Planning and Preparing for Electric Transportation

Music City Power Quality Association

November 1, 2011

Carla K. Nelson, PE

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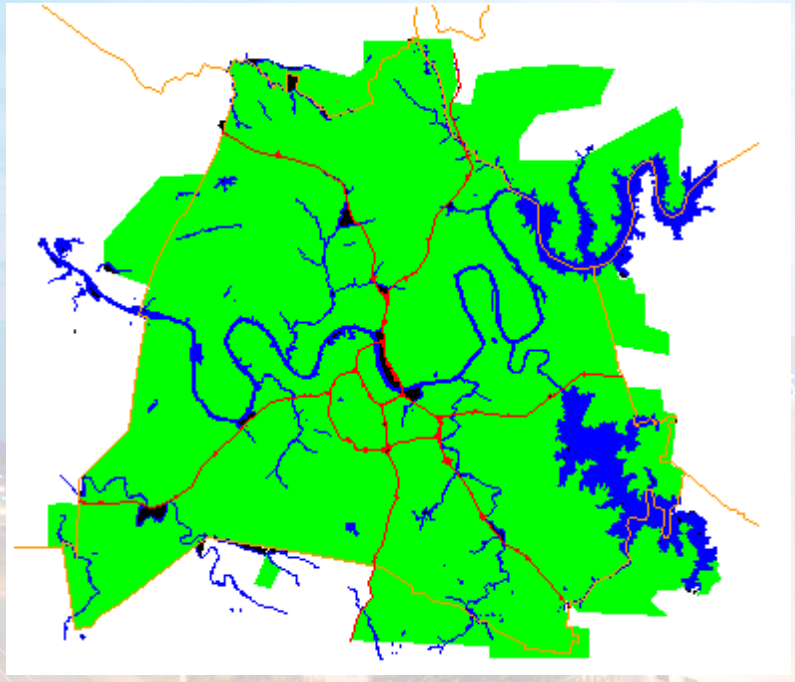
About NES



- 700 square miles of service territory
- Approx. 360,000 Customers

62 Major substations

161 kV & 69 kV transmission voltages

23.9kV, 13.8kV & 4kV distribution voltages

Secondary network system downtown

Over 5,700 pole line miles

Summer peak 2,712 MW, July 2008

Winter peak 2,447 MW, January 2009

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NES Participation

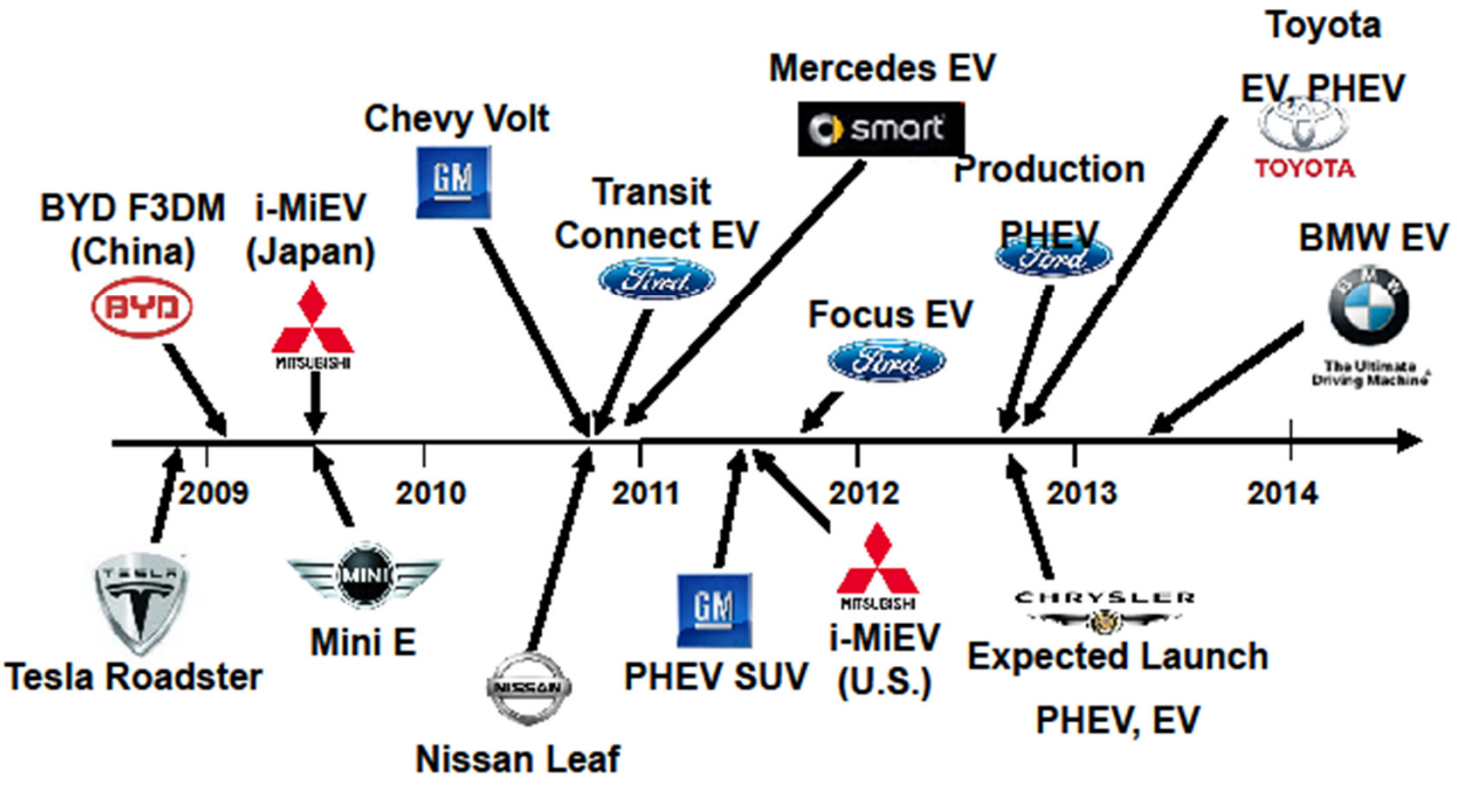
- Original member of the Governor's Zero Emission Vehicle Partnership with Nissan
- Partnering with TVA and EPRI on studying the impact of plug-in electric vehicles on the electric distribution system
- Member of the Ecotality DOE-FOA-28 Partnership to deploy EVs and charge infrastructure
- Participating in site determination of public charging infrastructure, EVSE data analysis, and R&D work
- Participating in TVA's deployment of solar SMART charging stations

NES Participation

- Collaboration with local universities on forecasting EV penetration at the neighborhood level
- Member of IEEE P2030.1 working group on applications for electric-sourced vehicles and related support infrastructure
- Participating in TVPPA Smart Grid Roadmap development
- Participating in the EPRI-DOE Plug-In Hybrid Medium Duty Fleet Demonstration Program

Plug-in Vehicles

Plug-In Vehicle Commercialization Timeline



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Infrastructure and Charging Requirements

Type	AC	DC
Level 1	120 VAC ≤ 12 amps, 16 amps ≤ 1.44 kW, 1.92 kW	200 – 450 VDC* ≤ 80 amps ≤ 19.2 kW
Level 2	208 - 240 VAC, 1Φ ≤ 80 amps ≤ 19.2 kW	200 – 450 VDC* ≤ 200 amps ≤ 90 kW
Level 3	TBD* assumed ≥ 19.2 kW 1Φ or 3Φ	200 – 600 VDC* ≤ 400 amps? ≤ 240 kW?

Source – Gery Kissel, SAE

* Specifications not finalized

Plug-In Vehicles Come to Market

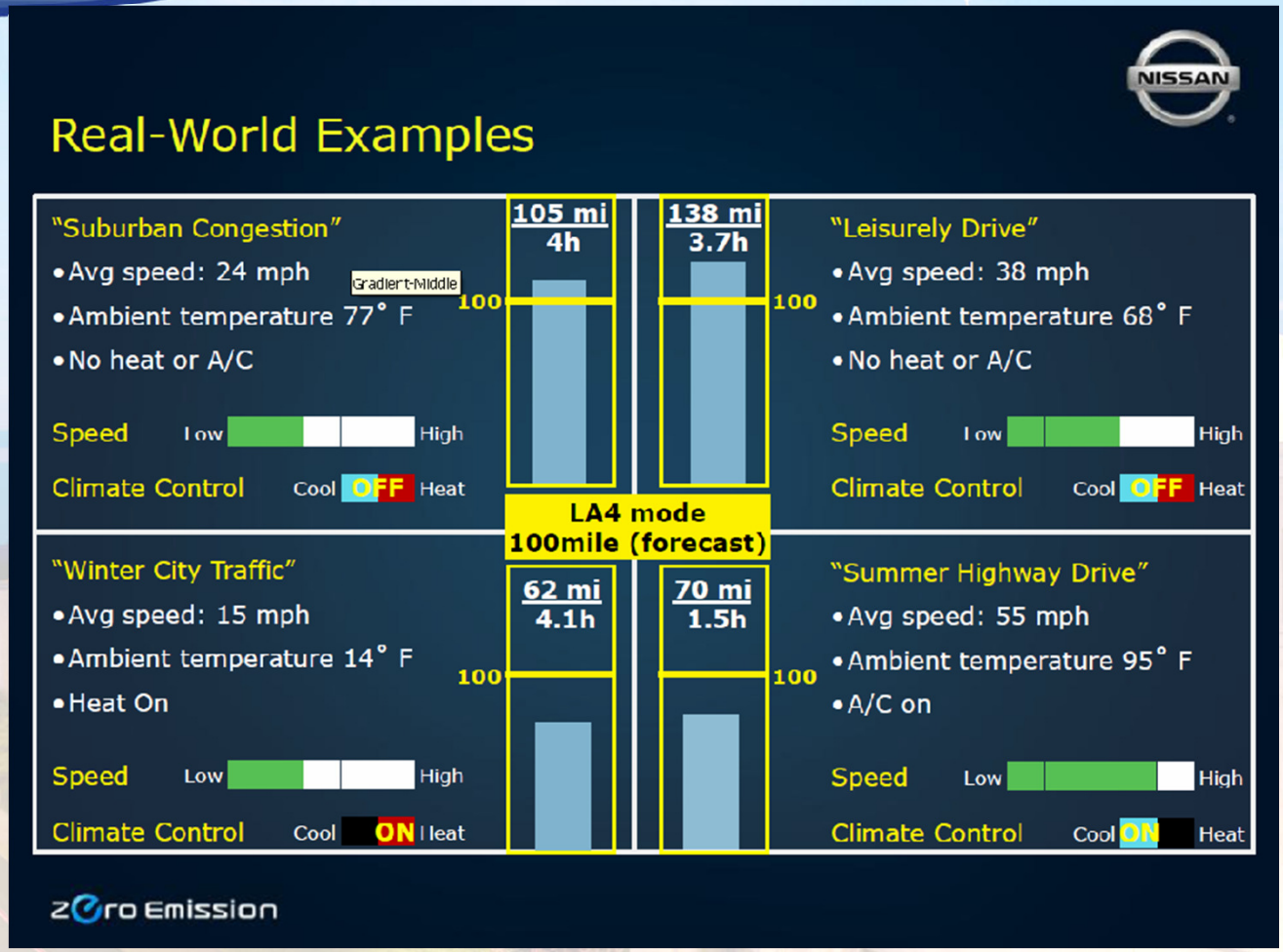
Chevrolet Volt

- Extended Range Electric Vehicle (EREV - A plug-in hybrid with a guaranteed electric range).
- 40-mile range
- Charging: 8-9 hours at 120V, 12A
  3 hours at 240V, 15A

Nissan Leaf

- Battery Electric Vehicle
- 100-mile range
- Charging: 20 hours at 120V, 12A
  8 hours at 240V, 15A
  30 min at 400V, 150A

Nissan Leaf



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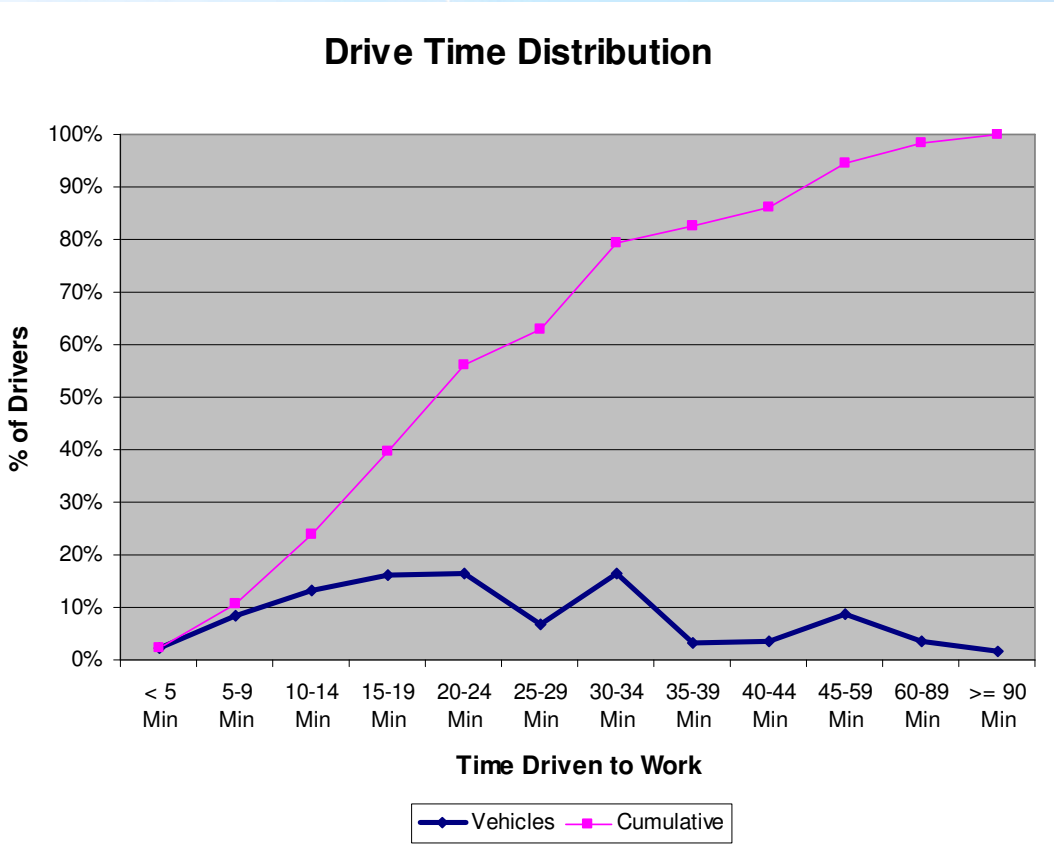
Distance Driven When Arriving Home

- Overall driving patterns in the NES service area – 82% of drivers drive less than 40 minutes to work, 40% drive less than 20 minutes to work [1]
- People do not necessarily drive far enough to completely discharge their car battery



[1] Source: U.S. Census Data

NES Assumptions
EV Early Adopter Customer Profile

- Income >$100,000 per year
- High level of education
- Majority of buyers between 45 & 54
- Gender: 50% Male, 50% Female
- Single family homes with garages
- Current hybrid owners likely to purchase an EV
- Current diesel owners less likely to purchase an EV
- Plan to keep car > 5 years
- Above average tech skills
- Travel time to work < 30 minutes
- 38% Democrat, 34% Independent, 14% Republican

– Sources: J.D. Power 2004, J.D. Power 2007, Walter McManus, University of Michigan's Transportation Research Institute, 2007 Scarborogh Research survey

Predicting Early EV Penetration Using Publicly Available Data

Census Data:

–Household Income

–Gender: Male, Female

–Education Level

–Travel Time to Work

–Age

–Population Density

Voting Records:

–Political Affiliation

Property Tax Records:

–Type, value, garage, age

Vehicle Registration Records:

–Vehicle make, model, and year

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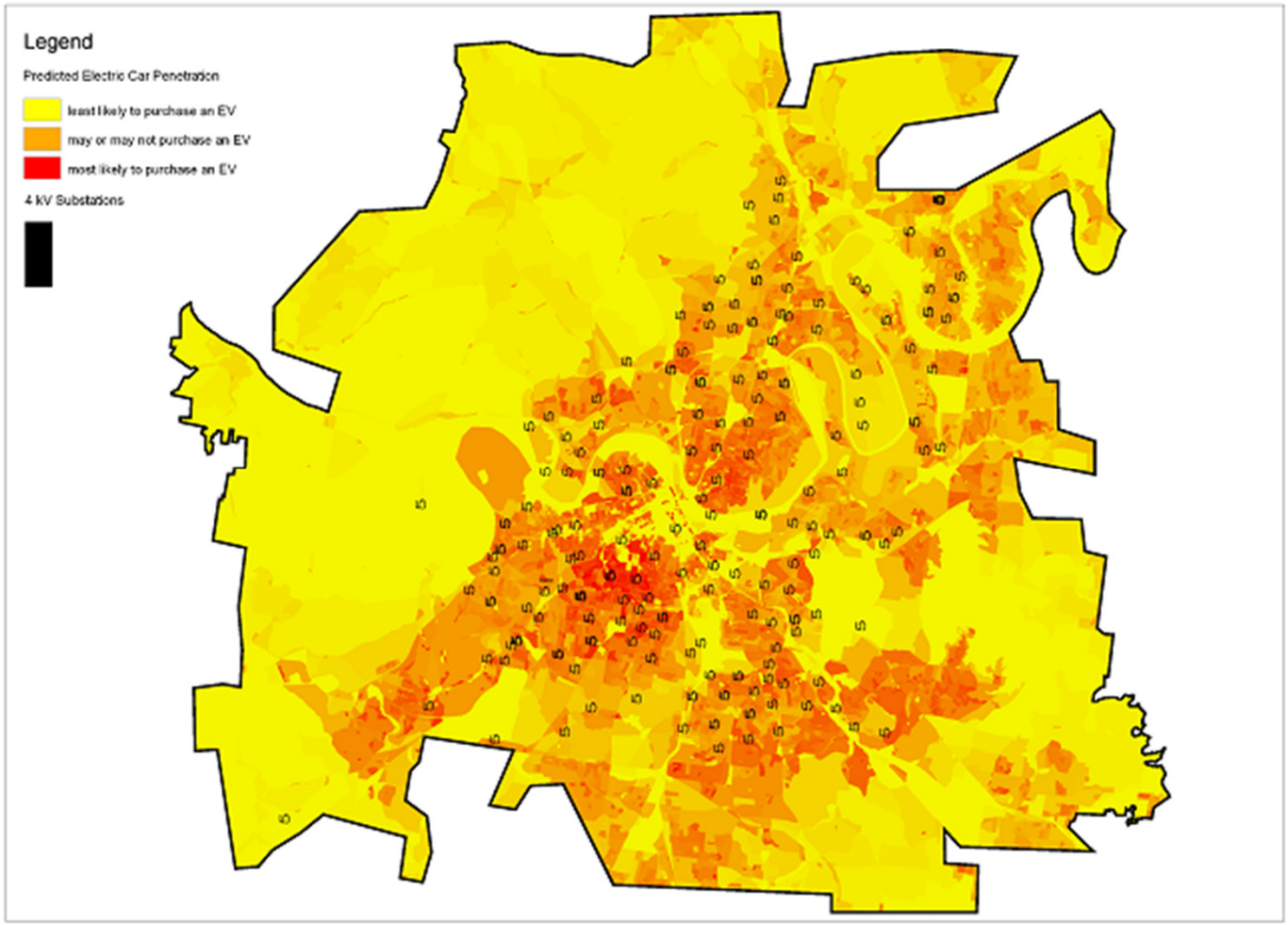
NES Service Area
EV Hot Spot Mapping



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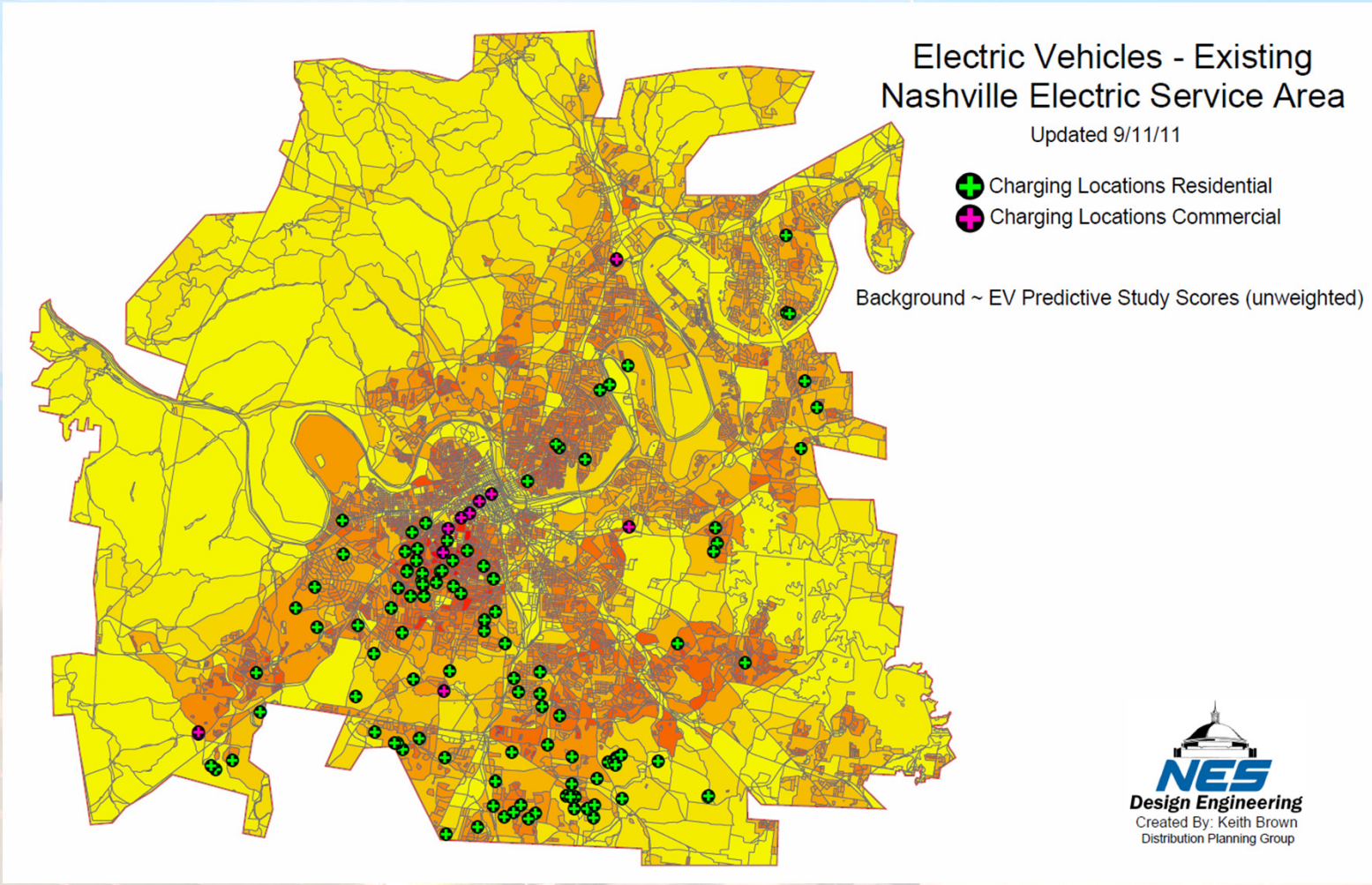

NES
Design Engineering
Created By: Keith Brown
Distribution Planning Group

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NES Circuit Selection for EPRI EV Impact Studies

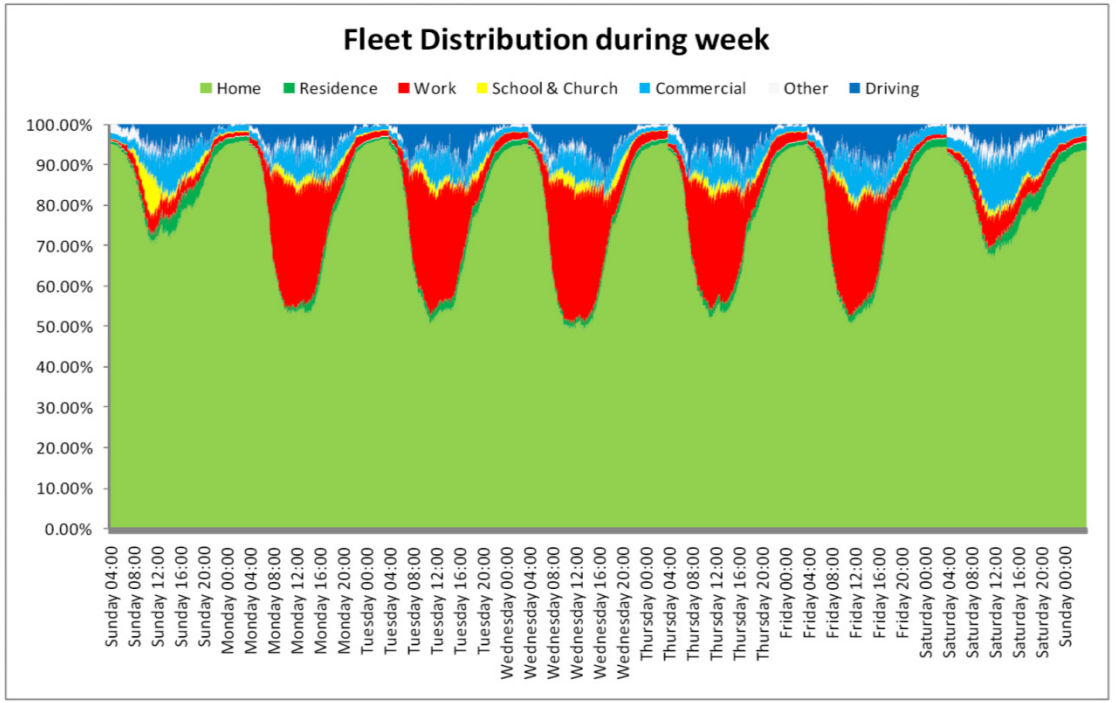
National Household Travel Survey (2001)

Charge at Home Scenario:

- Circuit feeding 13.8kV & 4kV loads
- 4kV circuit ≈ 80% Loaded
- 900 residential, 300 commercial
- Fits EV Buyer Profile

Charge at Work Scenario:

- Downtown Nashville
- 4-feeder secondary network
- 550 commercial, government, mixed-use & residential



Source: Tate and Savagian (GM) SAE 2009-01-1311

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EPRI Distribution Impact Study
Vehicle Data Used for the Analysis

Household Vehicles

Source: http://www.fhwa.dot.gov/ctpp/jtw/nas_graph.htm

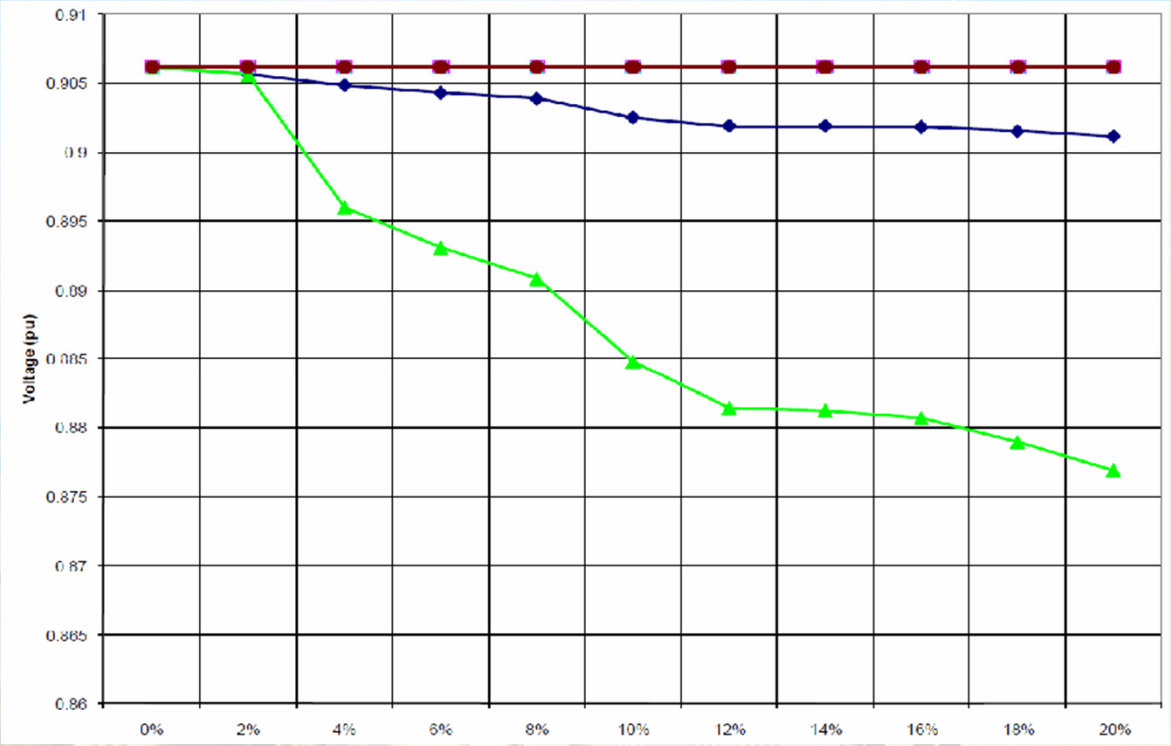
	1990	2000		1990	2000
Total household velicles	665,090	865,327	% 0 vehicle households	8.3	6.5
Vehicles per person	0.68	0.7	% 1 vehicle households	32.2	32.9
Vehicles per household	1.77	1.8	% 2 vehicle households	40.8	41.4
Vehicles per worker	1.34	1.39	% 3+ vehicle households	18.8	19.2

Probabilities of a residential customer owning 0, 1, 2,& 3+ PEVs

Market Penetration	P(PEV/Household)			
	0	1	2	3
2%	96.57%	3.39%	0.04%	0.00%
4%	93.23%	6.62%	0.15%	0.00%
8%	86.76%	12.63%	0.60%	0.01%

EPRI Distribution Impact Study
Minimum Voltage Sensitivity Analysis

Minimum Peak Day Voltage



240V diversified or off-peak

120V diversified or off-peak

120V Peak

240V Peak

Voltage profile is sensitive to time & type of charge

- Less sensitive to off-peak, diversified or 120V charging

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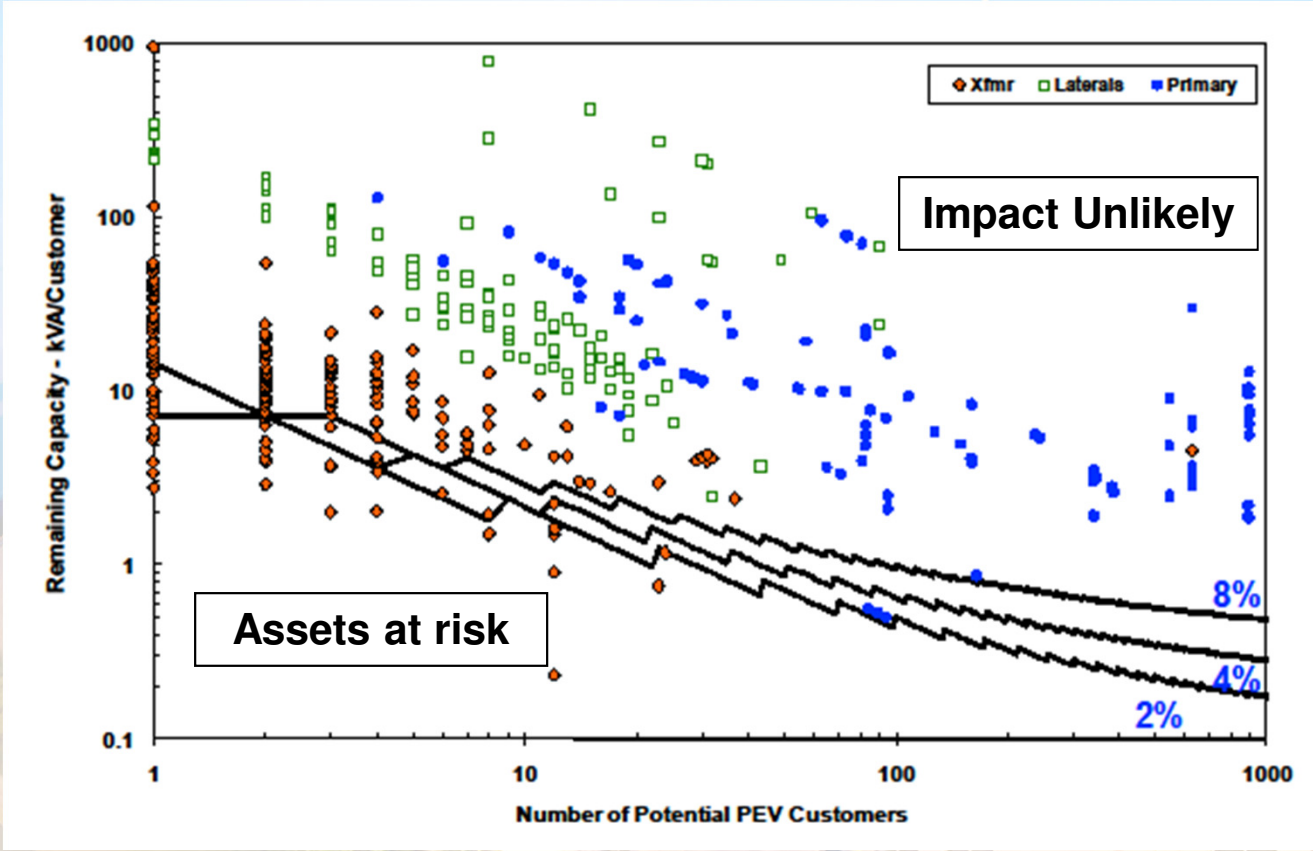
EPRI Distribution Impact Study
Remaining Asset Capacities & Maximum PEV Demand

Asset Capacity vs. 2, 4 & 8% Market Penetration, Level 2 Charging



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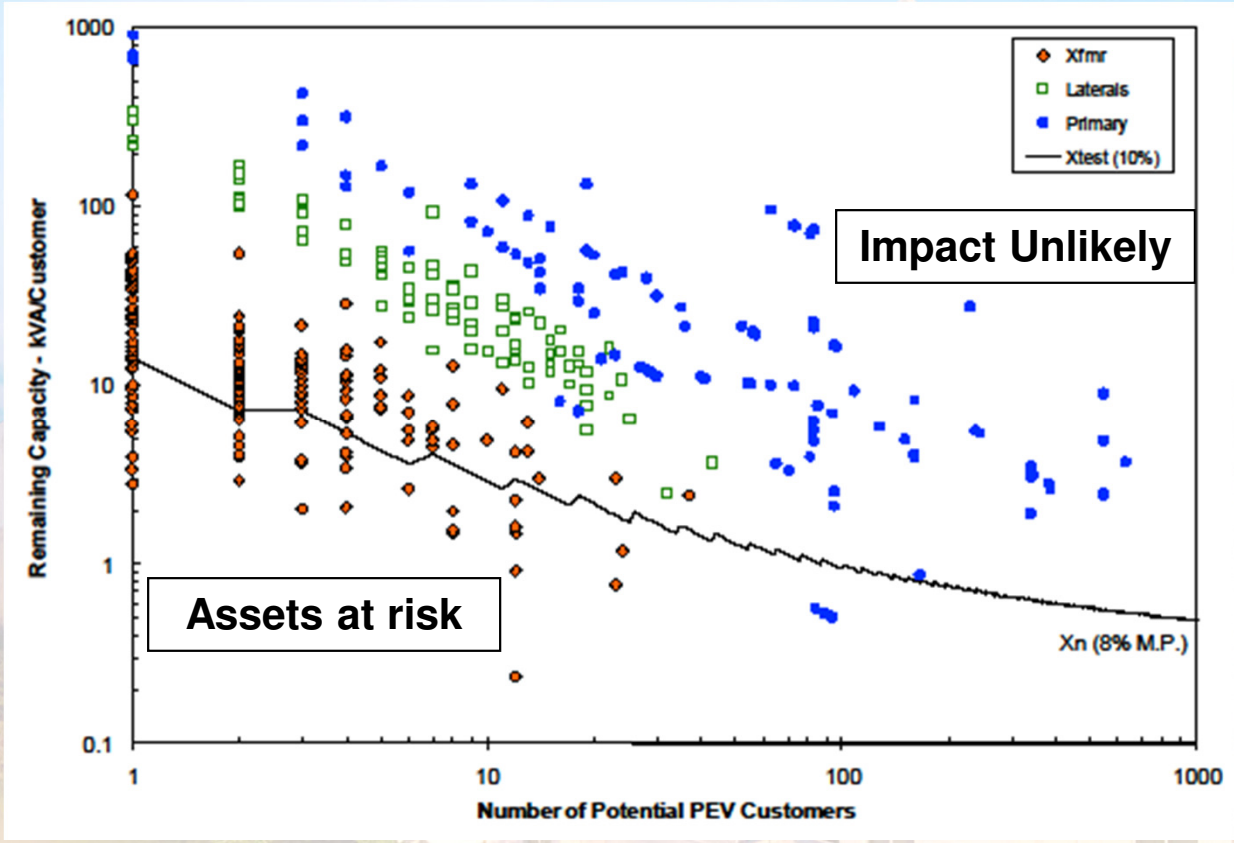
EPRI Distribution Impact Study
Remaining Asset Capacities & Maximum PEV Demand

Asset Capacity - 4kV, 8% Market Penetration, Level 2 Charging



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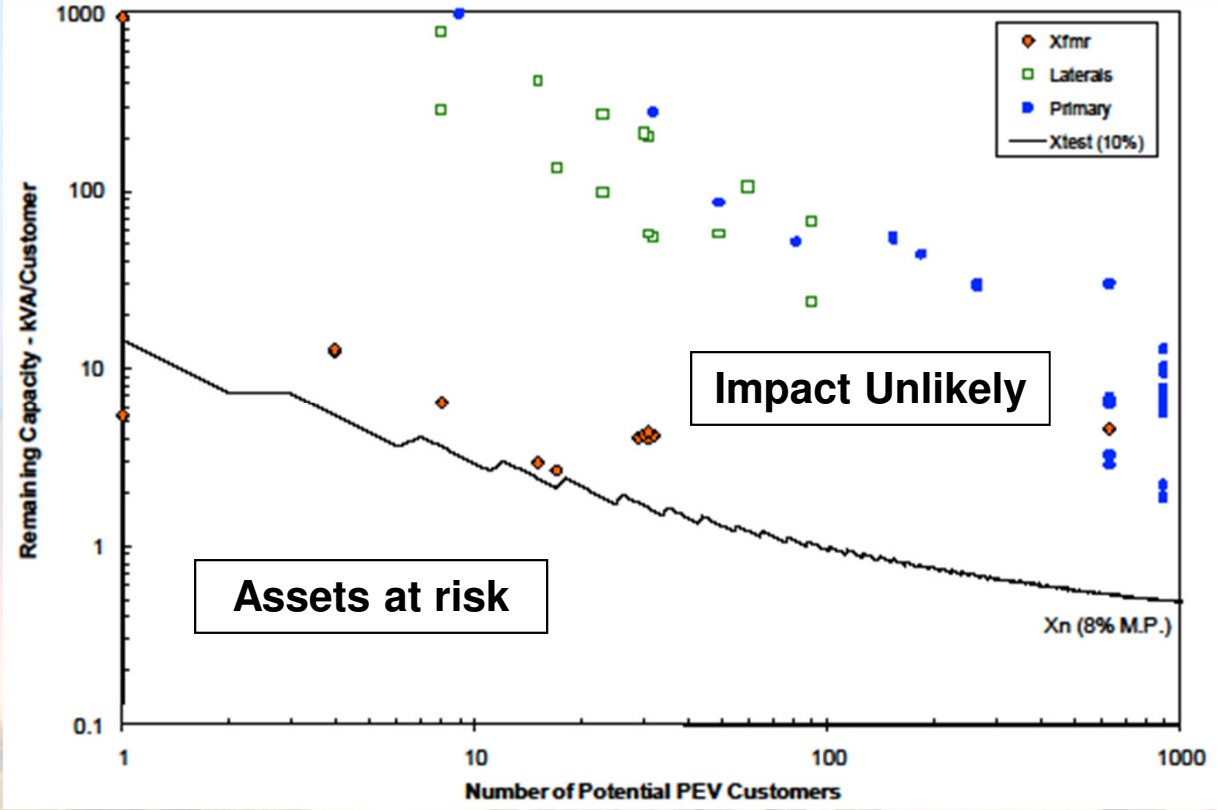
EPRI Distribution Impact Study
Remaining Asset Capacities & Maximum PEV Demand

Asset Capacity – 13.8kV, 8% Market Penetration, Level 2 Charging



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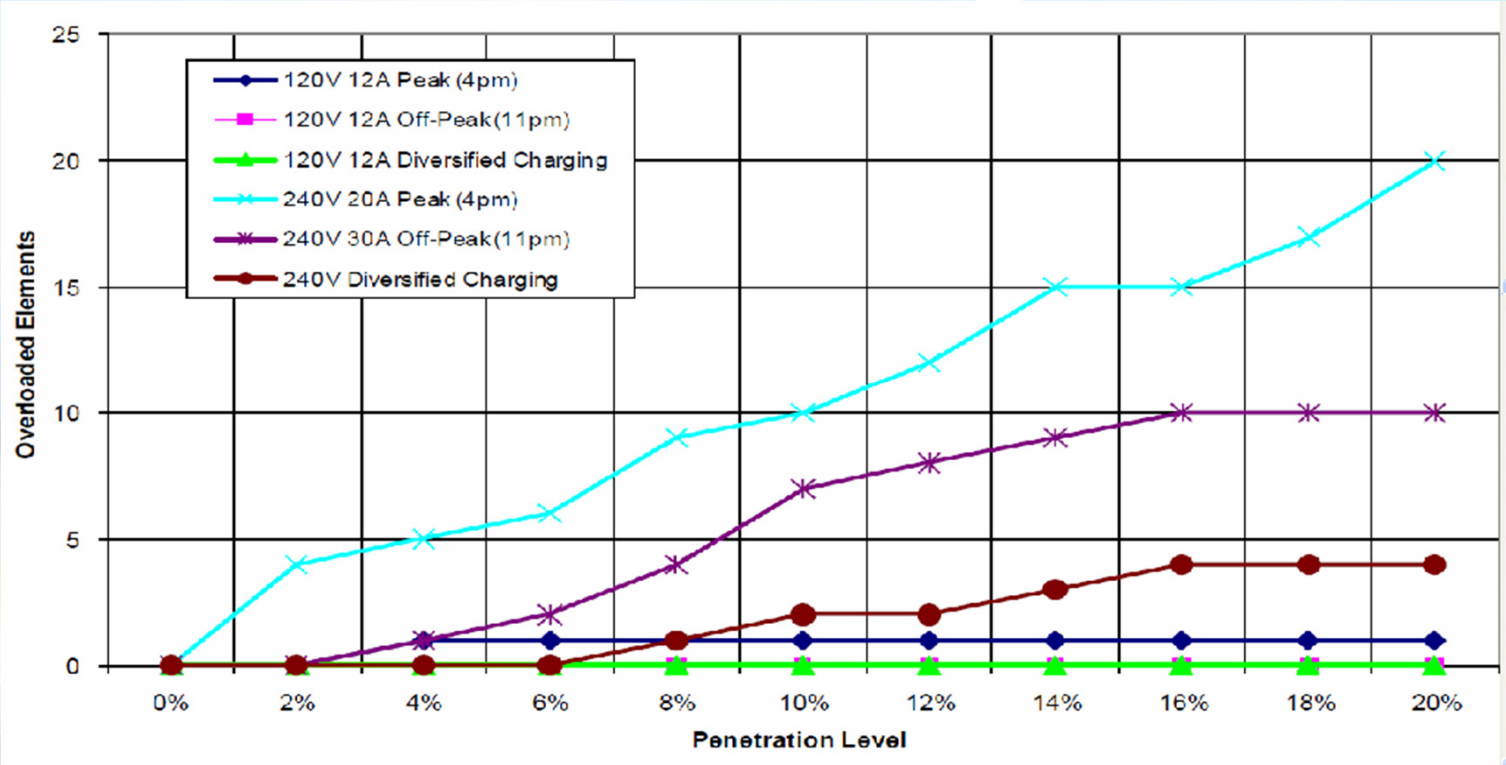
EPRI Distribution Impact Study
Transformer Overloads

	% Cases w / Overloads	Ave # of Overloads	Xfmr Involved	% of Total Xfmr
Low	**32**	**1.2**	**10**	**0.69%**
Med	**61**	**1.3**	**14**	**0.78%**
High	**95**	**1.9**	**22**	**1.11%**

Total # of service transformers with potential PEV customers: 171

EPRI Distribution Impact Study
Transformer Overloads Sensitivity Analysis

Number of Additional Transformers Exceeding Emergency Ratings



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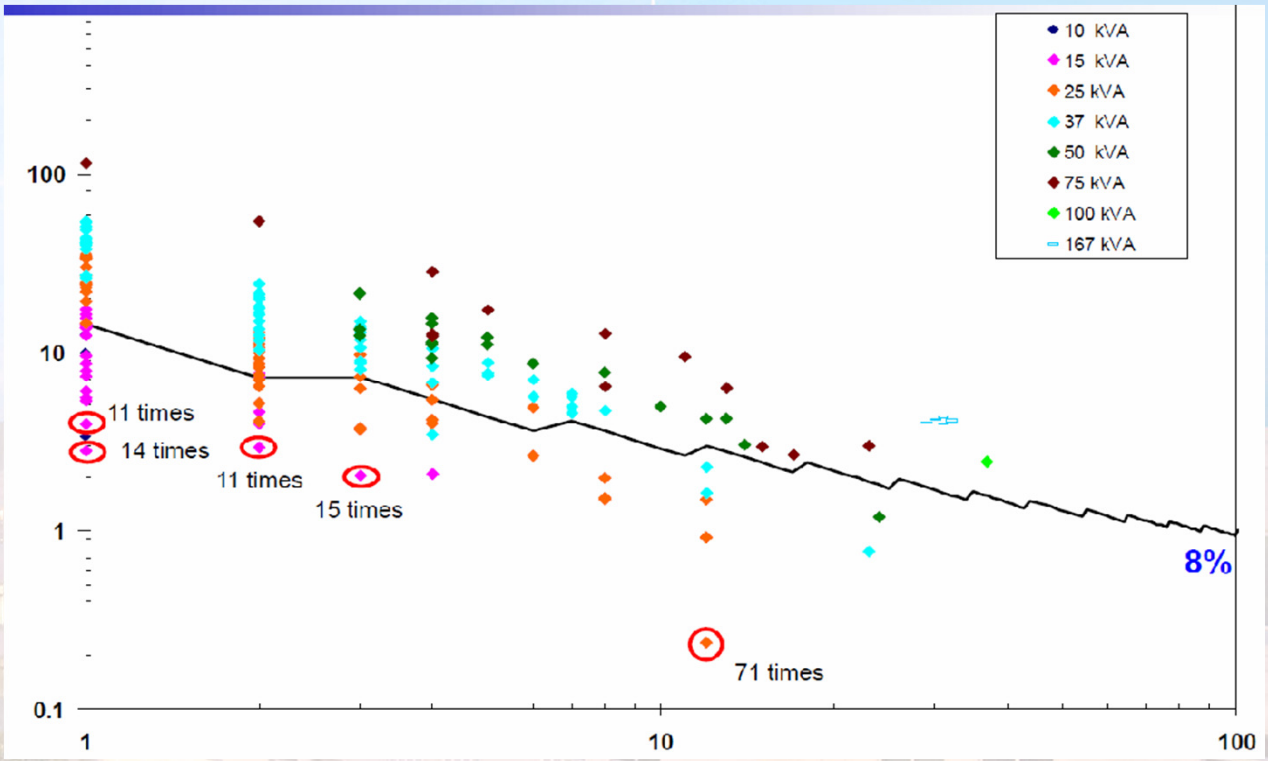
EPRI Distribution Impact Study
Transformer Overloads – High PEV Penetration (8%)

- Heavily loaded in the base case
- Small transformer size
- Large # customers relative to transformer size
- Clustering



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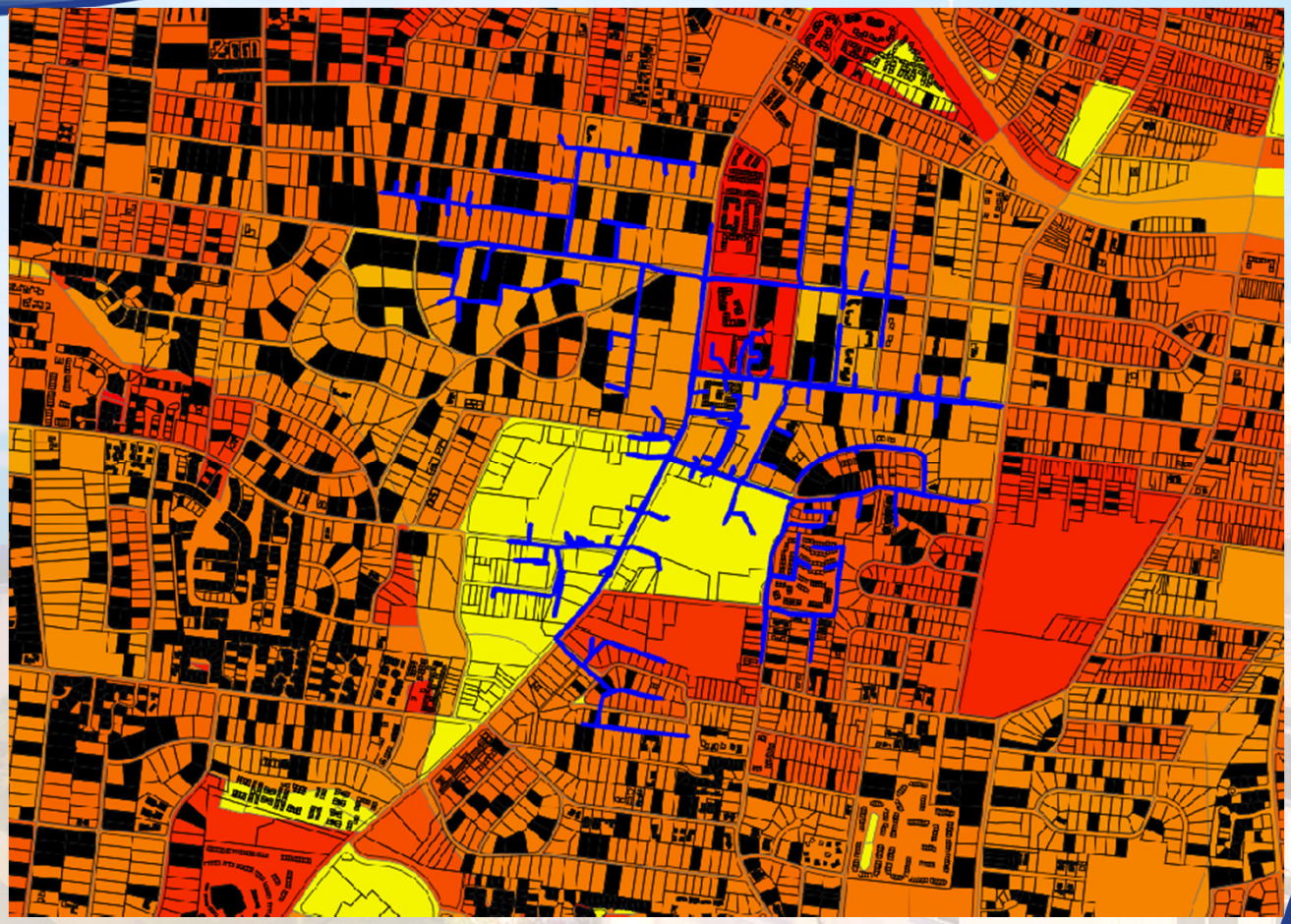
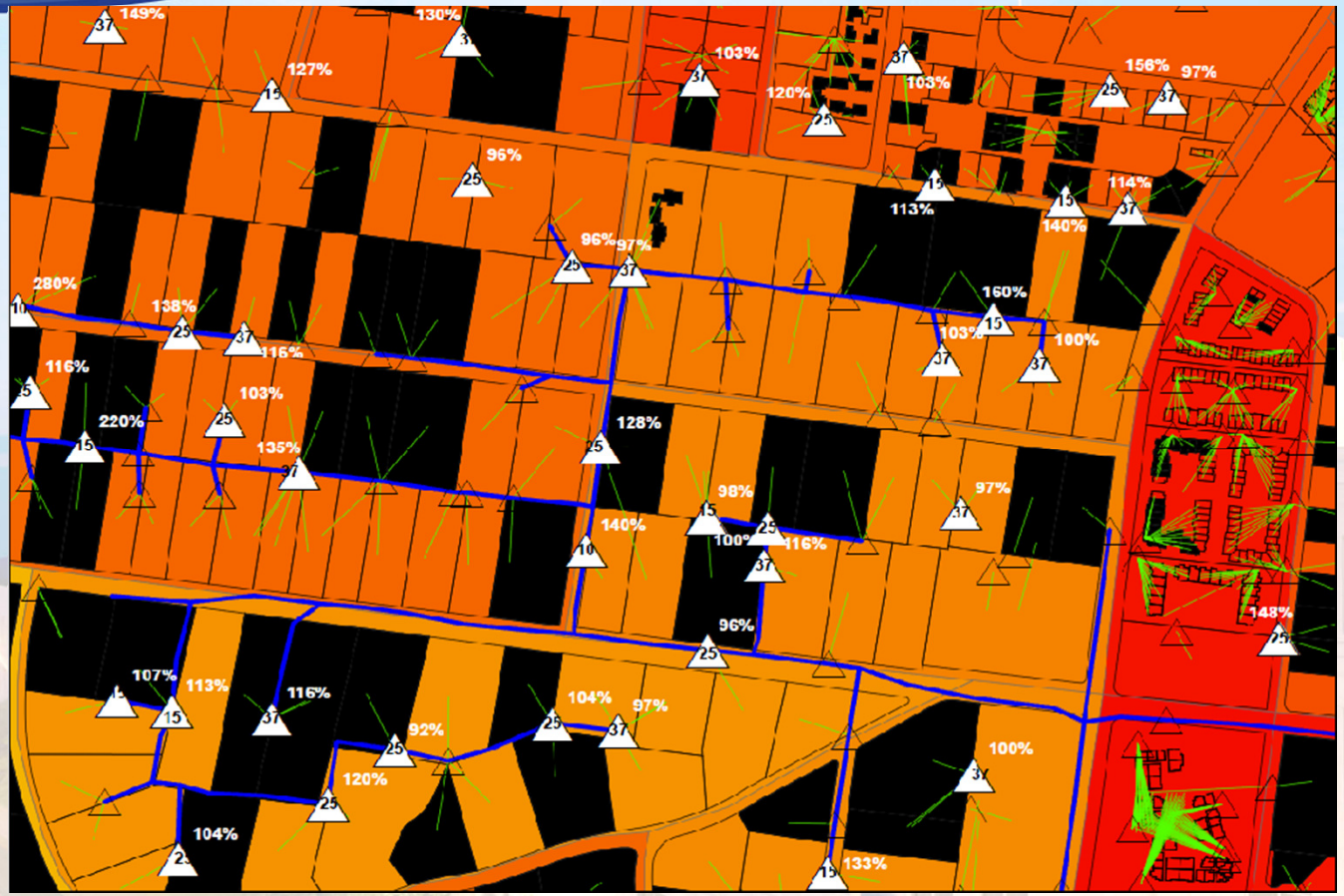
NES Circuit with High Probability of EV Adoption

Garage Data



NES Circuit with High Probability of EV Adoption

Residential Garage Data & Transformer Loading



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Items being Addressed

- Utility Notification of EV buyers
- EV Metering and Billing
- Rate Options
- Transportation Taxes
- Customer Education

- Standards and Best Practices
- Vehicle-to-Home
- Vehicle-to-Grid
- NES Website
  http://www.nespower.com/ElectricVehicles.html

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Conclusions

- Electric vehicles will likely be concentrated/clustered in particular neighborhoods
- Distribution transformers will be sensitive to the deployment of Plug-in Vehicles
- As battery technology improves and consumers demand faster recharging, storage capacity and onboard charging kW rates will likely increase providing additional challenges for electric utilities
- Vehicle-to-Grid will likely provide additional challenges for electric utilities
- There are more questions than answers, but NES is committed to providing our customers with the most reliable electric service at a competitive cost

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Thank you

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