DGEM 2.0 Preliminary Results

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Agenda

- Background
- Data inputs
- Methods
- Results and takeaways
- Next steps

Purpose of DGEM

- The purpose of the DGEM studies is to utilize established CEC Integrated Energy Policy Report (IEPR) forecasts to estimate the potential costs of upgrading the distribution grids of California’s 3 largest investor-owned electric utilities (PG&E, SCE, and SDG&E) to support the state’s electrification goals.
- We do not perform our own forecasts; instead we spatially allocate the IEPR forecasts and combine them with existing utility data to estimate potential infrastructure costs.

Background

- Our previous **Distribution Grid Electrification Model** (DGEM 1.0) studied the cost of upgrading the distribution grid to support electrification, primarily focusing on transportation electrification (TE) load growth.
- DGEM 1.0 was published in August 2023. DGEM 1.0 used 2022 IEPR load growth forecasts for 2023-2035.
- DGEM 1.0 results indicated that the total cost of upgrading the IOUs' distribution grids by 2035 will be approximately **$26 billion**.
- Kevala conducted an Electrification Impacts Study Part 1 (EIS), published May 2023, which predicted upgrade costs to be **$51 billion** by 2035.
- EIS Part 2 is expected in 2025.

DGEM 1.0 → DGEM 2.0

DGEM 1.0

- Focused mostly on the TE components, as this dominated the 2022 Integrated Energy Policy Report (IEPR).
- Took "peanut butter" approach for rest of load, spreading non-TE load growth evenly across the IOU territory.
- Derived load shapes from 2022 IEPR—does not show an evening peak for electric vehicle charging (contrary to EIS 1.0).
- Estimated costs out to 2035, which is the final forecasted year in the 2022 IEPR.

DGEM 2.0

- Refreshes key data inputs, introduces managed EV charging load profiles, and better incorporates building electrification data.
- Given greater impact of building electrification (BE) in 2023 IEPR, DGEM 2.0 includes new analysis to allocate BE load at the feeder level.
- Explores new managed charging load profiles to determine the impact of load shape on upgrade needs and costs.
- Estimates costs out to 2040,which is the final forecasted year in the 2023 IEPR.

Data Utilized

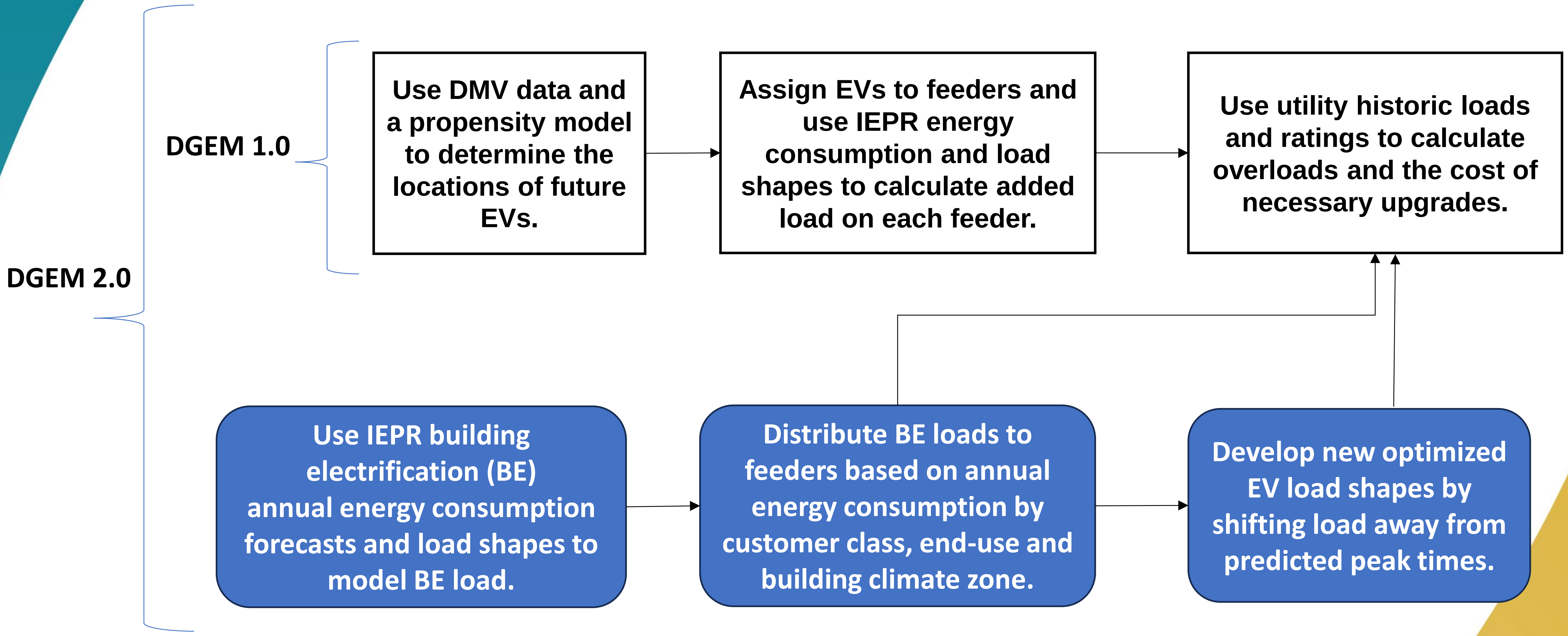
We have obtained updated data from the California Energy Commission (CEC), the three large electric IOUs, and the California Department of Motor Vehicles (DMV).

- CEC provided data from the 2023 Integrated Energy Policy Report (IEPR):
  - Annual energy consumption by climate zone, end-use and customer class (***new***).
  - Load shape by climate zone, end-use and customer class (***new***).
  - Electric Vehicle (EV) load shapes (*update*).
  - Load growth for all load categories (*update*).

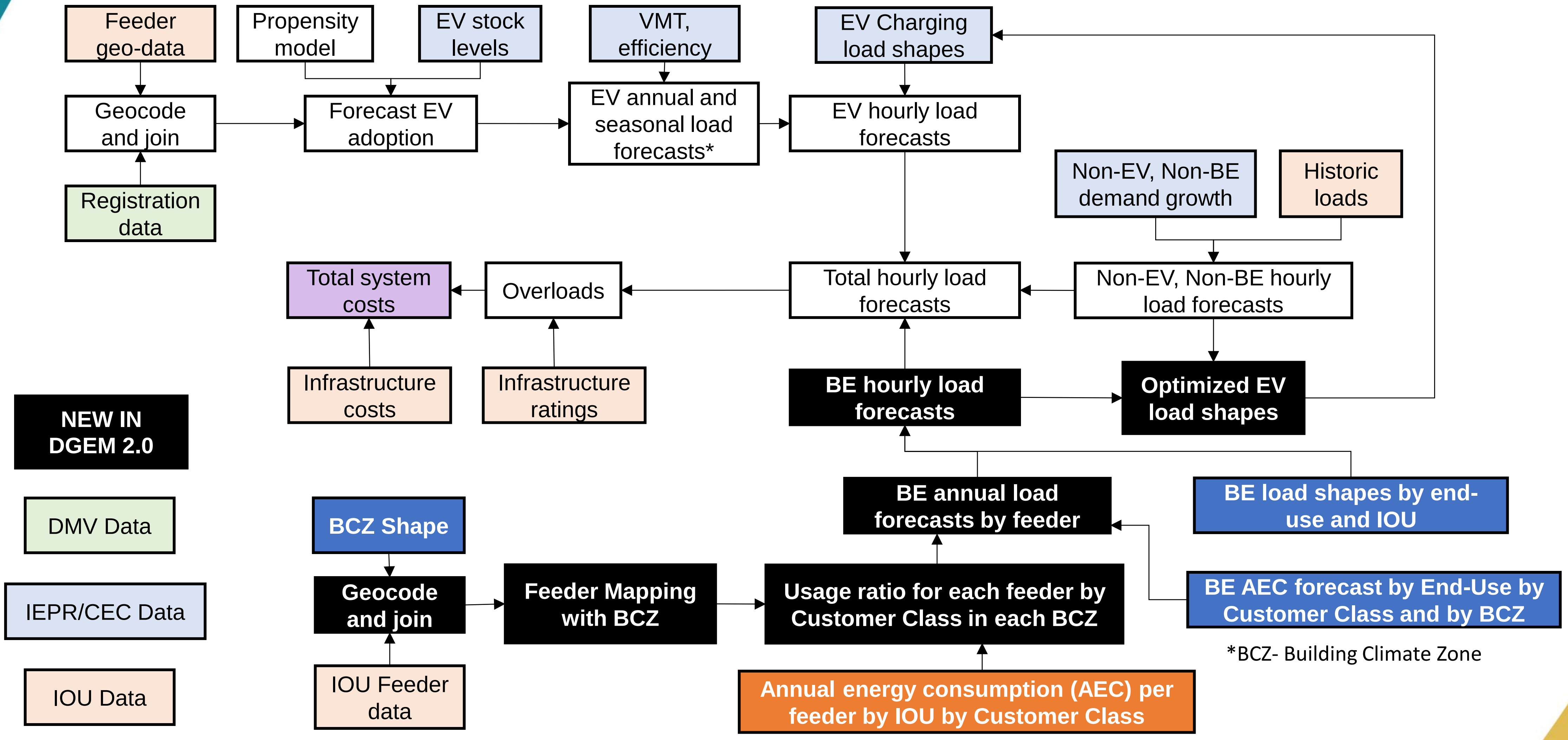
- IOUs provided confidential feeder-level load, rating, and consumption data:
  - Annual energy consumption of each feeder by customer class (***new***).
  - Load data for each distribution feeder (*update*).
  - Feeder and substation rating data (*update*).

- DMV provided confidential vehicle location data (*update*).

Methods – Overall Model 2.0

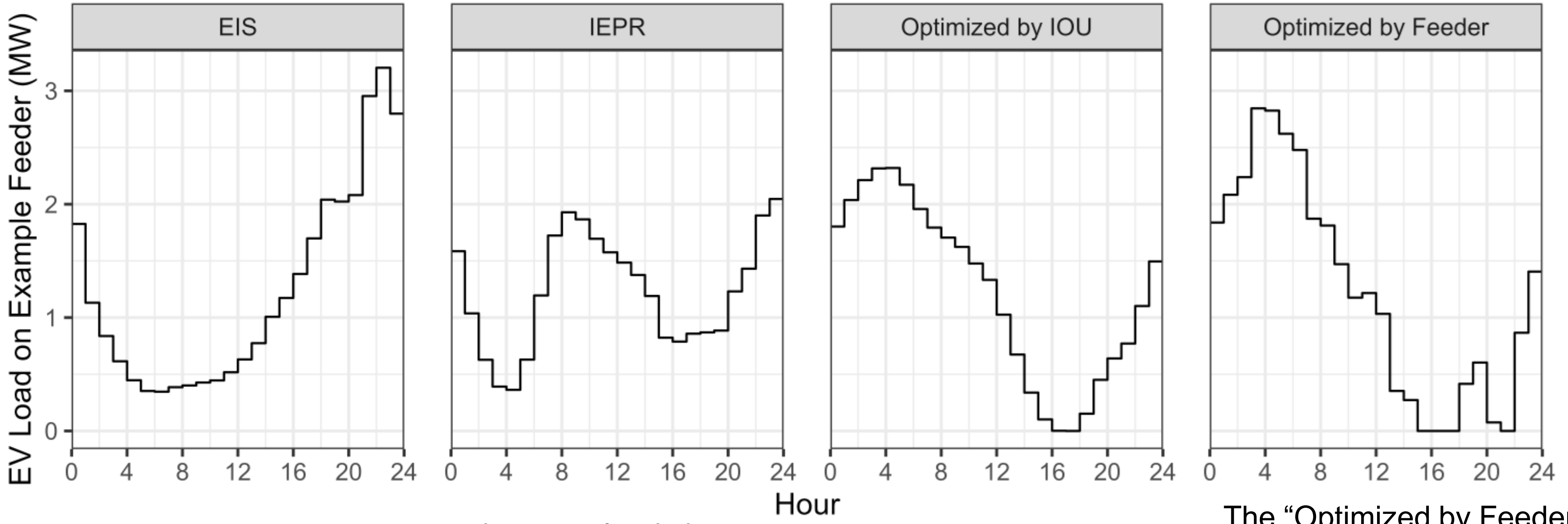


Methods – Model Detail



Methods – New EV Load Shapes

- DGEM 2.0 probes additional load shapes to demonstrate the impact of managed EV charging.
- We generate two "optimized" load shapes by allocating EV load to hours with more available capacity on the grid. One optimization creates an ideal load shape for each IOU for each year, and another optimization creates an ideal load shape for each individual feeder for each year.
- We also apply the load shape used in Kevala's Electrification Impact Study (EIS), which represents a scenario with little or no managed charging and a very high evening peak.



These example loads are taken from the SCE "Mar Vista" feeder, for the year 2035. This feeder was chosen as a representative high-load growth feeder because it has 75th percentile peak predicted EV and BE loads.

The EIS load shape is the same across all feeders and years.

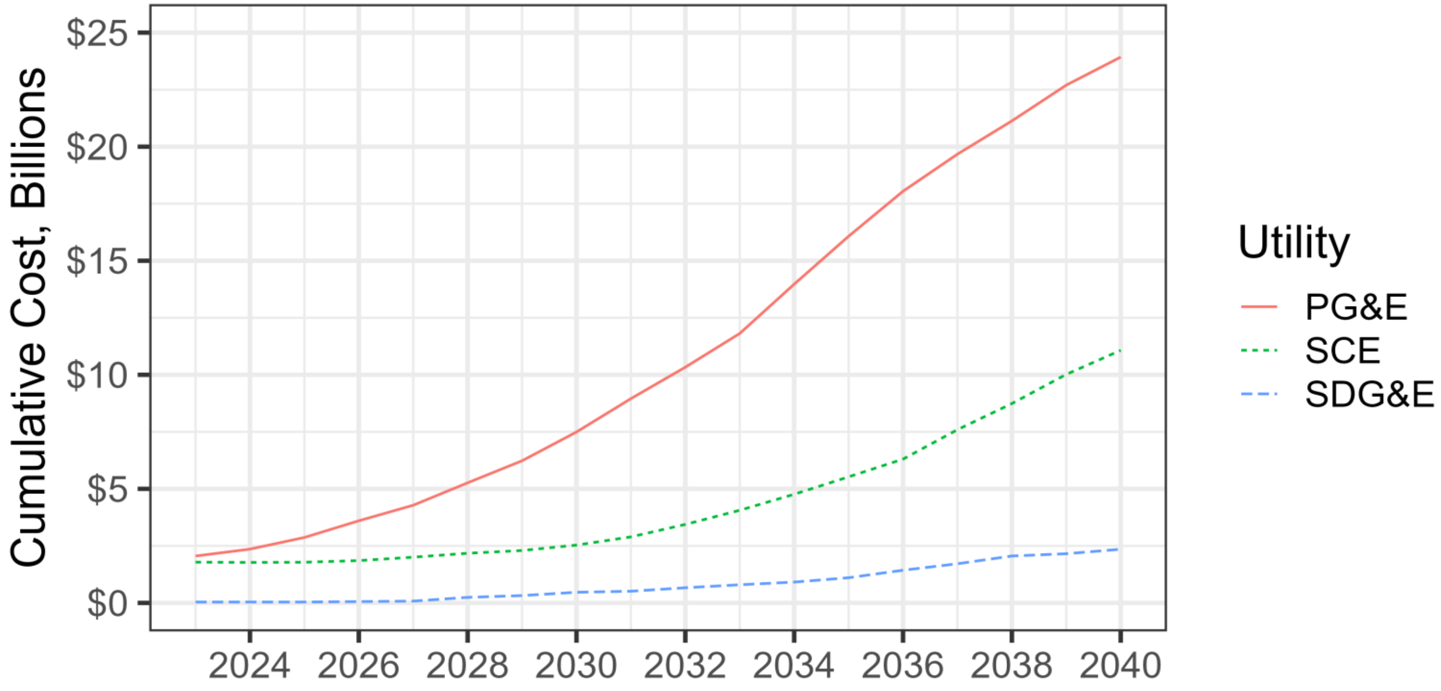
The IEPR load shape varies slightly by year but is the same across all feeders.

The "Optimized by IOU" load shape varies by year and by IOU.

The "Optimized by Feeder" load shape is unique to each feeder for each year.

Preliminary Results – Total System Cost

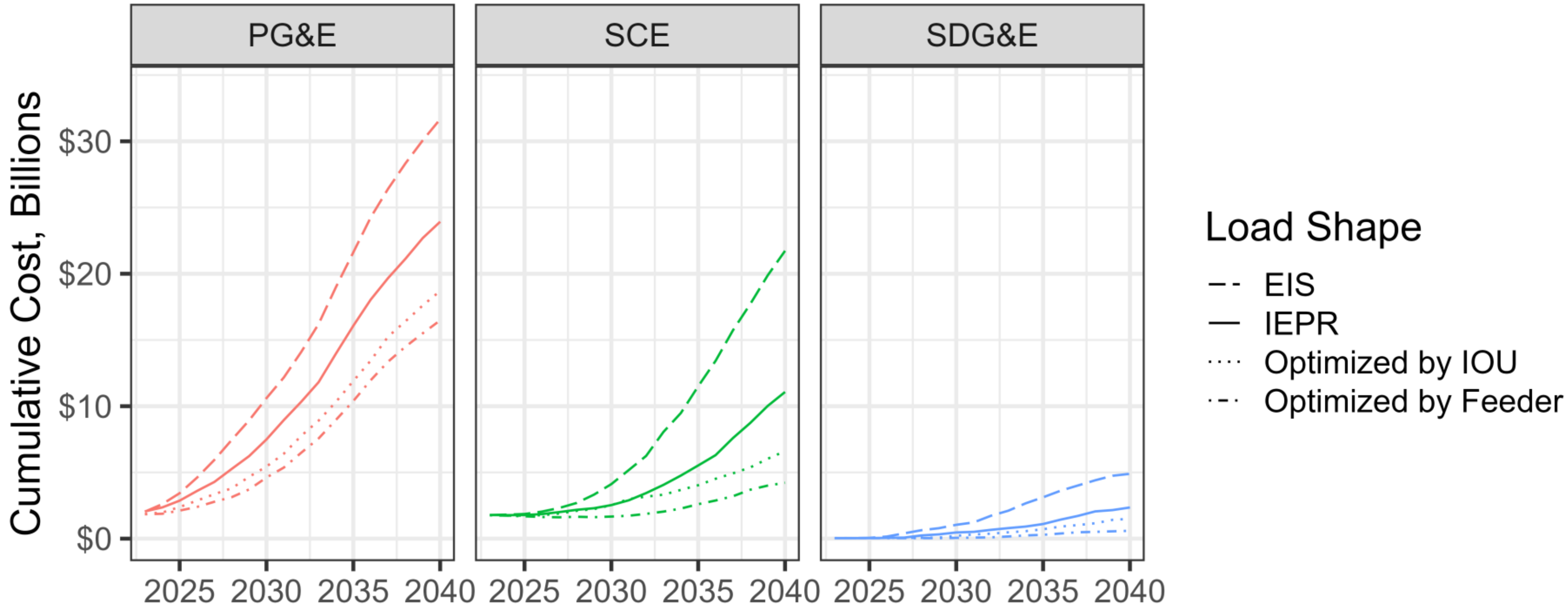
- We estimate the cost to upgrade the distribution grids of the three Utilities **through 2035 to be $22.7 billion** and **through 2040 to be $37.4 billion** (this figure and all other costs are in present-day dollars).
- Our results estimate that **costs will continue to grow roughly linearly** between 2035 and 2040.
- Our infrastructure cost dropped slightly for 2035 ($22.7 billion) compared to DGEM 1.0 ($26 billion).
  - This decrease is possibly driven by changes in the IEPR forecast. We plan to investigate further.



IOU	DGEM 1.0 2035 Cost (bn)	DGEM 2.0 2035 Cost (bn)	DGEM 2.0 2040 Cost (bn)
PG&E	$18.2	$16.1	$23.9
SCE	$5.7	$5.5	$11.1
SDG&E	$2.3	$1.1	$2.4
Total	**$26.3**	**$22.7**	**$37.4**

Preliminary Results – Impact of Load Shape

- EV charging load shape has an enormous impact on cost. A peaky, non-managed load shape, like the one used in Kevala's Electrification Impact Study (EIS), could increase costs by **57%** compared to the IEPR load shape.
- Additional managed charging could further reduce cost. Avoiding charging during peak hours on system peak days could avoid **27%** of the upgrade costs, while avoiding local peaks on specific feeders could avoid **42%** of the upgrade costs, compared to the IEPR load shape.



Load Shape	2035 Cost (billions)	2040 Cost (billions)
EIS	$36.2	$58.3
IEPR	$22.7	$37.4
Optimized by IOU	$16.6	$26.8
Optimized by Feeder	$13.3	$21.3

Preliminary Results – Impact of Load Shape

- The optimized load shapes we generated are not realistically achievable with current load management methods, in large part because they require zero EV load at peak hours on peak days. Load shapes like these may become more achievable as new load management technologies and strategies are developed.

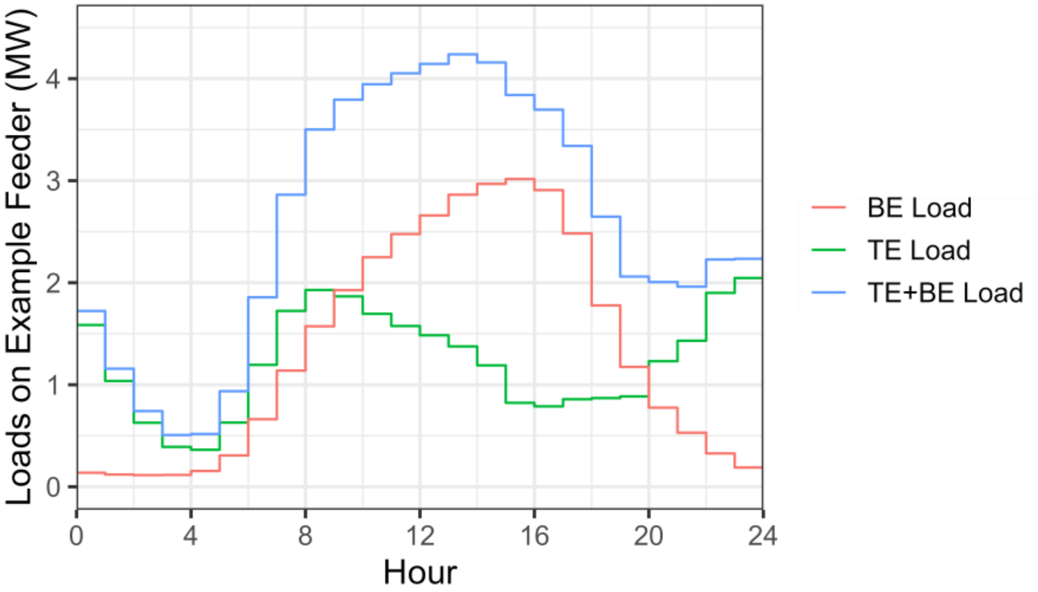
- These results indicate that many billions of ratepayer dollars of upgrade costs could potentially be saved through managed charging, even if these optimized load shapes are not fully reached.

- Locally targeted managed charging could have an especially large impact and save ratepayers additional money.

Preliminary Results – Impacts of BE

1. Allocating BE load on a more granular basis compared to the IEPR "peanut buttering" approach may slightly increase cost estimates pre-2035 but decrease cost estimates in the longer term (by 2040).
2. The BE forecast shows less GWh total compared to TE, but the BE load is peakier than the TE load. BE and TE load growth appear to have similar impacts on cost, with neither conclusively dominating the upgrade cost.
3. Results show some "complementarity" between BE and TE load. That is, some upgrades needed for BE may also support TE load growth, and vice versa. We are further analyzing the extent of complementarity between TE and BE and its potential to reduce infrastructure upgrade costs.

These example loads are taken from the SCE "Mar Vista" feeder, for the year 2035. This feeder was chosen as a representative high-load growth feeder because it has 75th percentile peak predicted EV and BE loads.



Modeling Method	2035	2040
Total Cost (BE load growth spread evenly)	$21.7 bn	$45.4 bn
Total Cost (DGEM 2.0 BE spatial allocation)	$22.7 bn	$37.4 bn

Preliminary Summary/Takeaways of Results

1) Overall DGEM cost estimates have decreased, possibly due to changes in the IEPR forecast from 2022 to 2023.

2) Shifting EV load away from system peak hours reduces the need for grid upgrades and the cost to ratepayers.

3) Feeder-level managed charging, responding to local capacity and local peak usage, can further reduce grid upgrade costs. Compared to system-level managed charging, feeder-level managed charging can provide even more savings.

4) A more spatially granular BE load allocation leads to lower total costs through 2040. BE and TE load growth complement each other to some extent but this may not result in major savings to ratepayers unless BE and TE loads are managed significantly.

Future Analysis/Next Steps

- We plan to continue to analyze different scenarios of future load growth to help show the impacts of different electrification approaches and outcomes.
- These scenarios may include variations to the levels of total EV and BE load (following different degrees of electrification), combined with variations in load profiles (including variations in peakiness of load and variations in when peaks occur).
- We also plan to provide further analysis of the cost, such as analyzing upgrade cost scenarios and measuring the impact on rates.