

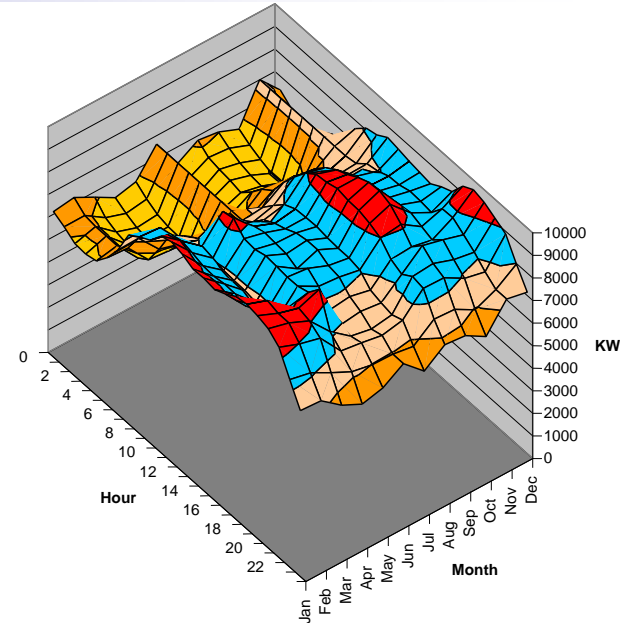
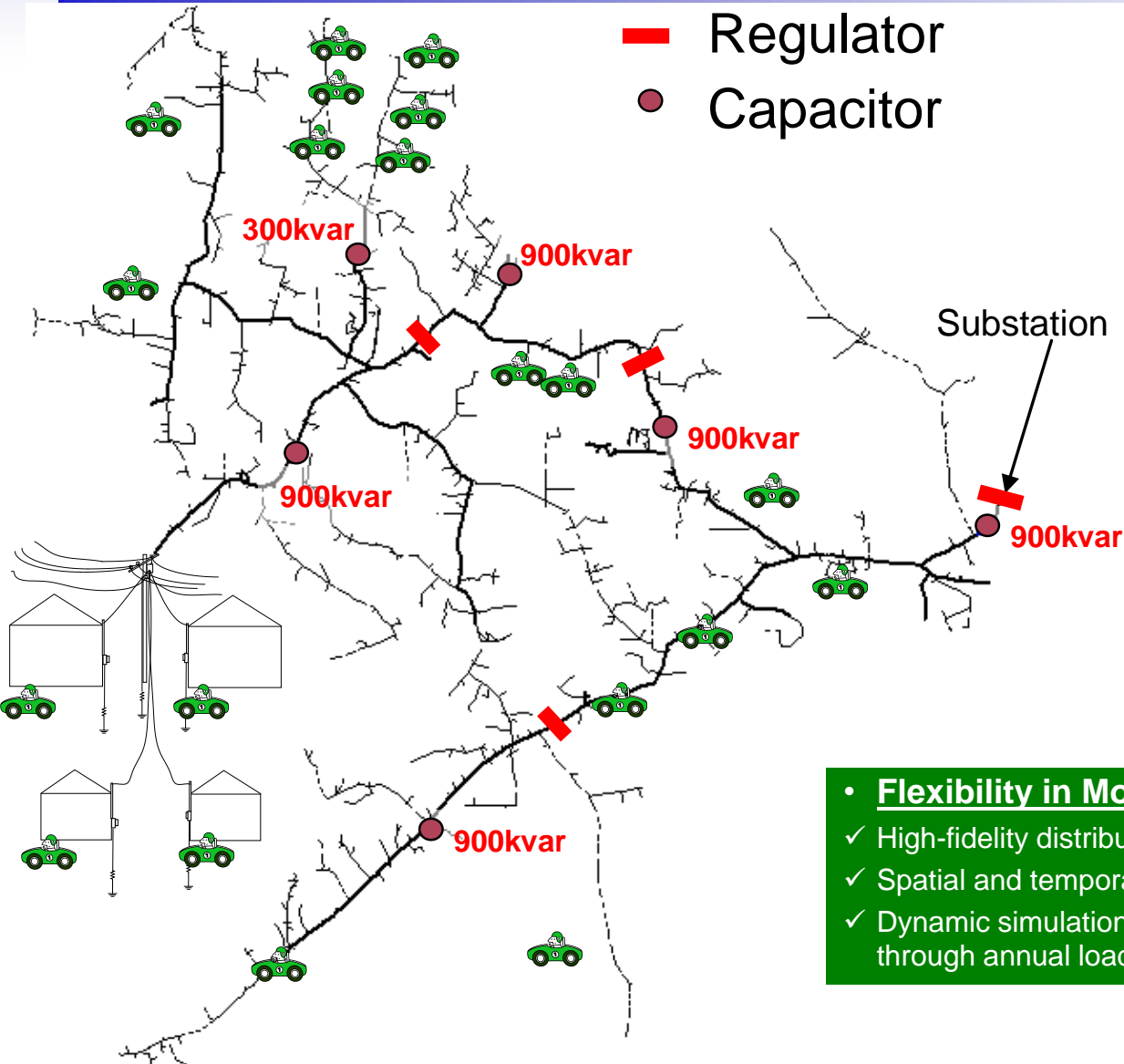


# Effects of Transportation Electrification on the Electricity Grid

2010 SAE Government/Industry Meeting

Dr. Arindam Maitra

# EPRI PHEV Distribution System Impacts – Modeling/Simulation Analytical Framework

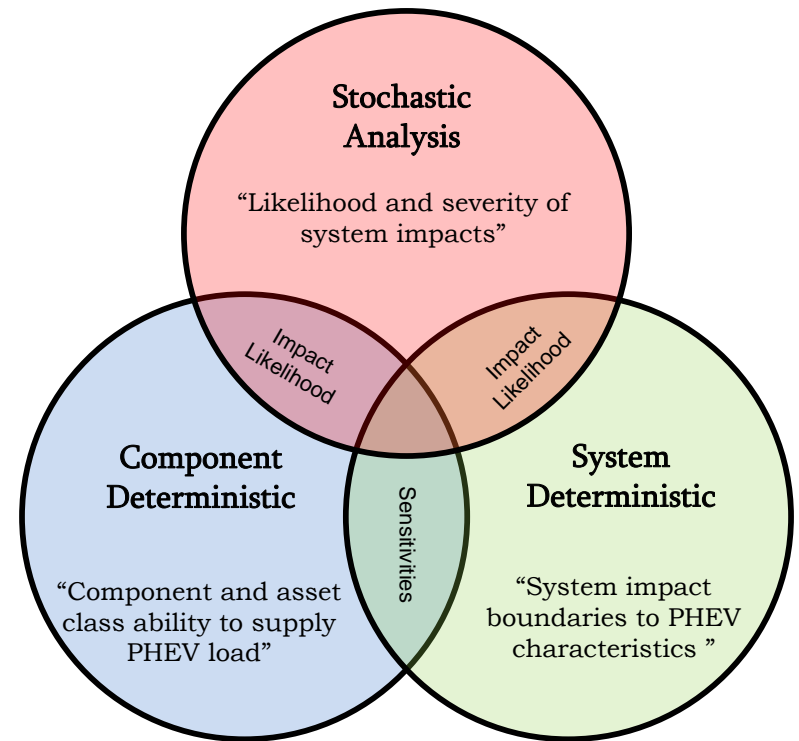


## • Flexibility in Model Development

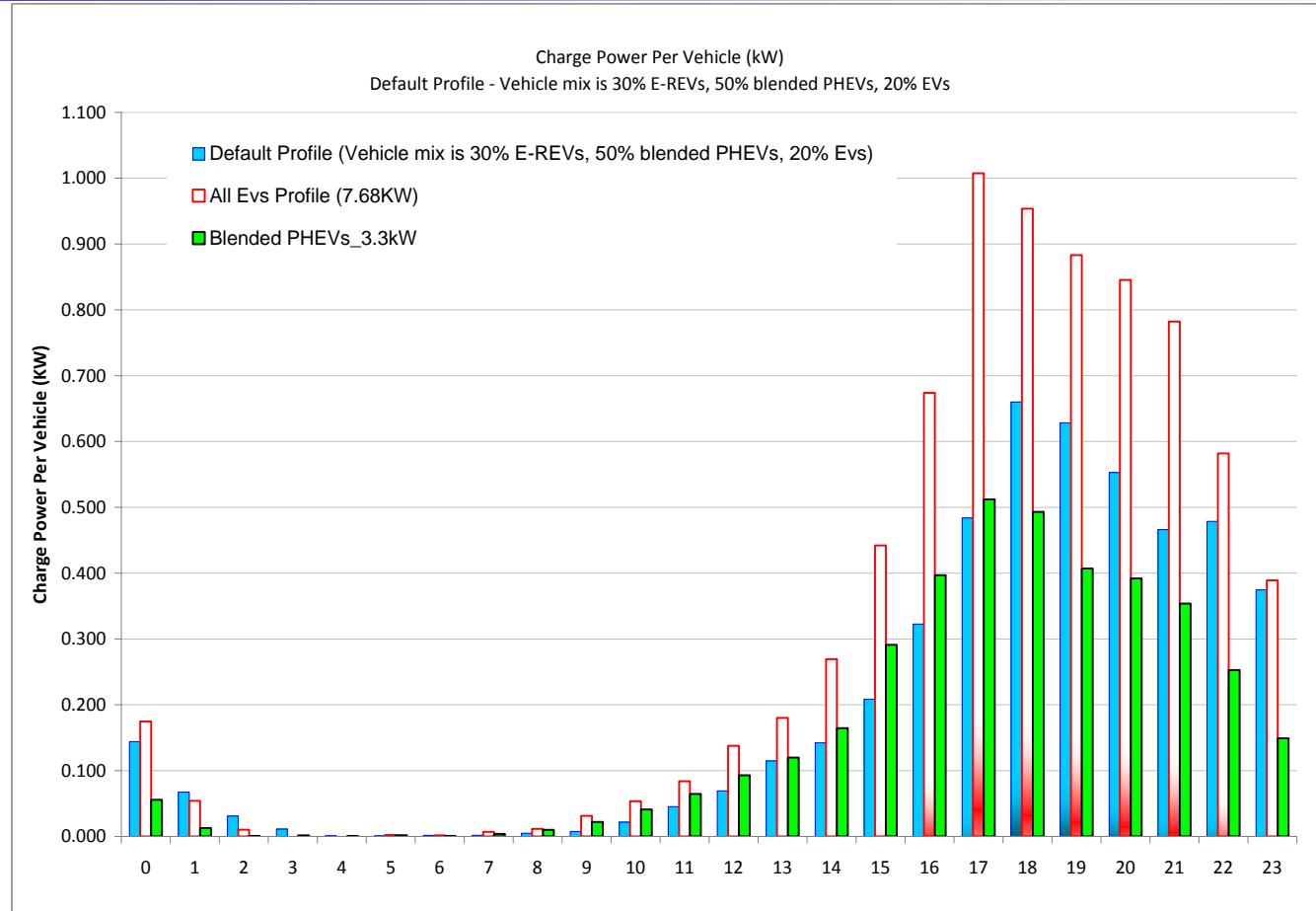
- ✓ High-fidelity distribution feeder models
- ✓ Spatial and temporal variation of circuit loads and PHEV Loads
- ✓ Dynamic simulation of full electrical model serving PHEV loads through annual load cycle

# Distribution Impact Project Summary

- Multi stage analysis designed to capture and characterize impacts due to PEV load
- Wide range of circuits studies
  - Radial System, Network
  - 13KV, 25KV, 35KV, 4KV
  - Residential, Commercial
  - Single-family, Multi-dwelling
- Diversity Influences
  - Type of charge
  - Time of charge
  - Customer charging habits



# Feeder Loading Analysis: Aggregate Power Demand for Uncontrolled Charging

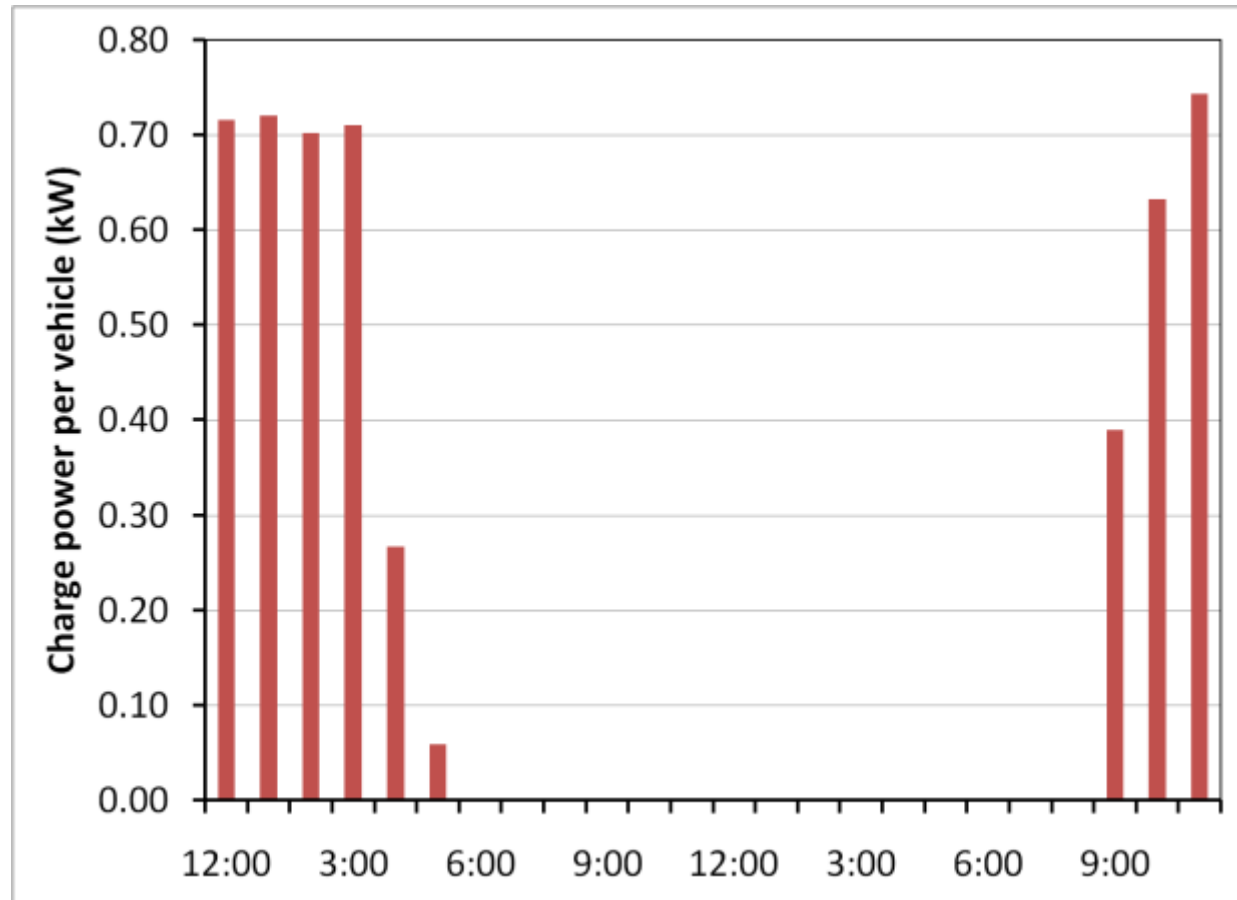


## Aggregate Level

Average on-peak load for a PEV will be about 500-1100 W

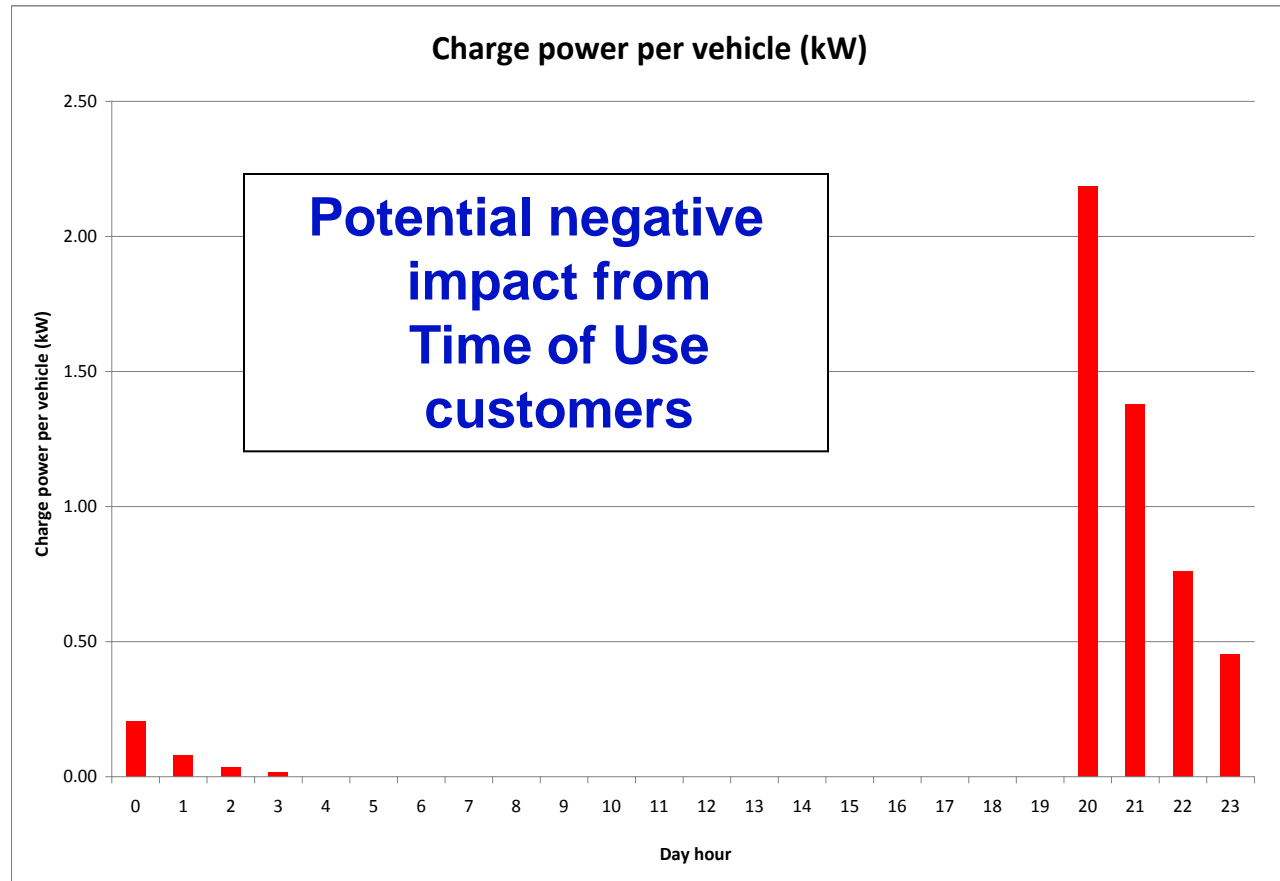
- If it's bigger, it will finish sooner
- If it's smaller, they'll overlap more

# Power demand with Simple Charge Control



- Shifts the charge load to nighttime, but spreads it out relatively evenly over 6 hours.

# Power demand from *badly* controlled charging



- What if all of the vehicles waited until 8 PM to charge?
- Maximum power requirements are about 2-3 **times higher**

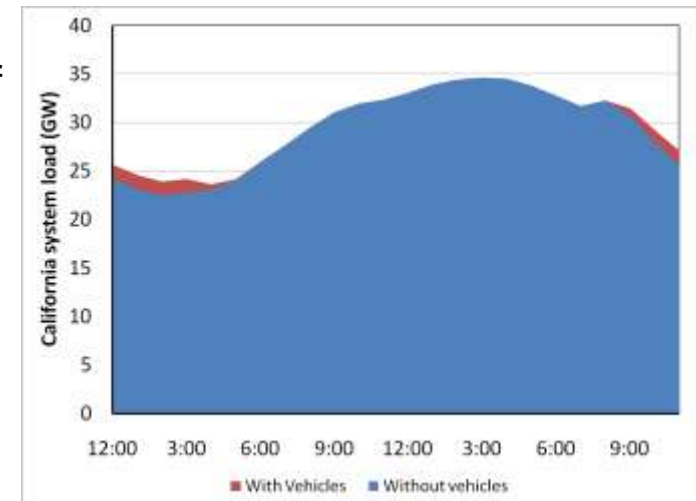
# EPRI PEV Distribution System Impacts

## • Charging Behavior

- Correlate more closely with statistical driving patterns
- Controlled charging can significantly resolve projected impacts of PEV to assets
- Simple TOU program could create potential high level of coincident charging

## • Localized Adoption

- Initial PHEV adoption is likely to be geographically contained within residential neighborhoods
- Even for low overall customer PEV adoption rates, PEV clusters can still occur.
- When geographic clustering occurs, distribution planners need to know the possible impact on local service transformers compared to their capacity.

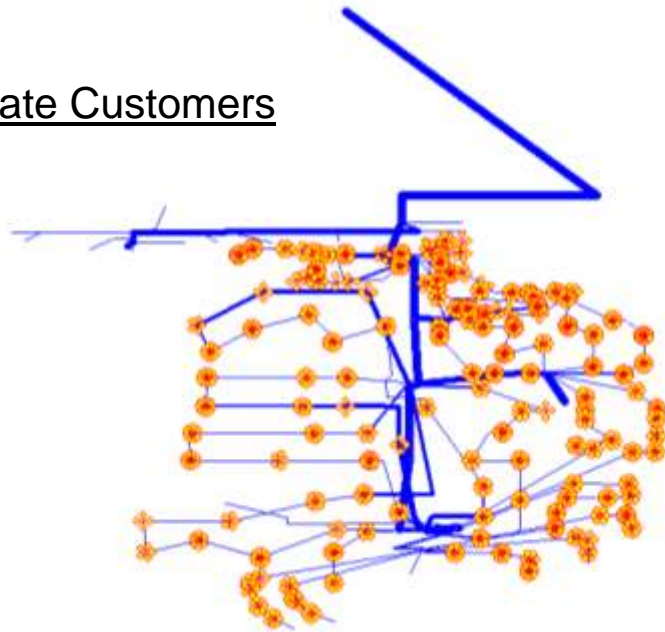


# Flat Rate vs TOU Customers

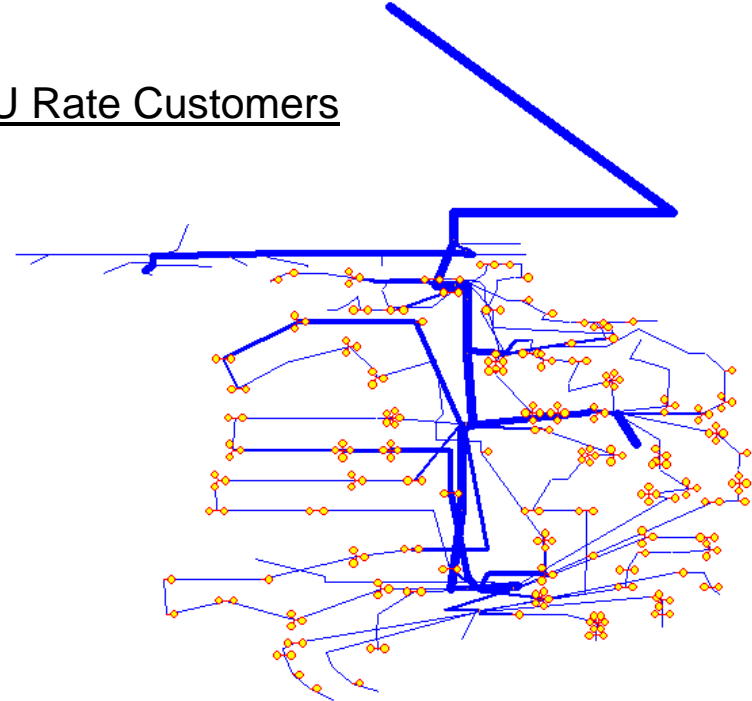
- 101 out of 145 transformers have TOU customers (70%)
- Maximum ratio of TOU customers per transformer is 50%

Xfmr kVA	Total xfms	Xfms with TOU Customers
25	5	2
37.5	1	1
50	57	36
75	81	61
100	1	1

Flat Rate Customers



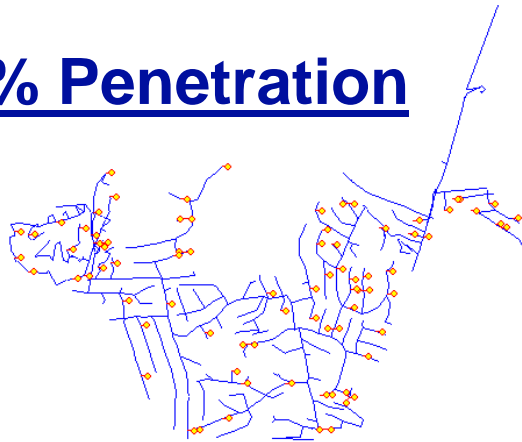
TOU Rate Customers



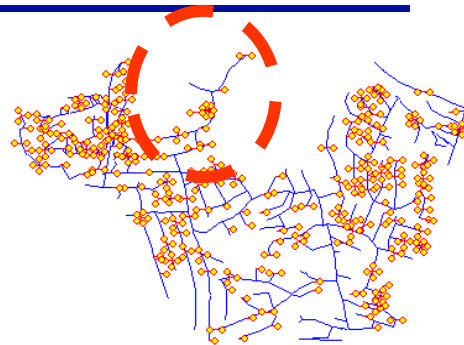
# PHEV Clustering

- No data to support differentiation of customer preference
- Clusters occur from penetration and system configuration

**2% Penetration**



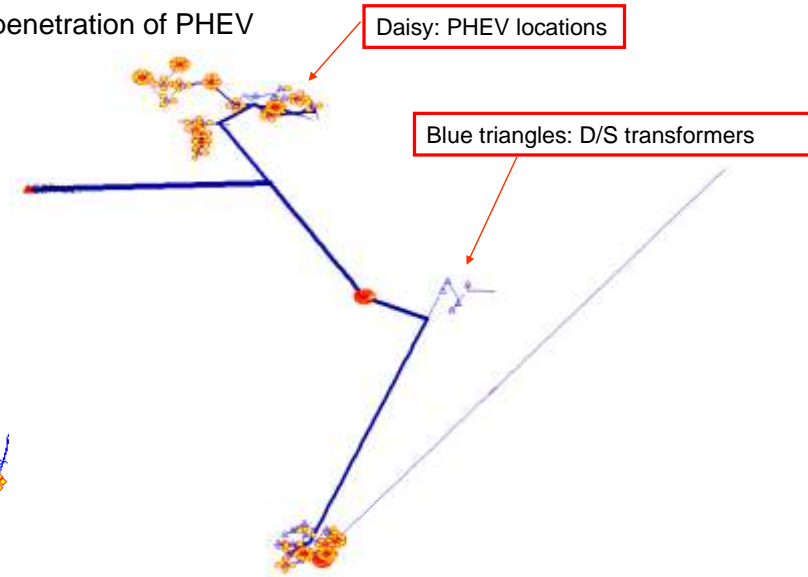
**8% Penetration**



×8% penetration of PHEV

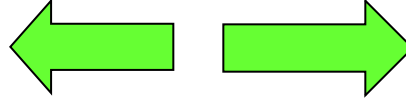
Daisy: PHEV locations

Blue triangles: D/S transformers



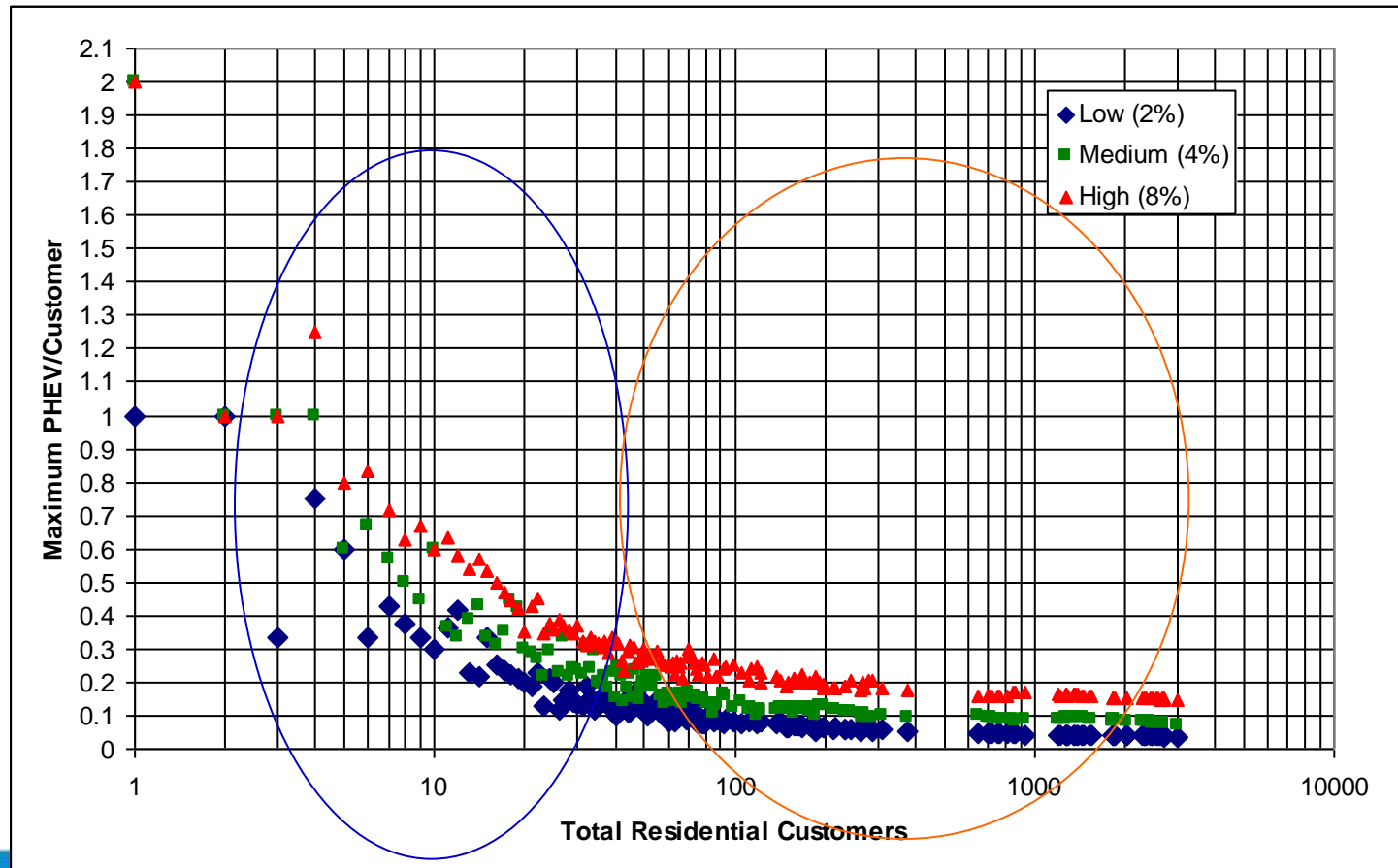
# Clustering/Penetration Relationship

Cluster

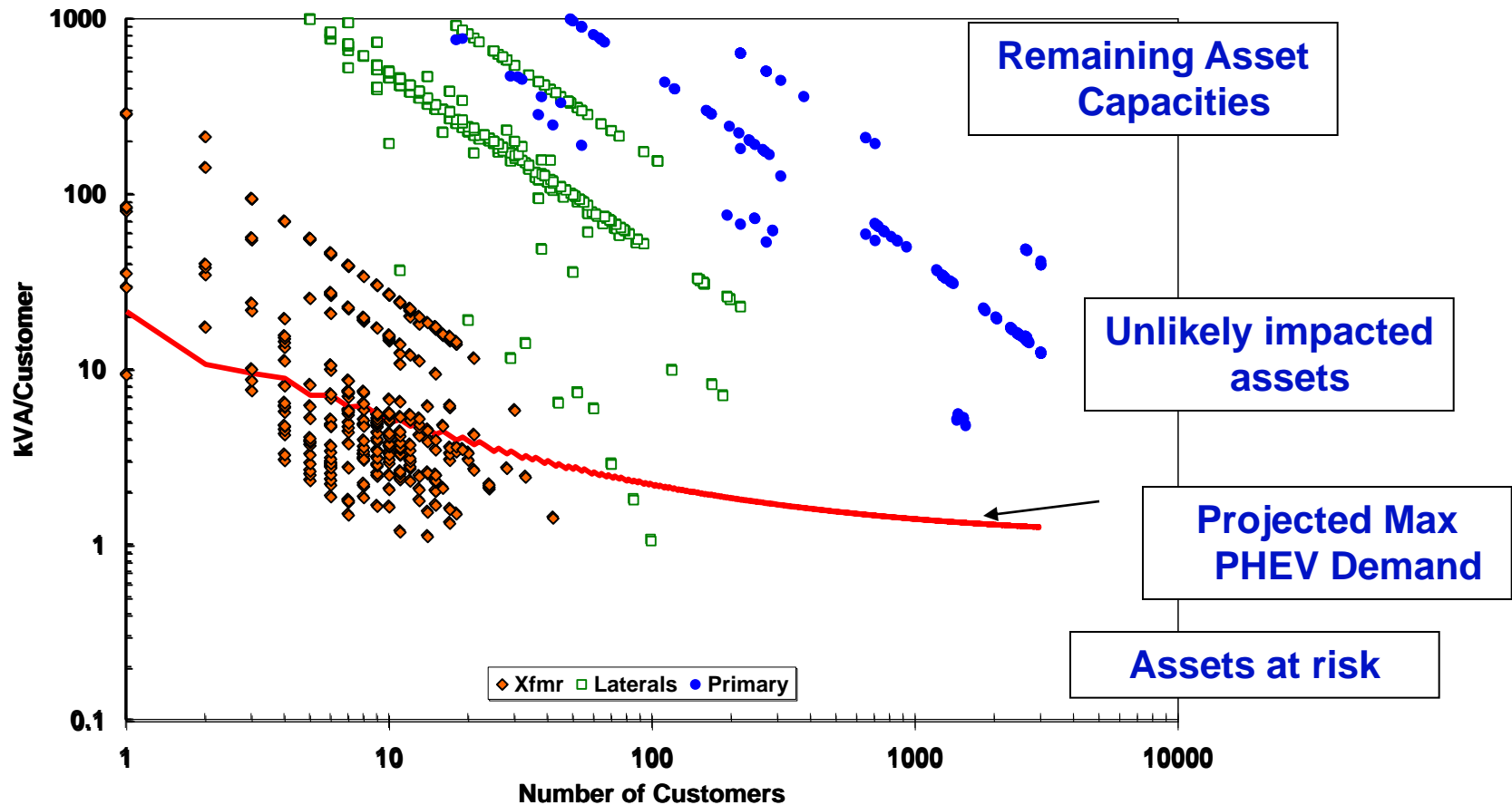


Penetration

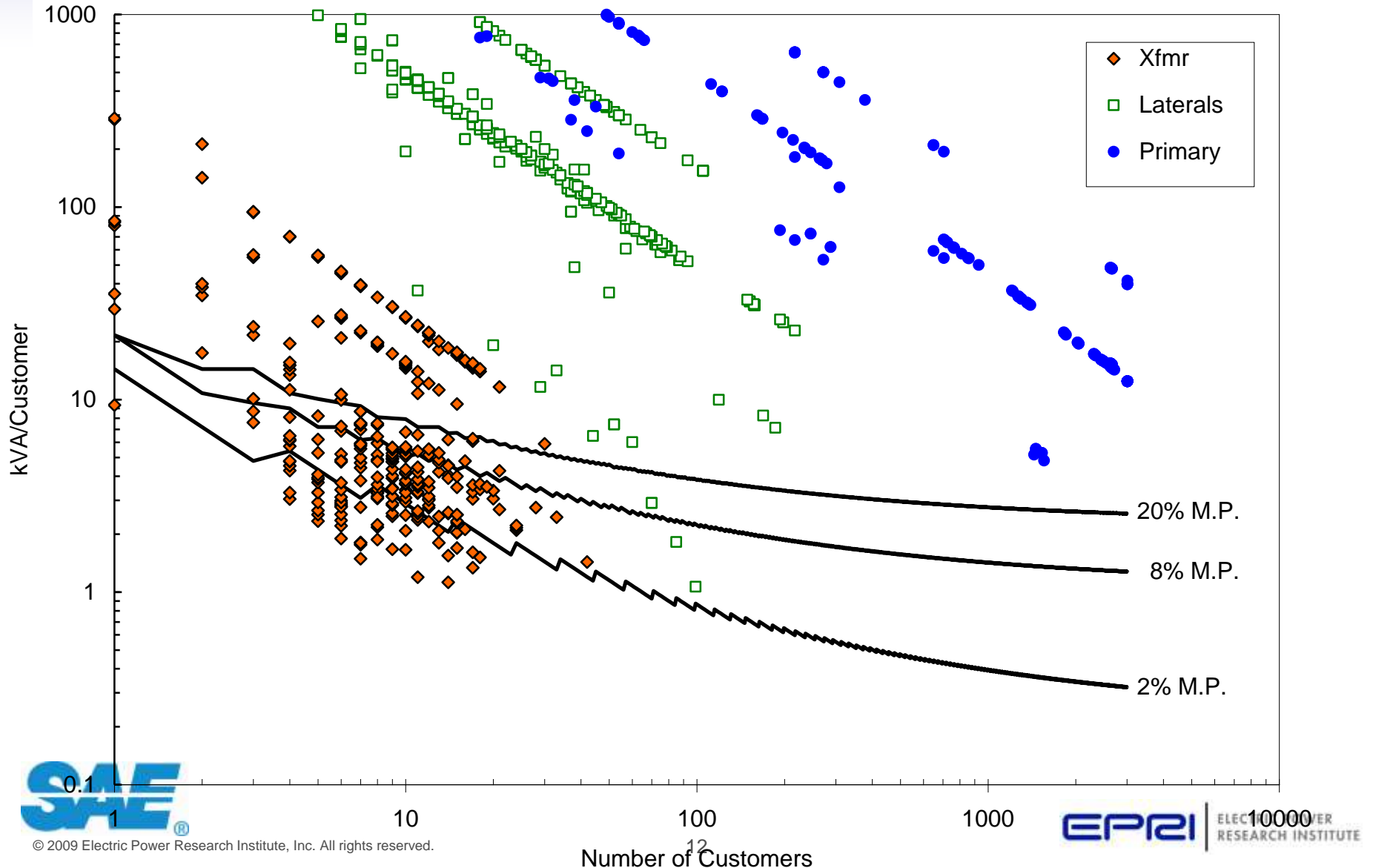
PHEV Cluster size versus Customers Served



# Evaluating Thermal Overload Risk



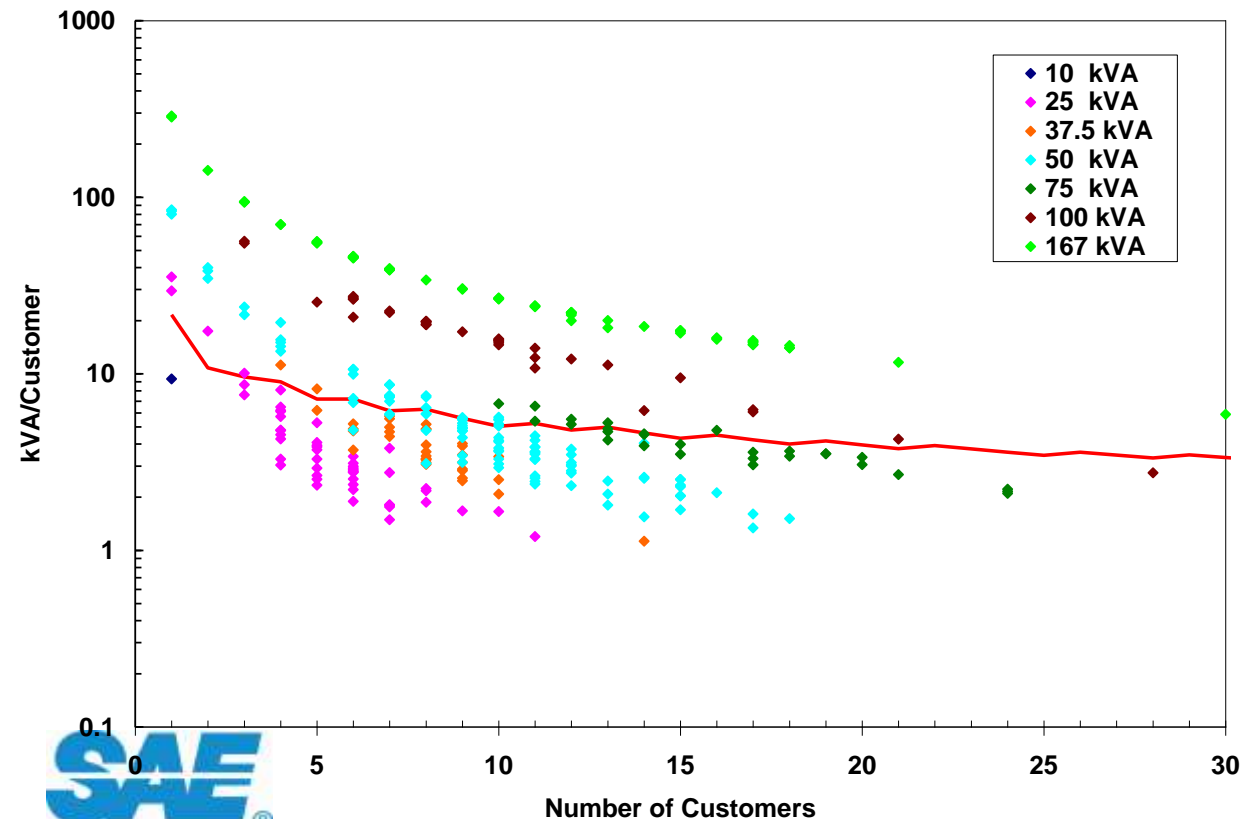
# Evaluating Thermal Overload Risk



# Risk Factors

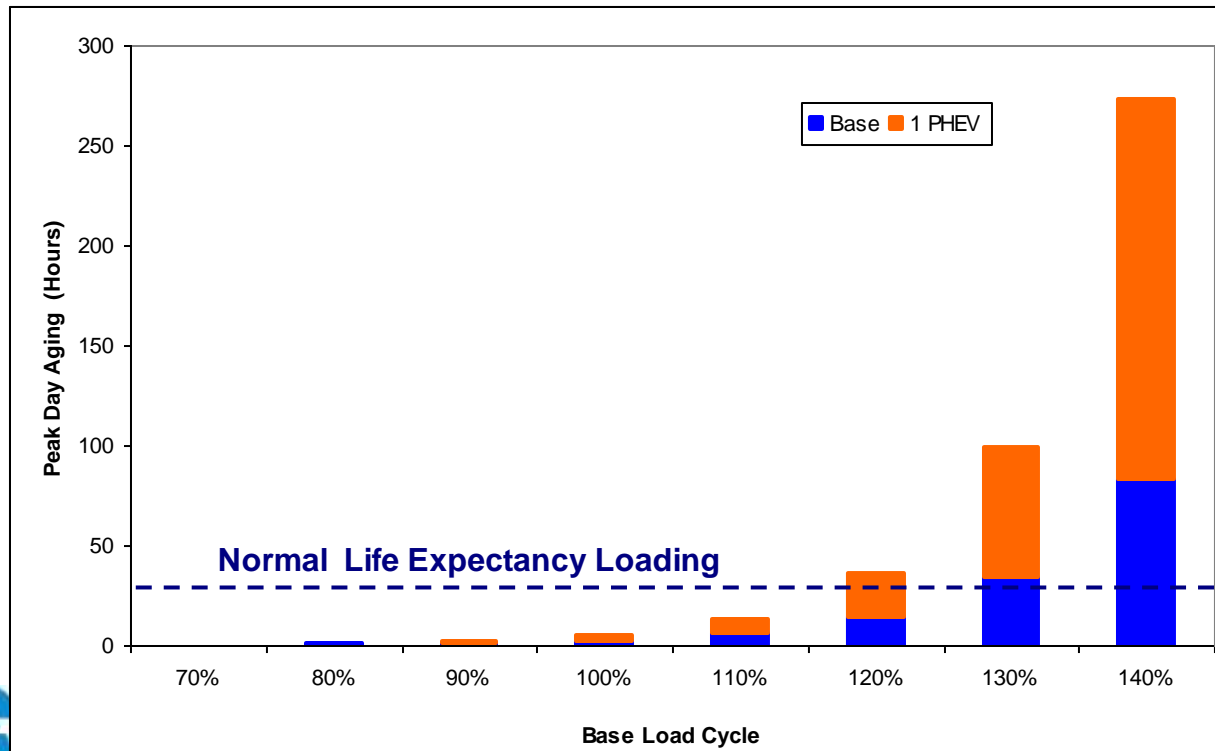
- Rating
- Loading
- Customers served

“Assets closest to the customer will benefit the least from load diversity”



# Transformer Loss of Insulation Life

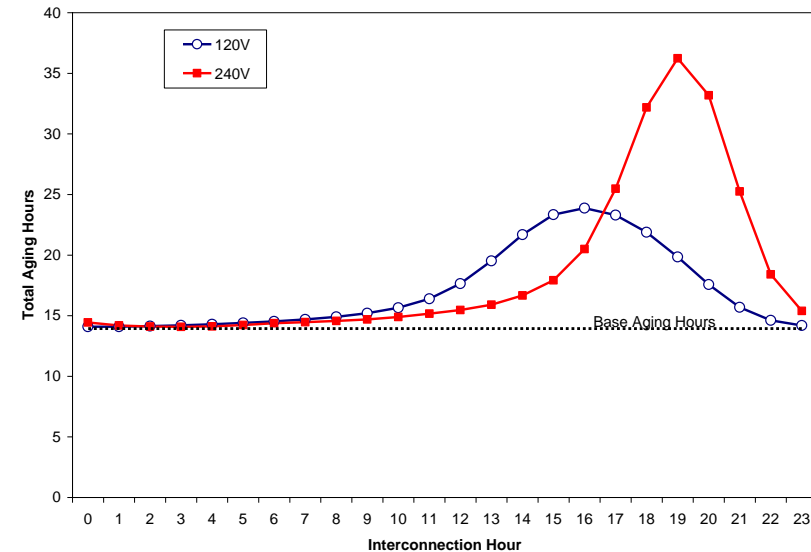
- Thermal ratings are the strongest indicator of potentially significant impacts
  - Existing loading conditions
  - Additional PEV load



**“Planned Loading Beyond Nameplate can account for high peak day aging”**

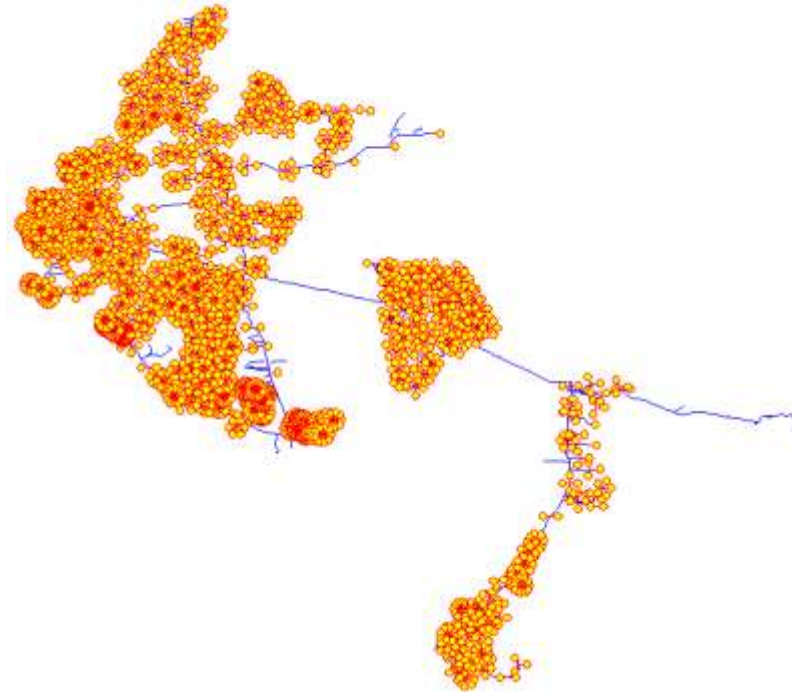
# Transformer Loss of Insulation Life

- Thermal overload results indicate:
  - Which assets are at risk
  - Likelihood of impacts
  - Required PHEV loading conditions
- These results characterize the feeder/utility impact
- Thermal aging calculations must take these specific factors into account along with accurate
  - Ambient temperature data
  - Transformer thermal characteristics
- Thermal Aging
  - Largest impacts occur when the base load levels are already high
  - Late night charging minimizes additional impacts



# Circuit Characteristics and Behavior

- PEV impact is specific to characteristics of each utility circuit.
- Most significant impact on assets closest to the point of interconnection of these loads
  - Older neighborhoods with aging infrastructure and limited additional capacity
    - Low capacity per customer ratios combined with low PEV load diversity
    - Low voltage distribution (4kV)
    - Highly loaded transformers
    - Undersized customer entrance wiring
    - Networked Circuits



# Near-term Impacts

- Similar nature to standard load-growth
- PEV clustering has the potential to impact assets
  - Closest to the customer
  - Existing heavy loading
  - Smaller transformer sizes
- Potential adjustments to planning standards
  - Transformer sizing
  - Customers served off each transformer
  - Transformer thermal ratings