EVS 27

The 27th INTERNATIONAL ELECTRIC VEHICLE SYMPOSIUM & EXHIBITION.
Barcelona, Spain
17th-20th November 2013

Electricity Distribution and Grid Management - Where do we Stand?

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EVS 27, Barcelona, Spain
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PEV Charging Options

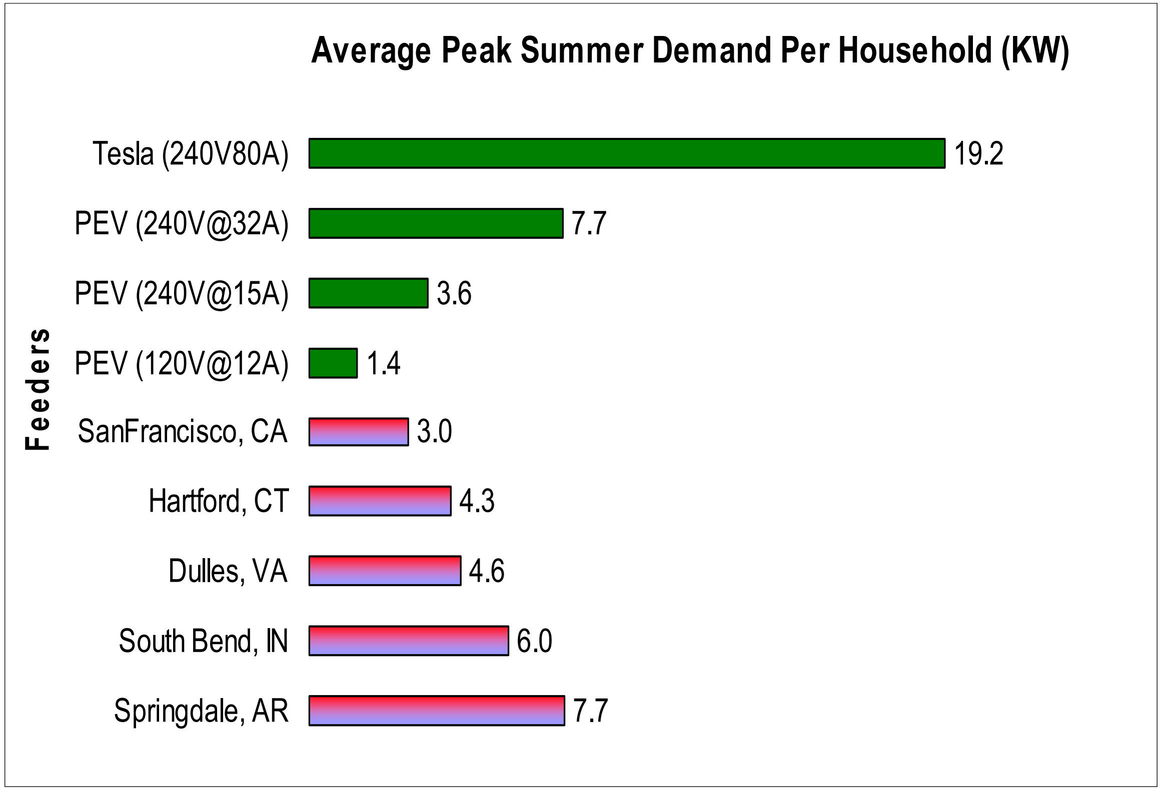
Name:	Level 1 AC	Level 2 AC	Level 2 DC
Voltage:	120V AC, 1 phase	208/240V AC, 1 phase	200V-480V, 3 phase AC
Amps (max):	16a	80a (30a typical)	70a @ 480V (max 200a)
Power:	1.44 kW	3.3 – 6.6 kW (max 19.2 kW)	Up to 90 kW
Standardized:	Yes	Yes	No
Range/charging hour:	~5 miles	~10 – 20 miles	
Connector:	SAE J1772	SAE J1772	SAE combo / CHAdeMO

Data is still being gathered how much power customers "need"

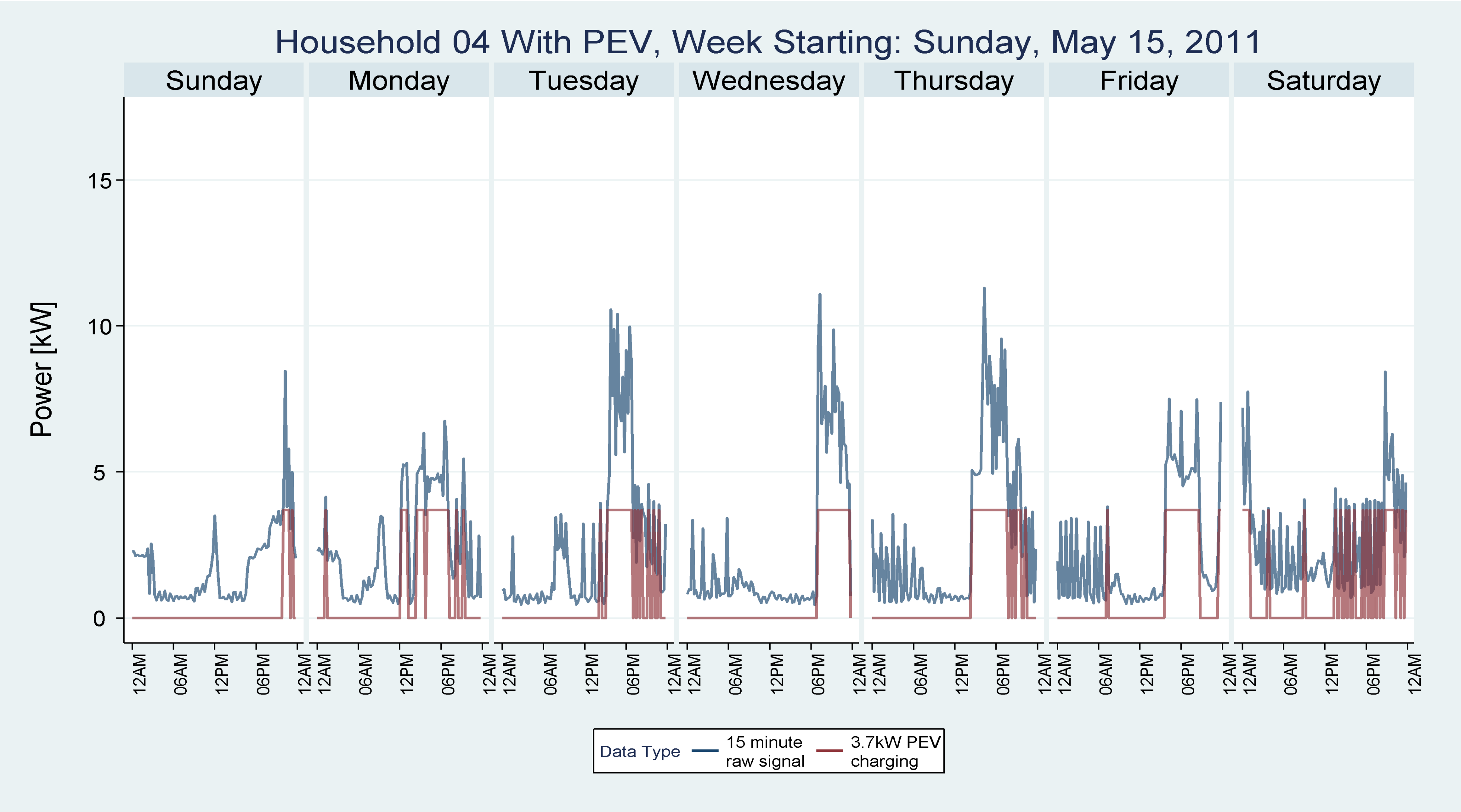
Source: Electric Drive Transportation Association, www.electricdrive.org, Society of Automotive Engineers (SAE)

Distribution Impacts of PEV Charging

- Local distribution transformers are among the first equipment impacted
- Charge power is the likely dominant factor determining impact, not time-of-day
- Charge power is increasing—automotive OEMs trend to about a four-hour charge time
  - 19.2 kW is the maximum for residential AC charging
- TOU rates and other off-peak charging programs mitigate upstream impacts but offer limited help to local transformers
  - Especially true with clustering



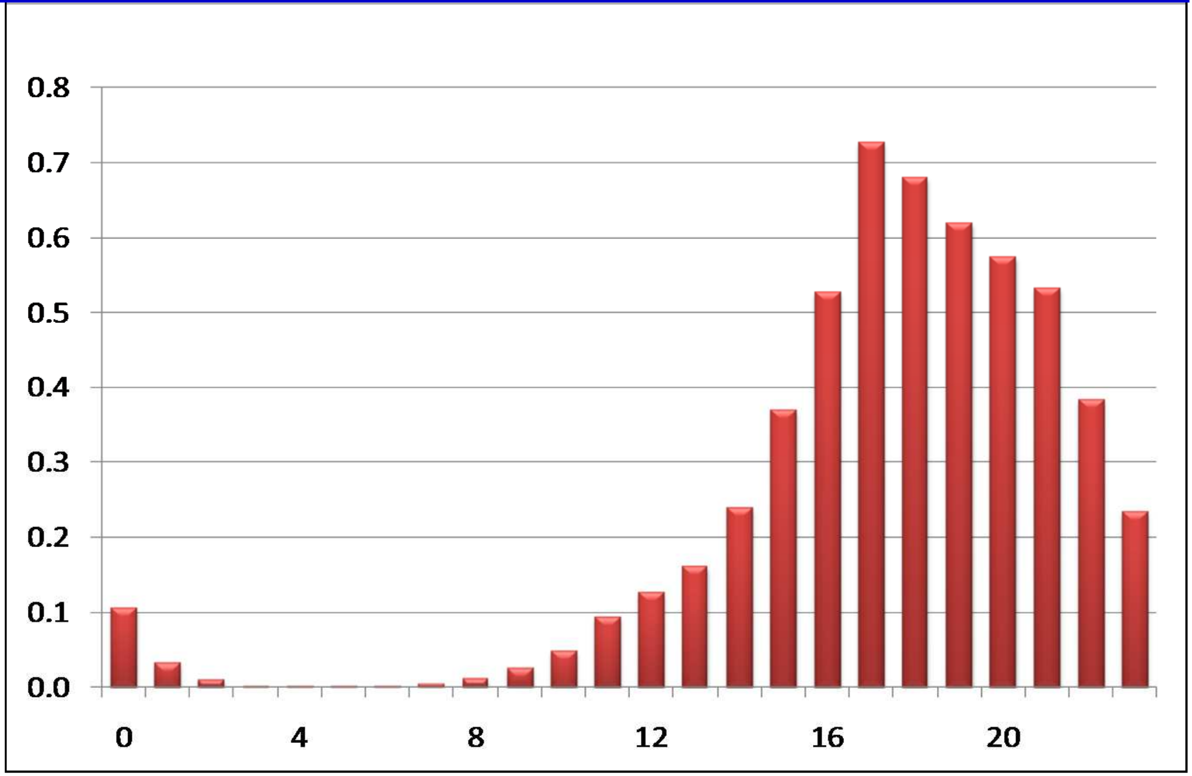
PEV Location Determination Using Smart Meter Data



Source: Oncor.

Aggregate PEV Demand

Hourly Demand per PEV (kW)



Peak Demand
720 W / PEV

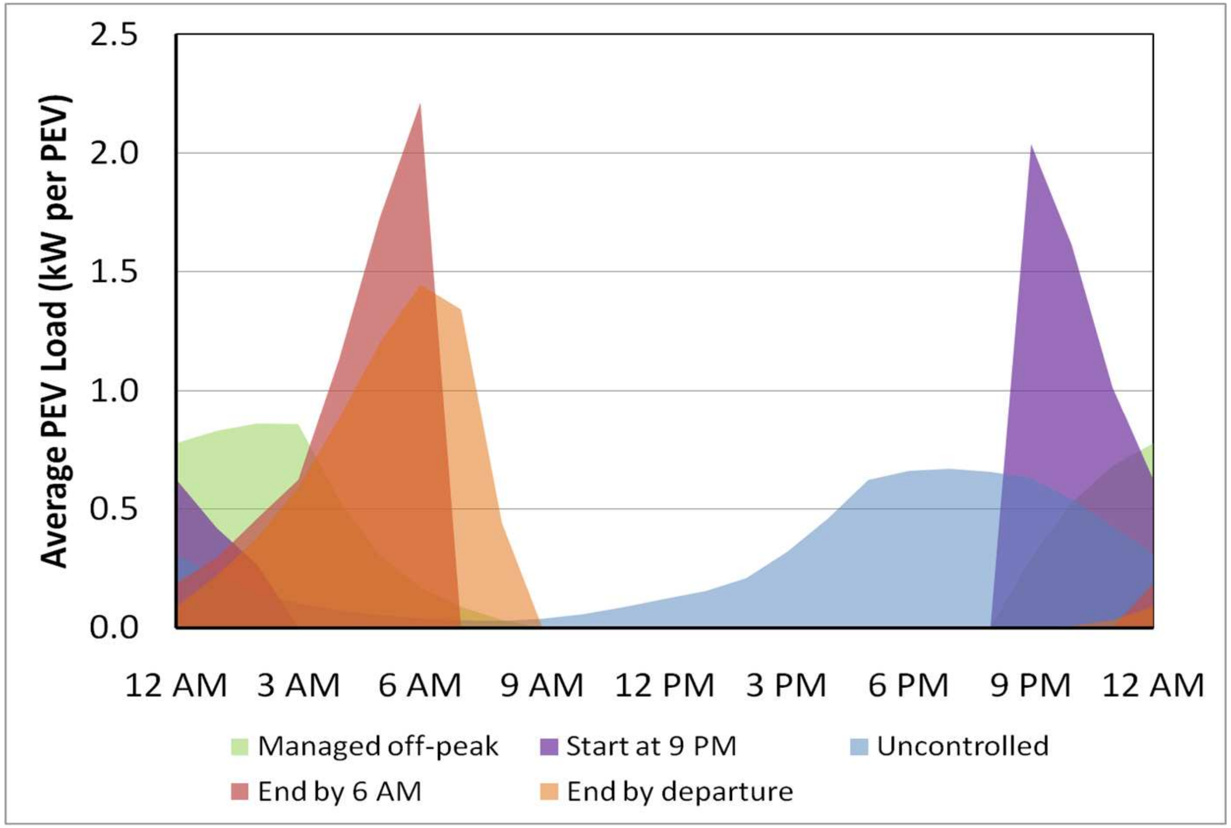
Average Energy Consumption
5 kWh / day

75% of charging occurs between 4 – 9 pm

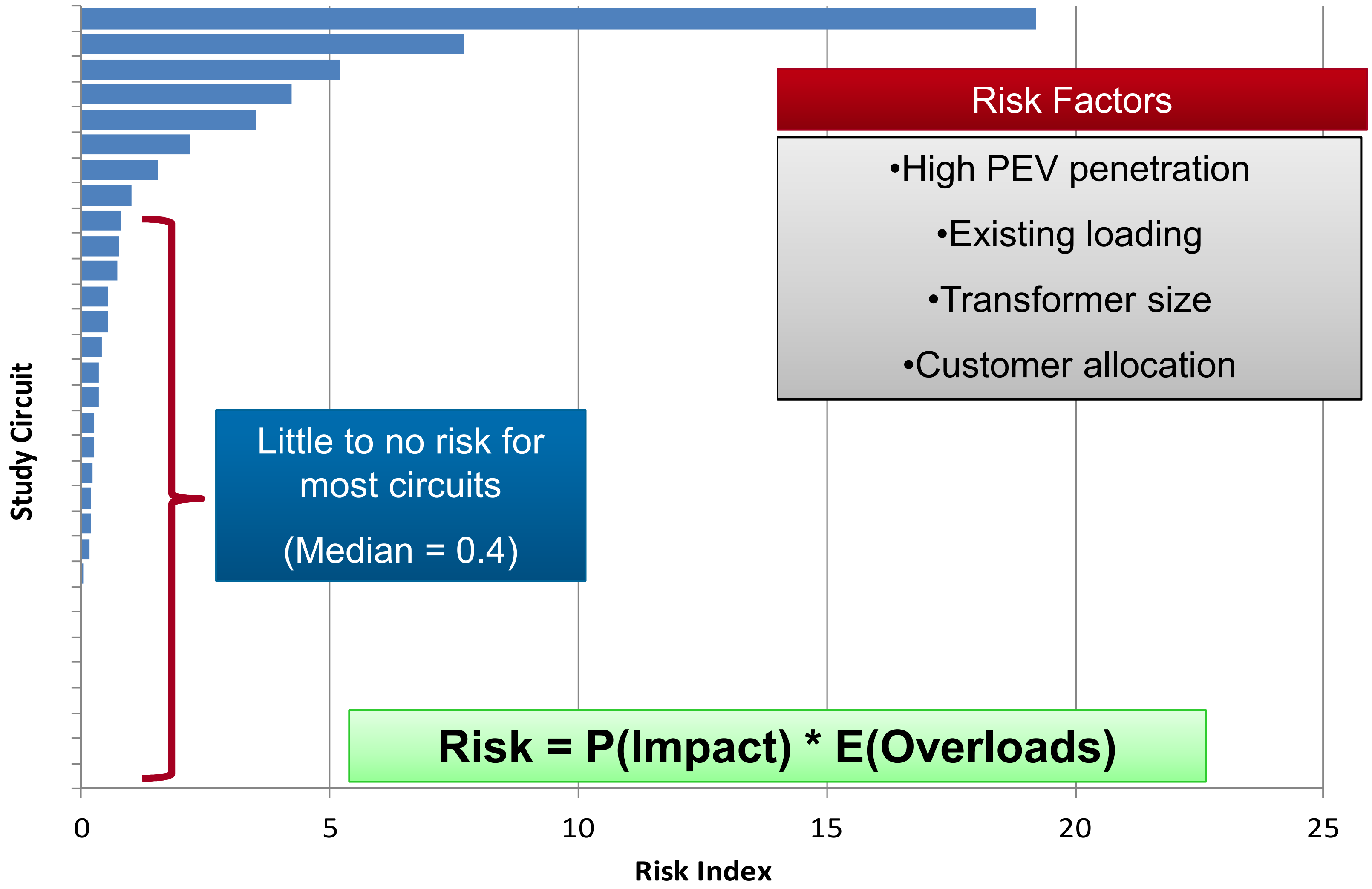
Demand strongly correlates with home arrival

Different Charging Algorithms Impact Timing, Magnitude of Demand

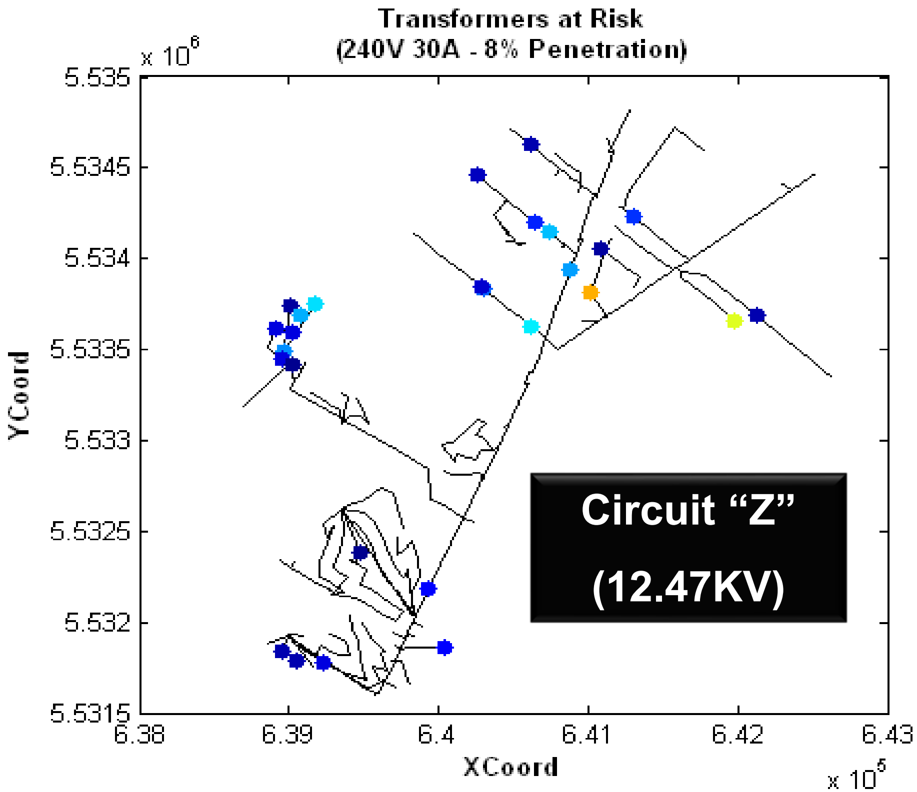
- Timed charging increases per vehicle peak demand, but shifts load away from the peak
  - May be possible to create a second peak, but diversity can minimize
- Managed off-peak charging best combination
  - Low peak demand
  - Fill nighttime valley
  - How to implement on a widespread basis?

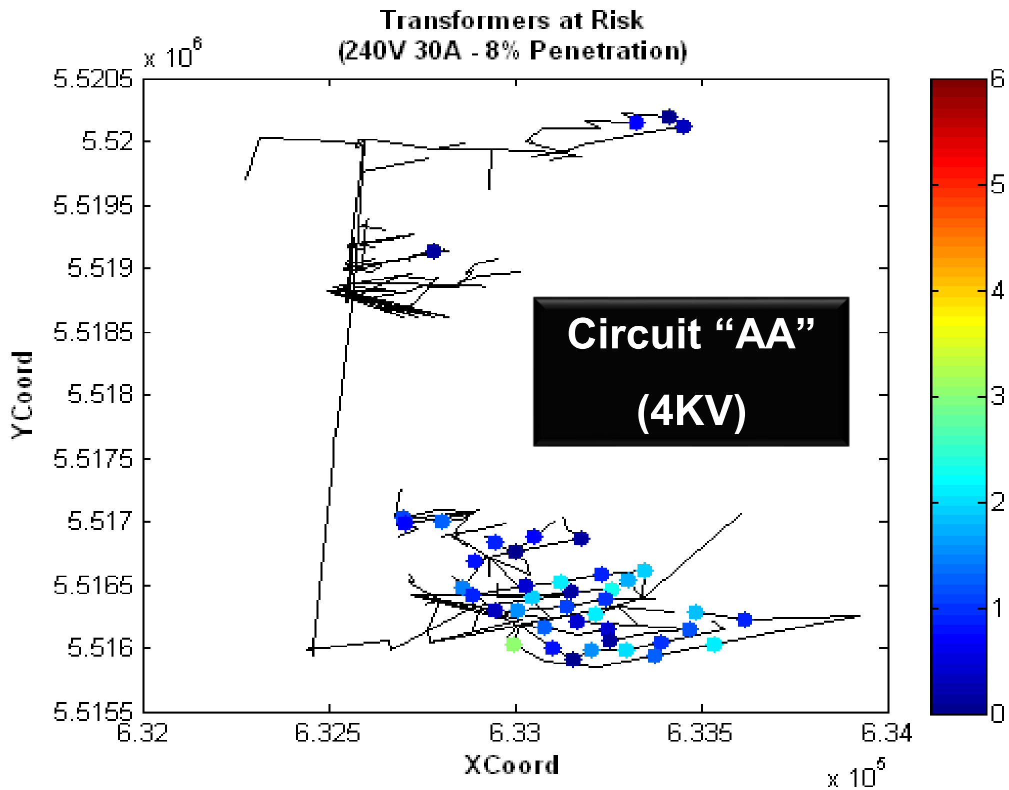


Service Transformer Overload Risk



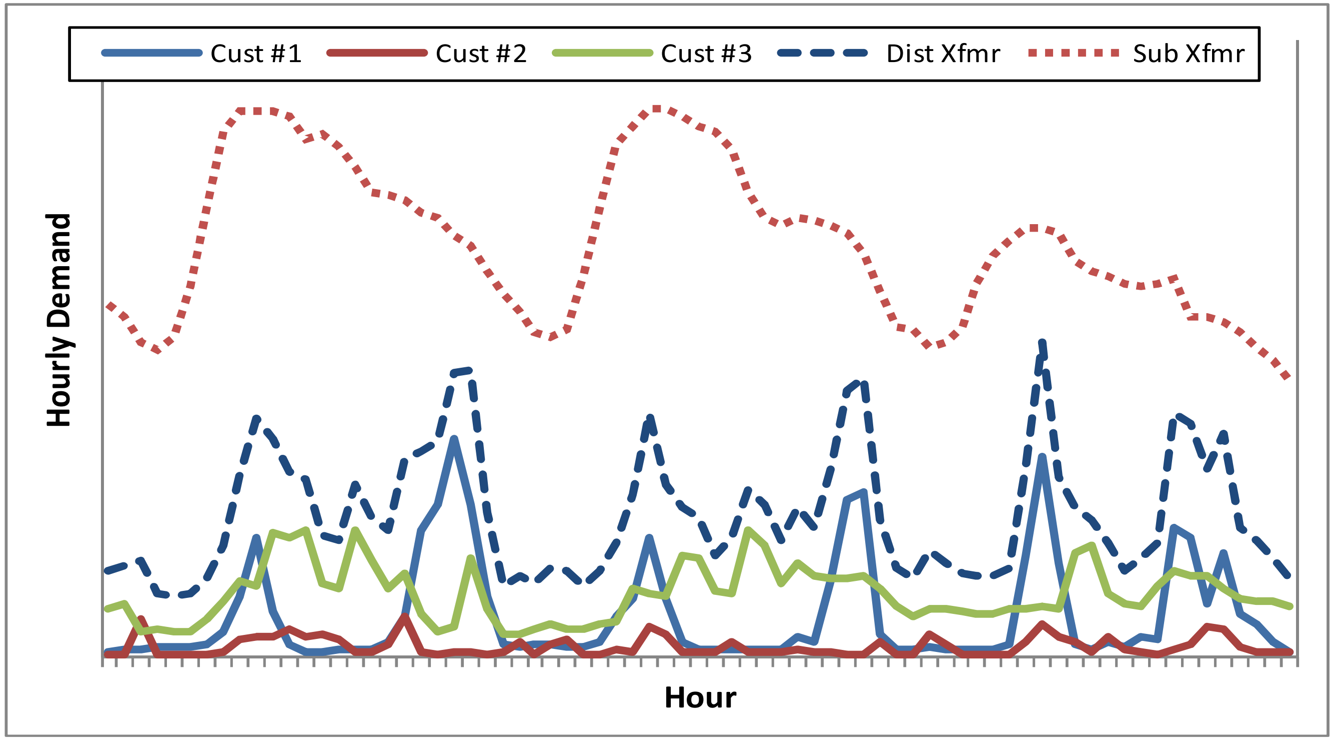
Circuit Characteristics and Design – 4KV Versus 13KV Systems





Clustering cannot result in widespread system impacts

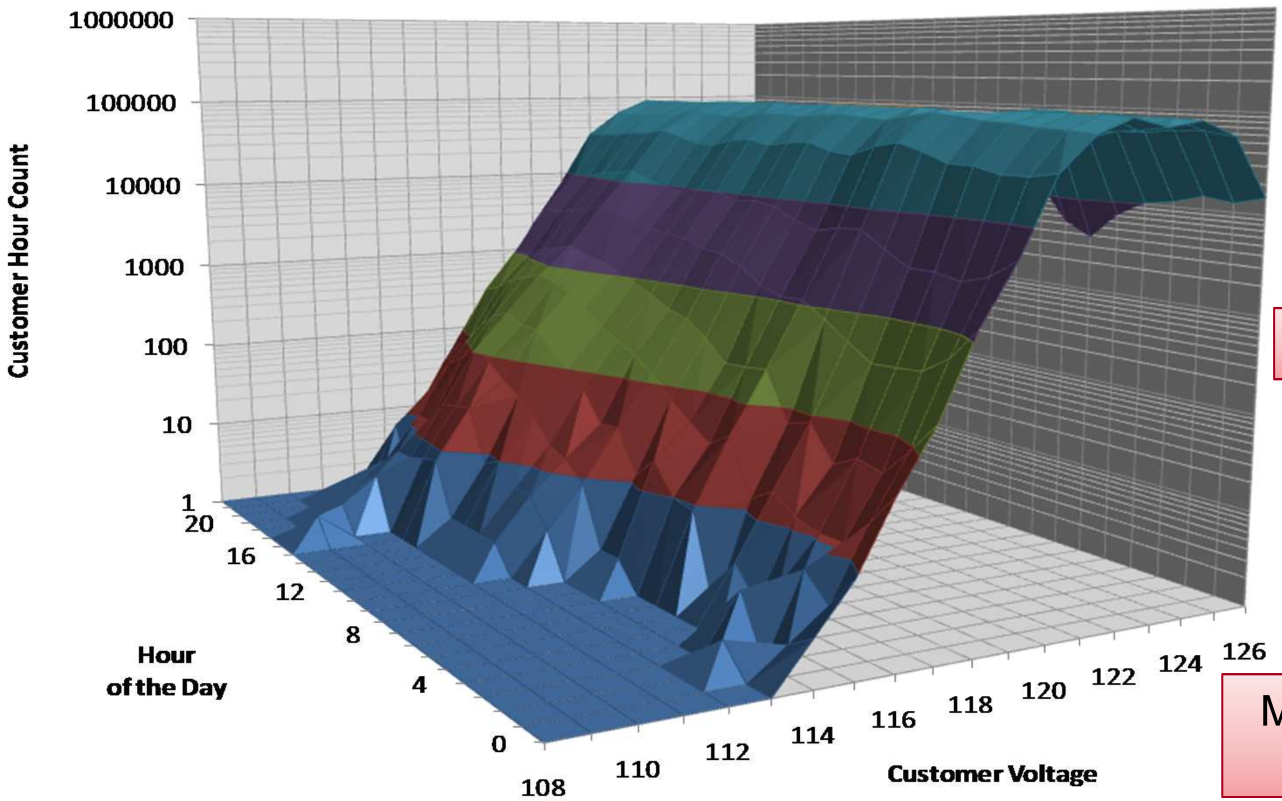
AMI Data – Substation Versus Transformer Loading



Localized peaks do not always correlate with substation demand

Controlled Charging must consider loading conditions for both substation and individual distribution transformers

AMI Low Voltage Occurrence – Consumers Energy



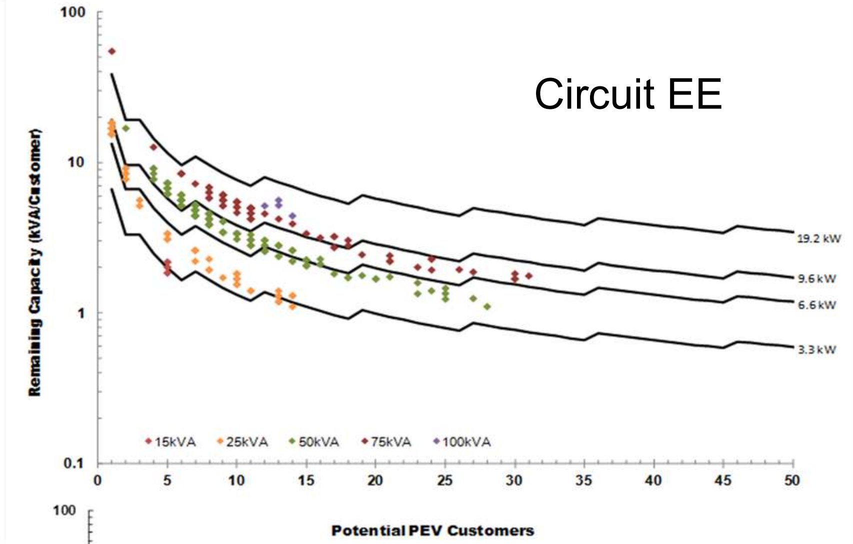
0.005% of Customer hours < 114V

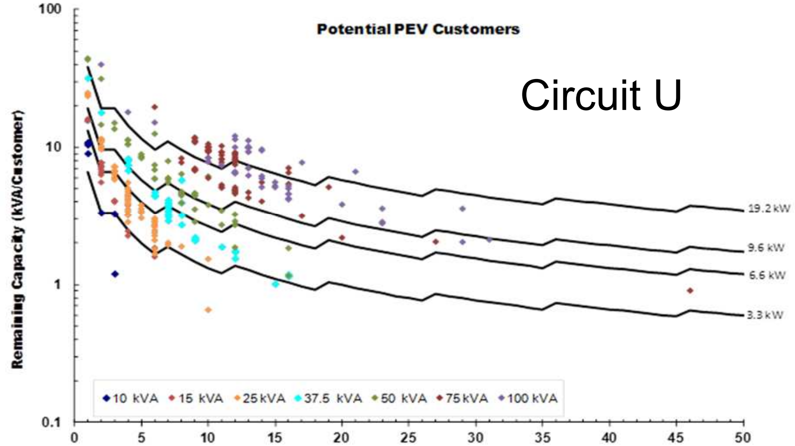
Majority of hours spent at the upper range of the ANSI requirements

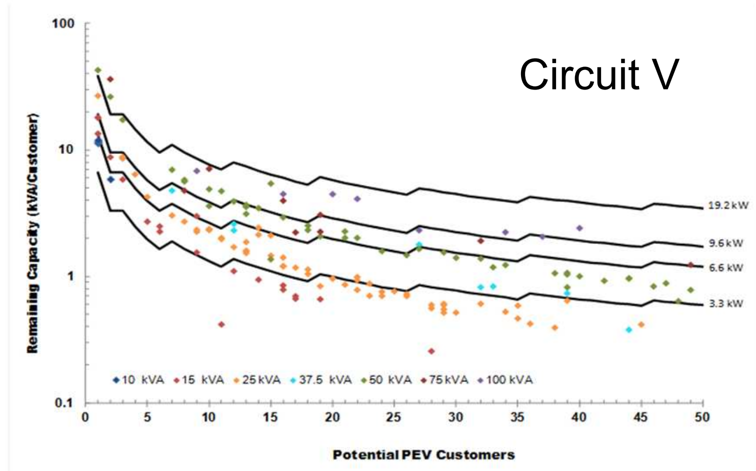
Overall customer voltages do not vary greatly over time (Good voltage regulation)

3 CA Distribution Circuits

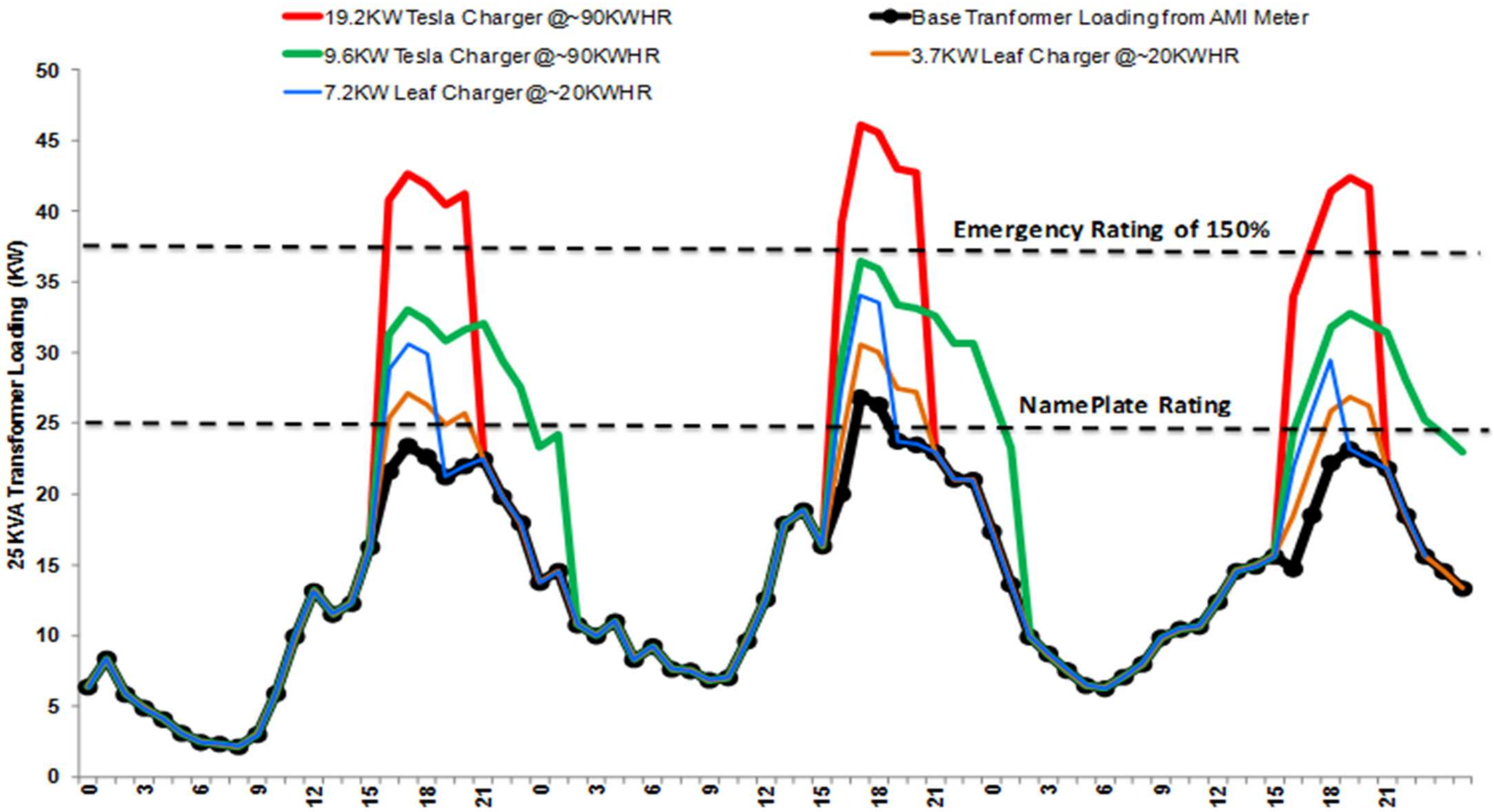
- 8% penetration with different charging rates for the three circuits
  - Circuit EE – 358 potential PEV customers out of a total of 2803 utility customers
  - Circuit U – 318 potential PEV customers out of a total of 2482 utility customers
  - Circuit V – 426 potential PEV customers out of a total of 3325 utility customers



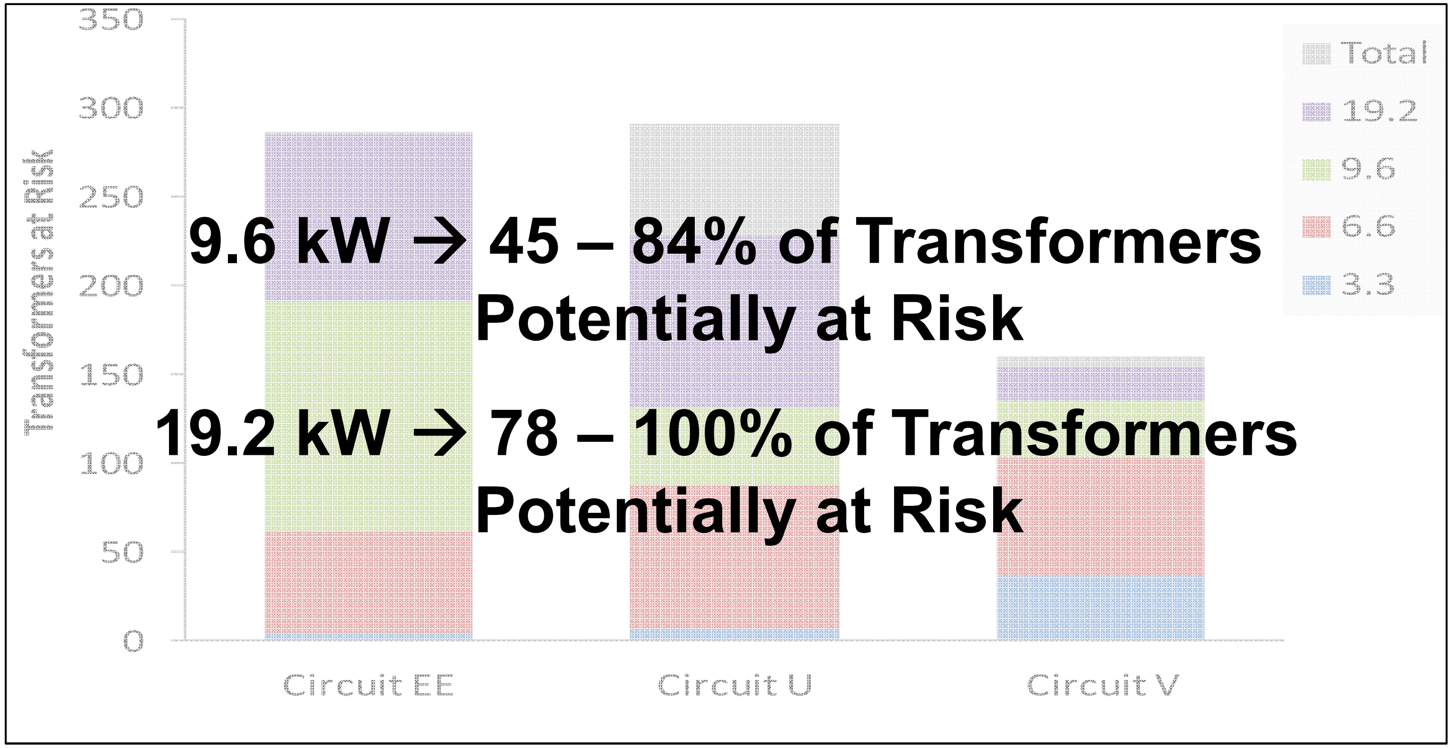




Sensitivity of Different PEV Charge Levels on Example 25KVA Distribution Transformer Loading

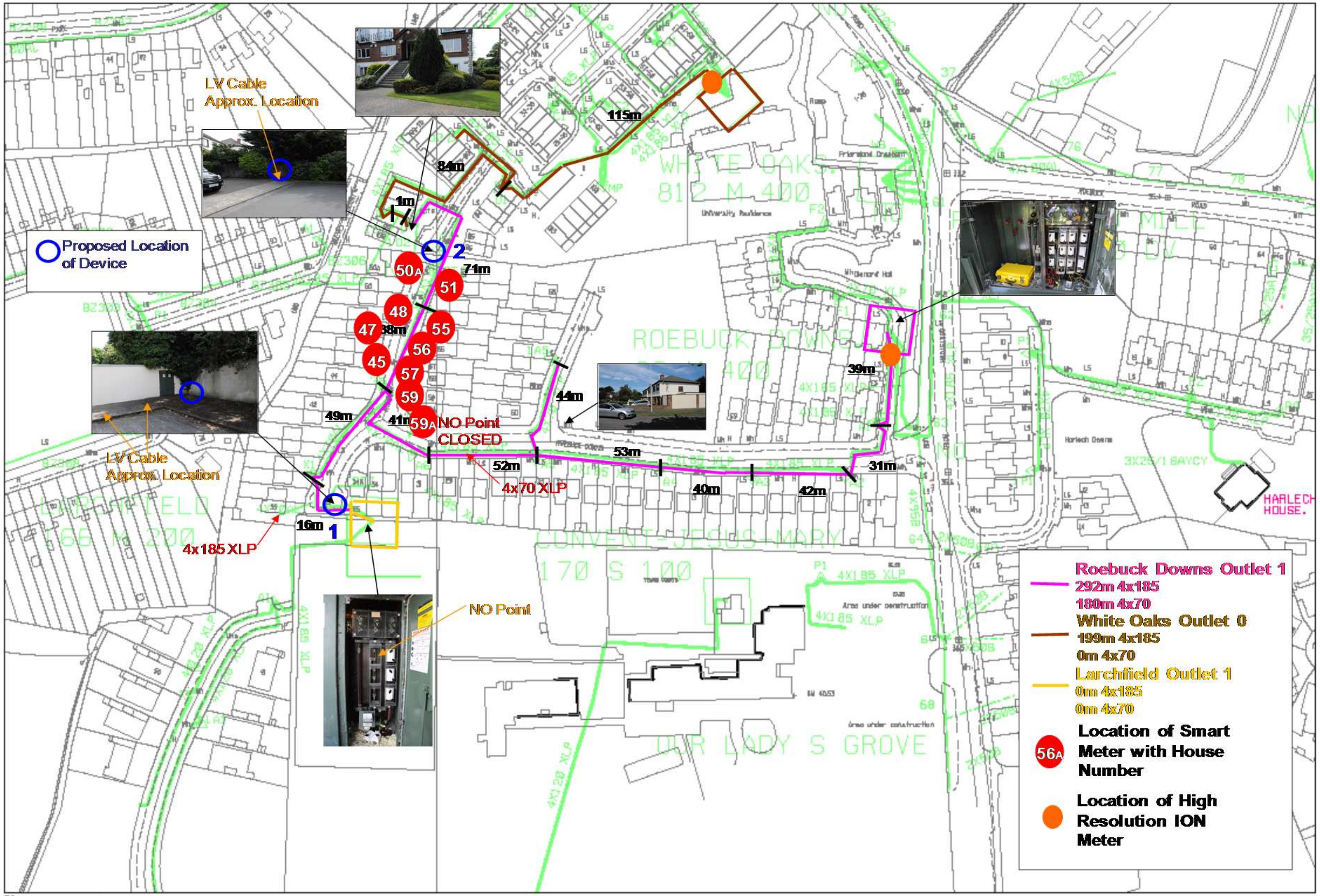


Increasingly High Charge Rates Create Disproportionate Grid Impacts – 3 CA Distribution Circuits



Charge Rate	Count of Transformers at Risk (% of Transformers at Risk)		
	Circuit EE	Circuit U	Circuit V
3.3	5 (2%)	7 (2%)	37 (23%)
6.6	62 (22%)	88 (30%)	103 (64%)
9.6	192 (67%)	132 (45%)	136 (84%)
19.2	285 (100%)	229 (78%)	155 (96%)
Total Xfmrs	286	292	161

ESB Distribution Field Trial



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FRAMME Web View

ESB Residential Network Field Trial Measurements

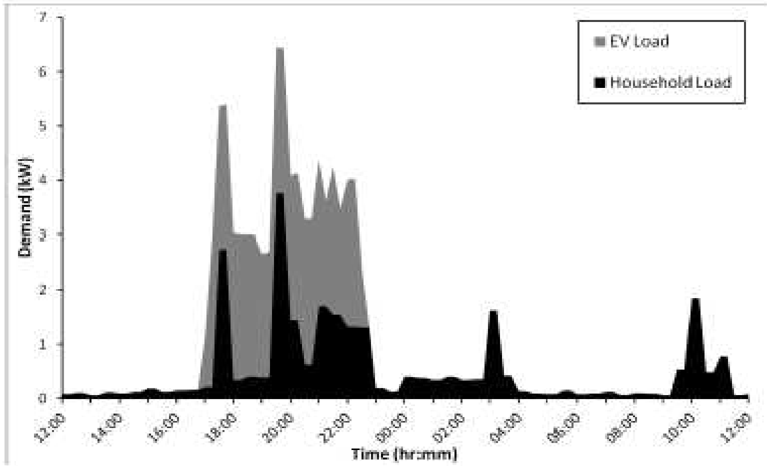


Fig. 3. Sample 24-hour residential demand and EV demand profiles for single customer with EV charging occurring during peak load hours.

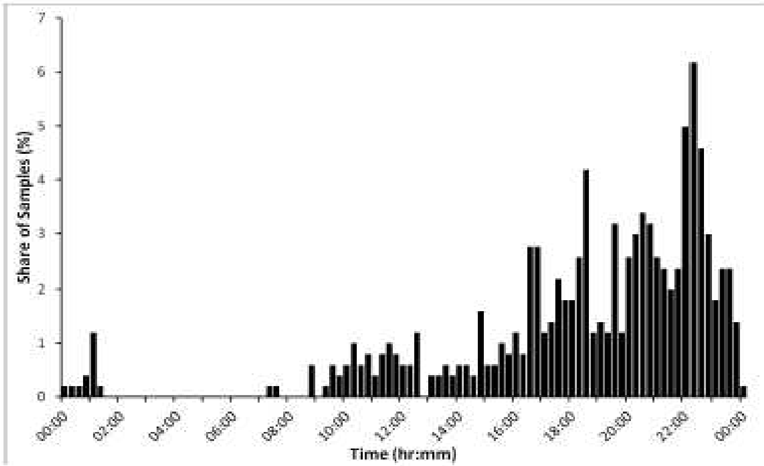


Fig. 5. Probability distribution function of EV connection times recorded during the field trials.

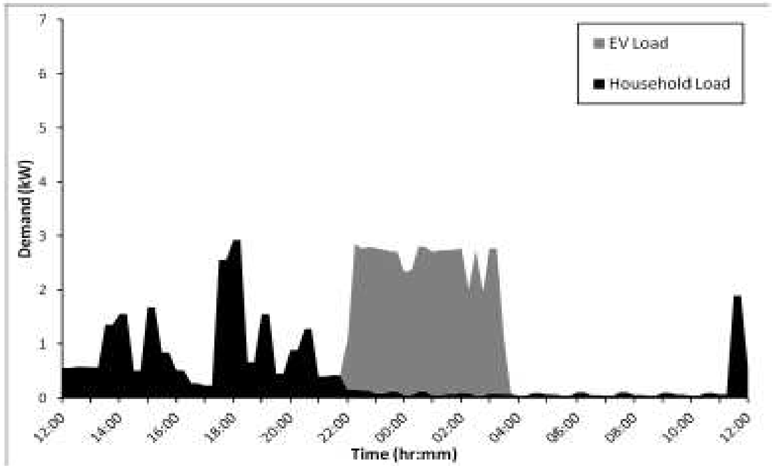


Fig. 4. Sample 24-hour residential demand and EV demand profiles for single customer with EV charging occurring during off-peak load hours.

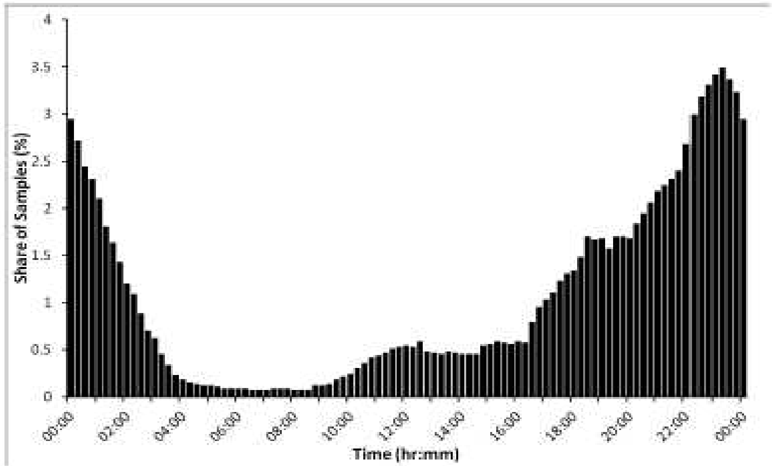
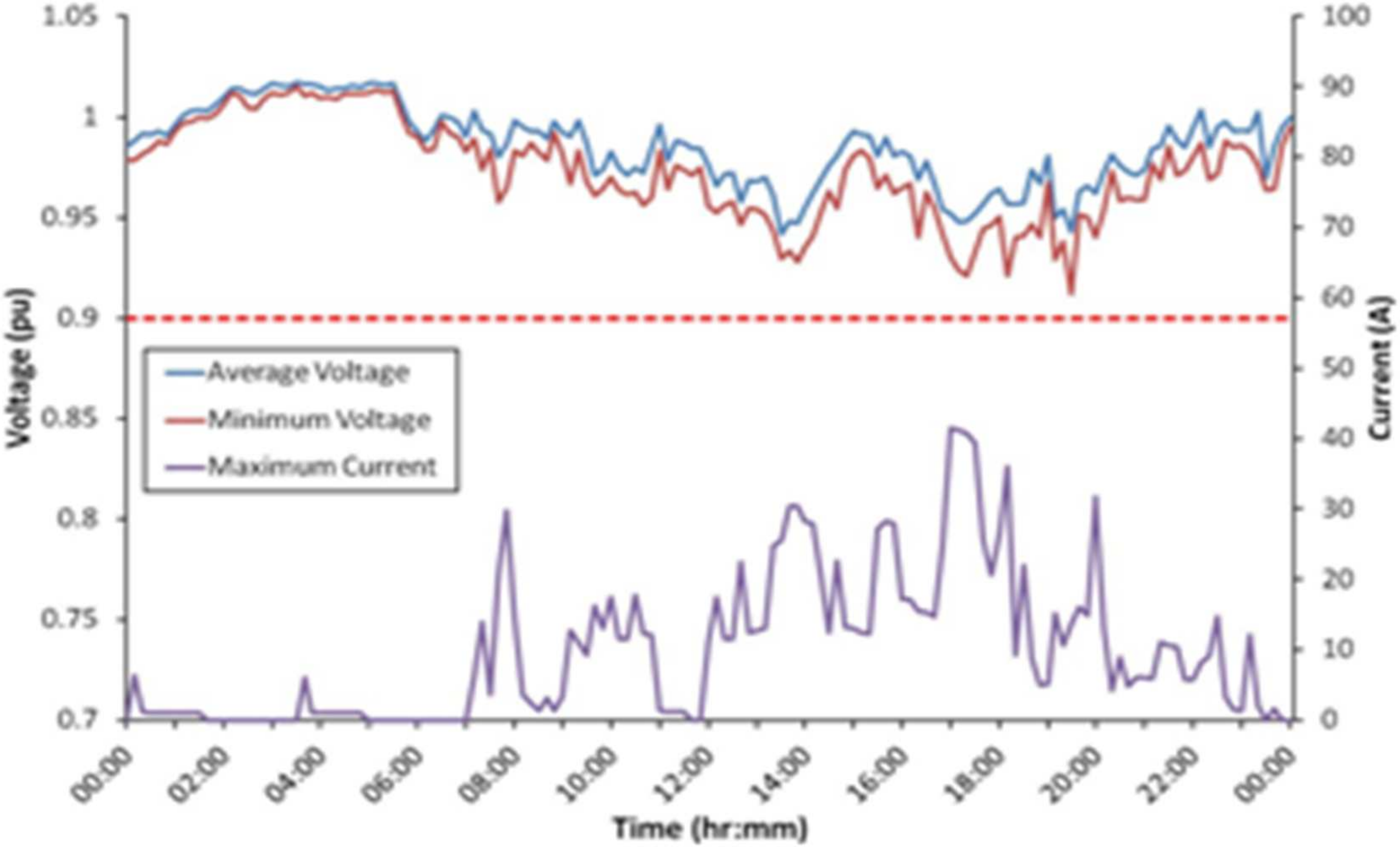


Fig. 6. Probability distribution function for the occurrence of EV charging over a 24-hour period.

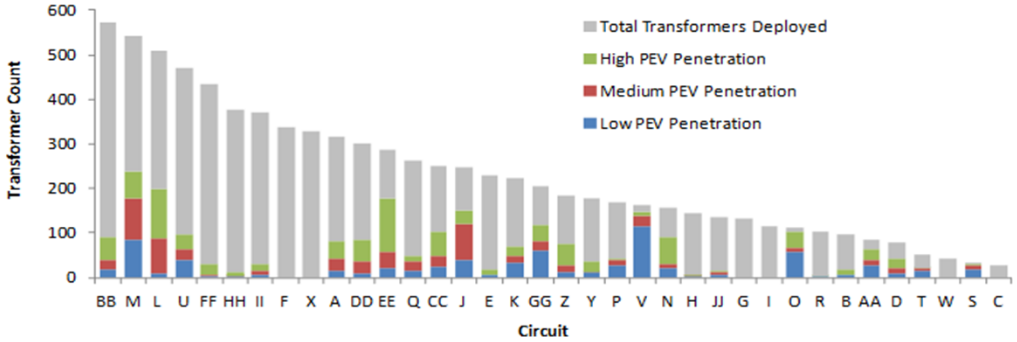
ESB Residential Network Field Trial Measurements



Voltage and Current Profiles for a Household at Remote End of Feeder for the 24-hour Period

Phase 1 PEV Distribution Impact Study

- **EPRI concluded multi-year Phase 1 – 19 utilities ~ 40 circuits**



Negligible Impacts

- System losses
- Primary voltage
- Power quality

Distribution analysis will guide smart charging implementations

Initial Impacts

- **High power PEV Charging (>6.6KW)**
- Transformer overloads and Loss of life
- Low secondary voltages

- **EPRI Report ID # 1024101**
  - Compilation and cross cutting results
  - Summaries of general concerns, asset risks, contributors, impact of charging profiles

Planning Adjustments

- Equipment sizing
- Asset-to-customer allocations
- Transformer ratings

Key Elements for Territory Wide Assessment

PEV Characteristics → P (Demand)

Distribution Asset Data

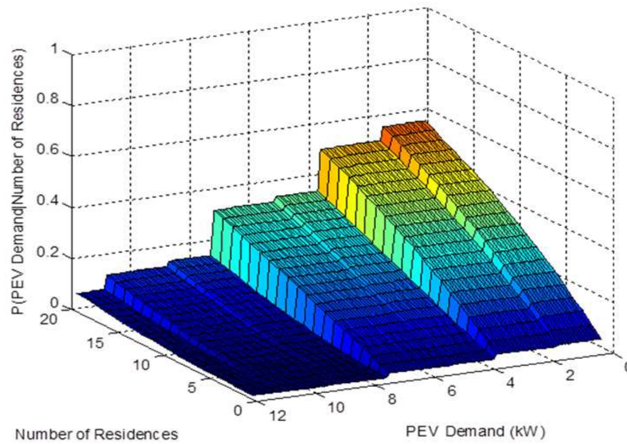
Asset Loading Database

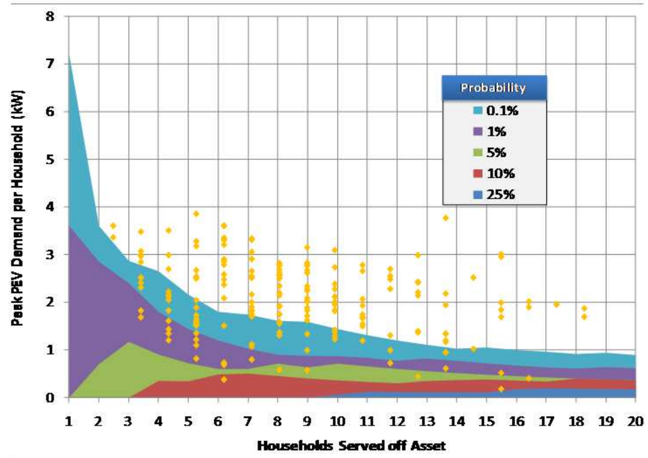
Asset Characteristics Database

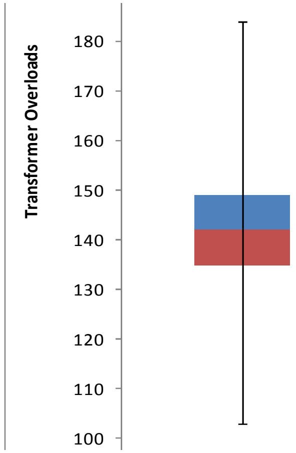
→ P (Capacity)

P (Demand) and P (Capacity) → P (Overload) → Asset Upgrade Assessment

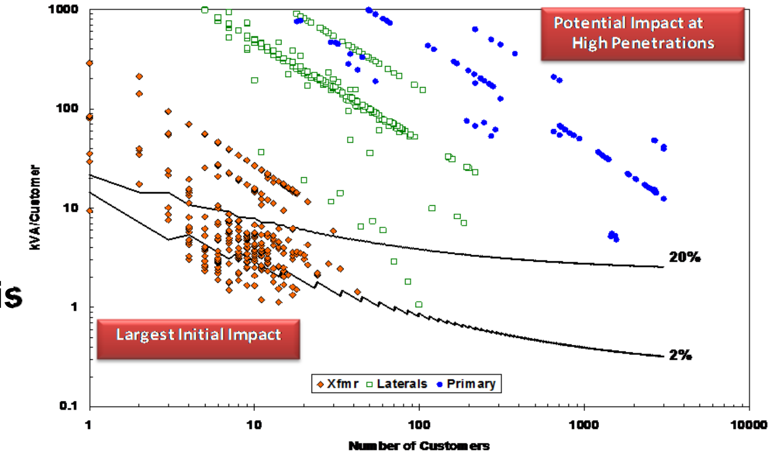
Probabilistic Risk Assessment



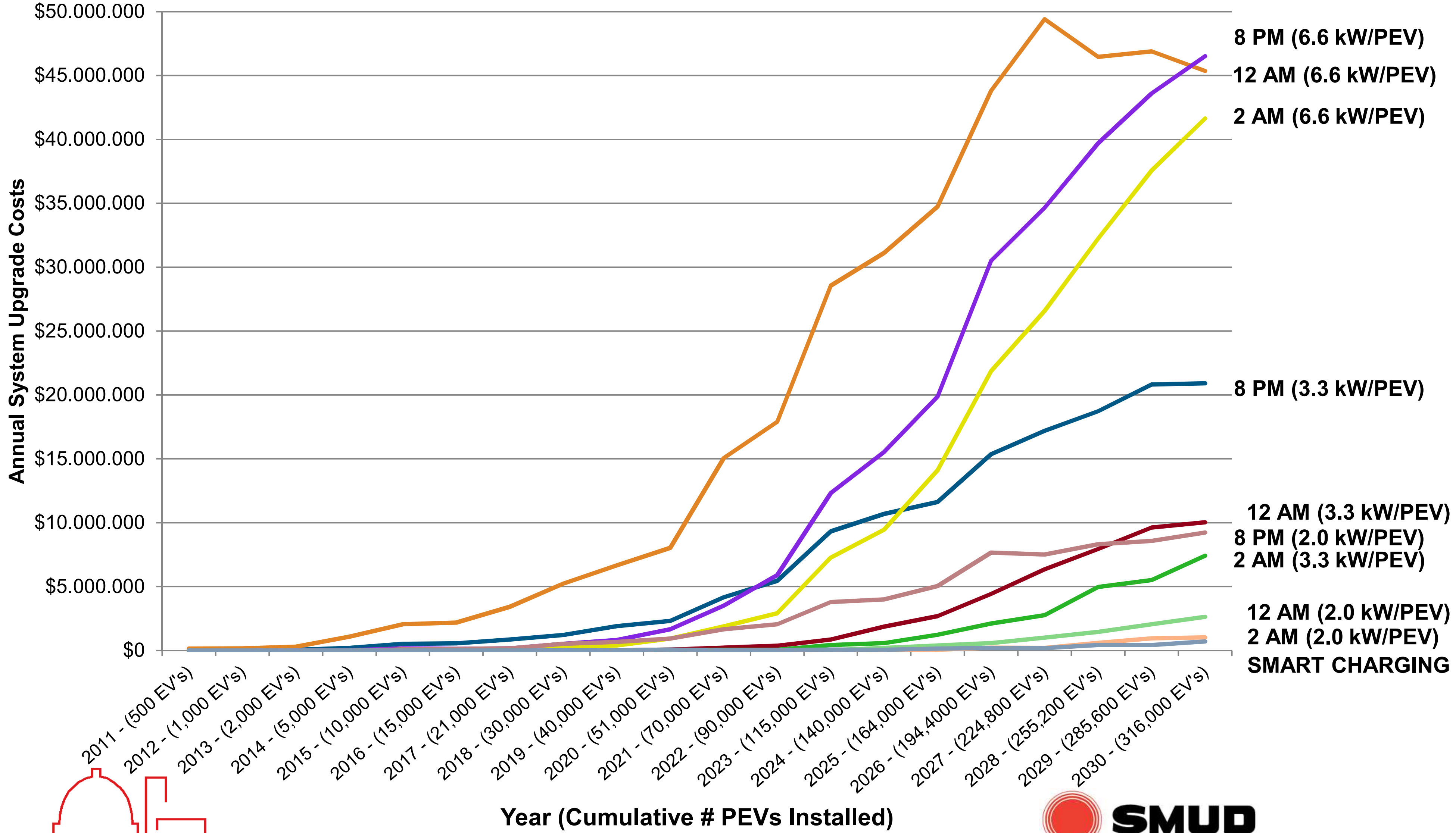




Hot Spot Analysis



Latest Research Shows Mid to Long-Term Impact of Charging Load Over Time of Day



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