES OF OVERHEAD DISTRIBUTION & TRANSMISSION LINES

6,090 POLES UPGRADED TO FIRE-RESISTANT

SCE VISION FOR DECARBONIZATION AND AN ADVANCED GRID DRIVES FORWARD THROUGH SUCCESSIVE EFFORTS

California's climate-change goals include a 40% reduction in absolute greenhouse gas (GHG) emissions from 1990 levels by 2030, and 80% by 2050, as well as net-zero GHG emissions economy-wide by 2045



SCE is required by law to meet the following retail sales requirements for the power it delivers to customers:

- ✓ By 2020 – **33%** of power from Renewables Portfolio Standard (RPS)-eligible resources *(requirement met)*
- ❑ By 2030 – **60%** of power from RPS-eligible resources
- ❑ By 2045 – **100%** carbon-free power

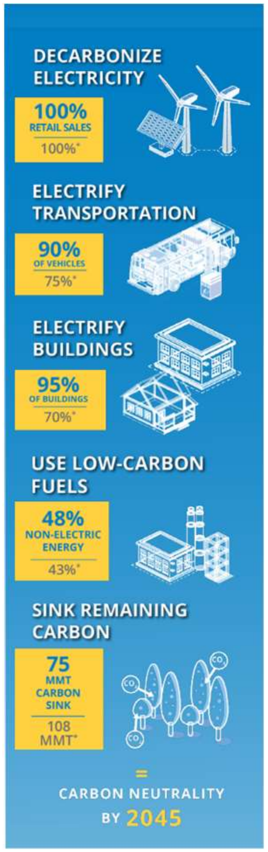
SCE whitepapers outlining cross-sector collaboration for achieving carbon neutrality:

Pathway 2045 (2019)
SCE's 2019 data-driven analysis of the steps that California must take to meet the 2045 goals to clean our electric grid and reach carbon neutrality.

Reimagining the Grid (2020)
An assessment of the grid changes needed to support GHG reduction goals, while adapting to evolving customer (EV, DERs) and climate-change driven needs.

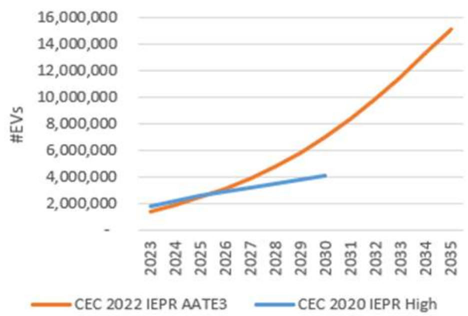
Mind the Gap (2021)
An assessment of policy changes and additions needed to ensure California meets its GHG emissions reductions targets by 2030 in anticipation of its goal to decarbonize by 2045.

Countdown to 2045 (2023)
A data-driven analysis of the steps that California must take to meet 2045 goals, which identified 5 key actions for affordably achieving carbon neutrality

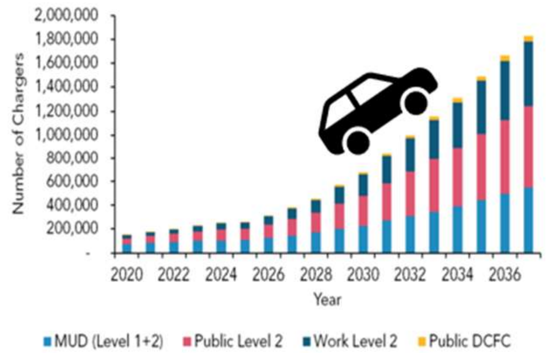


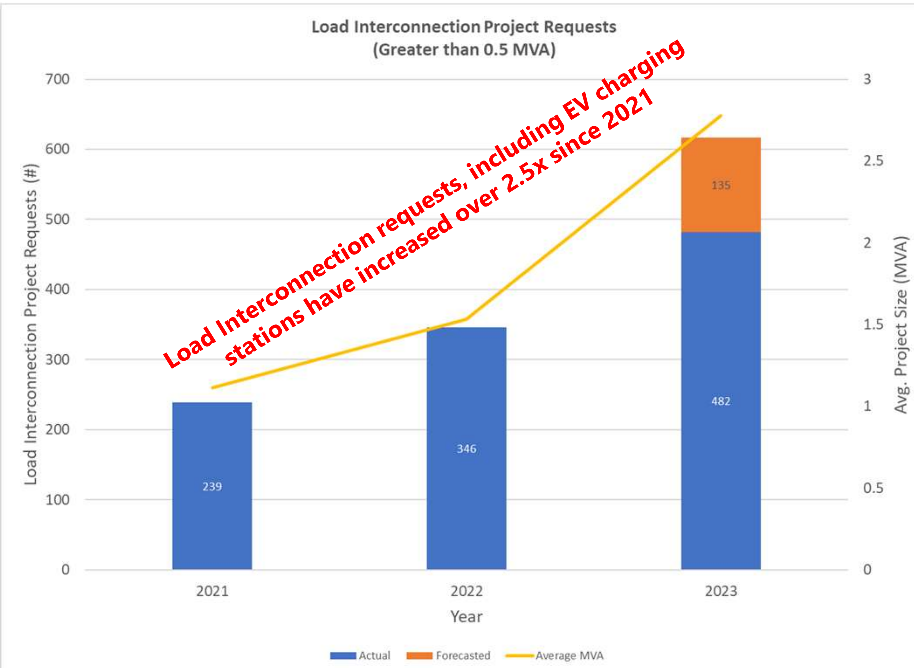
By 2035, 15 million+ light-duty and 378,000+ medium/heavy-duty EVs are forecast to be adopted requiring over 1.7 million chargers to be installed, including nearly 50,000 DC fast chargers

Light-duty EV Adoption forecast[1]

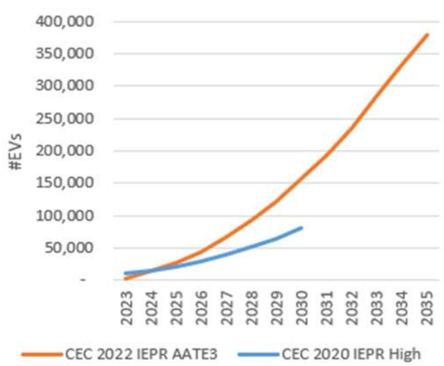


Light-duty electric vehicle charger forecast[2]

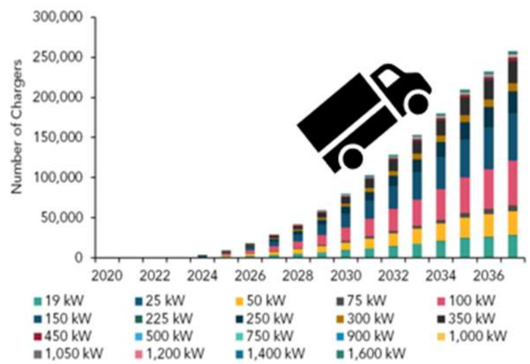




Medium/Heavy-duty EV Adoption forecast[1]



Medium/heavy-duty EV charger forecast[2]



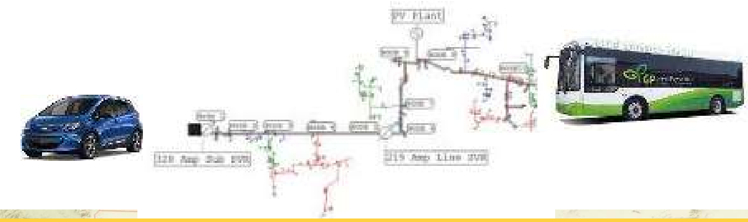
1. Source: 2020 IEPR and 2022 IEPR (CEC) which incorporated recently-approved CARB policies and future anticipated policies
2. Source: 2022 State Strategy for the State Implementation Plan (CARB)

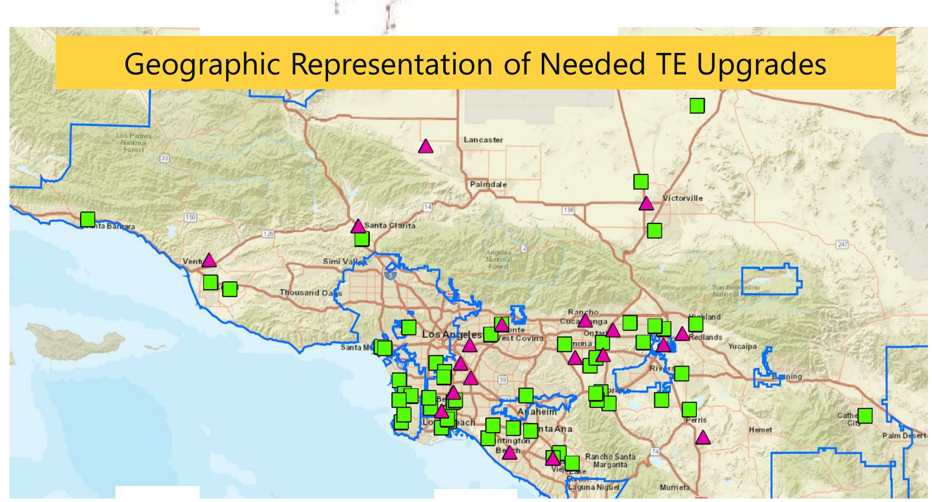
Enhancing Our Understanding of Where and When EV/TE Load Will Materialize

Understanding of where EV/TE will materialize:
- customers likely to adopt EV
- Identifying large fleet operators
- Mapping EV/TE adoption by customer type
- Factoring customer plans

Understanding of when EV/TE will materialize
- Mapped propensity for TE adoption
- Factoring customer plans, including load project requests

Other data points that reflect potential for EV/TE adoption
- Identification of truck stop locations
- Large warehouses
- Drayage truck companies
- Information and insights from External Engagement efforts:
  - TE Fleet Operator Engagement Workshops & Webinars





Distribution projects (12 to 36 months)

Sub-transmission projects (24 to 70 months)

Electrifying Airport Ecosystems

NARUC-DOE Transportation Electrification Planning Workshop
November 15th, 2023

Matt Cloud – Strategy Development Director

Enterprise Mobility

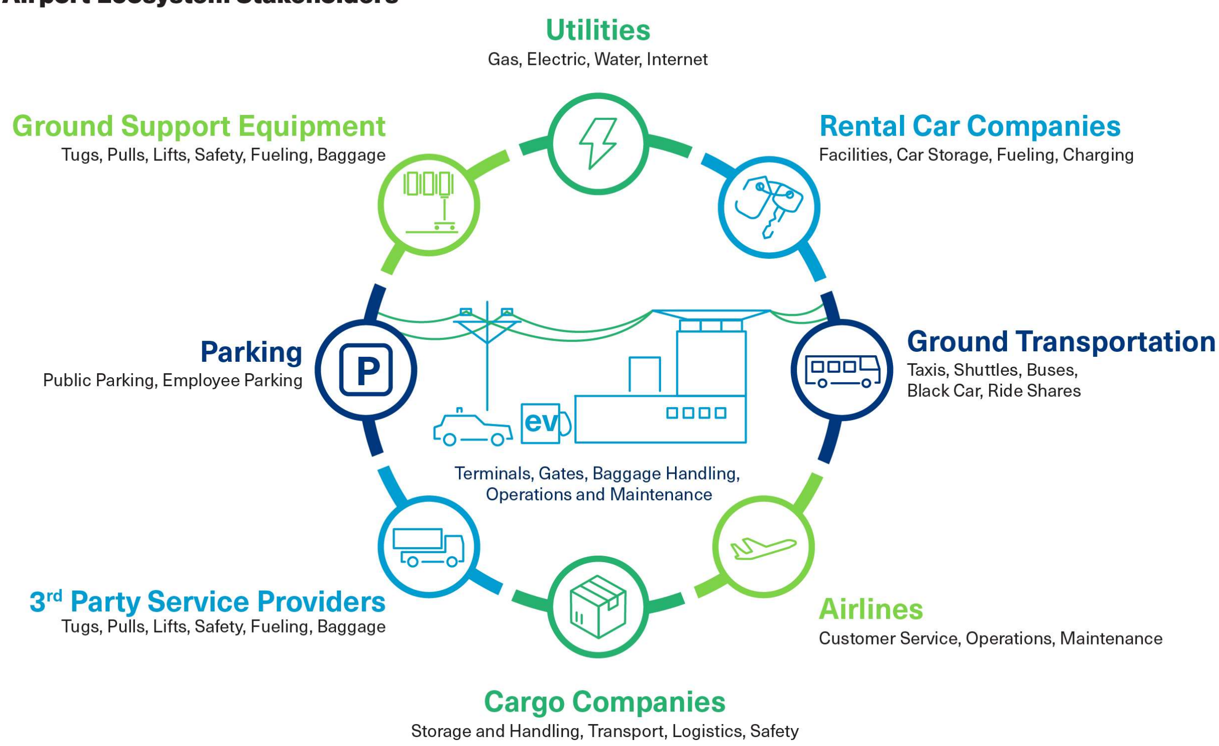
Airport ecosystems contributed more than 7% of the US’s gross domestic product in 2023[1]

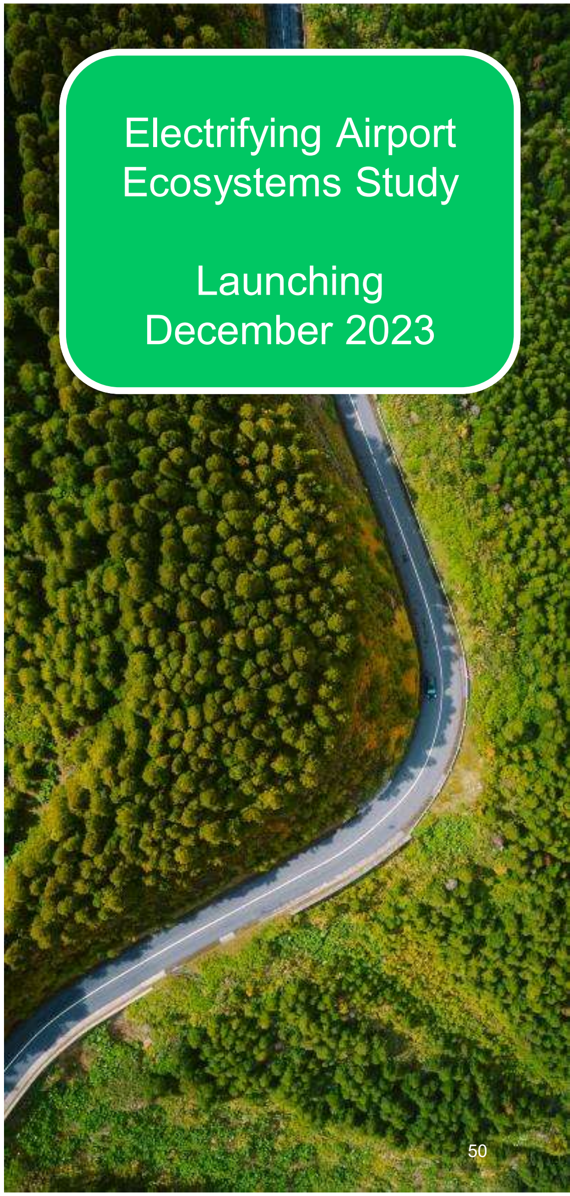
[1]Airports Council International North America Infrastructure Needs Report

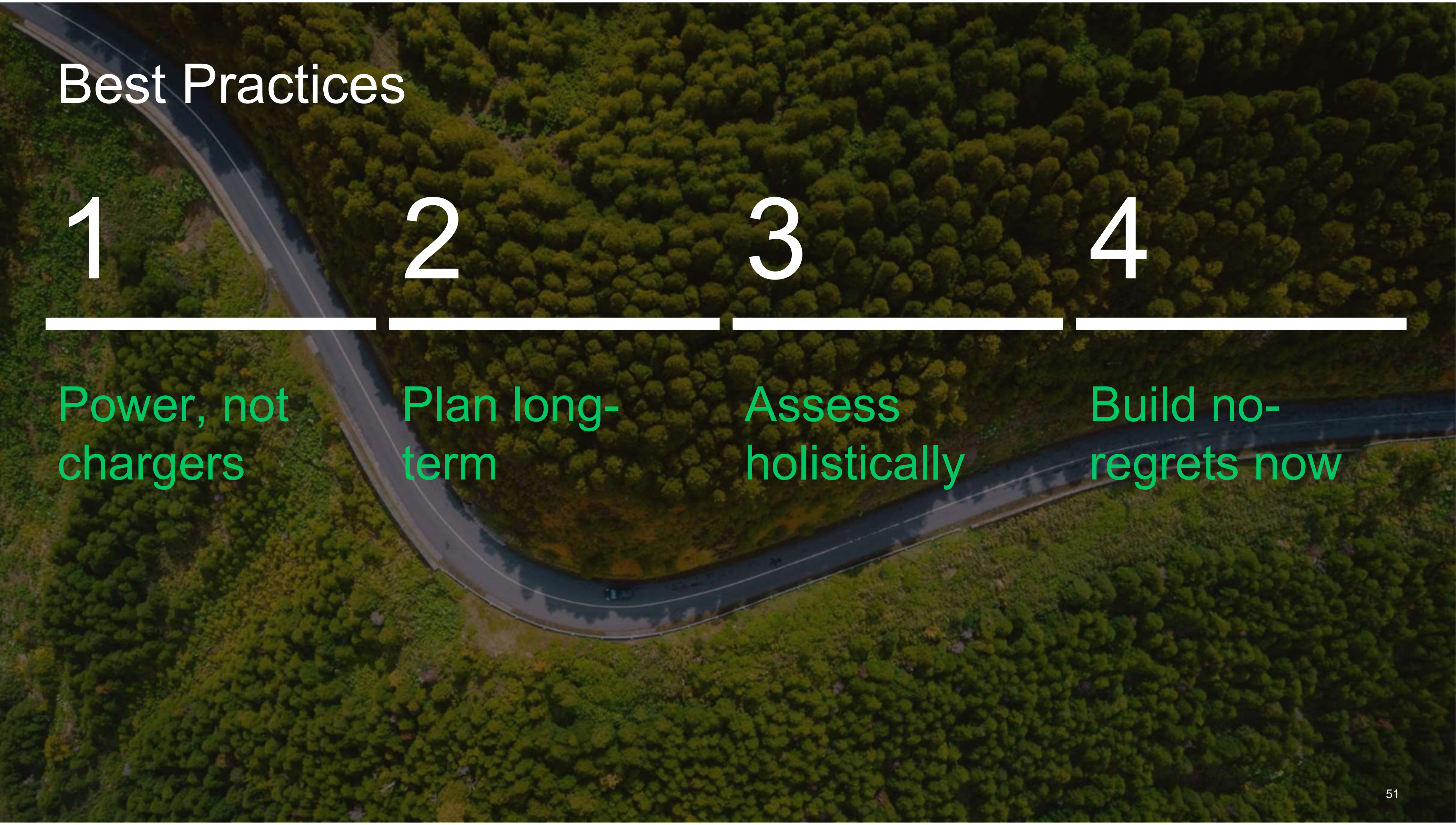
Airport Ecosystems Are Electrifying

And rapidly adding power demands, the rental car industry alone could require 40MW+

Airport Ecosystem Stakeholders







Best Practices

1 — Power, not chargers

2 — Plan long-term

3 — Assess holistically

4 — Build no-regrets now


Thank you
Enterprise Mobility™

Break!

Return at 3:05 pm

Understanding Grid Infrastructure Needs

Moderator:
Hon. Milt Doumit, Washington Utilities and Transportation Commission

- Brenda McDermott, Xcel Energy
- Bin Wang, Lawrence Berkeley National Laboratory

HEVI-LOAD National Infrastructure Analysis

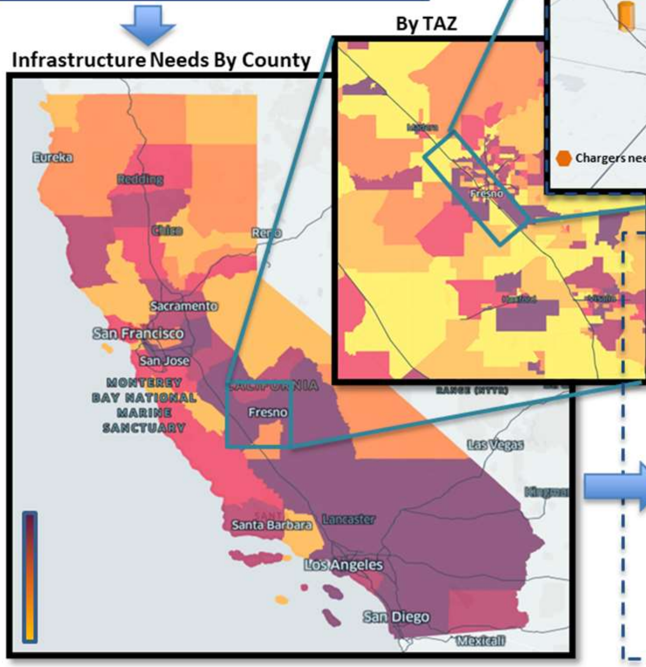
Bin Wang, Ph.D.
Research Scientist, Lawrence Berkeley National Laboratory

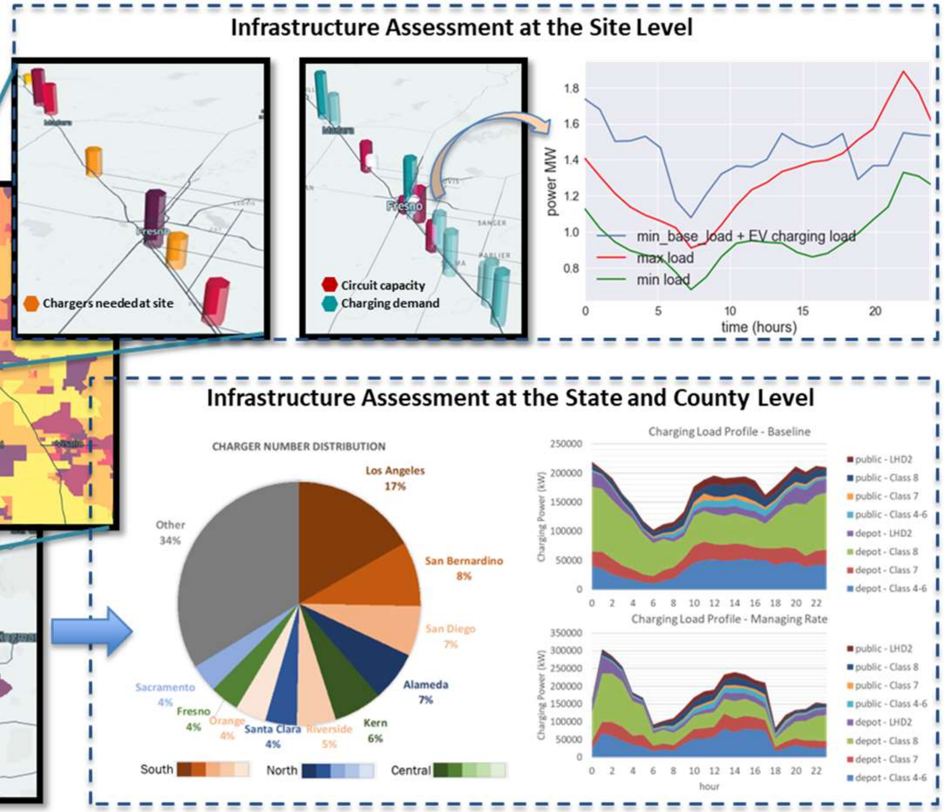
ENERGY TECHNOLOGIES AREA
BERKELEY LAB

HEVI-LOAD Augmentation from Regional to National-Scale Infrastructure Analysis

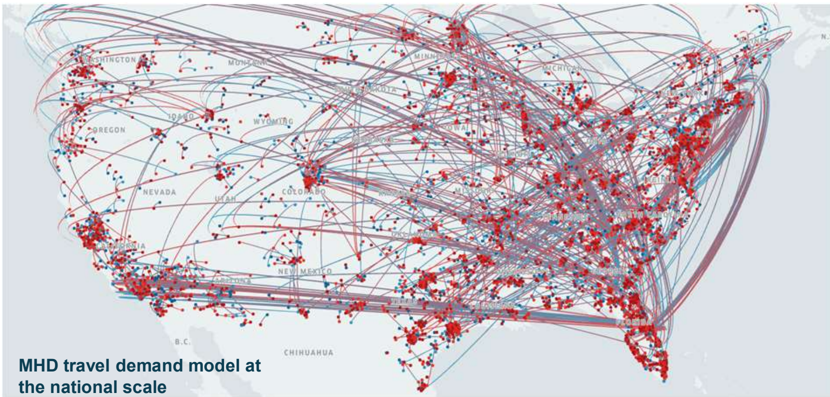
HEVI-LOAD Inputs
- MDHD travel demand (trips),
- parking and infra. location,
- truck GPS data,
- adoption scenarios,
- vehicle specifications, etc.

HEVI-LOAD Agent-Based Simulation
- Integrated driving-parking-refueling behavior modeling and simulation
- Smart/managed charging strategies

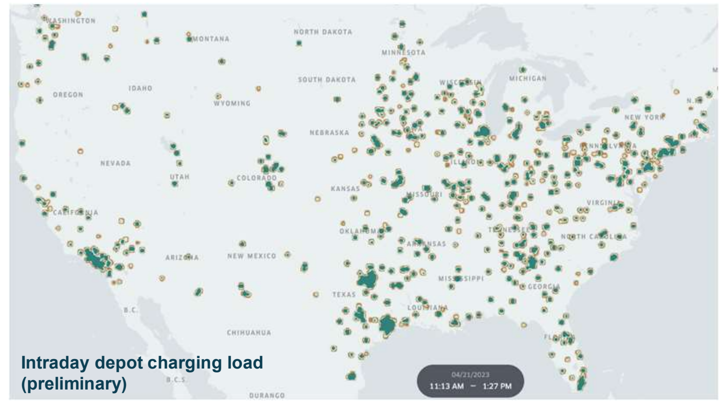




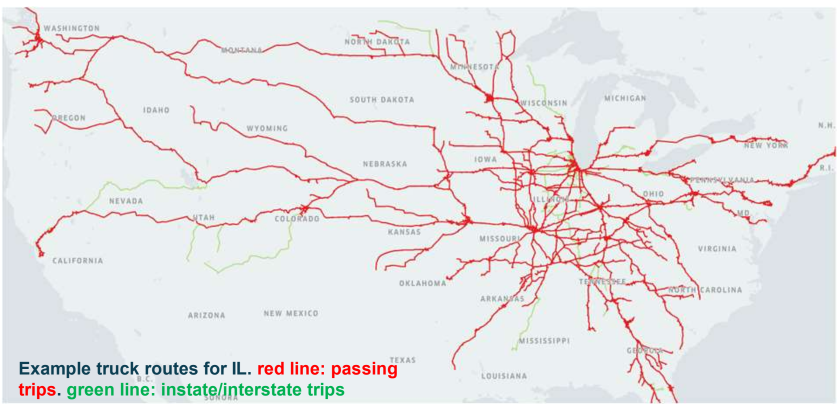
HEVI-LOAD Simulation for US (Preliminary Results)



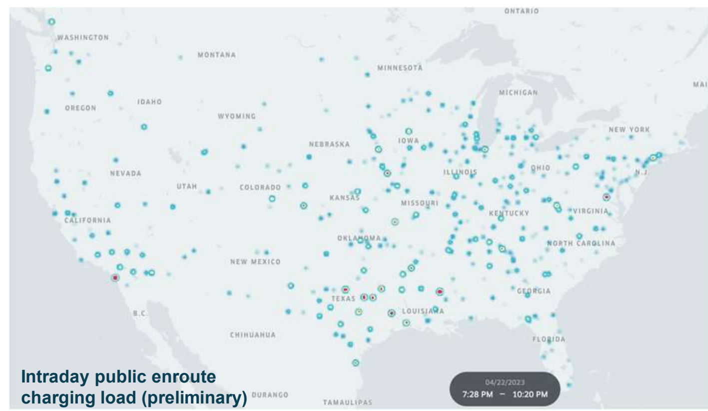
MHD travel demand model at the national scale



Intraday depot charging load (preliminary)

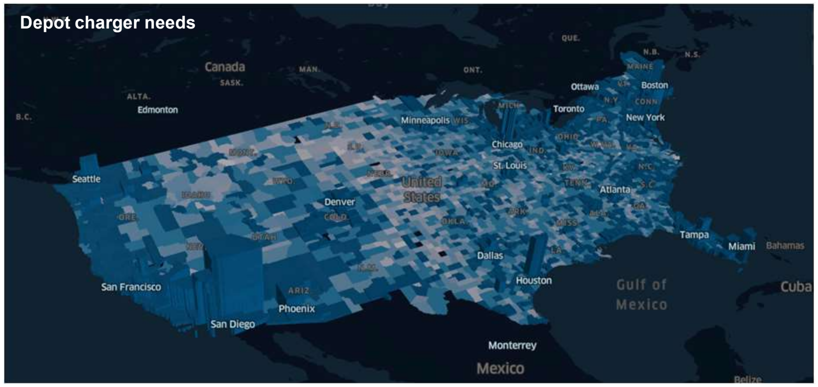


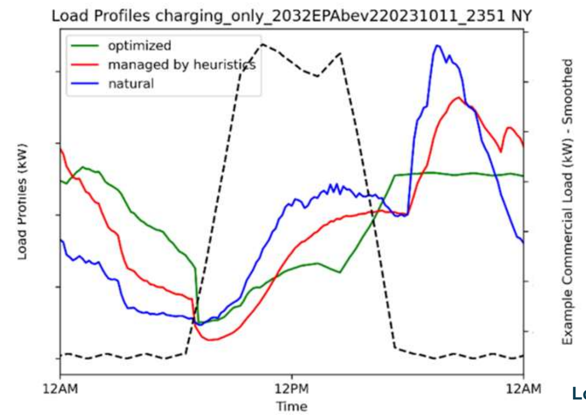
Example truck routes for IL. red line: passing trips. green line: instate/interstate trips



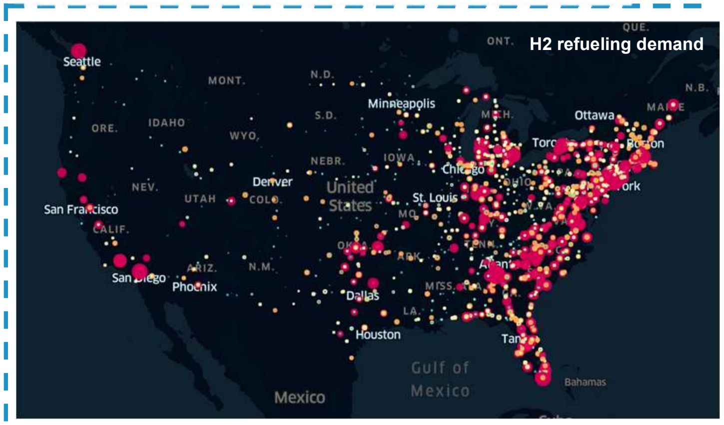
Intraday public enroute charging load (preliminary)

Infrastructure and Load Results (Preliminary)





Load mitigation



Thanks!

Bin Wang,

wangbin@lbl.gov

Identifying and Evaluating Solutions to Meet Needs

Moderator:
Hon. Katherine Peretick, Michigan Public Service Commission

- Steve Nadel, American Council for an Energy-Efficient Economy
- Ben Shapiro, RMI

Planning for Electrification of Truck Fleets

Steven Nadel, ACEEE

NARUC Transportation Electrification Planning Workshop

November 2023

Smart Energy. Clean Planet. Better Lives.

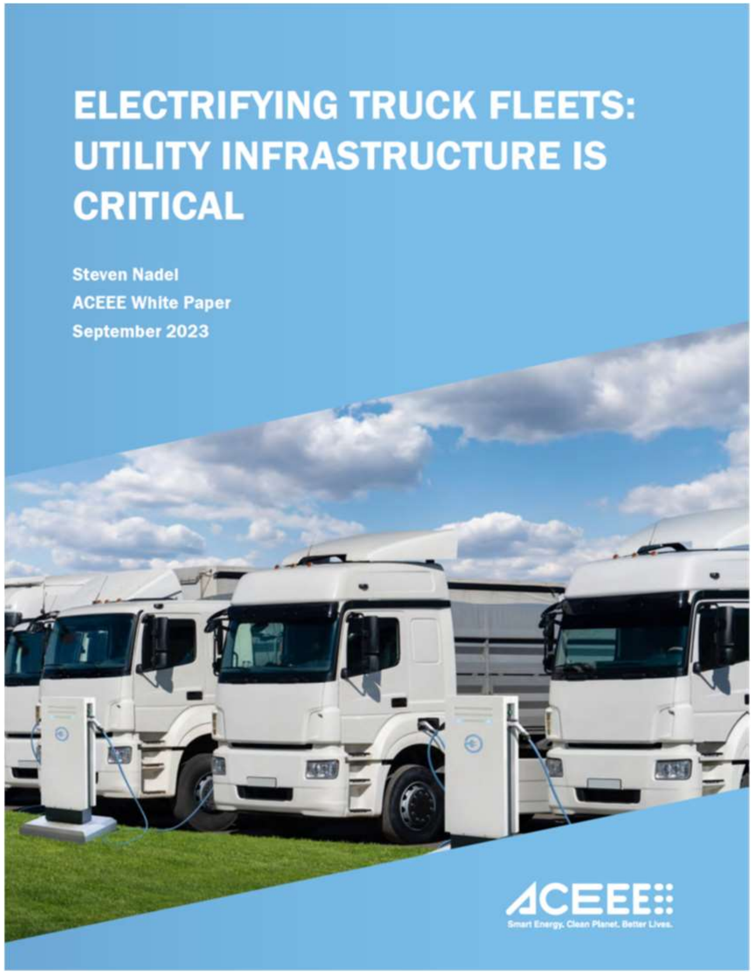
About ACEEE:

The American Council for an Energy-Efficient Economy (ACEEE), is a nonprofit research organization that develops policies to reduce energy waste and combat climate change. Its independent analysis advances investments, programs, and behaviors that use energy more effectively and help build an equitable clean energy future.

Learn more at aceee.org

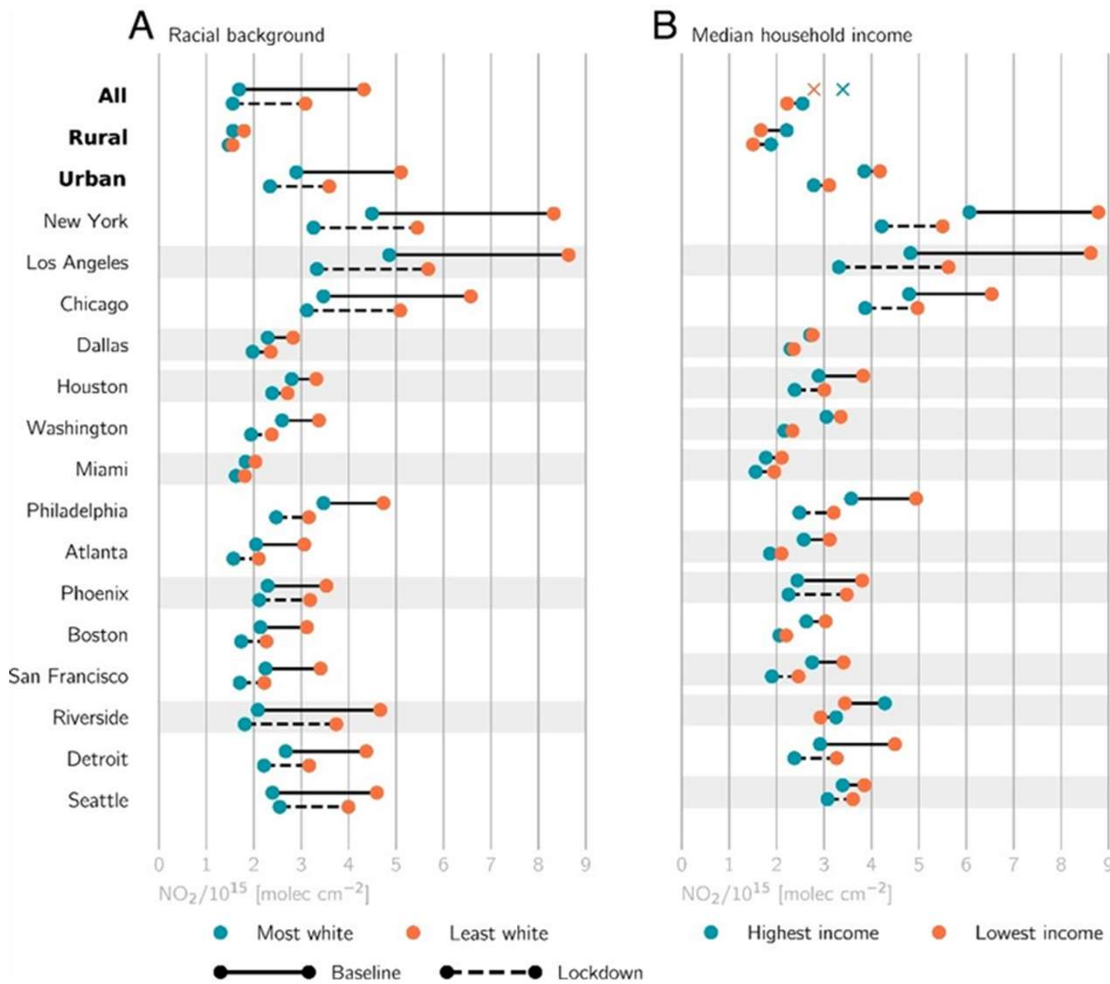
ACEEE

Smart Energy. Clean Planet. Better Lives.



https://www.aceee.org/white-paper/2023/09/electrifying-truck-fleets-utility-infrastructure-crucial

Disparities in NOx Levels



Source: Kerr, Goldberg and Anenberg. 2021

Examples of Fleet Charging Loads

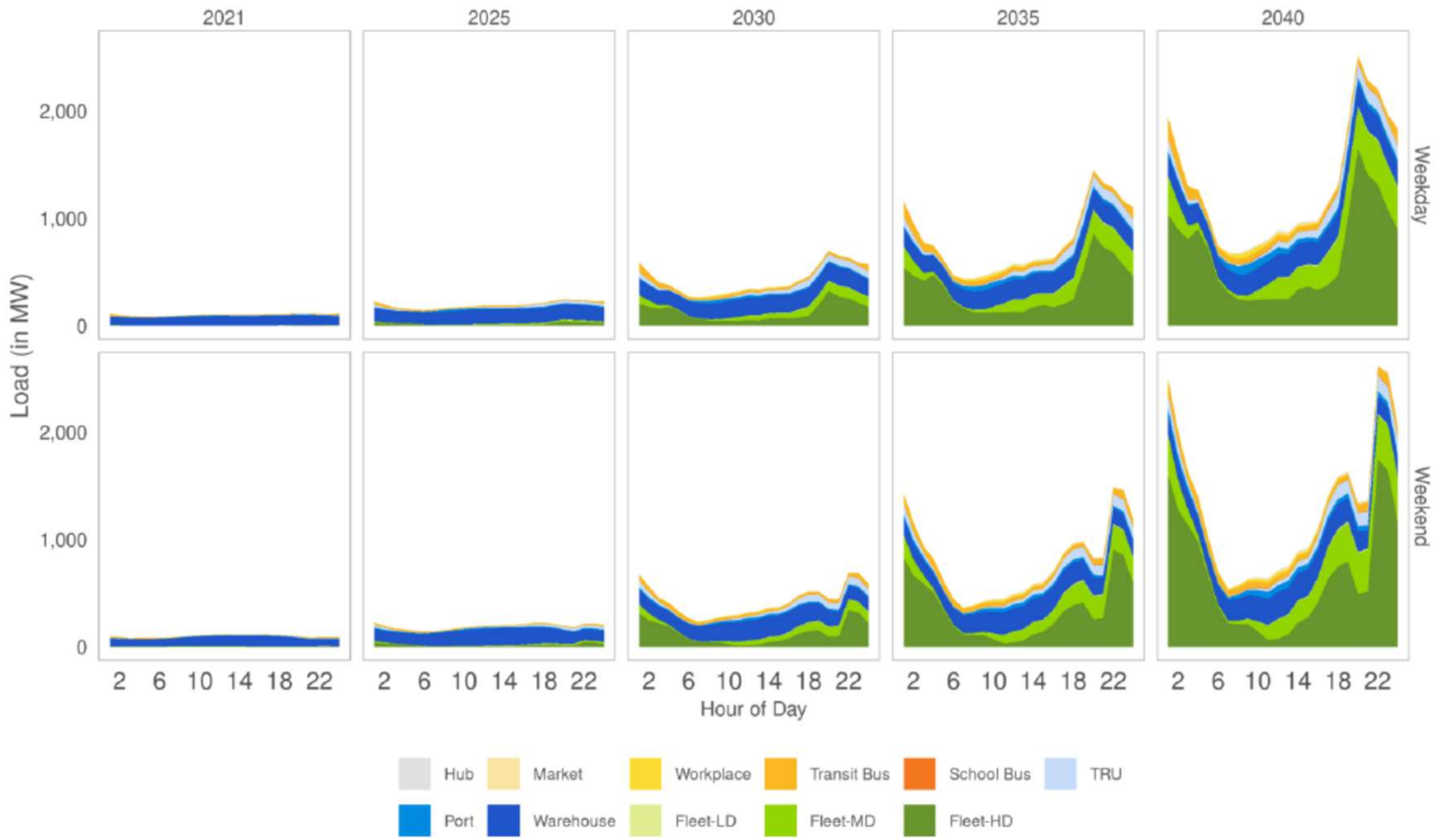
- Amazon delivery center (200 vans): ~4 MW

- Electric school bus depot (100 buses): ~4 MW

- Airport bus depot: 13 MW

- I-5 truckstop proposal: 23.5 MW

Load Shapes (forecast for California)



Source: Guidehouse 2021

Typical Distribution Upgrade Needs

Amount of new load (MW)	Upgrade typically needed	Example Timeframe
20	New substation	24-48 months or more
10	New transformer bank/substation upgrade	12-24 months or more
5	New circuit	6-26 months
2	Customer needs to take higher voltage service	3-6 months
1	Upsizing wire or cable to the site or reconductoring	6-14 months

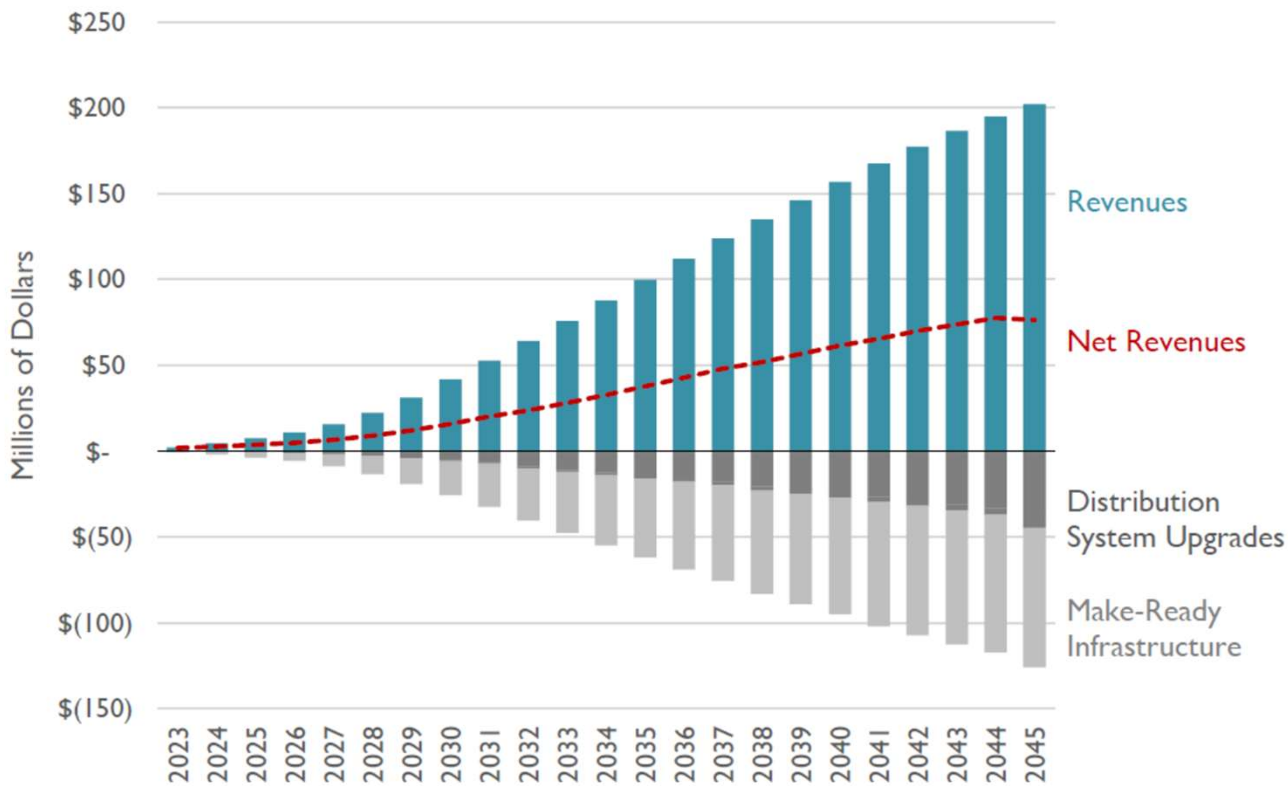
Source: ACEEE based on Black & Veatch and Borlaug et al.

Typical Upgrade Costs

Item	Typical Cost
New substation	$4–35 million
Substation upgrade	$3–5 million
Install/upgrade feeder circuit	$2–12 million
Install distribution transformer	$12,000–175,000

Source: Borlaug et al. 2021

Cost and Revenue for a Make-Ready Program (Con Ed, unmanaged charging)



Source: Synapse 2023

Notes: The program generates net positive revenue in all years. All values shown using a 3 percent discount rate.

Case Studies of Leaders

- Massachusetts: Grid Modernization Advisory Council
  - Eversource as planning example

- New York State
  - Clean school bus mandate covers new buses beginning 2027
  - NYPSC medium and heavy-duty vehicle docket

- California
  - SCE Charge Ready Transport program
  - CPUC docket on preparing the grid for widespread electrification

Lessons Learned

- Utilities should proactively reach out to and educate fleet owners
  - Inventory locations, vehicles, distances traveled, EV plans
- Establish TA and make-ready programs
- Regulators should encourage utilities to expand distribution planning to consider fleet needs.
- Move towards 10-20 year distribution plans
  - Revise them every 1-2 years
- Consider major trucking corridors together (due to interrelationships)
- Be transparent with planning, educating and seeking input from affected communities

Contact

Steven Nadel,
snadel@aceee.org

Timing is Everything

Managing EV Load to Reduce System Costs & Emissions

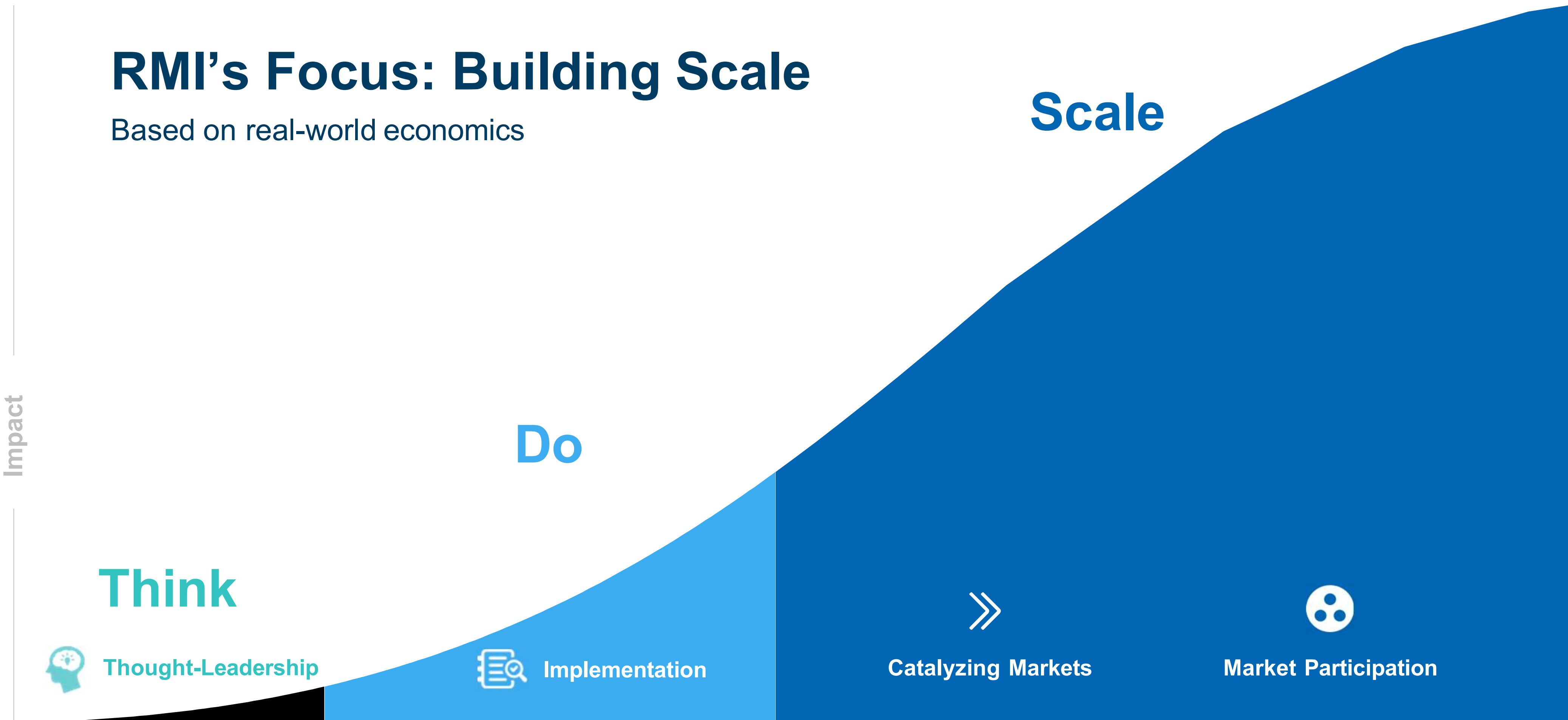
Ben Shapiro |RMI

NARUC Transportation Electrification Planning Workshop

November 15, 2023

RMI’s Focus: Building Scale

Based on real-world economics



Establish an alternative vision for the energy future

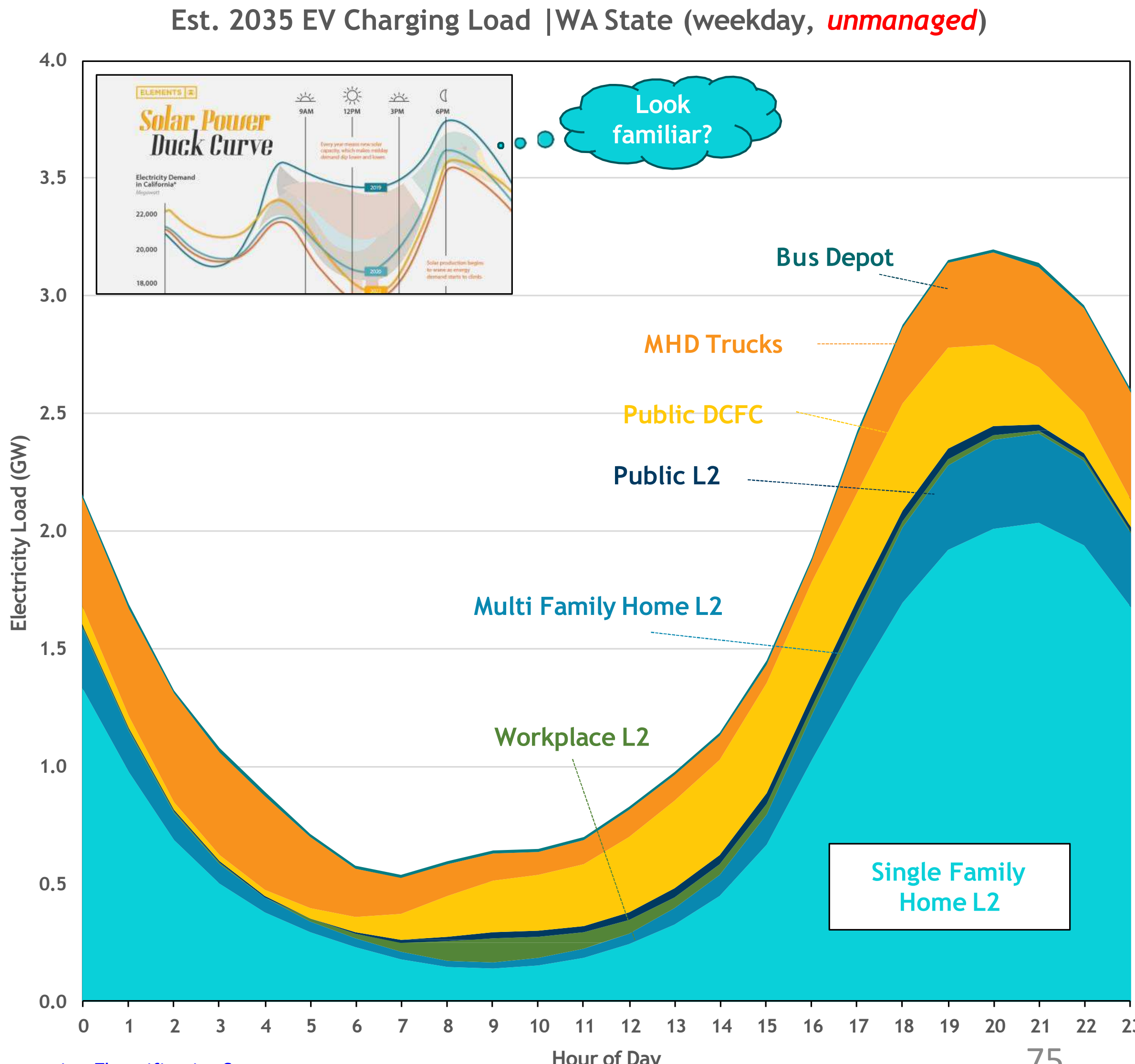
Validate critical proof-points for the clean energy transition

Remove existing market barriers, spur competitive innovation and accelerate adoption through market affiliates.

What’s the scale of the challenge (opportunity)?

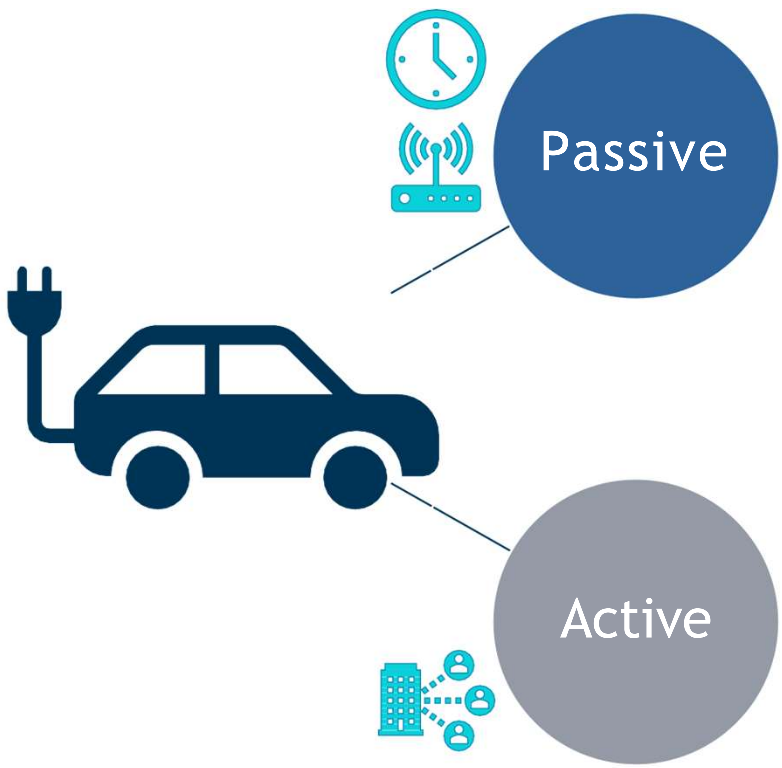
- **By 2035, RMI estimates EVs in Washington state will require 14-15 TWh annually**

- **Critical to manage load and avoid driving up peak (3+ GW)***



RMI analysis for [Washington Transportation Electrification Strategy]
*Northwest Power Pool (not WA state) current peak of ~55 GW (summer), 63 GW (winter), [FERC Electric Power Market Assessment]

Refresher: two broad flavors of managed charging



- Time-variant rates (e.g., TOU)
- Behavioral demand response

- Direct load control
- Using EV, EVSE (charger), smart panel / breaker

Adapted from Smart Electric Power Alliance

Brief case studies highlight different options

- Passive (behavioral)
- 2017-present
- Telematics-based
  - ev.energy (2023)

SmartCharge NY

conEdison

- Active (DLC*)
- 2022-present
- Telematics-based
  - WeaveGrid DISCO**

EV Smart Charge

SRP

Sources: ConEd SmartCharge New York | SRP EV Smart Charge
*DLV: Direct Load Control | **DISCO: Distribution Integrated Smart Charging Orchestration

Programs to date provide important lessons

No one-size-fits-all approach

Customers

- Customer ease is key
- Utilities are essential; partnerships w/ other stakeholders hold significant value
- Targeted messaging can be highly effective

Grid

- Significant potential value from load shifting (+ V2G)
- Grid value is not uniform across customers
- Secondary peaks can easily occur if not planned for

Food for Thought

- **We are creatures of habit.**
  - Establish desirable charging behavior ahead of mass market adoption
- **Opt-in vs. opt-out? (both can be effective)**
- **EVSE, telematics, both?**
- **How can we avoid a singular focus on single-family homes?**

Further reading, SEPA 2023: *Managed Charging Programs: Maximizing Customer Satisfaction and Grid Benefits*

RMI
ENERGY. TRANSFORMED.

Thank you!

Ben Shapiro
bshapiro@rmi.org

SMALL GROUPS

AT YOUR TABLE

Promising Practices to Incorporate into Transportation Electrification Planning

At your table:

Develop initial thoughts about promising approaches for Public Utility Commission transportation electrification planning and investment processes across states.

Each table will focus on one of four planning forums:

1. General Rate Case
2. Transportation Electrification Plans
3. Distribution System Plans (DSP)
4. Other planning process/forum

Promising Practices Discussion

Key Questions

- Based on today's presentations or personal experience, what promising approaches could be useful to overcome the particular challenges or sticking points noted in our scenario?
- What tools, data, or information could be leveraged in this forum?
- What policies or regulatory incentives are needed to improve transportation electrification planning?

Promising Practices Discussion

Report Out

From your table, what examples and ideas do you most want to share?

Next Steps

- NARUC will share PPT slides & flip chart photos
- Commissioners and Commission staff are invited to join NARUC's EV State Working Group
  - Monthly webinars + peer exchange discussions
  - Highlights of EV-related news & NARUC events

www.naruc.org/cpi-1/energy-customers/electric-vehicles/

Thank you for attending!

NARUC EV Getting Started Guide

NARUC 2023 TE Planning Workshop Appendix Slides

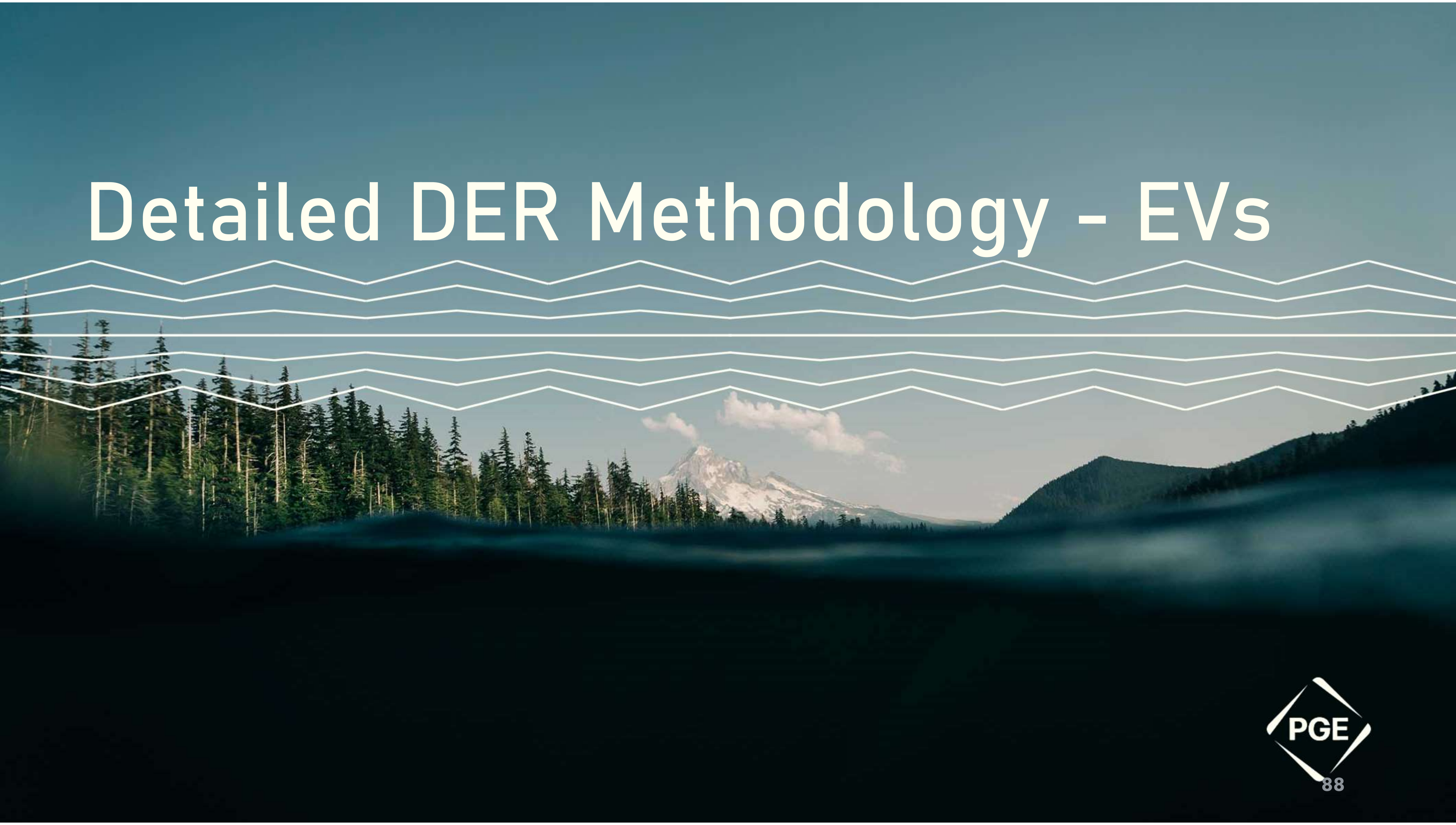
- Jason Salmi Klotz, Portland General Electric
- Ben Shapiro, RMI

The Following slides are shared as detail and further reference.

Jason Salmi Klotz , Senior Manager Distributed Resource Planning & Engagement

November 2023

Detailed DER Methodology - EVs



TE Forecast Methodology

LDV adoption based on Brattle econometric model

- Purchase Incentives
- EV Battery Price
- Relative Fuel Price
- Available Models
- ZEV State Mandate
- Vehicle Miles Traveled
- Green Views
- Charging Rate

Fleet LDV/MDV/HDV adoption based on Delphi panel model

Both scaled to DMV registration data and vehicle stock turnover model

For EV charging requirements, estimate plugs needed and vehicle charging loads using:

- LDV, workplace L2, and public L2 using NREL's EVI-Pro Lite model*
- Public DCFC usage patterns come from PGE Electric Avenue sites
- MDHDV shapes are based on combination of engineering calculations and third-party data

Vehicle Inputs and Eligibility Criteria

Start with DMV registrations for State of Oregon (3.7M), filtered to PGE service area (1.8M)

Match to address (~80% of records) and identify vehicles registered in PGE zip codes for remainder of unmatched (20%)

Run modified VIN through NHSTA VIN-decoder API to standardize inputs around drive-train (PHEV or BEV), battery size, & weight class

Table 4-12. Private EV Charging Eligibility

Measure	Eligibility Criteria	Measure Size
All Level 1	Residential or Non-Residential, has EVs not addressed by other onsite charging, has driveway or garage	Number of plugs
Residential Level 2 (smart and standard)	Residential, has EV, has spare 220V breaker, has driveway or garage	Number of plugs: minimum of number of EVs/2, number of available 220V breakers available
Nonresidential Level 2 (smart and standard)	Nonresidential, has EVs not served by DCQC	Rated capacity multiplied by number of plugs (number of EVs/2)
DCQC	Nonresidential, has MDV/HDV	Rated capacity multiplied by number of plugs (number of MHDVs/4)

Brattle LDV EV Regression Variables

Variable Name	Variable Type	Description
Dependent Variable: EV sales per capita	Continuous	Defined as the total incremental sales of EV (BEV or PHEV) per million residents
State incentives	Continuous	The maximum incentive (rebate, tax credit or tax exemption) offered by a state upon purchase of a BEV or PHEV, in $/vehicle
Federal Tax Credit (FTC)	Continuous	A tax credit offered by the federal government upon purchase of a BEV or PHEV, in $/vehicle
Total Incentive	Continuous	Sum of the state incentives and FTC
Battery price	Continuous	Lithium-ion battery cost index in $/kWh, as a proxy of electric vehicle cost (BNEF)
Vehicle miles travelled (VMT)	Continuous	Average vehicles miles travelled annually, per capita
Tesla Cap dummy	Binary	A dummy variable to indicate a period of spike in EV sales after Tesla hit the cap for the FTC – Q3'18 and Jan'19
Model availability	Continuous	Number of EV models available across a state by year
Green views score	Continuous (0-100)	Average environmental voting score of state House and Senate reps (League of Conservation Voters Annual Environmental Scorecard)
High Occupancy Vehicle (HOV) lane exemption	Binary	Indicates the presence of an HOV lane exemption for EVs
Traffic density	Continuous	Weighted average daily traffic per lane for all principal arterials
Zero Emission Vehicle (ZEV) mandate	Binary	Indicates the presence of a ZEV mandate enacted by the government
EV charging rate	Binary	Indicates whether or not at least one utility offers an EV rate for charging in a given state

EV Forecast Methodology - MDHDV

LDV market has significant historical data to develop mathematical models

Nascent MDHDV market does not have comparable data

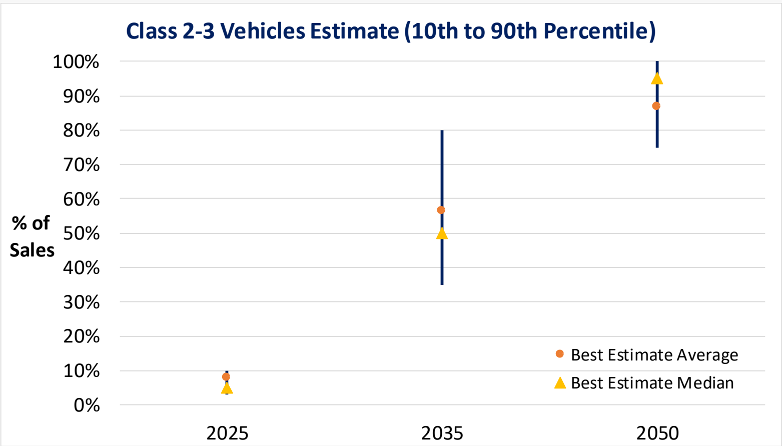
Brattle employed a Delphi Method, which is well established forecasting method the relies on panel of experts over two rounds

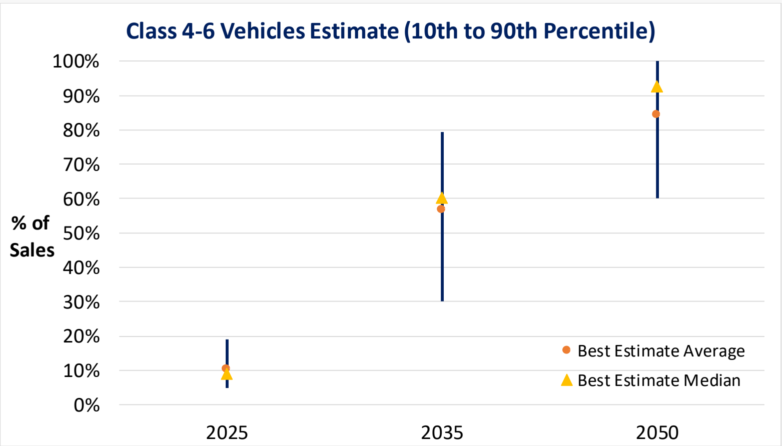
Used range of market size estimates at near/mid/long term to calibrate s-curves for adoption

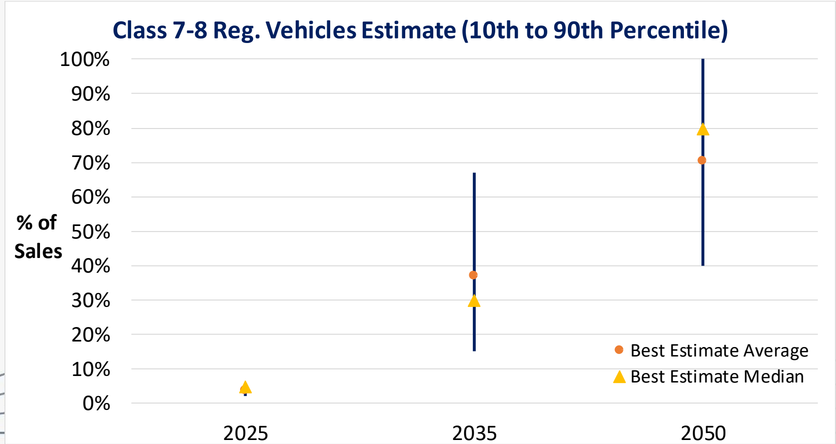
Participating Experts and Affiliations

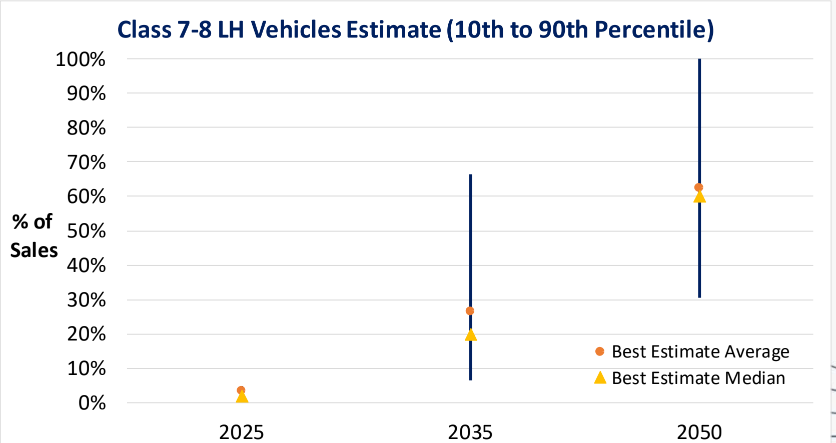
Research/Non-Profit
Atlas Public Policy
CTE
CTE
Electrification Coalition
NREL
Rocky Mountain Institute
Union of Concerned Scientists
Government
DOT
Utility
Duke Energy
Seattle City Light
Industry
ACT Research
American Trucking Associations
NA Council for Freight Efficiency
VEIC
VEIC

MDHDV market shares with uncertainty

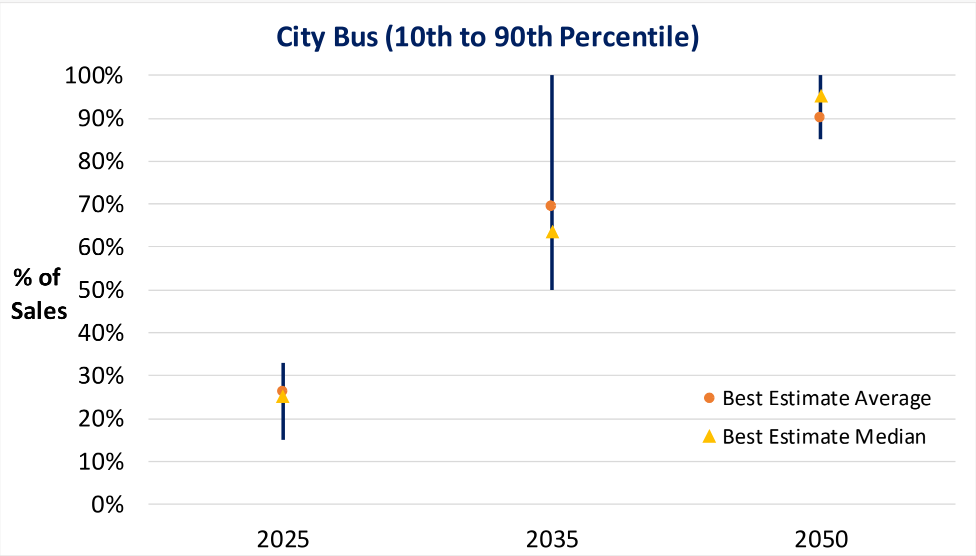


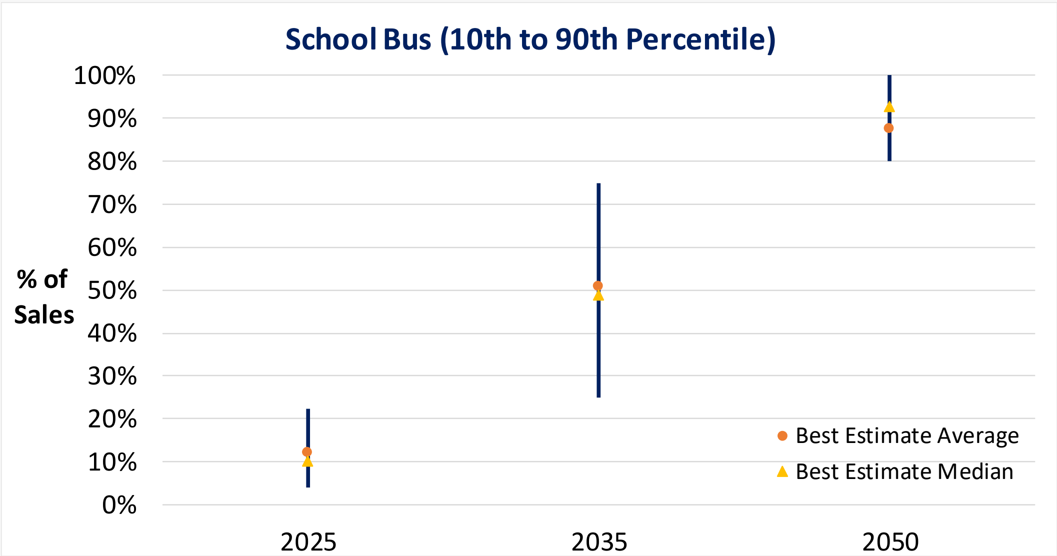






MDHDV market shares with uncertainty





EV Adoption Sensitivities

Brattle's econometric model for LDV adoption uses data from 50 states, from 2011 through 2018 to explain drivers of US EV sales

Starts with the simplest model with one explanatory variable, e.g., total state incentives, and gradually added other variables while paying attention to multi-collinearity issues

The objective was to come up with a robust model, i.e., the addition or removal of a variable or subsets of data (i.e., certain states) does not have a significant impact on coefficient estimates

Final specification is decided based on the in-sample and out-of-sample tests

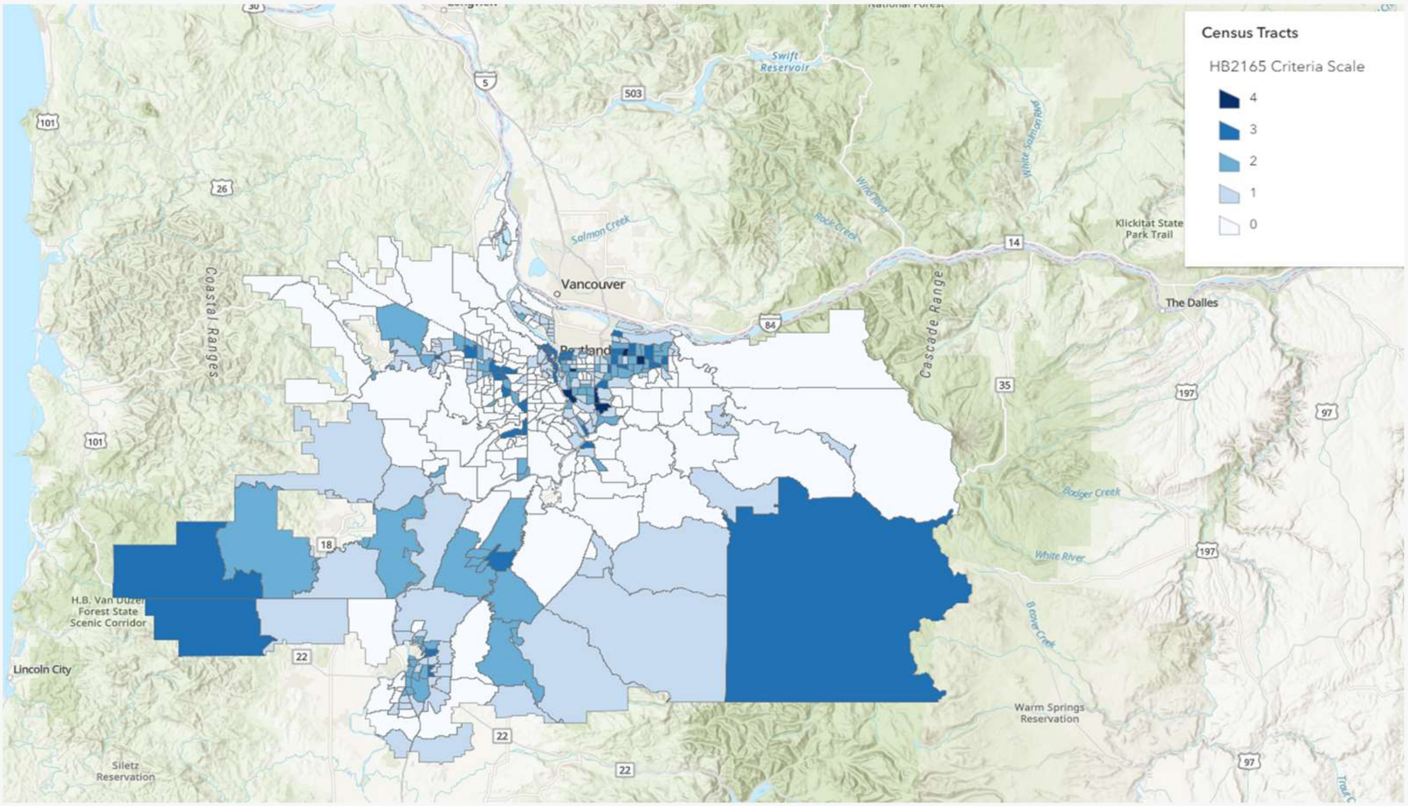
Model is most sensitive to:

- Vehicle model availability
- State/local incentives
- Chargers in range (i.e., battery capacity and charging infrastructure)
- Vehicle price decline (as proxied through battery pack costs)

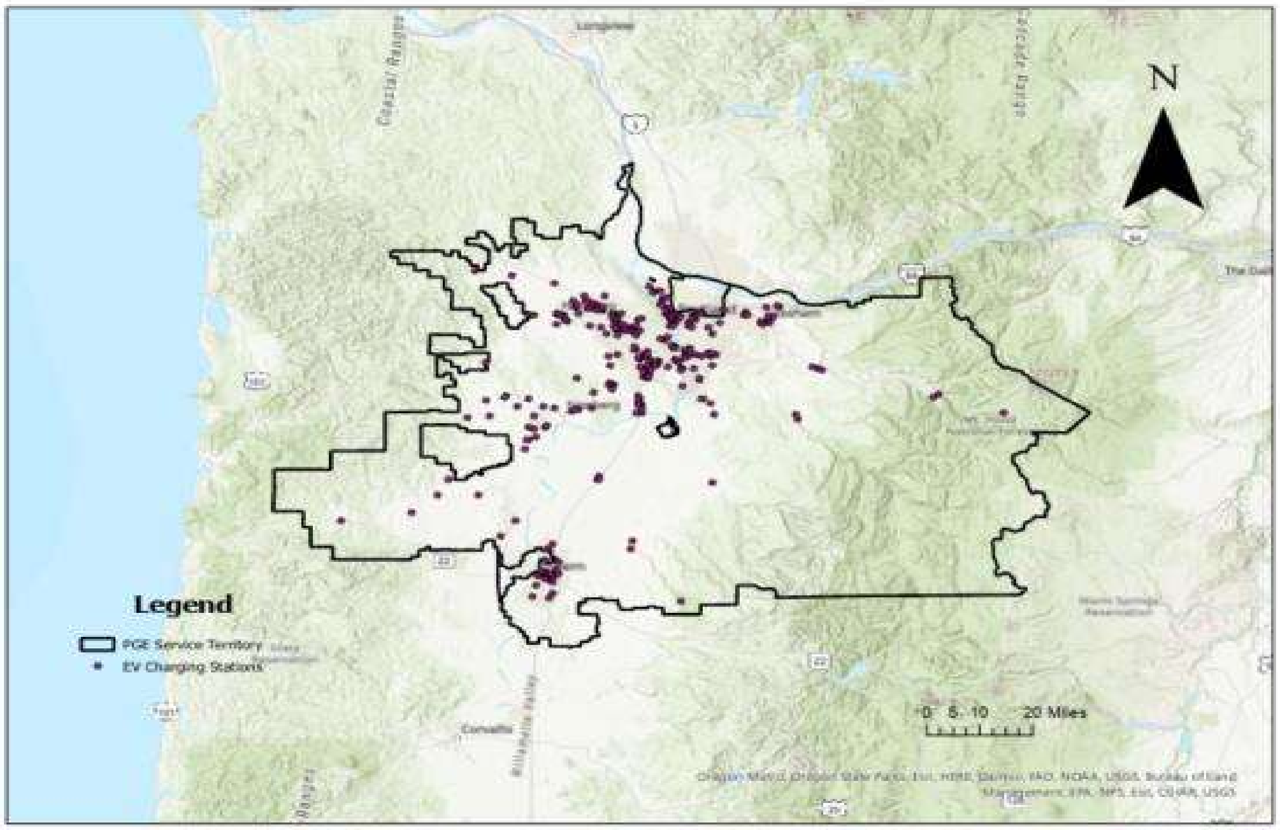
HB2165 Underserved Communities Criteria

1) Residents of rental or multifamily housing
2) Communities experiencing lower incomes
3) Tribal communities
4) Rural communities
5) Frontier communities
6) Coastal communities
7) Adversely harmed by environmental or health hazards

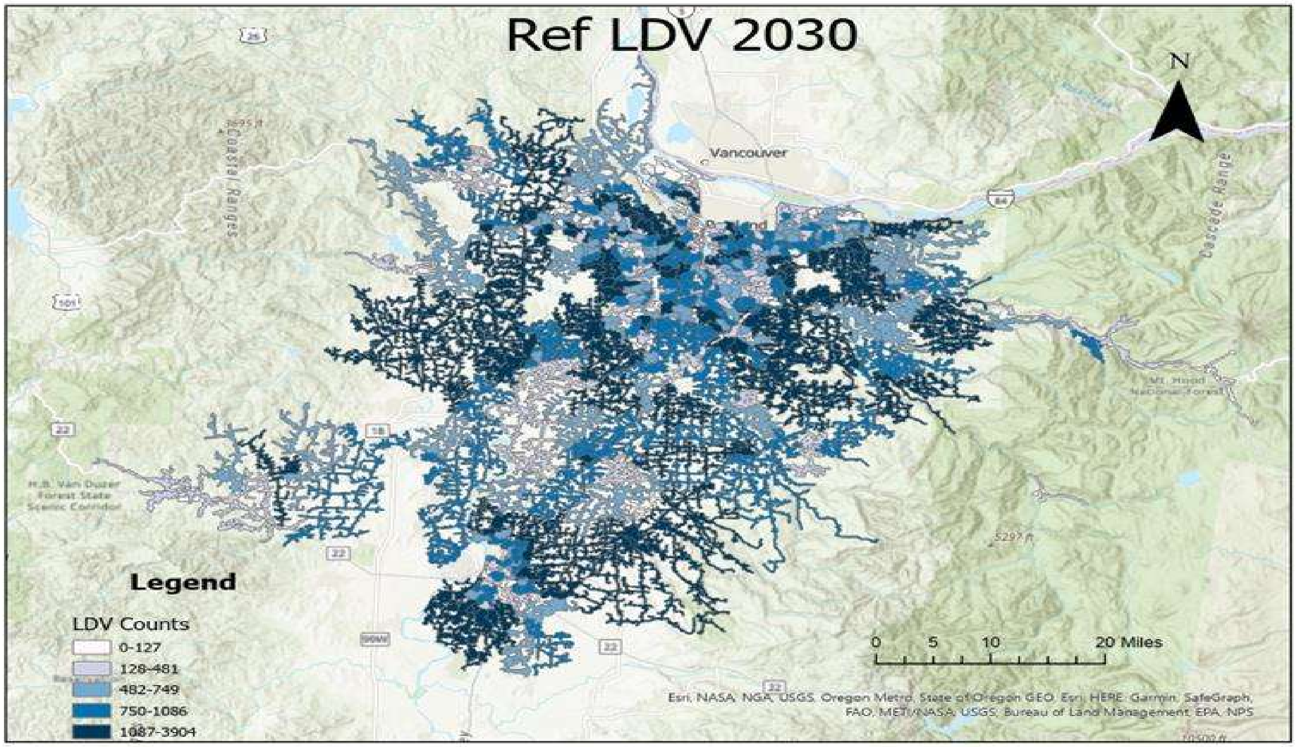
PGE Underserved Communities under HB2165 Criteria



EV Charging Stations in PGE Territory BY April 2023

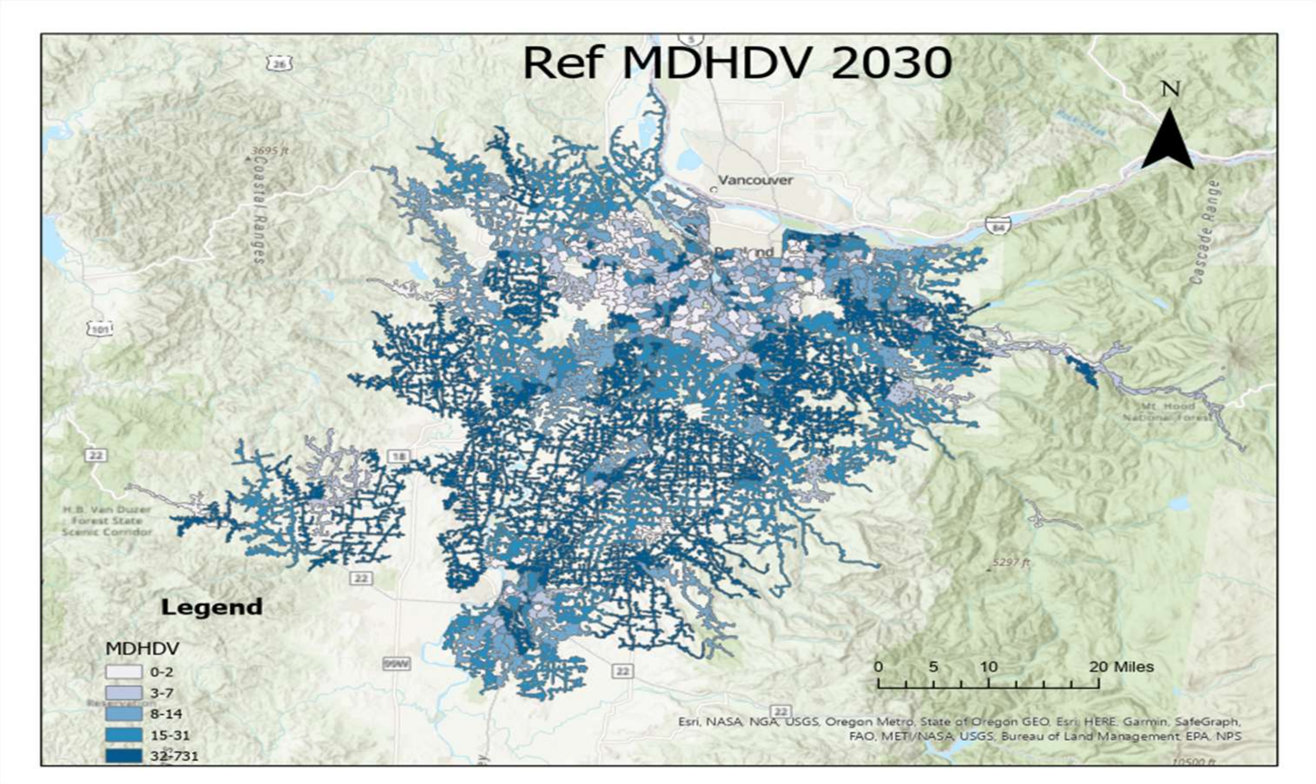


Reference Case LDV Adoption at Feeder Level in 2030



Source: [PGE analysis, DSP Part II, Ch 3]

Reference Case MDHDV Adoption at Feeder Level in 2030



Source: [PGE analysis, DSP Part II, Ch 3]

Planning for Heavy Duty Charging

PGE partners with fleet customers providing fleet electrification analysis at no cost and gaining insights into fleet customers' plans

***Early* engagement with the utility** is critical, especially for heavy duty charging sites

Challenges to rapid deployment:

- Some fleet sites will require significant electrical upgrades on site and on the distribution system
- Supply chain delays for vehicles, chargers, electrical infrastructure

State and federal funding can help build public heavy-duty charging; West Coast Clean Transit Corridor Initiative provides a framework

PGE Fleet Partner:
A turnkey solution for fleet electrification

- Free planning and technical services for fleet customers
- Installation of make-ready infrastructure with custom cost incentives
- Rebates for qualified Level 2 chargers
- Fleet Partner Phase 1 reserved all funding, hoping to expand January 2024

Reduces cost and complexity associated with transitioning to electric fuel

Commercial

Municipal

School

Non-profit

Transit fleets

How to charge your fleet

Slow, overnight charging is the most cost-effective way to charge an EV:

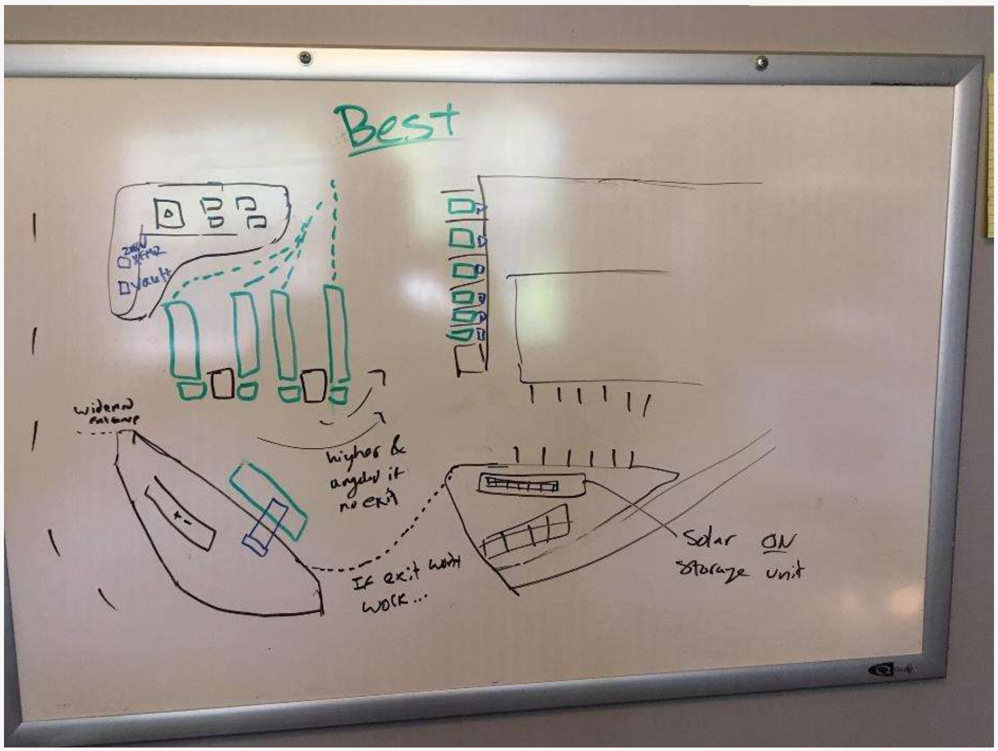
- A lower charge rate means less expensive equipment and infrastructure.
- Customers benefit from lower demand and off-peak electricity pricing.
- By using charge management software, customers can optimize charging and further reduce costs.

Electric Island

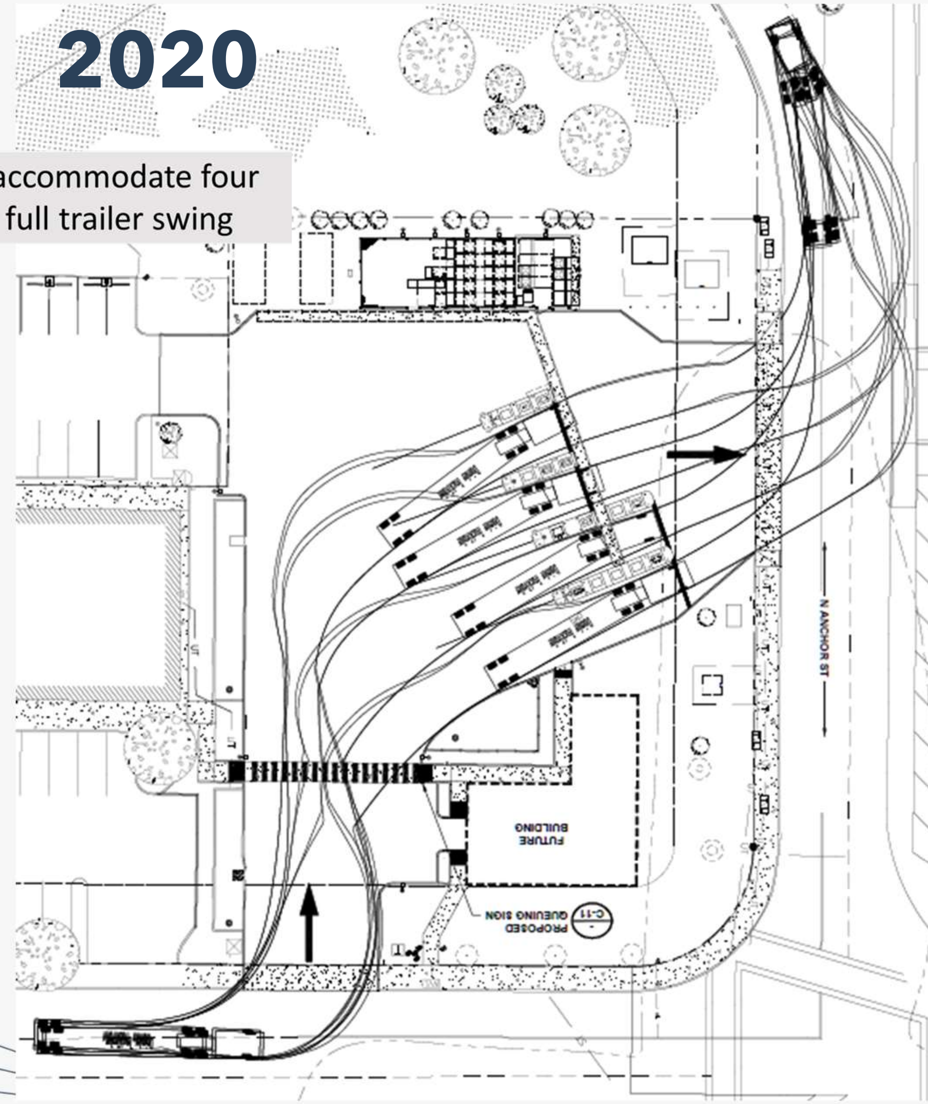
Site Design

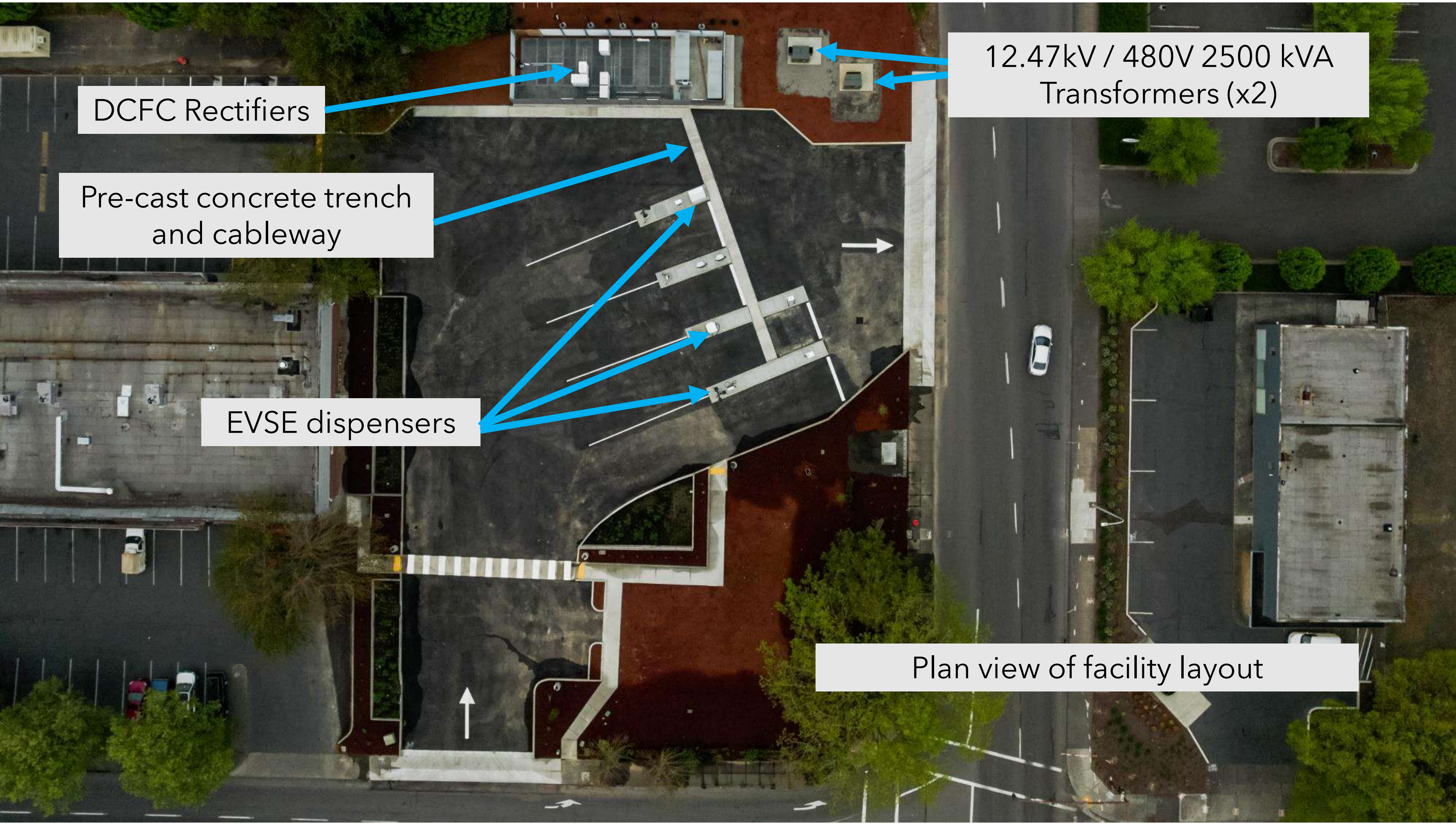
2020

Facility designed to accommodate four Class 8 trucks with full trailer swing



2019




12.47kV / 480V 2500 kVA
Transformers (x2)
DCFC Rectifiers
Pre-cast concrete trench
and cableway
EVSE dispensers
Plan view of facility layout


Located adjacent to Daimler Trucks North America HQ, as well
as several other industrial fleet customers in Portland, OR
PGE

Tons of conduit!
(for long-term electrical capacity)

Pre-cast concrete trenches during construction

Steel mounting plates for EV dispensers allow for easier install/removal as chargers are replaced

Finished site – note the extra bollards to prevent any accidents during truck maneuvering

Detailed DER Methodology – Solar + Storage

Solar PV Forecast Methodology

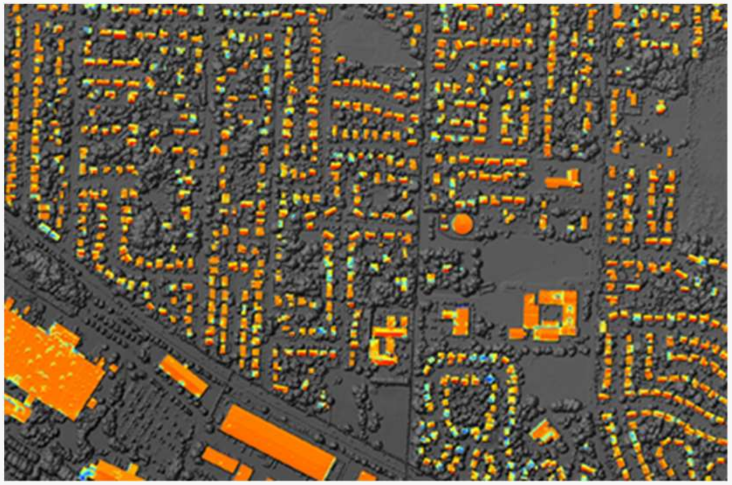
- Used NREL's dGen model to forecast solar adoption rates as a function of Oregon-specific electricity and cost inputs
- Included adjustments for solar and storage capital costs under different scenarios
- These market shares were then calibrated against technical potential modeled using site-level data, PVWatts, Google Project Sunroof

Solar PV Eligibility Criteria

We leverage multiple sources to inform our estimate for non-programmatic solar and storage adoption. The technical potential for solar is informed by eligibility criteria below.

Table 4-11. DER Measure Eligibility – Solar and Storage

Measure	Eligibility Criteria	Measure Size
Solar PV	Residential or Non-Residential, Roof ≤ 10 years old, owns property, solar potential from Project Sunroof > 0, has available breaker	Project Sunroof kW, scaled such that annual generation = annual consumption
Behind-the-Meter (BTM) Energy Storage	Residential SF or MH homeowner, or Non-Residential. Residential must have available breaker.	Residential & non-res with peak load < 50kW: 5 kW Non-res, with peak load ≥ 50kW: 50 kW



Solar radiation potential for residential customers (illustrative only)

Solar + Storage dGen Model Inputs

NREL open sourced the dGen model in 2020

Read an overview of the model setup process here: Open Source dGen: Beta Release (nrel.gov)

User inputs are selected on the model inputs sheet shown on image to the right

Cost and other assumptions from NREL's Annual Technology Baseline (ATB) report series

dGen Model Input

Scenario Options	Value	User Defined File
Scenario Name	or_res_ref	
Technology	Solar + Storage	
Agent File	Use pre-generated Agents	agent_df_base_res_or_revised
Region to Analyze	Oregon	
Markets	Only Residential	
Analysis End Year	2040	
Load Growth Scenario	AEO2019 Reference	
Retail Electricity Price Escalation Scenario	User Defined	ATB19_Mid_Case_retail
Wholesale Electricity Price Scenario	User Defined	ATB19_Mid_Case_wholesale
PV Price Scenario	User Defined	pv_price_atb19_mid
PV Technical Performance Scenario	User Defined	pv_tech_performance_defaultFY19
Storage Cost Scenario	User Defined	batt_prices_FY20_mid
Storage Technical Performance Scenario	User Defined	batt_tech_performance_SunLamp17
PV + Storage Cost Scenario	User Defined	pv_plus_batt_prices_FY20_mid
Financing Scenario	User Defined	financing_atb_FY19
Depreciation Scenario	User Defined	deprec_sch_FY19
Value of Resiliency Scenario	User Defined	vor_FY20_mid
Carbon Intensity Scenario	User Defined	carbon_intensities_FY19
Random Generator Seed	1	

Save Scenario

Solar + Storage Cost Inputs

Evaluated adoption trends under three scenarios impacting DER costs (low/reference/high)

Cost and performance inputs from NREL's dGen open-source inputs, as follows

Low

- **Solar**: pv_price_atb19_high
- **Storage**: batt_prices_FY20_mid

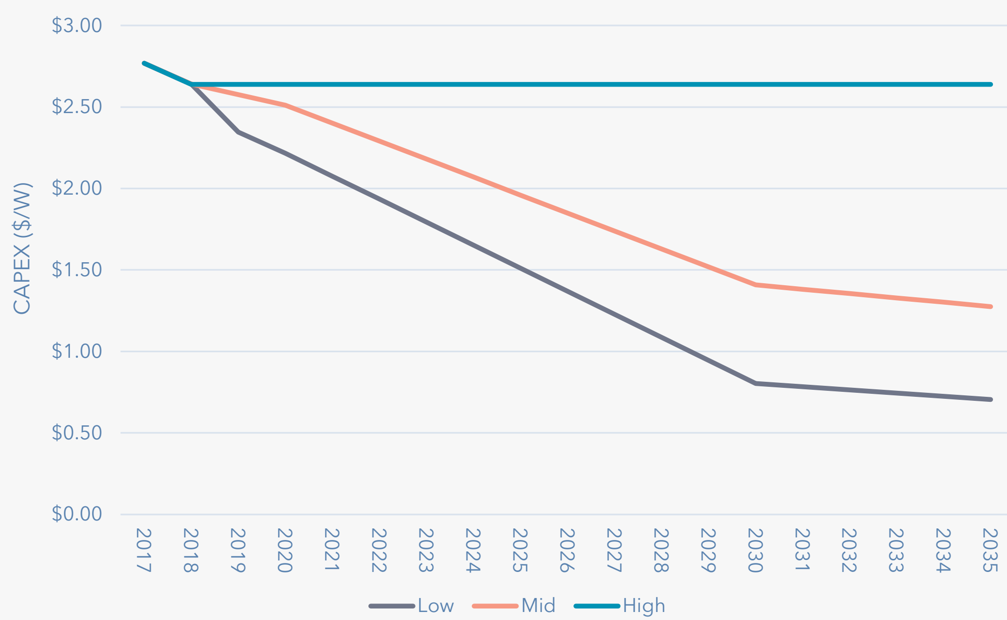
Reference

- **Solar**: pv_price_atb_mid
- **Storage**: batt_prices_FY20_mid

High

- **Solar**: pv_price_atb_low
- **Storage**: batt_prices_FY20_low

Annual Technology Baseline FY19 – CAPEX ($/W) Solar PV



Source: https://atb.nrel.gov/electricity/2021/index

Forecasting Methods Update – Solar PV

During the January DSP Partner meeting, we discussed solar adoption using dGen

Based on feedback, we are reviewing possible changes to better reflect:

- Low- and moderate-income (LMI) solar adoption for both multifamily buildings and renter-occupied buildings
- State tax credits for storage available to low-income customers
- Other data and insights from Energy Trust and stakeholders

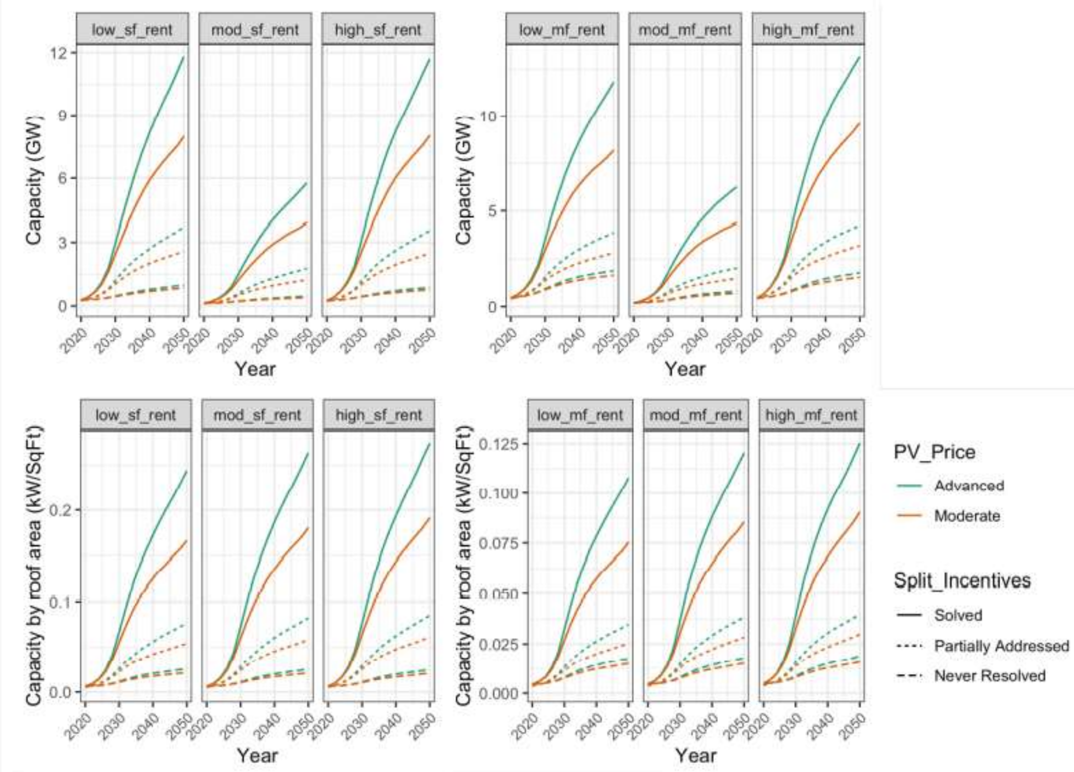


Figure 4. Solar adoption in renter-occupied buildings

Source: Heeter et al. (2021) Affordable and Accessible Solar for All: Barriers, Solutions, and On-Site Adoption Potential. NREL Technical Report available at: https://www.nrel.gov/docs/fy21osti/80532.pdf

Oregon Solar + Storage Rebate Program

Launched Jan 2020 and fully reserved by Sep 2020

HB 2618 allocated additional $10M for solar + storage rebates in 2021 for 2021-2023 biennium

Variety of eligibility screening methods (SNAP, LIHEAP, etc.) or income verification at 100% of state median income

Report found barriers to low-income service providers accessing rebate due to conflict with Federal ITC

87 out of 369 projects were for LMI residents or low-income service providers

System Component	Customer eligibility type	Incentive	Incentive unit	Incentive cost cap
Solar	Res Low-moderate Income (LMI)	$1.80	per watt (DC) of installed capacity	$5,000 or 60% of project cost
	Low-income service providers	$0.75	per watt (DC) of installed capacity	$30,000 or 50% of project cost
	Non-LMI not eligible for utility incentives	$0.50	per watt (DC) of installed capacity	$5,000 or 40% of project cost
	Non-LMI eligible for utility incentives	$0.20	per watt (DC) of installed capacity	$5,000 or 40% of project cost
Storage	Low-income service providers	$300	kWh of installed capacity	$15,000 or 60% of project cost
	LMI customers	$300	kWh of installed capacity	$2,500 or 60% of project cost
	Non-LMI residential customers	$300	kWh of installed capacity	$2,500 or 40% of project cost

Source: Oregon Solar + Storage Rebate Program, 2021 Program Report. Available at:
https://www.oregon.gov/energy/Data-and-Reports/Documents/2021-Solar-Storage-Rebate-Program-Legislative-Report.pdf

Detailed DER Methodology – Flex Load + Building Electrification

Flex Load Adoption Methodology

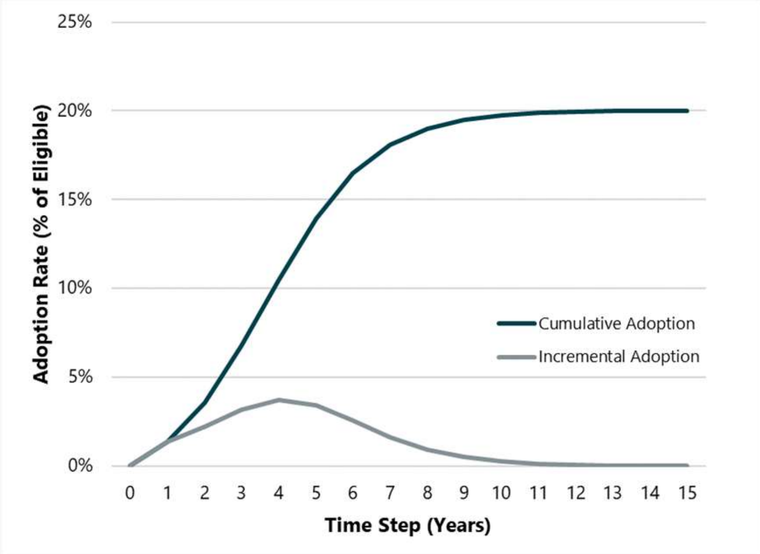
Developed Bass diffusion curves to estimate adoption of each measure

Many products still early in pilot stage and do not necessarily represent long-term designs/costs

Cadeo team estimated the M and T parameters for each program by:

- Estimate empirical M and T parameters from PGE program participation data.
- Conduct literature review to find M and T parameters from similar programs.
- Average empirical and literature review to determine final M and T parameters

Figure 4-5. Example of Bass Diffusion Curve (M=20%, T-10)



$$Cumulative\ Probabilty(t) \approx M * \frac{1 - Exp\left(-14 * \frac{0.5}{T} * t\right)}{1 + 13 * Exp\left(-14 * \frac{0.5}{T} * t\right)}$$

Flex Load Economic Screening

Cost-effectiveness screening applied after initial pilot phase (5-years after inception)

Only assesses the DR portion of measures that have shared EE and DR benefits

Table 4-18. Key Cost Effectiveness Assumptions

Variable	Value	Units	Source
Avoided cost of generation capacity	109.74	$/kW-yr	2021 IRP Update
Avoided cost of transmission capacity	9.57	$/kW-yr	2020 Flexible Load Plan
Avoided cost of distribution capacity[1]	24.39	$/kW-yr	2020 Flexible Load Plan
Incremental avoided cost of flexible capacity	25.4	$/kW-yr	Using a 2.7-hour battery value (via res storage, interpolated from 2019 IRP)
Distribution losses	4.74%		PGE staff
Distribution marginal-to-average line loss ratio	70%		PGE staff
BPA line factor	1.90%		PGE staff
Reserve margin requirement	15%		PGE staff
Real discount rate	4%		PGE staff
Inflation rate	2%		PGE staff
Pilot life	5	Years	Analytical assumption
Program life	10	Years	Analytical assumption

1. We include distribution avoided costs only in the high DER adoption scenarios.

Building Electrification Forecast Methodology

- Modeled turnover of HVAC, WH, and cooking equipment for all sites
- Developed adoption curves for fuel switching based on LBNL Electrification Futures Study results for Oregon
  - Factors in trends in codes & standards, policy changes, carbon pricing, etc.
- Assumed no new code changes or any programmatic intervention
- Used Energy Trust assumptions as baseline probabilities for different equipment types
- Applied fuel switching probabilities incrementally
- For March 2022 update – will explore integrating IECC contemplated electrification proposals which have gained momentum as another scenario

Locational adoption methodology

This study informs DER adoption for PGE DSP

Cadeo developed AdopDER model in 2020-2021 to simulate the load impacts from the co-adoption of 40+ distributed energy resources in PGE service area between 2021 and 2050

Examples

Two project phases

Phase 1

- **Service territory** technical, economic, achievable potential study for PGE IRP
- Measure feasibility varies by customer
- Adoption probability varies by DER and time, but not by premise

Phase 2

- **Locational** technical, economic, achievable potential
- Measure feasibility varies by customer
- Adoption probability varies by DER, time, and premise

We are here

EV Charging Requirements Methodology

Main input assumptions for charging infrastructure and load from EVI-Pro Lite (see figure to right):

Input PGE-specific forecast by drivetrain and range

- PHEV 20/50 mi
- BEV 100/250 mi

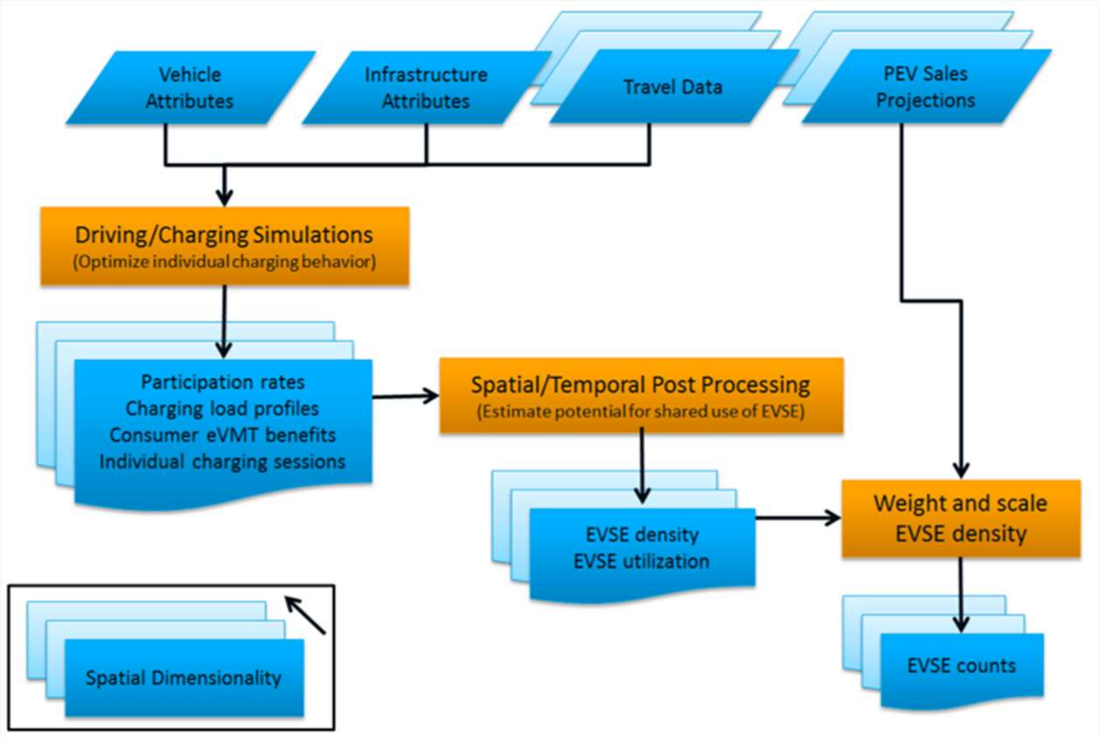
Share of Sedan/SUV in vehicle fleet

VMT determined by national and state travel surveys, weighted by population density

Ambient temperature (affects losses)

Home charging access and charging preferences

Figure 1. EVI-Pro Lite Load Profile Development Data Flow



Source: https://afdc.energy.gov/evi-pro-lite/load-profile/assumptions

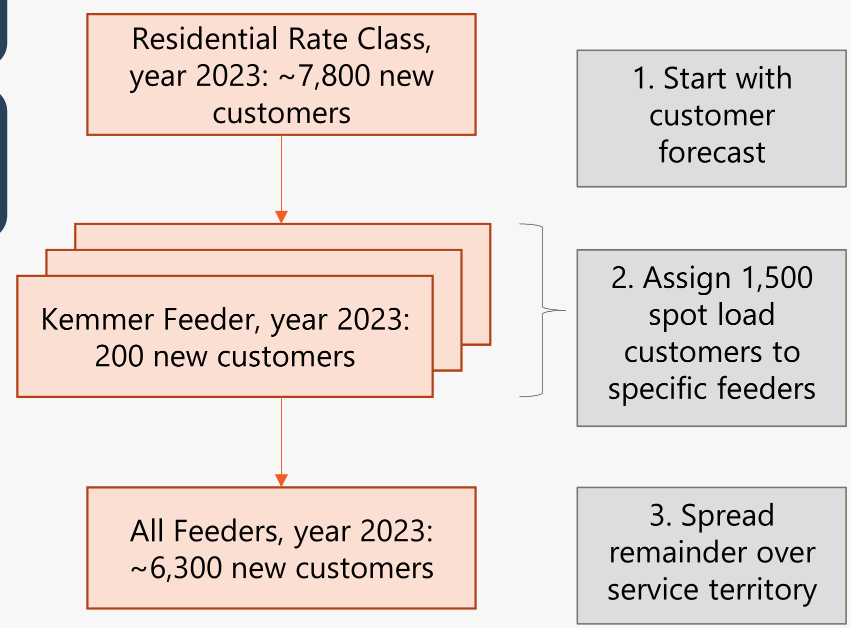
Incorporating locational load growth

We use a structured process to build up locational load growth assumptions that match the Corporate load forecast

We account for known customer load additions, key drivers (e.g., zoning), and macroeconomic trends

- Leverage the Key Account large customer additions list
- Incorporate any known zoning changes & permitting activity at the locational level
- For remainder of load growth, assign proportionally by revenue class and SIC code
- Allows AdopDER to captures feeder-level spatial variability in revenue-class level new customer additions (residential, commercial, industrial)

Illustration of Spot Load Allocation



Adoption propensity methodology

Premise-specific measure adoption probability with statistical and heuristic models

Statistical models where sufficient data exists, heuristic elsewhere

Statistical Model

- EV LDV (Res, non-Res Fleet)
- Solar PV (Res, non-Res)

Heuristic Model

- EV Charging
- BTM Storage (Res, non-Res)
- Microgrid

We use a structured framework for statistical modeling

For all DER types modeled with statistical modeling approach, we follow the below steps to:

- select variables
- test the strength of the model, and
- apply to the full population

Acquire Data
- Identify candidate variables

Combine
- Join all candidate variables into single dataset

Sample
- Train model on 70% of premises
- Validate model on 30% of premises

Train
- Variable Selection
- Model specification

Validate
- Test rank order with validation KS

Deploy
- Add scorecard to AdopDER
- Dynamic scoring in AdopDER

Model selection and validation uses an empirical process

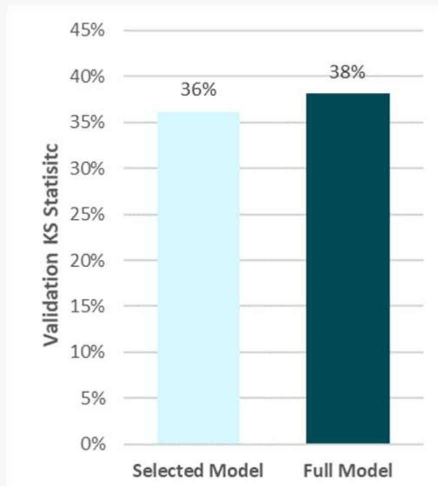
- Example of **statistical** model selection and validation for residential solar
- Similar process for other models

Univariate Screening and Model Selection: Res Solar

Variable	Information Value
building_type	0.788
ct_med_hh_inc	0.637
ct_num_solar_adopt	0.554
ct_tot_pop	0.492
HomeOwnerRenterPremPlusAX	0.438
ct_num_bev_adopt	0.365
xEstimatedIncomePremPlus	0.327
ch_num_vehicles	0.302
AgeCustName	0.256
AX_Score_GreenAffinity	0.242
consump_last_12_mos	0.240
ct_pv_kw_median	0.231
vintage	0.176
AX_Score_TechPropensity	0.084
has_battery	0.058
ct_avg_energy_burden_pct	0.040
ct_urban_rural	0.014
psps_zone	0.011

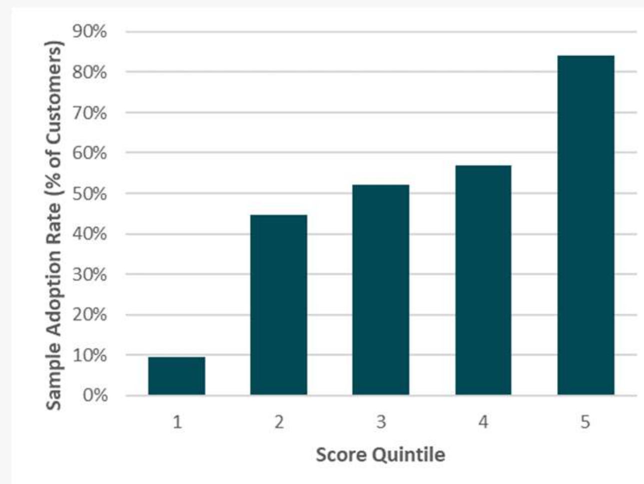
Selected Variable
Fails Univariate Screen

K-S Fit Statistics: Res Solar



- Selected model = model with blue-shaded variables in univariate screening table.
- Full model = model with all variables that pass univariate screen

Validation Sample Adoption Rate by Score Quintile: Res Solar



We're looking for rank ordering here.

We use statistical "scorecards" to rank-order adoption probability

Scorecard is a transformation of logistic regression coefficients

More points = Higher adoption probability

Model scoring is simple, fast – important when done at AdopDER scale

Model Scorecard: Residential Solar

Variable	Bin	Score Points
basepoints		493
building_type	MF	-325
	MH%,%SF	31
ct_med_hh_inc	missing	-17
	[-Inf,40000)	-26
	[40000,50000)	-13
	[50000,65000)	-2
	[65000, Inf)	7
ct_num_solar_adopt	missing	-80
	[-Inf,10)	-169
	[10,20)	-64
	[20,25)	-25
	[25,75)	22
	[75, Inf)	95
HomeOwnerRenterPremPlusAX	missing	-97
	O	34
	R	-112

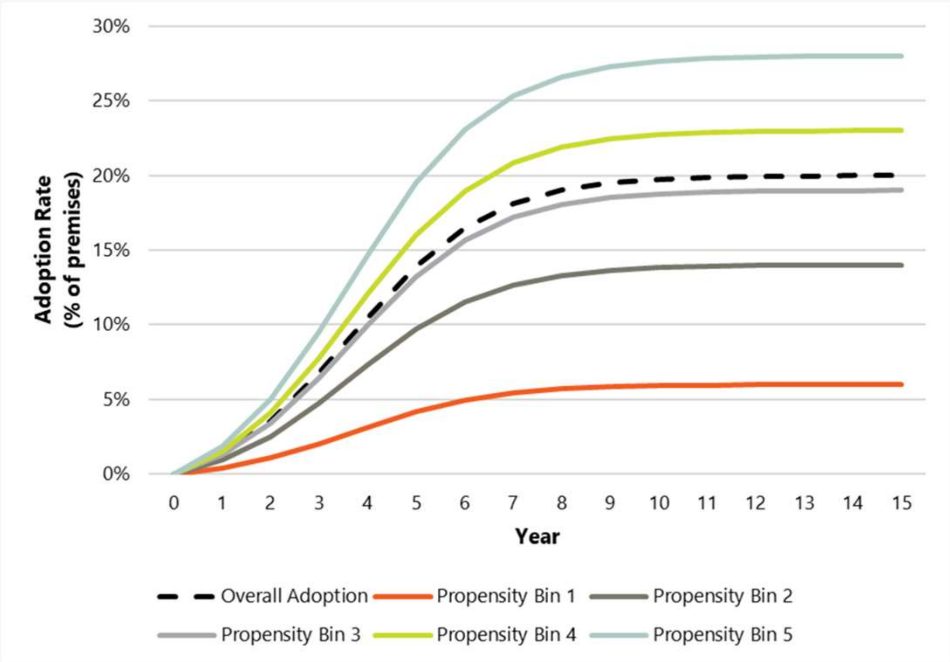
AdopDER uses scorecards to adjust adoption probability

Add variables (statistical and heuristic) to AdopDER customer input files

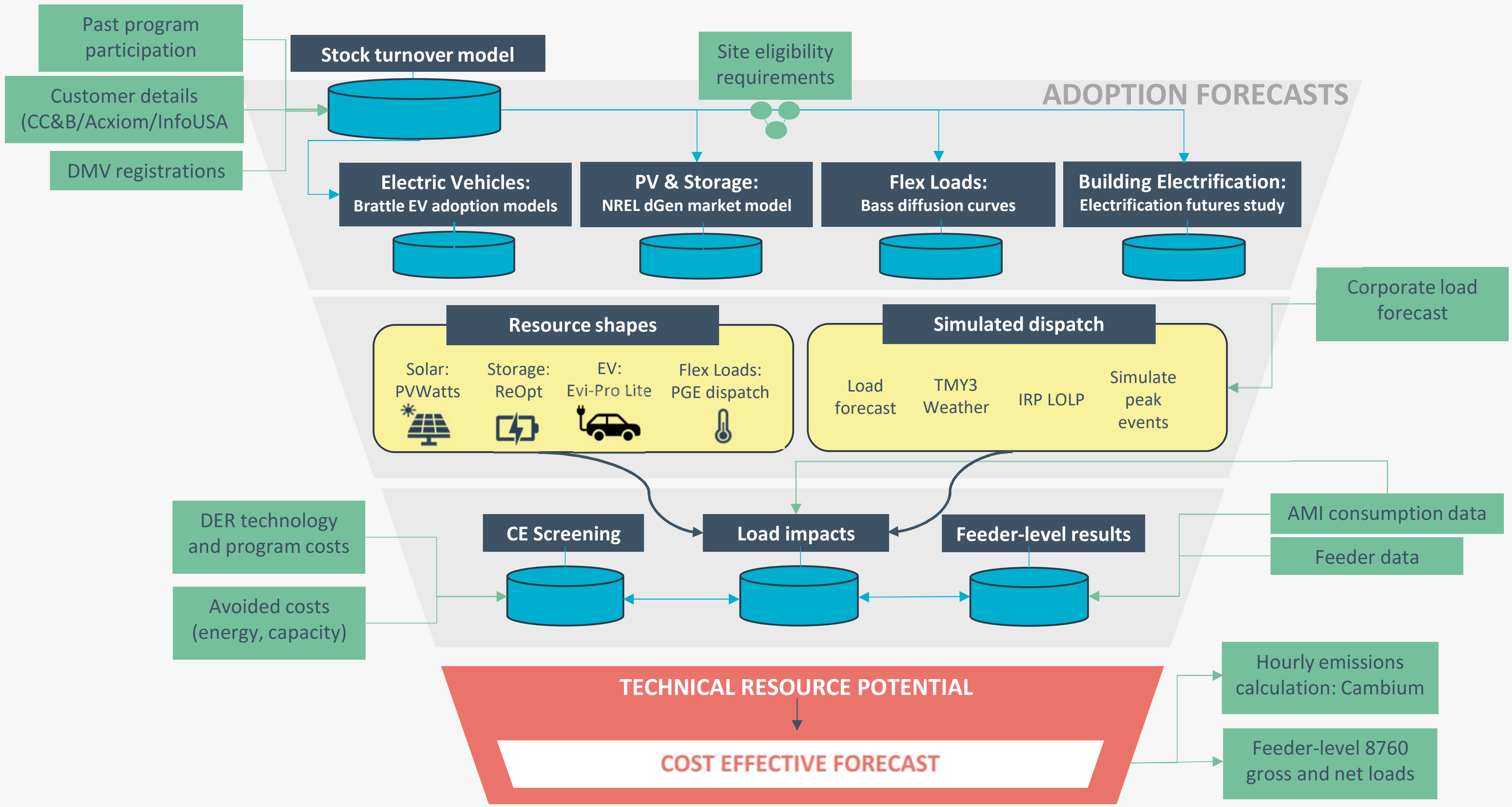
For each year, premise, and measure, we use a function to

- Calculate score from scorecard
- Assign each score to a quantile-based bin
- Adjust adoption probability

Illustration: Scorecard-based Adjustment to Adoption Rate

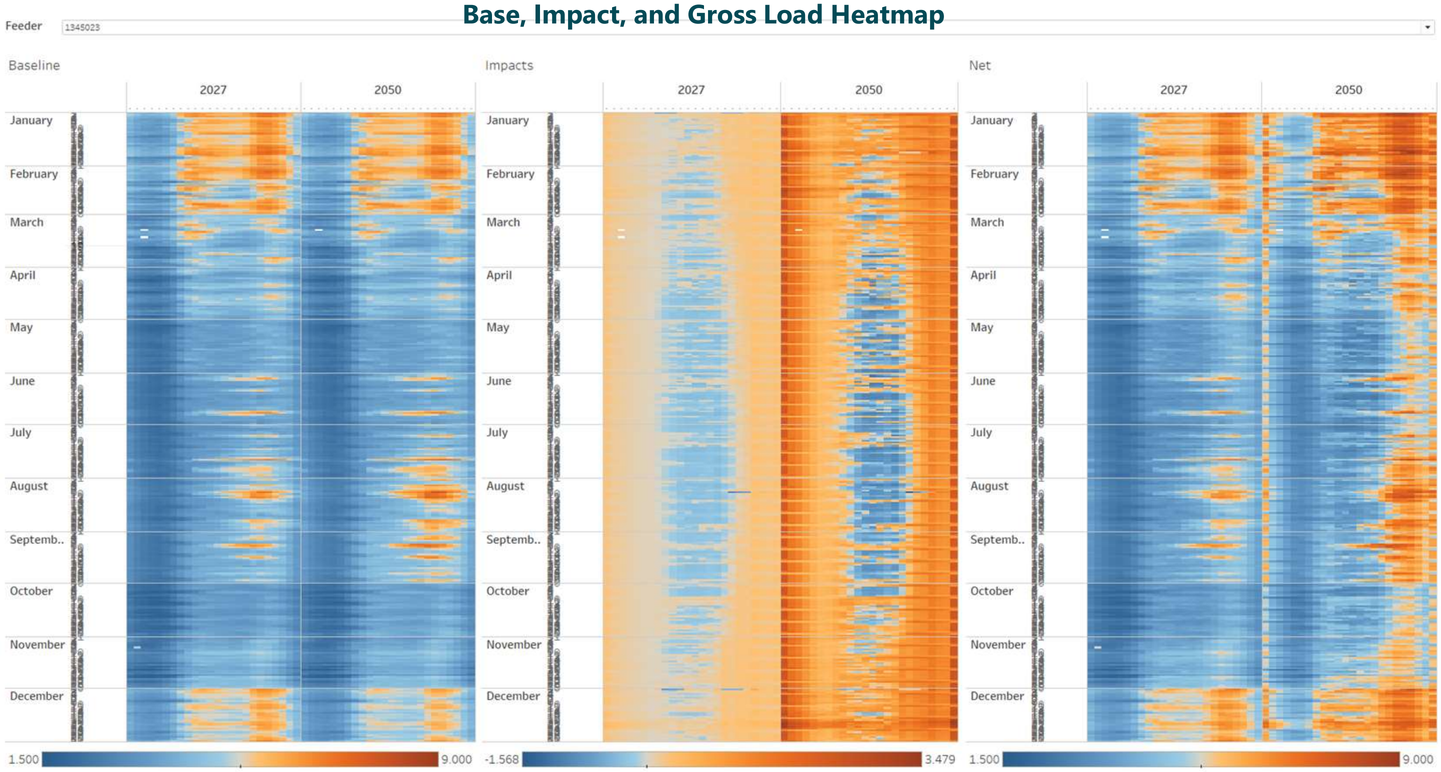


AdopDER Flow Diagram



AdopDER produces rich, hourly load impacts from DER adoption

Island Substation, Feeder 1345023
Base, Impact, and Gross Load Heatmap



Step 3: Reporting

Appendix

Table 2. Types of Pricing and Other Economic Incentives Discussed by Parrish et al.	
Price Based Schemes	**Description**
sTOU (static time-of-use)	Prices vary by time of day between fixed price levels and over fixed periods. These may vary by season.
CPP (critical peak pricing)	Prices increase by a known amount during specified system operating or market conditions. This applies during a narrowly defined period and is usually applied only during a limited number of days annually.
TOU-CPP (time-of-use plus critical peak pricing)	Critical peak pricing overlaid onto time-of-use pricing. TOU-CPP therefore has two pricing components - daily time-of-use pricing, and occasional critical peak pricing applied during critical system events.
VPP (variable peak pricing)	Similar to time-of-use, but the peak period price varies daily based on system and/or market conditions rather than being fixed.
dTOU (dynamic time-of-use)	Prices vary between fixed price levels, but the timing of different prices is not fixed.
RTP (real time pricing)	Prices can differ on a daily basis and change each hour of the day (or more frequently) based on system or market conditions.
Incentive-Based Schemes	**Description**
CPR (critical peak rebate)	Similar to CPP, but customers are provided with an incentive for reducing usage during critical hours below a baseline level of consumption.
DLC (direct load control)	Customers are provided with an incentive for allowing an external party to directly change the electricity consumption of certain appliances. Customers can usually override control although they may lose some incentive. DLC may also be combined with time varying pricing.

Source: Parrish, B., Gross, R., & Heptonstall, P. (2019). *On demand: Can demand response live up to expectations in managing electricity systems?* Energy Research and Social Science, 51, 109. https://doi.org/10.1016/j.erss.2018.11.018

Source: Smart Electric Power Alliance

Behavioral and Direct Load Control Measures for Enabling and Incentivizing Responsible EV Charging

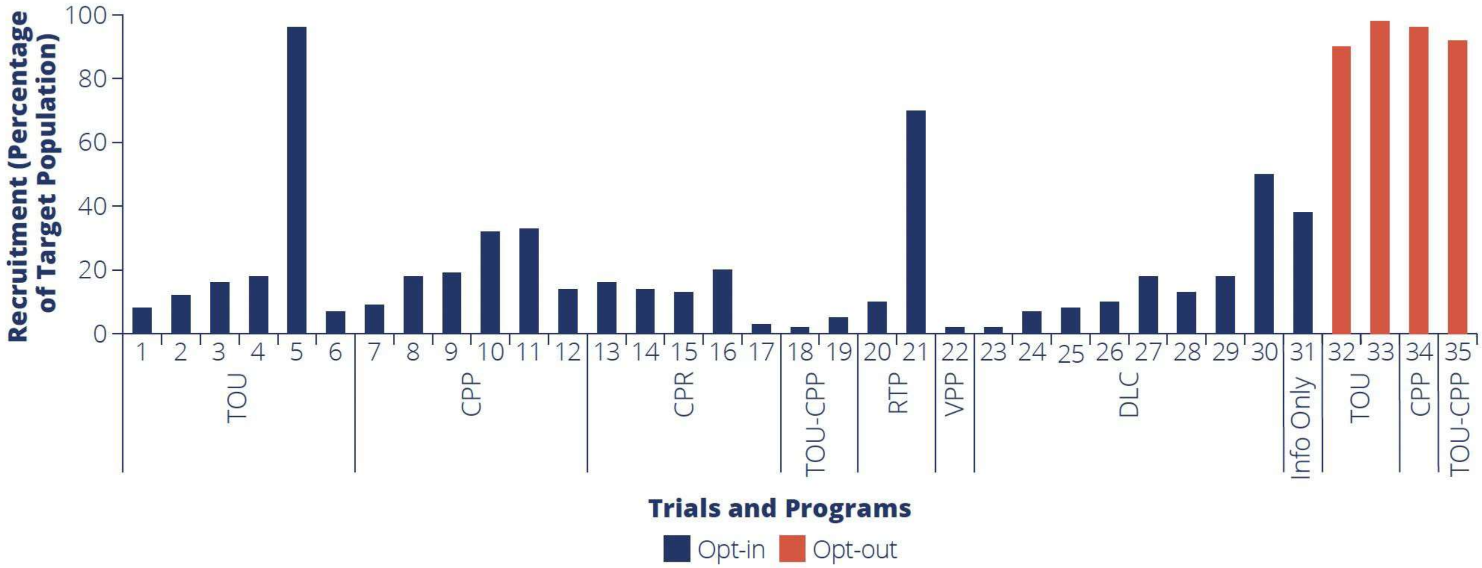
Utility Goal	Utility Benefit	Charge Management Measure	Type*	Example
Avoid Charging at Peak	Reduces peak load on grid—generation at peak load has the highest cost per kWh.	Time-based energy rates	B	Con Edison's SmartCharge Rewards Program[15]
		Time-based demand rates	B	
		Charge scheduling	DLC	Eversource's ConnectedSolutions[16]
Avoid Synchronized (Multiple EV) Charging	Reduces peak load on grid—generation at peak load has the highest cost per kWh.	Staggered peak rates	B	
		Customer notification of rate increase.	B	
		Charge scheduling	DLC	
Encourage Lower-Power Charging	Reduces demand spikes, which can place strain on grid infrastructure.	Time-based demand rates with customer chosen kW threshold.	B	
		…with utility chosen thresholds.	B	PG&E & SCE's Business EV Rates[17,18]
		…with choice of charging level	B	
Avoid High-power Charging	Reduces demand spikes, which can place strain on grid infrastructure.	Demand limiting	DLC	Eversource's ConnectedSolutions[19]
		Monthly demand rates	B	
		Real-time demand notification	B	
Avoid Critical Peaks	Reduces peak load on grid—generation at peak load has the highest cost per kWh.	Customer notification of reduced power levels due to upcoming peak period.	DLC	• PG&E EV Charge Network Load Management Plan[20] • PG&E + BMW iChargeForward pilot[21]
		Dynamic energy rates	B	
		Dynamic demand charges	B	
		Dynamic load control	DLC	• Green Mountain Power Unlimited EV charging Rate[22] • Eversource's ConnectedSolutions[23] • SMUD EV Innovators TG3[24]
		Communicating charger with end-of use-charging, choice of charging level, high price avoidance, managed charging.	B	
Increase Consumption of Renewables	Reduces curtailment of renewable generation by deploying flexible demand to coincide with instances of high renewables penetration.	Time-based energy rates	B	PG&E & SCE's Business EV Rates[25,26]
		Dynamic load control	DLC	

* Behavioral (B) or Direct Load Control (DLC) measure type.

Source: NYSERDA, Cadmus, and WRI

Reported Enrollment by Type of Demand Response

Figure 3. Reported Enrollment by Type of Demand Response



Source: Parrish, B., Gross, R., & Heptonstall, P. (2019). *On demand: Can demand response live up to expectations in managing electricity systems?* Energy Research and Social Science, 51, 108. https://doi.org/10.1016/j.erss.2018.11.018

Source: Smart Electric Power Alliance