Geospatial Forecasting of Electrification Load and Effects on the T&D System

ESIG 2024 Forecasting and Markets Workshop

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Energy+Environmental Economics

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Who is E3?

Energy and Environmental Economics, Inc. (E3) is a leading economic consultancy focused on the transition to clean energy resources.

Climate Pathways / Policy Analysis

- Climate and energy policy analysis
- Long-term energy & climate scenarios
- Electrification and low-carbon fuels
- Future of gas

Asset Valuation & Strategy

- Asset valuation and due diligence
- Strategic advisory
- Energy market price forecasting
- Market design
- Transmission planning

Integrated System Planning

- Integrated resource planning for electric systems: reliability and resource mix
- Planning for utility and state RPS + GHG targets
- Utility planning and procurement decisions

DER / Electrification / Rates

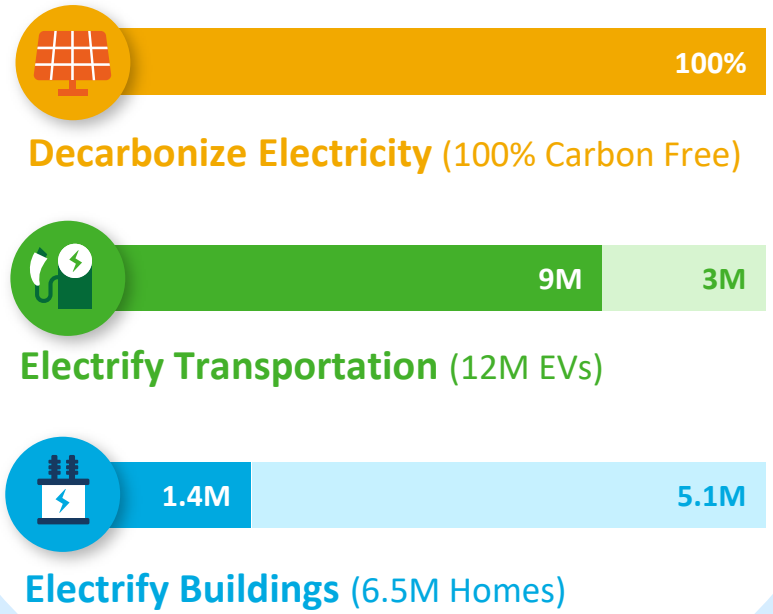
- Valuation of DERs
- DER dispatch and asset optimization
- Rate design
- Grid modernization
- Building electrification
- Vehicle electrification

Economy-wide energy systems — Bulk grid power systems — Grid edge & behind-the-meter

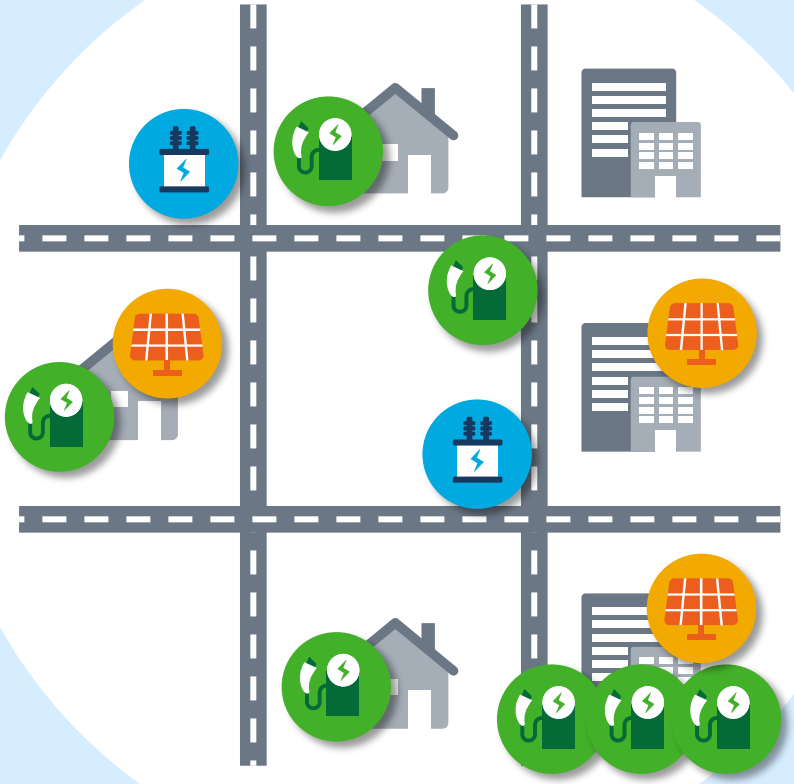
The Big Picture Challenge

Planners Must Simultaneously Understand Picture at Both the Very Large and Very Small Scale

Regional



Local



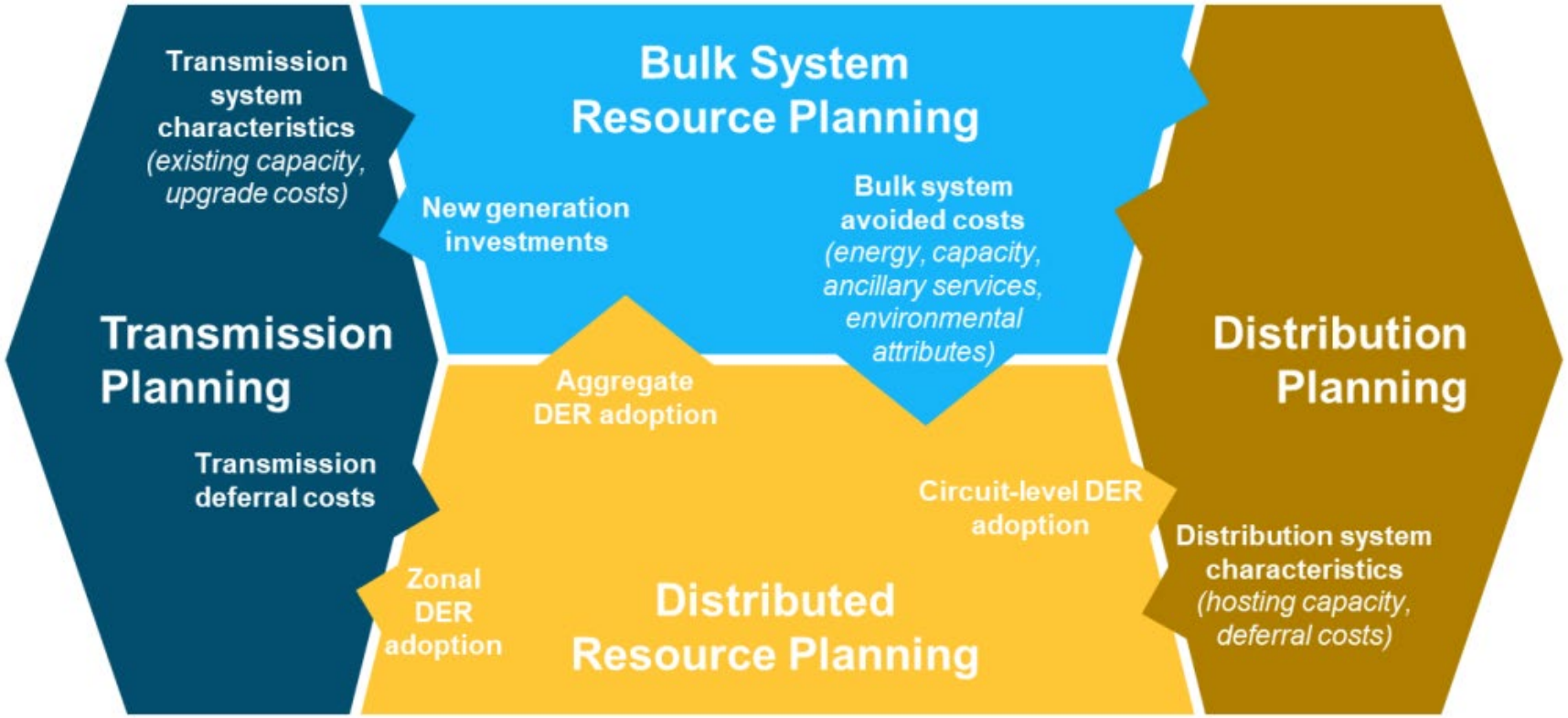
The Specific Challenges

Key Questions Planners and Policy Makers Are Grappling with

- Magnitude and timing of new infrastructure need
- Comparing costs for alternative net-zero pathways
- Anticipating customer interconnection needs
- Translating state clean energy goals to local infrastructure needs
- Where will adoption happen with and without public policy & funding?
- Prioritizing feeder upgrades
- Visualizing impacts for local planners and stakeholders

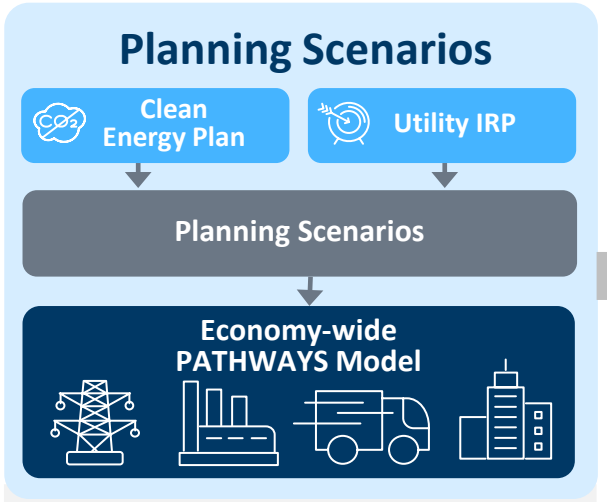
Big Picture Solution: Integrated System Planning

- Integrated system planning aims to unify planning across all parts of the system to arrive at better solutions for meeting customer needs and sustainability goals reliably, safely, and cost effectively
- Increasing coordination and optimization across the functional areas will require new planning methods and tools enabled by people, process, and system developments that will be achieved over time

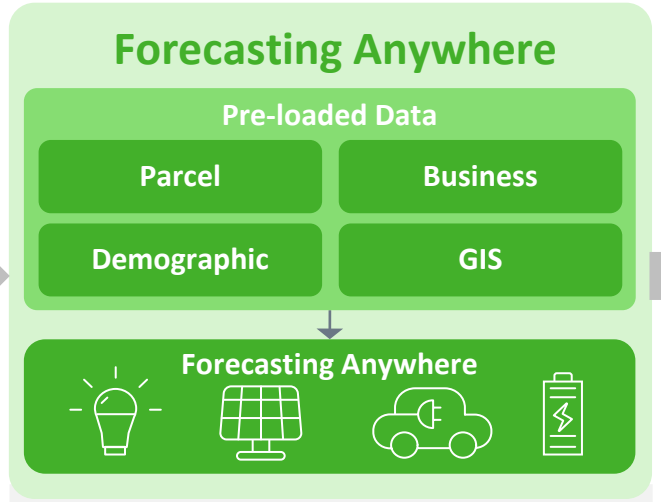


Specific Solution: Geospatial Forecasting of DERs

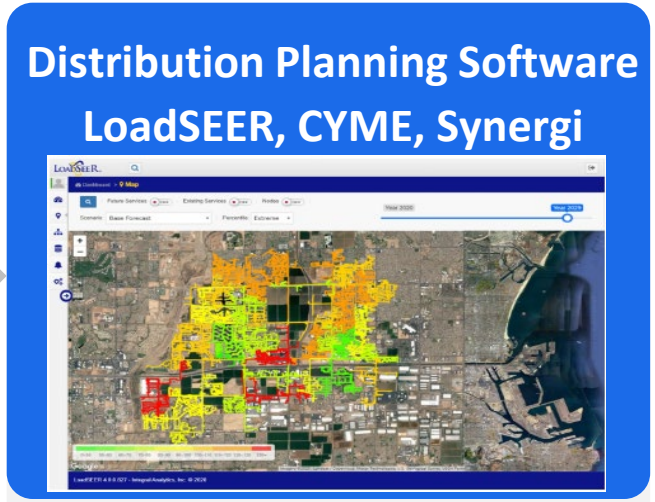
Three steps for translating economywide decarbonization plans to geospatially explicit expectations of DERS and electric devices, including **EVs**, heat pumps, distributed generation and solar.



Comprehensive long-term planning scenarios informed by policy, macro-economics and technology drivers



Advanced geospatial DER adoption and load growth scenarios using machine learning and heuristic analysis



Scenario based distribution planning and cost impacts consistent with utility resource plan and state policy goals

Geospatial forecasting of DERs helps solve some critical shortcomings of current distribution planning norms:

- Quicker, diversified set of results instead of one planning scenario that takes months to develop
- Anticipates needed infrastructure upgrades so that the distribution system is not the bottle for achieving transportation and building electrification goals
- Offers more precise plans as demands on the distribution grid and utilities is ever increasing (e.g., resiliency, wildfire risk, electrification, large new loads)
- Gives utilities a convincing case to regulators and stakeholders that their preferred distribution plan is prioritizing the right investments

Forecasting Anywhere Workflow

1 **Determine technical potential**

# of chargers, square footage, MW capacity

Parcels

Businesses

Parking lots

2 **Calculate propensity** (likelihood) to adopt

Propensity score

Businesses

Customer energy usage

Existing adoption

Demographics

3 **Determine local level adoption**

Allocate regional adoption

Regional vehicle and heat pump projections

Units adopted

4 **Geospatial aggregation**

Units adopted

5 **Calculate load impacts**

Hourly, annual, peak load impact

Hourly load shapes

Annual load growth factors

6 **Data, reports, visualizations**

Technical potential of workplace L2 charging

Key Modeling Elements

1. Designing Effective Scenarios

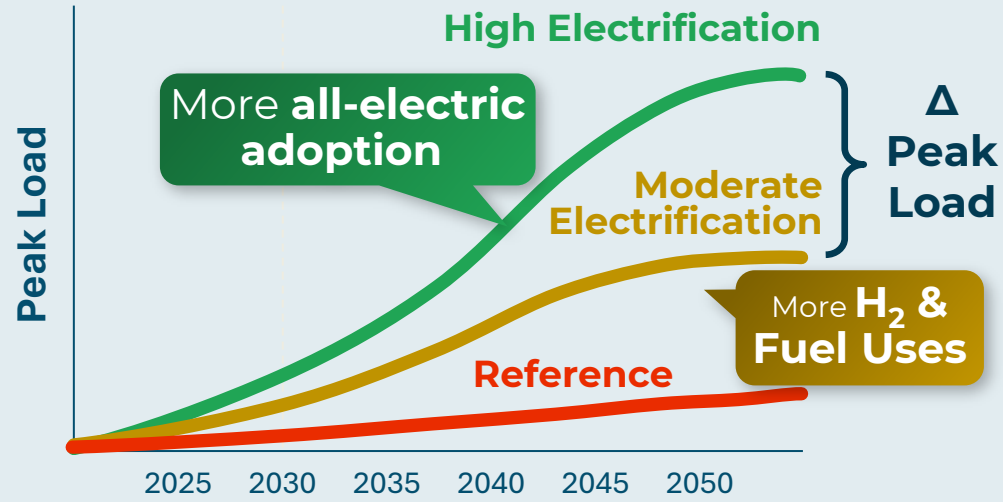
Strategic scenario design allows planners to capture diverse facets of economywide decarbonization and account for both supply- and demand-side variables

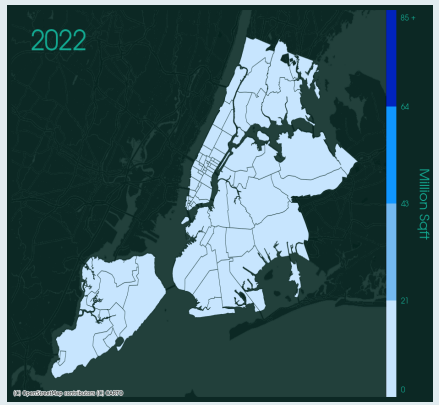
Possible scenario levers:

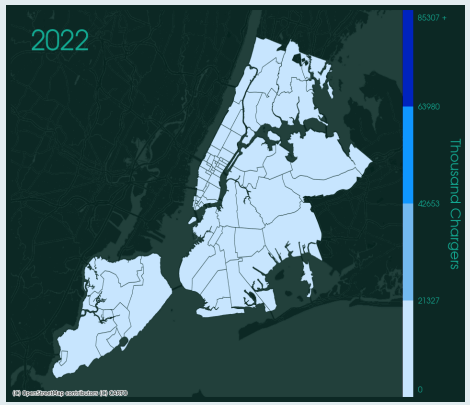
- Different EV and BE adoption and geospatial allocation
- Load management strategies
- Emerging high-demand technologies
- Investment in low-income and disadvantaged communities

Resulting outputs:

- Quantified impact of electrification and DER programs
- Detailed, disaggregated outputs to inform proactive distribution capital investment
- Regulatory case for both increased and proactive distribution capital investment







2. Collecting Geospatial Information

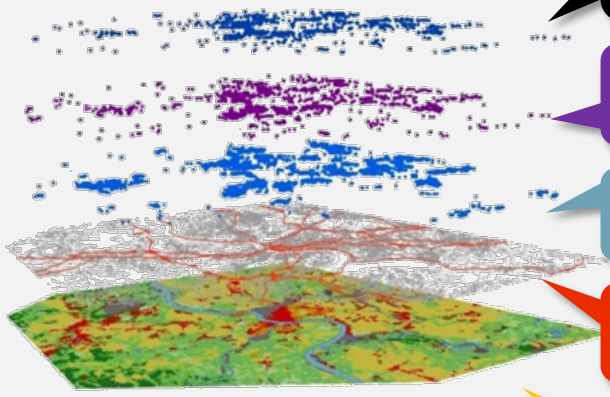
Geospatial datasets

- **Parcel Level Data** (Zoning, Value, Size, Etc.)
- **Existing Building Stock Data** (Size & Customer Class)
- **Business Filings**
- **Existing EV Charging Stations**
- **Existing PV sites**
- **USGS, USDA, NOAA, etc. Environmental Data**
- **Open Street Maps, Census, and other data**

Machine learning estimates granular adoption potential

Heuristic rules developed by subject matter experts where available data is limited

Map full of potential points for various end-uses, EV, PV, fuel switching, land use growth, etc.



- **Demand Side Management / Load Control**
- **Optimal Solar Power Sites**
- **Building Electrification**
- **Transportation**
- **Future Land Use**

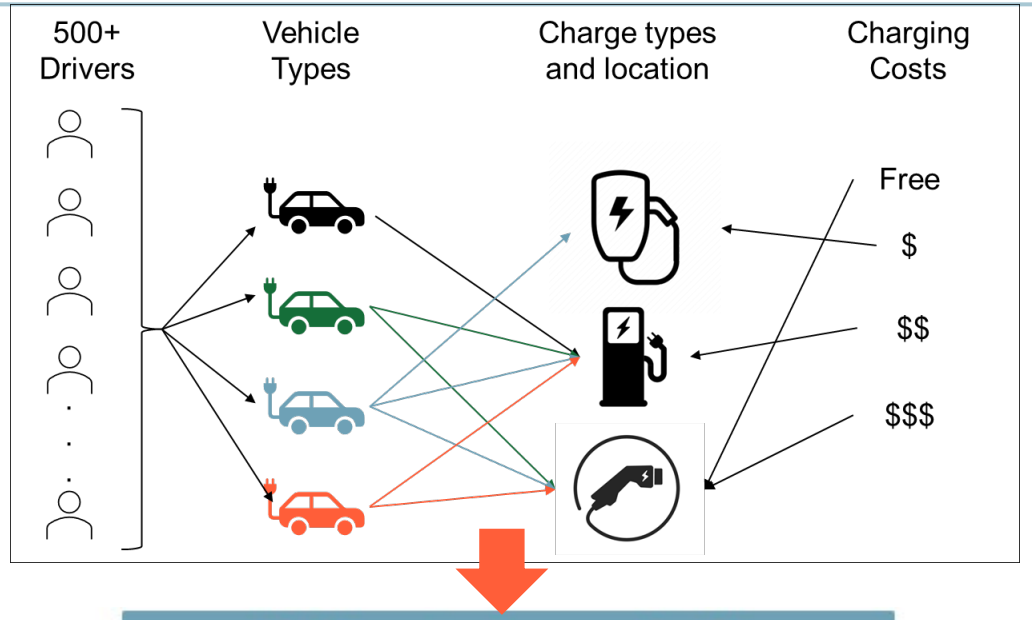
Artificial Intelligence

Machine Learning

Deep Learning

3. Creating Custom EV Charing Load Shapes

E3's RESHAPE-EV model generates diversified EV charging load shapes based on the driving patterns of thousands of drivers and characteristics of the driver population, including charger access, vehicle types, and cost to charge vehicles in various locations.



E3's RESHAPE-EV model is leveraged to model custom scenarios of EV charging load shapes:

Unmanaged charging load shapes are created based on drivers' travel needs and access to different charger types

Managed charging load shapes are then developed by optimizing load in response to price signals from time-of-use rates

3. Creating Custom Building Electrification Load Shapes

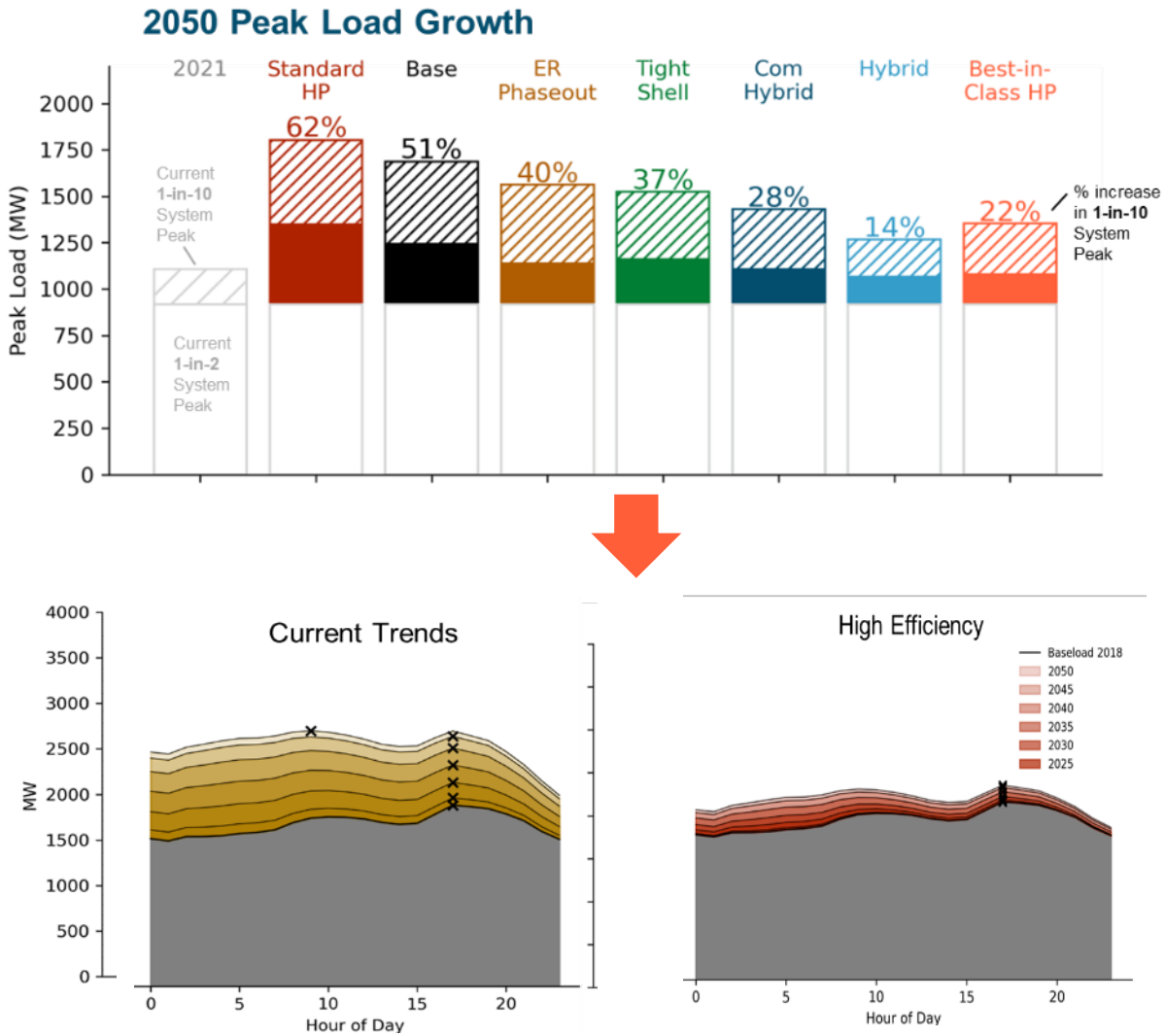
E3's BldStock model generates diversified building electrification load shapes based on NREL ResStock and ComStock building simulation tools

E3's BldStock model is leveraged to model custom scenarios of building electrification load shapes:

Standard Efficiency HVAC load shapes are created for a variety of building and customer types

High Efficiency load shapes represent increased emphasis on shell improvements and best in class heat pumps

Hybrid Heat Pumps are a particularly important sensitivity for distribution peak loads in colder climates

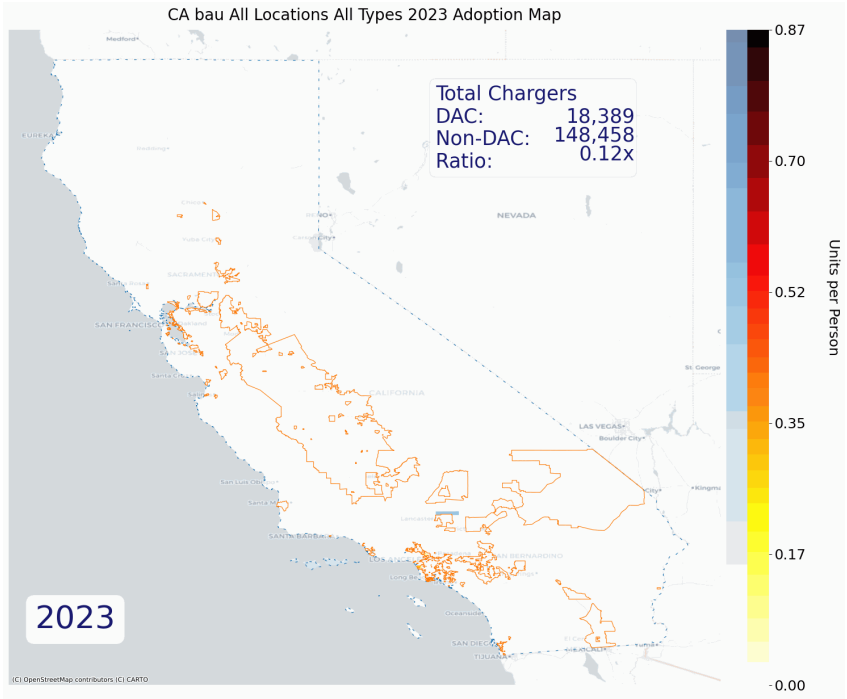


Examples of Forecasting Anywhere Findings

Lyft: How does investing in disadvantaged communities impact adoption?

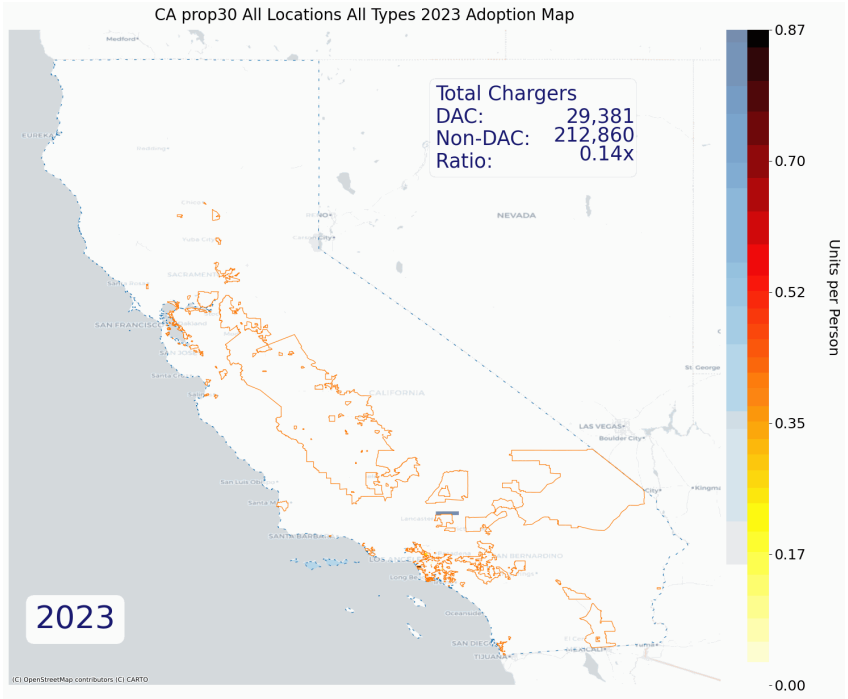
- **Summary: Proposition 30 proposed to introduce a tax on income to support EV infrastructure**
- **E3 Analysis: E3 assessed the potential impact of Prop 30 on EV charger build in CA focusing on Incorporation of Existing CA Policy, Disadvantaged Communities (DACs), and Charging Deserts**

Business-as-usual



+7.4 million *chargers*

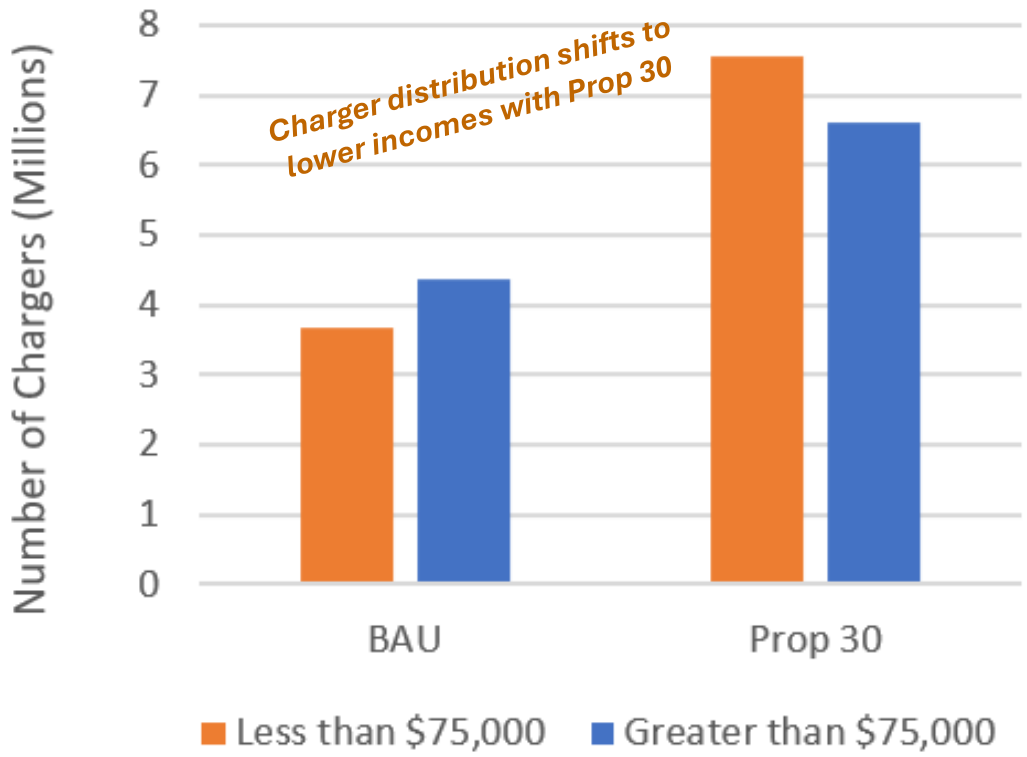
Prop 30

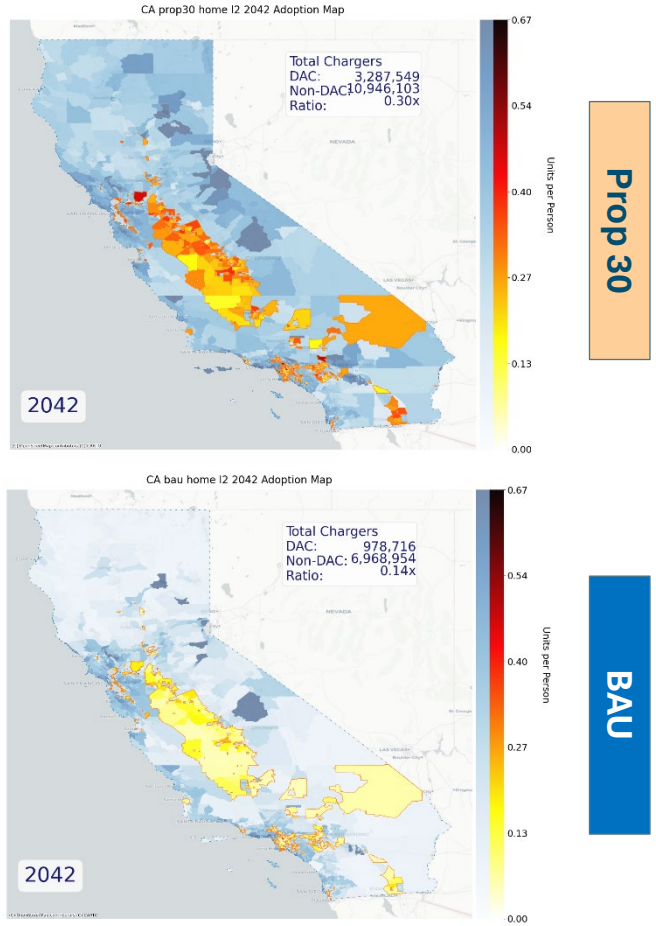


All
Disadvantaged

Prop 30 Shifts Home Charger Buildout to Low Income

Charger Count by income bracket



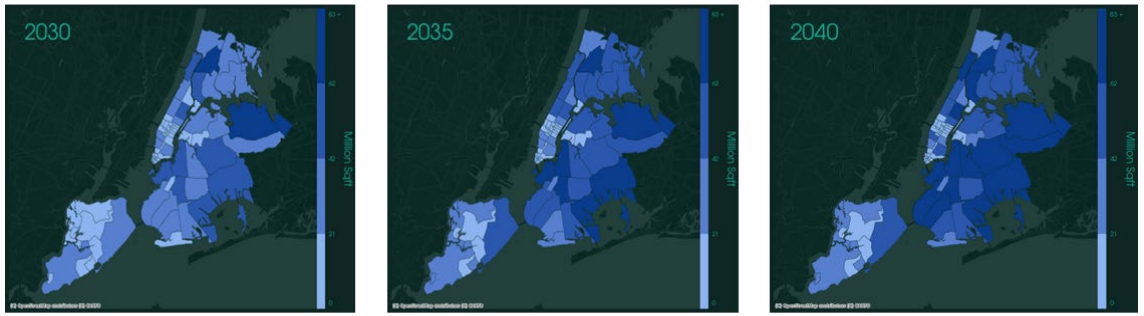


Results Shown for 2042

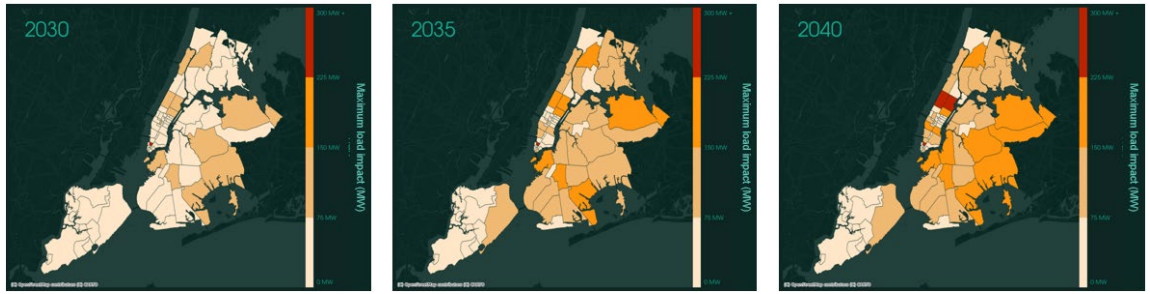
PowerUp NYC: Where can the City expect building and transportation electrification, and what areas of the grid are constrained?

- Goals of the study were to understand: Adoption of BE & TE, Peak load impacts of BE & TE, How headroom overlays with these components
- E3 Analysis: Geospatially allocate citywide electrification to each Con Edison distribution network to assess load impacts and to determine where additional investment is needed to avoid reliability issues.

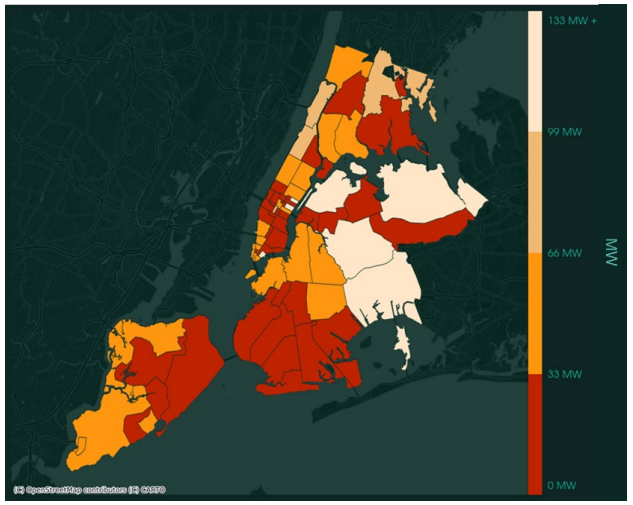
BE & TE Adoption



BE & TE Unmanaged Load Impacts



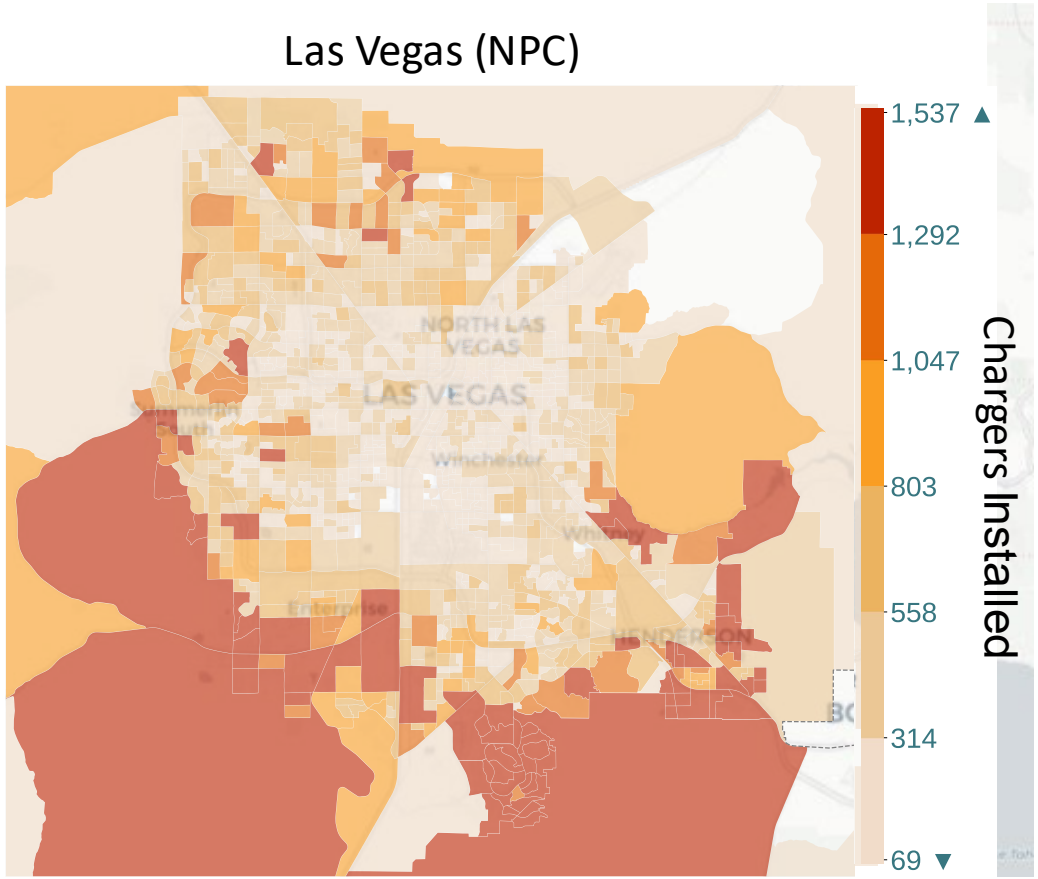
Headroom



NV Energy Integrated Resource Plan: How do DER adoption scenarios and DSM strategies impact the grid?

- Multiple clean energy and decarbonization pathway scenarios
- Three distinct demand side management strategic portfolio designs
- Geospatial and temporal allocation of DSM adoption with Forecasting Anywhere
- Assessment of impacts on low-income communities under different scenarios
- Distribution planning analysis in LoadSEER

2044 Home L2 EV Charger Adoption



How can we improve the modeling?

We are actively working to answer new questions and improve the model through:

+ **Coordination between researchers, utilities and Public Utility Commissions**
  - Incorporating feeder data into the study allows for much more granular predictions of adoption and can help planners prioritize which feeders and substations to upgrade.
+ **Incorporating vehicle trip data to strengthen and ground truth several aspects of our model, including verifying charger locations and charging load shapes**
+ **Greater insight into how the medium and heavy-duty sectors are evolving**
+ **More detailed assessments of how investing in DACs impacts adoption**
+ **Higher temporal resolution and granularity in load shapes for distribution planning (e.g., integrating various vehicle types, changing load management assumptions over time)**
+ **Increasing granularity of building electrification data**
  - Who has gas versus electric heating in a service territory? Sometimes electric utilities don't know.
+ **Generating rapid, high-level distribution planning area-level costs and impacts**

Thank you!

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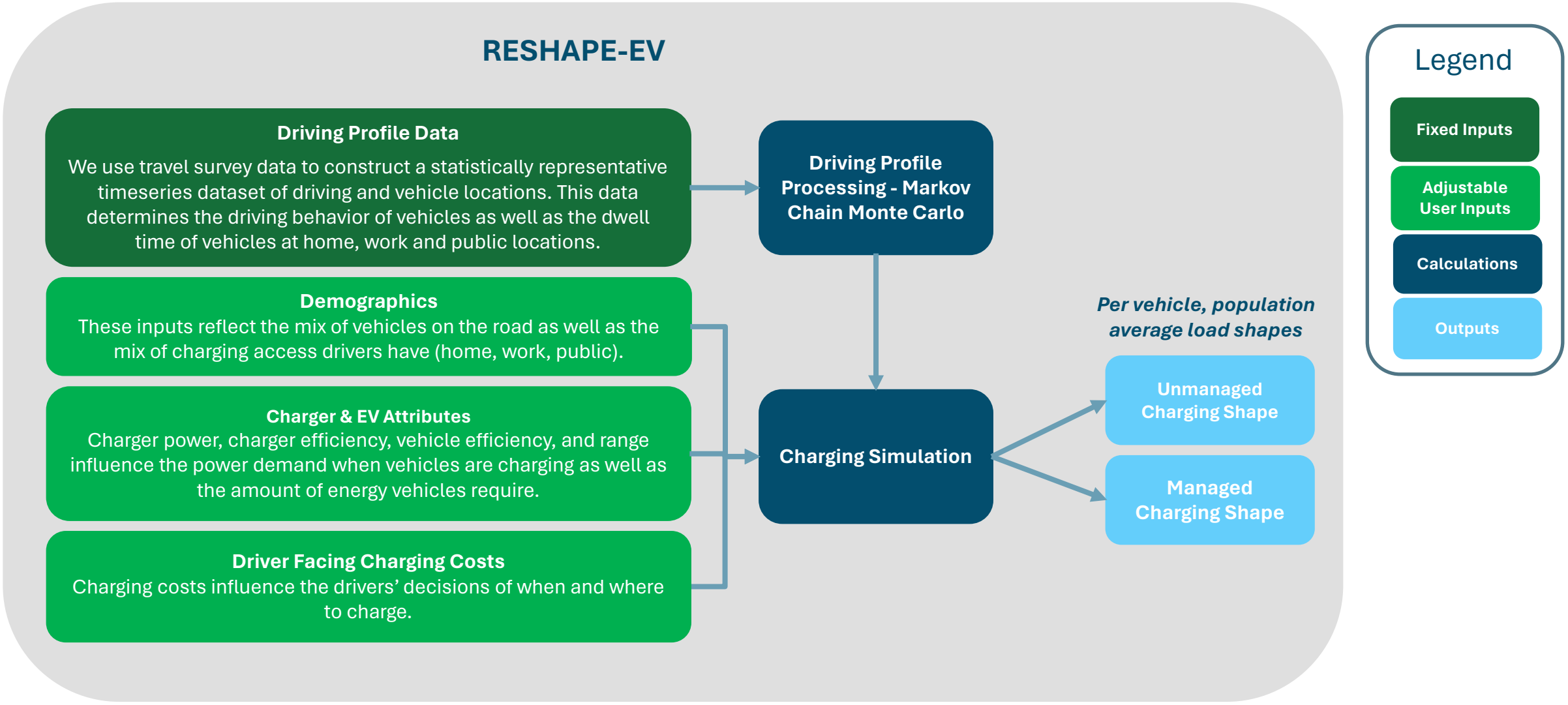
RESHAPE-EV


RESHAPE-EV
Driving Profile Data
We use travel survey data to construct a statistically representative timeseries dataset of driving and vehicle locations. This data determines the driving behavior of vehicles as well as the dwell time of vehicles at home, work and public locations.
Demographics
These inputs reflect the mix of vehicles on the road as well as the mix of charging access drivers have (home, work, public).
Charger & EV Attributes
Charger power, charger efficiency, vehicle efficiency, and range influence the power demand when vehicles are charging as well as the amount of energy vehicles require.
Driver Facing Charging Costs
Charging costs influence the drivers' decisions of when and where to charge.
Driving Profile Processing - Markov Chain Monte Carlo
Charging Simulation
Per vehicle, population average load shapes
Unmanaged Charging Shape
Managed Charging Shape
Legend
Fixed Inputs
Adjustable User Inputs
Calculations
Outputs

EV Charging Management

Unmanaged

+ **Drivers make the decision on where to charge based on the *average cost to charge* in that location.**
  - The EV is charged at max power immediately if the driver choses to charge at that location.
  - This assumes the driver decides whether to charge in each location based on driving needs and the average price at that location.

Managed

+ **Drivers decide when to charge based on the price they see on their *time-of-use rates*.**
  - The driver sees the price for charging in each 15-minute interval for the full week and choses when and where to charge to minimize their charging cost

In both cases, driver charging behavior is based on:

1. **Charging access – where they can charge**

2. **Convenience / their driving behavior – when they are at a charging location**

3. **Cost of charging in each location – what the driver pays**