

Where Does It All Go?

Using Simple Loggers to Dis-aggregate Whole Building Energy Data

Ryan Stroupe, Pacific Energy Center



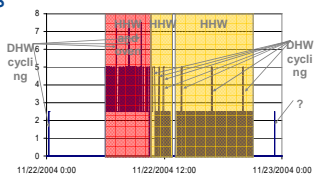
April 20, 2006
San Francisco, California



NATIONAL
CONFERENCE ON
BUILDING
COMMISSIONING

Topics Covered Here

- Value of baselining energy use within Cx process
- Methods for capturing whole building energy data
- How to monitor subloads using data loggers
- Overview of resources
 - Tool Lending Library
 - Universal Translator



2

The Value of Baselining

How dis-aggregating energy use supports Cx projects

- Focus retro-commissioning effort
- Can help identify problems during retro-Cx
- Persistence benefits
- Understand utility rates and customer bills
- Supports measurement & verification

How to Target the Cx Effort

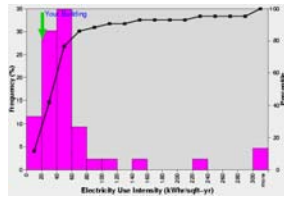
- Whole building data
 - Utility billing data
 - Benchmarking tools
- Dis-aggregated data
 - Commercial building surveys
 - Sub-metering
 - Motor control panels/Subpanels/Relay panels
 - Individual loads



7

Building Benchmarking

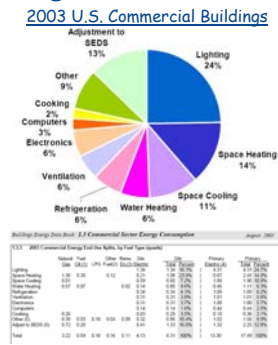
- Energy Star® <http://www.energystar.gov>
- ARCH (LBNL) <http://poet.lbl.gov/arch/>
- CALARCH (LBNL) <http://poet.lbl.gov/cal-arch/>
- One-2-Five <http://www.one-2-five.com/>
- CustomNet (PG&E) http://www.pge.com/biz/energy_tools_resources/customnet/



8

The Next Level: Looking at Subloads

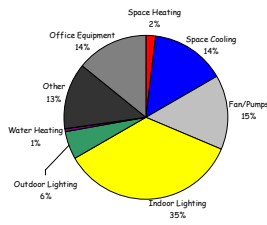
- 2005 Building Energy Outlook-USDOE
- Annual Energy Outlook 2003-USDOE
- BOMA Data <http://www.boma.org/>
- PG&E Commercial Building Surveys http://www.pge.com/biz/energy_tools_resources/building_survey/index.html



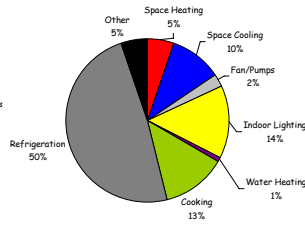
9

PG&E Commercial Building Surveys: Electric

Large Office Buildings

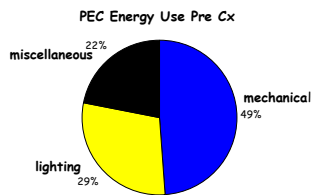
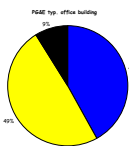
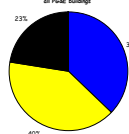


Grocery Stores



10

Comparing Typical to Actual

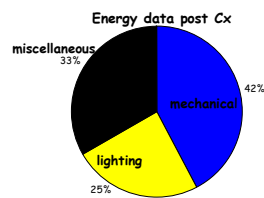
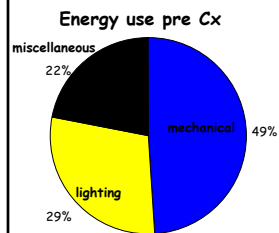


- Exact building type not represented in study
- Compare to "all buildings" and "office"
- Mechanical % is higher than typical
- Lighting % lower than typical



11

PEC Energy Use Pre & Post Cx

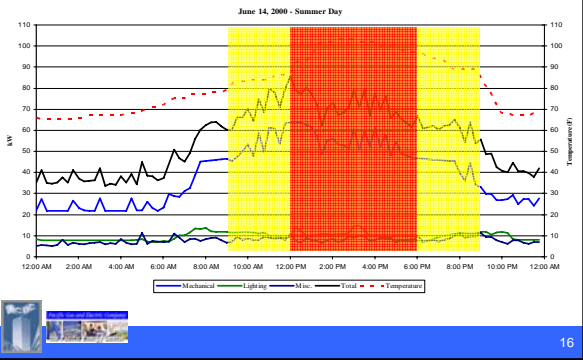


- Consider post energy is 25% lower than pre energy
- Electric energy for mechanical reduced by over 40%
- Electric energy for lighting also reduced substantially
- Miscellaneous energy use is essentially at the same level



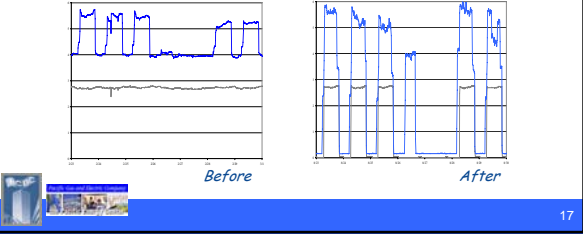
12

Understanding Rates and Costs



Measurement and Verification

- Continuous data collection can be used to calculate savings from additional changes
- Dis-aggregation and further isolation of loads helps determine impact of each action taken



Collecting Whole Building Data

Using billing data, meters, trend data and data loggers

Adding Whole Building Meters

- Electricity
 - Can be easy installation but electrician required
 - Requires voltage clips and current transducers
- Natural gas
 - Can install in-line, utility-grade meters (must cut pipe)
 - Clamp-on ultrasonic now available
- Steam
 - Can install in-line, utility-grade meters (must cut pipe)
 - Clamp-on ultrasonic now available
- Chilled water
 - Instrumentation includes flow and temperature measurement
 - Clamp-on ultrasonic is available for liquid flow measurement
 - Temperature can be taken on surface of pipe (under insulation)



22

Data Collection for Whole Building Meters

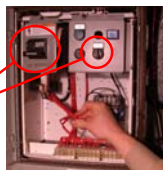
- Output signal
 - Meter has integrated pulse output
 - Meter has other analog (4-20ma, 0-5Vdc)
 - Pulse output is added to meter
- Data collection
 - Signal sent to energy management system (trend)
 - Meter has integrated memory
 - Signal sent to external data logger



23

Installing Electric Meters

- Licensed electrician required
- Voltage clips measure potential
 - Try to place these in a "spare" panel
 - Switch off load and disconnect voltage first
 - One clip/phase plus one for neutral
- Current transducers (CTs) measure amperage
 - CTs are placed around conductors
 - One CT/phase
 - Split core CTs can be installed quickly
 - CTs are directional (see CT label)
- Enclose all equipment into panel or secure electrical room



24

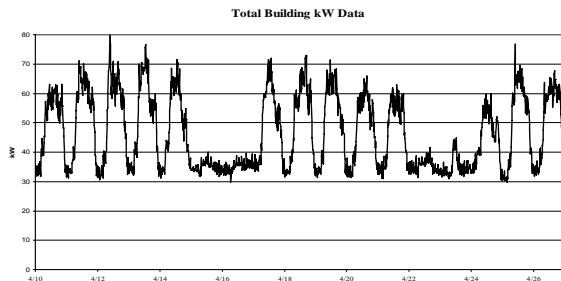
Notes on Current Transducers

- Use shunted CTs (mV rather than mA signal)
- If sized too small, peak amperage data is lost
- If sized too big, signal lost in noise
- Verify phasing is using PF reading
- CTs are directional



25

Whole Building Electric Use



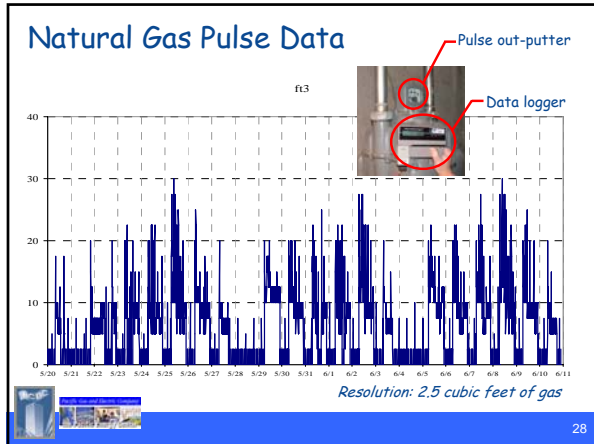
26

Adding a Pulse Out-putter to Gas Meter

- Utility personnel required to install
- New face plate with pulse can replace old
 - Face plate must be compatible with meter
 - Pulse output is integrated into device
- Magnet can replace smallest rotating dial
 - Works with most meters
 - Equipment must fit inside glass enclosure
- Signal must be received out of gas meter room

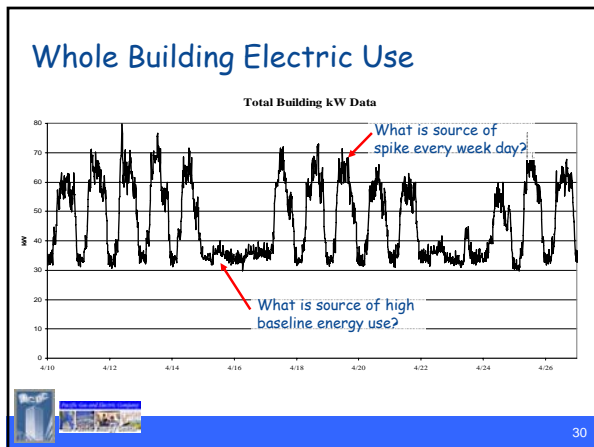


27

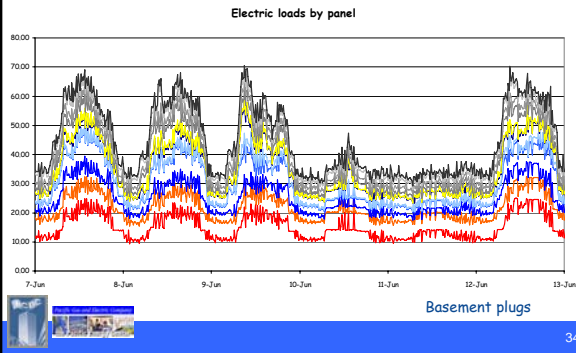


Disaggregating Energy Data

Methods using simple data loggers



Data Example View #2



Monitoring Individual Electric Loads

- Power logging
 - Use on variable loads
 - Best approach if power meters are available
- Logging current only
 - Use on variable loads where current and power correlate
 - Must have some simultaneous power and current data
 - Best approach if power meters are unavailable
- Logging run time only
 - Use on equipment with fixed power draw
 - Power is measured with one-time reading

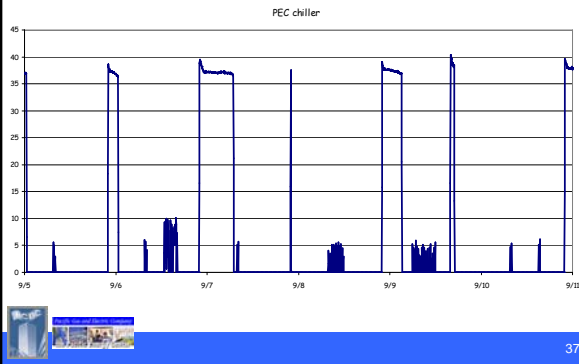


Power Logging

- Records voltage & current
- Calculates power, PF, energy
- Battery powered (120V option)
- 3-4 channels
- Applications
 - Whole panel loads
 - Packaged units



Power Data Example



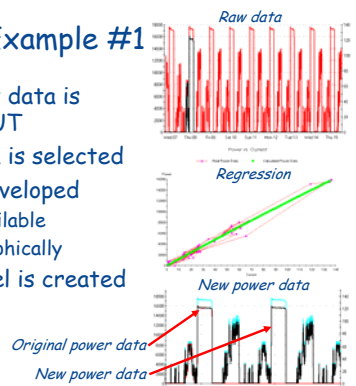
Logging Current Only

- Records current for long duration
- Records power for short duration
- Regression developed to convert current to power
- Battery powered (120V option)
- 3-4 channels
- Applications
 - Chillers
 - Variable speed fans and pumps
 - Dimmable lighting



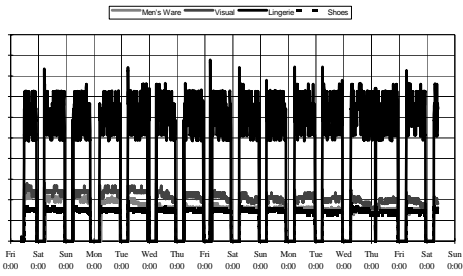
Current Data Example #1

- Power and current data is entered into the UT
- Simultaneous data is selected
- A regression is developed
 - 1 to 6 order is available
 - Fit is verified graphically
- A new data channel is created



Current Data Example #2

Retail Store Stockrooms



40

Logging Run Time Only

- Records run time
- Data may need to be converted to status
- Measure power with one-time reading
- Convert run time to power with a multiplier
- Battery powered
- Single channel
- Applications
 - Constant speed fans and pumps
 - Lighting



41

Measuring Instantaneous Power

- Measures voltage & current
- Calculates power, PF, energy
- Best to use meter with display
- Better than nameplate data



42

Monitoring Individual Gas Loads

- **Dedicated gas meter**
 - Use on variable loads
 - Expensive to install (must cut pipe)
- **Status logging**
 - Use on constant loads
 - Must correlate usage rate to master meter
 - Measurement approaches
 - Temperature
 - Light

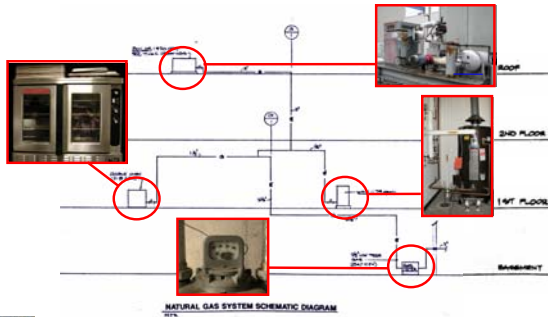


Measuring flue gas temperature



46

Single-line Diagram: Natural Gas

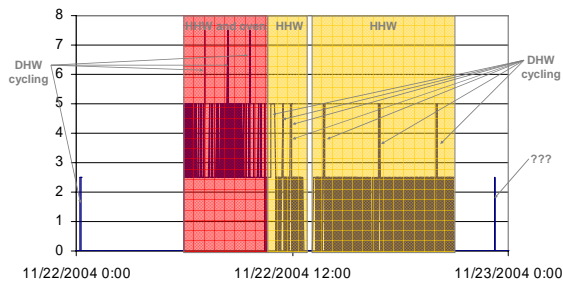


NATURAL GAS SYSTEM SCHEMATIC DIAGRAM



47

Dis-aggregation: Preliminary Findings



48

Domestic Hot Water Boiler

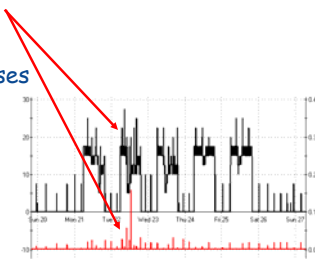
- Used light loggers facing flame
- Full combustion easily distinguished from pilot light
- Shielded sensor from overhead light



49

Analyzing DHW Data

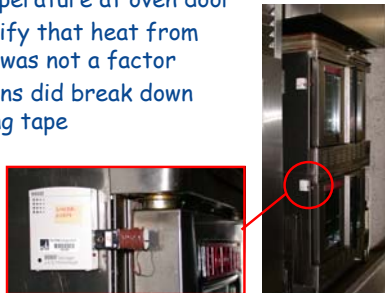
- Cycling of boiler visible in data from master gas meter and data logger
- Usage rate is steady
- Each 5-minute cycle uses 9 cubic feet of gas on average



50

Two Kitchen Ovens

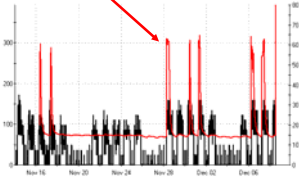
- Measured temperature at oven door
- Needed to verify that heat from adjacent oven was not a factor
- Heat from ovens did break down logger mounting tape



51

Analyzing Oven Data

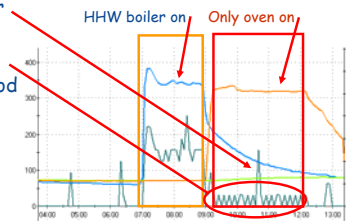
- Oven run time occurs when door temperature exceeds 250°F
- Usage rate is steady
- Each 5-minute cycle uses 1.65 cubic feet of gas on average



52

Calculating Gas Usage Rate

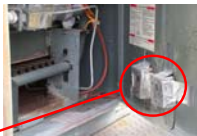
- If load of interest is only one running, then master meter can be used to determine usage rate
- Data from DHW boiler removed from total
- Usage rate based on average over this period



53

Heating Hot Water Boiler

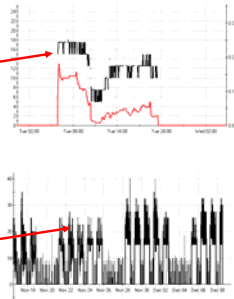
- The most difficult gas load to measure and analyze
- Experimented with light and temperature loggers
 - Light loggers facing flame and shielded from heat
 - Temperature probe in flue



54

Analyzing HHW Data

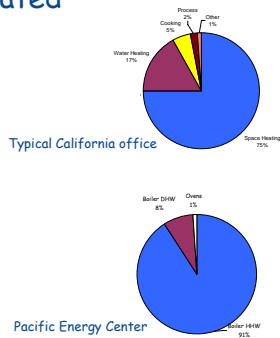
- Run time does correlate to light and temperature, but...
- Usage rate is NOT steady
- Developed a regression to correlate light level to CF gas
- Regression produced multiplier for converting light data to CF gas
- Total is within 3% of actual



55

Gas Data Disaggregated

- Heating hot water system accounts for 91% of gas use at PEC
- Is 75% in typical CA office
- Is worth investigating this system further



56

Tool Lending Library

A Free Service for Californians

Sign-out Sheet

- To borrow tools
 - Business card
 - Signature
- Agree
 - To return tools
 - That borrower is liable for damages to equipment and/or customer facility
 - Use licensed electrician for installing meters on equipment over 12v
 - Software cannot be copied for use after loan

PEC 01-00 01-2014-10 P.1

Pacific Energy Center
Tool Signout Form

Project: **Aeri Energy** Start Date: **2/2/2020**

Address: **2578 Highway 119** Invoice no.: **19090000000000000000**

City: **Turkey**

State: **CA**

Zip: **92376**

Tool/Kit Name	Type	Quantity	Due
1000 1000 1000 1000	1000 1000 1000 1000	10000	1/1/2020
1000 1000 1000 1000	1000 1000 1000 1000	10000	1/1/2020
1000 1000 1000 1000	1000 1000 1000 1000	10000	1/1/2020
1000 1000 1000 1000	1000 1000 1000 1000	10000	1/1/2020
1000 1000 1000 1000	1000 1000 1000 1000	10000	1/1/2020

Signed Out by: *[Signature]*

Print Name: *[Name]*



On-line Catalog



Application Notes

Application Notes

The Tool Lending Library specifies metering measurement techniques and steps for the installation for specific tools. The notes are for reference for the user and are not intended for installation. Users handling help with specific questions.

Specific Tools

- 1. **ELITEpro™ Recording Poly-Phase Power Meter**

Power & Energy

- 1. **ELITEpro™ Recording Poly-Phase Power Meter**

Installation

- 1. **ELITEpro™ Recording Poly-Phase Power Meter**

Measurement Techniques

- 1. **ELITEpro™ Recording Poly-Phase Power Meter**



Universal Translator Software

A Data Management and Analysis Tool

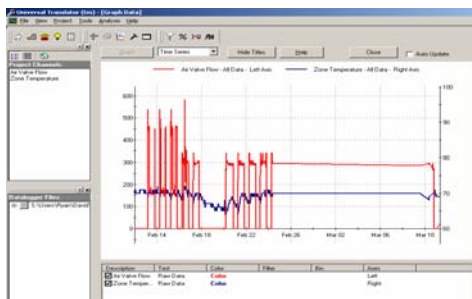
Universal Translator (utonline.org)

- Data Management Tool
 - Trend and logger data
 - Re-sampling
 - Time corrections
 - Slope and offset corrections
 - Calculated channels
 - Schedule and data filters
- Data Analysis Tool
 - Economizer
 - Run time of equipment
 - Lighting controls
 - Plug load controllers
 - Psychrometrics



65

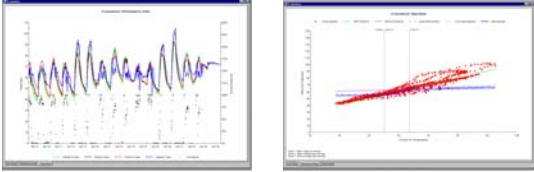
Universal Translator Interface



66

Economizer Analysis

- Determines functionality of economizer in three performance zones
- Ability to separate data when unit is not in operation
- Two modes of graphic analysis
- Produces an automated report



67

Questions?

And thanks for listening...
