Demand Response & Forecasting: Keys to a Smarter Grid

Problem: Peak energy demand issues induce harmful grid instability, elevate generation costs, and reduce the efficacy of renewable generation sources.

Goal: To forecast consumer energy demand using empirical modeling techniques with the vision to better handle peak energy demand and alleviate grid strain.

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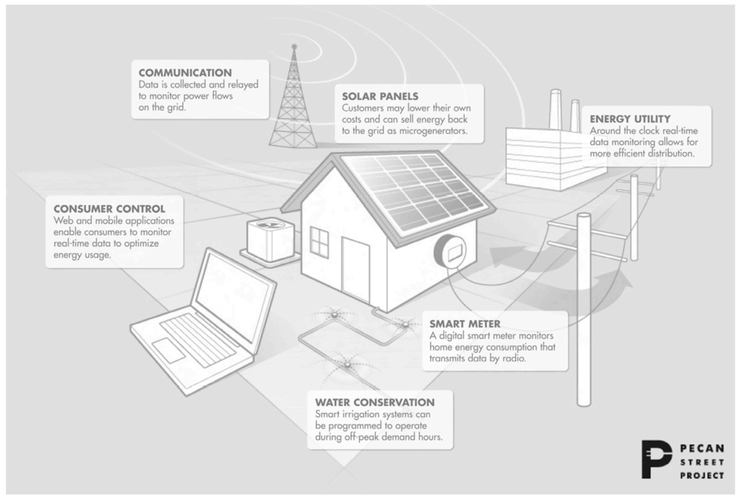
IGERT
Sustainable Grid Integration of Distributed and Renewable Resources

Cockrell School of Engineering · Pecan Street Inc. · NSF

What is the Smart Grid?



Reducing peak demand is a primary goal of the smart grid

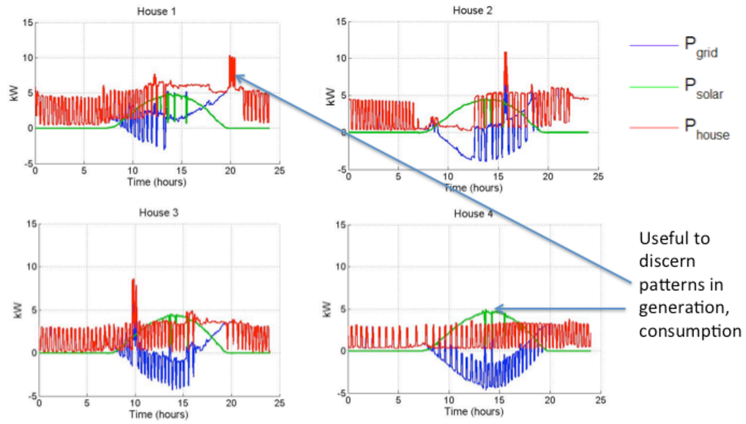
- Peaking plant use leads to higher capital and operating expenditure
- Peak demand threatens grid stability with voltage fluctuations, brownouts, and blackouts
- Time of day demand mismatch with renewable sources (solar, wind) further complicates intermittency issues

Demand response and forecasting can mitigate these issues

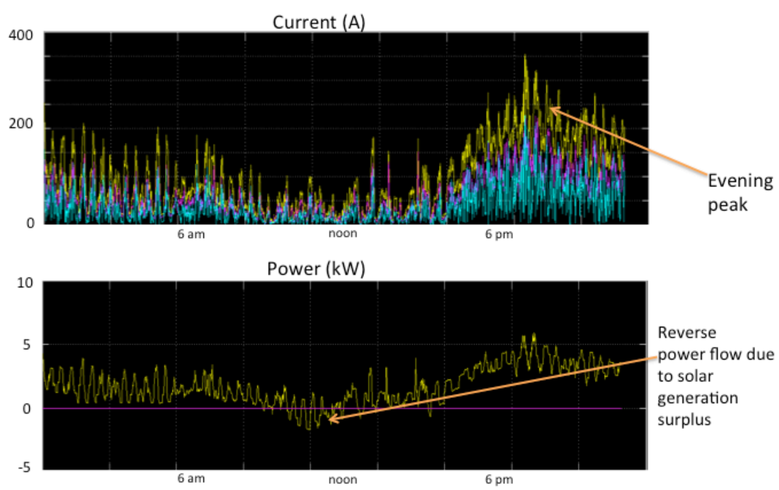
- Demand response refers to strategic load curtailment
- We employ a new dynamic simulation model for neighborhood power distribution for understanding the micro- to macroscopic effects of consumer demand patterns
- Additionally, we will explore the effects of consumer behavioral patterns, weather phenomena, time-of-use (TOU) pricing, energy storage, photovoltaics (PV), and the advent of electric vehicles (EV).

Pecan Street Inc.

- Smart grid demonstration project in Austin, TX
- Robust data set from mixed-use residential development
- Highest concentration of PVs and EVs in the United States



Diurnal cycle of residential energy consumption (data from four homes, Fall 2011)

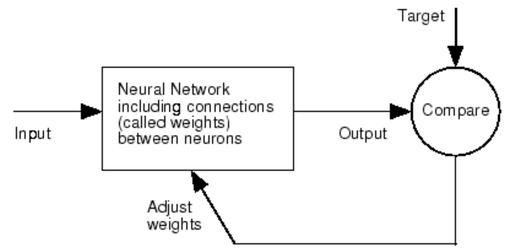


Diurnal transformer throughput (data from eight homes, Fall 2011)

Predictive Models for Energy Consumption

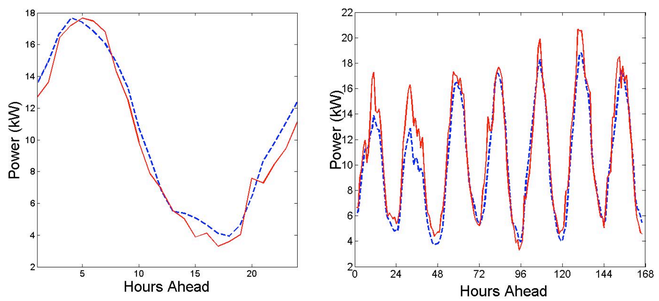
Predictable patterns of residential energy consumption appeared in the data and we used artificial neural networks (ANN) to quantify them. ANN is a powerful and robust empirical modeling technique that is well suited to systems where a physical first principles model is infeasible.

A nonlinear autoregressive with exogenous inputs (NARX) network was used in our modeling, as feedback from previous values in the time series played a crucial role in model accuracy.



General artificial neural network diagram. Credit: Matlab r2011b

Ambient temperature, relative humidity, and hour of the day were found to be highly correlated with residential energy consumption. Results of the forecast are shown below and make a strong argument for predictive modeling techniques in demand response applications.



Sample diurnal and weekly demand forecasts, red-actual blue-model