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
Where is the Smart Grid?

Pecan Street offices

Ctr. for Electromechanics

Texas Advanced Computing Center

Pecan Street’s Smart Grid (Mueller Community)

pecanstreet.org
Austin’s Mueller Community

- 711 acre mixed use
- 3 miles from Texas Capitol
- all new green-built buildings
- world’s first LEED platinum hospital
- native landscaping
- includes 25% affordable housing
- Mueller Megawatt program
- experience with rooftop solar leasing
- reclaimed water system
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
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)
Granularity Comparison
August 10, 2011: 15-minute Consumption Data (kW)
Granularity Comparison
August 10, 2011: 1-minute Consumption Data (kW)
August average

Whole-home electricity usage (kW)
August average

Consumption and PV
August average

Consumption, South PV, West PV
August average

No PV, South PV, West PV
September average
Whole-home net electricity usage (kW)

No PV, South PV, West PV
October average

Whole-home net electricity usage (kW)

No PV, South PV, West PV
November average
Whole-home net electricity usage (kW)

No PV, South PV, West PV
December average
Whole-home net electricity usage (kW)

No PV, South PV, West PV
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  - A sample house-day
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Overview

- West versus South PV Generation
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  - 2012-12-21 to 2012-06-20 split array data
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• Chris Holcomb
• cholcomb@pecanstreet.org
Impact of PVs and EVs on Distribution Transformers: A first Look

Dr. Fabian Uriarte
Center for Electromechanics
University of Texas at Austin
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
Pecan Street Data Pool

- More than 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

(Chart showing data collection timeline from January 2011 to April 2012)
PV Generation

0.5 - 1 MW of distributed PV generation daily
EV Penetration

Mix of 120 V and 240 V charging > 4 PM
Transformer Utilization

Before PVs / EVs

After PVs / EVs

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

- **PVs produce 23% increase**
- **EVs produce 2% increase**
- **PVs produce 20% decrease**

*before: 25%, after: -5%, change = |after|-before = -20%.

Sign indicates direction of real power

0.45x previous usage
5.8x previous usage
0.3x previous usage

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

Before PVs and EVs

After PVs and EVs

- 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 entire 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

Subtransmission 69 kV
- Feeder
- T1: 30 MVA
- T2: 30 MVA
- Substation
- 12.47 kV
- Lateral
- Phase A
- Phase B
- Phase C
- Circuit 1
- Circuit 2
- Circuit 3
- Circuit 4
- Circuit 5

Community energy storage at 1 xfm.
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
Residential and PV Input Data

Residential load does not reach transformer capacity.

More energy consumed than produced by PV.

Reactive power is assumed.

Fluctuations shown in 1-min intervals.

Real PV data recorded from 5 kW PV (scaled to estimate 25 kW PV data).

Fluctuations shown in 1-min intervals.
30 kW is considered high demand here

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

25 kWh
- Battery available most evenings
- Less frequent charging (2x week)
- Battery available when needed
- More charging power

100 kWh
- Battery not available most evenings
- Prolonged PV support discharges battery fast and forces daytime recharging
- Battery not available when needed
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
Questions?