

Integrating Electric Vehicles to the Distribution Grid

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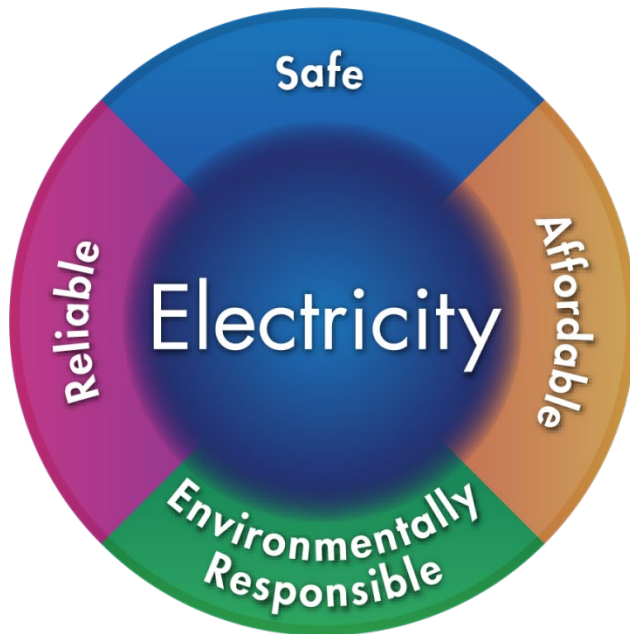
E-mobility Integration Symposium
October 14, 2019



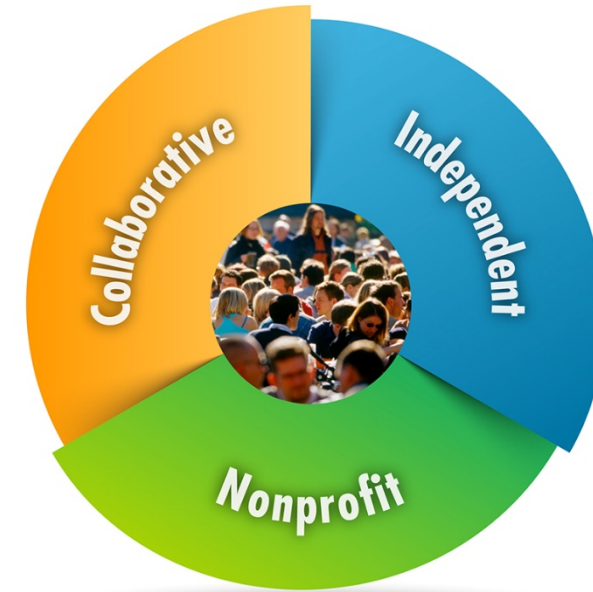
Who are EPRI?

Our Mission

Advancing *safe, reliable, affordable* and *environmentally responsible* electricity for society through global collaboration, thought leadership and science & technology innovation



Key Aspects



Independent

Objective, scientifically based results address reliability, efficiency, affordability, health, safety, and the environment

Nonprofit

Chartered to serve the public benefit

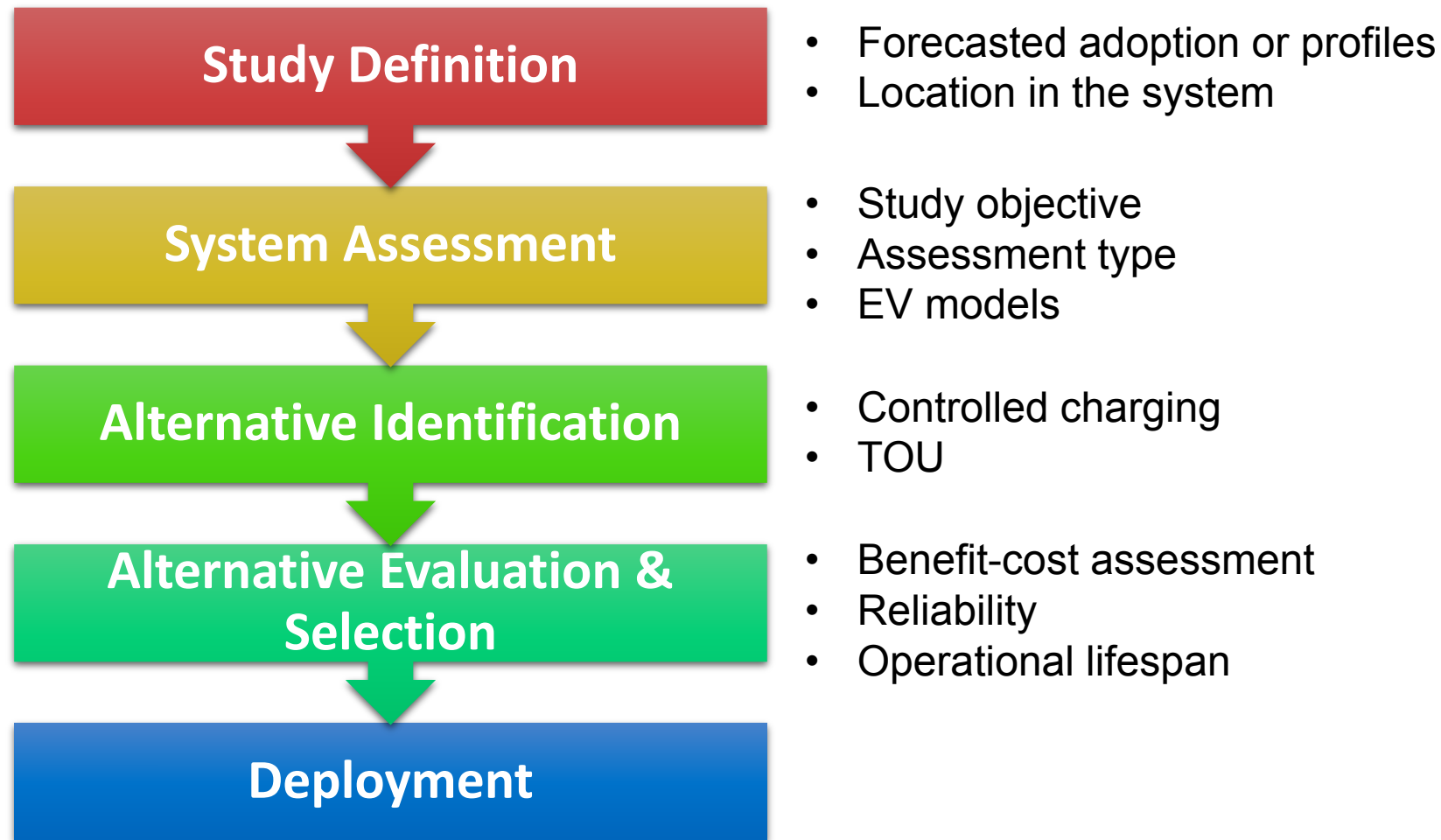
Collaborative

Bring together scientists, engineers, academic researchers, and industry experts

Incorporation in System Planning

Addressing EV in the Distribution Planning Process

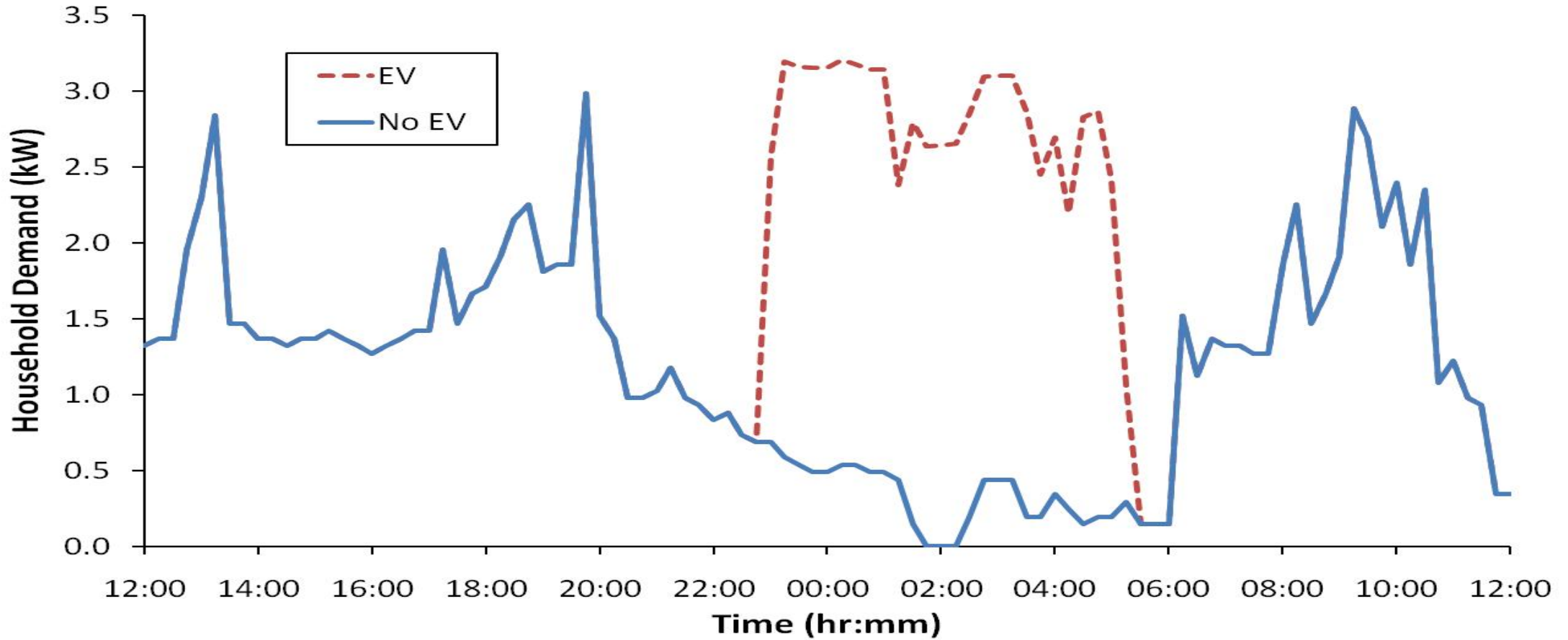
The process doesn't change but becomes more complicated



EV Demand and Profile Characterization

EV Example

Single residence demand profile with and without electric vehicle charging

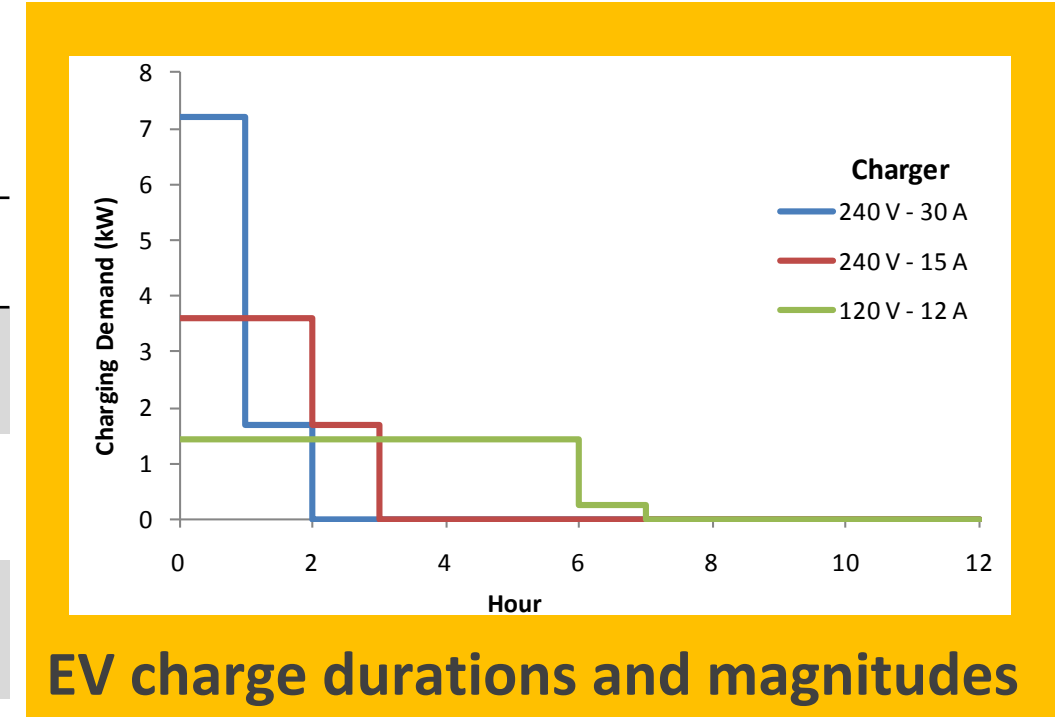


How can this demand potentially impact the system?
What factors can use to model this demand?

Characterization of the New Load Type

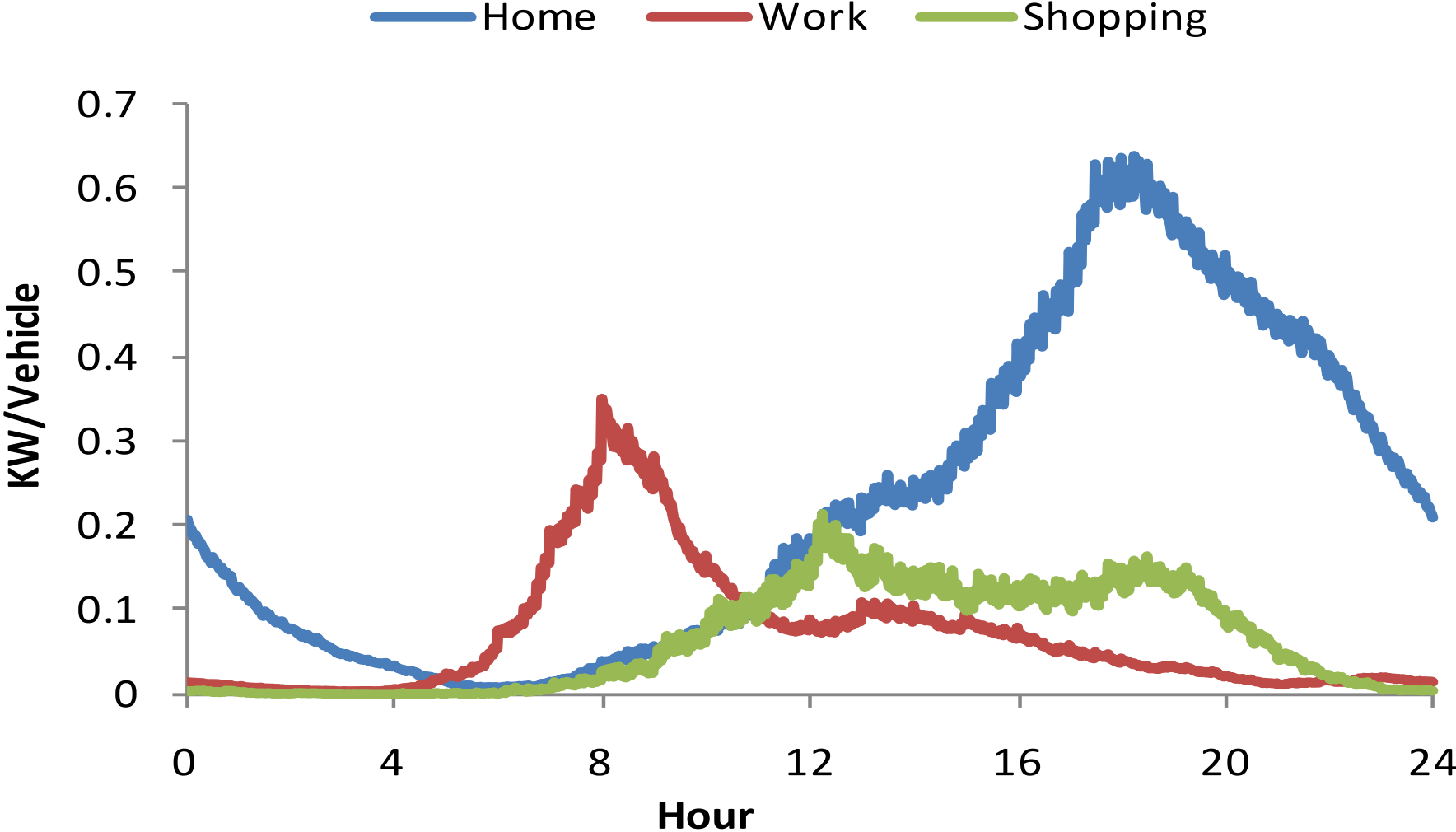
Demand and consumption characteristics

	Type #1	Type #3	Type #4
Battery Capacity (kWh)	4	9.6	9.6
Connection Voltage (V)	120	240	240
Max Charging Current (A)	12	15	30
Energy Consumption Rate (Wh/km)	100	124	124
Charging Efficiency (%)	90	90	90



What's going to drive when the charging will occur during the day?

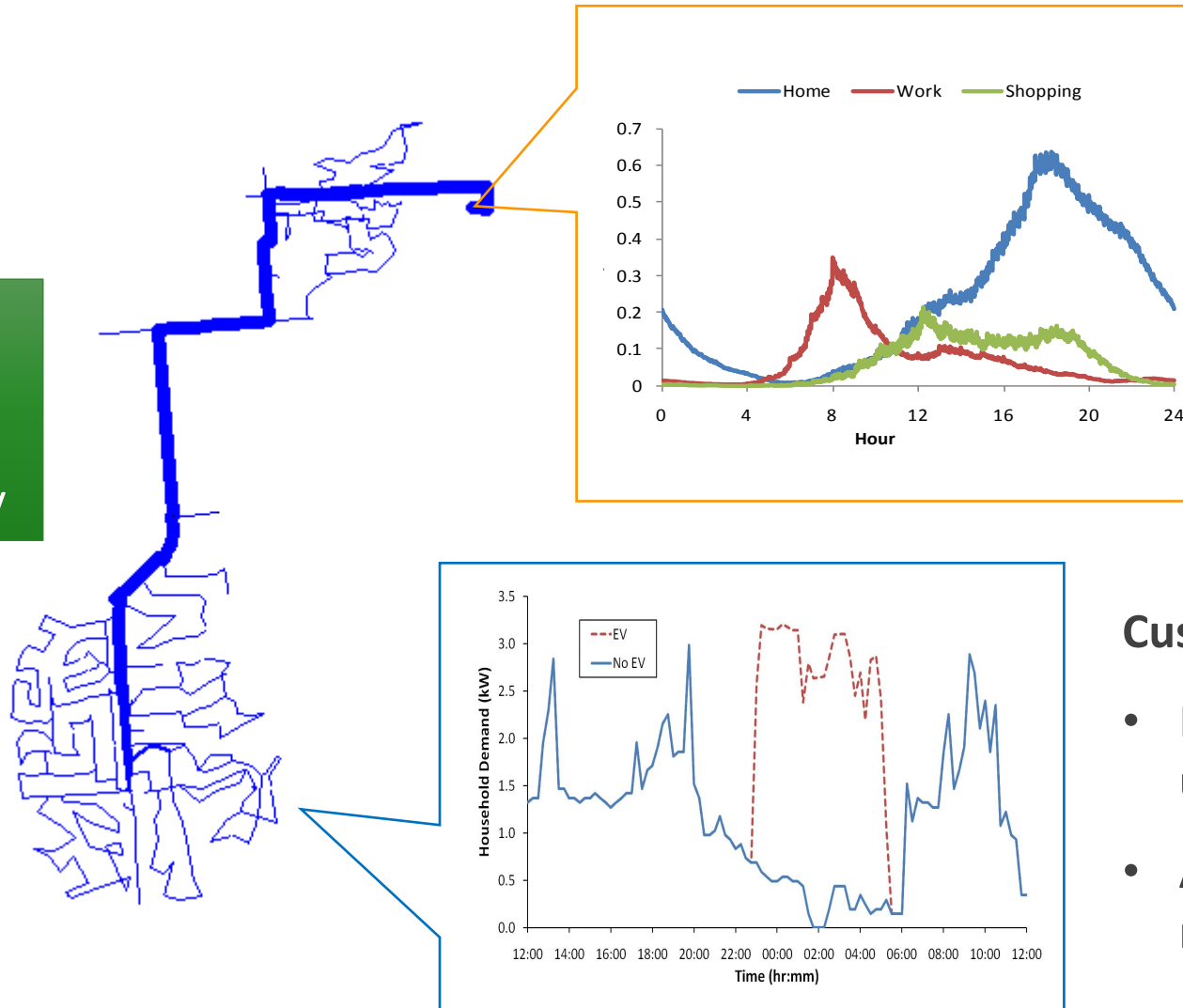
Characterization of Customer Usage



Influence on System Demands

Fast Chargers

- Defined load
- Interconnection study



Substation and Primary

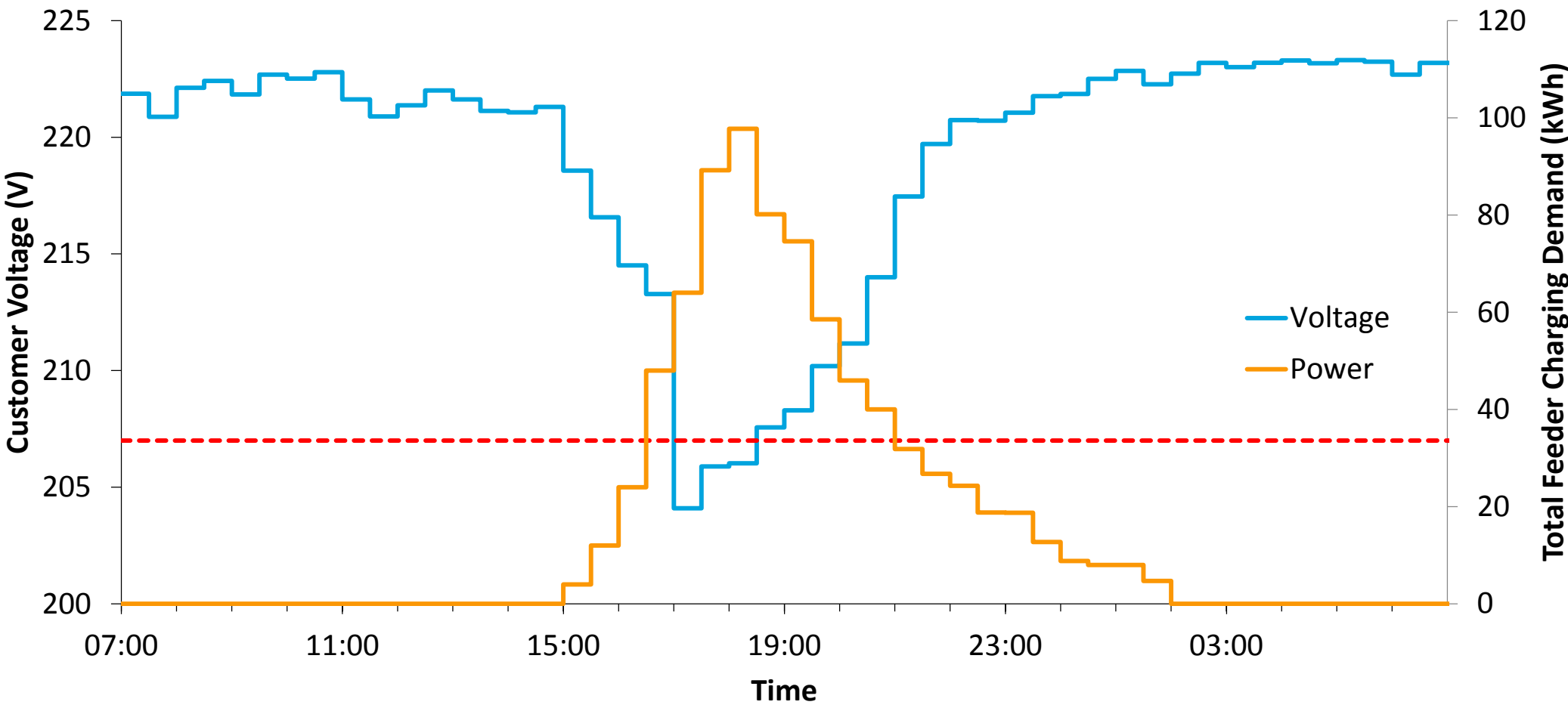
- Diversity in the EV load
- Longer mitigation lead times and higher mitigation costs

Customer Level (System Edge)

- EV load is highly variable and uncertain
- Assets typically reactively managed

Customer Level Impacts

Voltage Impacts



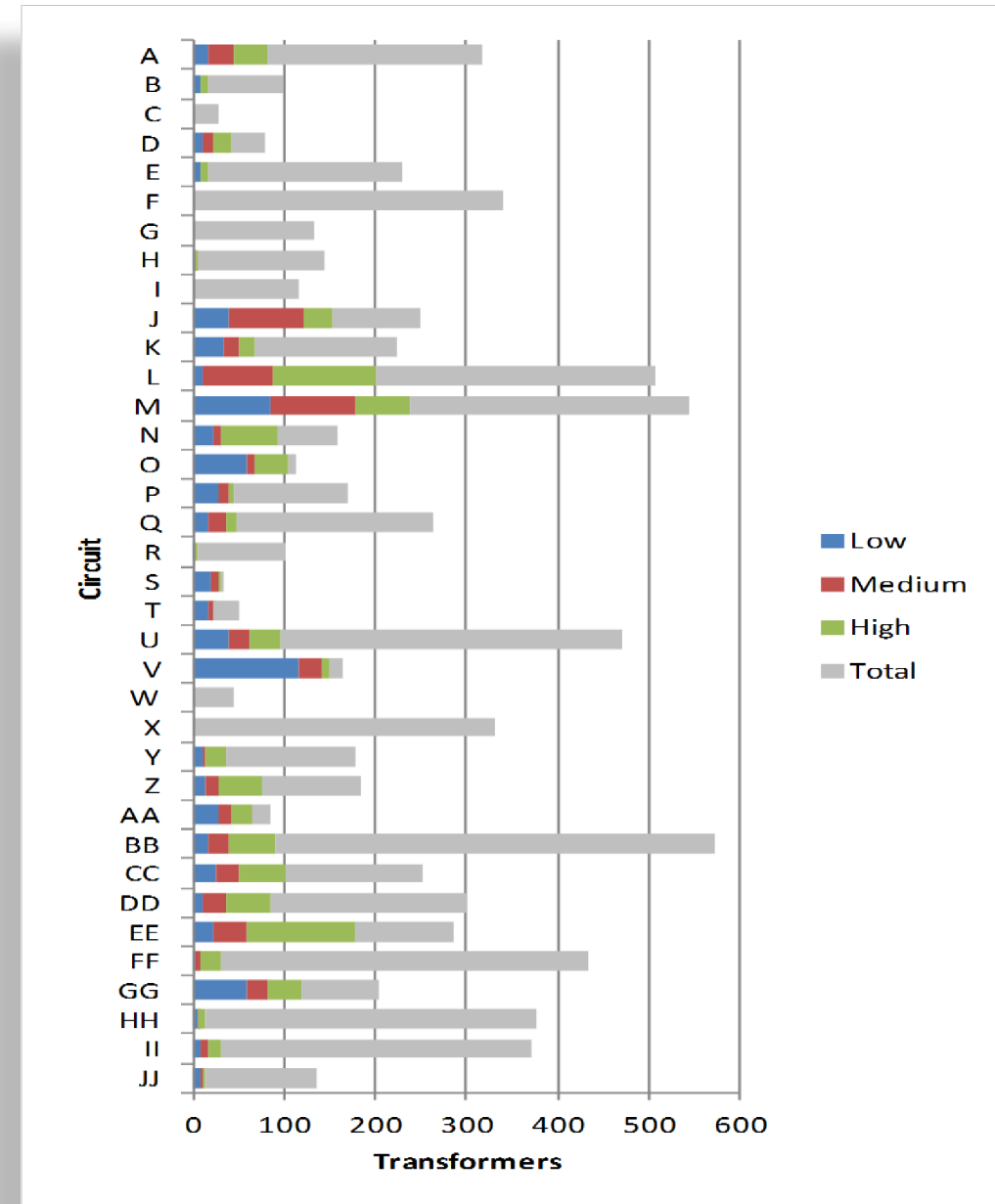
Service Transformer Assessment

Impact Risk Drivers

- Remaining capacity
- Number of connected customers
- EV forecast
- EV fleet makeup

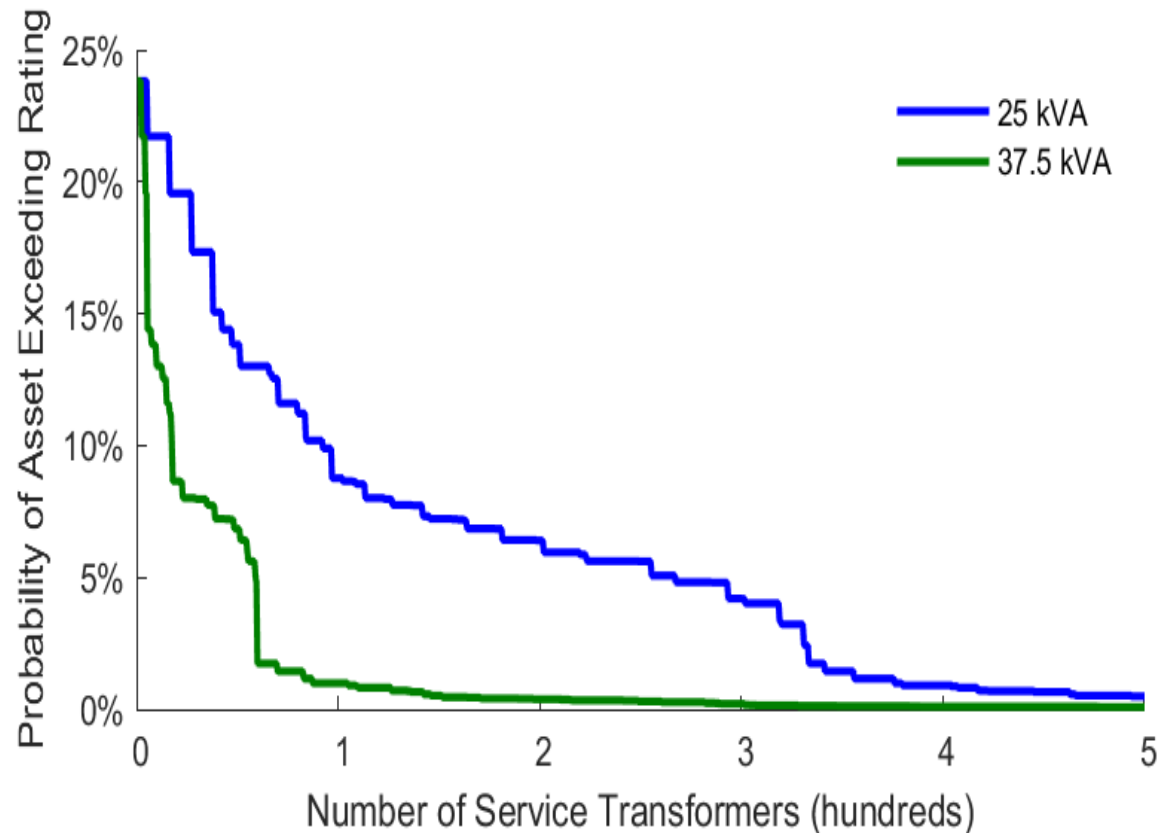
Fleet Assessment (EPRI Hotspotter)

- Individual transformer data & assessment
- Transformer fleet statistics



Example Fleet Impact Analysis Results

Examination of risk factors and mitigation options



Probability of impact for each transformer ranked in descending order

Assessment

- Quantification of likely impacts
- Translation into costs
- Understand key impact drivers

Alternative Evaluation

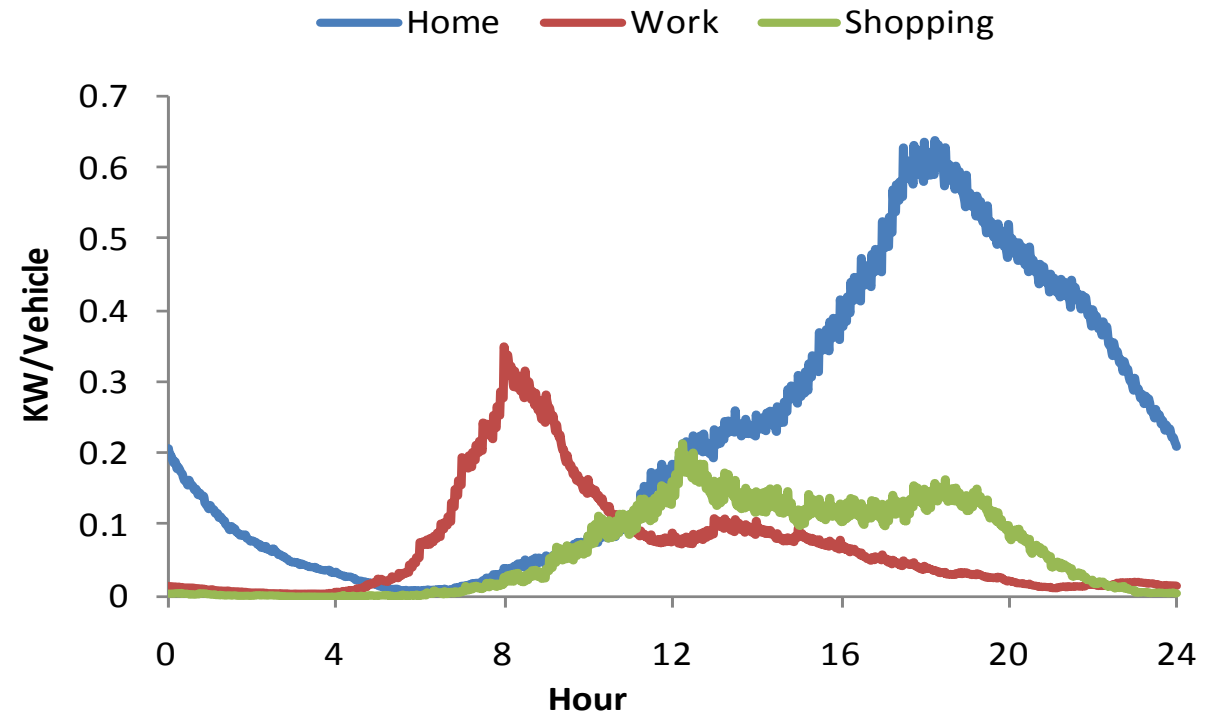
- Service design changes
- Asset management
- Control options
- Proactive replacement

Feeder Impact Assessment

Feeder (Primary) Assessment

Assessment objective

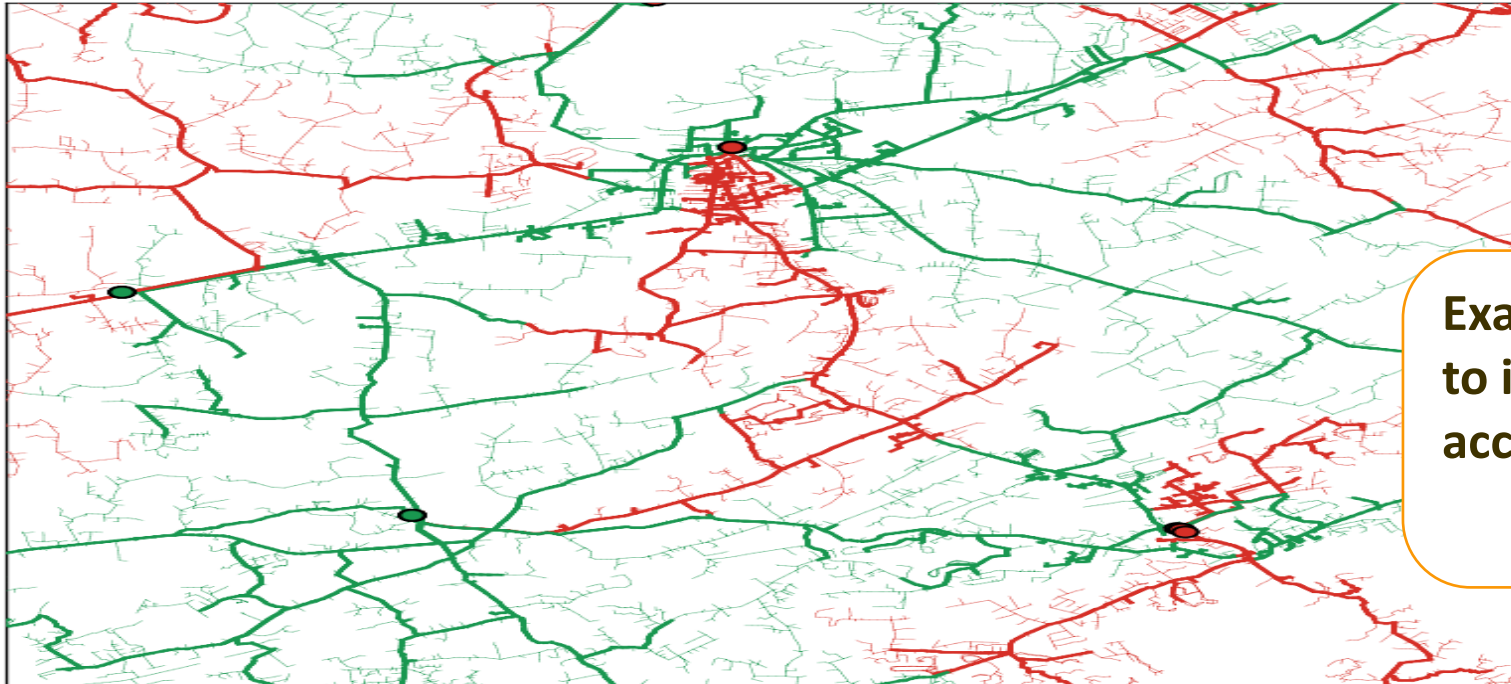
- **Peak Hour Load Flow**
 - Deterministic “Worst-case” expansion planning
- **Quasi-Static Time Series Load Flow**
 - Voltage regulation impacts
 - Energy and losses
 - Control design & evaluation



Vehicle Fleet and DC Fast Charging Integration

Interconnection studies

Value in guiding new demands to areas with sufficient capacity?



Example illustration using EPRI's DRIVE tool to identify distribution system's ability to accommodate charging stations



Change in Planning Process and Analytics: Substation Transformer Thermal Aging

Transformer Thermal Aging

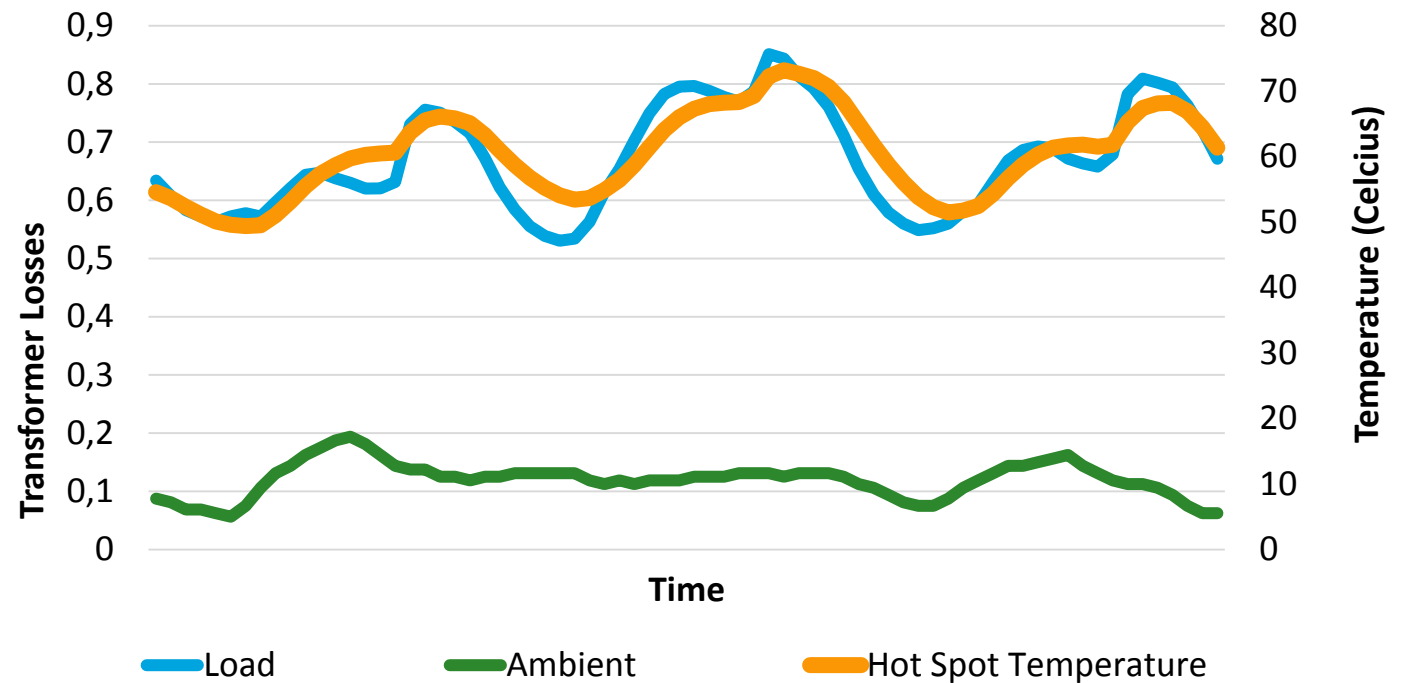
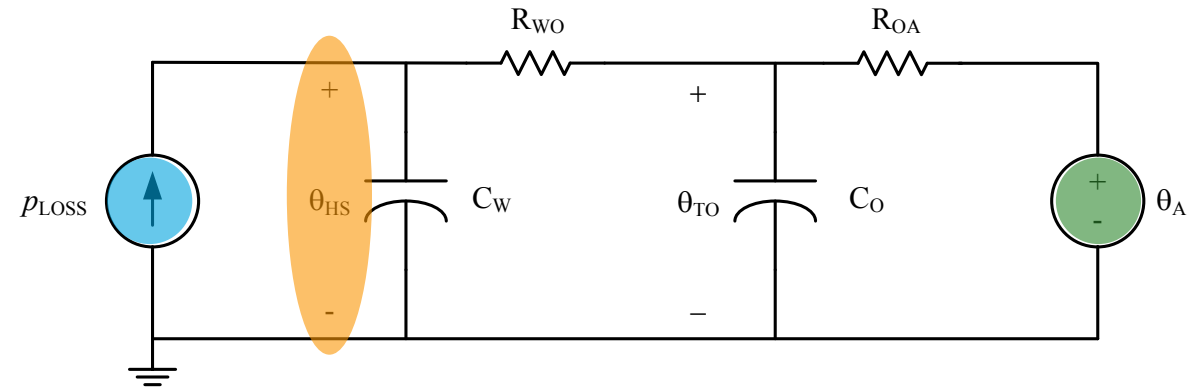
Assessments using ANSI/IEEE Standard C57.91

- Evaluate winding temperatures

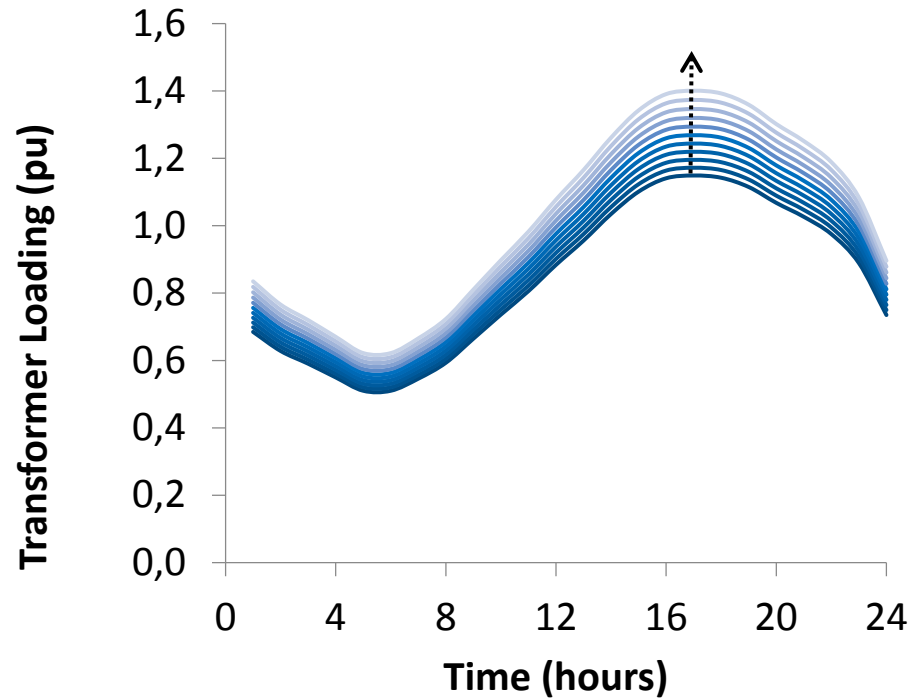
Data Needs

- Thermal Time Constants
- Ambient Temperature
- Losses (Loading)

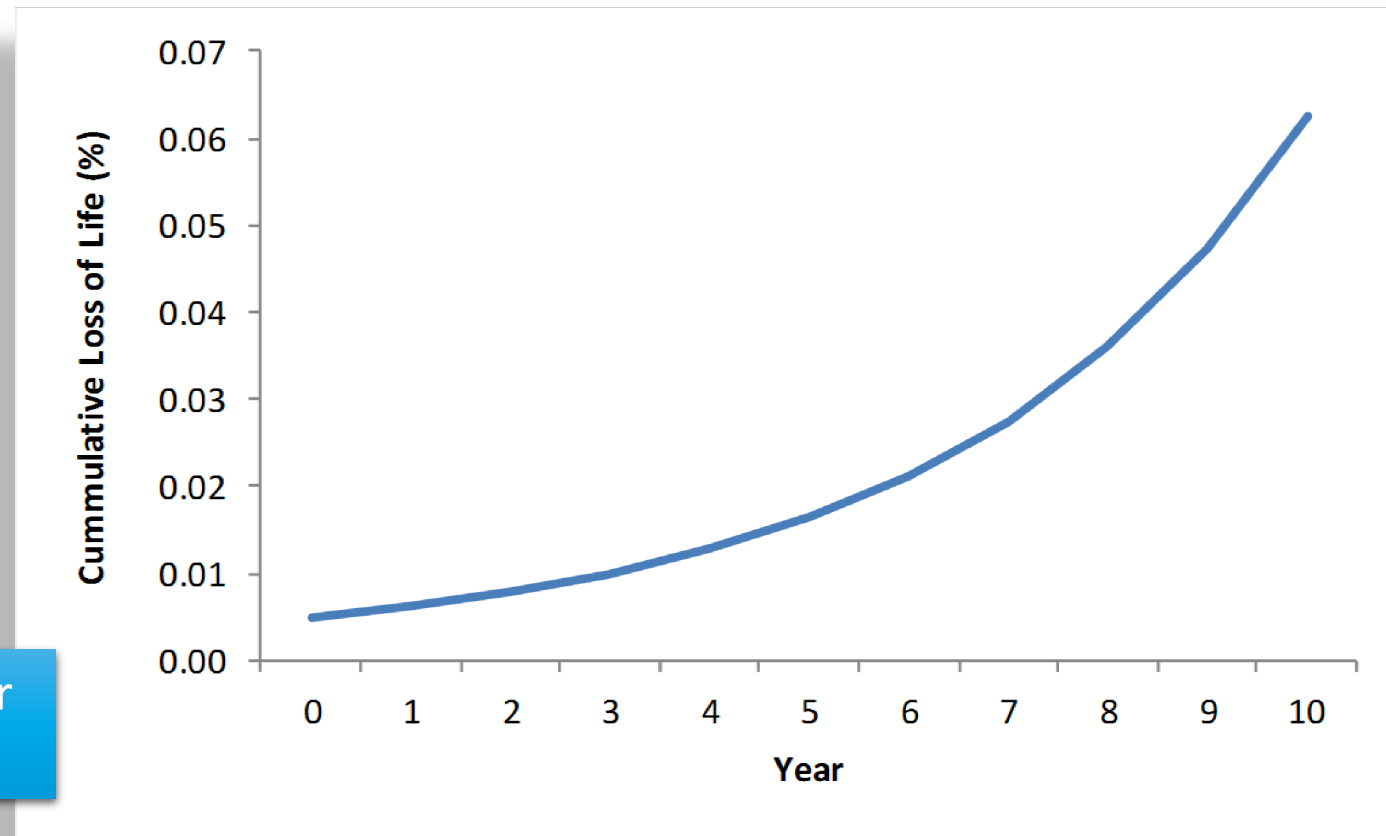
What's the impact of doing nothing? If we can change the EV loadshape does the benefit justify the cost?



Thermal Aging with Increased Load

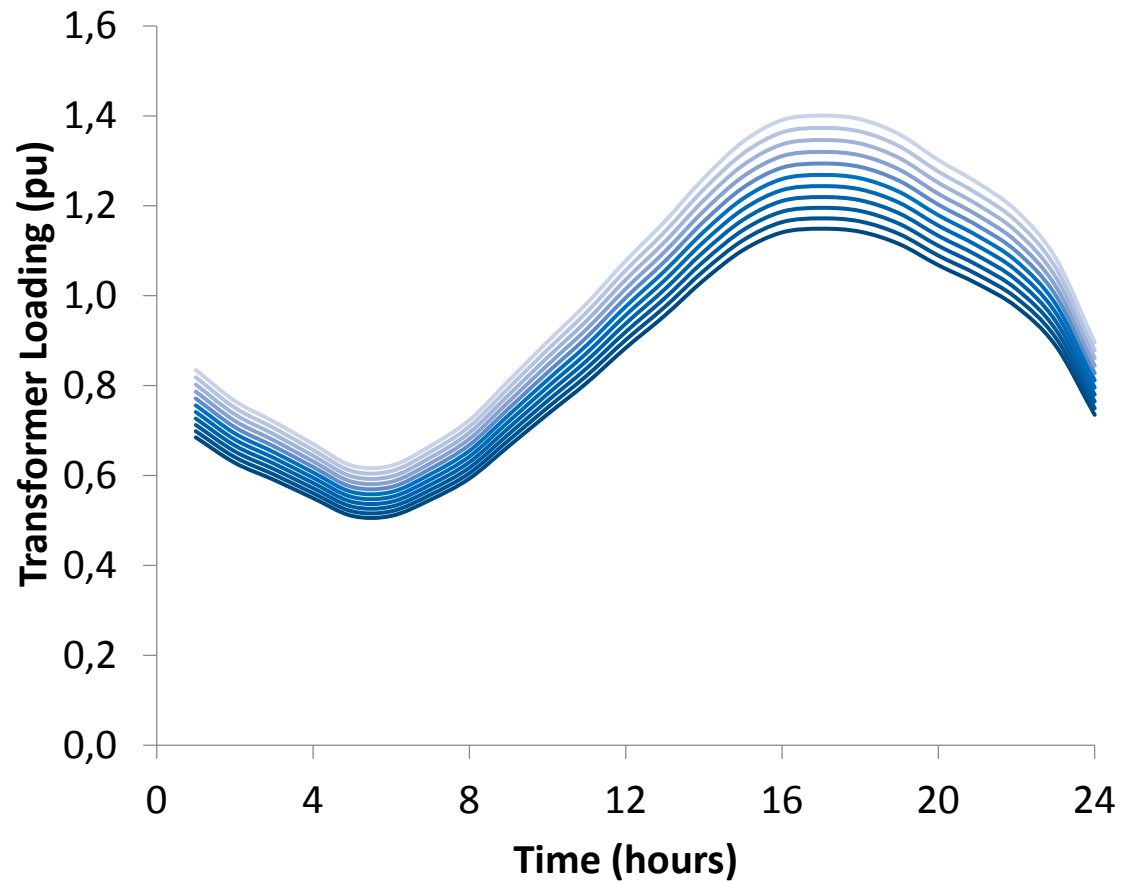


Baseline for comparing other profile changes

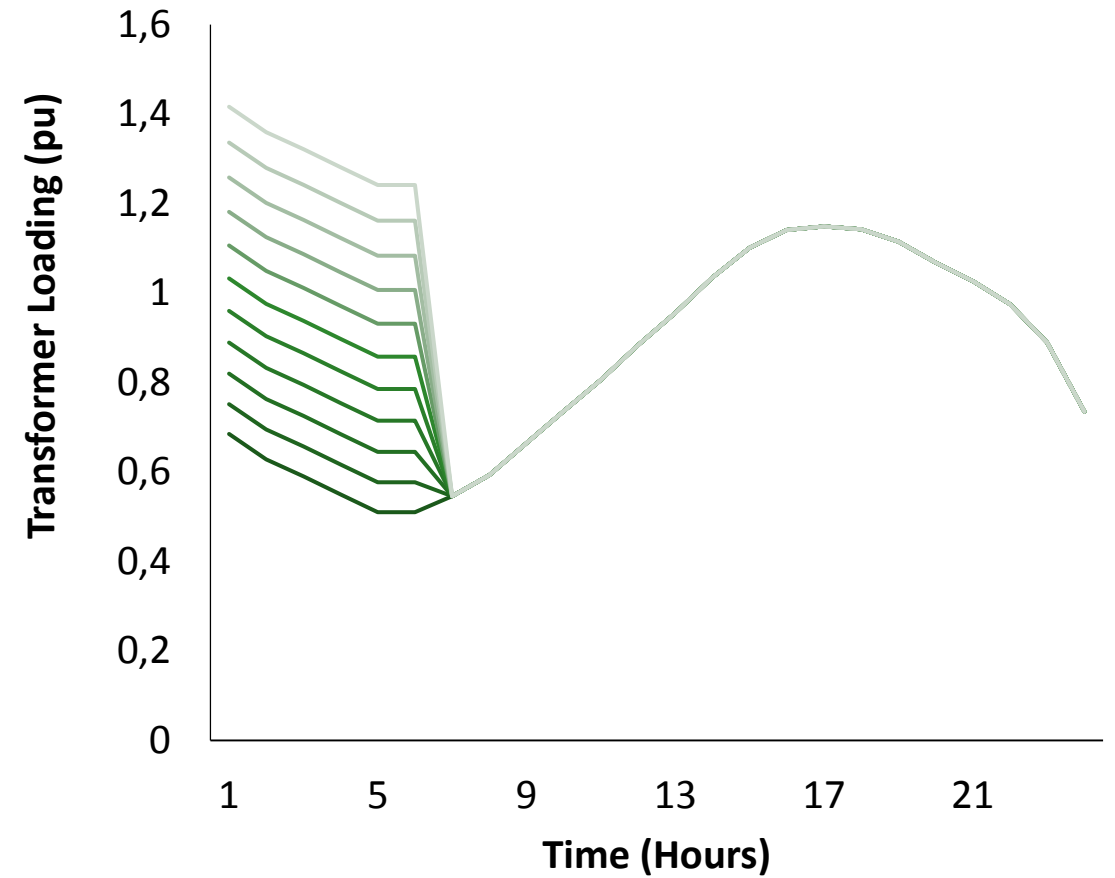


Transformer Thermal Aging Sensitivity

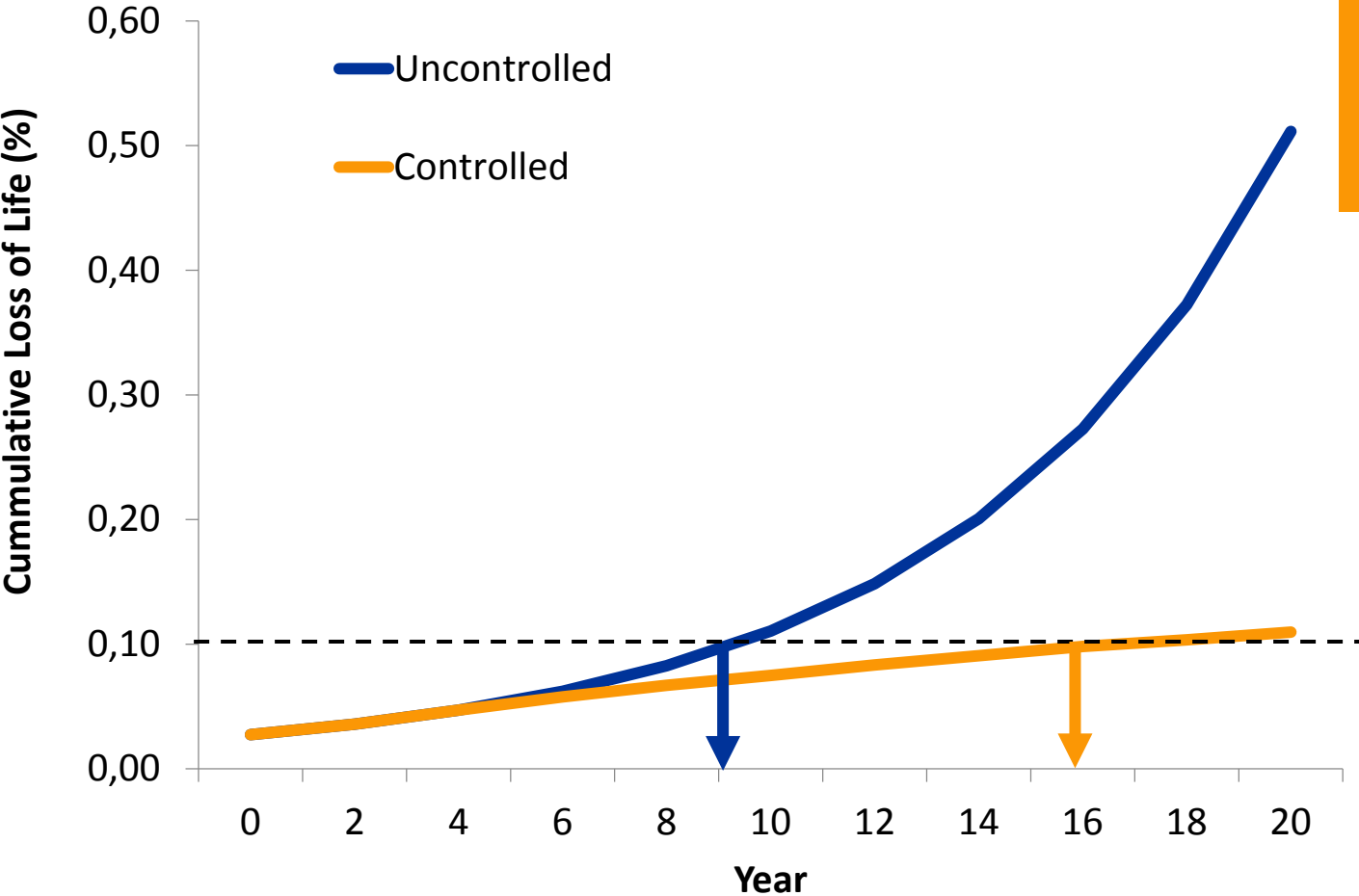
Uncontrolled Charging



Controlled Charging



Potential Deferment Benefits



Benefit of upgrade deferment
Vs.
Cost to alter EV charging behavior

Need to Expand Beyond a Peak Demand Mindset

- Electrification of all forms is altering load profiles
- Many traditional planning metrics and analysis assume traditional shapes or changes

$$\textit{Utilization Factor} = \frac{\textit{maximum demand}}{\textit{rated system capacity}}$$

$$\textit{Use Factor} = \frac{\textit{annual energy throughput}}{\textit{rated capacity} \times 8760}$$

Key Takeaways

- EVs will not change the distribution planning process but may add more complexity at certain levels
- EV load models vary depending on the type of EV and level of the distribution system being assessed
- EV impacts and necessary assessments vary between customer level, feeder level and substation thermal loading
- Planning beyond the typical worst case peak demand snapshot will likely be necessary

Together...Shaping the Future of Electricity