Pecan Street Inc.

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Pecan Street Background Information

What is Pecan Street

Who is Pecan Street

Research Objectives and Initiatives

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Residential Home Energy Data

Deepest residential energy available

Enables research and application development not possible with “normal” data

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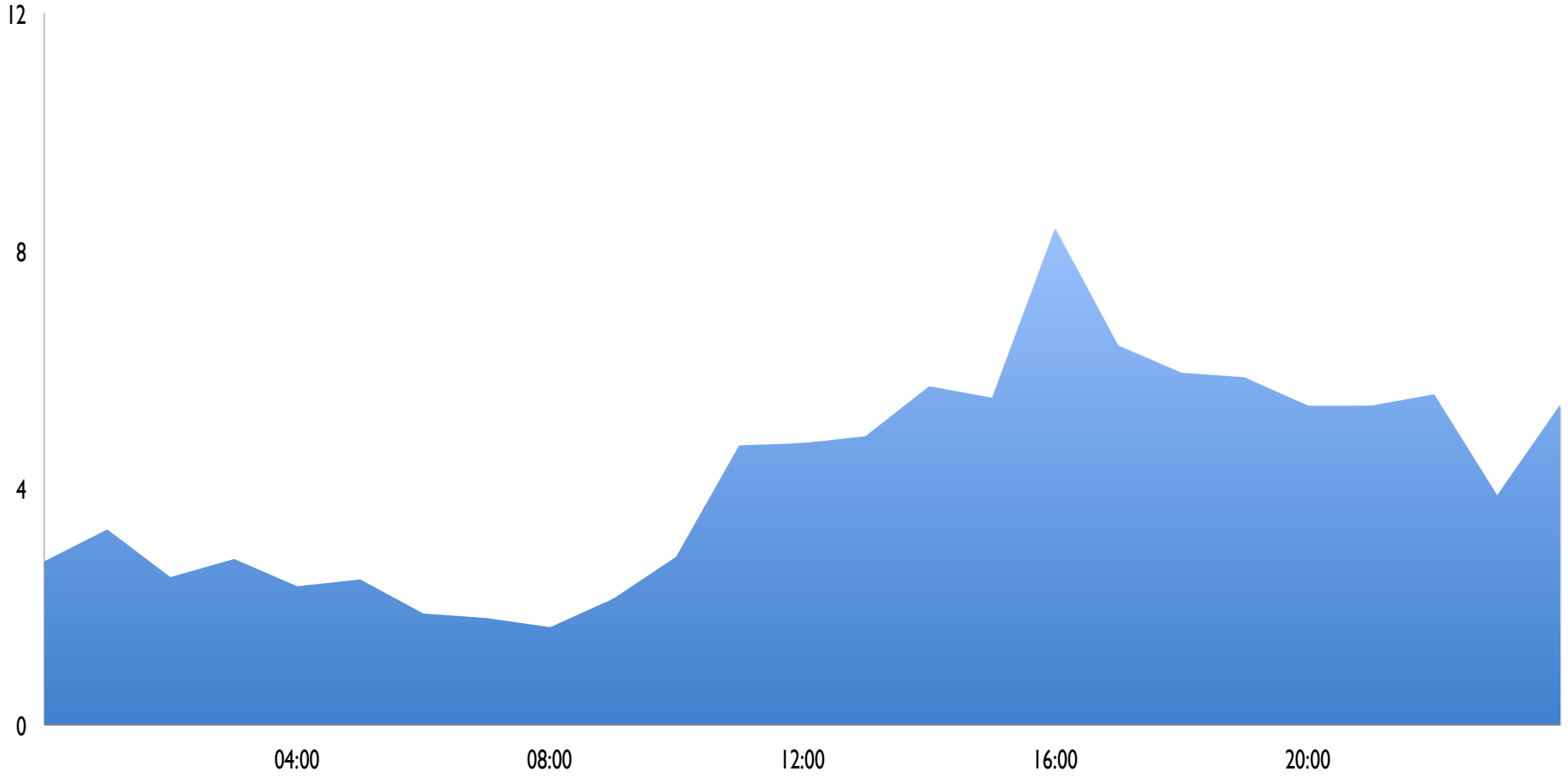
Granularity Comparison
August 10, 2011: 60-minute Consumption Data (kW)



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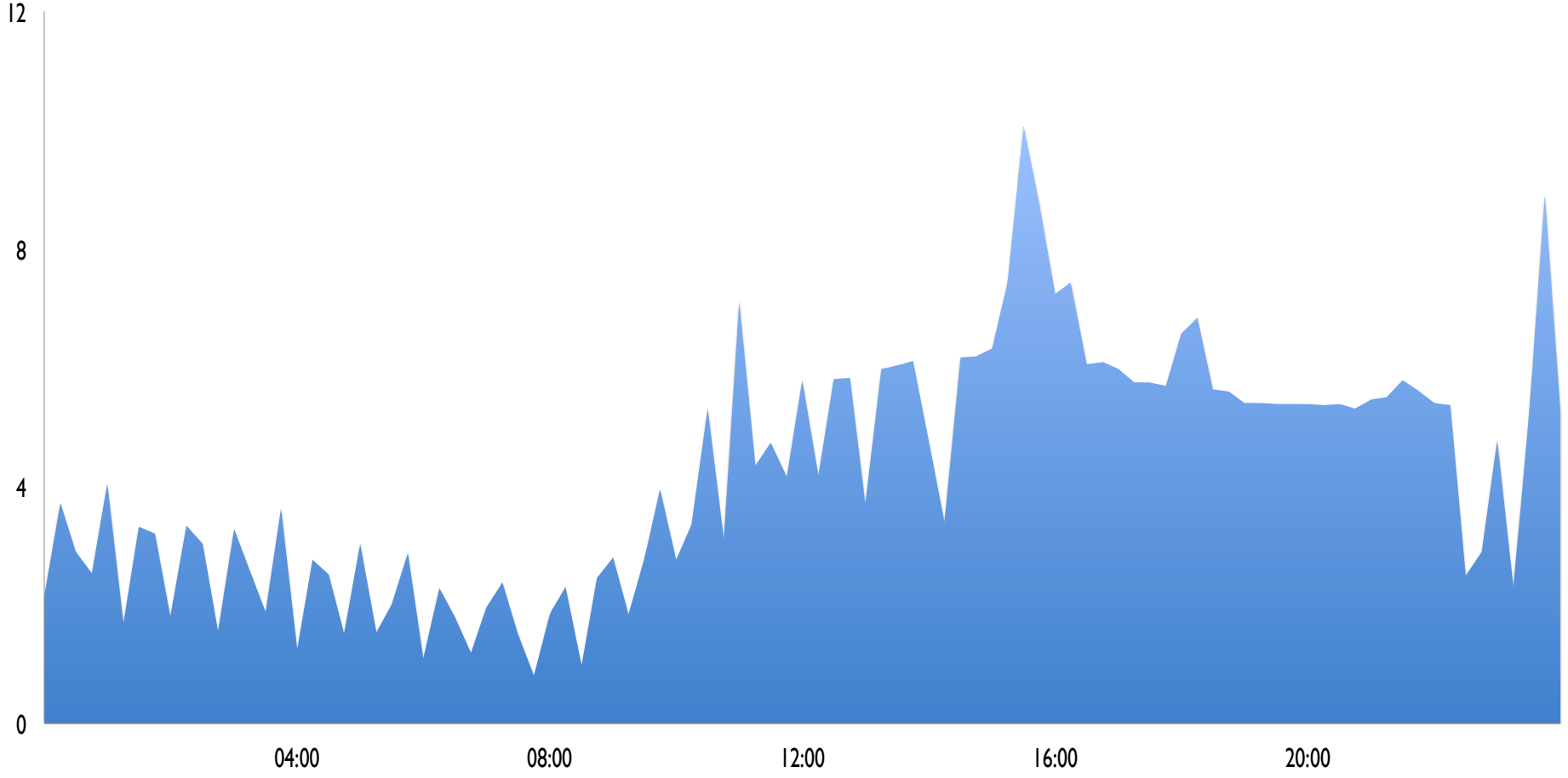
Granularity Comparison

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



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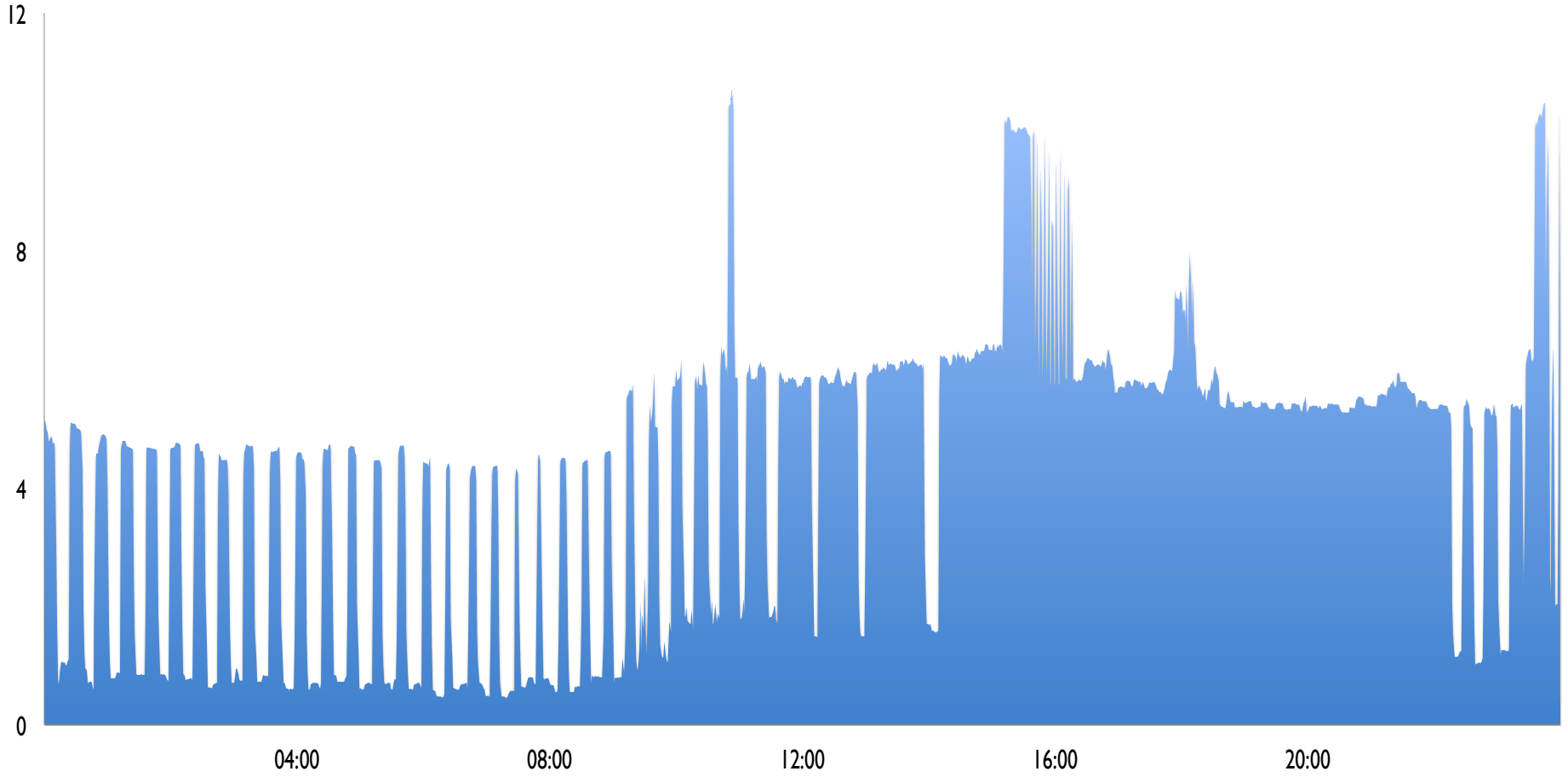
Granularity Comparison

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



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Residential Renewable Energy

- High Density Solar Deployment
  - Funded through a rebate program
  - Required participation in energy monitoring.

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Plug-in Electric Vehicles

Highest Density Deployment

100% Level-2 EVSE

Total Combined Electrical Load = > .333 MW

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Data Analytics

- Pecan Street Data Hosted at Texas Advanced Academic Computing Center (TACC)
- Complex Data Structures
- Massive Quantities of Data

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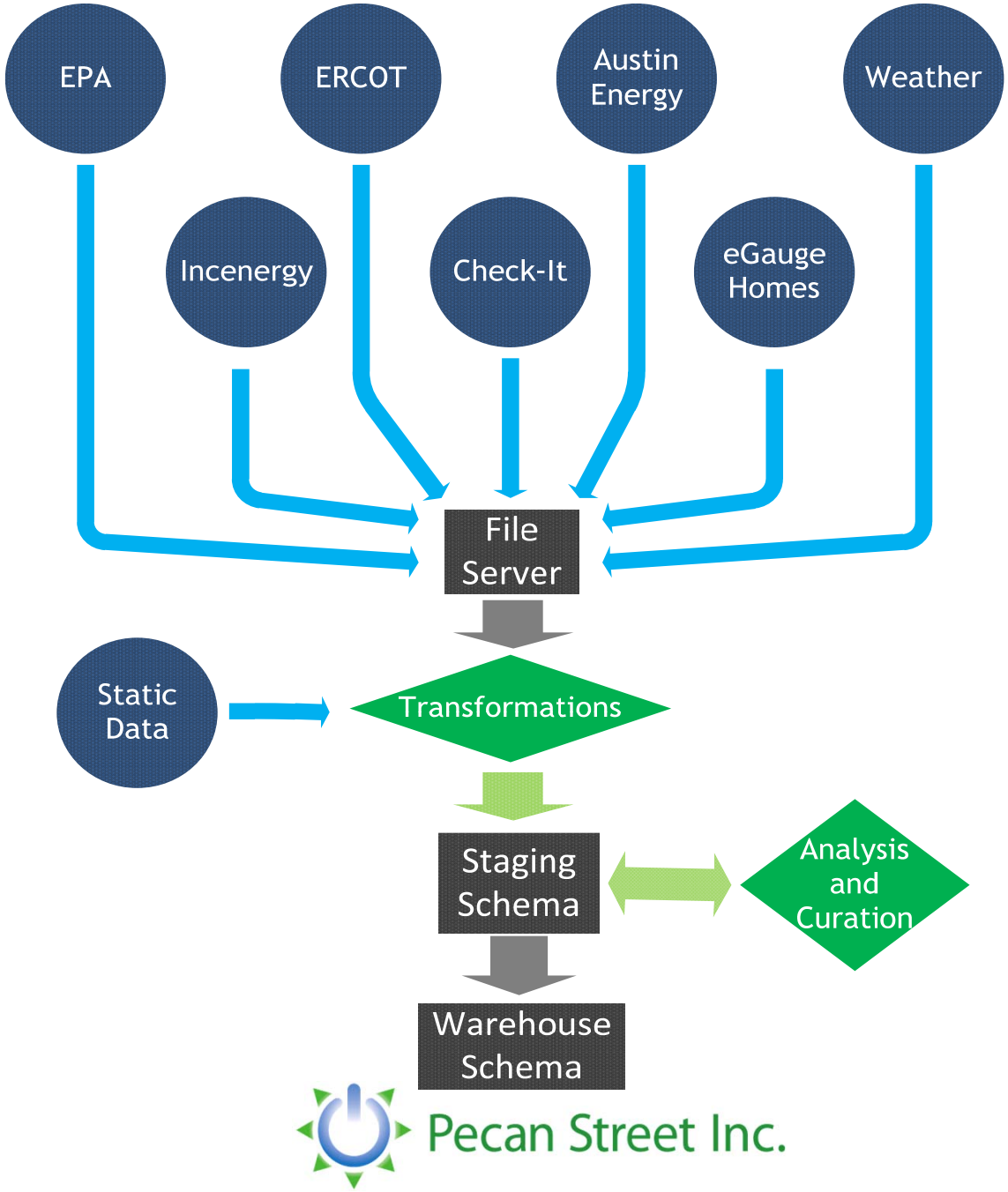
EPA
ERCOT
Austin Energy
Weather
Incenergy
Check-It
eGauge Homes
File Server
Static Data
Transformations
Staging Schema
Analysis and Curation
Warehouse Schema
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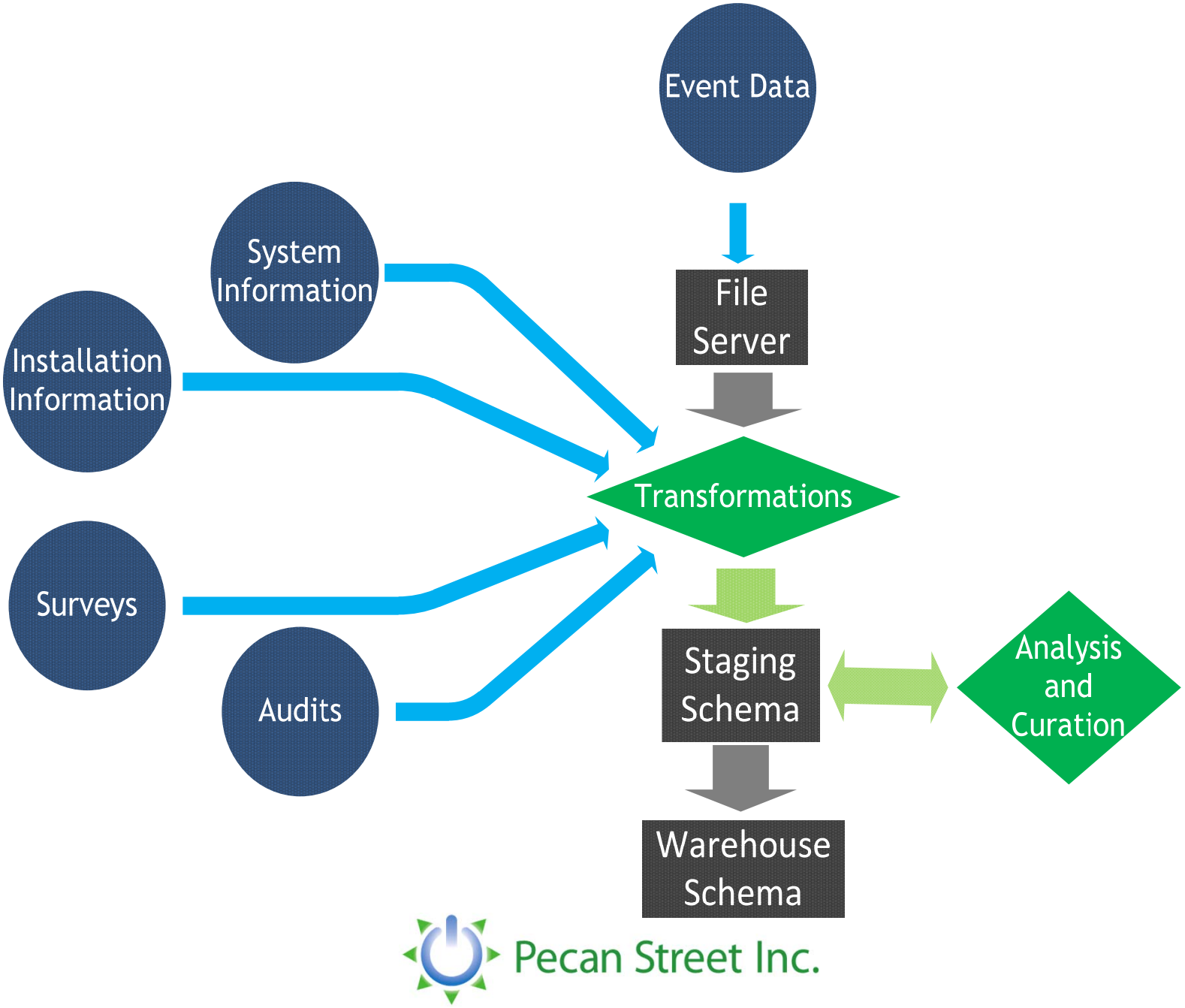
Event Data
System Information
Installation Information
File Server
Transformations
Surveys
Audits
Staging Schema
Analysis and Curation
Warehouse Schema
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TACC Database

3 Billion data points

Over 200 GB

Pecan Street data for 200 homes = 100,000 homes with 15-minute AMI data

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Affiliations

The University of Texas at Austin

Austin Technology Incubator

Industry Advisory Council

- Best Buy
- Freescale
- Intel
- Landis + Gyr
- LG
- Oncor
- Oracle
- Sony
- SunEdison
- Texas Gas Service
- Whirlpool

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Pike Powers Commercialization Lab

Michael Hsu Office Of Architecture	3423 Guadalupe Street, Suite 200 Austin, Texas 78705 (512) 706.4303	Pecan Street Project	Austin, Texas	31 May 2011	Exterior View

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Pike Powers Commercialization Lab

Purpose

Location

Capabilities

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Light Bulbs

Markets Change

Power Factor

Compact Fluorescent

LED

Whole Home Impact

Grid Impact

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Markets Change

Legislation (some examples)

- China 5 year phase out of >100 Watts, starting 2012
- EU, some types of incandescent as early as 2009
- Canada-Legal limbo…maybe 2014?
- US, budget-enforcement delays October 2012??

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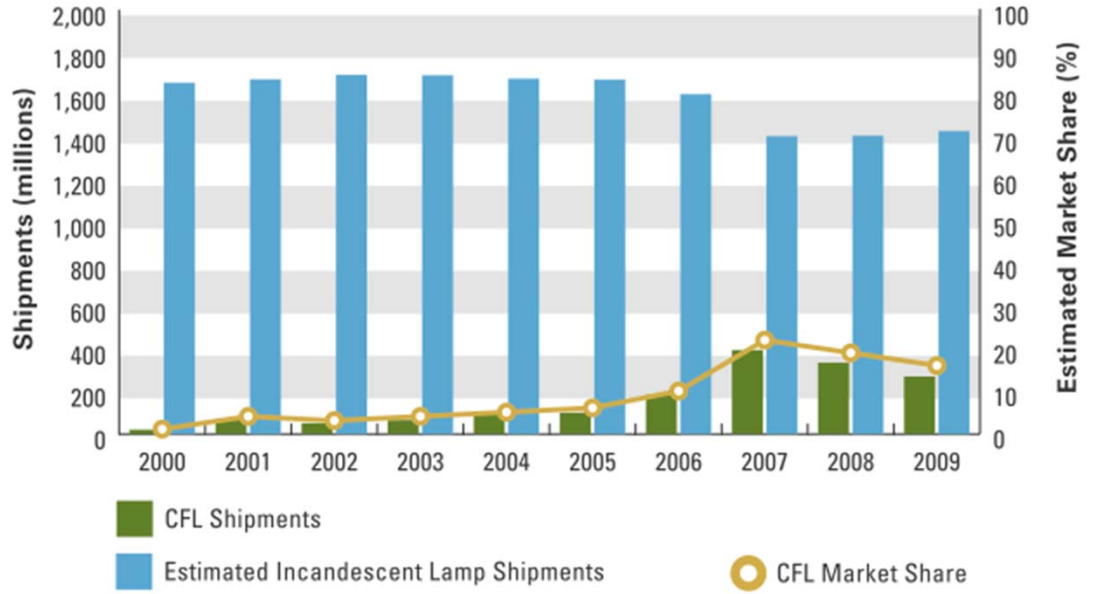
Markets Change

Figure 2 | CFL and Incandescent Lamp Shipments Plus CFL Market Share, by Year



Source: Energy Star CFL Market Profile 2010

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Define Power Factor

$$PF = \cos(\theta_v - \theta_i) = \frac{P}{V_{rms} I_{rms}}$$

$$P = \frac{1}{T} \int_{t_o}^{t_o+T} V_{rms} I_{rms} [\cos(\theta_v - \theta_i) + \cos(2\omega t + \theta_v + \theta_i)] dt$$

$$= \frac{V_{rms} I_{rms}}{T} \left\{ \cos(\theta_v - \theta_i) \int_{t_o}^{t_o+T} dt + \int_{t_o}^{t_o+T} \cos(2\omega t + \theta_v + \theta_i)\, dt \right\}$$

The complex power becomes

$$\boldsymbol{S} = V_{rms} I_{rms} \cos(\theta_v - \theta_i) + j V_{rms} I_{rms} \sin(\theta_v - \theta_i) = P + jQ$$

where the real part of the complex power (P) is the same time-average power expression found using instantaneous quantities. The real part of the complex power is commonly referred to as the *real* or *average* power and be expressed as the product of the apparent power and the power factor.

$$= \mathrm{Re}\{\boldsymbol{S}\} = V_{rms} I_{rms} \cos(\theta_v - \theta_i) = V_{rms} I_{rms} (PF) \qquad \begin{bmatrix} \textit{real} \text{ or} \\ \textit{average} \text{ power} \end{bmatrix}$$

The imaginary part of the complex power (Q) is commonly referred to as the *reactive* or *quadrature* power.

$$Q = \mathrm{Im}\{\boldsymbol{S}\} = V_{rms} I_{rms} \sin(\theta_v - \theta_i) \qquad \begin{bmatrix} \textit{reactive} \text{ or} \\ \textit{quadrature} \text{ power} \end{bmatrix}$$

Note that the magnitude of the complex power is the apparent power.

$$|\boldsymbol{S}| = \left| V_{rms} I_{rms} e^{j(\theta_v - \theta_i)} \right| = V_{rms} I_{rms}$$

The properties of the complex power and its components can be defined concisely in the complex plane using the *power triangle*.

Power Factor

In AC systems power flow has three components:

- Real Power, P
- Apparent Power, S
- Reactive Power, Q

In AC systems power factor (PF) is defined as:

PF = P/S

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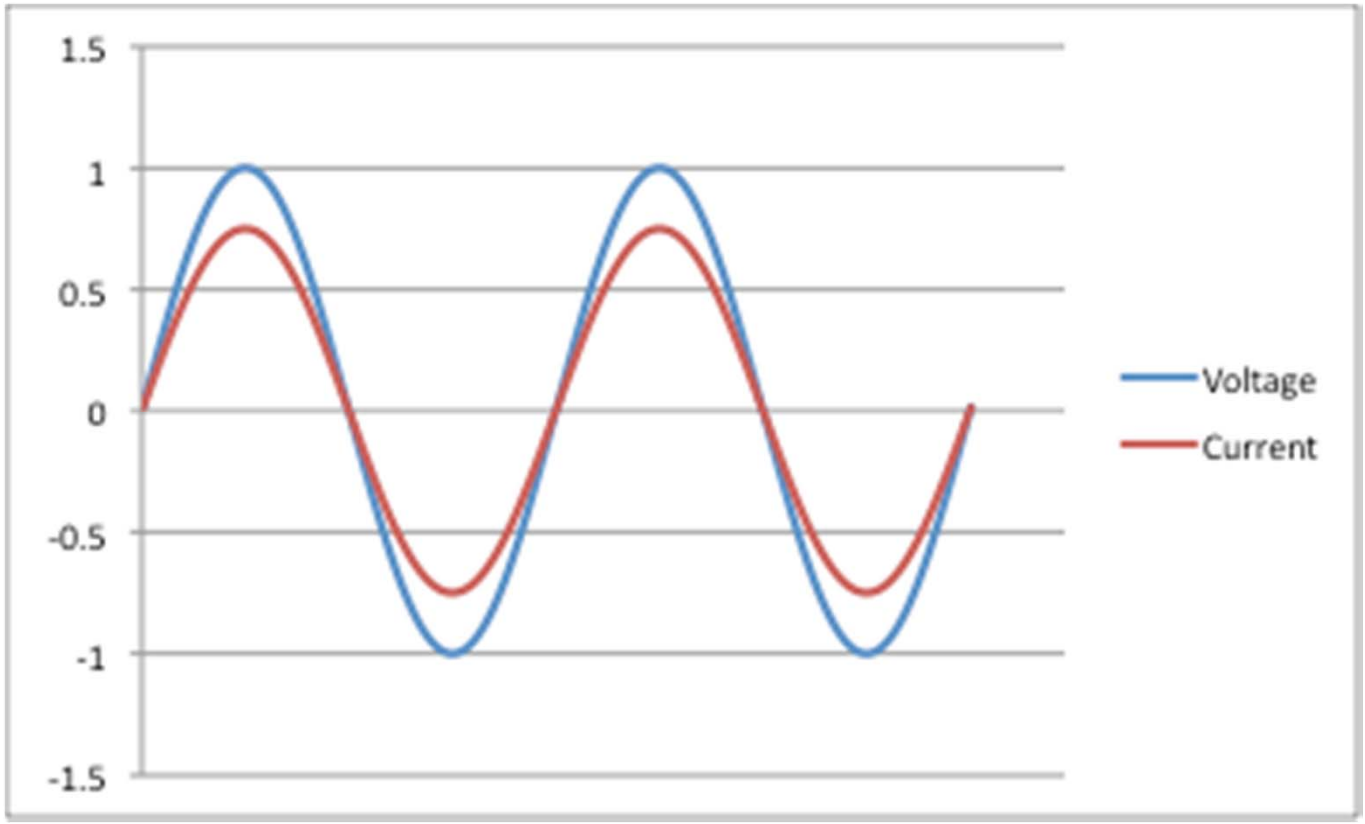
Graphical Example



Power Factor = 1

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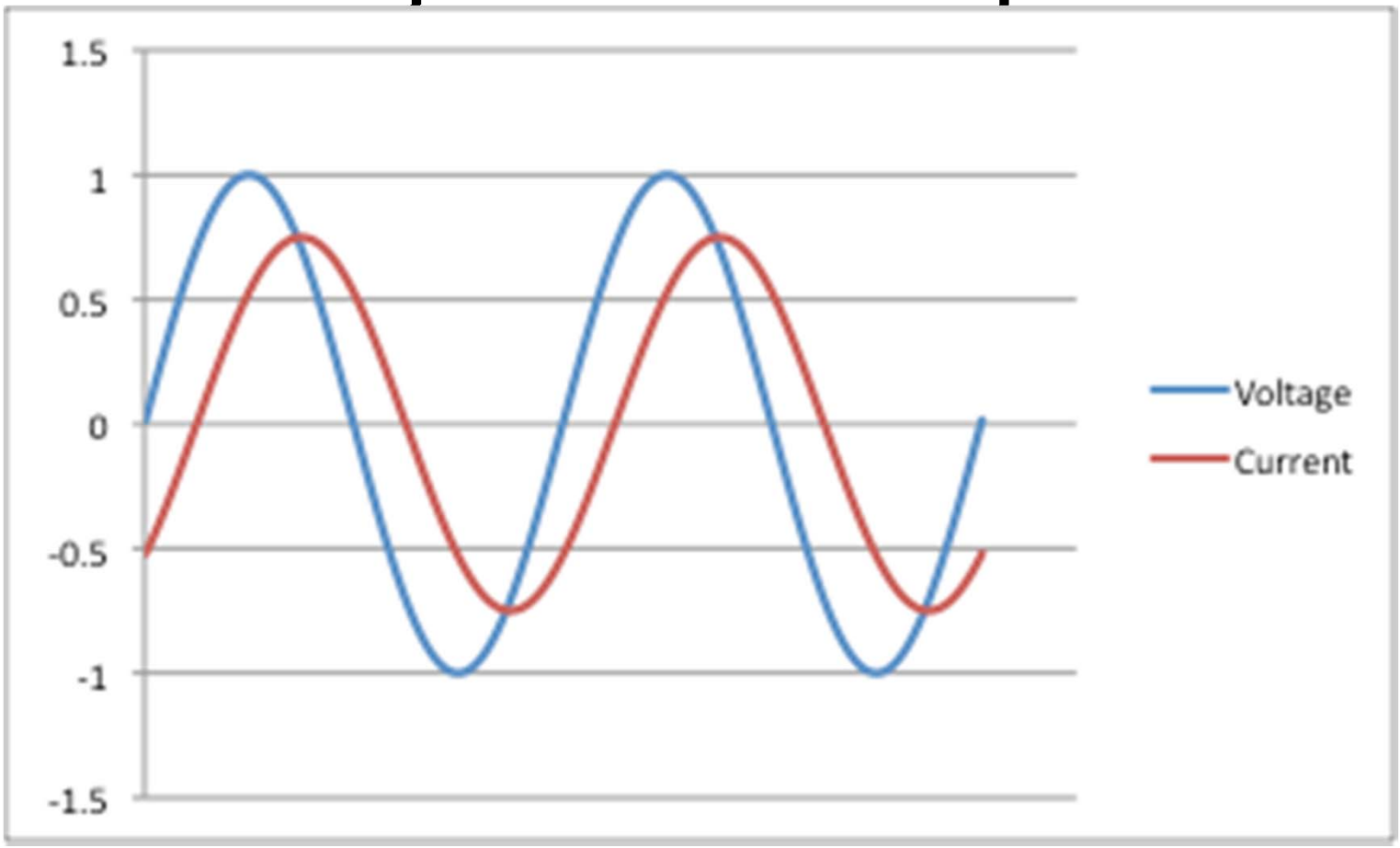
Graphical Example



Power Factor = .7 Lagging

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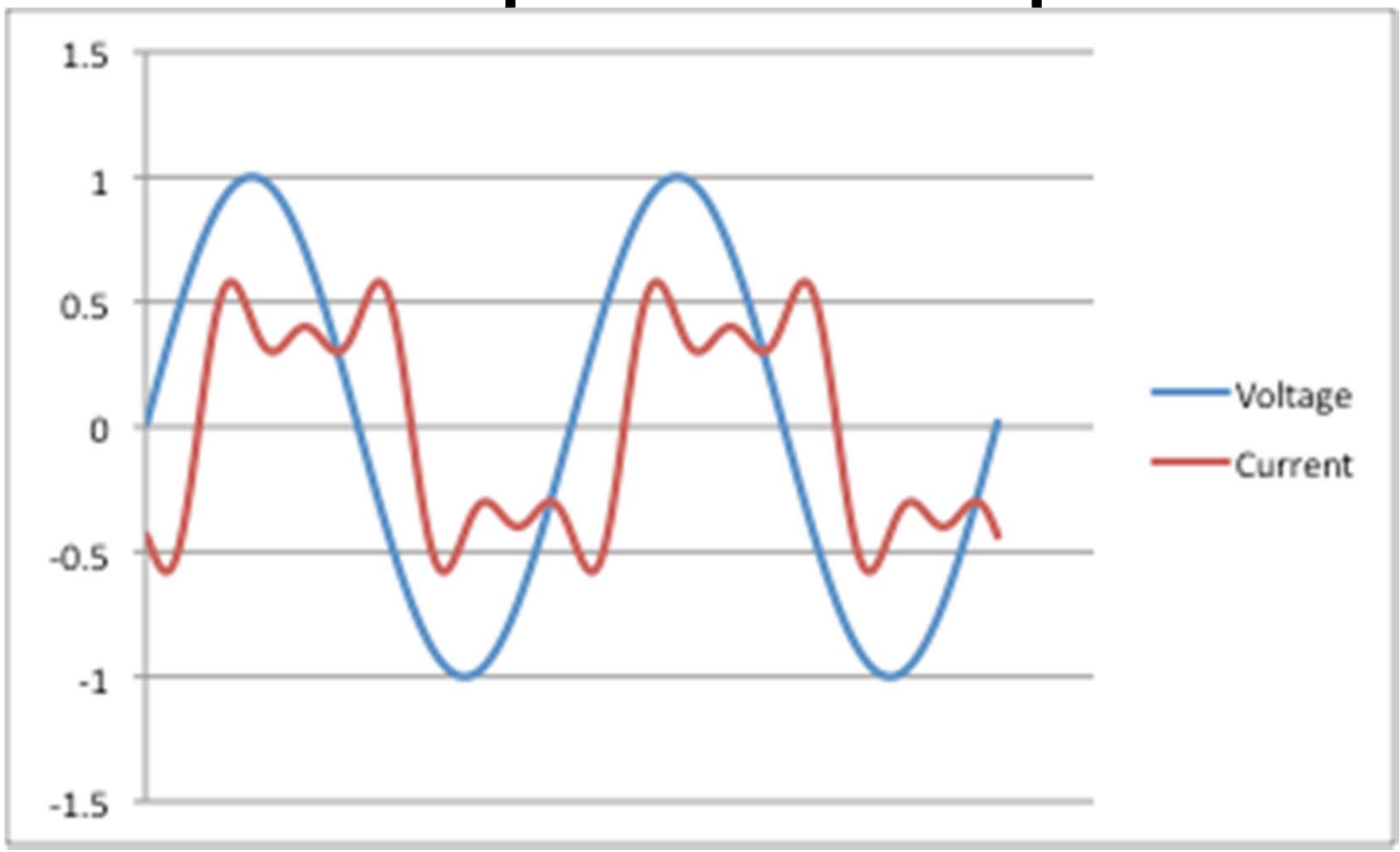
Current Harmonics

- Current harmonics are caused by connecting non-linear loads to the electric system
- Harmonics also play a role in power factor

Graphic Example



PF = .61Lagging

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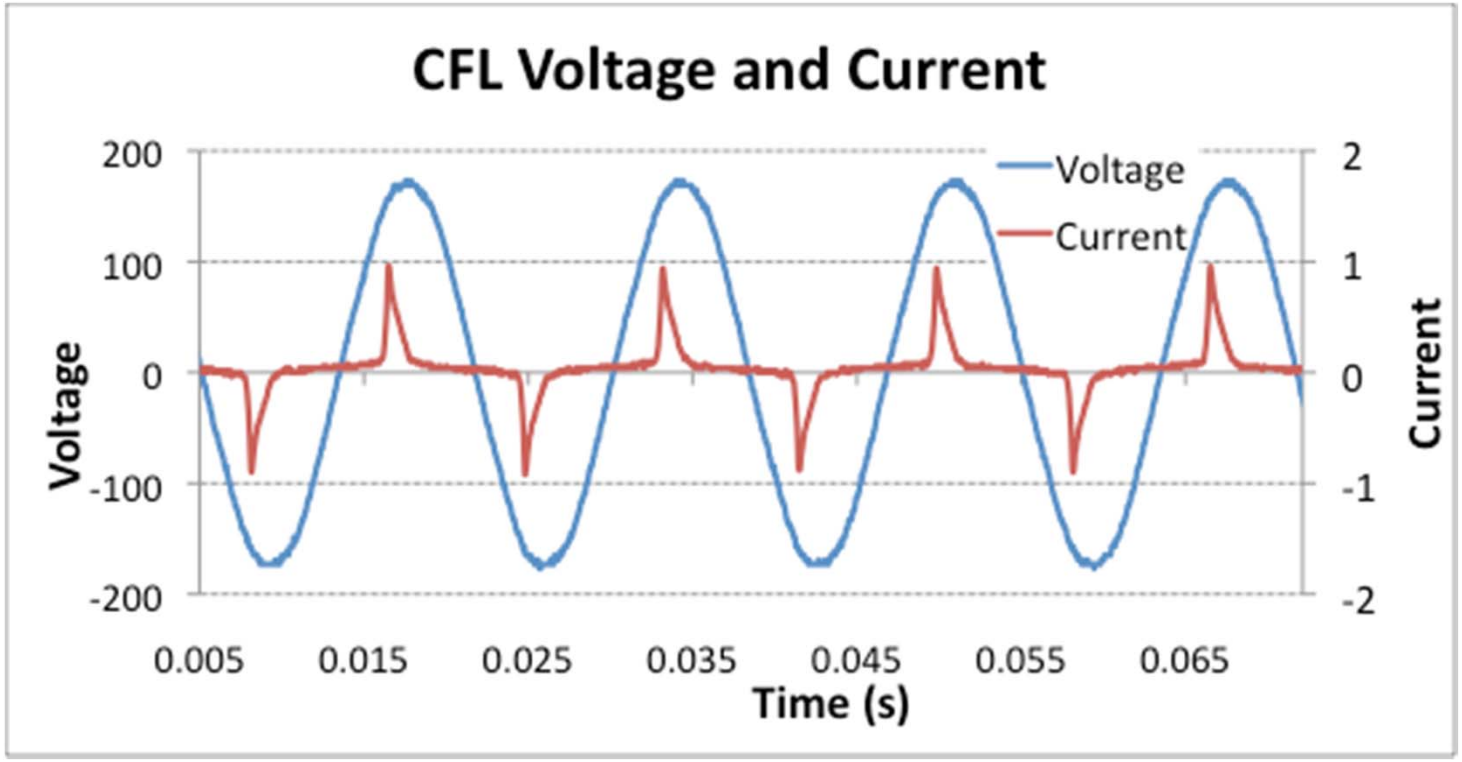
Compact Fluorescent Light Bulb



PF = .60 Leading

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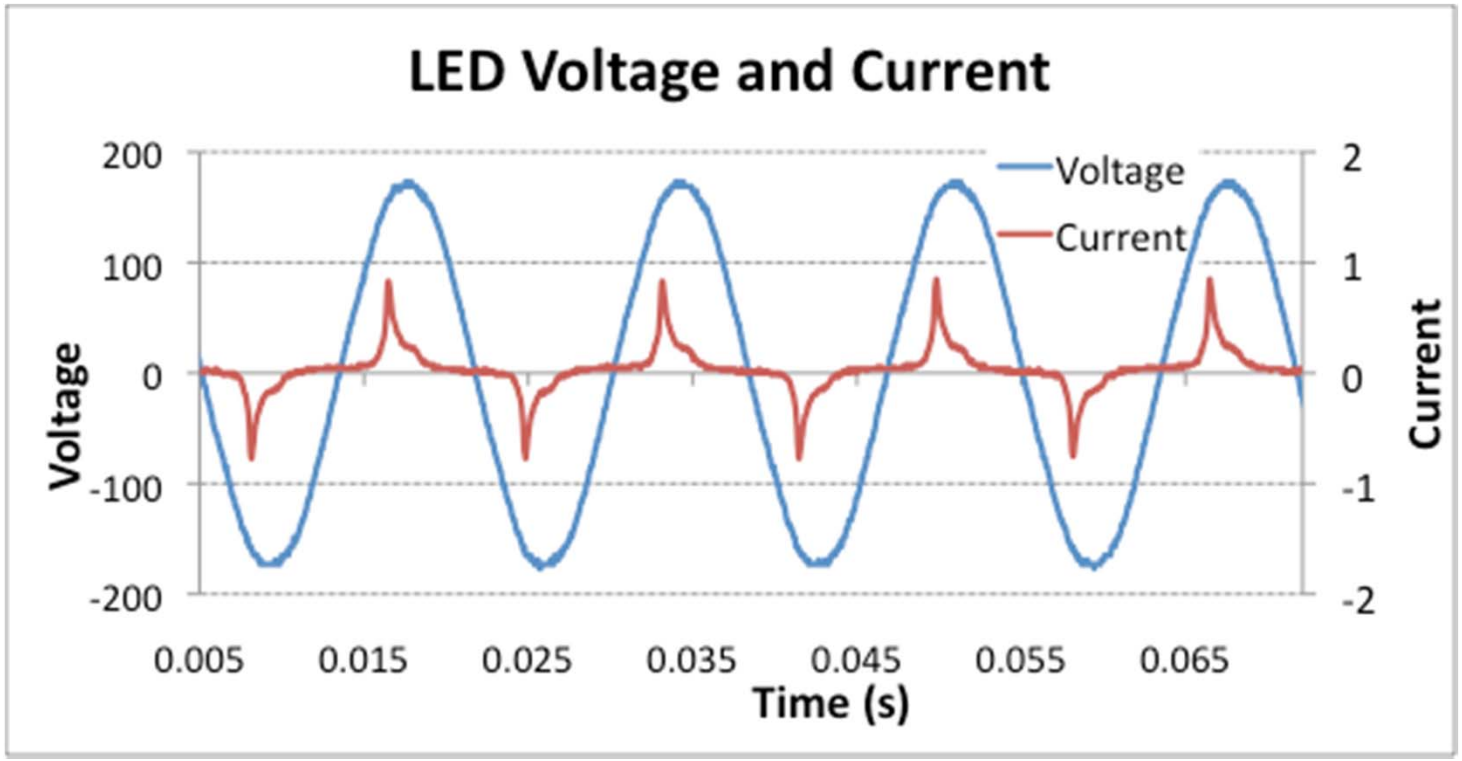
LED Light Bulb



PF = .70 Leading

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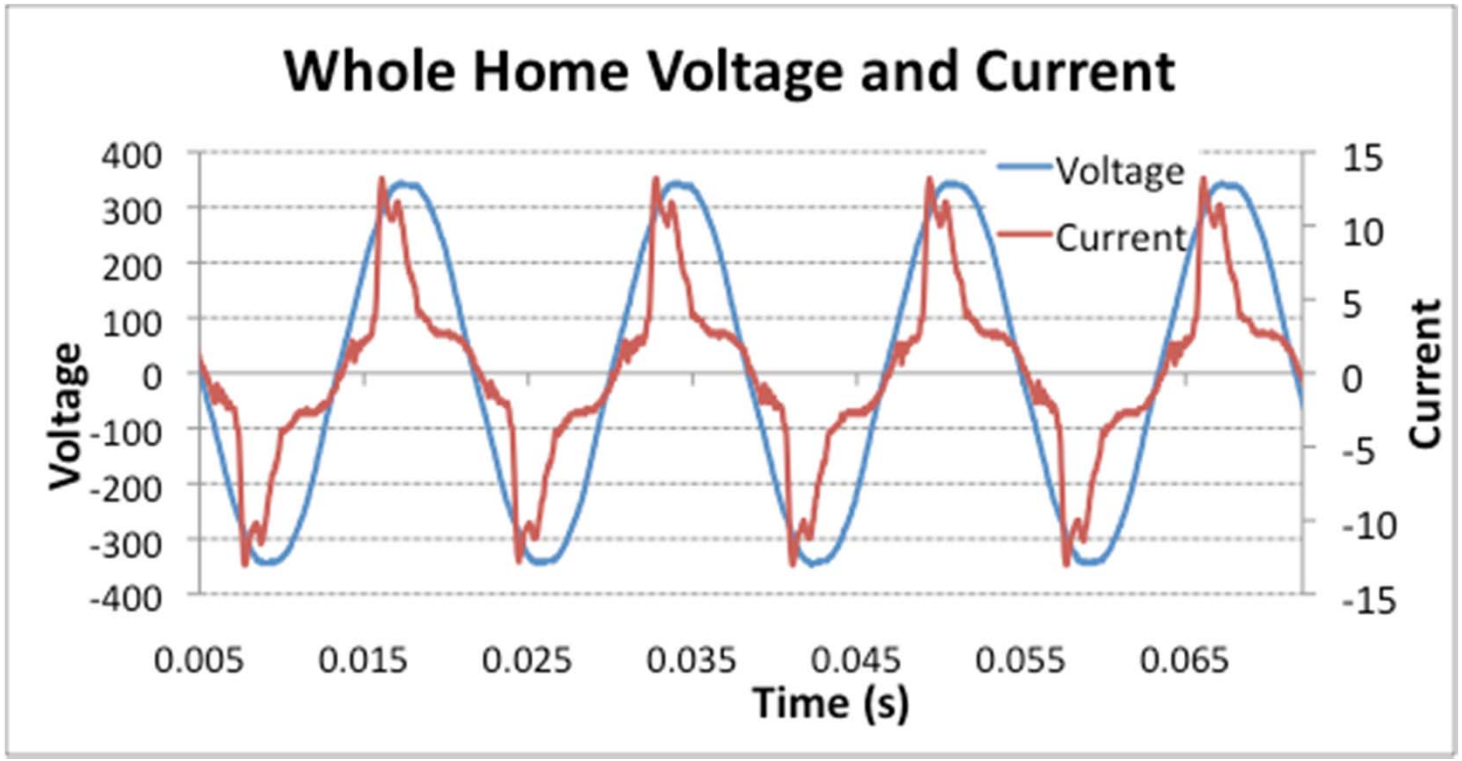
Whole Home Impact



PF = .89 Leading

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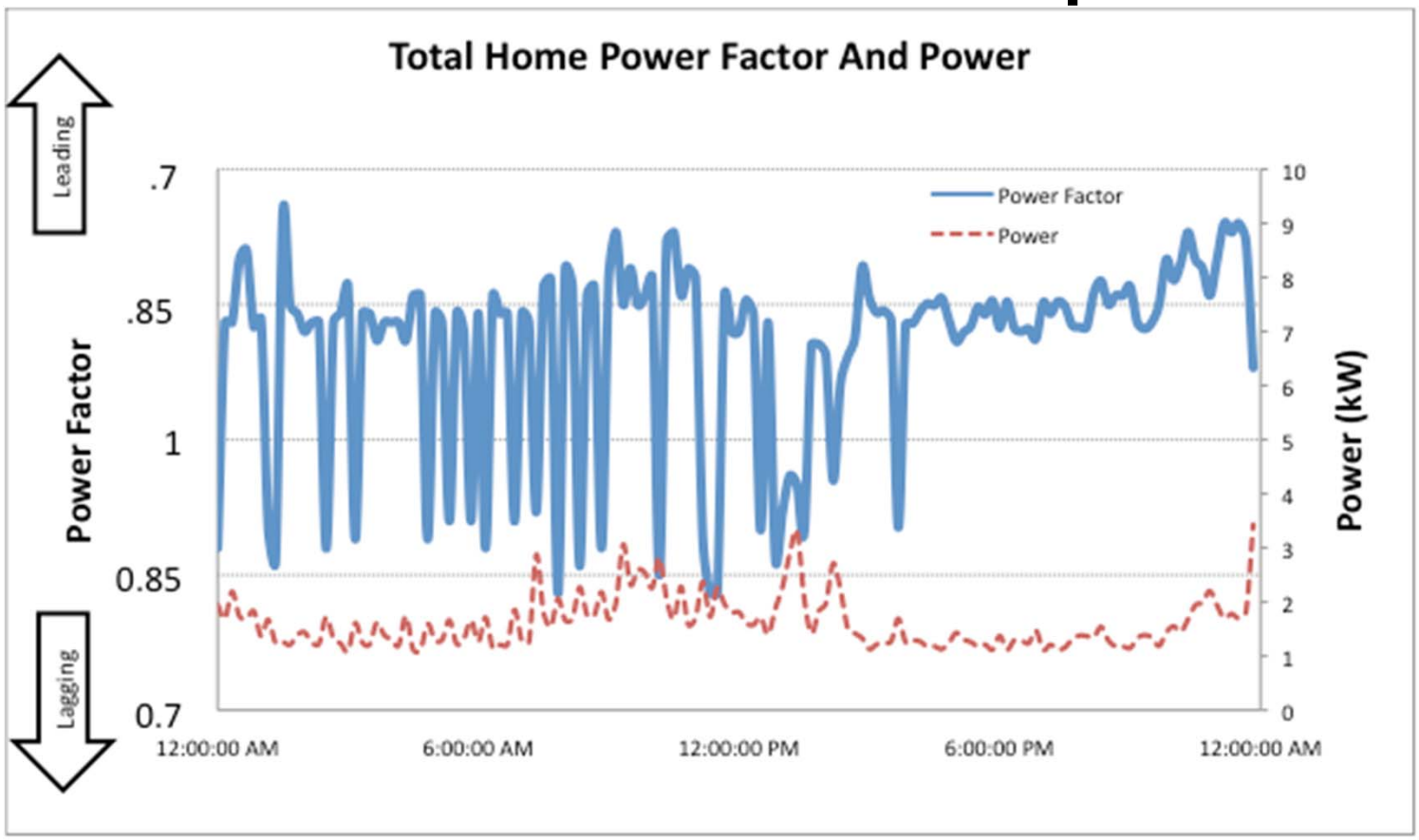
Whole Home Impact



Power and Power Factor 24 Hour Period-10 Minute Data

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Grid Impact

Low Power Factor and Harmonics Contribute to:

Reduced Transformer Life

Lower Grid Stability

Higher Grid Infrastructure Costs

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Solutions?

- Power factor correction/harmonic cancellation:
  - Individual loads
  - Whole home
- DC power distribution for lighting

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Thank You!

Contact Information:

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512-551-0787

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Further Reading

http://www1.eere.energy.gov/femp/technologies/eep_fluor_tips.html
http://ecmweb.com/lighting/hidden_costs_cfls_0109/index2.html
http://ecmweb.com/market_trends/cfl-market-share-20090818/index.html
http://www.energystar.gov/ia/products/downloads/CFL_Market_Profile_2010.pdf
http://eetd.lbl.gov/ea/ems/reports/47043.pdf

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