"Pecan Street Project Preliminary Study Results"

Carnegie Mellon University

Roger Duncan

Sept. 12, 2012

Pecan Street Inc.

Pecan Street Inc.

- Incorporated in August 2009
- Non-profit, 501 (c)(3)
- Founding Partners fill board positions
- Grant and member funded
- 10 staff, headquartered at UT's West Pickle Research Building

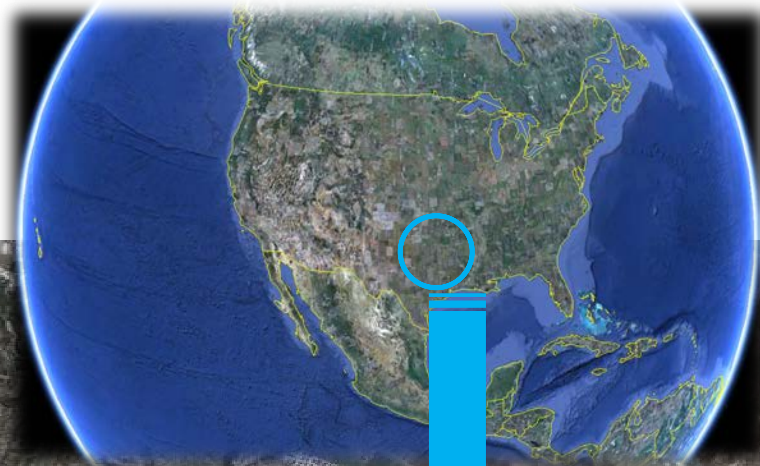
Pecan Street Consortium

freescale
Green Mountain Energy
intel
Landis+Gyr manage energy better

LG
LOCKHEED MARTIN We never forget who we're working for®
ONCOR
OnStar
ORACLE

SONY
SunEdison simplifying solar
Texas Gas Service A DIVISION OF ONEOK
Whirlpool

Where is the Smart Grid?



Austin’s Mueller Community

- 711 acre mixed use
- 3 miles from Texas Capitol
- all new green-built buildings
- world’s first LEED platinum hospital
- reclaimed water system
- native landscaping
- includes 25% affordable housing
- Mueller Megawatt program
- experience with rooftop solar leasing

Smart Grid Demonstration at Mueller

distributed solar

smart grid water

demand response

electric vehicles

energy storage

dynamic pricing

smart appliances

green building

built on Austin’s advanced smart grid platform

Home Energy Management System

- Management of pricing models
- Integrate gas, electric, and water
- Integrate solar, storage, and electric vehicle charging
- Diagnostics

Plug In Hybrids & Electric Cars

- Highest concentration of EVs in US
- Chevy, Nissan, Mitsubishi
- Level 2 chargers
- Integrated with solar and storage

Residential Solar

- 75% of participating homes with solar, west and south
- Integrate with storage, electric vehicles and energy management systems
- Test impact on grid

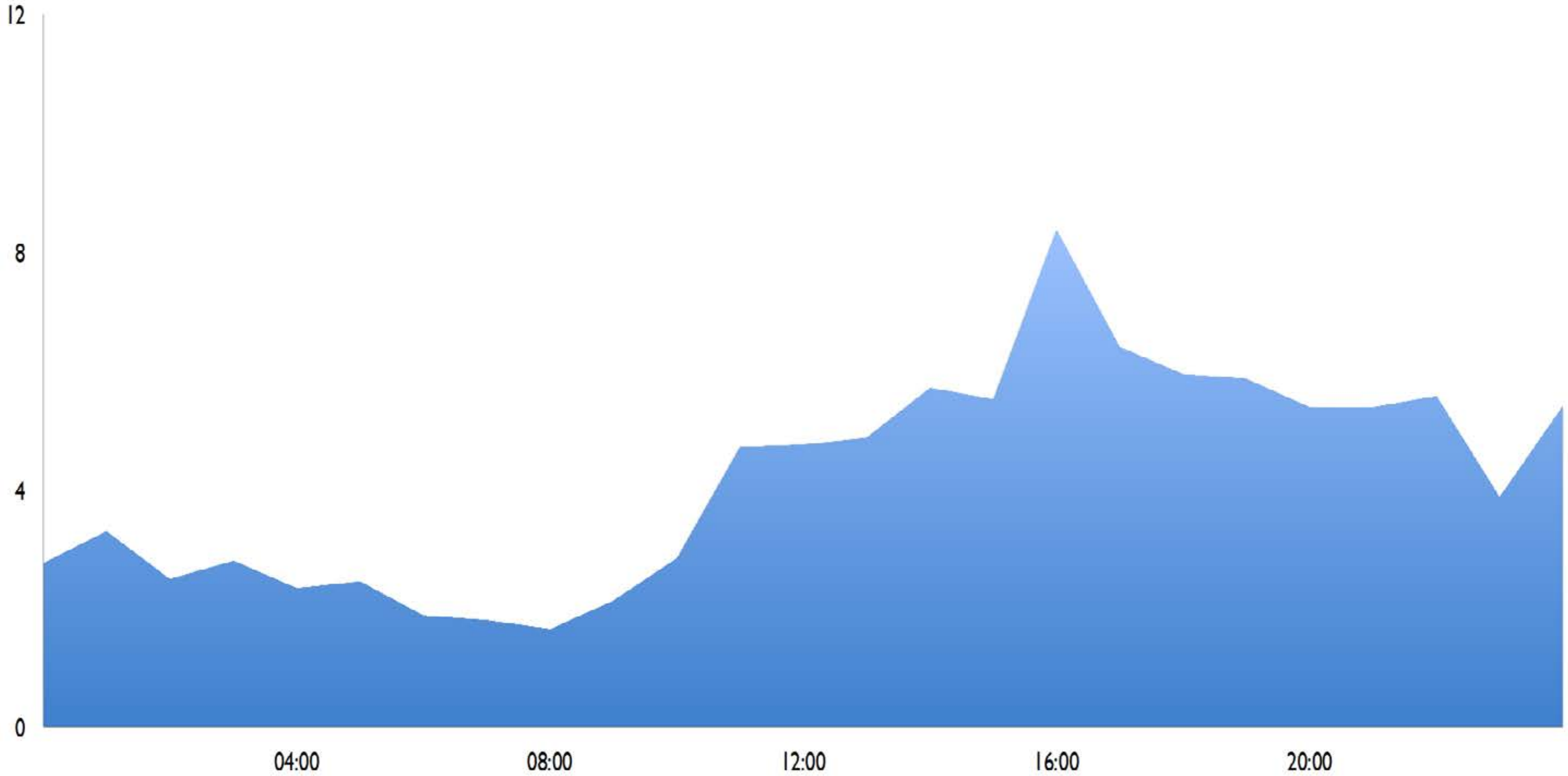
Pike Powers Lab

Overview

- West versus South PV Generation
  - 2011-12-21 to 2012-06-20 split array data
    - Actual, all West, all South
    - Consumption and Impact on grid
  - A hypothetical typical year and ongoing research

Granularity Comparison

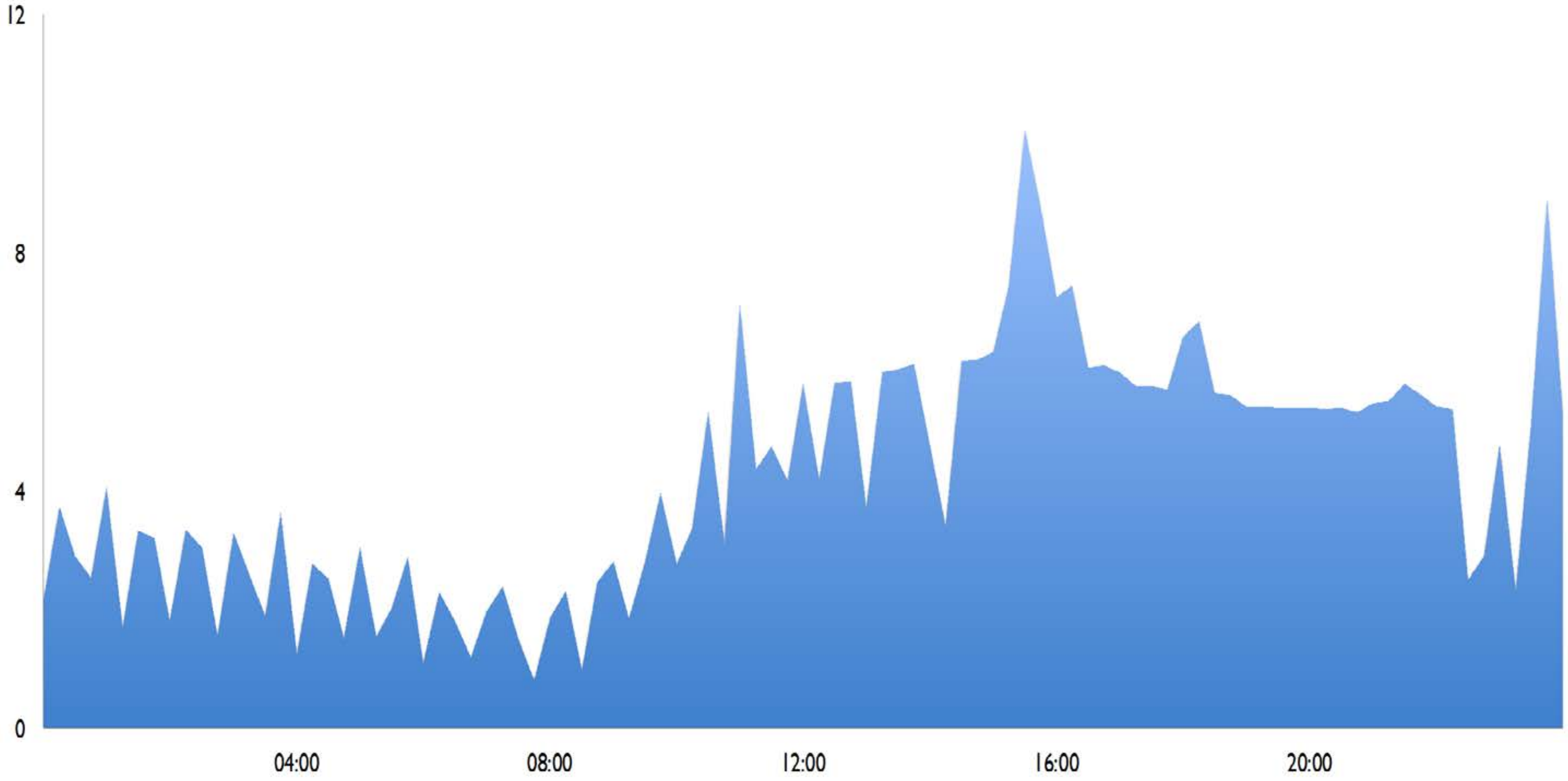
August 10, 2011: 1-hour Consumption Data (kW)



Pecan Street Consortium

Granularity Comparison

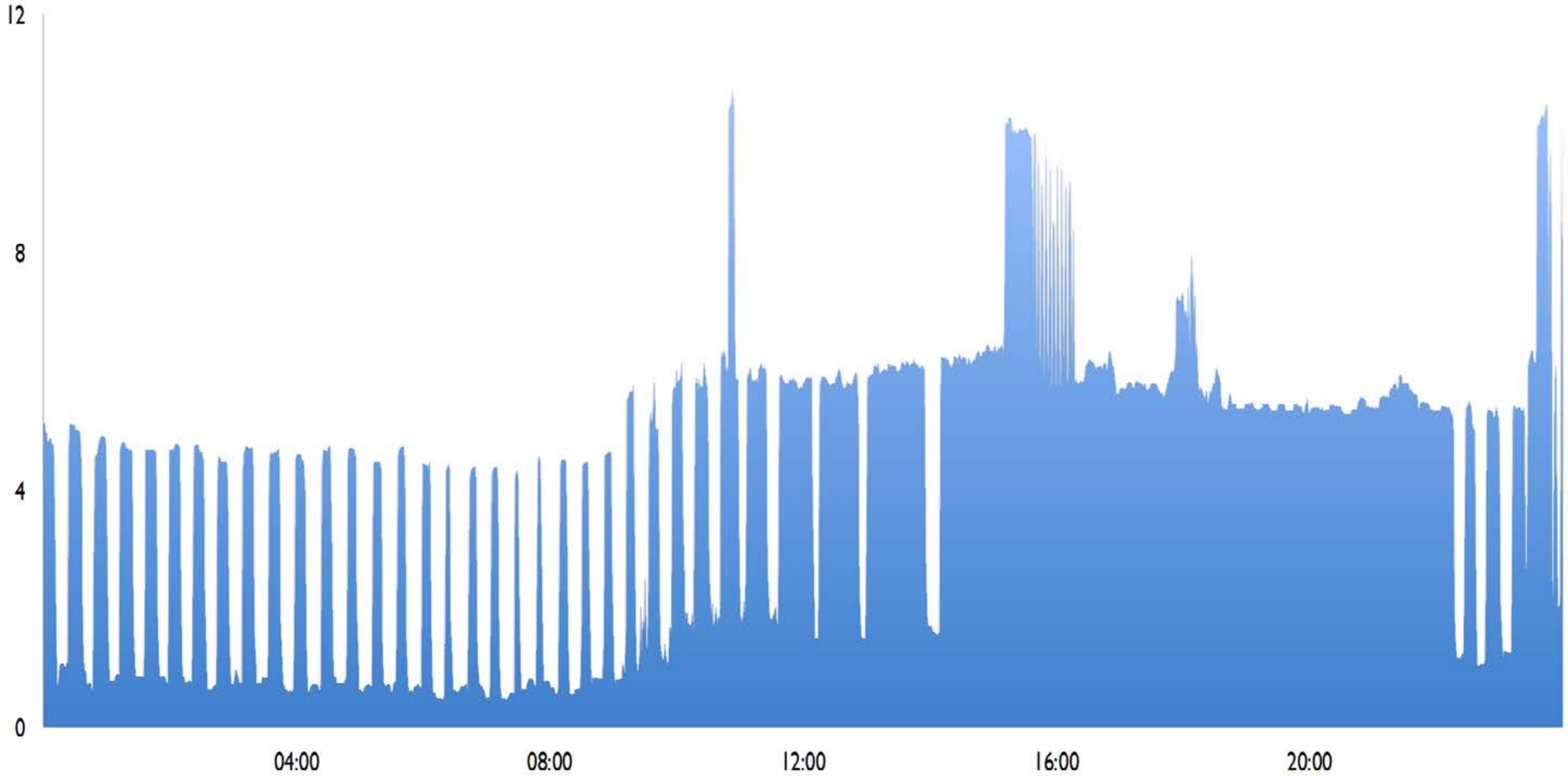
August 10, 2011: 15-minute Consumption Data (kW)



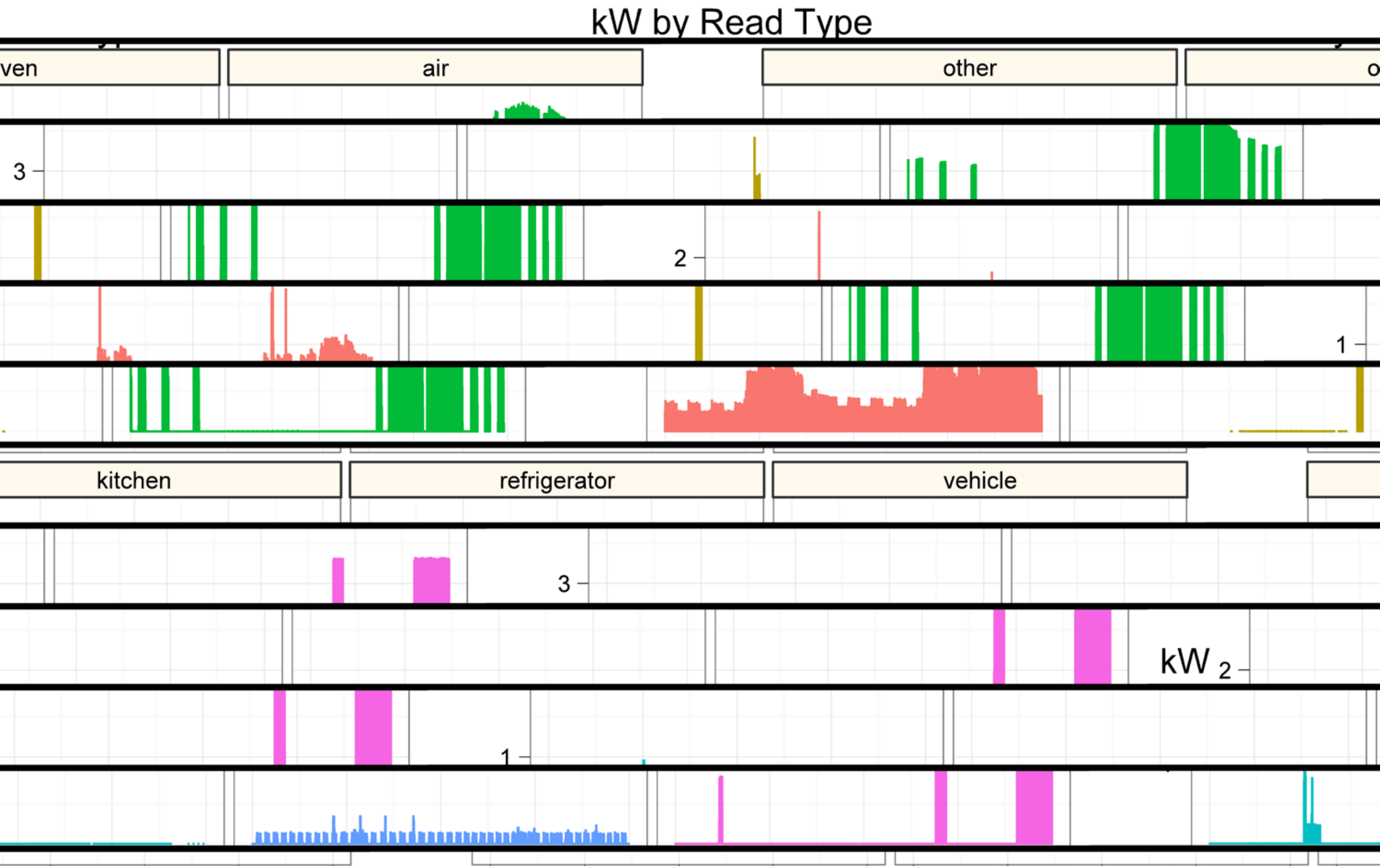
Pecan Street Consortium

Granularity Comparison

August 10, 2011: 1-minute Consumption Data (kW)

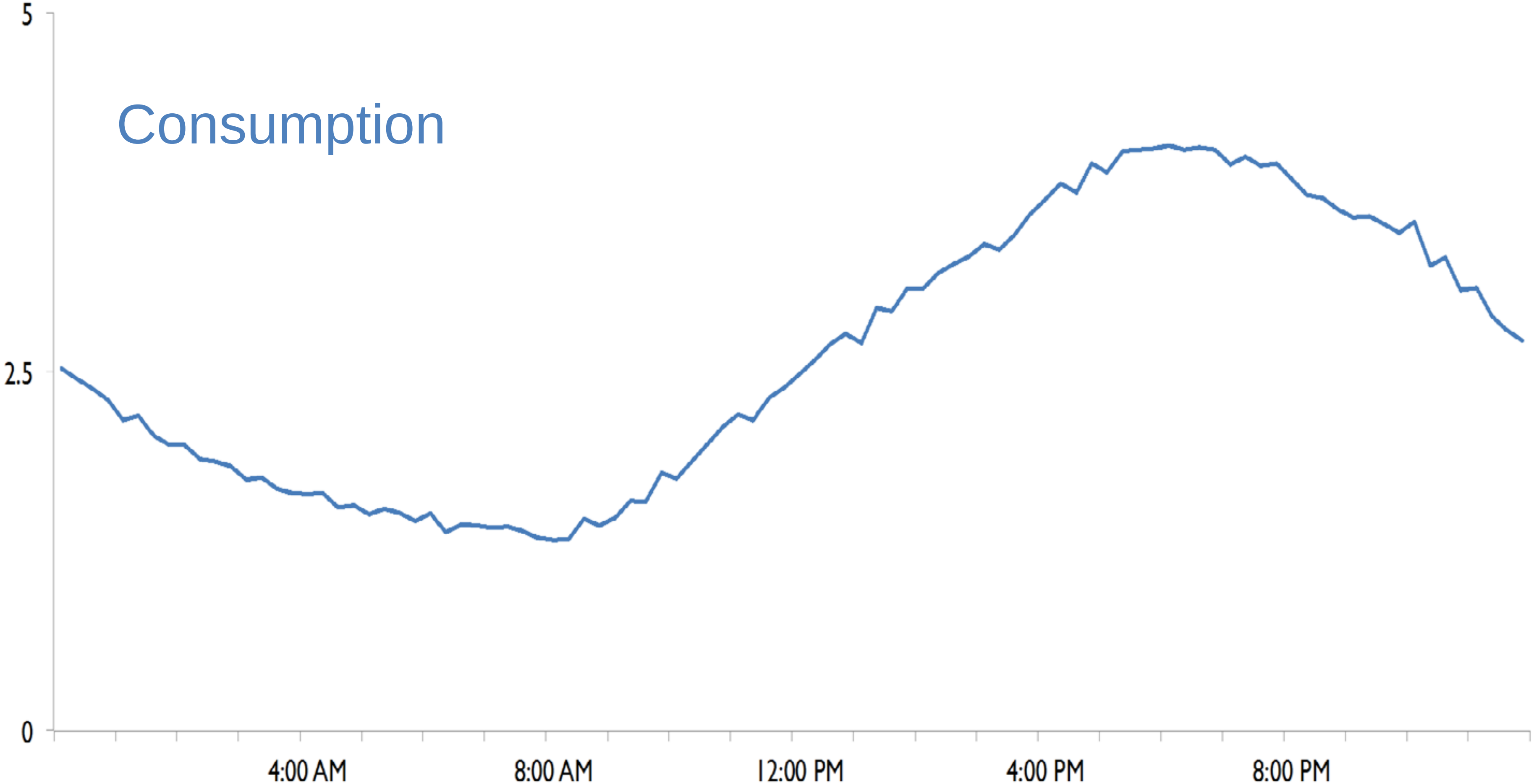


Pecan Street Consortium


kW by Read Type
ven
air
other
o
3
2
1
kitchen
refrigerator
vehicle
3
kW 2
1

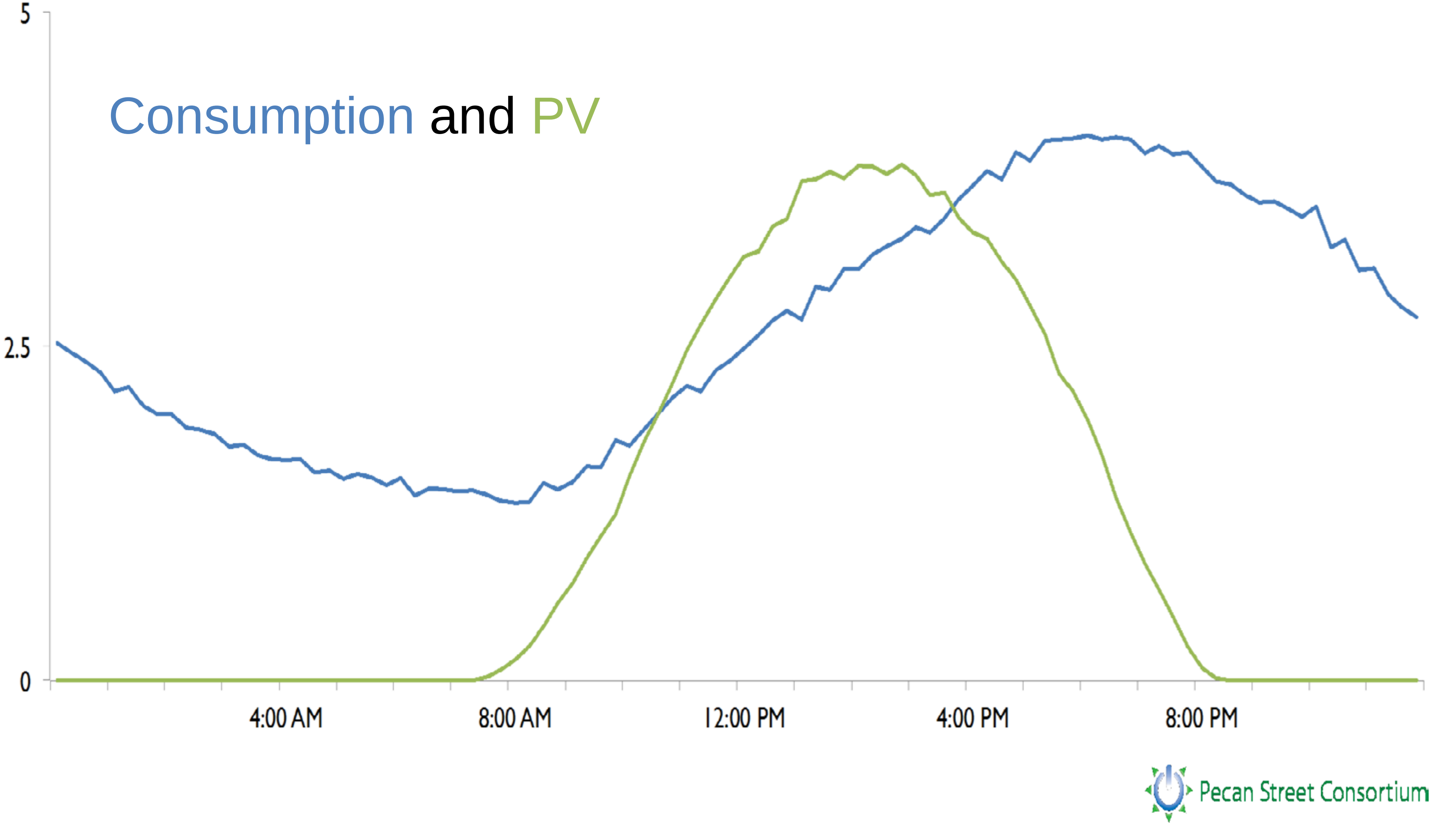
August average

Whole-home electricity usage (kW)

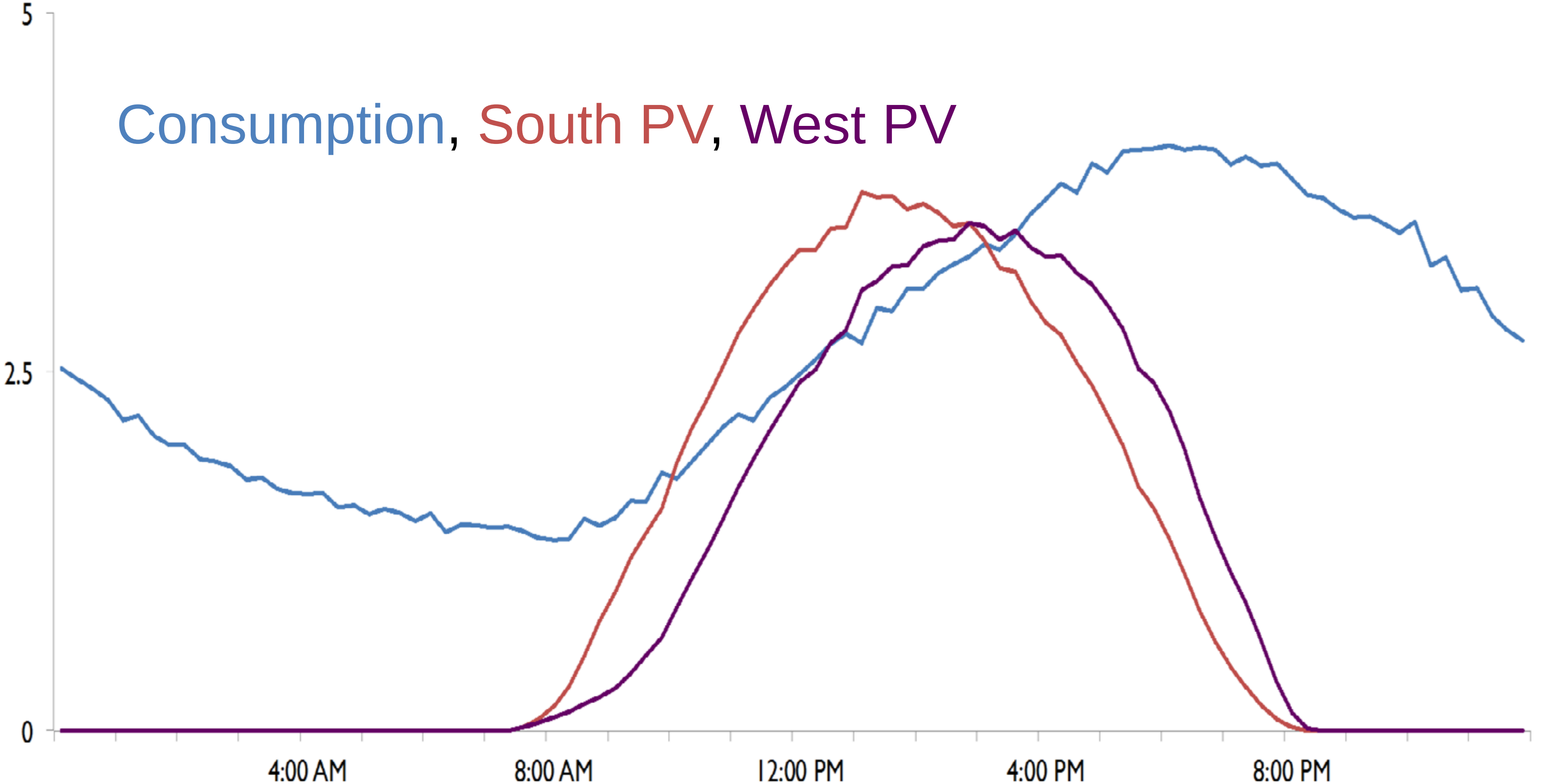


Pecan Street Consortium

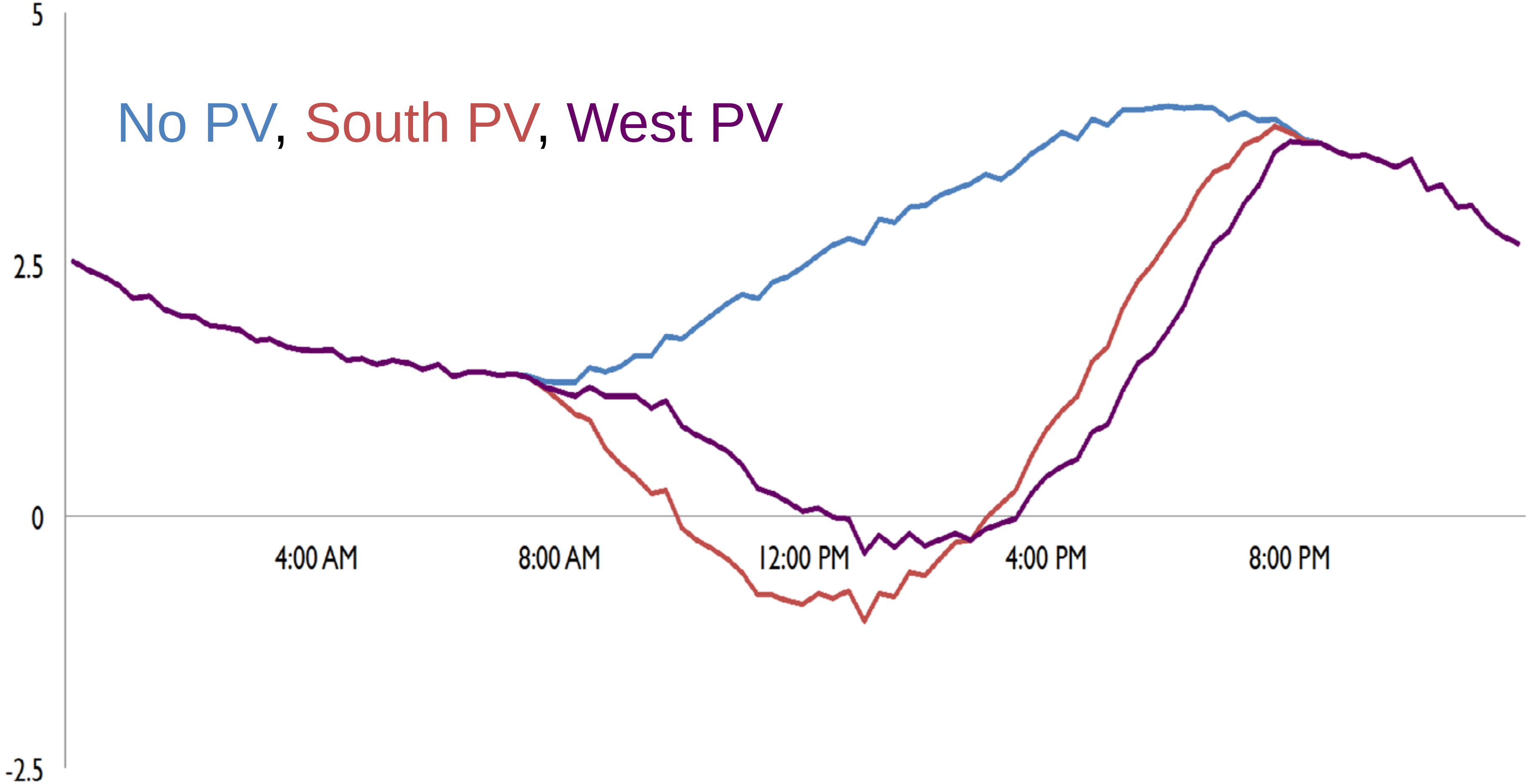
August average



August average



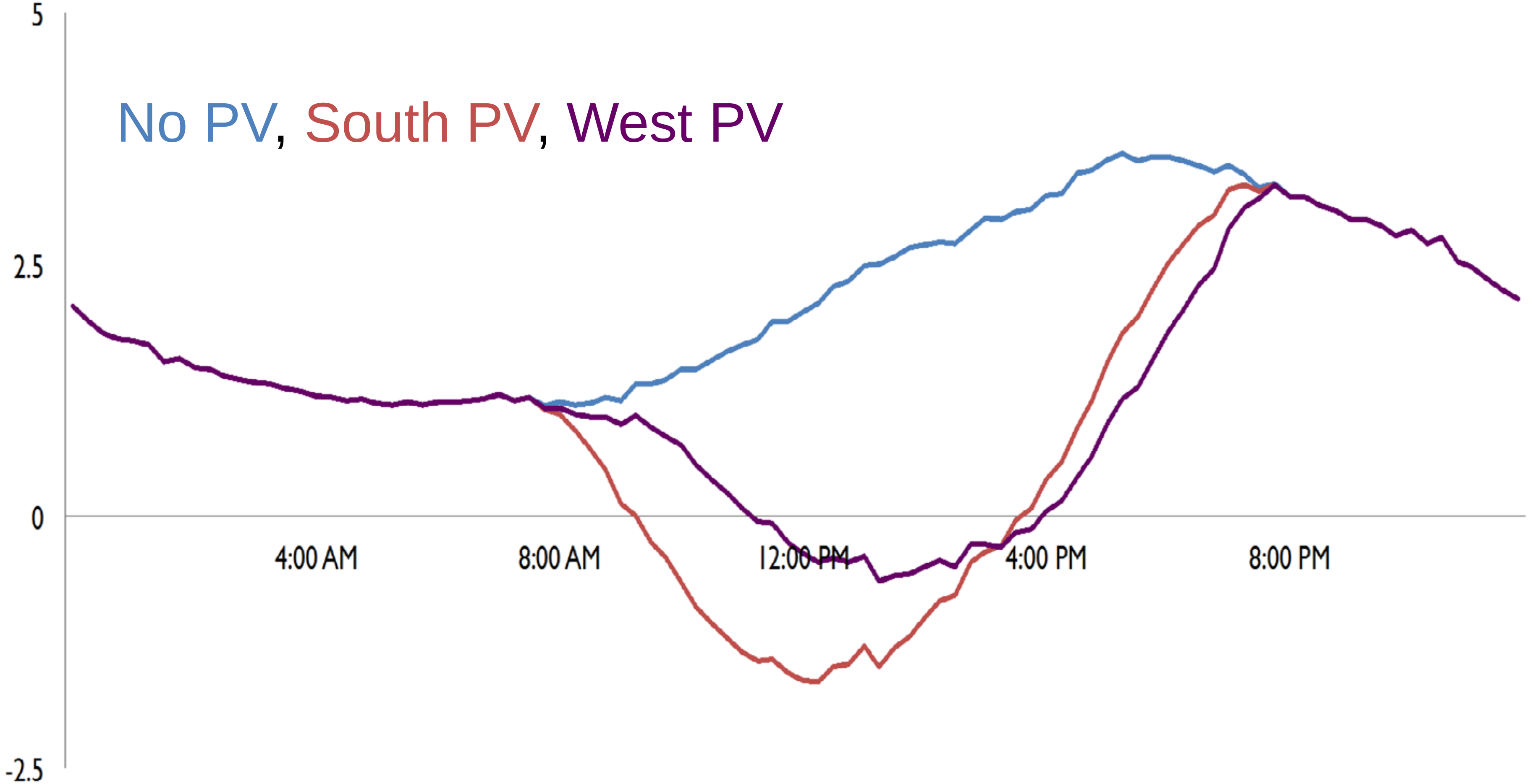
August average



Pecan Street Consortium

September average

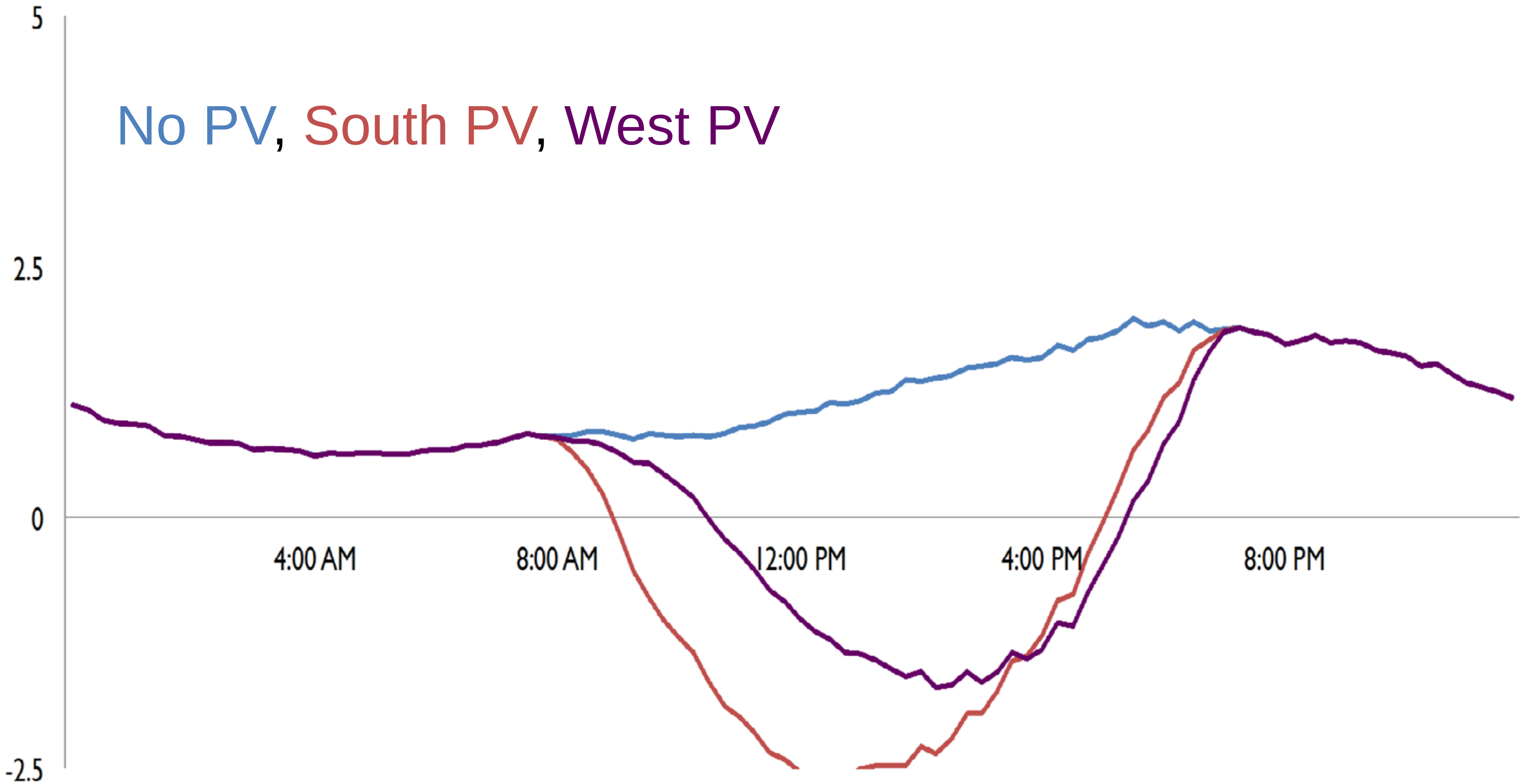
Whole-home net electricity usage (kW)



Pecan Street Consortium

October average

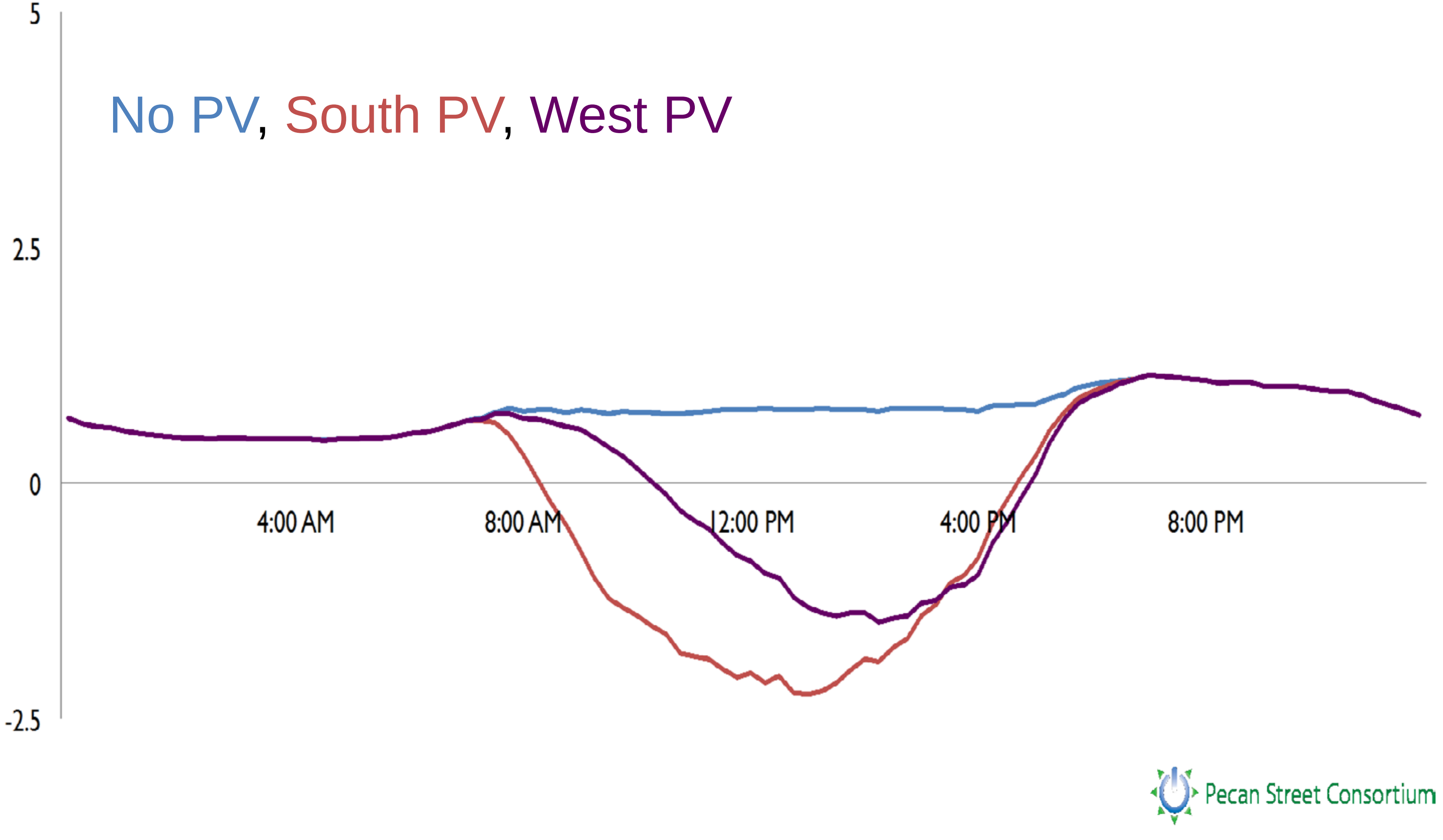
Whole-home net electricity usage (kW)



Pecan Street Consortium

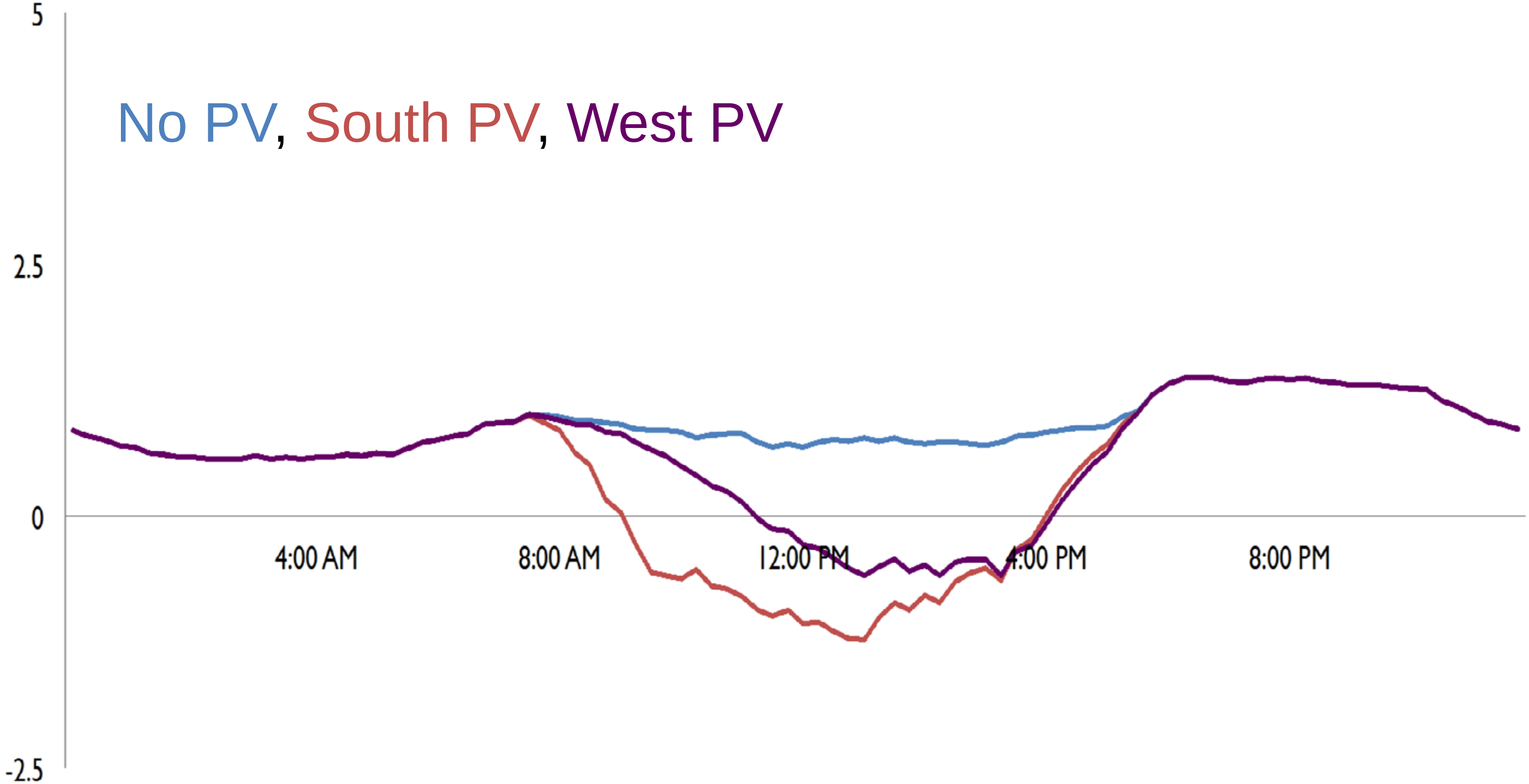
November average

Whole-home net electricity usage (kW)

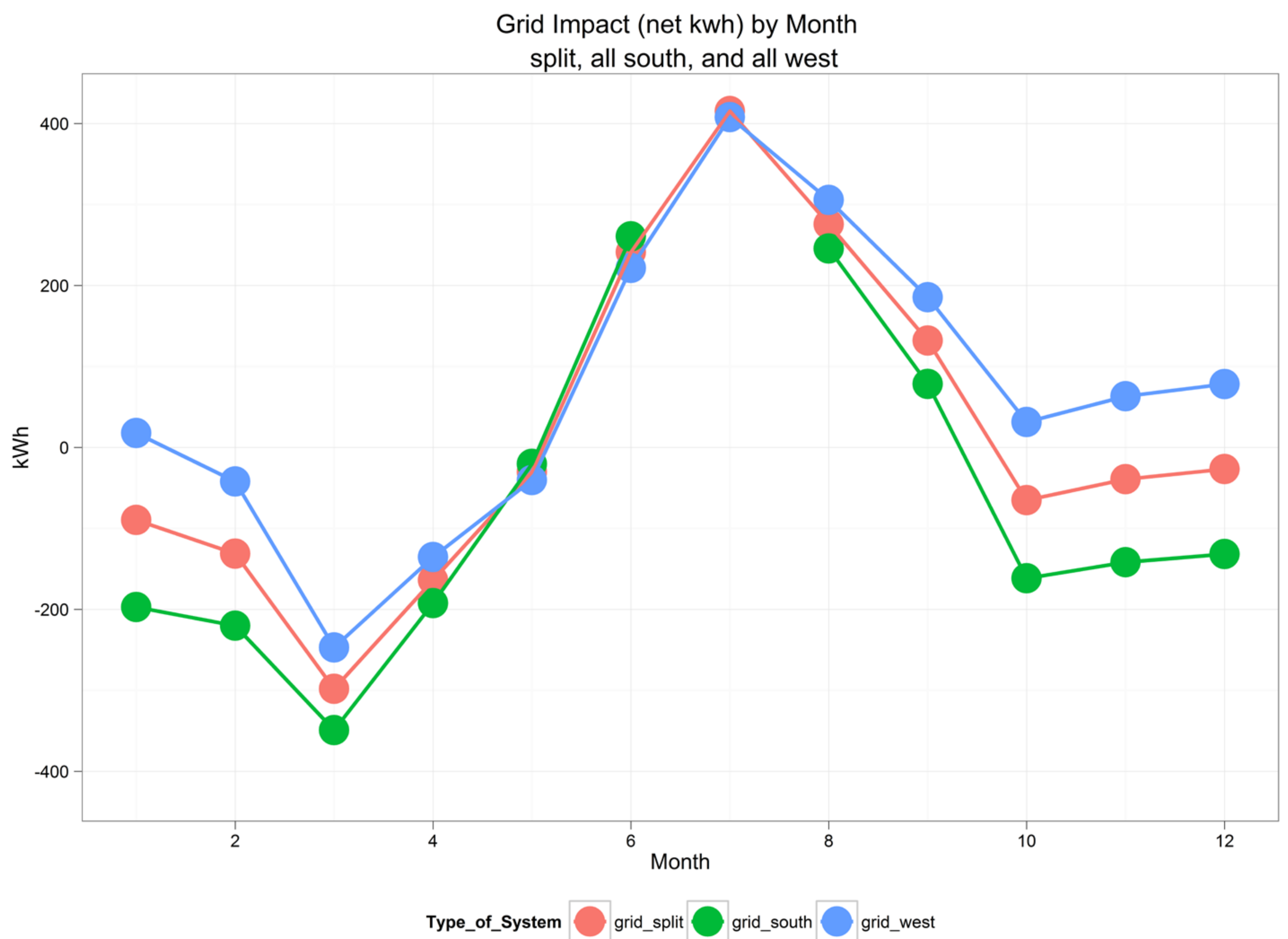


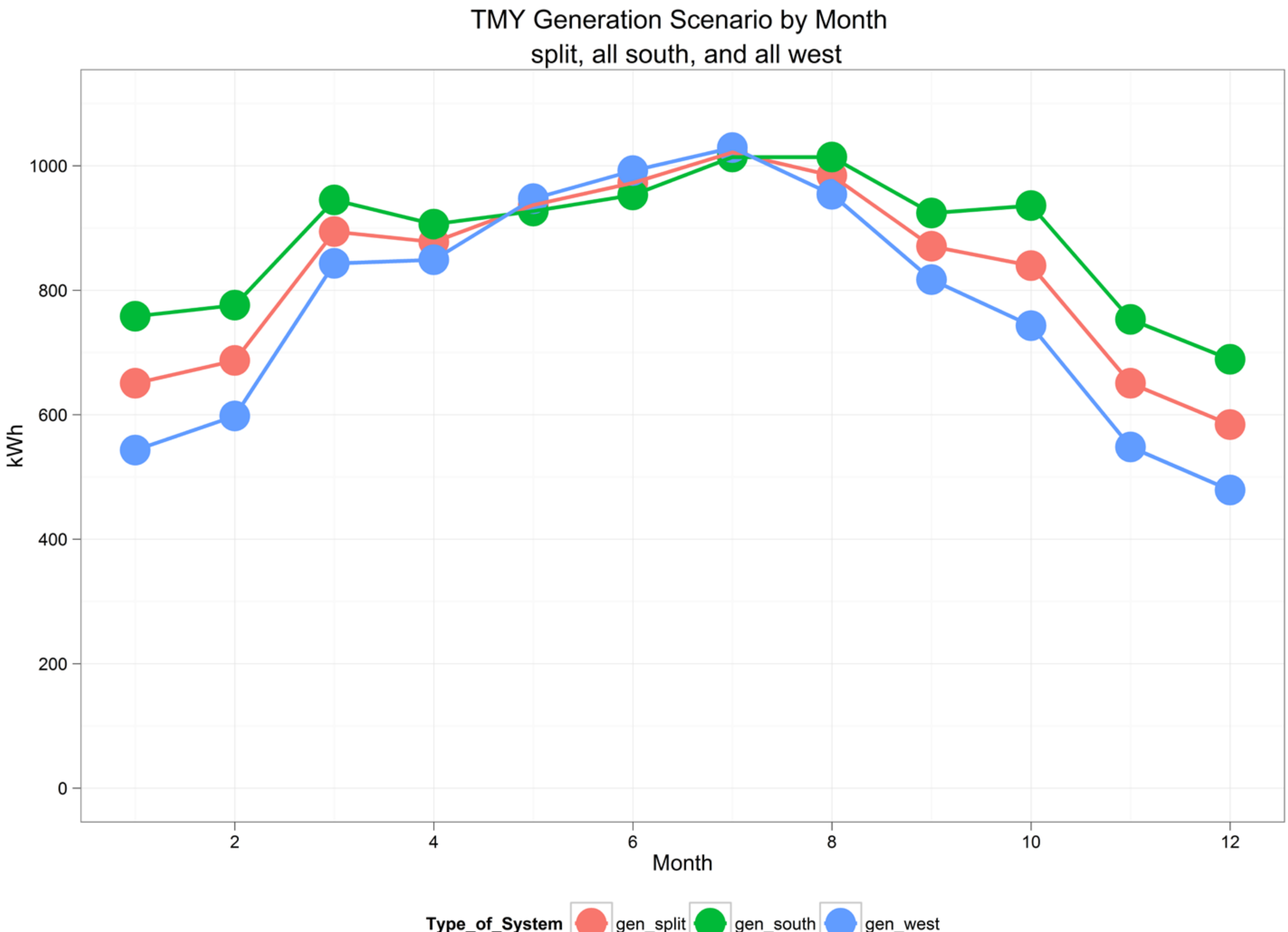
December average

Whole-home net electricity usage (kW)



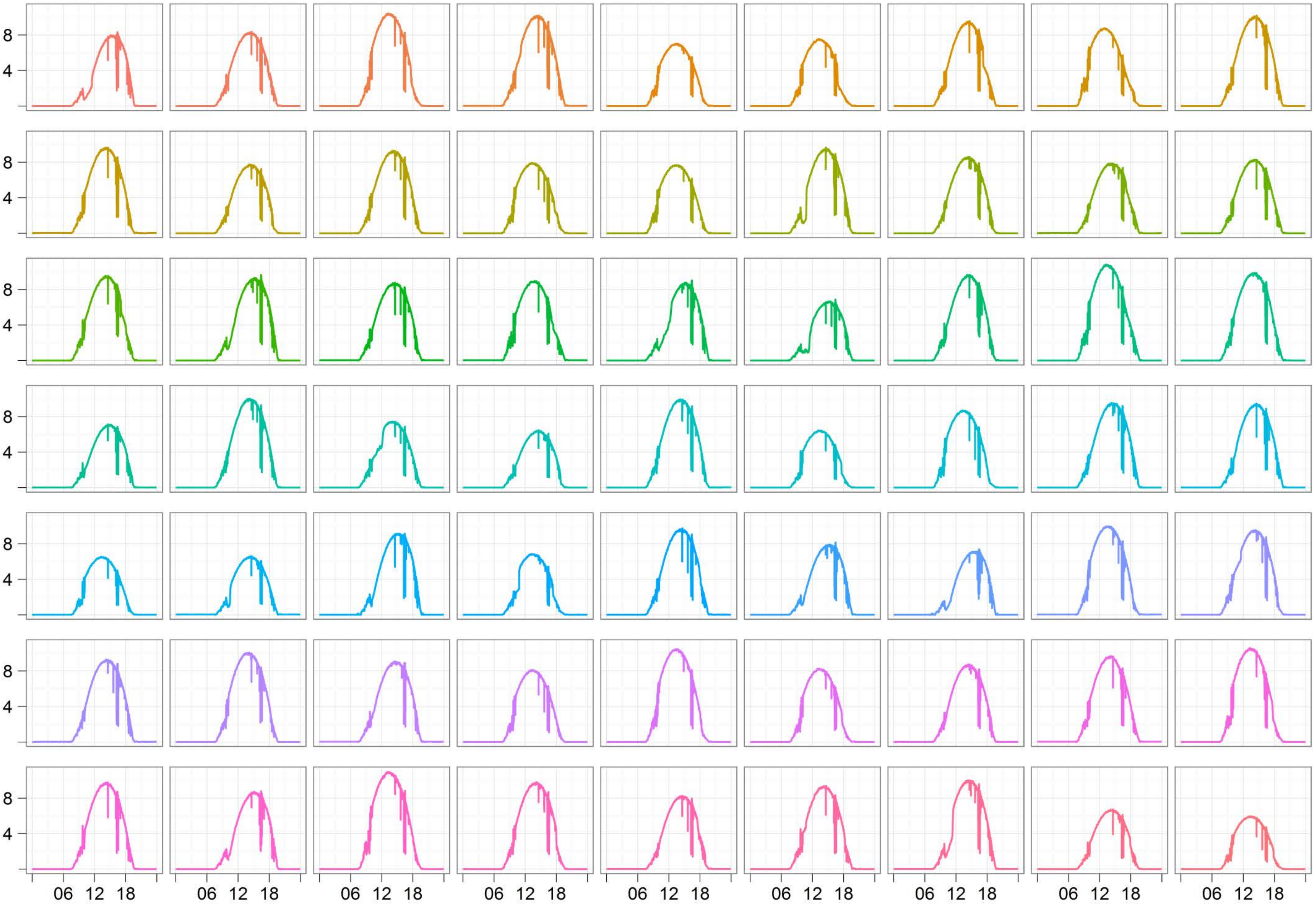
Pecan Street Consortium


Grid Impact (net kwh) by Month
split, all south, and all west
kWh
400
200
0
-200
-400
2
4
6
8
10
12
Month
Type_of_System
grid_split
grid_south
grid_west



TMY Generation Scenario by Month
split, all south, and all west
kWh
1000
800
600
400
200
0
2
4
6
8
10
12
Month
Type_of_System
gen_split
gen_south
gen_west

63 PV curves on 4/1/2012 (kW)



- Chris Holcomb
- cholcomb@pecanstreet.org

Pecan Street, Inc.

Center for Electromechanics

THE UNIVERSITY OF TEXAS AT AUSTIN

AUSTIN ENERGY

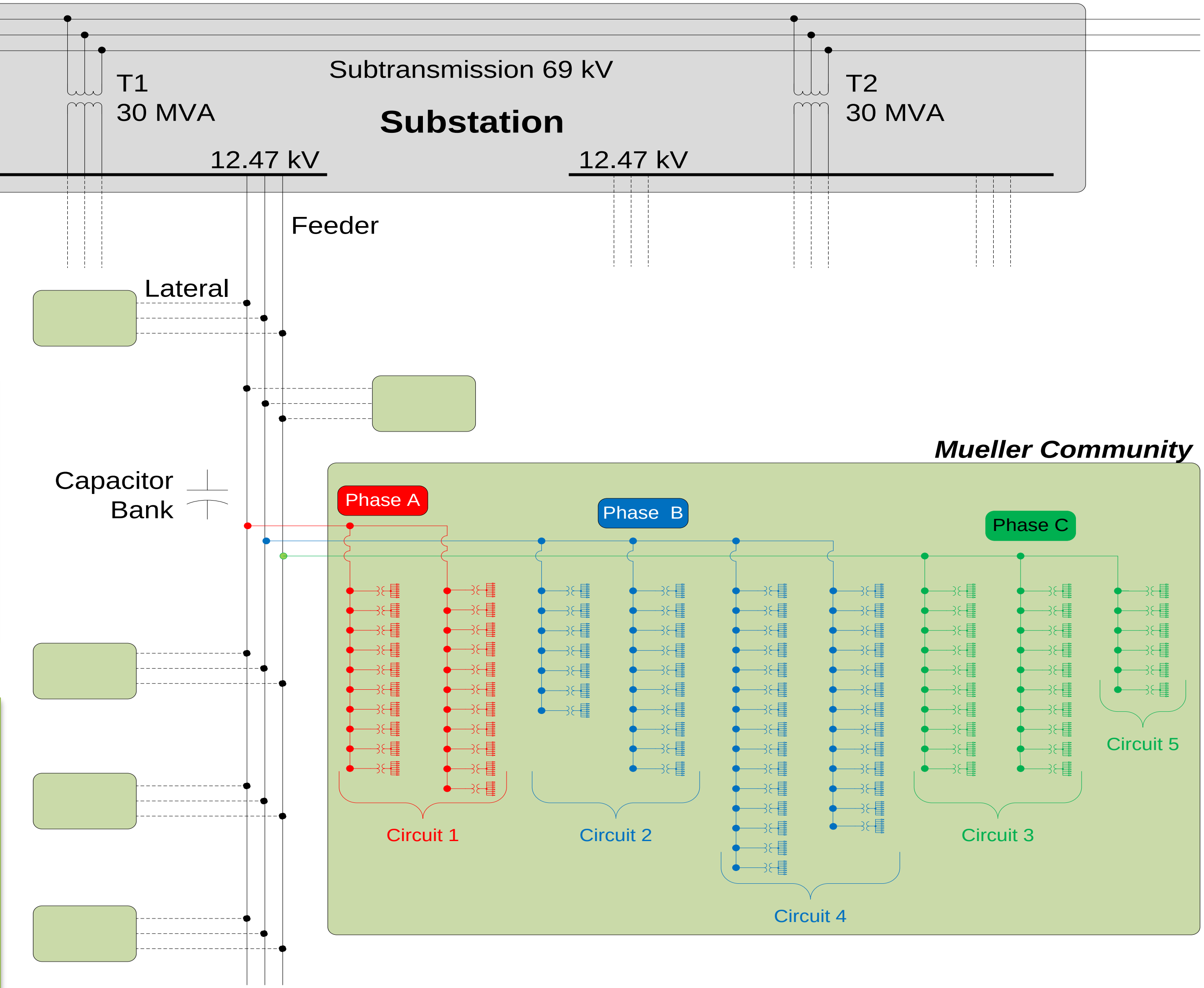
IEEE Photovoltaic Specialists Conference
June 3 – 8, 2012
Austin, Texas

Workshop Session

Impact of PVs and EVs on Distribution Transformers: A first Lo

Dr. Fabian Uriarte
Center for Electromechanics
University of Texas at Austin

Electrical Distribution



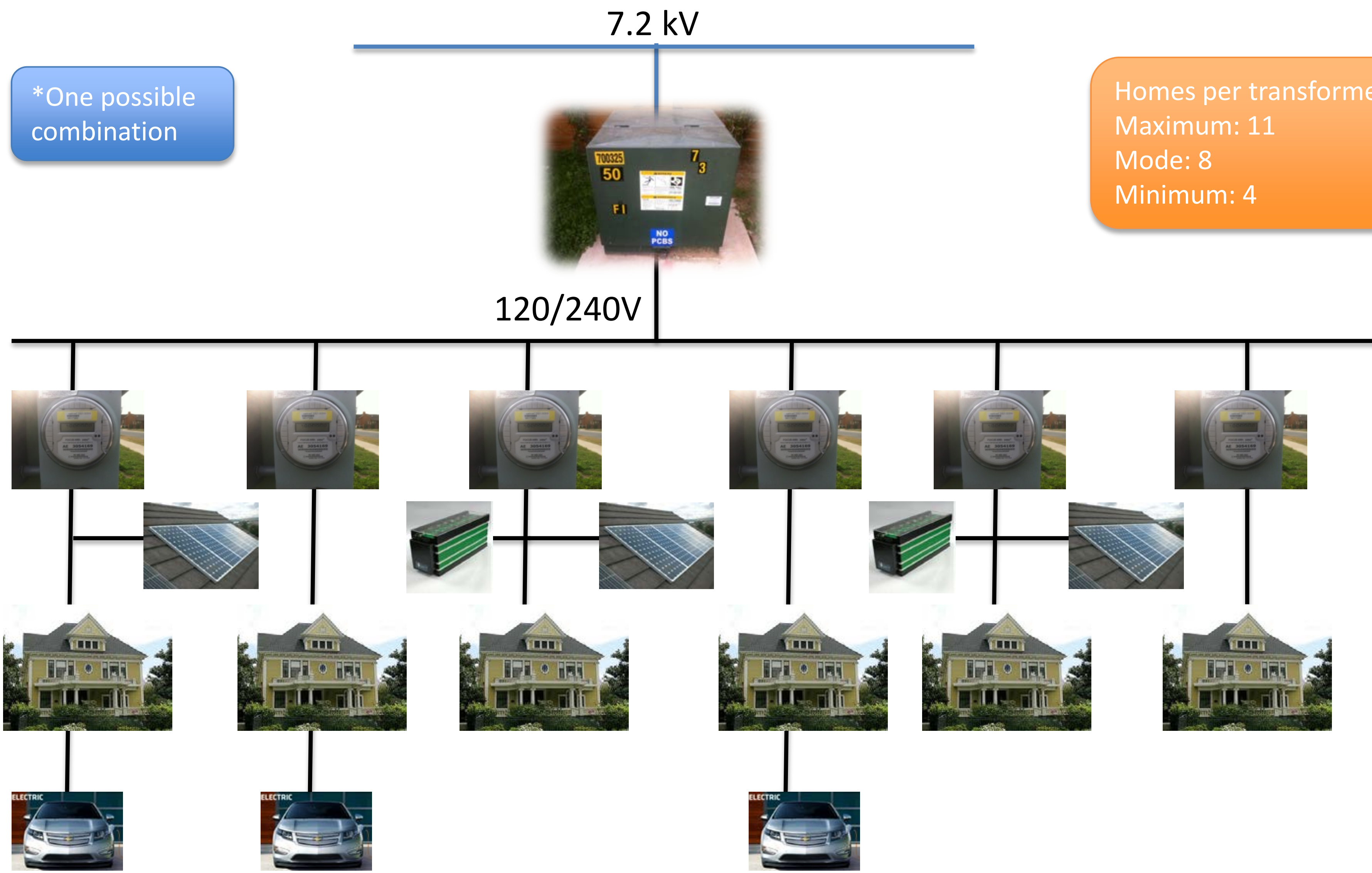
Mueller Community, Austin, Texas

- 735 homes (so far)
- 94 transformers
- 200 solar panels
- 100 electric vehicles

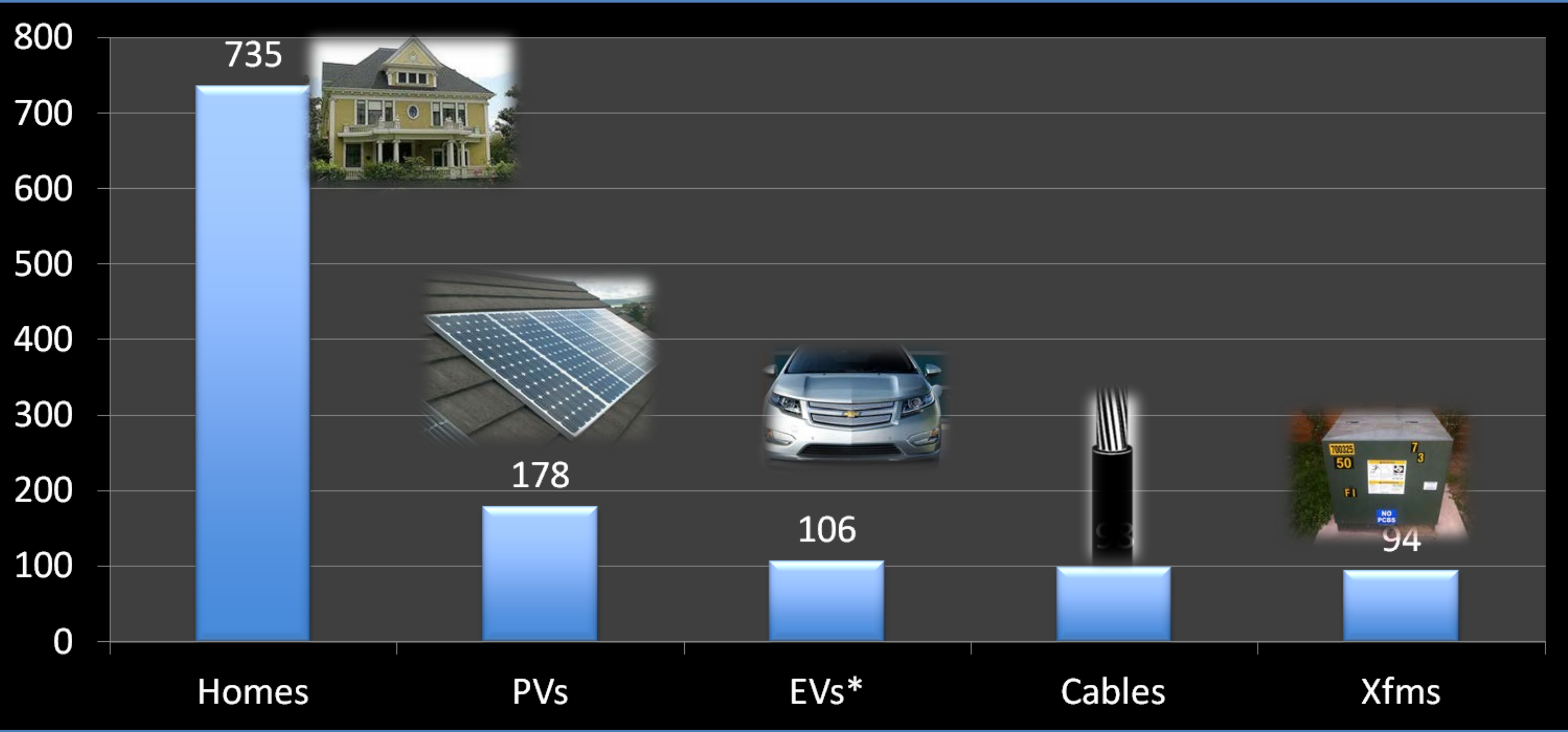
Each Transformer's Load*

*One possible combination

Homes per transformer:
Maximum: 11
Mode: 8
Minimum: 4



Case Study: 24 hrs in 1 min intervals

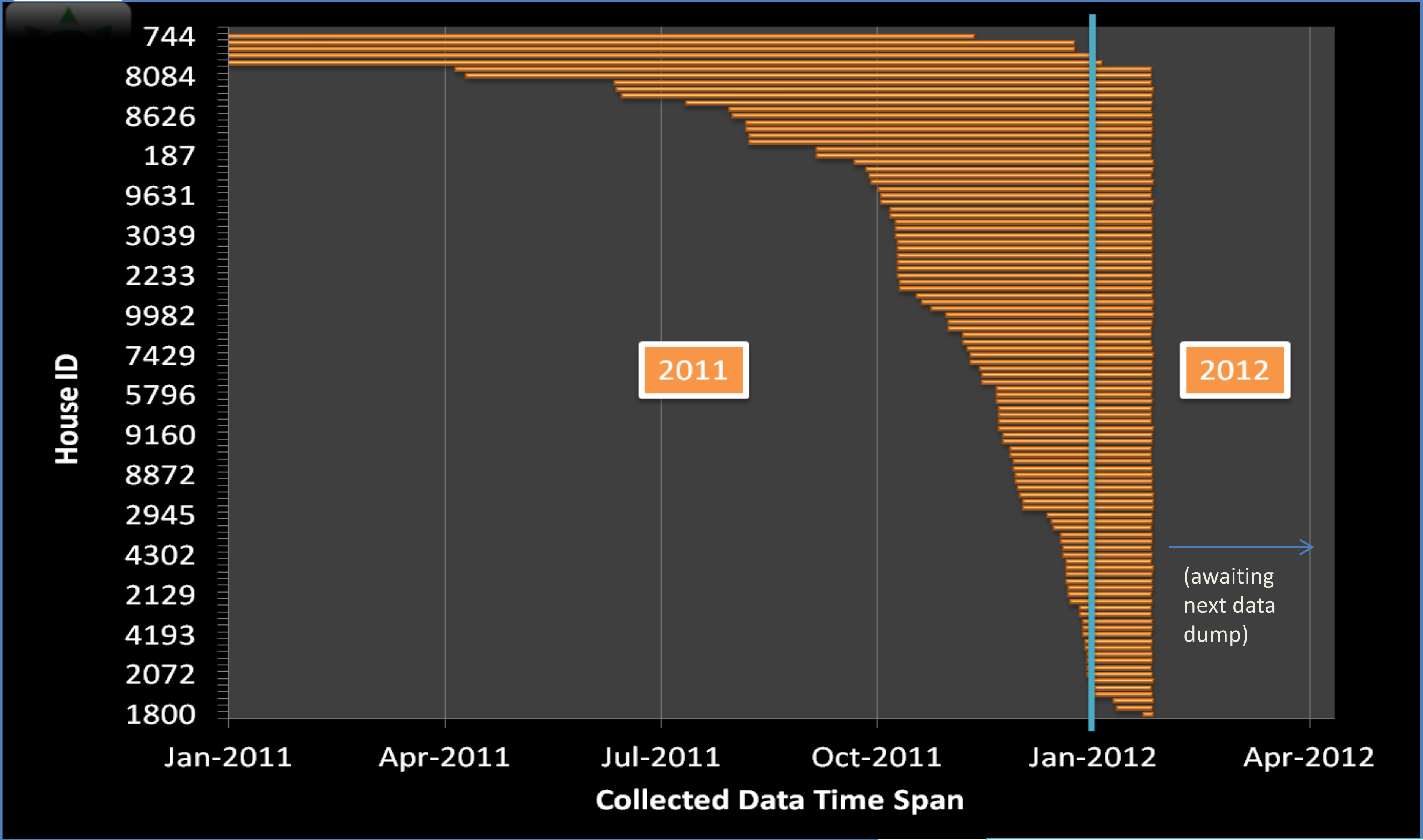


*EV charging randomizes 3 variables:
- Plug-in time (>4 PM)
- Charge rate (0.9, 1.4, 3.3 kW)
- Charge duration

CEM

Center for Electromechanics

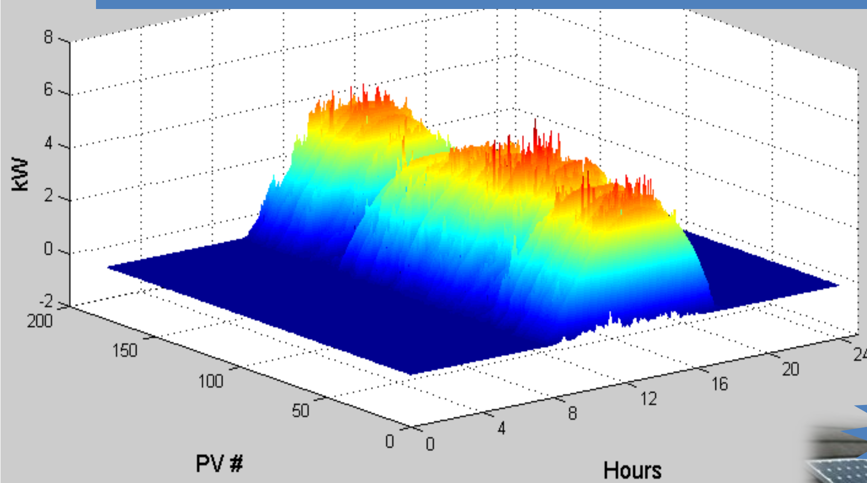
Pecan Street Data Pool

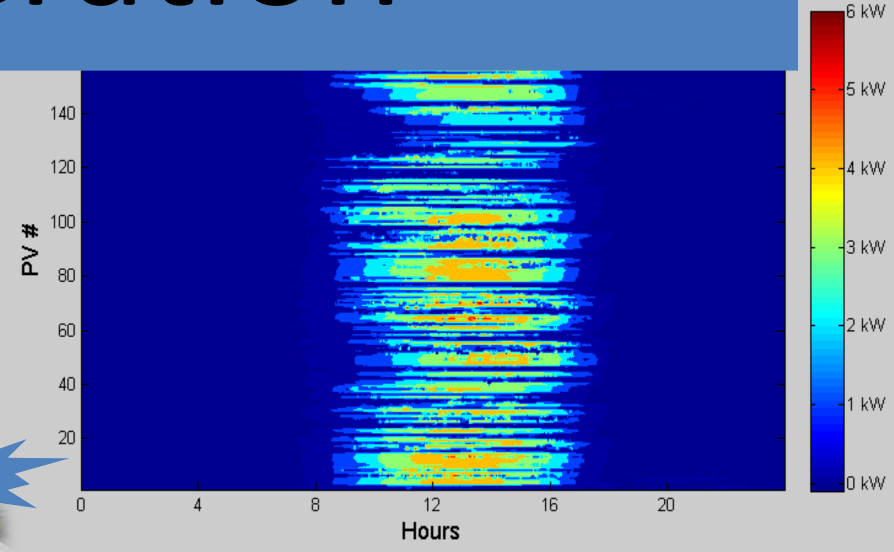


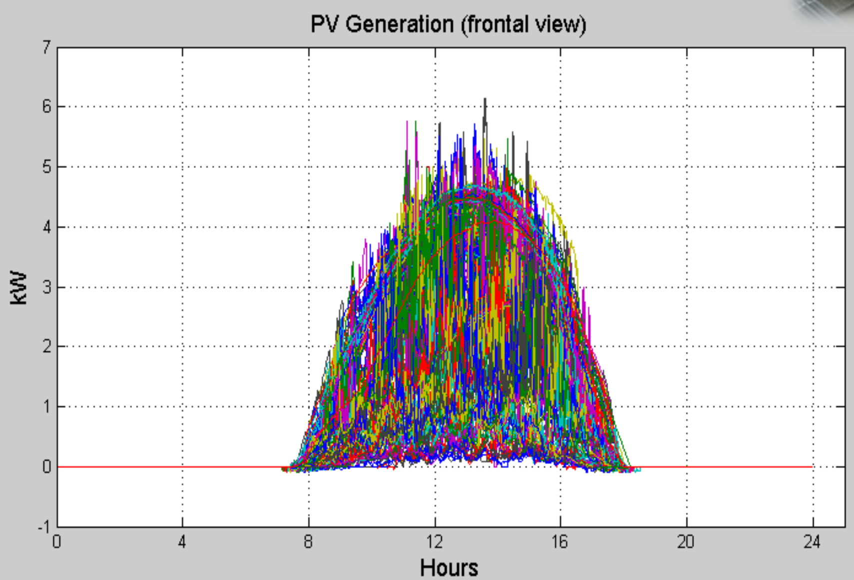
- >100 homes being measured (load and PV generation)
- 1 minute intervals
- Measurements start on different dates

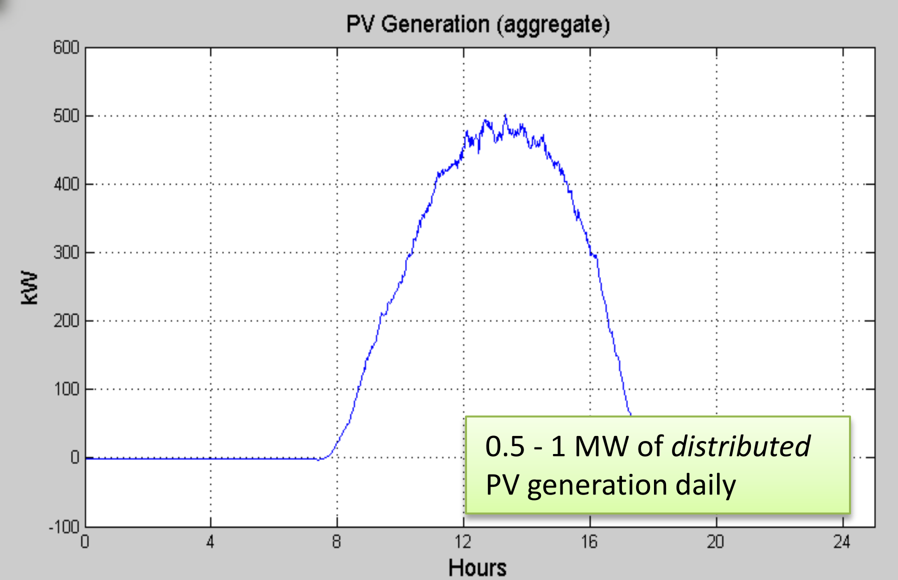
- 24 hrs of data per CSV file
- Everyday a new CSV file is created

PV Generation

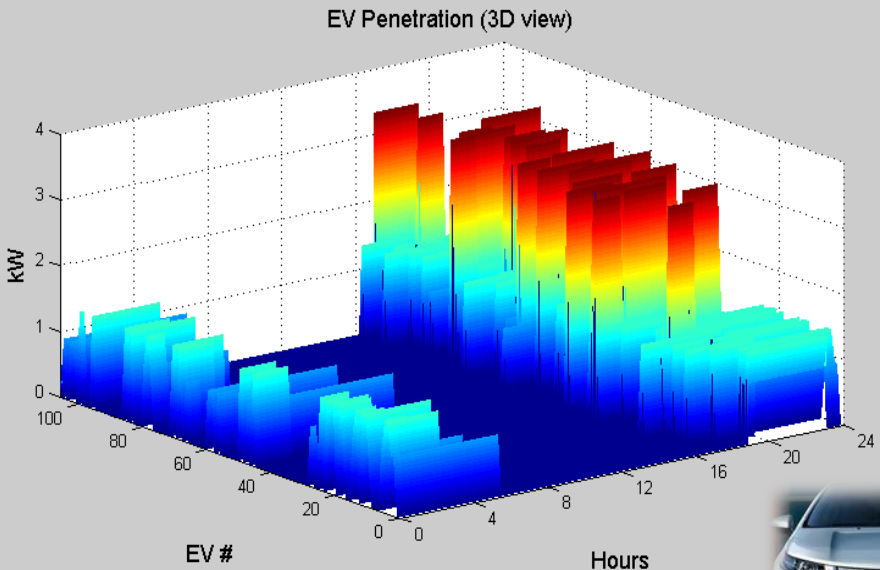


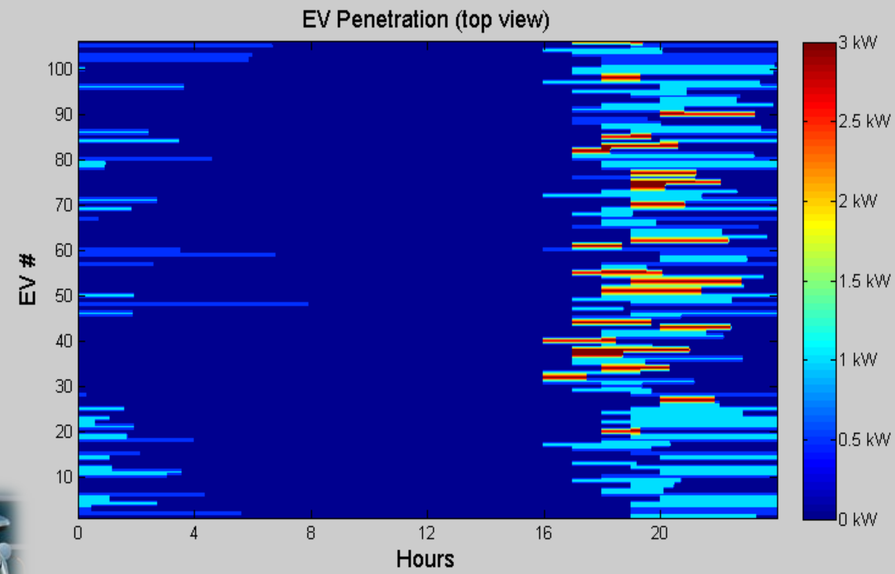


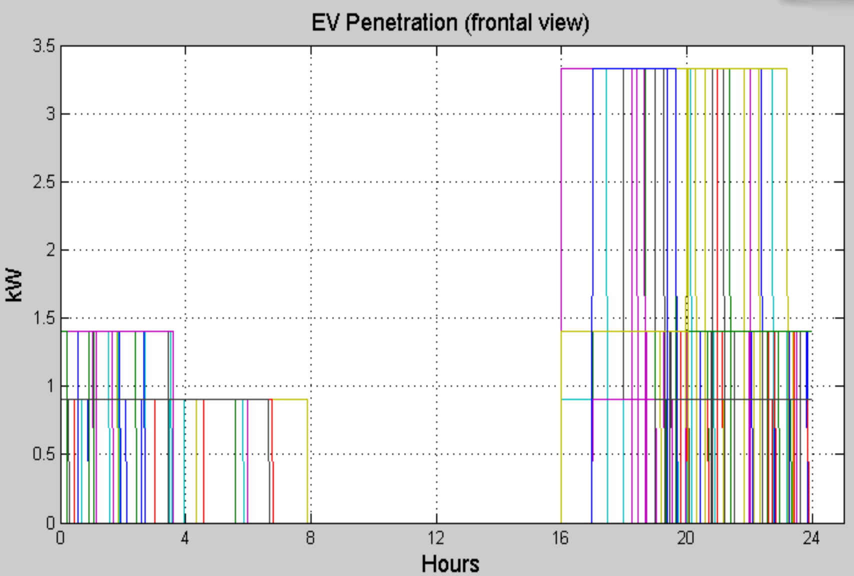


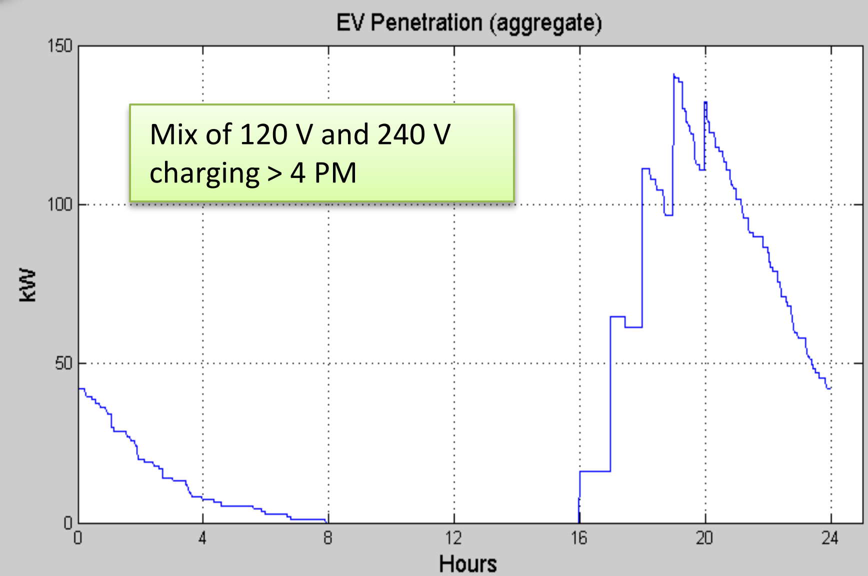


EV Penetration

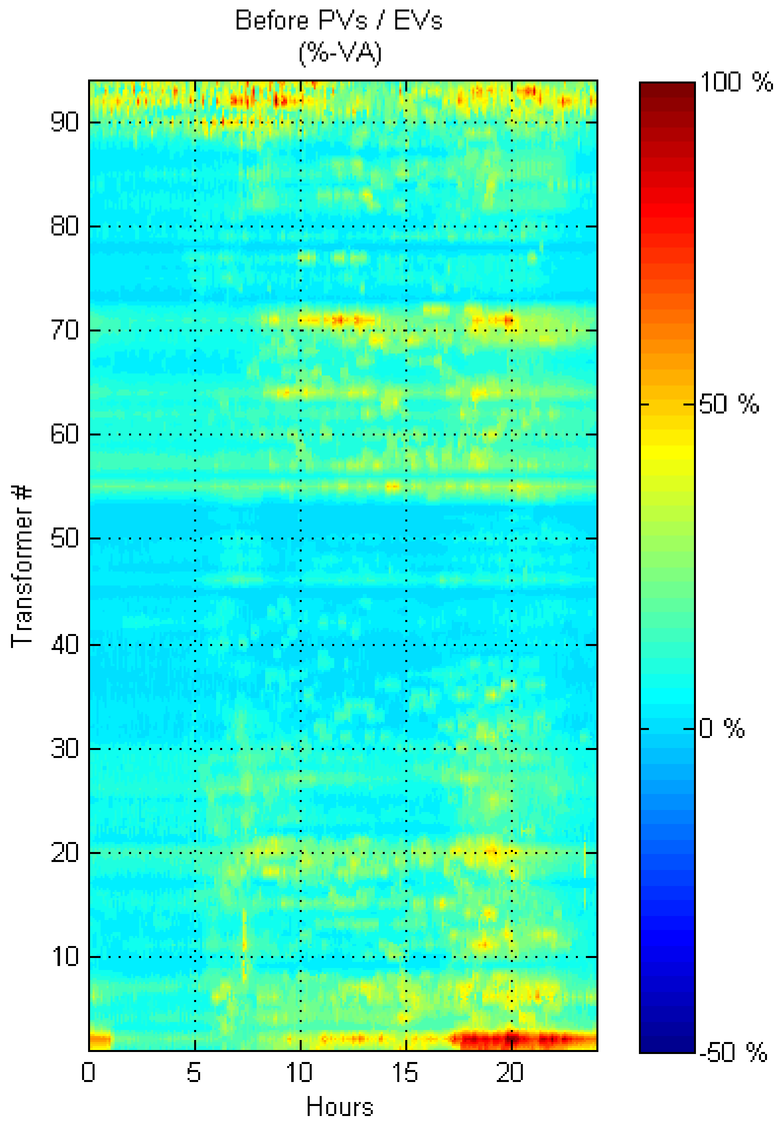


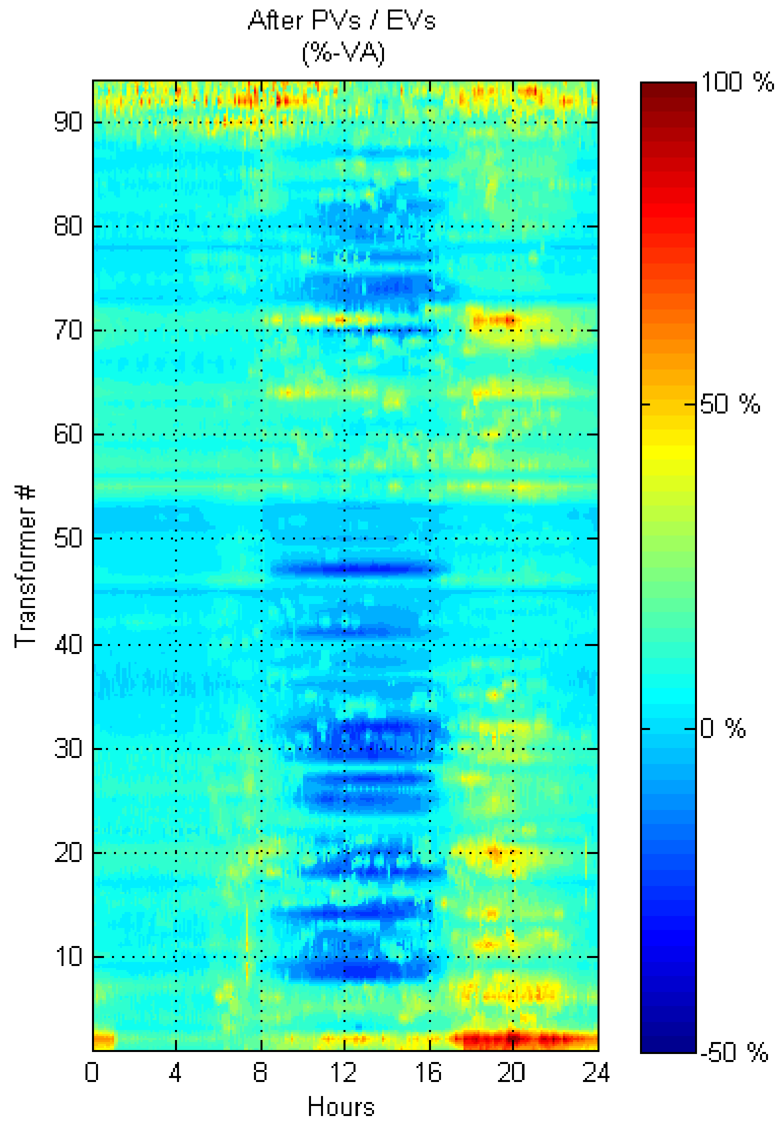






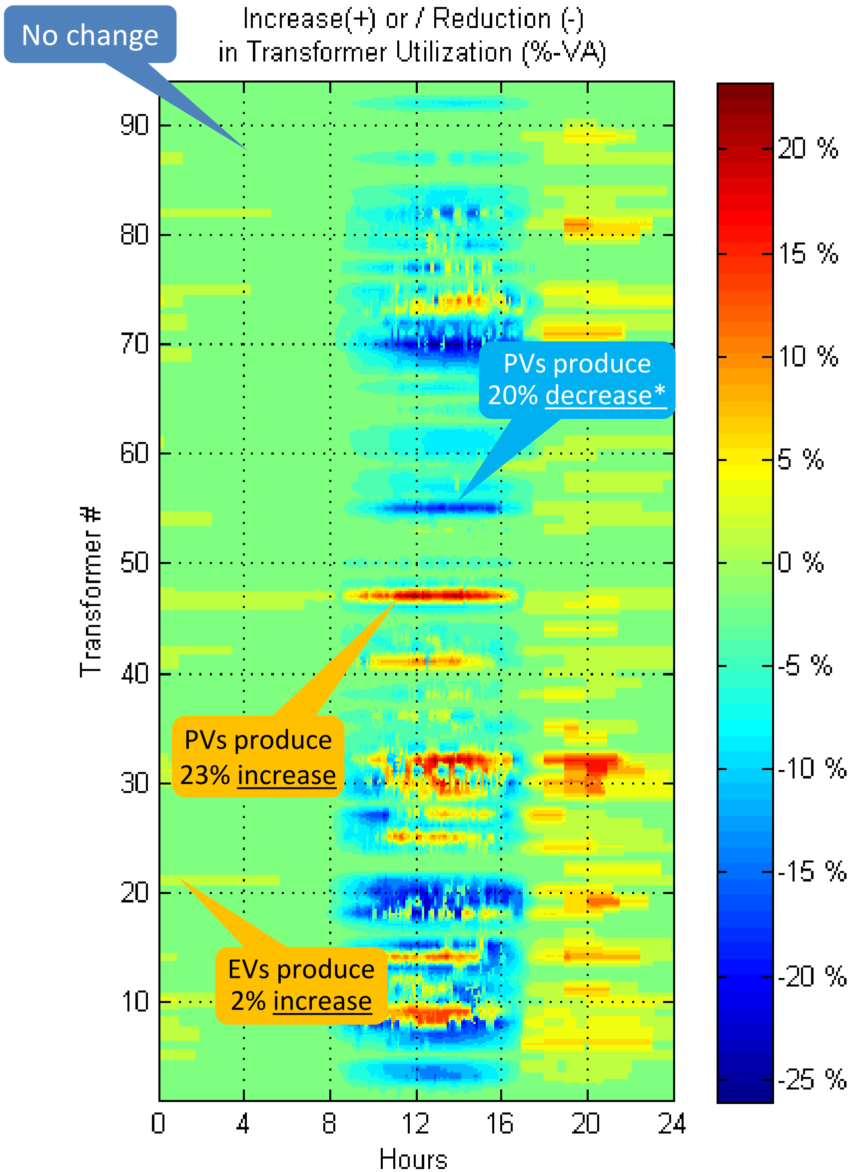
Transformer Utilization

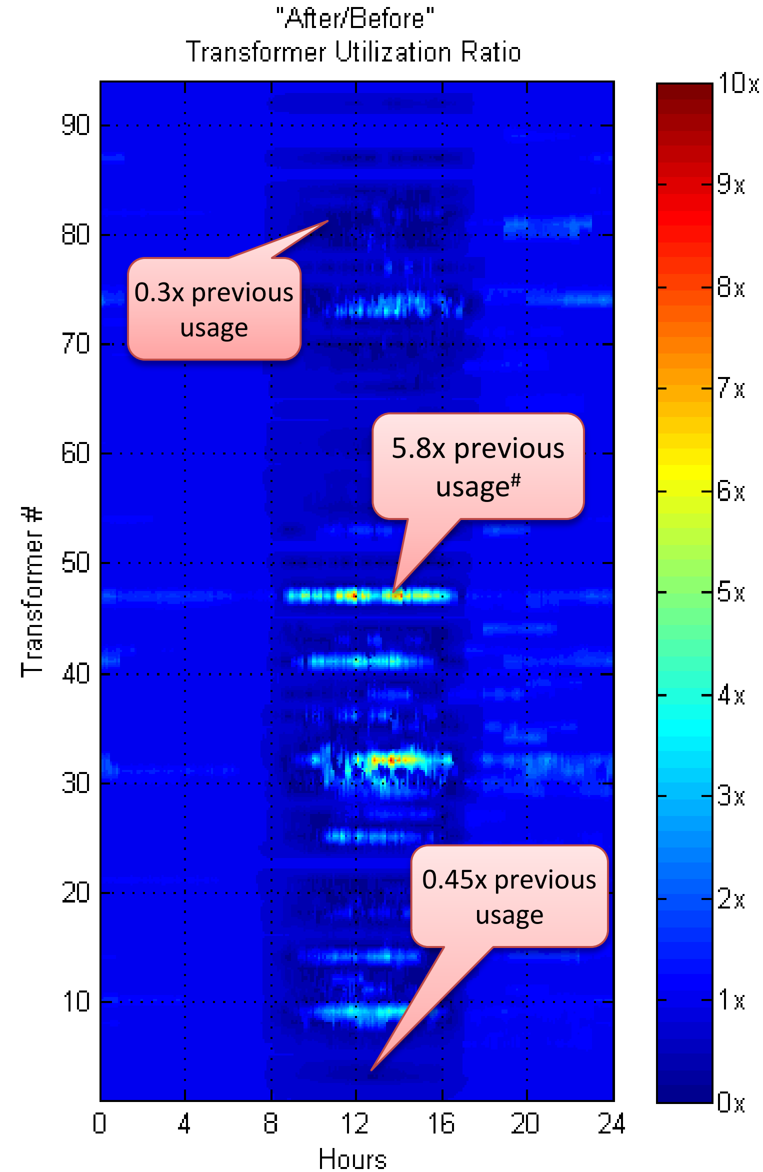




- High PV/Load ratio causes reverse flows
- Can increase or decrease xfm. utilization

Change in Transformer Utilization

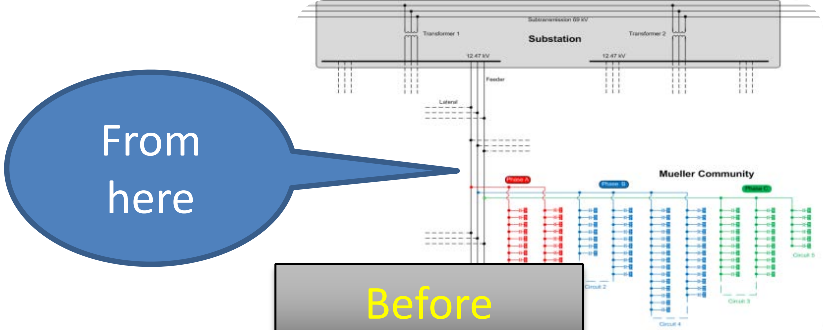


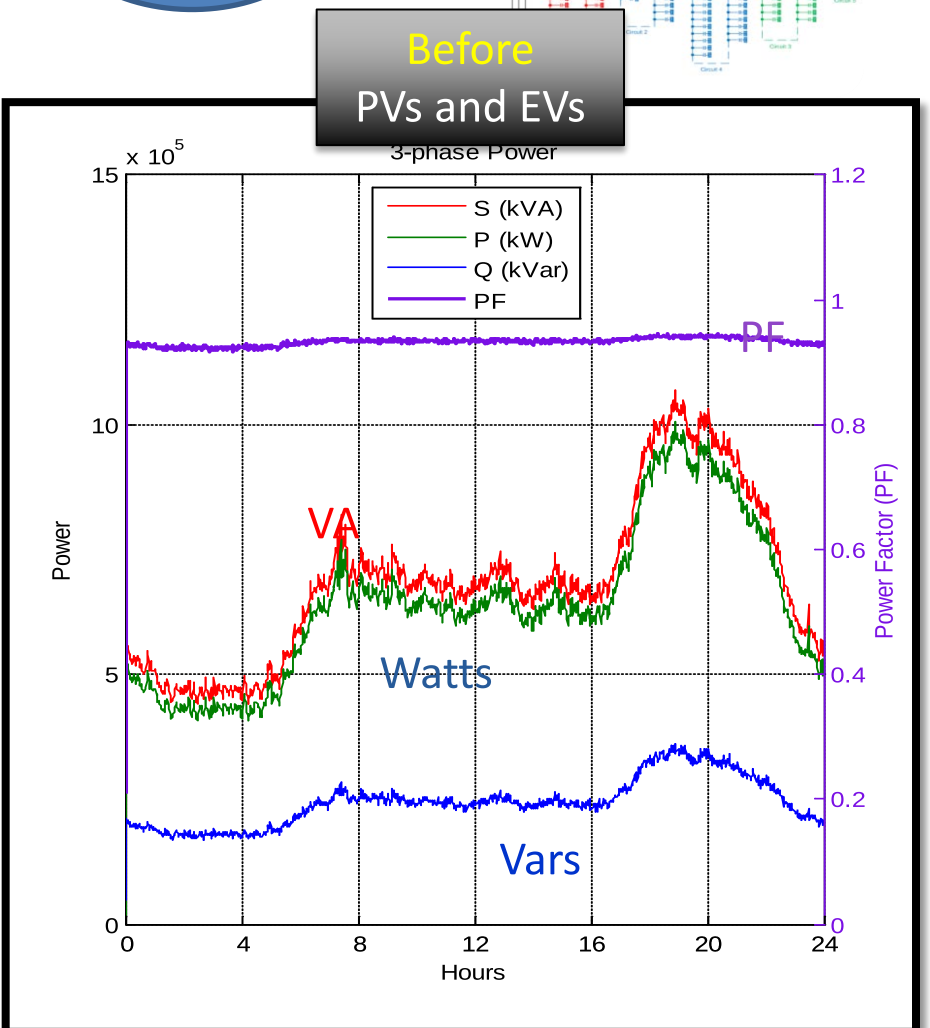


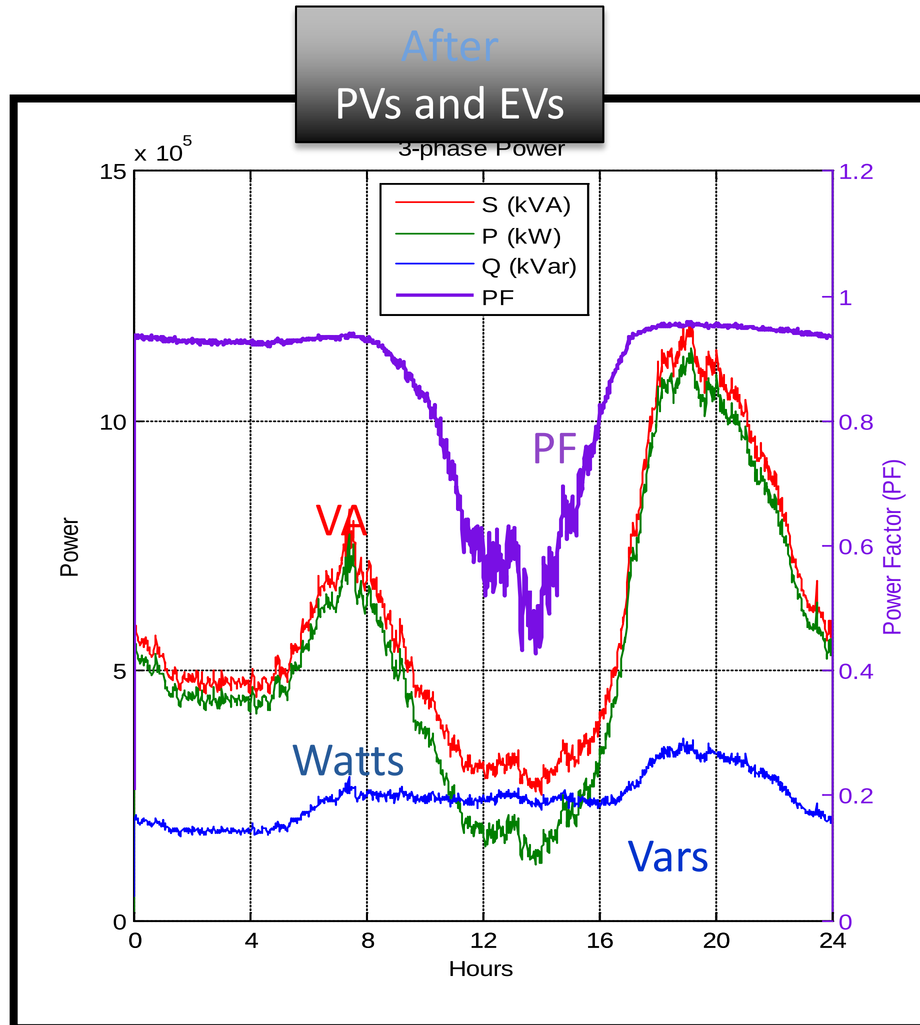
- *before: 25%, after: -5%, change = |after|-before = -20%.
- Sign indicates direction of real power

|after|/before = |-58%|/10% = 5.8x

Lateral Demand







- 0.5 MW reduction in **real** power demand
- Equal **reactive** power demand
- Power factor drops

Conclusions

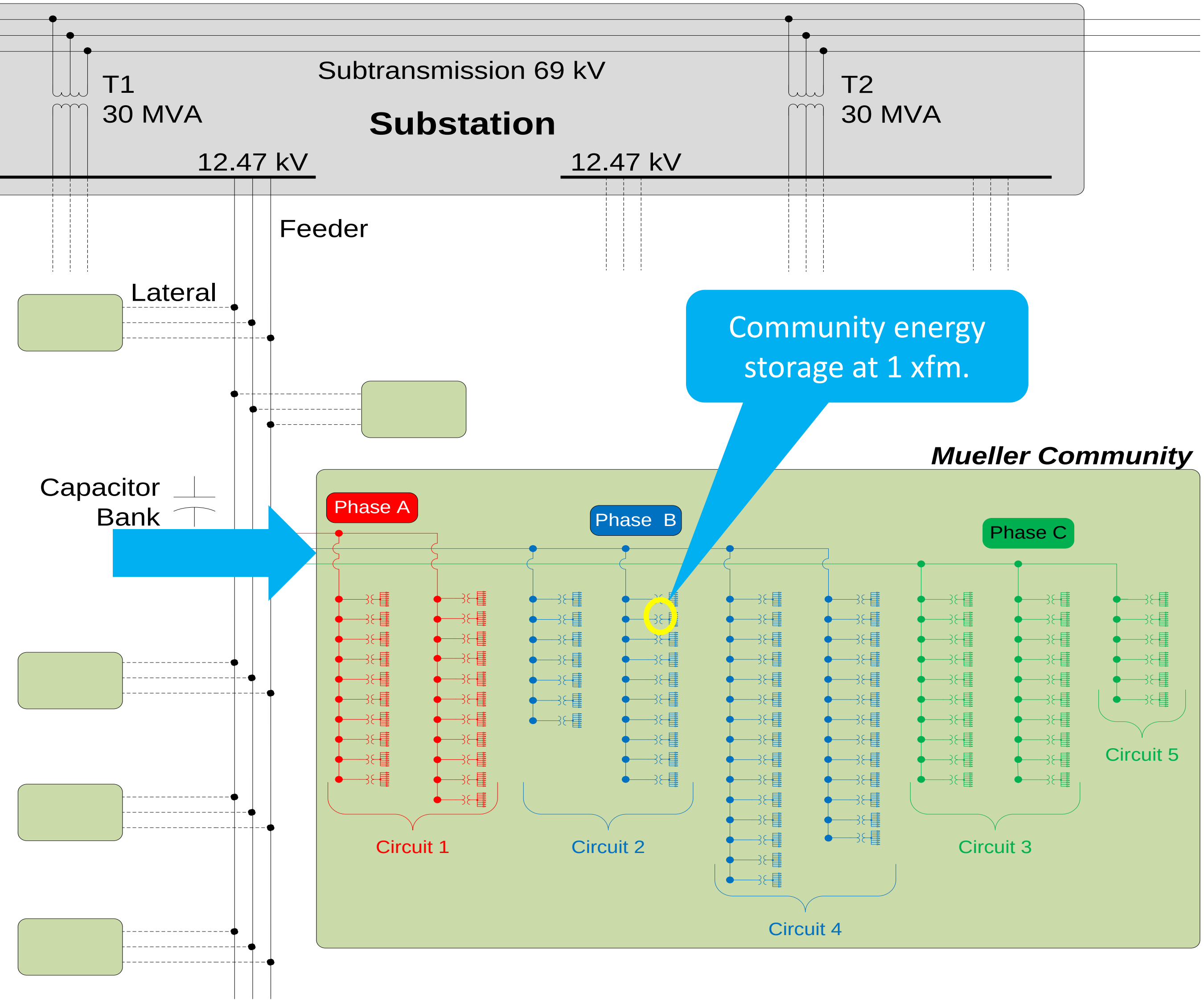
- Simulation Model
  - We have real data in 1-min. intervals
    - For house load
    - For house PV generation
  - Can simulate <u>entire</u> smart grid (735 homes)
  - Confidence in results
  - Simulations highlight areas needing attention
- Transformers
  - Some operating at 80%
  - Avg. losses per transformer = 120 W
  - Show enough capacity to meet EV load (at Mueller only)
  - Low diurnal power factor
- Residential Solar Panels
  - Cause reverse transformer flows
  - Reduces lateral and transformer power factor
  - Provide voltage support
  - Homes require reactive power (cannot detach from grid)
  - Residences getting reactive power from utility; diurnal real power from PVs
- Electric Vehicles (Chevy Volts)
  - Uncontrolled charging exacerbates peak demand
  - Electrical impact appears small due to transformer sizing

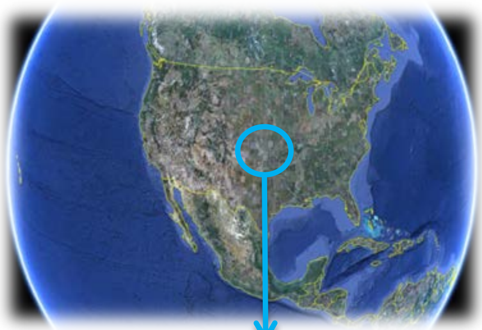
Community Energy Storage:
A 7-day Forecast

Dr. Fabian Uriarte
Dr. Robert Hebner
Center for Electromechanics

Jul. 2012 - Austin, Texas

Electrical Distribution

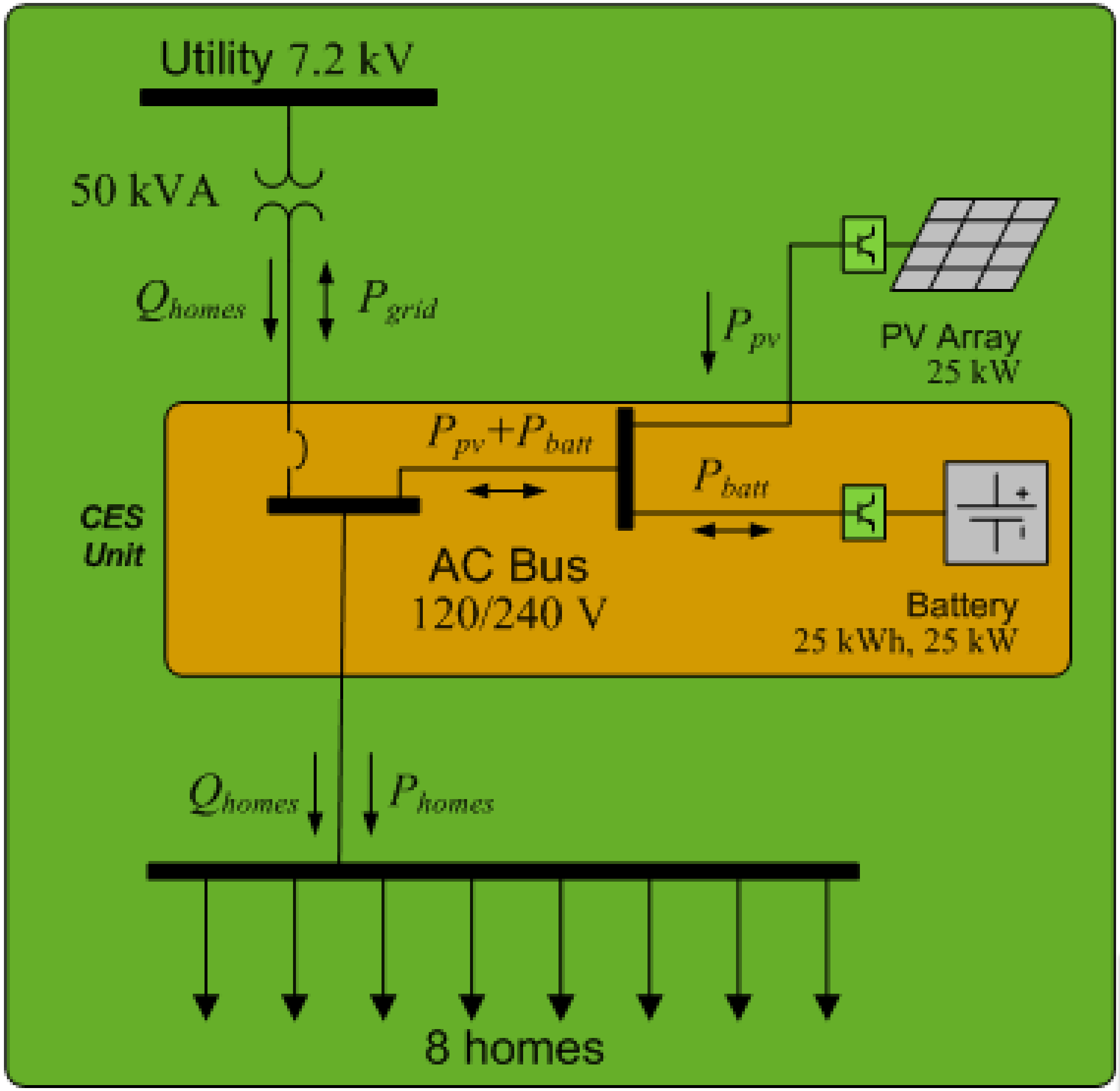




Mueller Community, Austin, Texas

- 735 homes
- 94 transformers
- 200 solar panels
- 100 electric vehicles

Community Energy Storage (CES)



Assumptions*

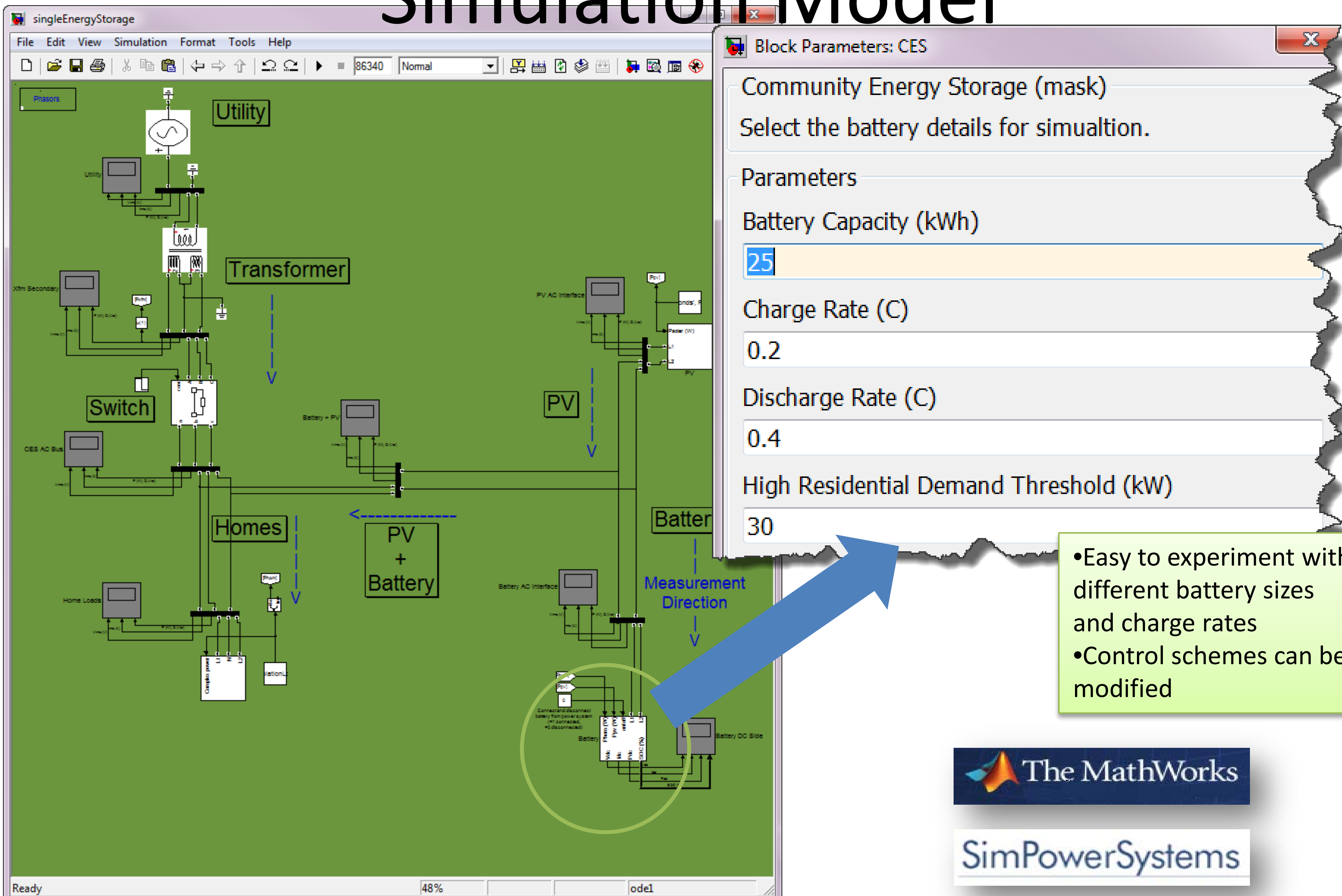
- AC configuration
- Data set: Jul 2011
- No electric vehicles
- Residential reactive power assumed (not measured)
- Battery provides real power only
- Generic battery model used

*Assumptions are for the initial simulation. So, they define the starting points but are not a constraint on the approach

Battery Control Strategies

- Charge
  a. When transformer load is low (< 30 kW)
  b. When sun is out (PV > 5 kW)
  c. When SOC reaches 10 %
  d. Charge logic: (a OR b) AND c
- Discharge
  a. When PV output fluctuates
  b. When transformer load is high (≥ 30 kW)
  c. When SOC reaches 90 %
  d. Discharge logic: (a OR b) AND c

Simulation Model



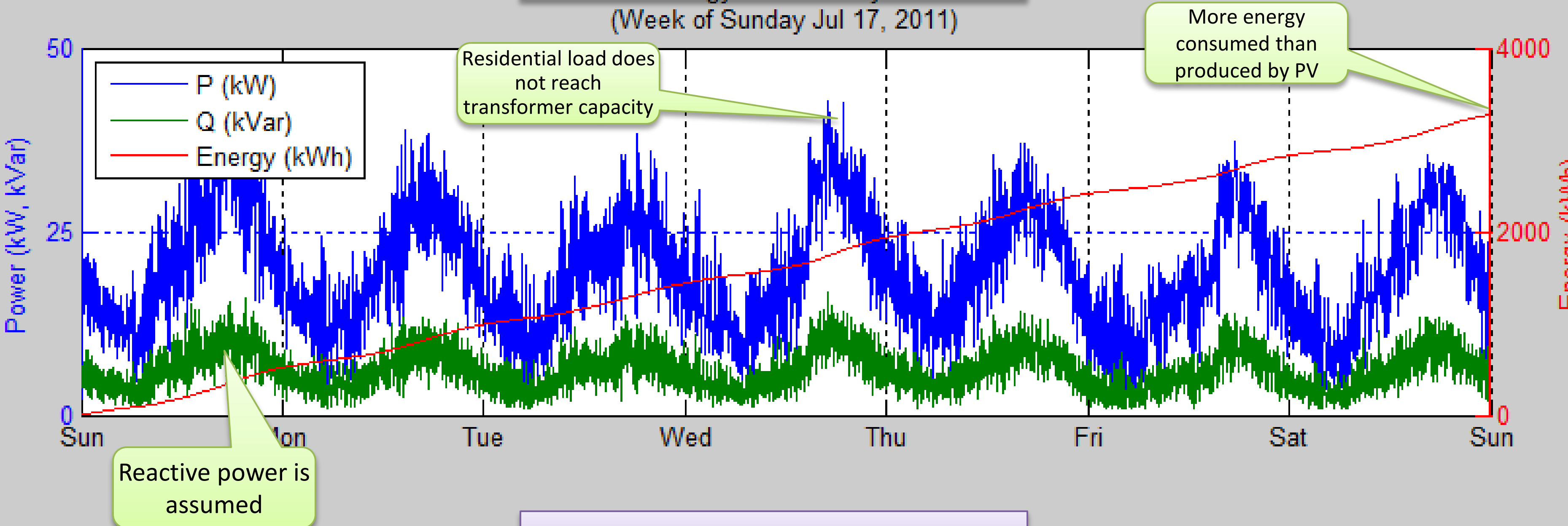
- Easy to experiment with different battery sizes and charge rates
- Control schemes can be modified

The MathWorks

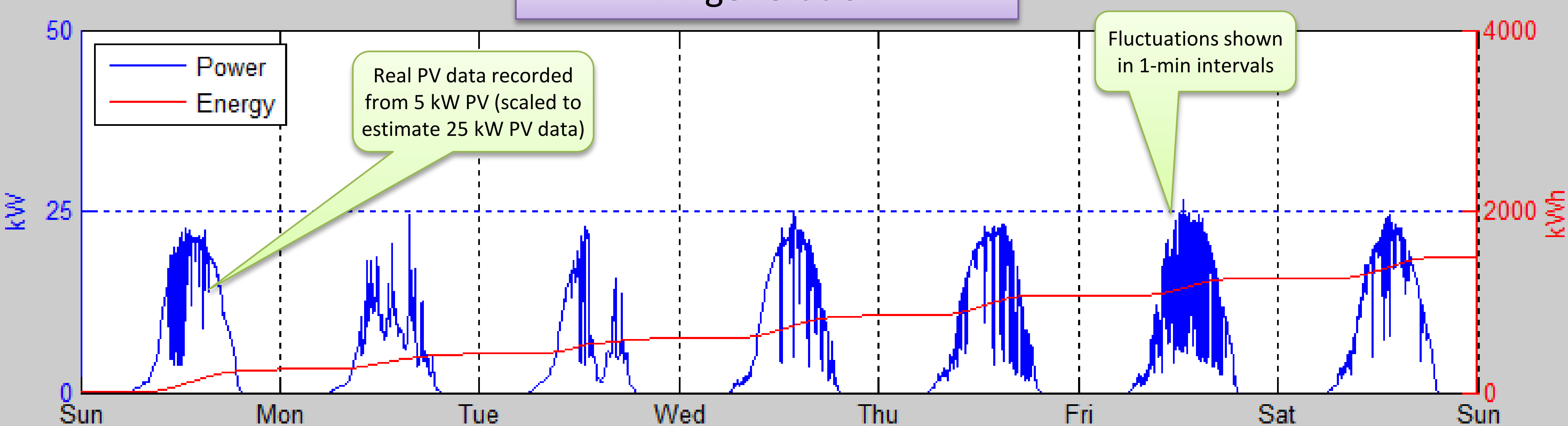
SimPowerSystems

Residen… ut Data

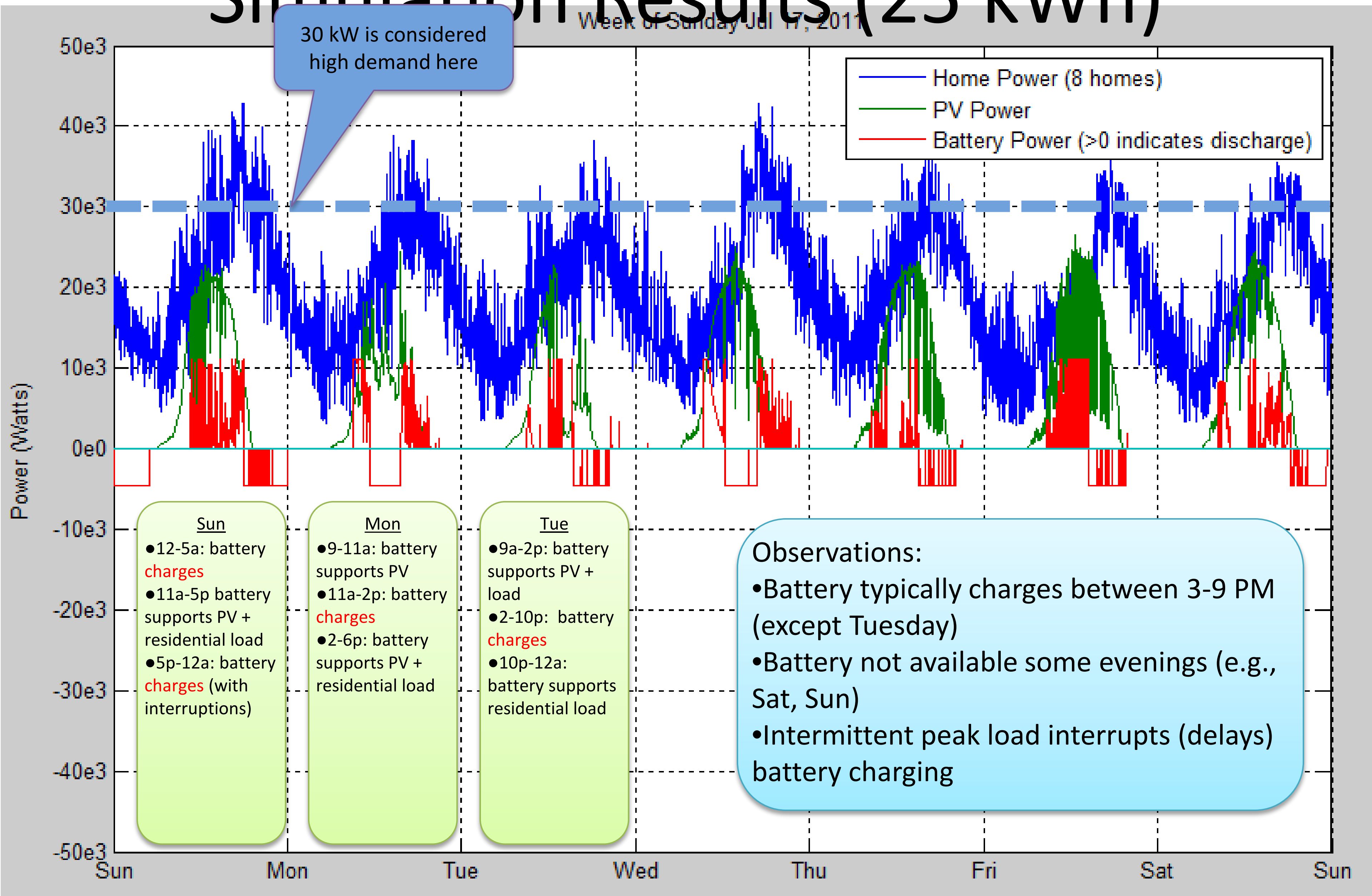
Transformer Load



PV generation



Simulation Results (25 kWh)



Sun

- 12-5a: battery charges
- 11a-5p battery supports PV + residential load
- 5p-12a: battery charges (with interruptions)

Mon

- 9-11a: battery supports PV
- 11a-2p: battery charges
- 2-6p: battery supports PV + residential load

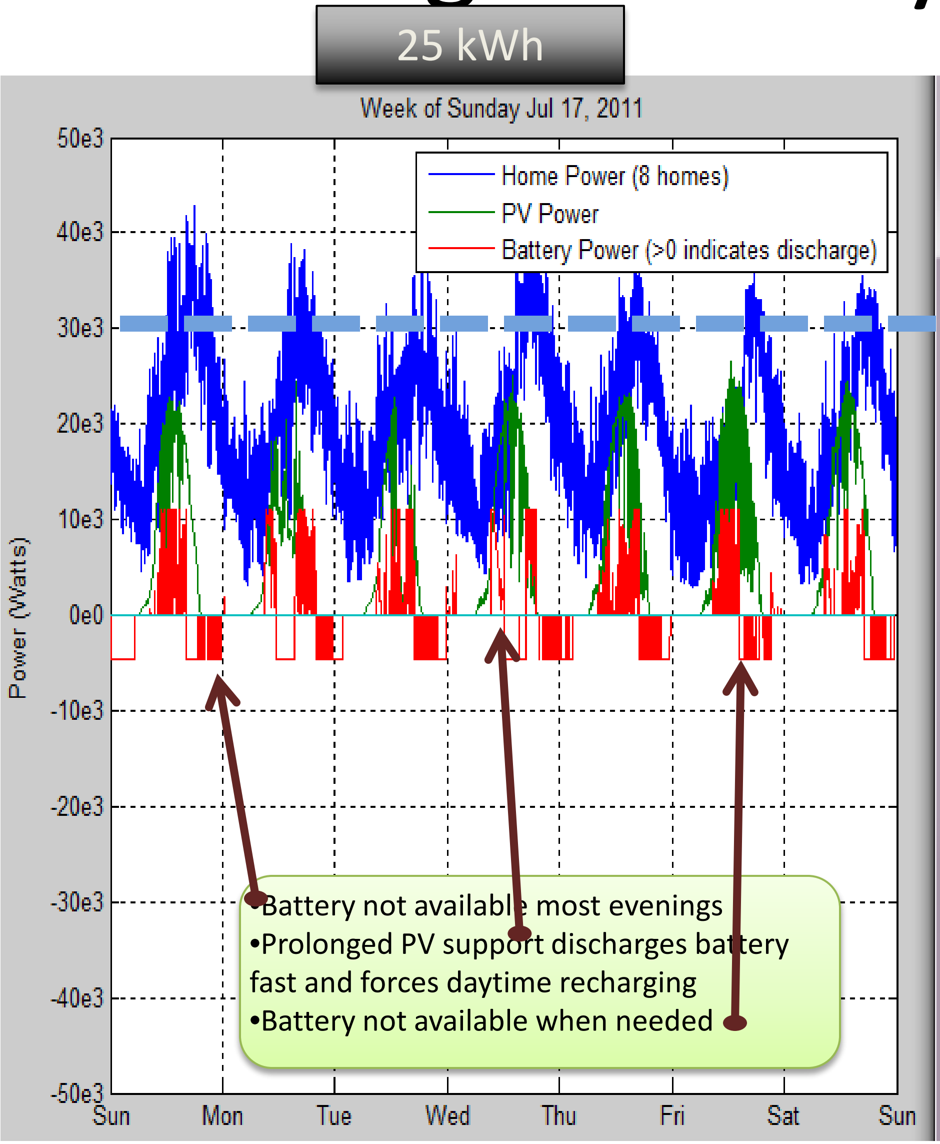
Tue

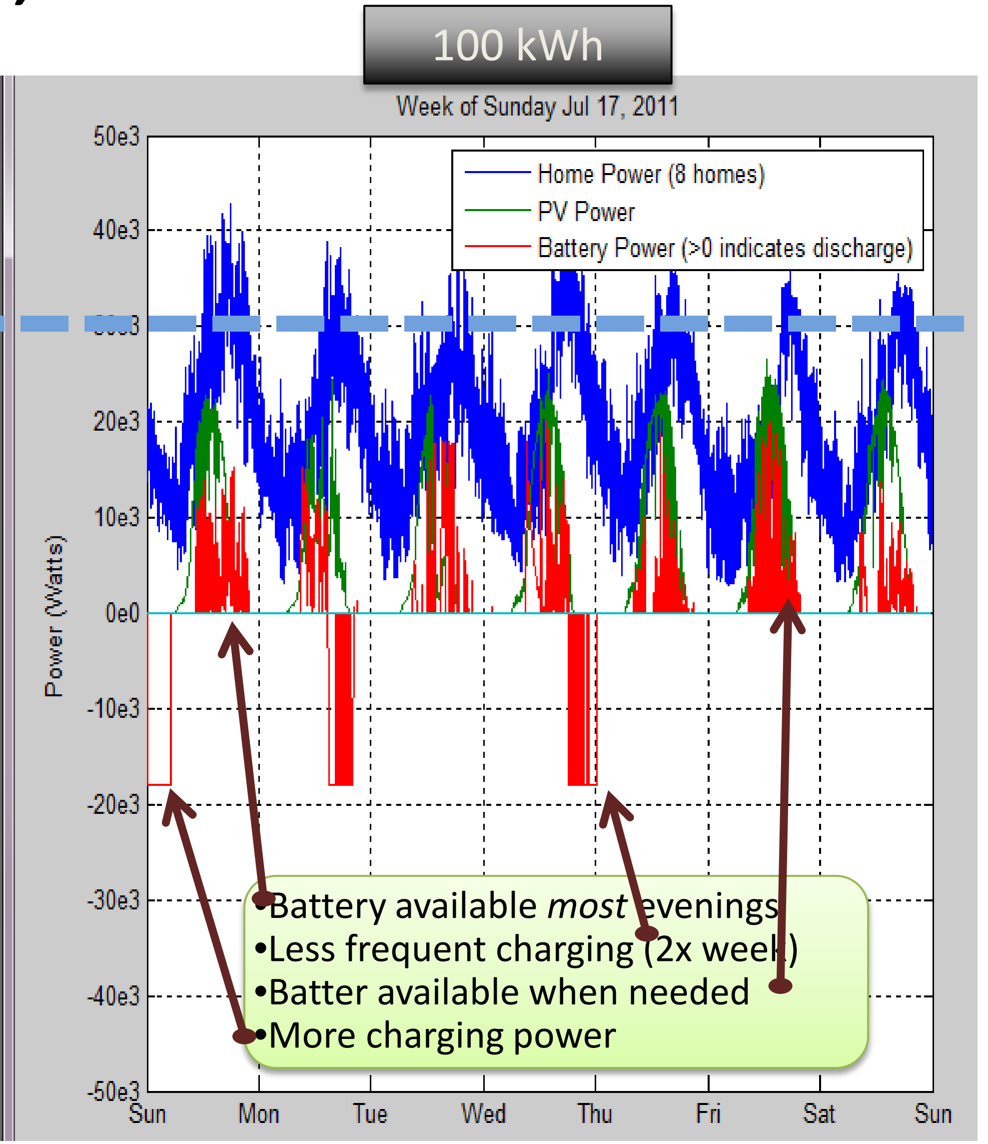
- 9a-2p: battery supports PV + load
- 2-10p: battery charges
- 10p-12a: battery supports residential load

Observations:

- Battery typically charges between 3-9 PM (except Tuesday)
- Battery not available some evenings (e.g., Sat, Sun)
- Intermittent peak load interrupts (delays) battery charging

Larger Battery, Same Control



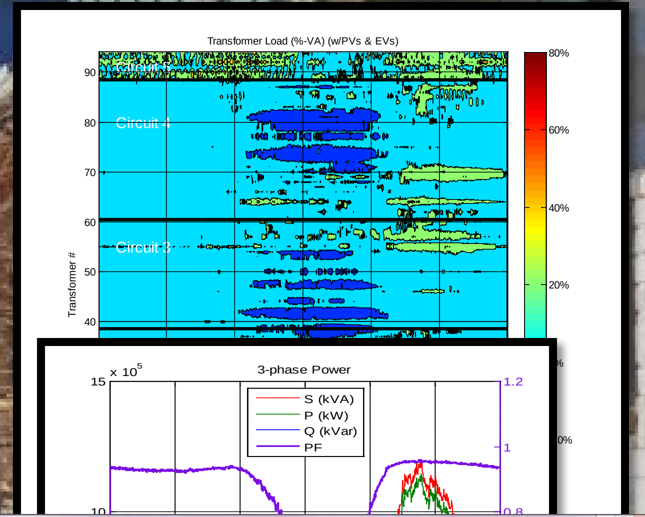


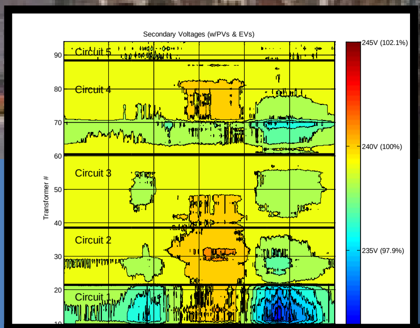
Conclusions

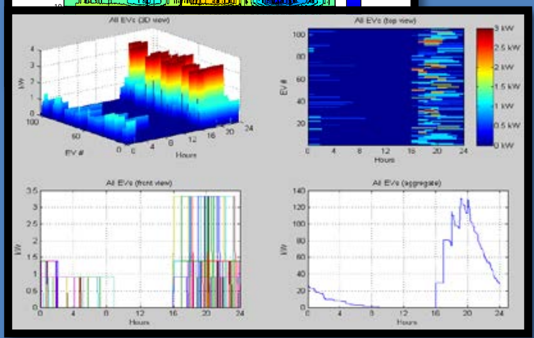
- 50 kVA transformer
  - oversized
  - load leveling support not needed
- PV
  - great for battery charging
  - fluctuation support not necessary
- 25 kWh battery
  - low availability
  - daily charging
  - small for 8 homes
- 100 kWh battery
  - less frequent charging
  - larger charging power
  - better load support
- Additional uses
  - Flicker and outage support
  - Time-of-use support in locations with rate structures

Center for Electromechanics

Questions





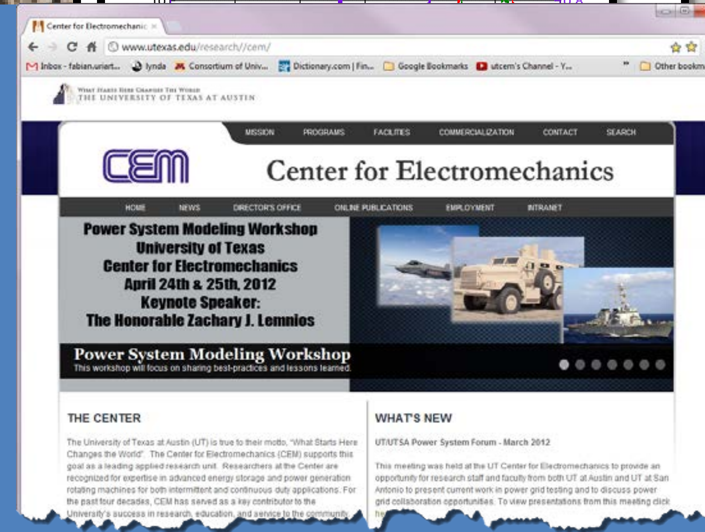


Dr. Fabian Uriarte

f.uriarte@cem.utexas.edu

Dr. Robert Hebner

r.hebner@cem.utexas.edu



Center for Electromechanics

The University of Texas at Austin

utexas.edu/research/cem

10100 Burnet Road, Austin, TX

Questions?