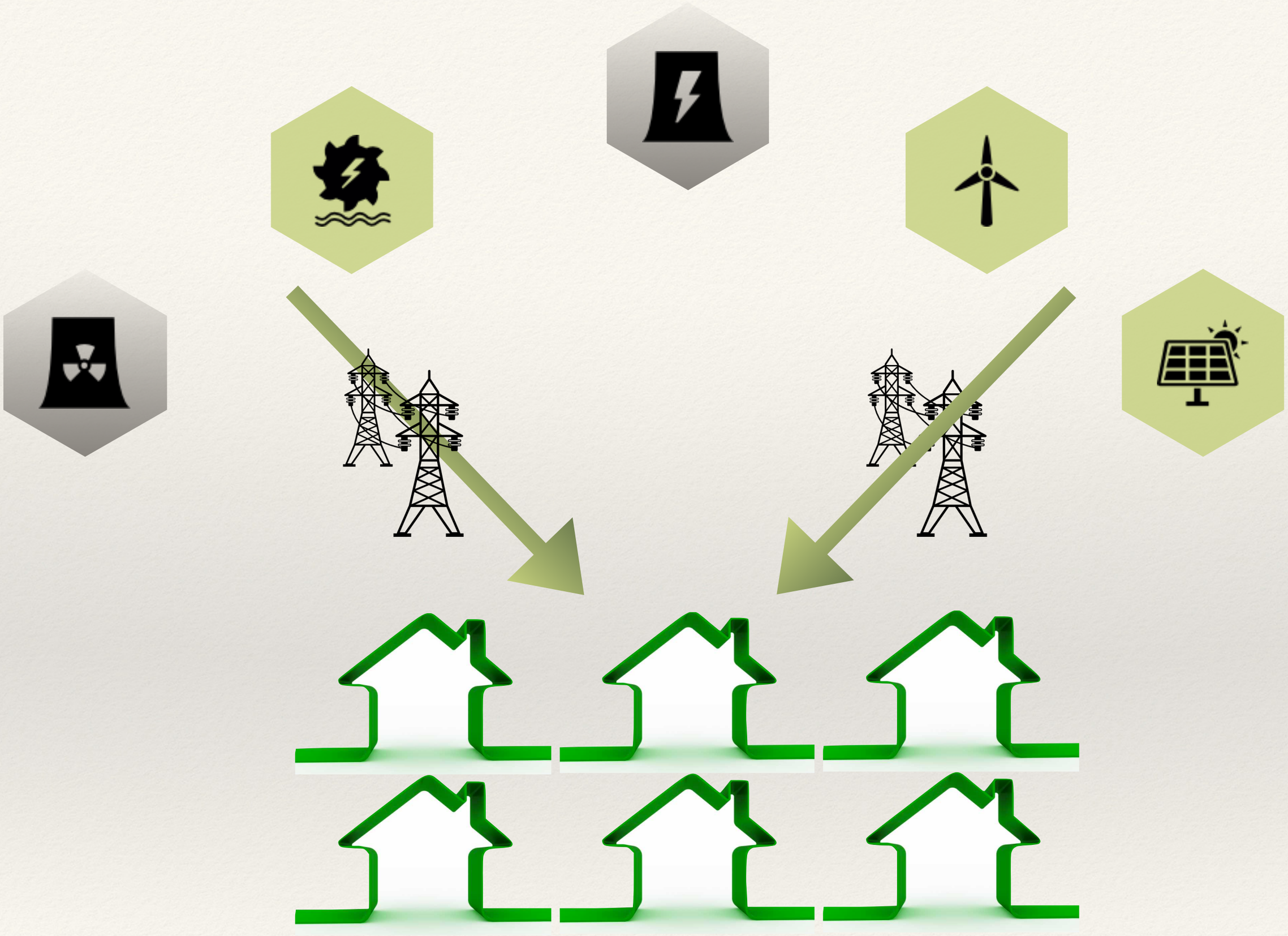
Professor Smedley and Linyi Xia

Smart Power For the Smart Home

Inverter Controls, Power Factor Corrections, And Peak Demand Reductions



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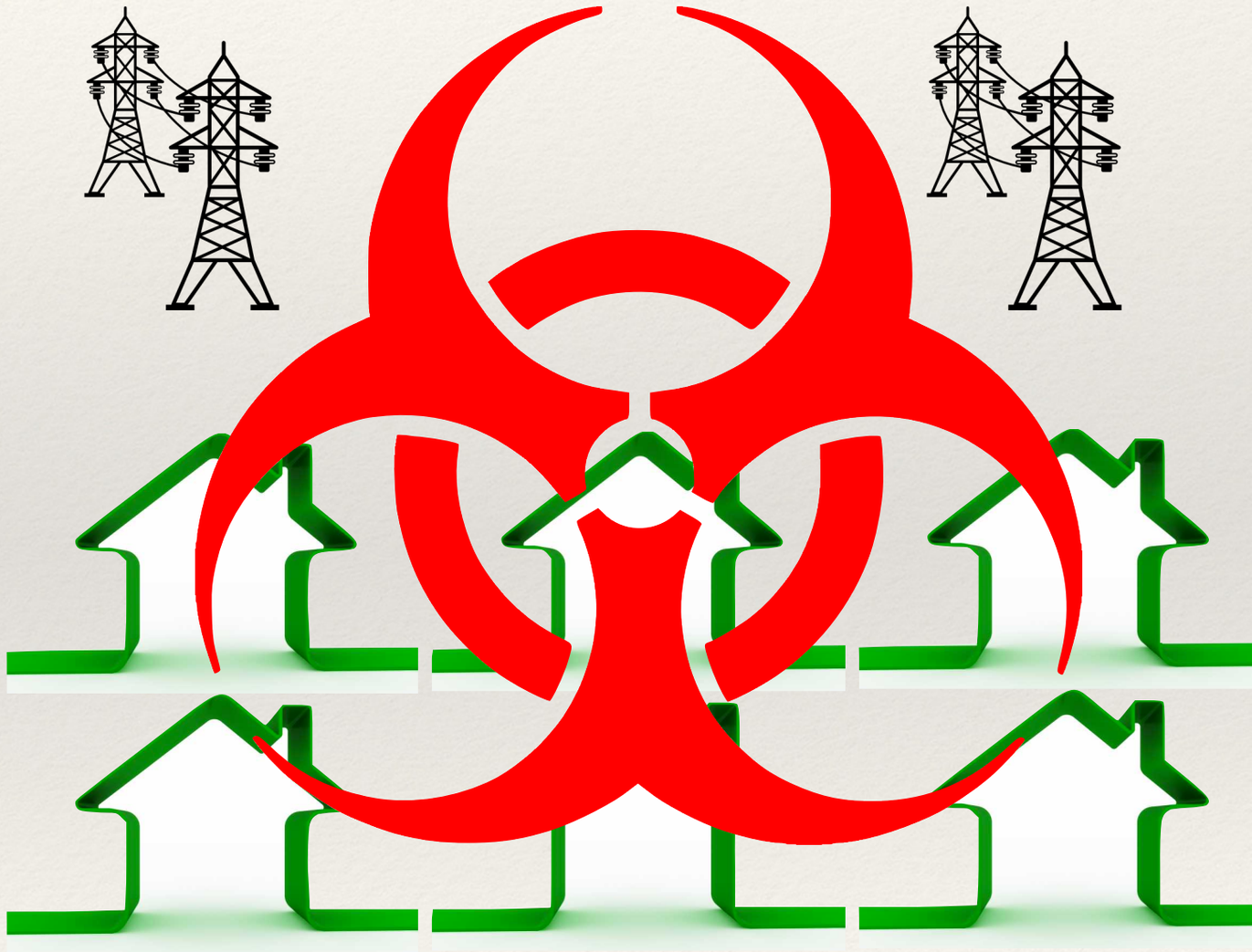
Negative Effects

- Less robust grid
- Harmonic and reactive power generated.
- Peak demand response challenges



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Efforts

- From the residents point of view: Load Disaggregation
- From the construction point of view: ZNE and electrical storage.
- From the grid point of view: APFC

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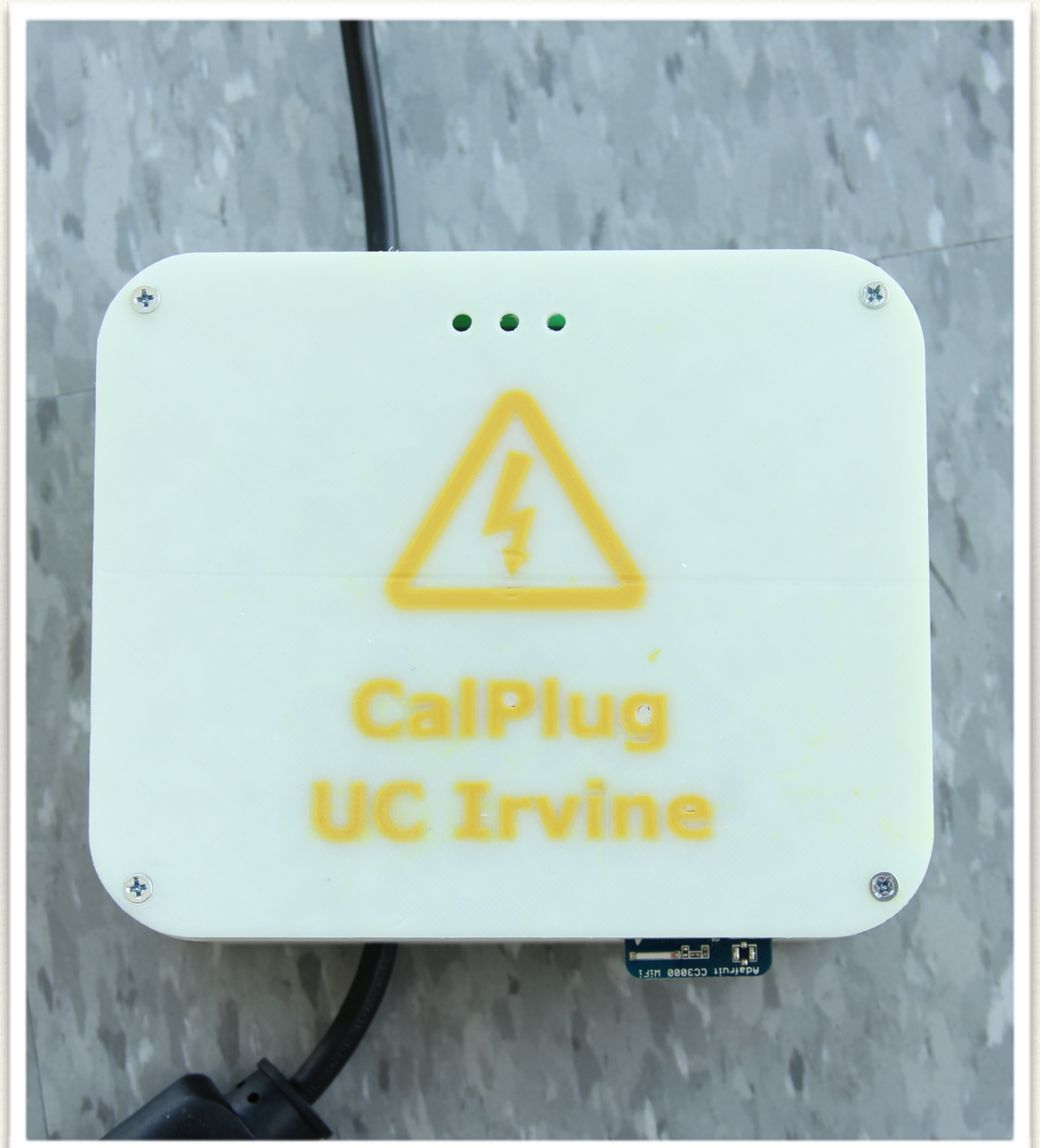
Load Signature Analysis and Disaggregation

- For residents to better understand how energy is consumed, the device performs:
  - Detect
  - Measure
  - Identify
  - Report



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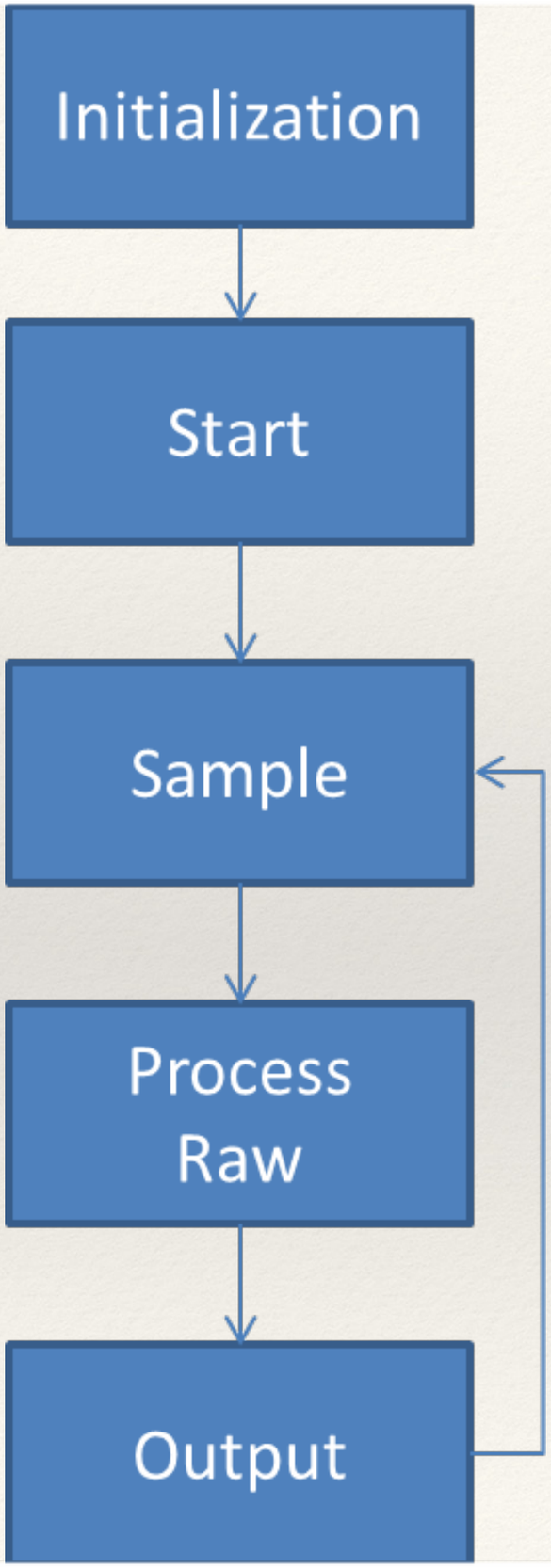
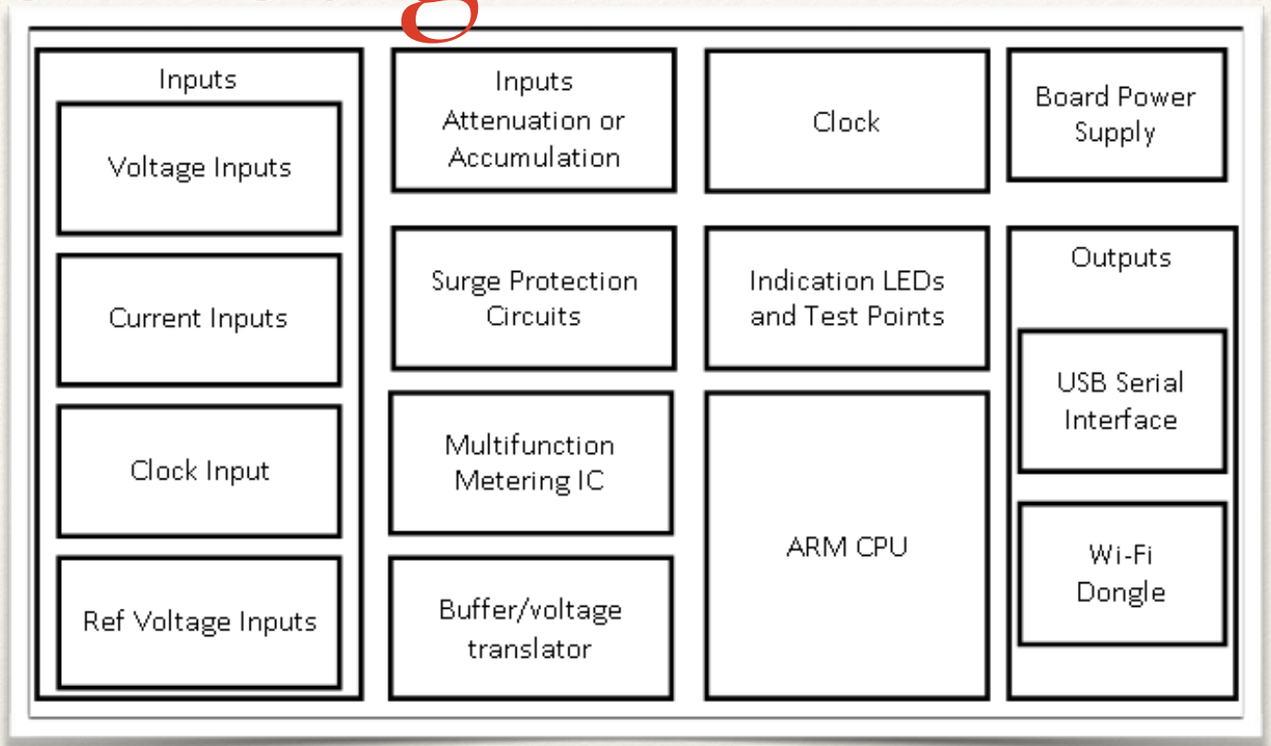
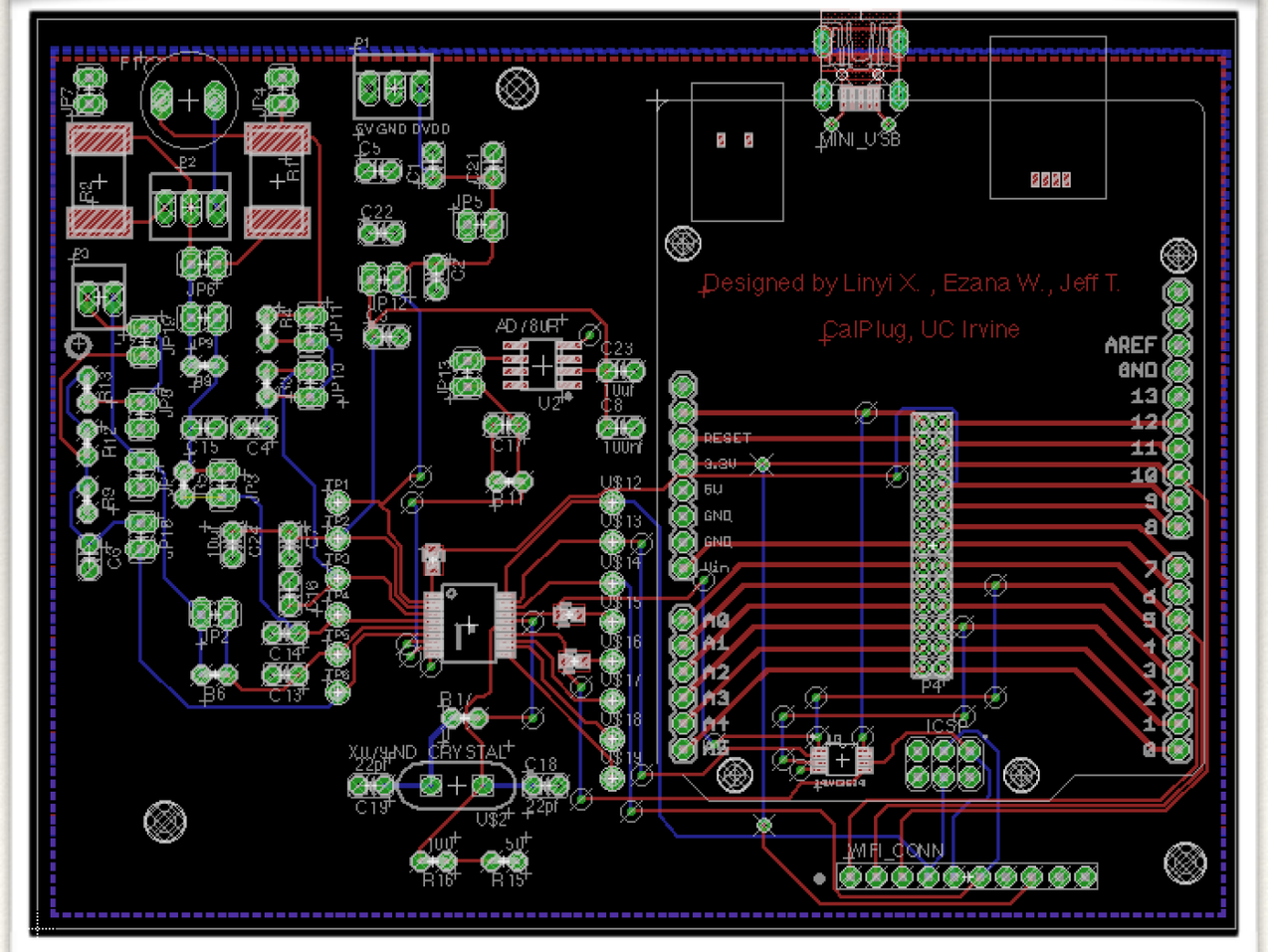
Hardware Design

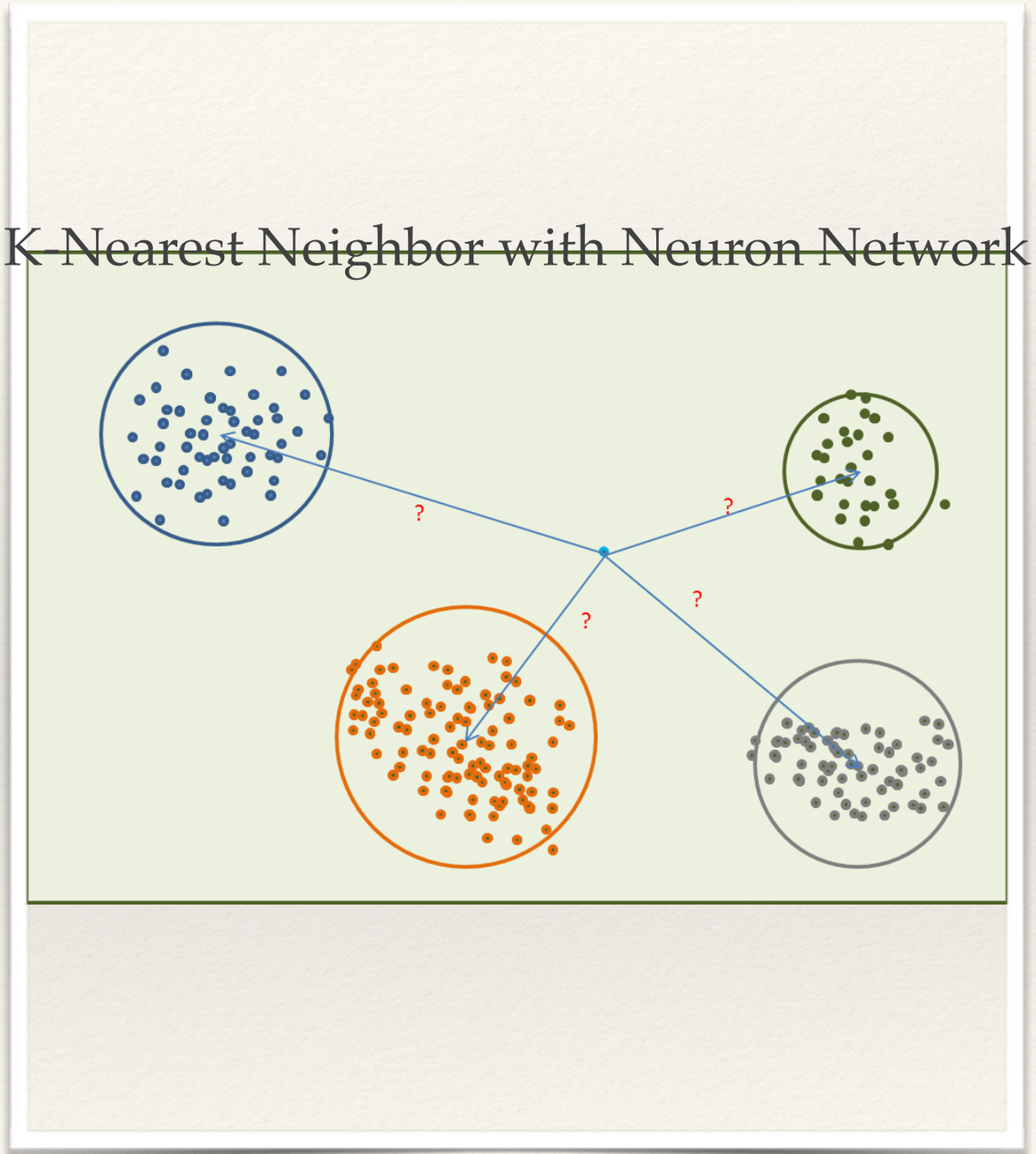






Device Identification (Machine Leanring)

- The system performs forward and backward machine learning algorithm based on:
  - Power (Real, Reactive) and Current
  - PF
  - Harmonic Analysis



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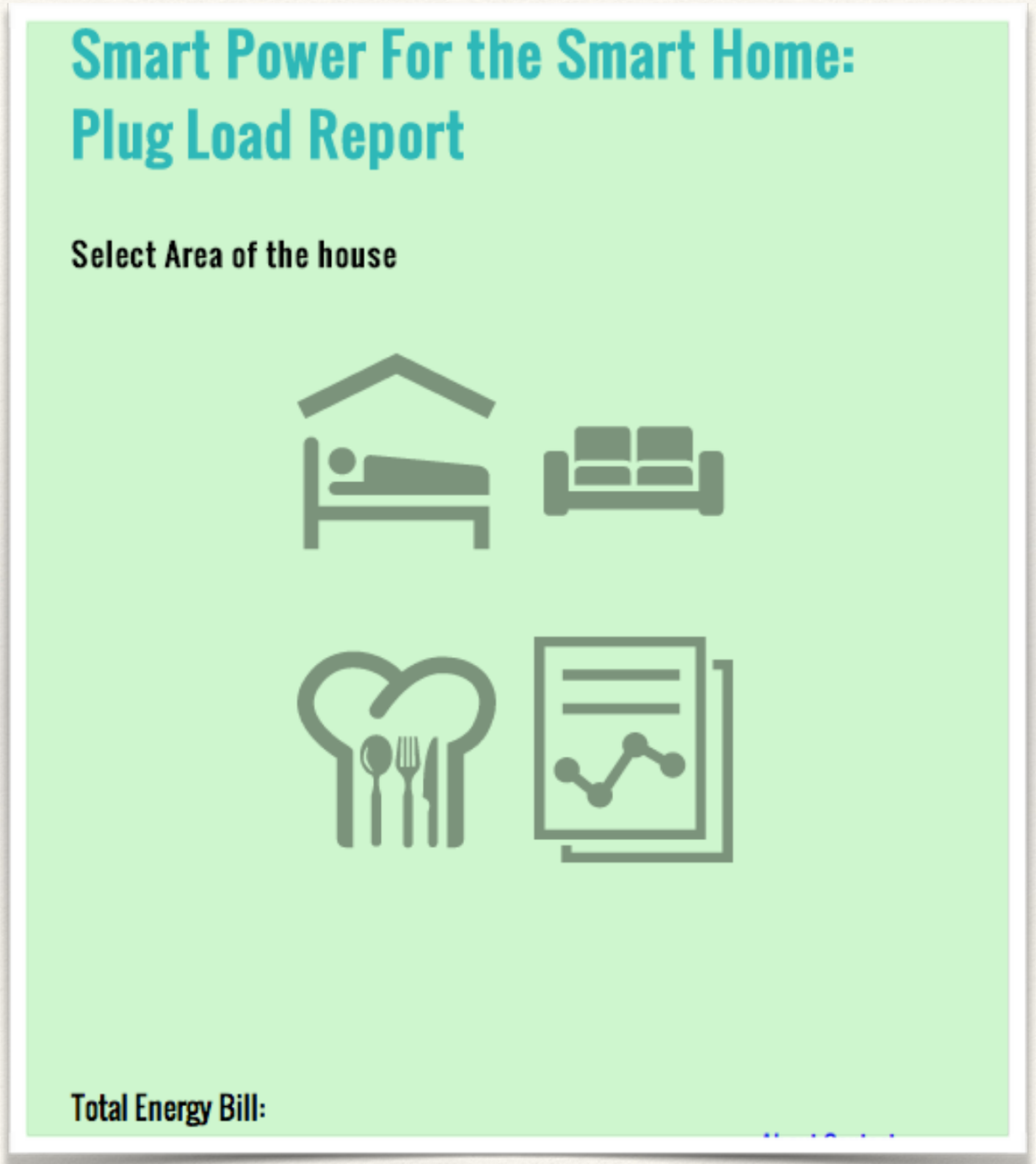
User Interface

- Reports energy consumption, devices detected and status
- Features a clean and simple user interface



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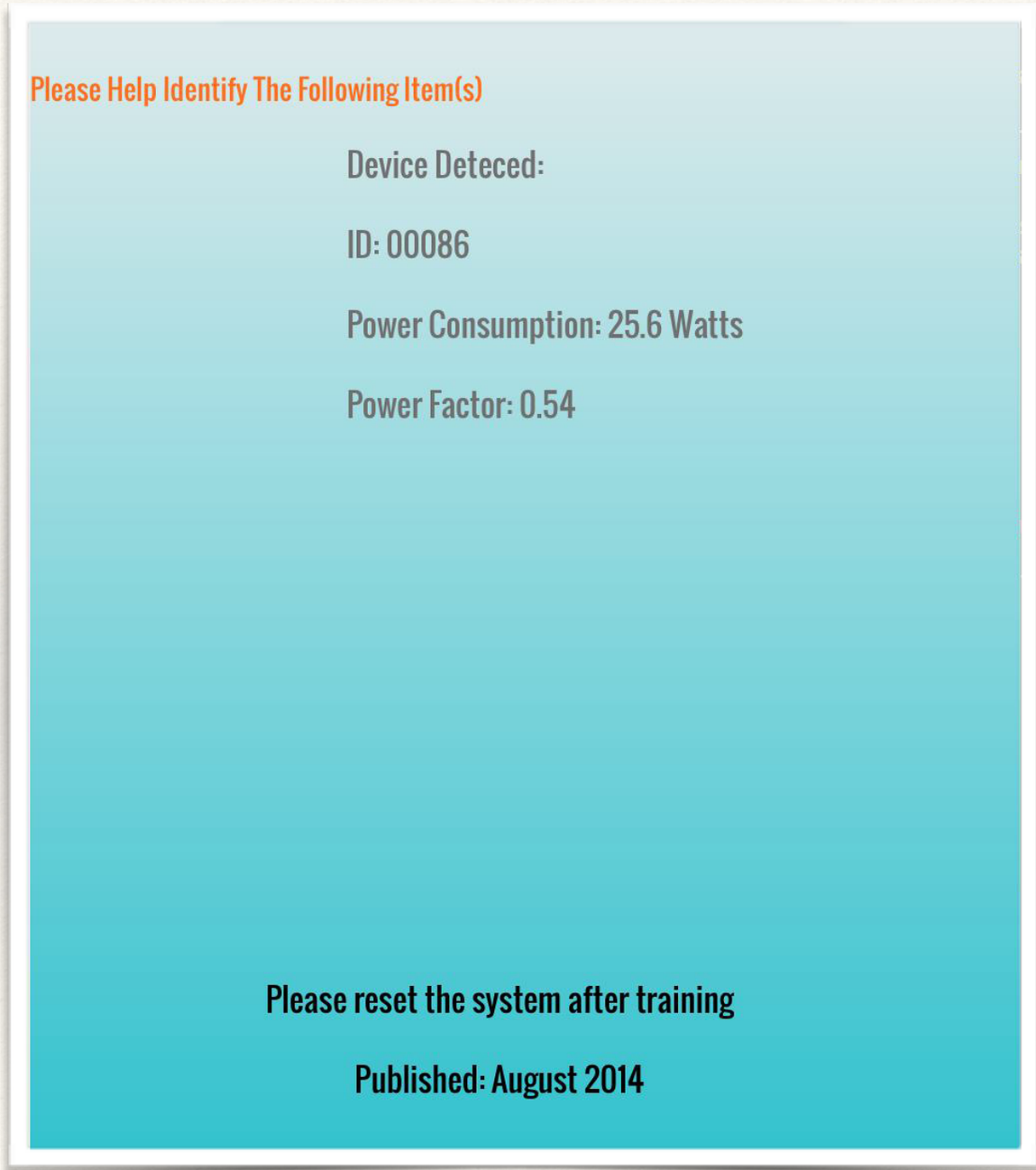
Training mode

- Training mode:
  - Asks for users' assistance to identify a load then remembers it for later



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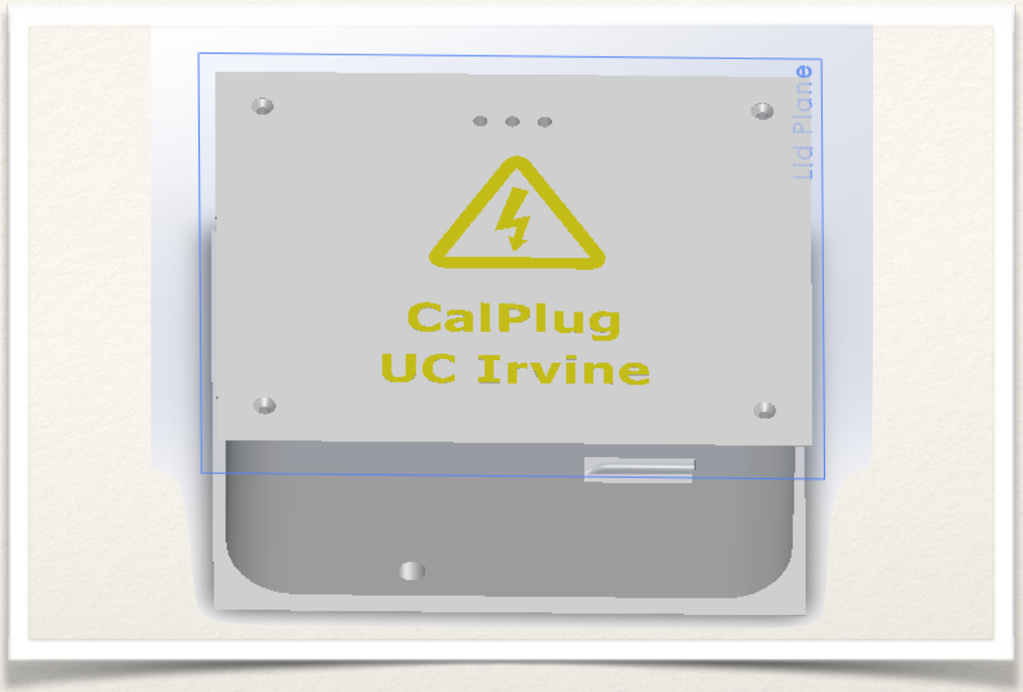
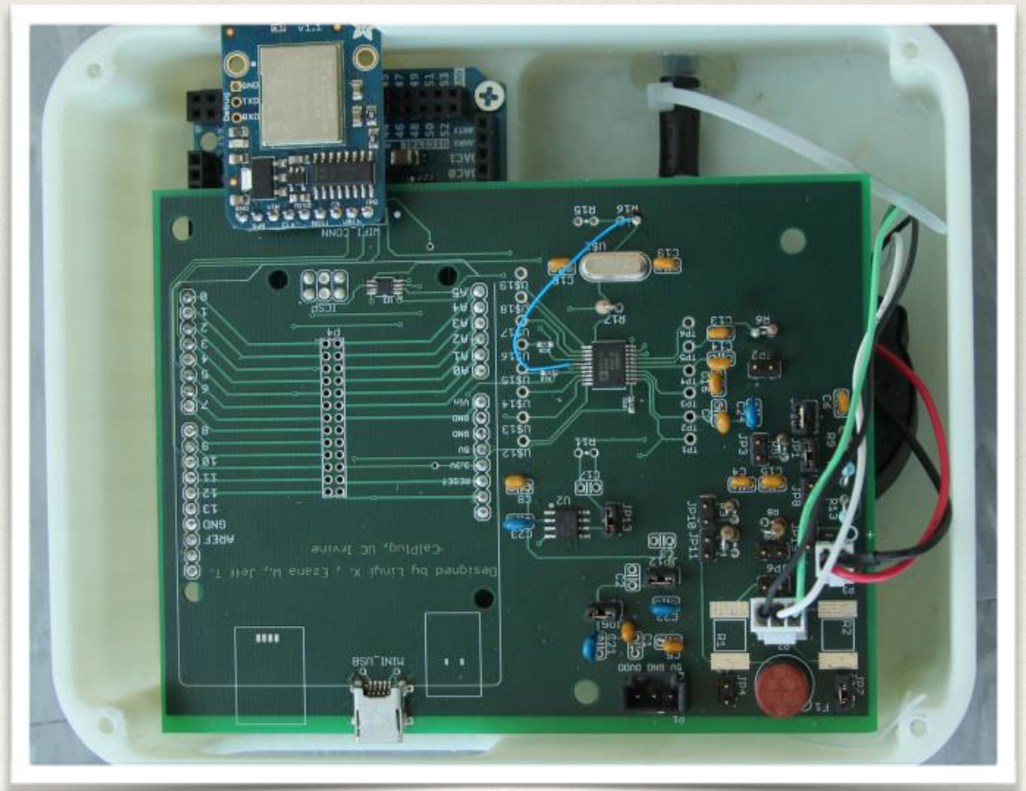
Industrial Design





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Conclusion and Future Works

- The load disaggregation system is capable of:
  - Detect, recognize and monitor loads at a household level
  - Perform machine learning techniques on distinguishing loads and learning on new appliances
- Future:
  - Potential integration with the Smart Meter
  - Conduct user behavioral studies to introduce additional savings to the users.

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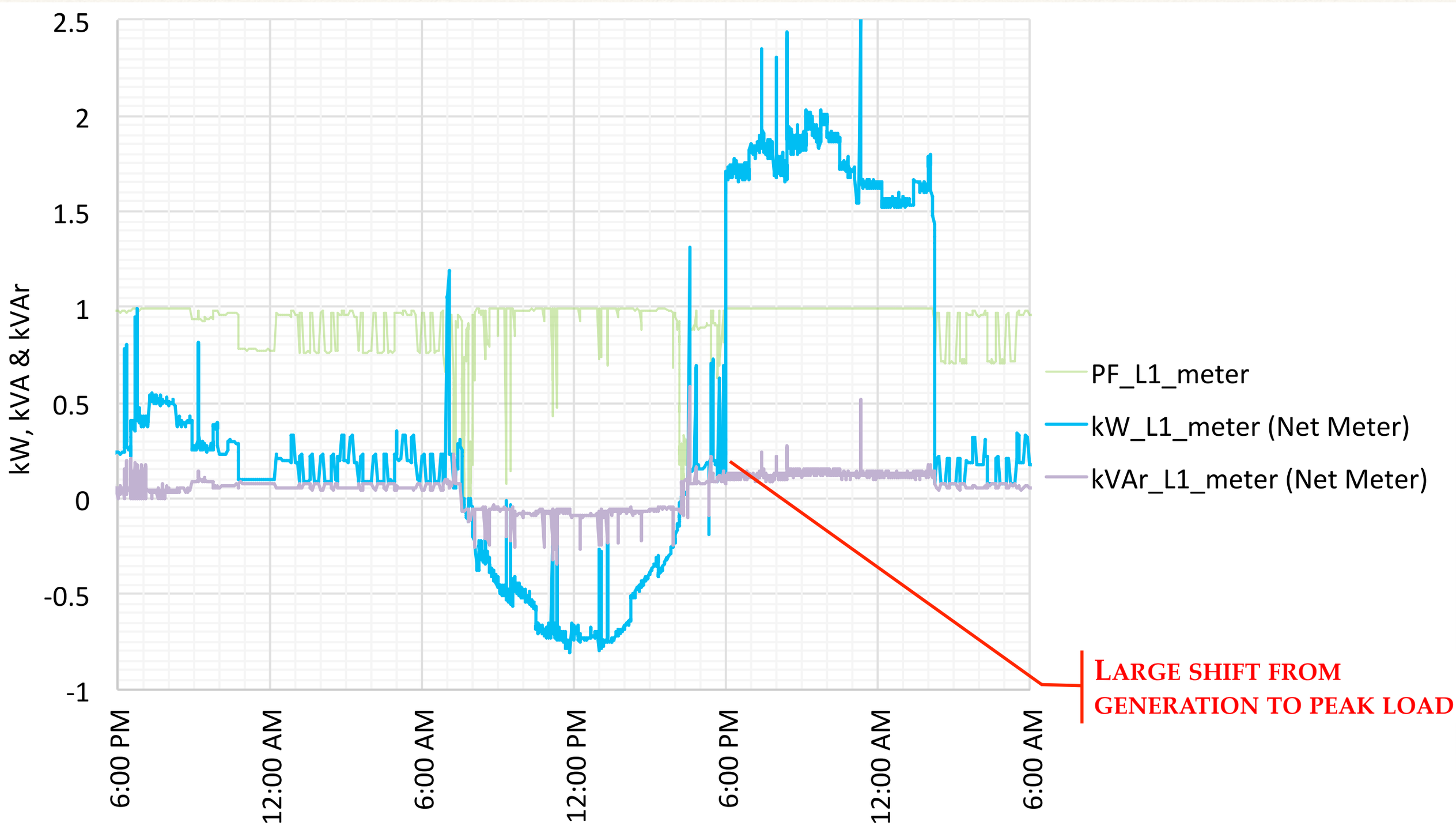
Smart Power for Smart Homes

Inverter Controls, Power Factor Corrections, and Peak Demand Reductions

Jonathan Woolley
Western Cooling Efficiency Center
University of California, Davis

May 12th, 2015
UC Irvine CalPlug Workshop

Example Daily Load Profile for Smart Home



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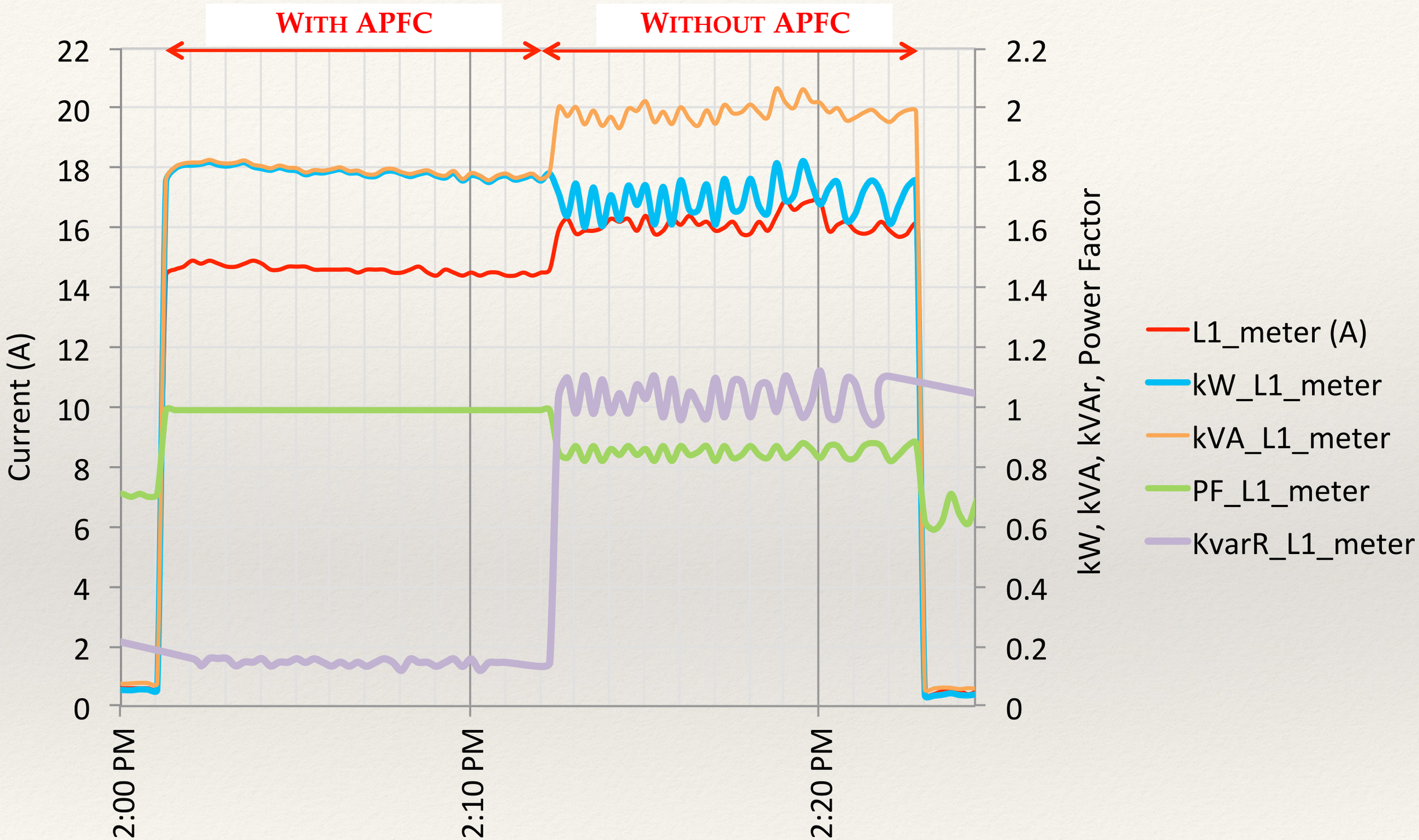
Example Results from Field Test of APF Device



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Major Conclusions from APFC Field Evaluation

- Power factor correction performs well in every scenario tested.
  - Even for power factor as low as 0.52 with non-linear waveform distortion, the device corrected power factor to 0.98.
  - Reactive power was reduced dramatically, by 60-85%
- However real power consumption increases simultaneously
  - Power increases are associated with thermal losses in APFC device
  - ~20W continuous draw + variable draw associated with VAr correction
- Improved power factor should have real benefits for utility infrastructure costs and management of grid reliability
  - Current decreases so required ampactiy for distribution infrastructure is reduced
  - Transmission losses are proportional to current so distribution efficiency increases
  - Utility infrastructure to correct voltage droop resulting from reactive loads can be reduced
  - The need for harmonics power quality management can be reduced

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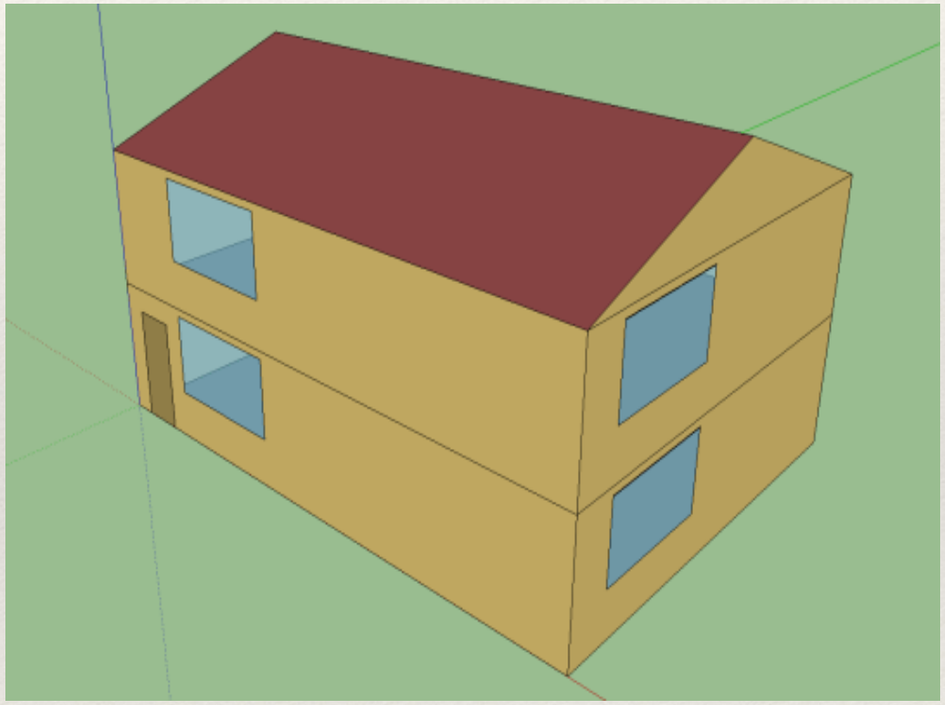
EnergyPlus Modeling of ZNE Home

- Started with T24 compliant home
- Focus on how solar impacts typ. net-load profile
- Tested impact of various energy efficiency measures
- *Can improved envelopes, efficient HVAC designs, controls, and elect. storage provide grid benefits by easing the variation in net-load profile?*



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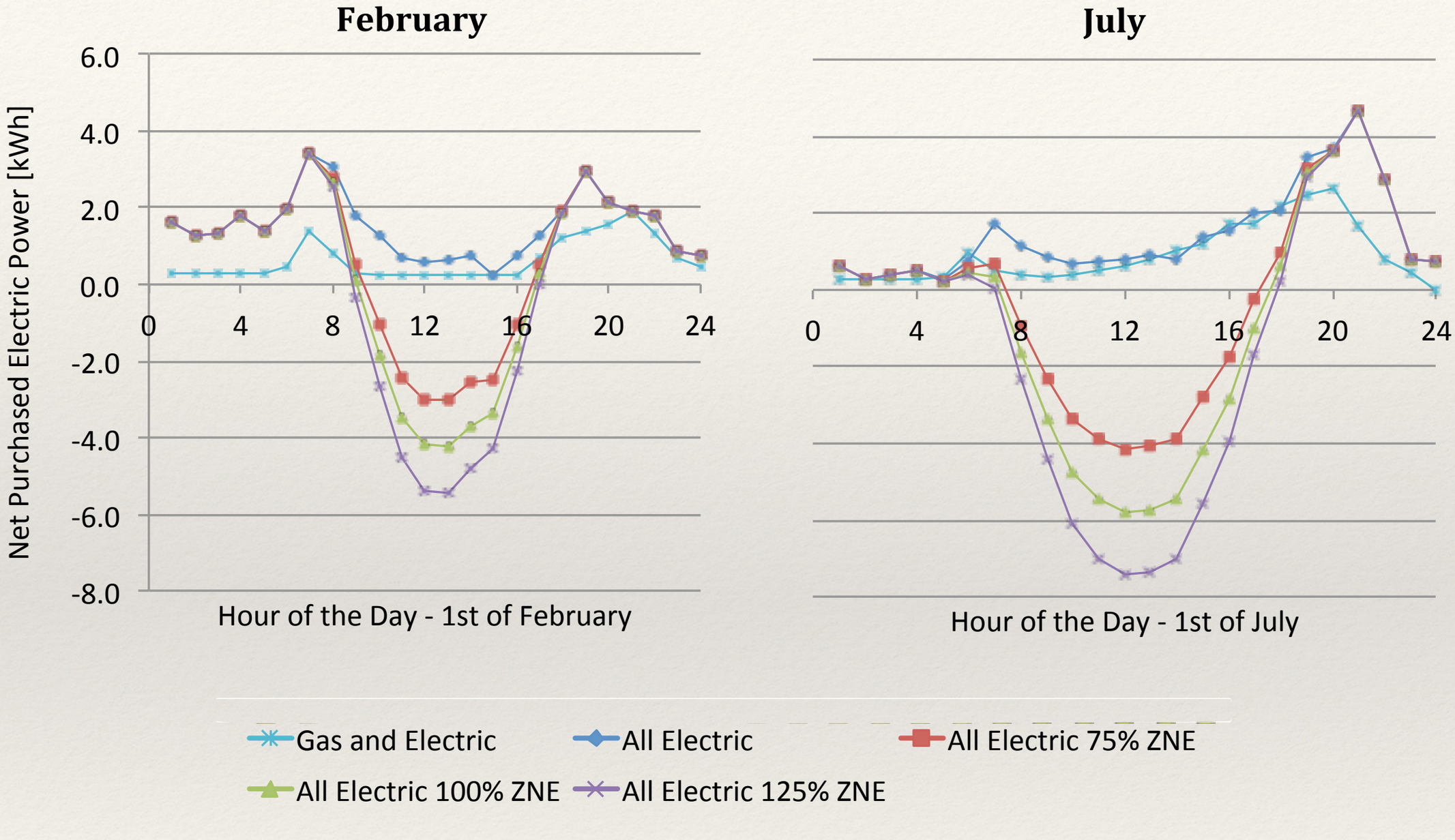
Net Load Profile for T24 Compliant Homes with and without Solar



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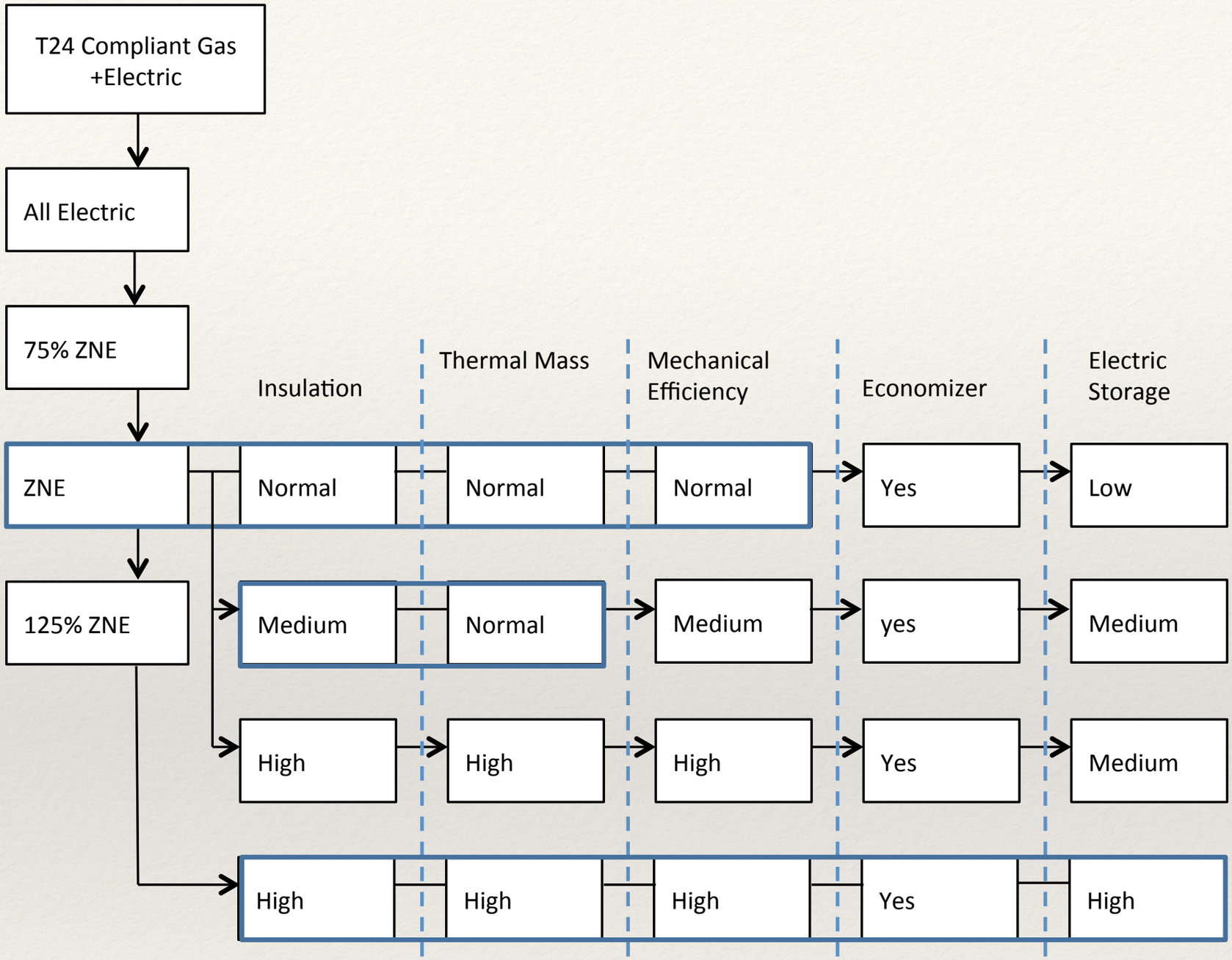
Parametric Analysis of Alt. Design Options



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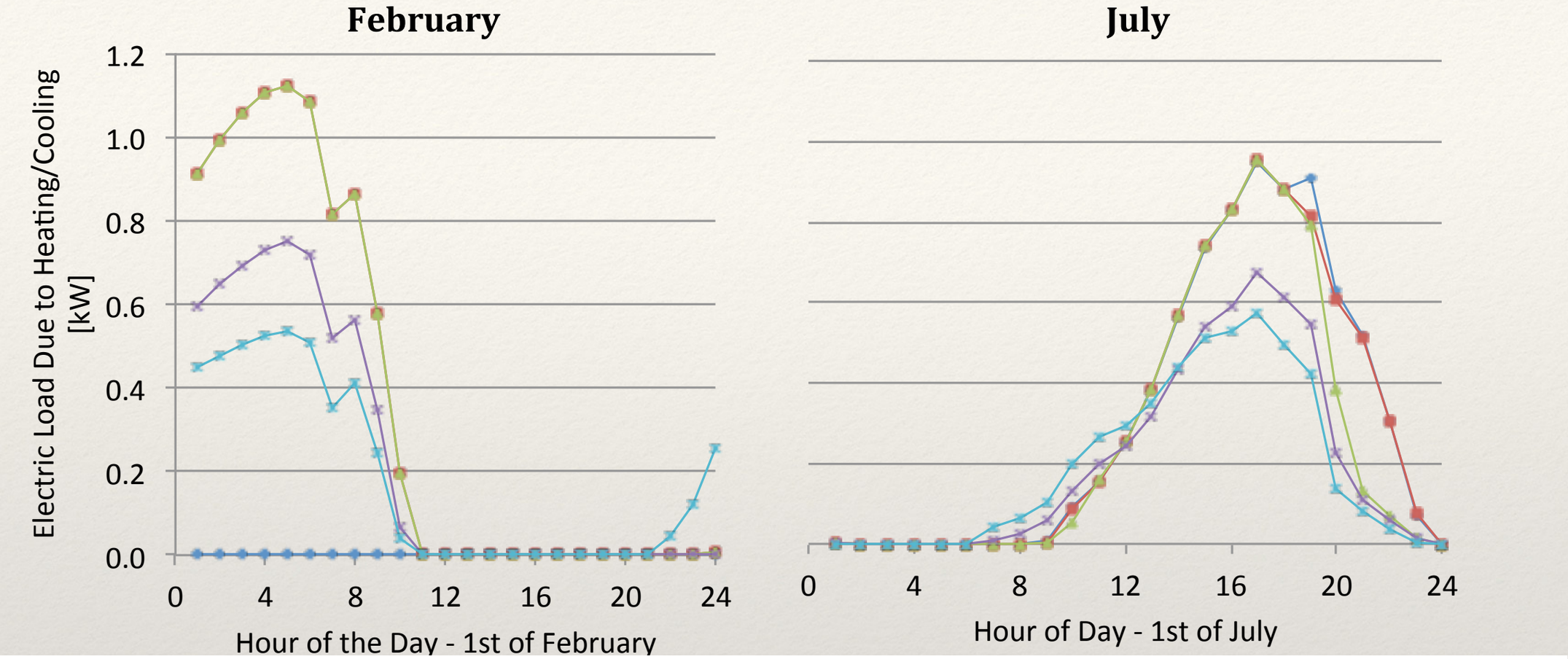
HVAC Elect. Loads for Four Alt. Designs



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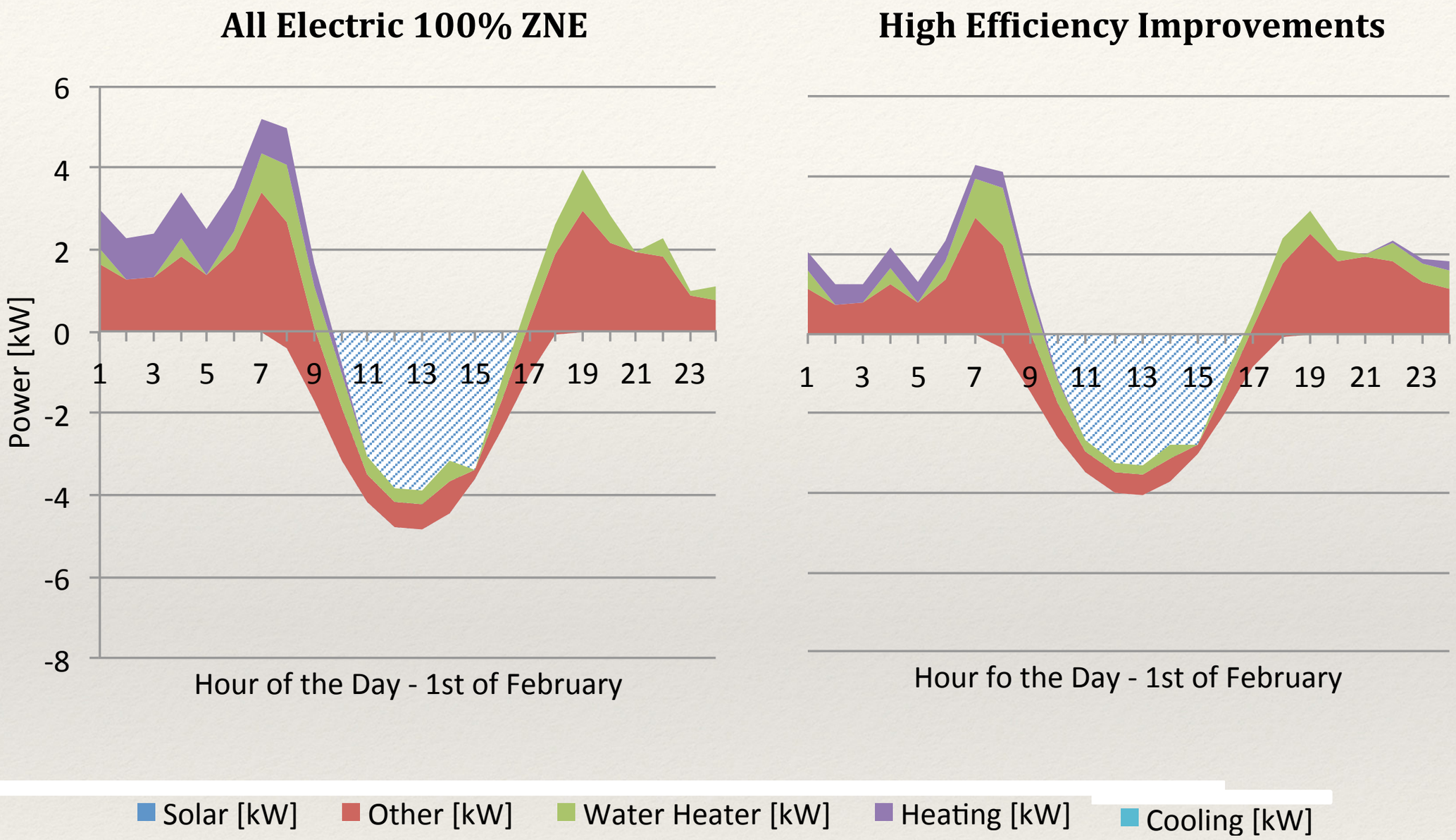
Resulting Net Load Profiles (Winter)



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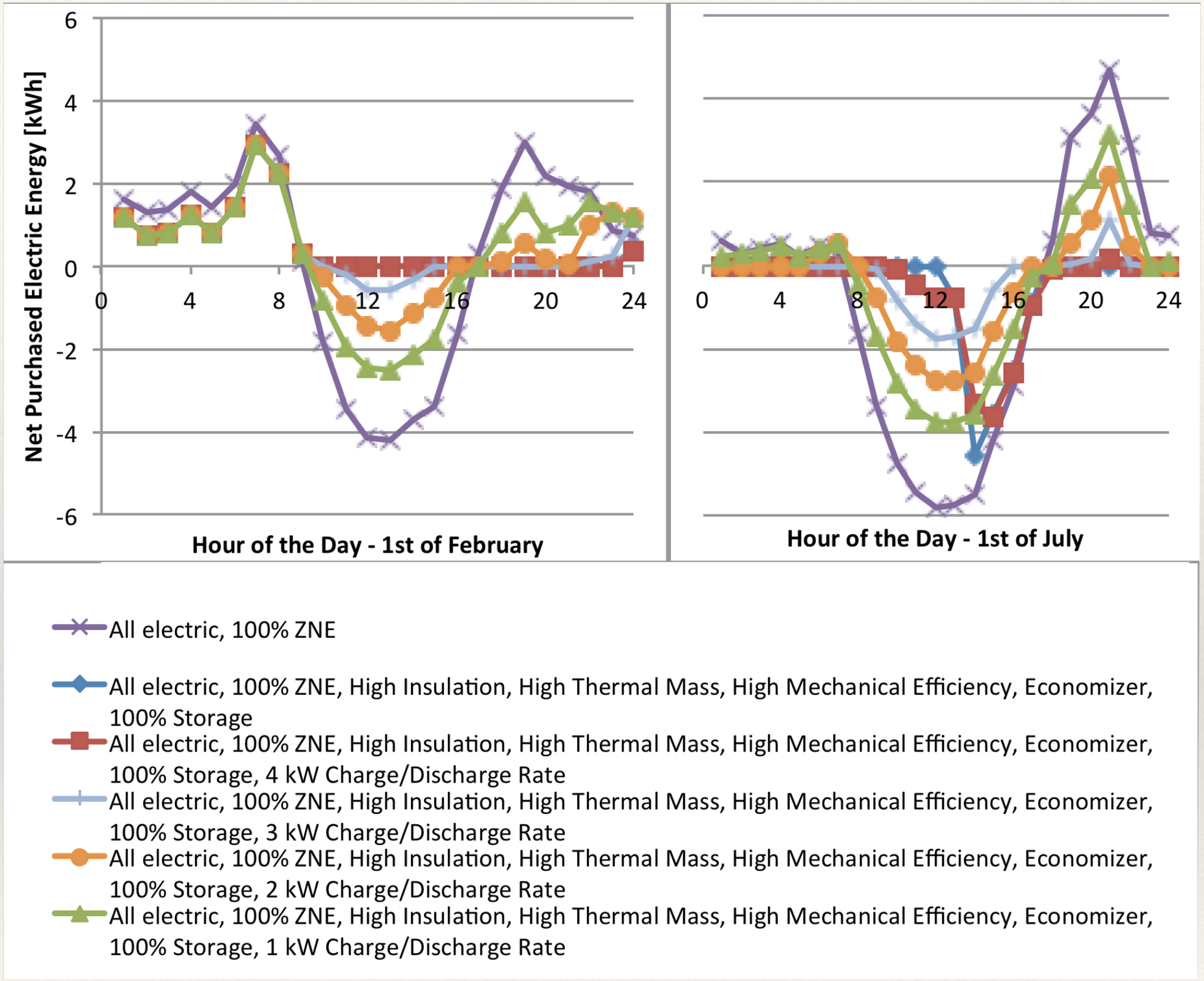
Limited electric storage charge and discharge rates



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Major Conclusions from Modeling

- For ZNE home owners, all electric systems are more cost effective than gas appliances and equipment.
- Peak in residential electric load on the grid are largely unaffected by addition of solar because generation and peak loads are not coincident.
- The potential benefits of a shift toward ZNE may not be realized unless deployed alongside electric storage measures
- Electric storage can worsen the net-load profile if it is not controlled appropriately.
- We recommend that California pursue a diversity of tactics to manage the grid stability concerns related to broad integration of solar and other intermittent renewable resources. To some extent, this should include on site storage, or other active load shifting technologies.

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