Evaluation of PEV Loading Characteristics on Hydro-Québec's Distribution System Operations

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About Hydro-Québec

- Largest electric utility in Canada
- One of the world's largest producer of hydropower
- 3.9 million customers across the province of Québec
- Peak load 38,000 MW – winter peaking (98% hydraulic)
- By 2015 – 4000 MW of wind power will be online

Understanding Grid Impact

- Only ***distribution system*** impacts
  - no generation/emissions
- Only the PHEV ***loading*** impacts
  - no two-way power considerations
- When are system/component ***limits exceeded***?
  - penetration and charging behavior
  - sensitivity to temporal/spatial variation
- What are ***likely*** near-term impacts?
  - representative penetration/charging
  - penetration levels 1-5 yrs out

Distribution Impacts

- Thermal Loading
- Voltage Regulation
- Xfmr Loss of Life
- Losses
- Imbalance
- Harmonics

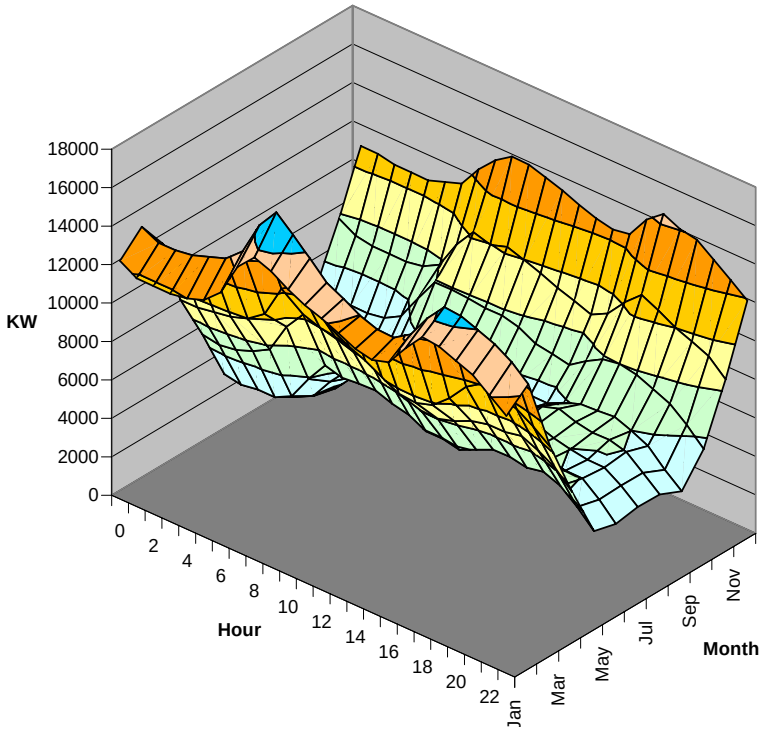
PEV Characteristics

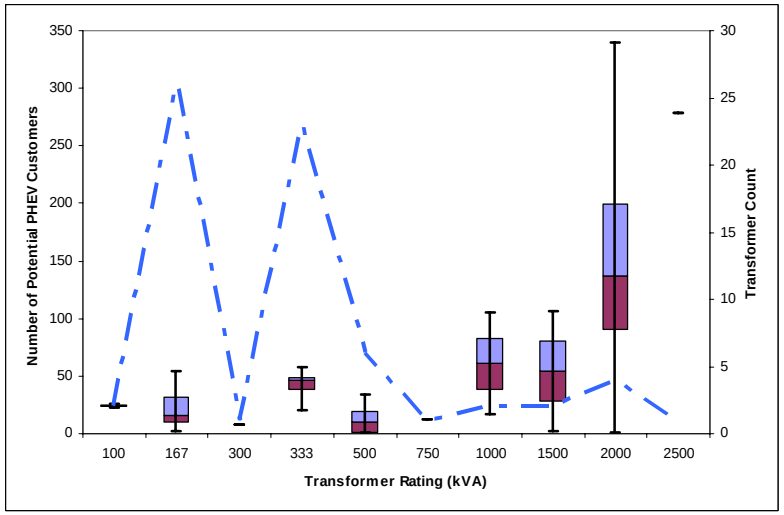
- Type / range
- Market share
- Charge profile and power level
- Customer charge behavior

Distribution Feeder – A

- This feeder supplies is a highly urban circuit containing a very large population density and lots of growth. The majority of the loads represent multifamily homes or high rise condos
  - **Number of customers** – 2801, 44% (1220 customers) of which are living at high rise condos which are served out of 3-phase transformers
  - **Territory** – 88% residential, 12% commercial, 95% underground
  - **Operating voltage** – 25KV
  - **Load factor** – 48%
  - **Load density** – 209
  - **Primary circuit length** – 13.4 miles
  - **Loading** – Winter Peaking Utility. Peak occurs on 2/28/2007. The first peak occurs at 8am and the second peak occurs at 7pm.
  - **Charging Scenario** – Evening and Night charging

Total Loading on Feeder A

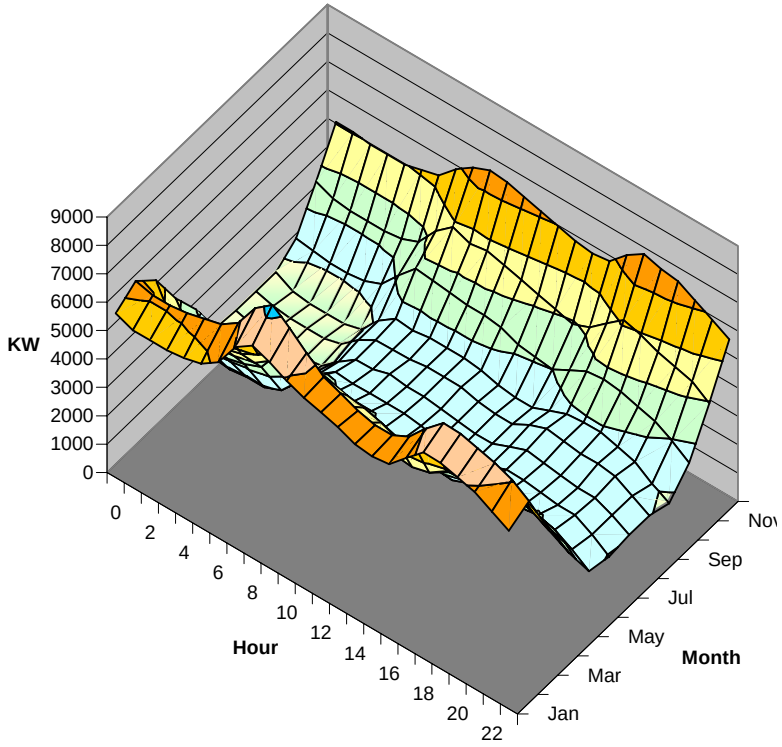


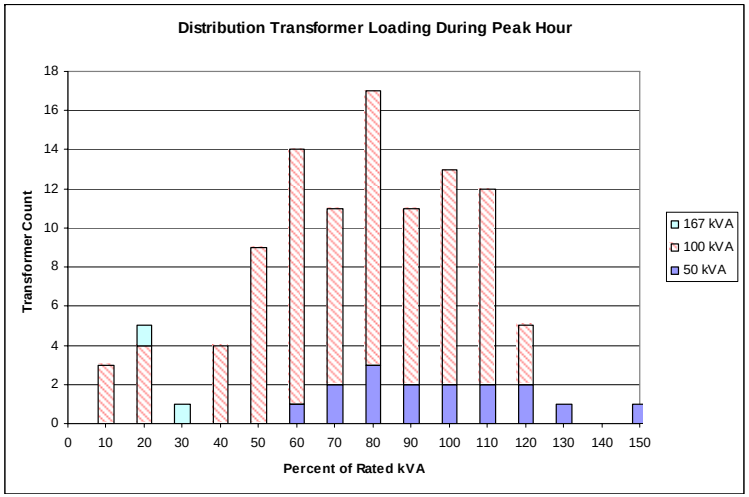


Distribution Feeder – B

- This feeder supplies a typical suburban neighbourhood. Mostly middle and upper middle class families travelling by car (low public transit penetration), very prone to buying a main or secondary car
  - ***Number of customers*** – *1132*
  - ***Customer type***– *97% residential, 3% commercial*
  - ***Operating voltage*** – *25KV*
  - ***Load factor*** – *46%*
  - ***Load density*** – *130*
  - ***Primary circuit length*** – *8.7 miles*
  - ***Loading*** – *Winter Peaking Utility. Peak occurs on 2/5/2007. The first peak occurs at 8am and the second peak occurs at 6pm*
  - ***Charging Scenario*** – Evening and Night charging

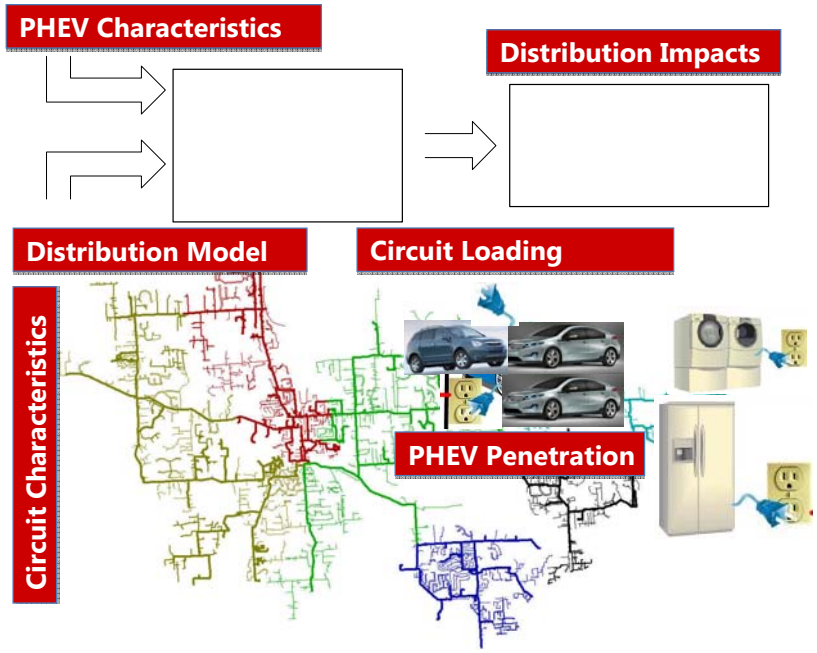
Total Loading on Feeder B





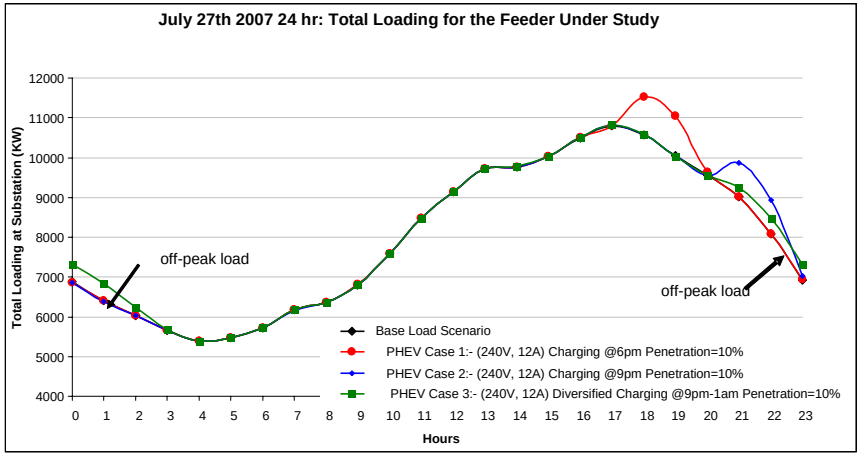
EPRI PHEV Distribution System Impacts

- **Micro level analysis of PHEV load impact**
  - full electrical model of specific feeders
  - sequential power flow through full year
  - sensitivity of PHEV spatial/temporal variation
- **Specific Utility Results**
  - impacts to specific circuits
  - implications to specific design/op practices
- **Generalized Collaborative Results**
  - rules of thumbs based on circuit characteristics



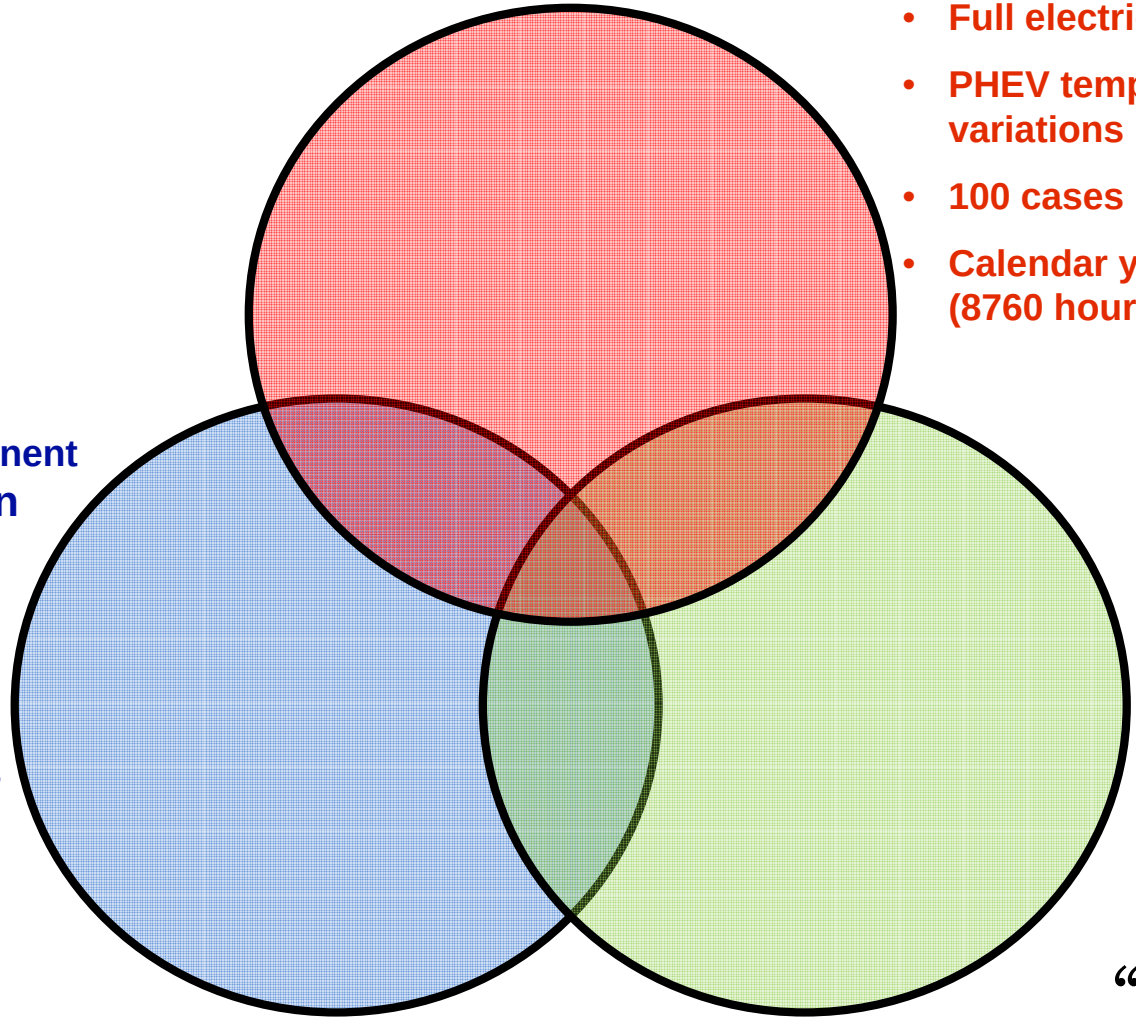
Question to be Addressed

- What system impacts are likely to occur?
- What level of penetration necessitates feeder/asset upgrades?
- How can the new load be managed?



Impact Analysis Methodology

- Full electrical system model
- PHEV temporal & spatial variations
- 100 cases per set
- Calendar year (8760 hours)



- Individual component capacity margin
- Asset class overload susceptibility
- Peak & off-peak (75% peak) hours

- Full electrical system model
- Fixed PHEV behavior – boundary cases
- Peak day (24 hours)

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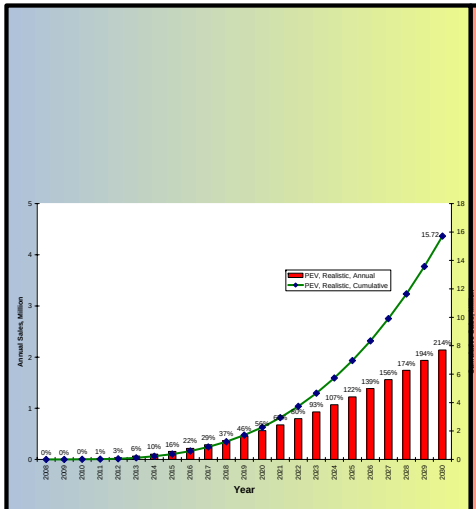
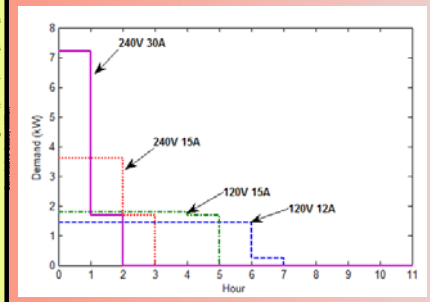
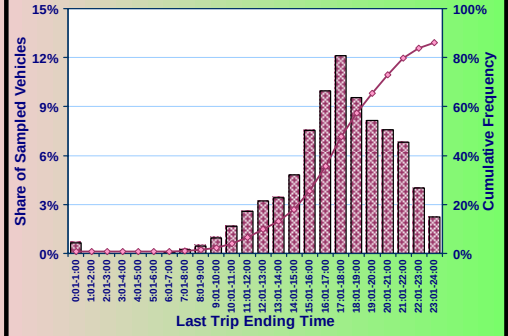
Developing PHEV Scenarios

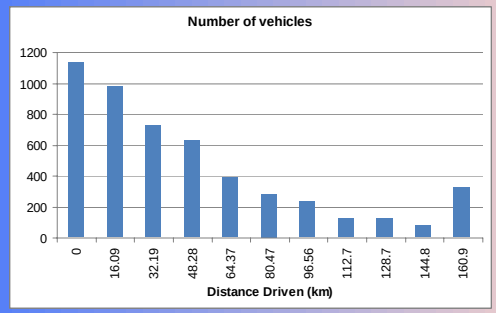




PEV Market Penetration



PEV Spectrum



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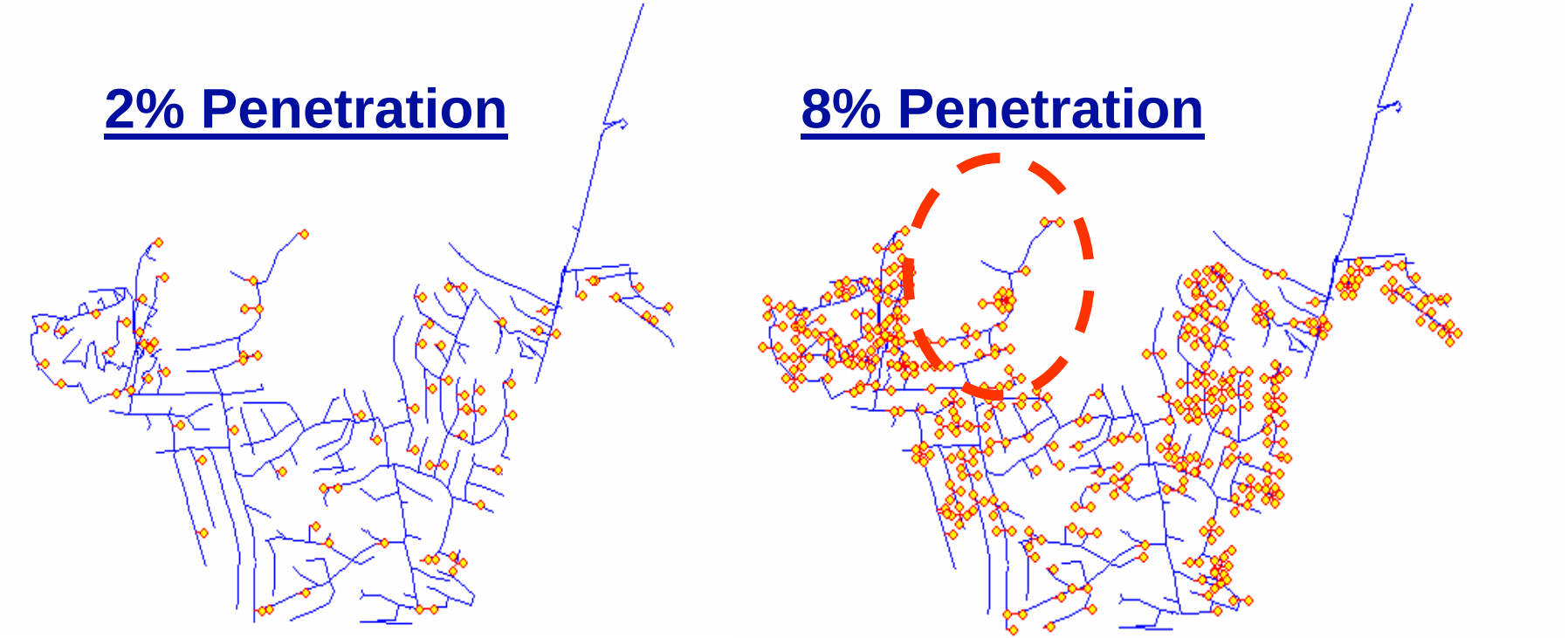
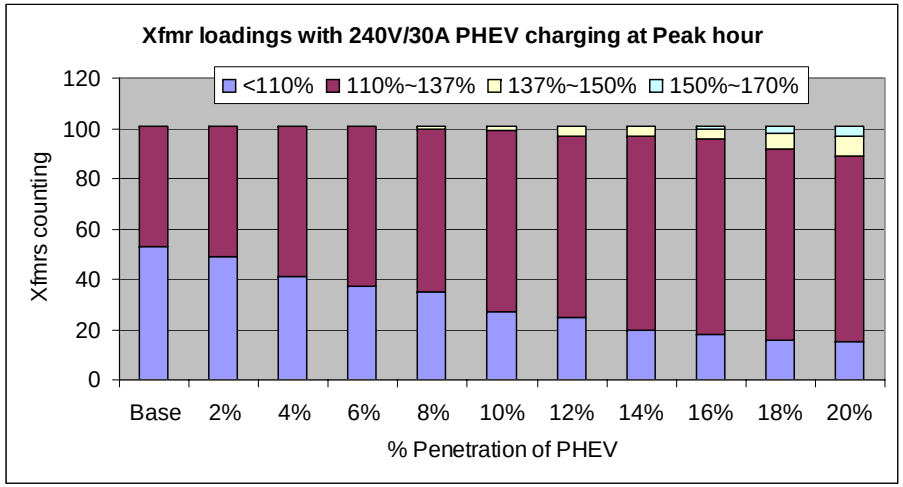
PHEV Clustering

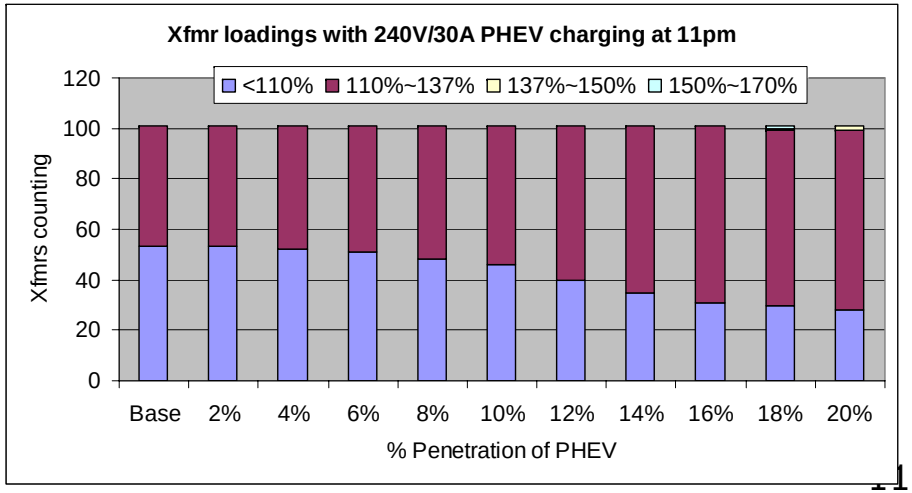
- No data to support differentiation of customer preference
- Clusters occur from penetration and system configuration



Asset Overloads - Component Deterministic Analysis

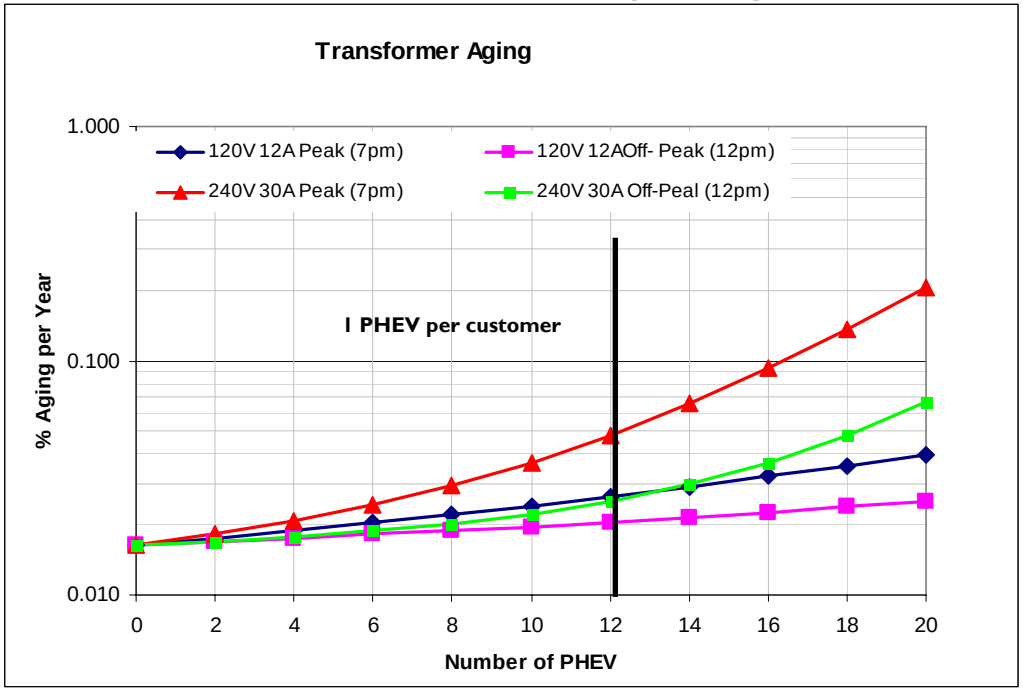
- Service transformers and underground cables are most susceptible asset to PHEV clusters/penetration
- Service transformer overload impact is minimal even at 20% penetration on specific feeder
- Charging on peak during peak hours less than 10% of transformers are critical



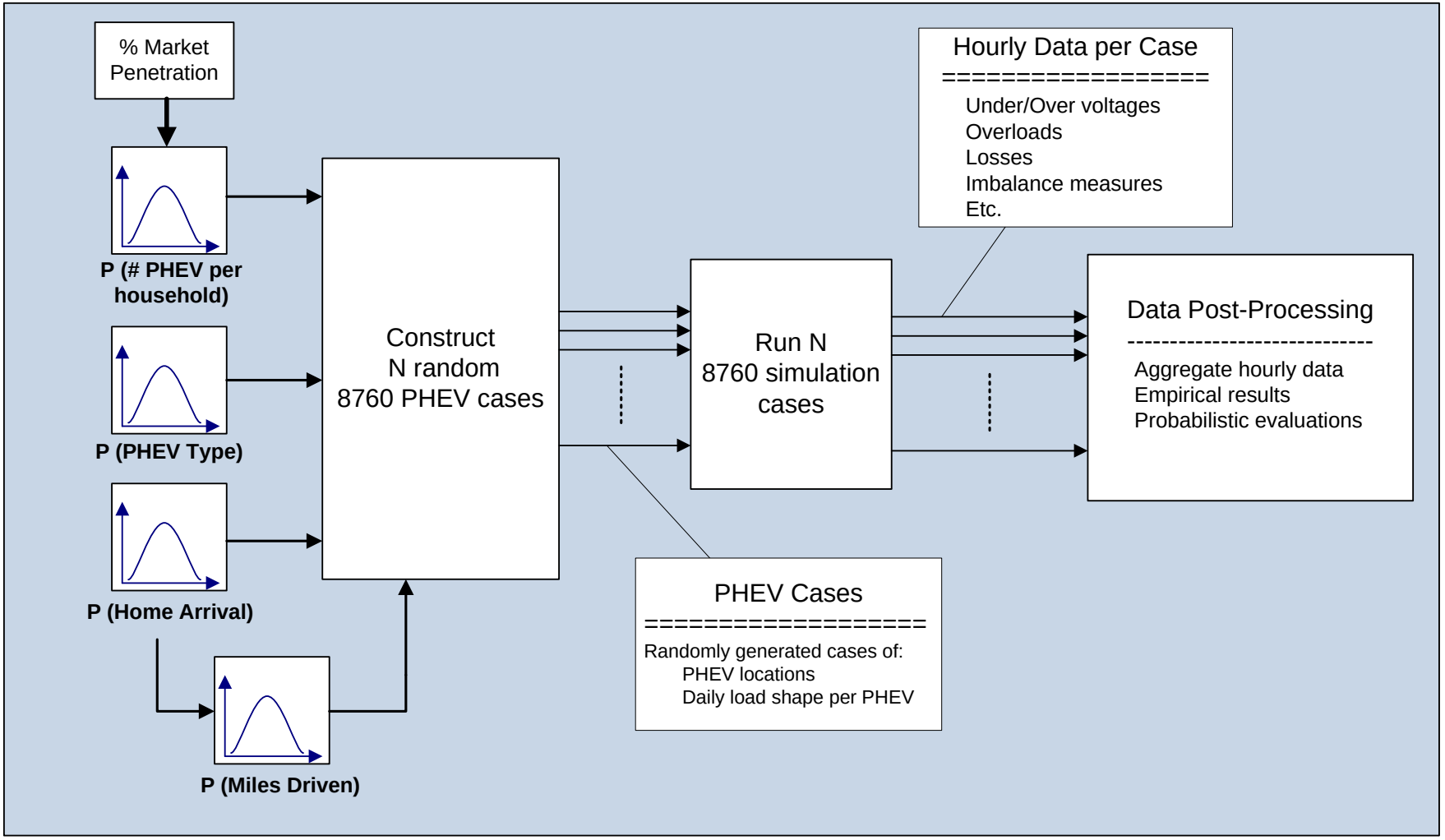


Transformer Loss of Life Analysis

- 167KVA rated transformer are the most common. For this circuit, the observed max and average peak hour demand for that transformer size of all the 167KVA transformers is 127% and 59% respectively
- Influence of transformer lifespan (% insulation aging per year) & hot spot temperatures on PEV loading
- Very minimal reduction to the lifespan of the transformer due to PEV loading with the 120V charging (less than 3 months over 40 years)



Stochastic analysis



Stochastic Analysis

- On 100 stochastic scenarios

KVA	# of Xfo	Penetration 2%		Penetration 4%		Penetration 8%	
		Prob (%)	Overloaded xfos	Prob (%)	Overloaded xfos	Prob (%)	Overloaded xfos
50	16	14	1	25	1	51	3
100	80	0	0	0	0	0	0
167	2	0	0	0	0	0	0
300	3	0	0	0	0	0	0

In scenarios with a relatively low penetration levels on a "normal" residential feeder, le probability of facing lots of overloads is low.

Scenarios with higher penetration levels are in preparation (over 25%)

FEEDER A

Summary / Q&A

- Feeder impacts: Very low on both deterministic and preliminary stochastic analysis
- Asset impacts: not significant
- Clustering may cause some problems, which will be addressed on a case by case basis
- More stochastic scenarios need to be examined
- Impacts on underground feeders and the transmission networks still need to be assessed

Merci!