Investigating Load Estimation Methods with the Use of AMI Metering for Distribution System Analysis

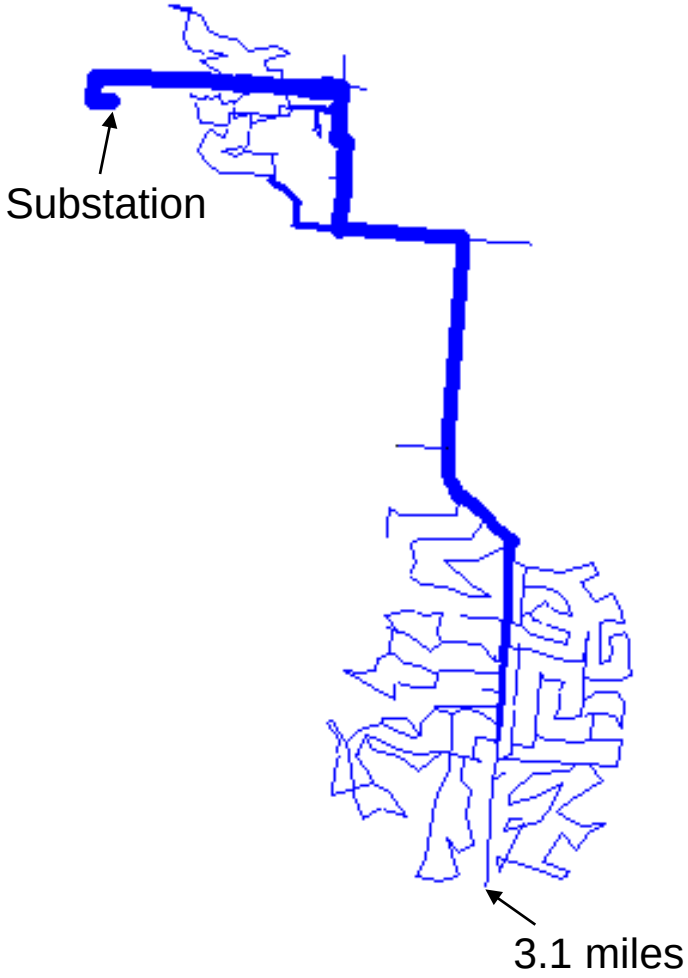
Robert F. Arritt, P.E.
Sr. Engineer

IEEE Rural Electric Power Conference
April 15-17, 2012

Contents

- Circuit Overview
- Review of Load Allocation Methods
  - AMI Allocation
  - SCADA Allocation
  - Monthly Usage Allocation
  - Class Loadshapes
- Simulation Results
- Summary

Circuit Overview



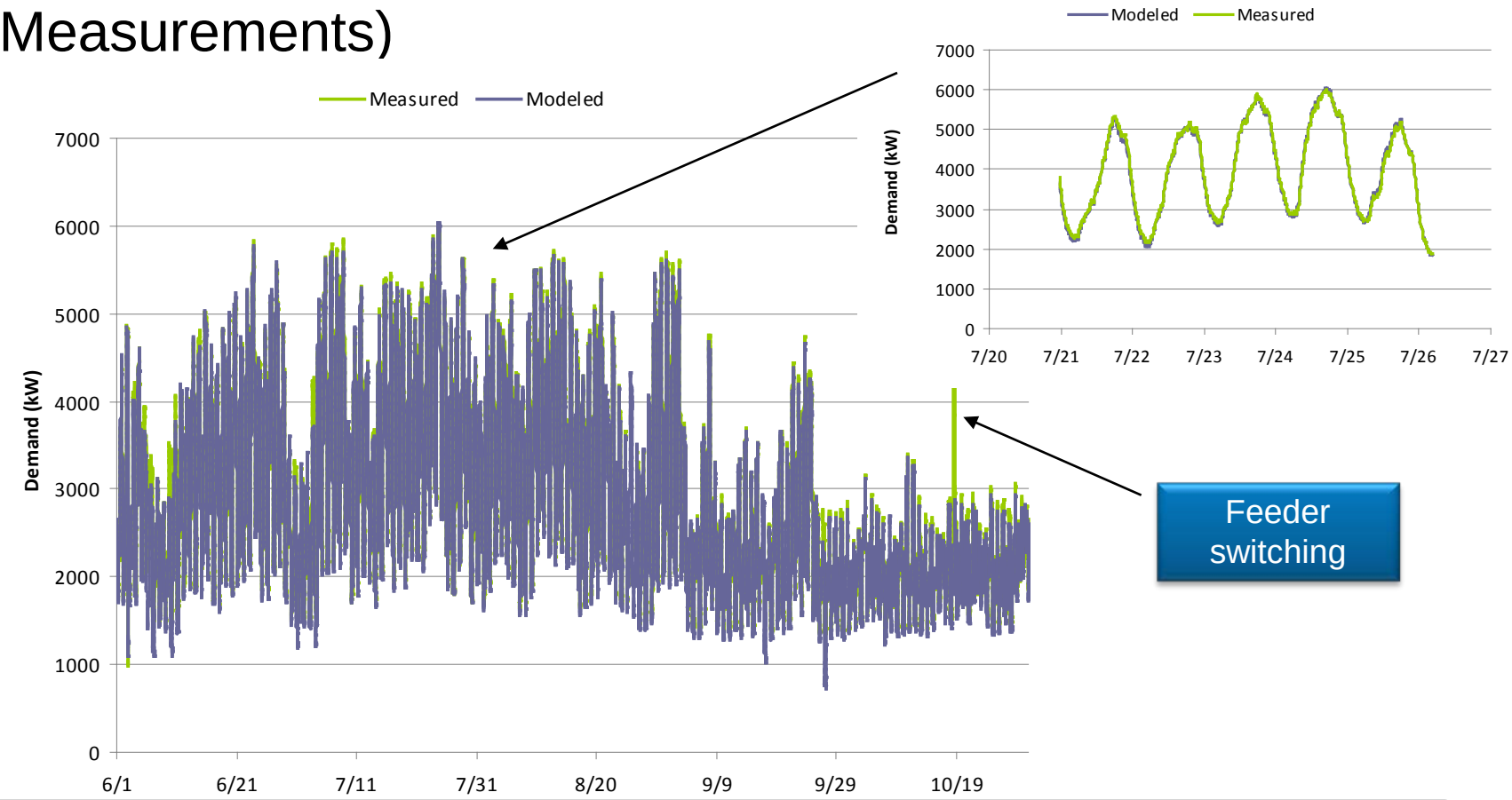
- System Voltage – 13.2 kV
- 1179 loads
- 46% load factor
- 5,800 kW peak load
- Load Class
  - 99% Residential
  - 1% Commercial
- AMI
  - 99% Coverage (Based on connected kVA)
  - Approximately 6 months
    - 6/1/2010 to 11/18/2010

Load Allocation Methods Studied

- AMI
  - Allocate average 15-minute kW measurements
  - AMI coverage – 99%
- Substation Allocation
  - Allocate substation SCADA measurements based on connected kVA
- Monthly Usage Allocation
  - Allocate based on customer's monthly average usage
  - Used SCADA data for loadshape generation
- Class Loadshapes
  - Historical load profiles and SCADA data to estimate load

AMI Overview

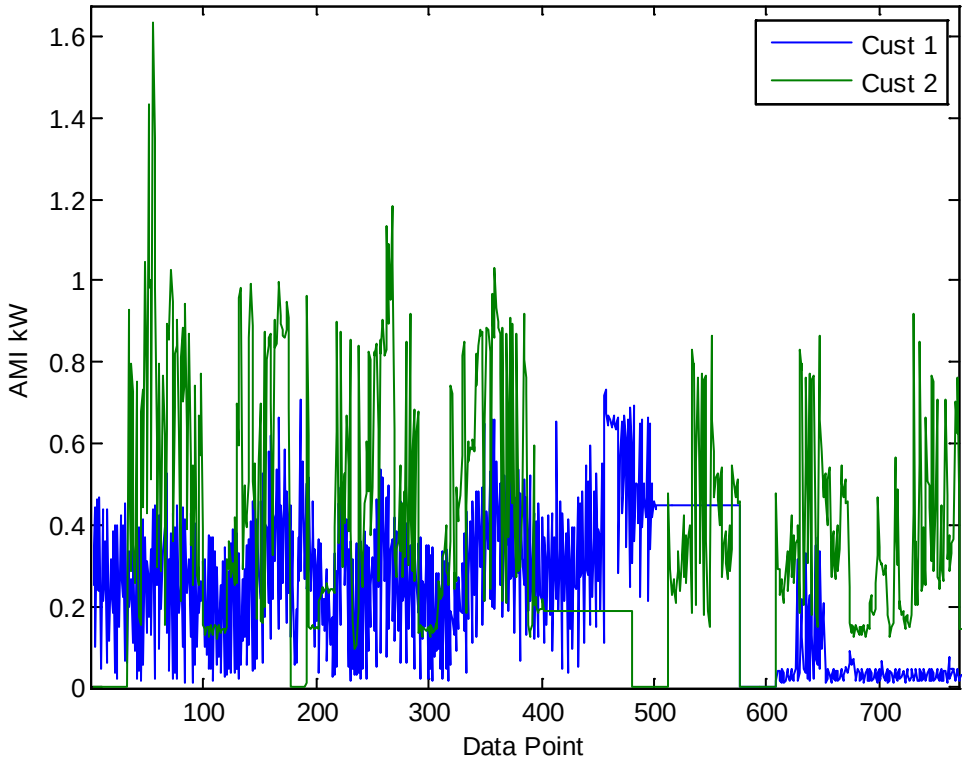
- Aggregate Demand (Compared to SCADA Measurements)



The unmetered load values were back calculated from substation measurements.

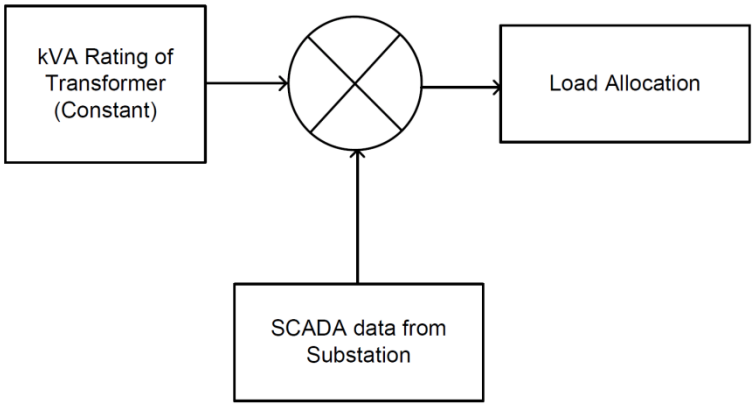
AMI Overview – Cont.

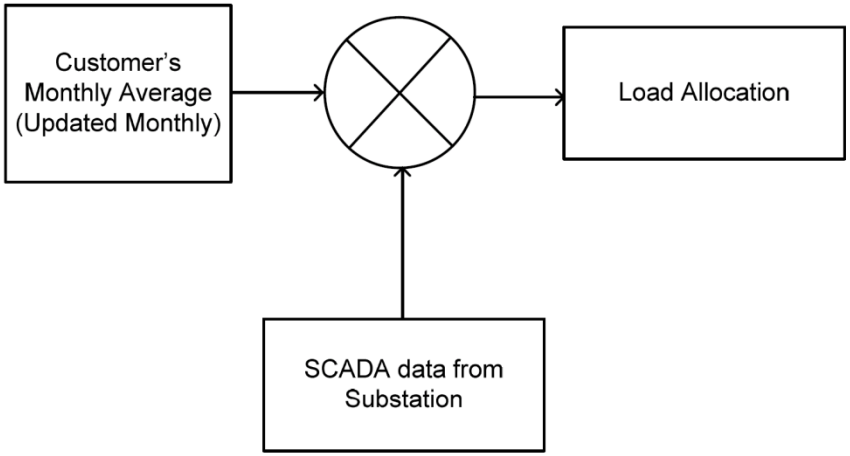
- Customer demands
  - Individual data errors do not appear to have a large impact on the aggregate



Substation and Usage Allocation

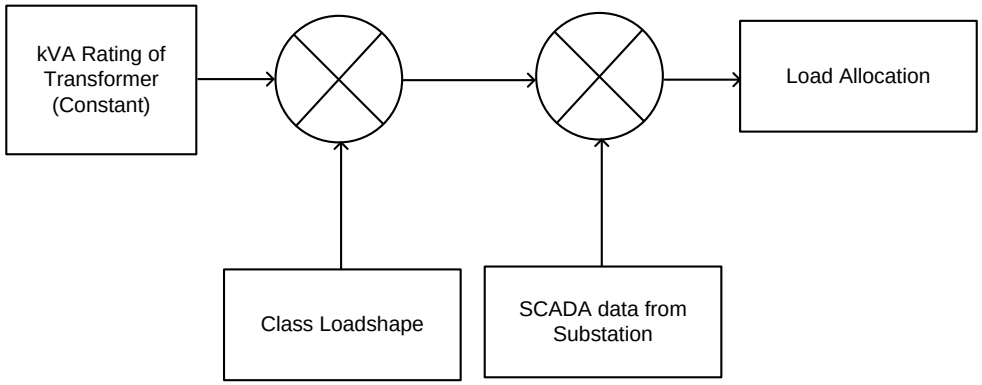
- Sub Allocation – kVA rating for each of customer's service transformer to allocate loads.
- Monthly Usage Allocation – used the monthly kWh usage for each customer. Therefore a customer's kW demand allocation was updated for each month.

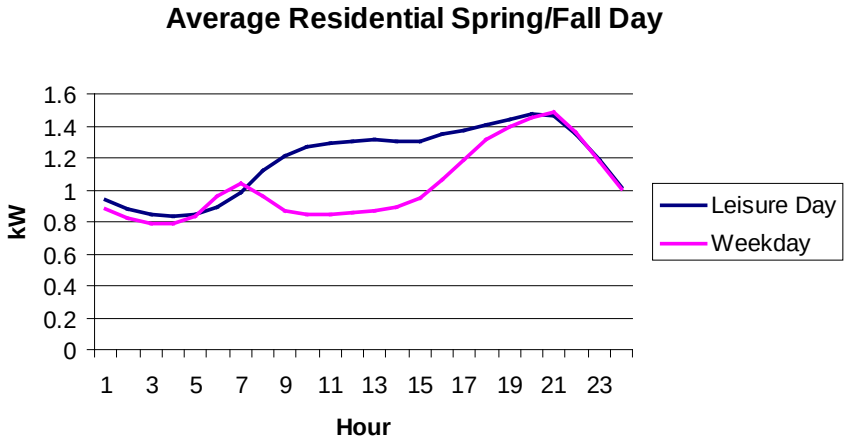


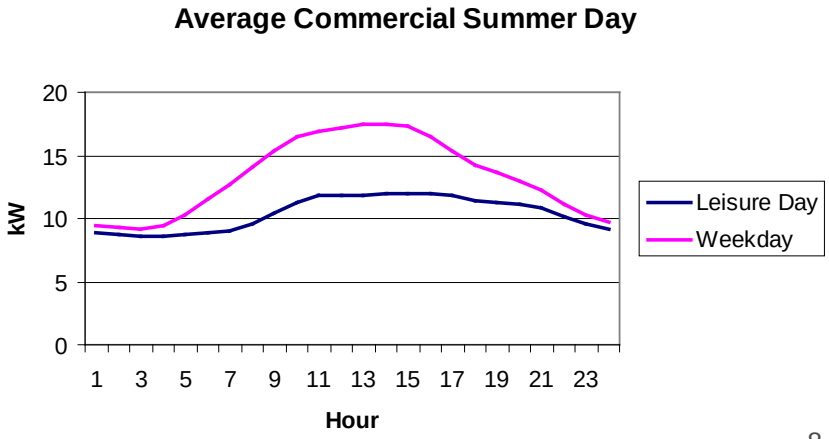


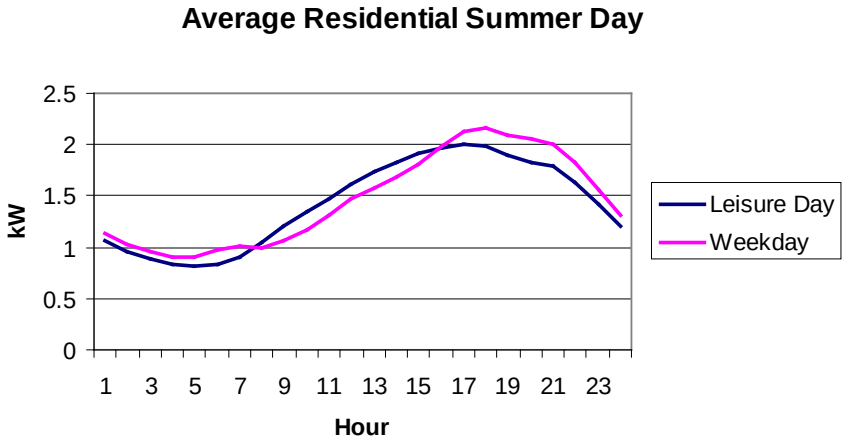
Class Loadshapes

- Allocate based on customer type.
  - 99% Residential
  - 1% Commercial



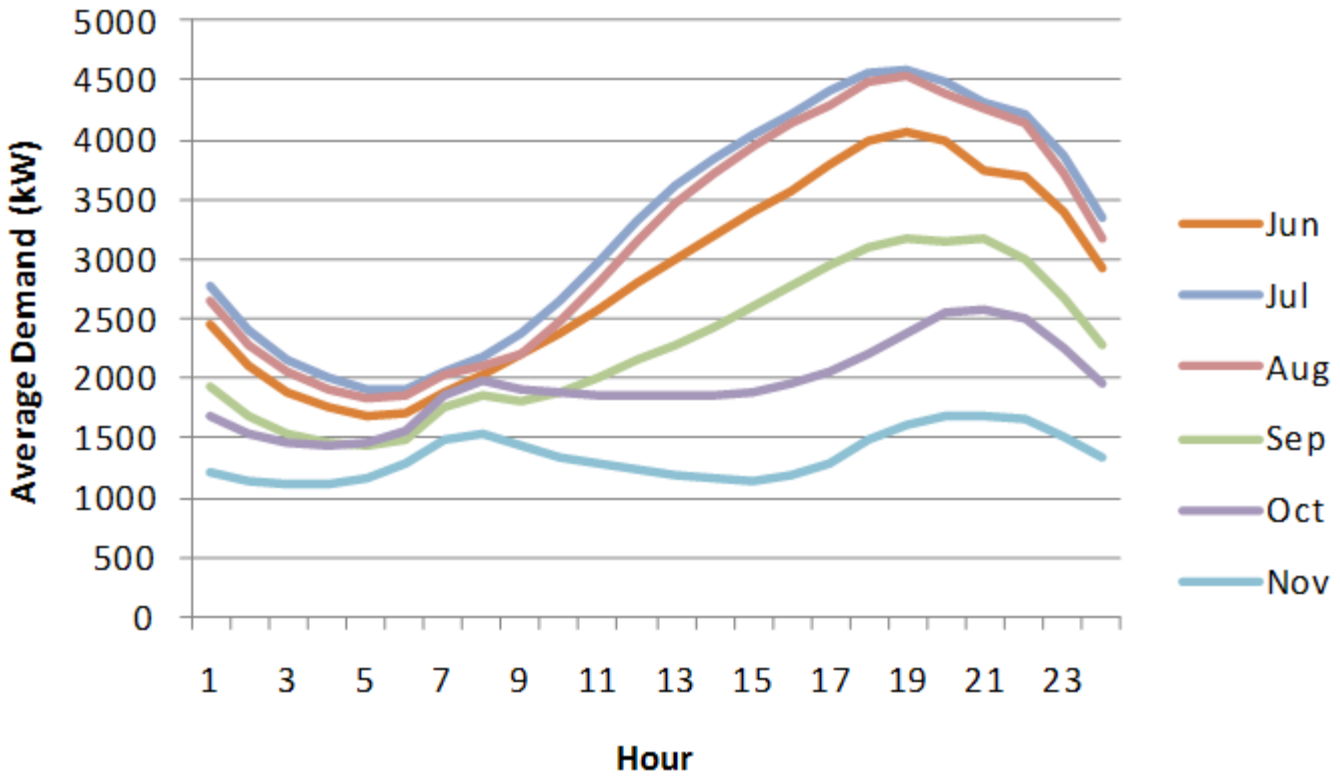






Hourly and Seasonal Demand – From AMI Simulation

- Summer peaking
- Mainly residential profile



Equipment Evaluations

- Overload report identifies transformers that exceeds its normal rating.
  - Normal overload exceeds 110% of rating

Number of Transformers Identified that Exceeded their Normal Rating			
AMI	**Substation Allocation**	**Monthly Usage Allocation**	**Class Loadshapes**
51	**5**	**27**	**4**

Because AMI load allocations do not allocate proportionally based on rating, the overload reporting is base on actual measurements.

Voltage Comparison

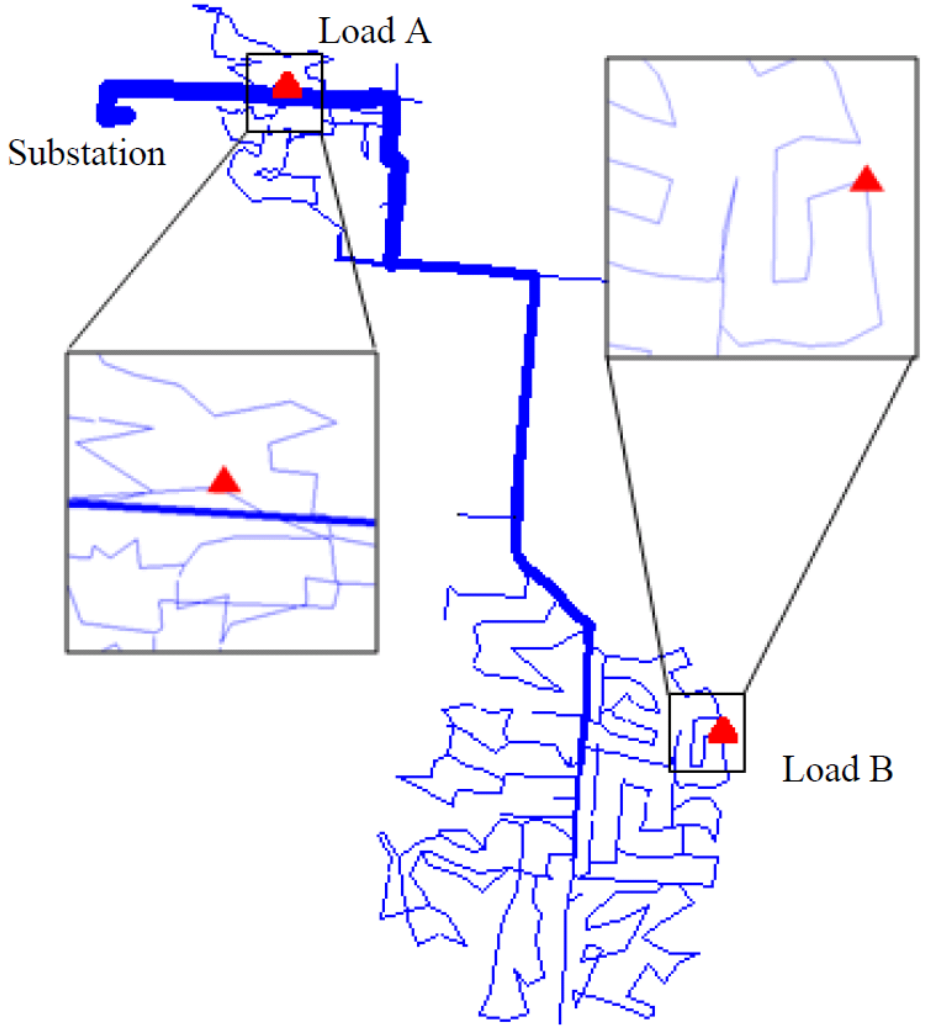
- Monthly Usage Allocation tracks the AMI voltage simulation results more closely.

Minimum Customer Voltage At Peak			
AMI	**Substation Allocation**	**Monthly Usage Allocation**	**Class Loadshapes**
119.95	**121.85**	**119.86**	**121.40**

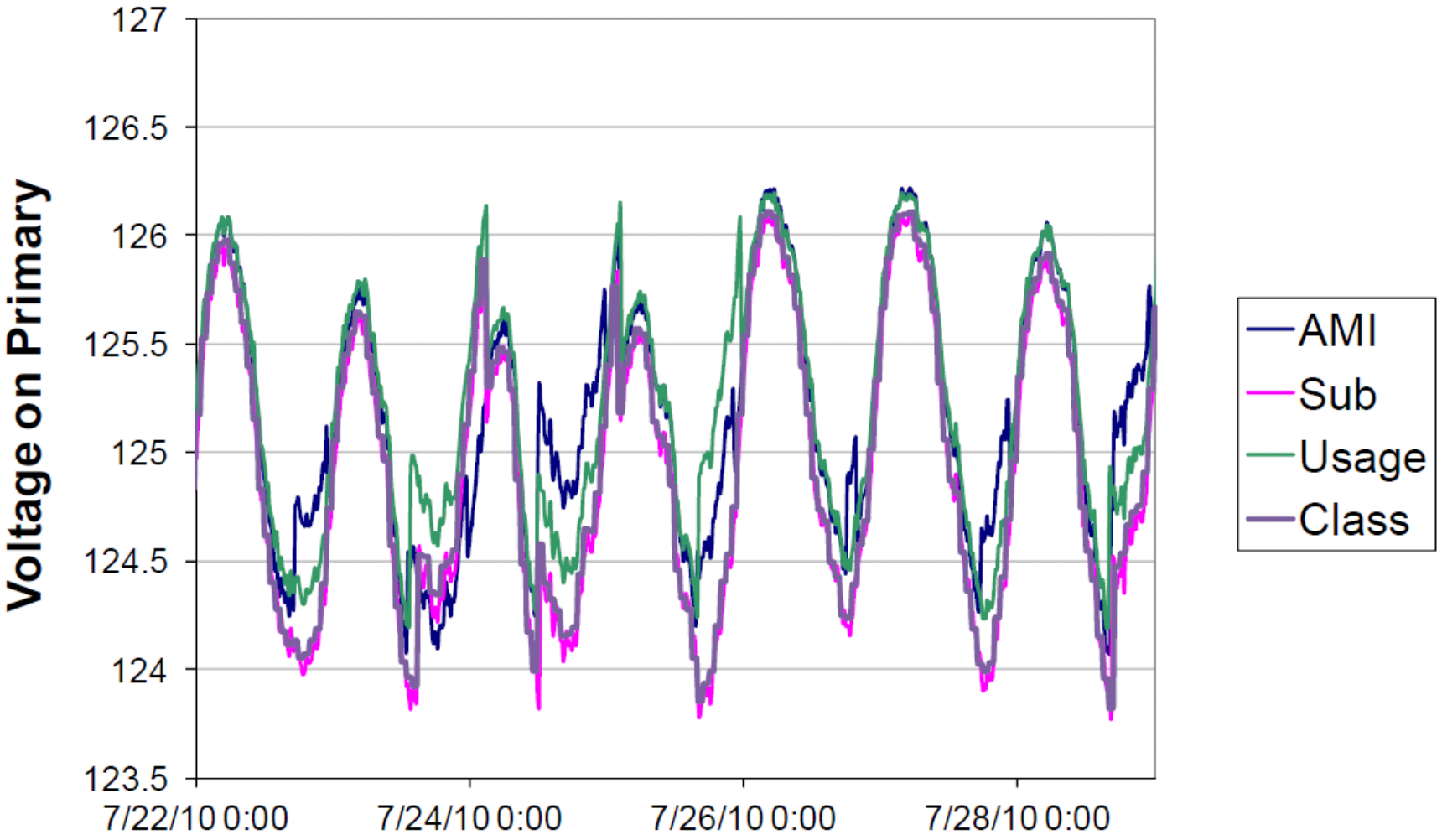
Because Monthly Usage results do not allocate proportionally based on rating, the voltage results are closer to the AMI simulations.

Voltage Comparison

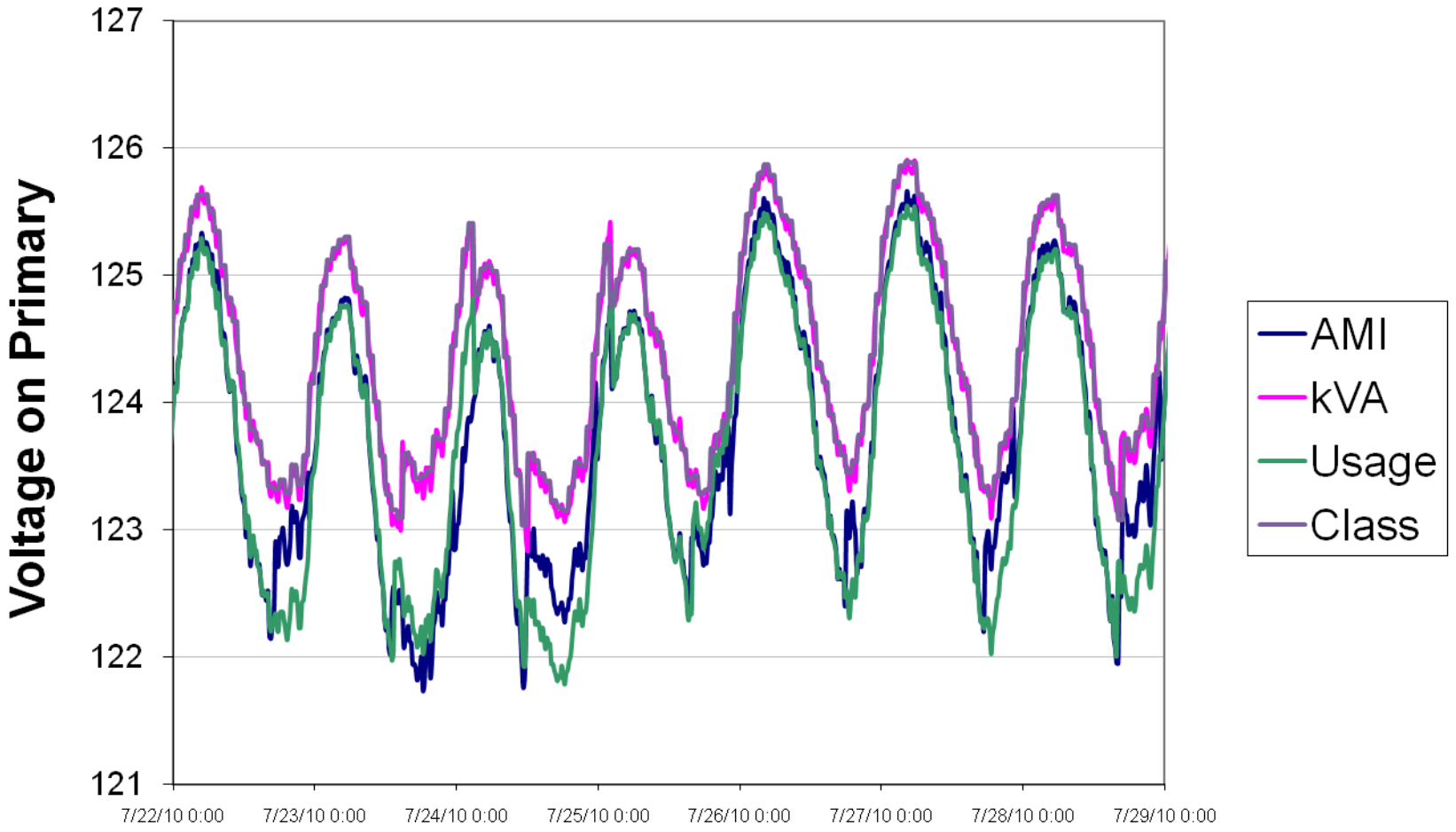
- To further examine the voltage estimations for each of the allocation methods, two loads were randomly selected.
  - Load A – Located 1 mile from the substation
  - Load B – Located 3.5 miles from the substation.



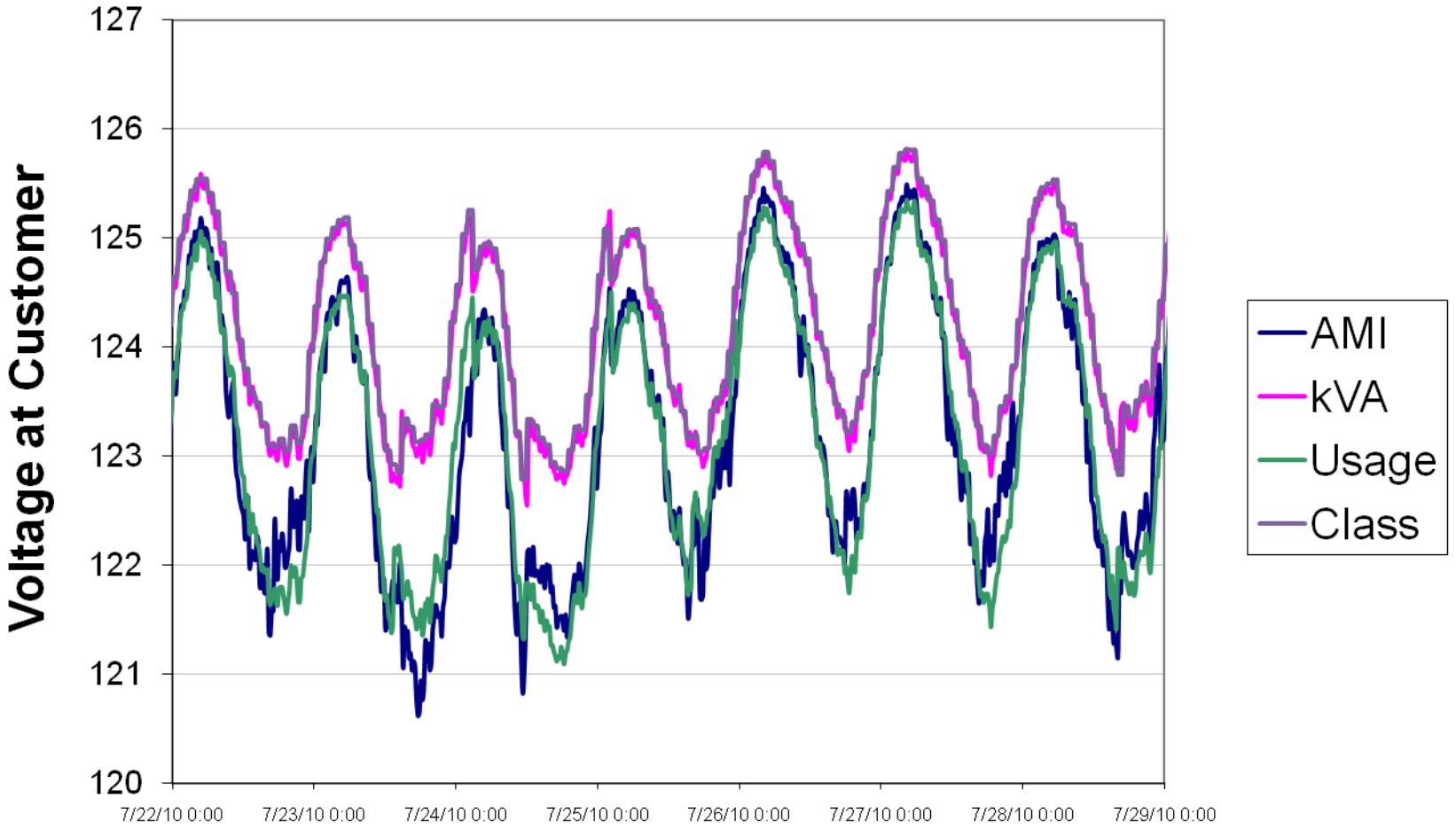
Primary Voltage for Load A



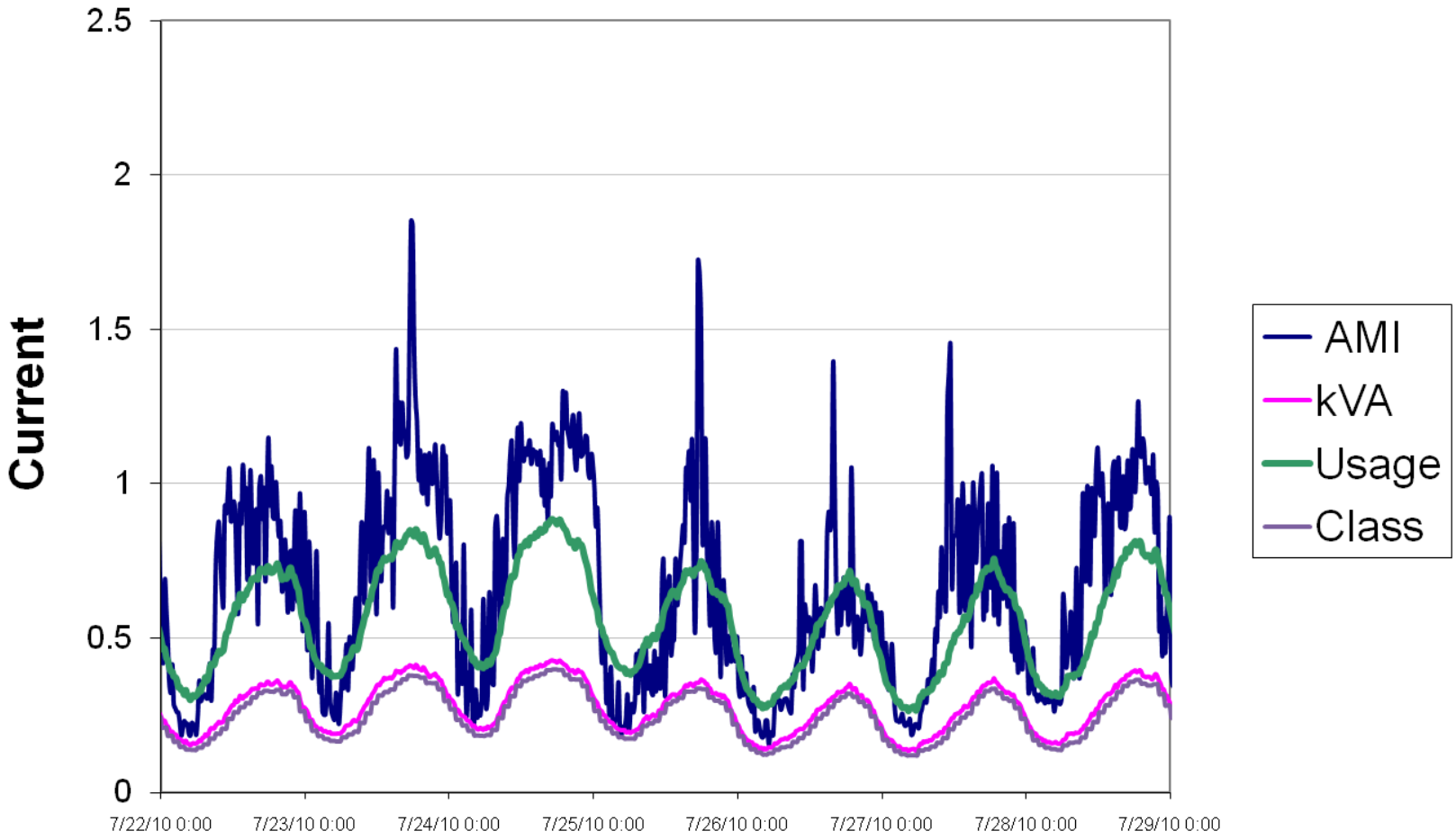
Primary Voltage for Load B



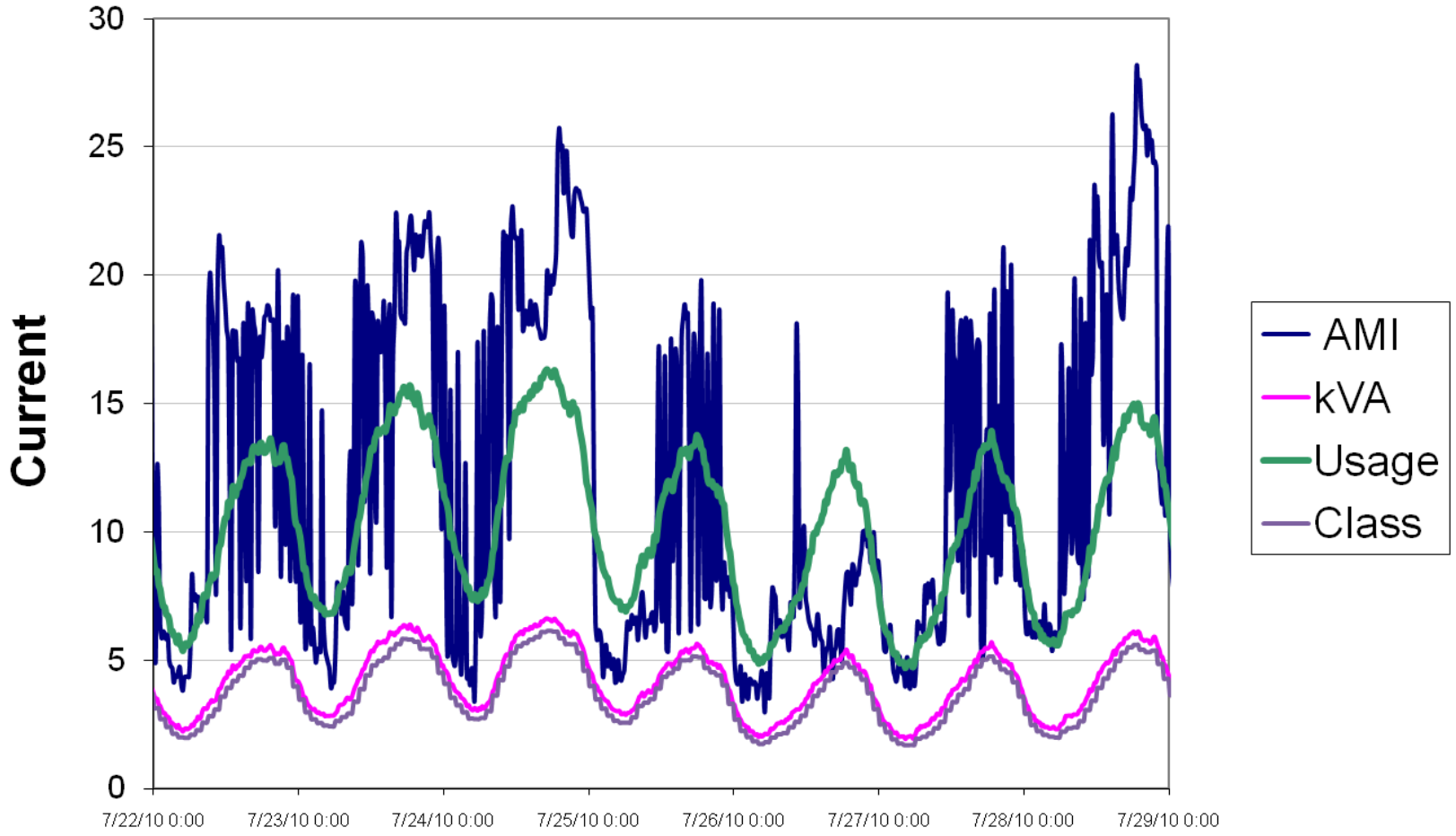
Example of Customer Voltage at Load B



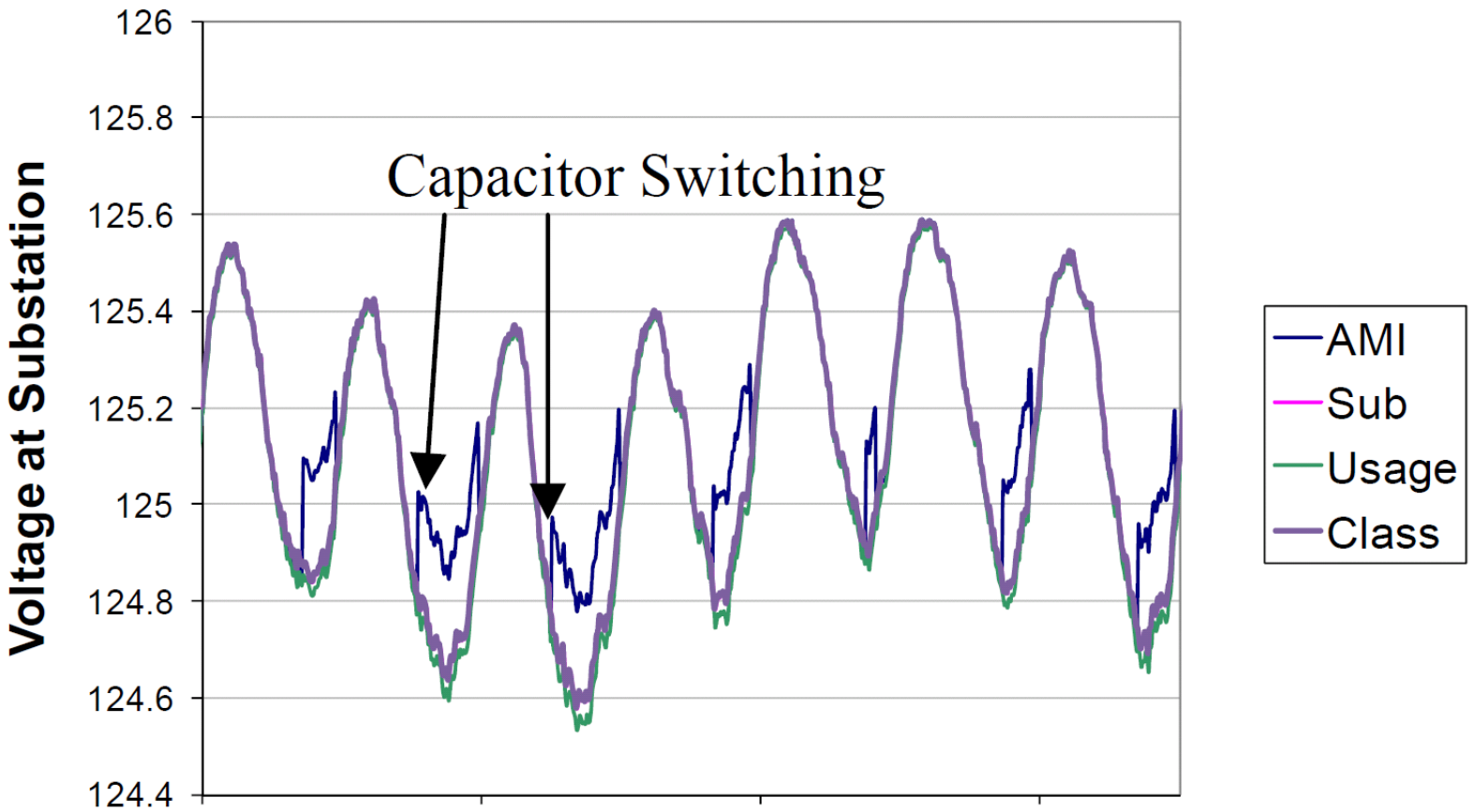
Customer Current at Load B (Primary)



Customer Current at Load B (Secondary)



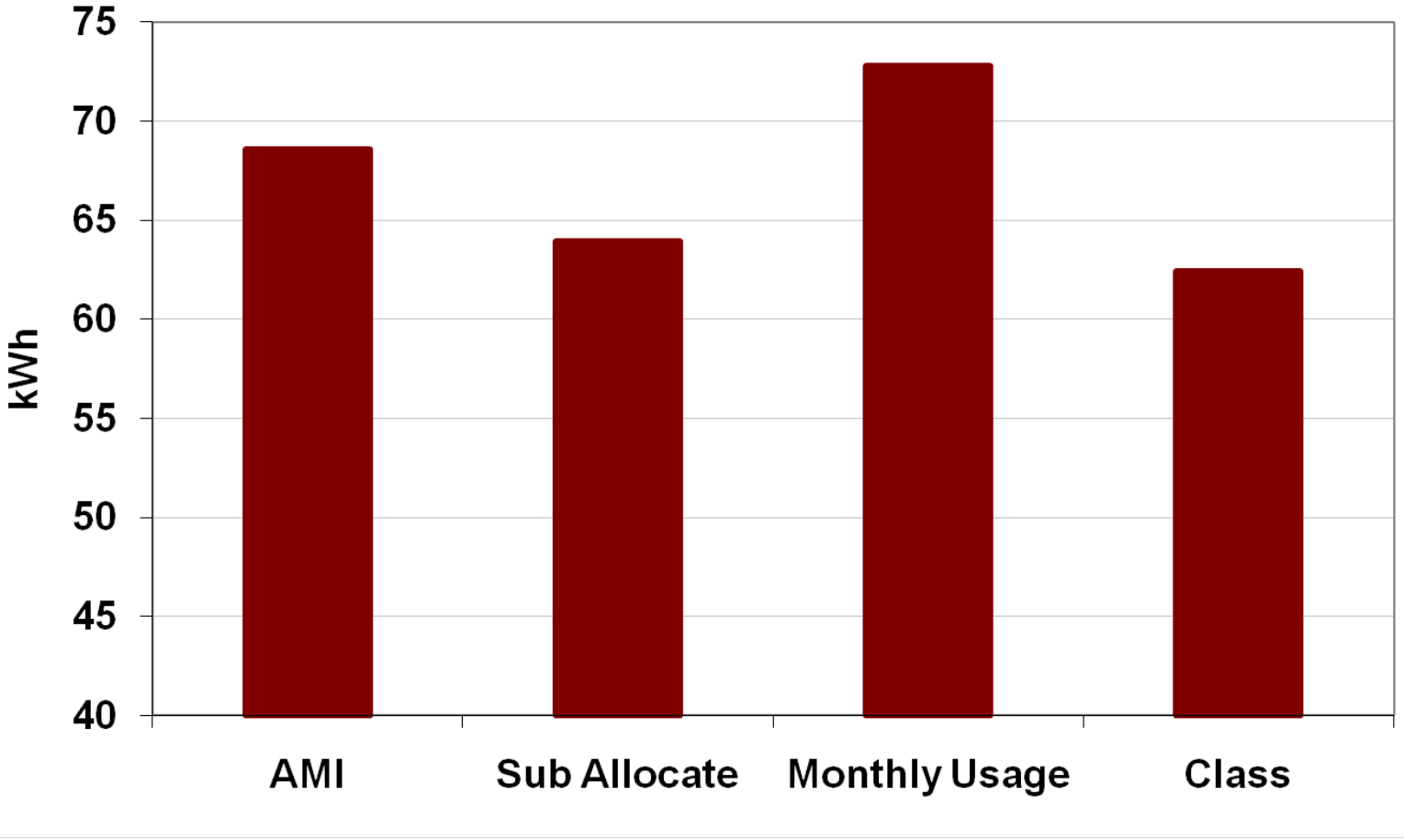
Substation Bus Voltage



The AMI base model causes the capacitor bank farthest downstream to change state..

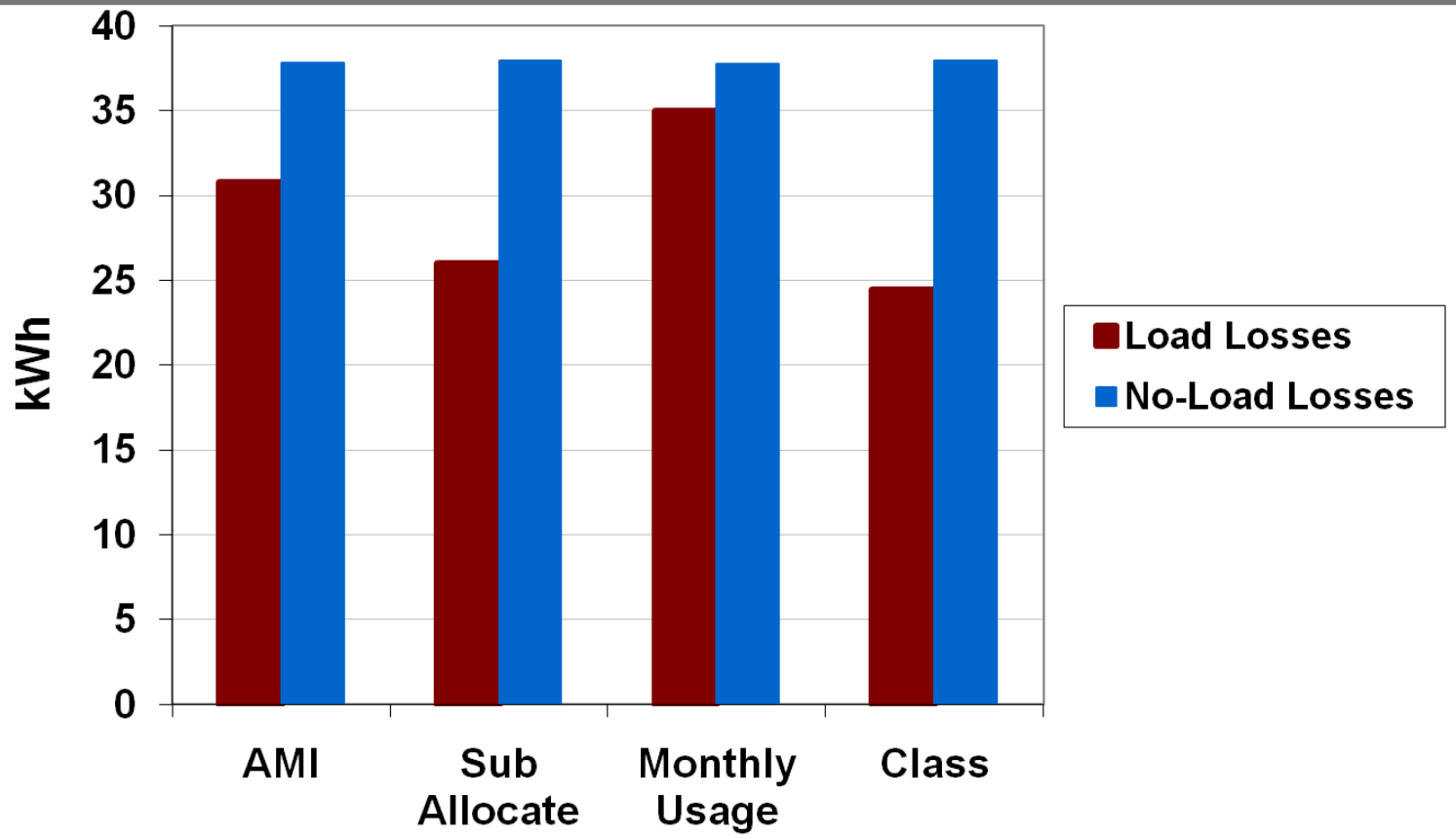
Average Losses

Both the AMI and Monthly Allocation case had more losses on the secondaries and primary compared to the Substation Allocation case.



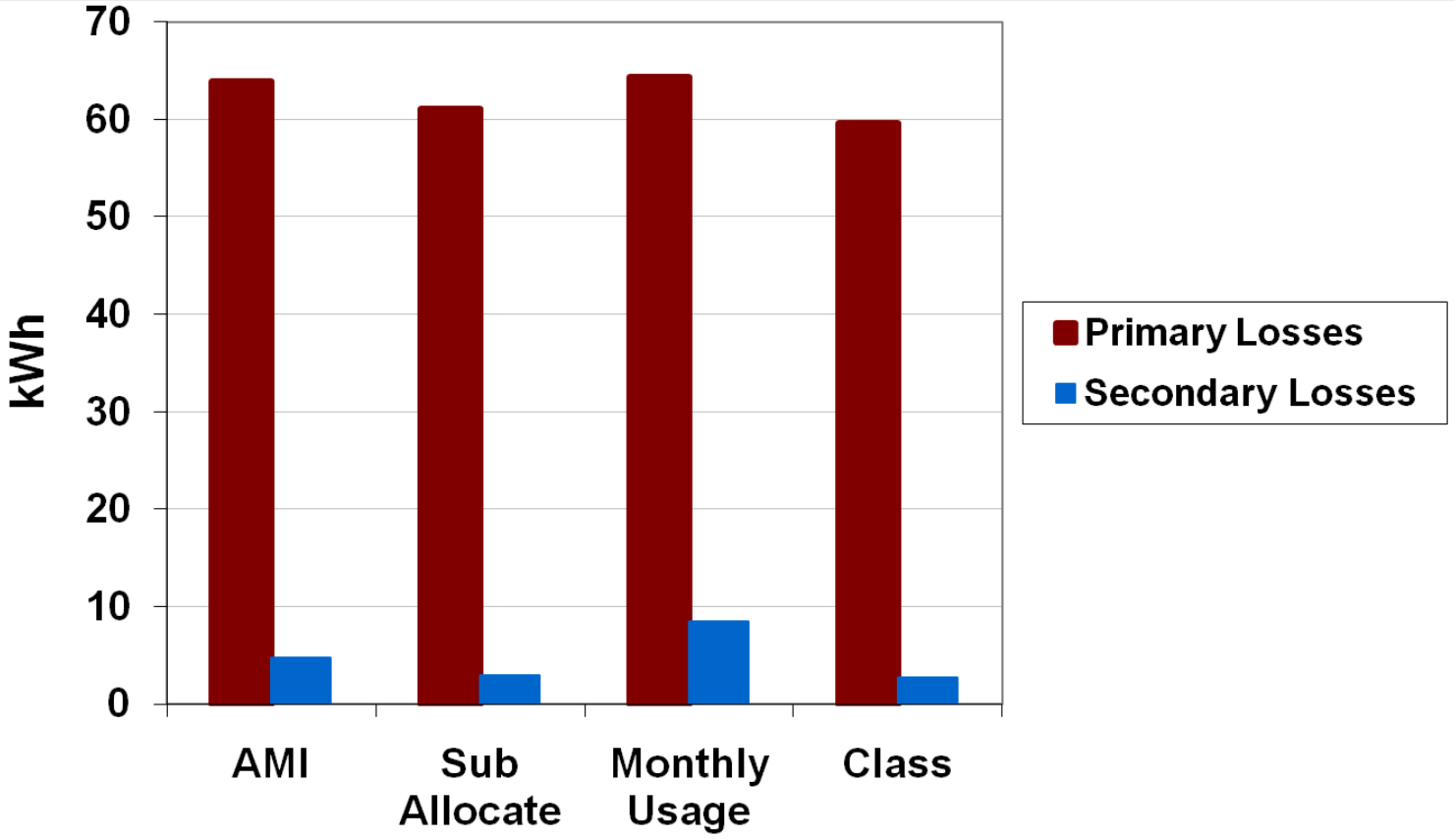
Average Load and No-Load Losses

Because the voltage profile across the simulation is relatively flat, the no-load losses are constant across all 3 cases.



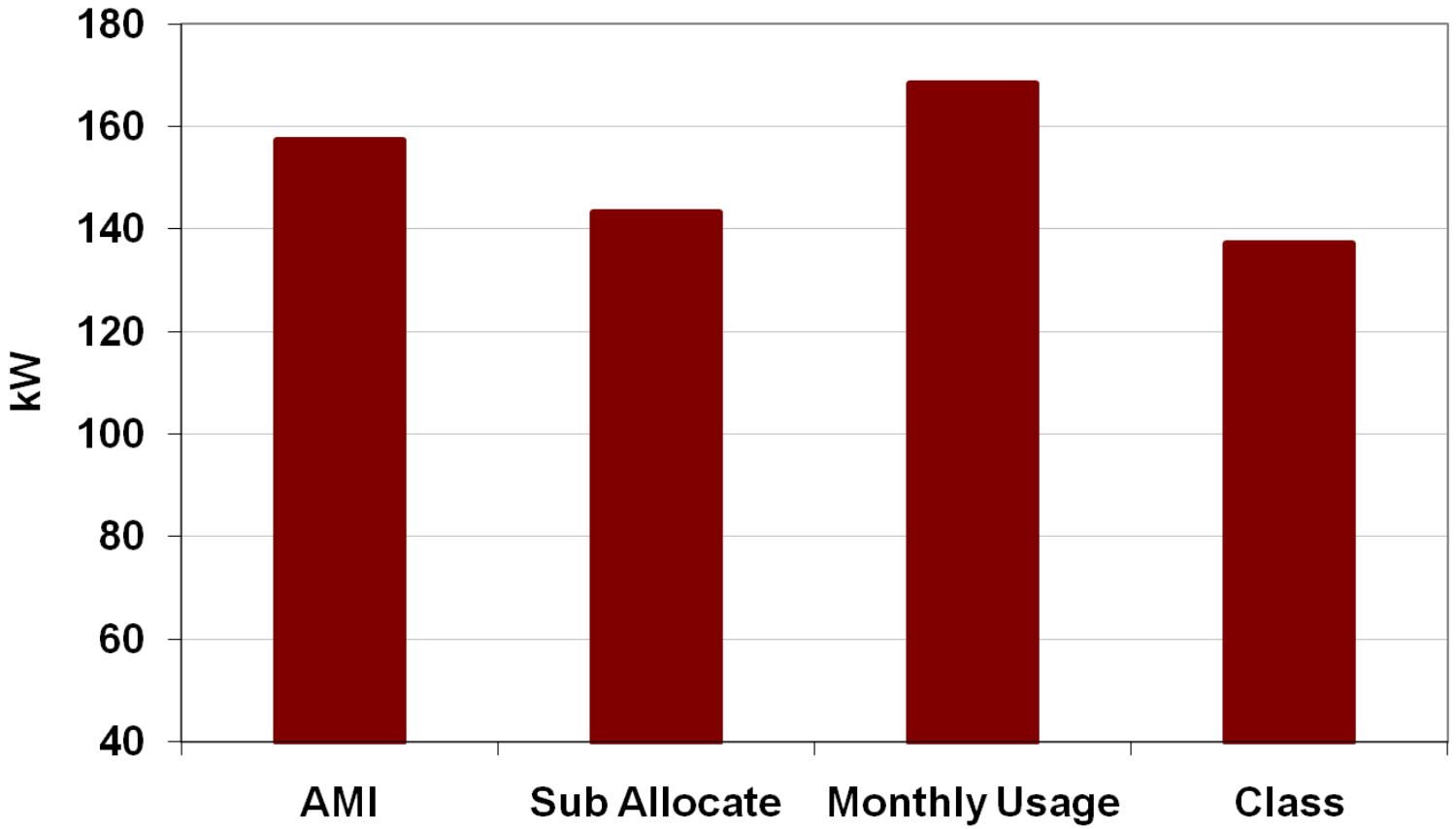
Secondary and Primary Losses

The AMI and Monthly Usage have the same primary line losses; however, the Monthly Usage case has more secondary losses.



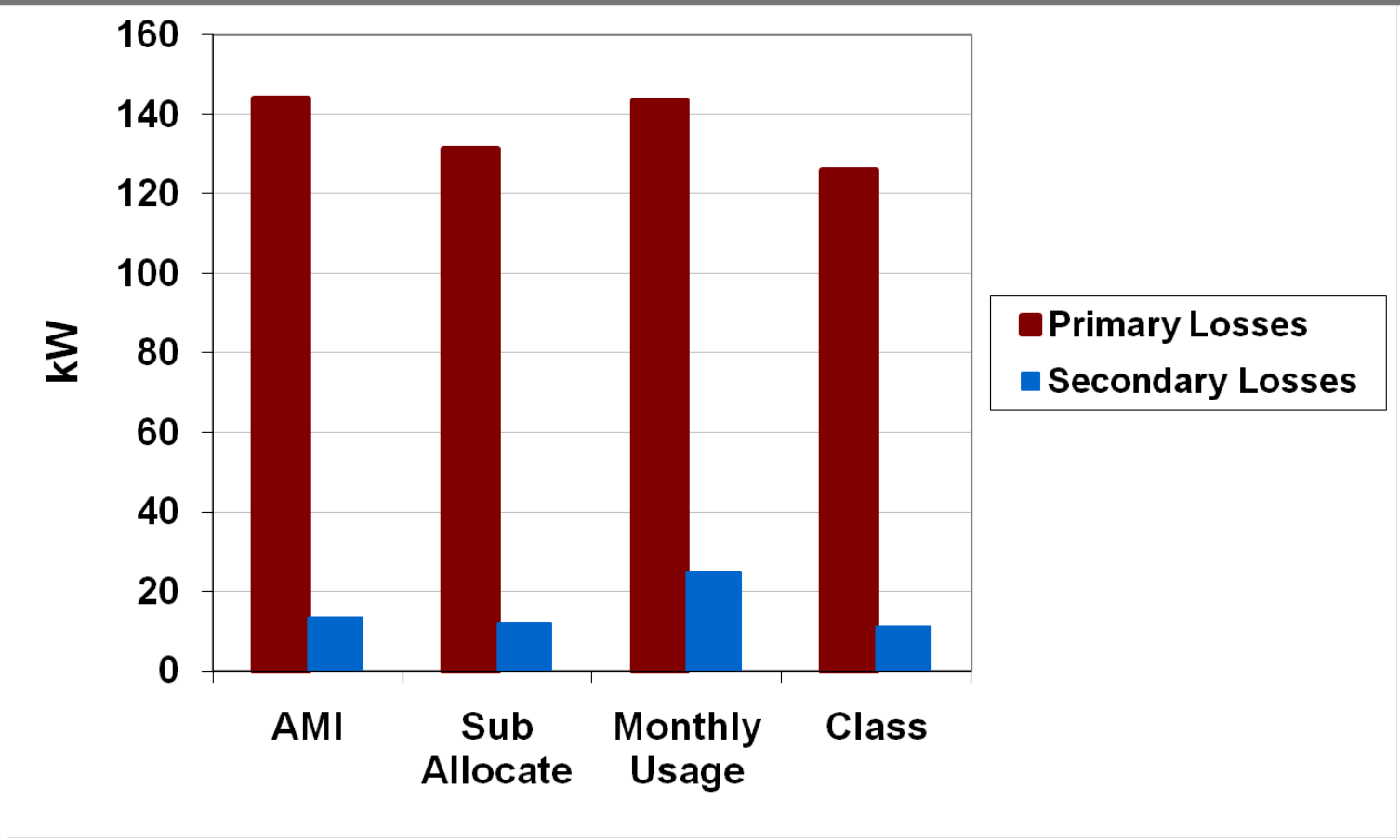
Peak Losses

The AMI case had 10% more losses on the secondary and the primary compared to the Substation Allocation case.



Secondary and Primary Losses

The AMI and Monthly Usage have the same primary line losses; however, the Monthly Usage case has more secondary losses.



Summary

- AMI metering provides a more accurate means to estimate loading for distribution system analysis. When the AMI method that is used for estimating customer load can have a significant impact on real-time distribution state estimation.
- The Monthly Usage Allocation case tracks the AMI voltage closer compared to the Substation Allocation case.
- With AMI load allocations the overload reporting is based on actual measurements. Methods such as allocating based on service transformer kVA rating (Substation Allocation case), not only under-report overloads but can also mis-report overloads.

Summary, Cont.

- The use of AMI can give a better indication of the state of the system components i.e. capacitors.
- The Class Loadshape case matched closely to the Substation Allocation Case due to the fact that 99% of the loads were residential. Therefore, general conclusions from the Class Loadshape allocation method should not be drawn from this example.
- The AMI and Monthly Usage cases show the same primary line losses, because the assumed load distribution is approximately the same. This suggests that if AMI data were lacking, the Monthly Usage method would be better than the other methods.

Questions?