GovEnergy
www.govenergy.gov
The Premier Energy Training Workshop
and Trade Show for Federal Agencies

A River of Energy Solutions

The Business Case for Metering

Carl E Lundstrom, PE, CCP – Eaton Corporation

Summary

- Successful metering program – best practices
- Sub-metering: Economic and Operational Benefits
- Case studies – example meter and sub-meter projects

GovEnergy
www.govenergy.gov
The Premier Energy Training Workshop and Trade Show for Federal Agencies

A River of Energy Solutions

Metering Program – Best Practices

Meter program – best practice

- Successful metering program will incorporate:
  - **Appropriate and accurate data** in a timely manner
  - Provide **analysis of meter information**
  - Data and analysis provided to user in a **format that leads to action**
  - **Operate continuously on a daily**, weekly, monthly, and annual basis

Meter program – metering plan

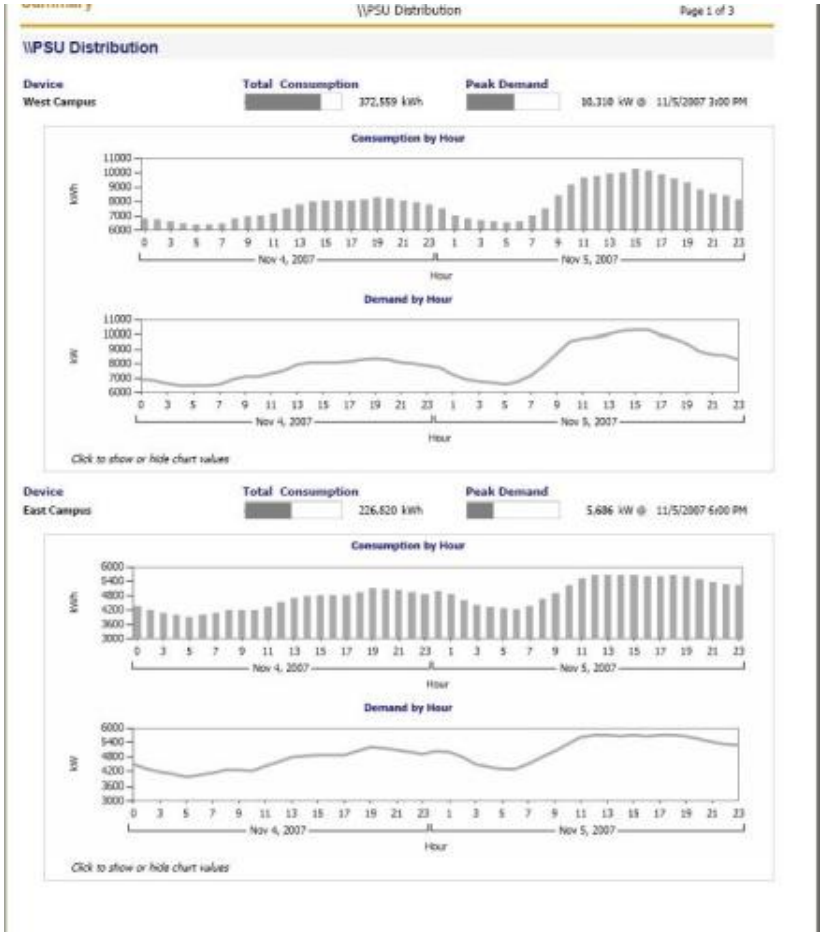
- Successful program - **start with a metering plan**
  - Program objectives – what are the goals, objectives, and risk
  - Identify current and future metering needs for all energy and water utilities
  - Recovery procedures when meter stops, deemed out of calibration, data lost, or considered questionable
  - Obtain and maintain management and stakeholder support
  - Identify key program milestones and assign roles and responsibilities
  - Detail the training and retraining requirements for meter and data analysis
  - On-going metering program monitoring

Metering program – metering plan

- Overall metering objectives:
  - Ultimate goal – reduce utility use and costs
  - Bill allocation throughout the entire facility
  - Manage utility loads to minimize costs
    - Example, electrical - time-based rates
  - Identify system-specific operational efficiency opportunities
  - Identify equipment malfunction or impending malfunction in critical use facilities – such as hospitals
  - Retro-commissioning & monitoring based commissioning
  - Special metering consideration
    - Data centers
    - On-site generation

Meter program – Analysis

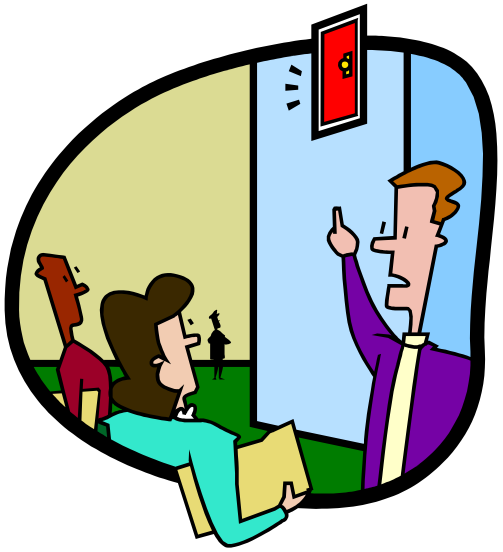
- Analysis methodologies are critical to site's metering program and metering plan
- Many commercial available software tools and service providers that can mine data
  - Very important for sites with multiple facilities
  - **Start with the end in mind – anticipate the desired output**



GovEnergy
www.govenergy.gov

Meter program – Other keys to success

- Meter programs are **not "set-them and forget-them"**
- Staffing resources needed to operate the metering system, when in place, are critical to a successful program
- Security requirements – IT staff participate early in development of system



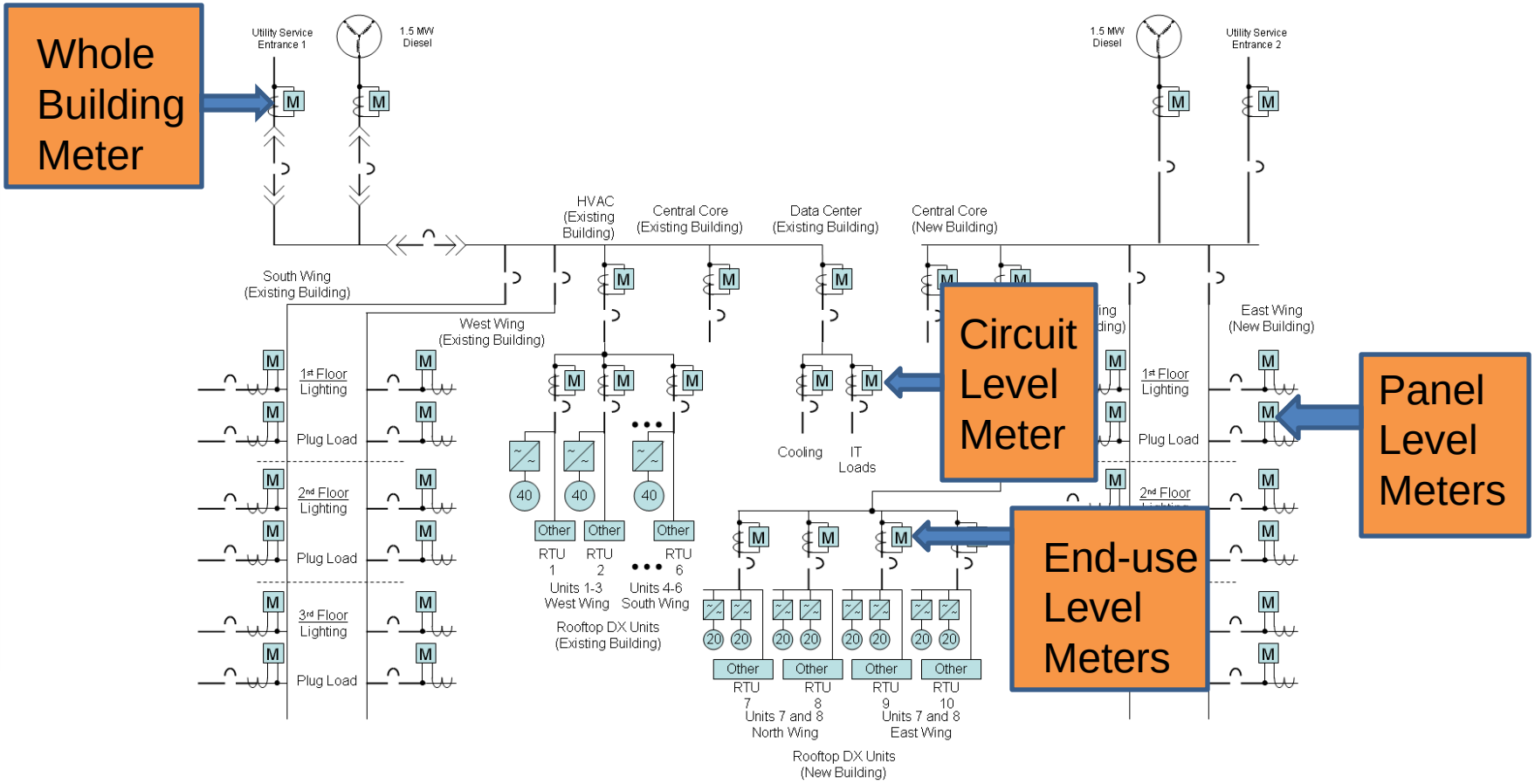
GovEnergy
www.govenergy.gov

Metering Costs

Metering Hierarchy - Maximize your metering value – minimize your metering costs

- Starts at Whole Building Meter
  - Diagnostic in identifying trends and variances
- Next finer level – Electrical Panel/Sub-Panel or mechanical system
  - Lighting, plug, or motor loads
- Moving down – Circuit-level monitoring
  - Specific load of interest
- Final level – End-use equipment (chiller, boiler, motor)

Metering program – meter and sub meter locations



GovEnergy
www.govenergy.gov

Metering program – Water, Air, Gas, Electric, Steam (WAGES)

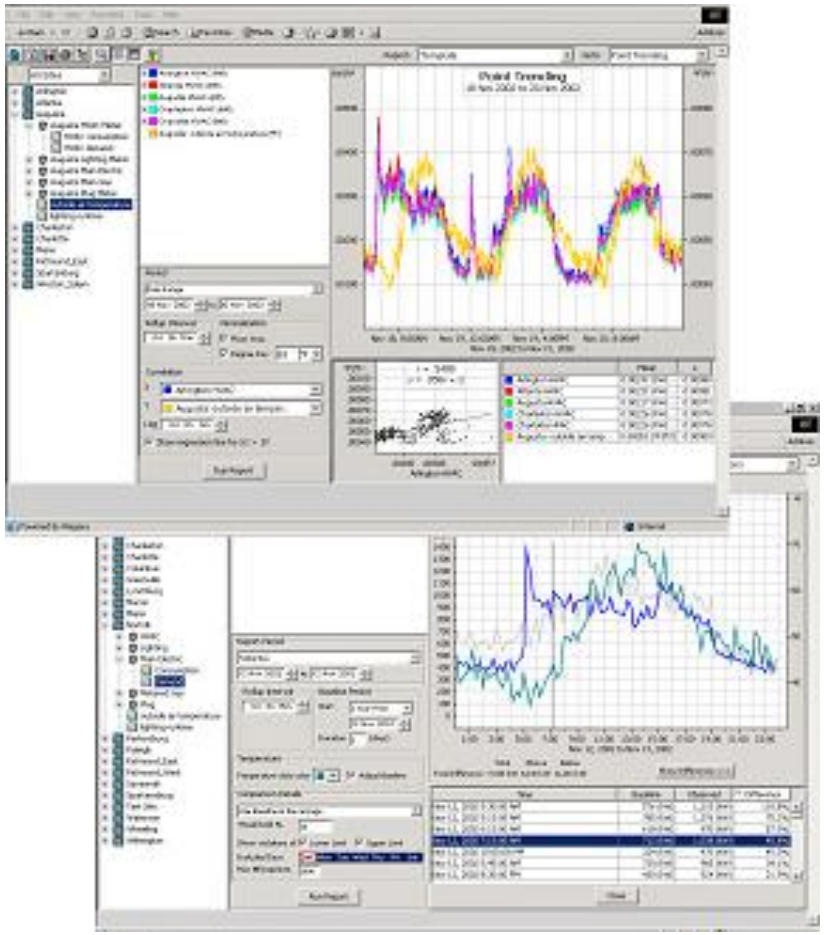
- Electric
  - Energy management
  - Power Quality
- Gas
- Water
- Air
- Steam

Where are your largest utility costs?
-Electricity
-Gas
- Water

GovEnergy
www.govenergy.gov

Metering Program – Data Acquisition

- Data acquisition
  - Why is this important?
  - How to do it?
  - What type of data?
  - Data transfer between systems
- Energy Information System (EIS)
- Building Automation System



GovEnergy
www.govenergy.gov

Metering Program – Benchmarking

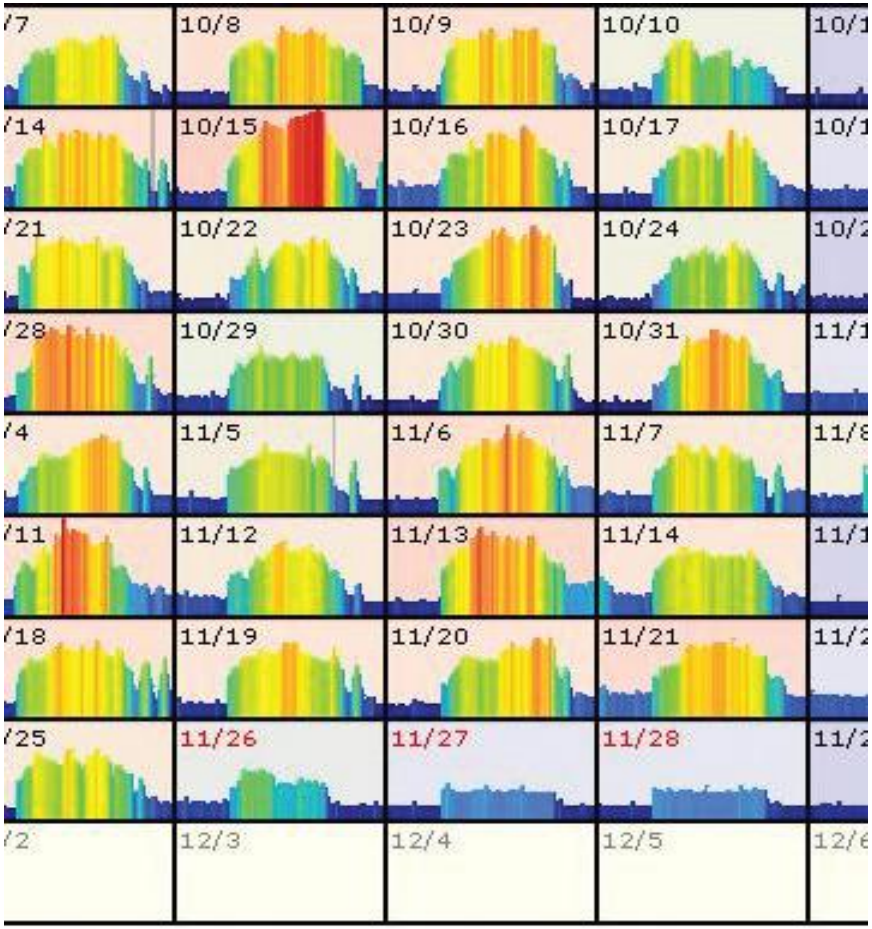
- **Decide on boundaries**
  - Plant, multiple plants, entire company
  - U.S. and global operations
  - Manufacturing operations or total operations
- **Choose a baseline year**
  - Establish base year (Year 0) or use existing baseline
- **Gather energy use data**
  - Energy use data by fuel source, device
  - Determine primary and site energy including renewable power
- **Decide on product grouping and units of output**
  - Identify product groups & units of output (Year 0)
  - Account for changes in product mix (Year 1-10)
- **Calculate energy intensity**
  - Baseline energy intensity (Year 0)
  - Determine change in energy intensity for subsequent years (Year 1-10)
- **Track and report progress**
  - Report select data to management (Year 1-10)
  - Adjust baseline energy use (Year 1-10)
- **EISA Section 432 Paragraph A:**
  - *The energy manager shall enter energy use data for each metered building that is (or is a part of) a facility that meets the criteria established by the Secretary under paragraph (2)(B) into a building energy use benchmarking system, such as the Energy Star Portfolio Manager.*

Adopted from: Steps to Develop a Baseline: A Guide to Developing an Energy Use and Energy Intensity Baseline and the Reporting Requirements for the *Save Energy Now* LEADER Pledge, U.S. Department of Energy website; http://www1.eere.energy.gov/industry/saveenergynow/pdfs/leaderbaselinestepsguideline.pdf

GovEnergy
www.govenergy.gov

Metering Program – Profiling

- In addition to benchmarks, owners should consider present usage profiling
- Profiling allows owners to compare "expected" energy consumption usage patterns to present usage.
- It flags areas of concern using deviations from modeled energy patterns



GovEnergy
www.govenergy.gov

U.S. Army Engineering & Support Center – Huntsville

- Electric Meter Specification
  - System Accuracy for the meter and associated devices (i.e. instrument transformers): +/- 1.5%
  - Meter Accuracy: Follow ANSI C12.20 Class 0.2% for loads greater than 1 MVA, follow ANSI C12.20 class 0.5% for loads less than 1 MVA.
  - Communications Protocol: meters communicate via Modbus RTU or LonTalk
  - Measurement quantities: power (kW), average demand over 15 min intervals, and energy (kWh)
  - Meter Data Storage: Interval data for least 30 days.
- Advanced Metering Data Management System (MDMS):
  - Data must be stored for at least 2 years; display of data upon request and selectable from 1 minute to 15 minutes for kW; display multiple graphical formats such as data vs. time comparison between metered data from two or more meters and other standard meter data.

GovEnergy
www.govenergy.gov
The Premier Energy Training Workshop
and Trade Show for Federal Agencies

A River of Energy Solutions

Economics and operational benefits through sub-metering

Economic & Operational Benefits through sub-metering

- One-time/spot measurement (system/sub-system)
- Run-time measurement (system/sub-system)
- Short-term monitoring (system/sub-system/whole building)
- Long-term monitoring (system/whole building)

Economic & Operational Benefits through sub-metering

One-time/spot measurement (system/sub-system)

- Energy efficiency projects measurements before and after retrofit (motors & lights)
- Efficiency performance of equipment (boilers)
- Clamp-on probes, contact temp sensors, ultra-sonic flow meters, combustion efficiency
- Does not meet EPACT 2005 or EISA 2007 requirements

GovEnergy
www.govenergy.gov

Economic & Operational Benefits through sub-metering

Run-time measurement

- Hours of operation are the critical variable
- Run time of pumps, fans, or lights
- Useful for constant load devices
- Does not meet EPACT 2005 or EISA 2007 requirements

GovEnergy
www.govenergy.gov

Economic & Operational Benefits through sub-metering

Short-term measurement/monitoring

- Verify performance, initiate trending, validate energy efficiency
- Term normally less than a year, in most cases weeks or months
- Portable data loggers, power, amps, temp, pressure, etc
- Used extensively in retro-commissioning
- Field downloading, or network connections
- Does not meet EPACT 2005 or EISA 2007 requirements

GovEnergy
www.govenergy.gov

Economic & Operational Benefits through sub-metering

Long-term measurement/monitoring

- Permanent installation metering
- Meet EPAct 2005 and EISA 2007
- High accuracy, captures most variance over long time duration
- Persistence of energy savings over time
- Communicate via network connection to host computer – Energy Information System (EIS)

GovEnergy
www.govenergy.gov

Cost of metering

Criteria useful for meter selection include:

- Ease of installation
- Ongoing operations and maintenance – the lowest cost metering technology may not be the best choice – life cycle cost approach
- Installation versus capital cost – in many situations, the cost to install a meter, can be greater than the capital cost of the meter
- Very hard to “rule of thumb” a meter project cost

Savings from Metering

Action	Observed Savings
Installation of meters	0-2% (“Hawthorne effect”)
Bill allocation only	2.5-5% (improved awareness)
Building tune-up	5-15% (improved awareness and identification of simple O&M improvement
Continuous Commissioning	15-45% (improved awareness, ID simple O&M improvements, and continuing management attention)

Source: “Guidance for Electric Metering in Federal Buildings,” Federal Energy Management Program, 3. Feb. 2006.

Energy Information System (EIS)

- First element for consideration – output information
- Volume of data and time to process
- Graphical output
  - Daily Profile
  - Day overlay
  - Calendar/Month of consumption

Analytical Outputs

- Benchmarking
- Aggregation
- Data mining (data slice/drill down)
- Normalization
  - Building area
  - Number of occupants
  - Cooling or heating degree days

GovEnergy
www.govenergy.gov

Energy Information System (EIS) – Use for Data

- Reimbursable billing
- Validation/Planning – shadow meter
- Efficiency Opportunity Identification
- Retro-commissioning
- Power Quality Application
- Measurement and Verification
- Benchmarking
- Active alarm notification

- Utilities Interaction
  - Demand limiting
  - Time of use pricing
  - Real time pricing
  - Load aggregation
  - Power factor
  - Demand response

GovEnergy
www.govenergy.gov

Energy Cost Allocation Report

– How $$$ much is your energy bill? Allocate costs where they belong.

How much is energy costing you?

Allocate costs between departments and facilities!

Aggregation of meter information

EATON

Energy Cost Allocation Report

11/3/2008 12:00 AM to 11/7/2008 12:00 AM (Day)

\\Energy

Unit Type=watts, Consumption Cost Allocation Method=Rate, Rate= $0.14, Demand Cost Allocation Method=Rate, Rate= $0.25

Help

Total for Period		Period Start	Usage	Rate	Cost
	Consumption	11/3/2008	191.9 MWh	$0.14 per kWh	$26,871.81
		11/10/2008	182.2 MWh	$0.14 per kWh	$25,512.02
	Demand	11/3/2008	2,568 kW	$0.25 per kW	$641.95
		11/10/2008	2,096 kW	$0.25 per kW	$523.89
	Total	11/3/2008			$27,513.76
		11/10/2008			$26,035.91

\\PSU Distribution

Device	Consumption	Cost	% of Total
West Campus	372,559 kWh	$29,804.73	62.16 %
East Campus	226,820 kWh	$18,145.62	37.84 %
Total	599,379 kWh	$47,950.35	100.00 %

\\PSU Distribution\East Campus

Device	Consumption	Cost	% of Total
East 1 + East 2	105,888 kWh	$8,471.04	17.67 %
East 3 + East 4	120,932 kWh	$9,674.58	20.18 %
East Campus	226,820 kWh	$18,145.62	37.84 %

Which facility is frugal, which one consume the lions share?

GovEnergy
www.govenergy.gov

Energy Information System (EIS) – Use for Data - Dashboards

Utility information dashboards

- Providing real-time information teaches and inspires behavior change and saves energy and water resources in buildings.
- Utility information dashboards give building occupants the data visualization and communication tools to manage and reduce their consumption.

GovEnergy
www.govenergy.gov

GovEnergy
www.govenergy.gov
The Premier Energy Training Workshop and Trade Show for Federal Agencies

A River of Energy Solutions

Metering & Sub-metering Examples

Submetering to verify savings of energy conservation measure

1997

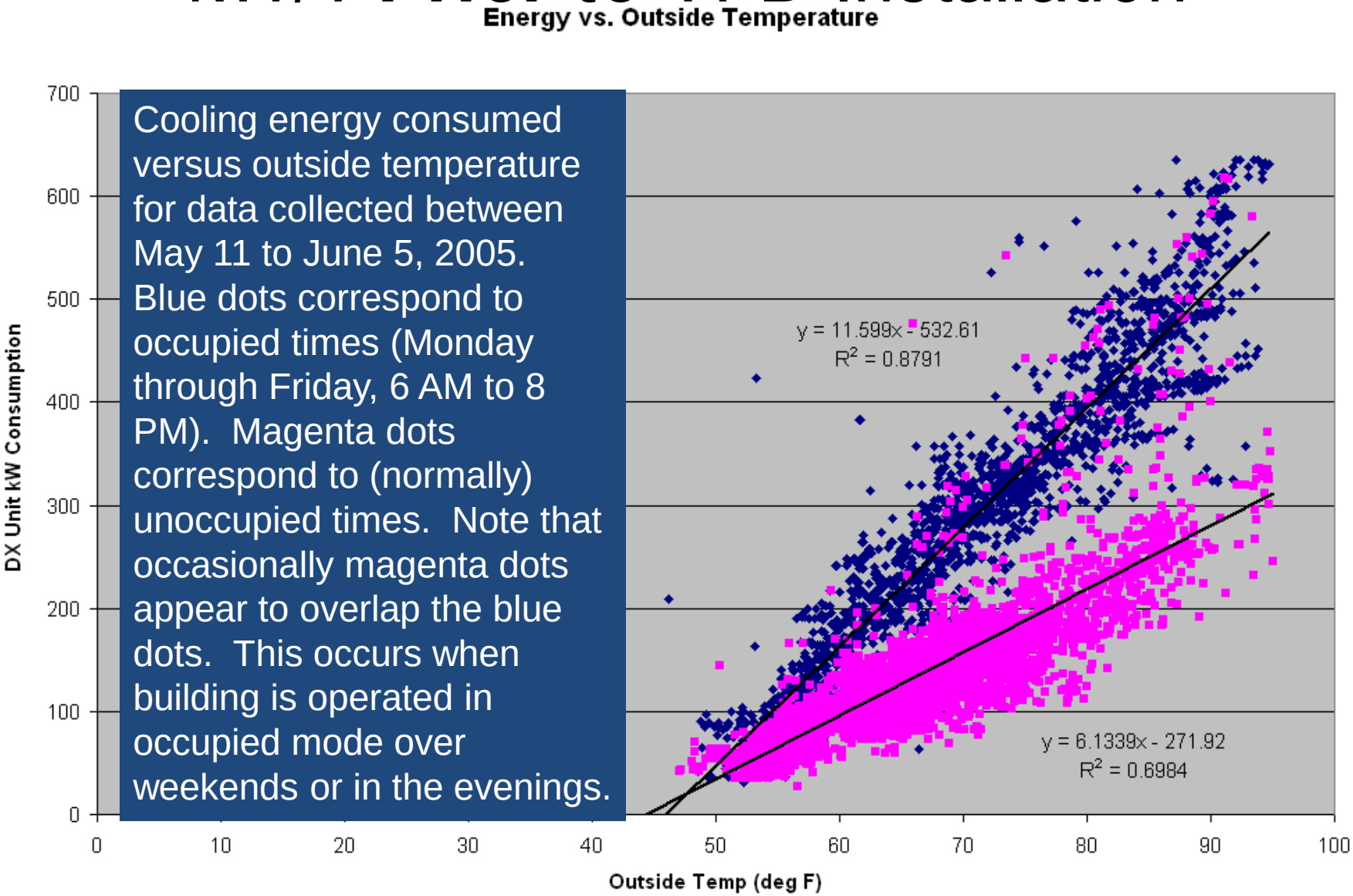
2008

- New addition to office building (2008) had VFDs on RTUs
- Submeter RTUs on original building (1997) to evaluate and justify adding VFDs to original RTUs

GovEnergy
www.govenergy.gov

© 2010 Eaton Corporation. All rights reserved.

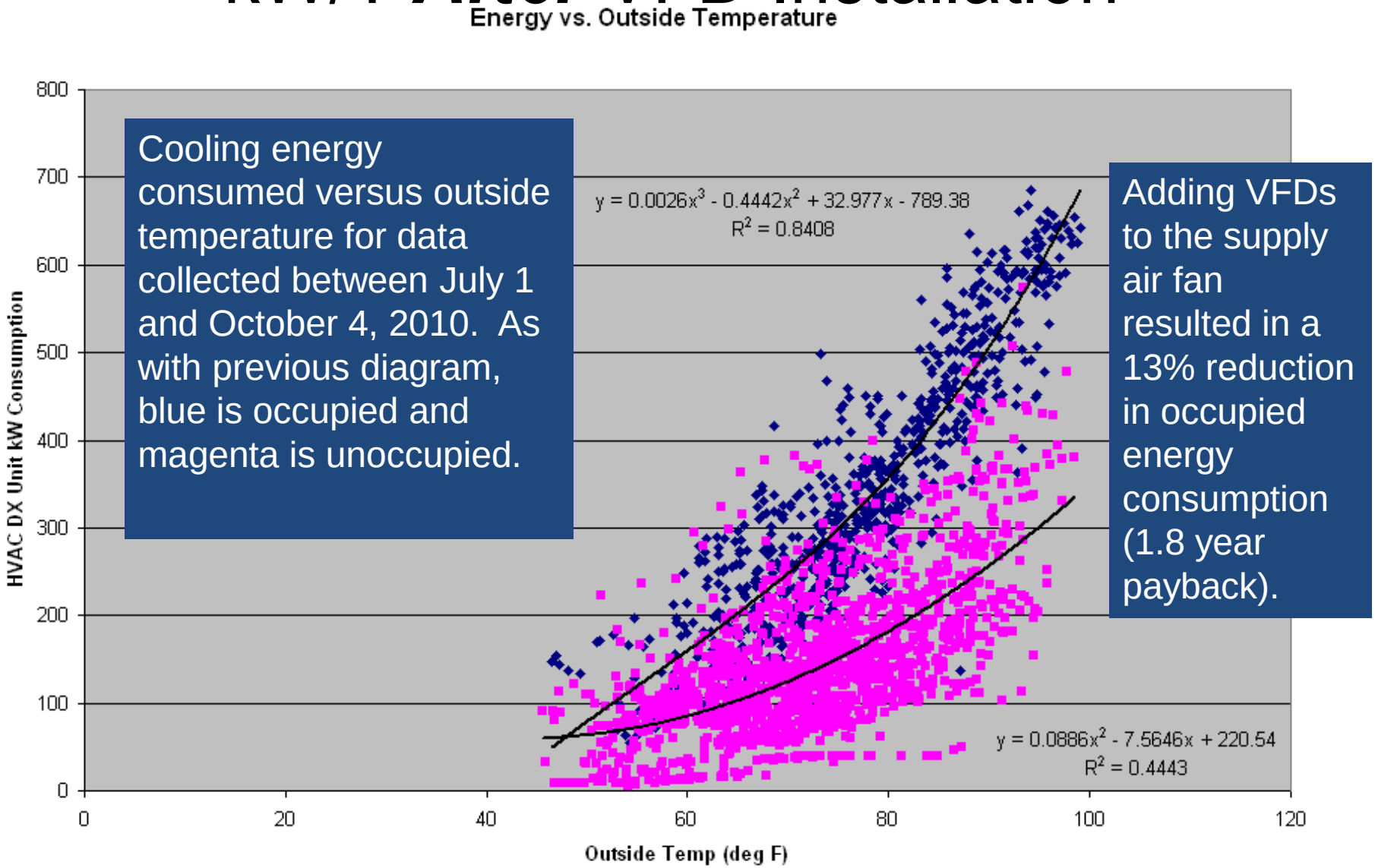
kW/T ***Prior to*** VFD Installation



Cooling energy consumed versus outside temperature for data collected between May 11 to June 5, 2005. Blue dots correspond to occupied times (Monday through Friday, 6 AM to 8 PM). Magenta dots correspond to (normally) unoccupied times. Note that occasionally magenta dots appear to overlap the blue dots. This occurs when building is operated in occupied mode over weekends or in the evenings.

© 2010 Eaton Corporation. All rights reserved.

kW/T *After* VFD Installation



Cooling energy consumed versus outside temperature for data collected between July 1 and October 4, 2010. As with previous diagram, blue is occupied and magenta is unoccupied.

Adding VFDs to the supply air fan resulted in a 13% reduction in occupied energy consumption (1.8 year payback).

© 2010 Eaton Corporation. All rights reserved.

No VFDs

Temp (deg F)	Occupied	Unoccupied
60	163 kW	96 kW
70	279 kW	157 kW
80	395 kW	219 kW
90	511 kW	280 kW

VFDs Installed

Temp (deg F)	Occupied	Unoccupied
60	152 kW	86 kW
70	234 kW	125 kW
80	337 kW	182 kW
90	476 kW	257 kW

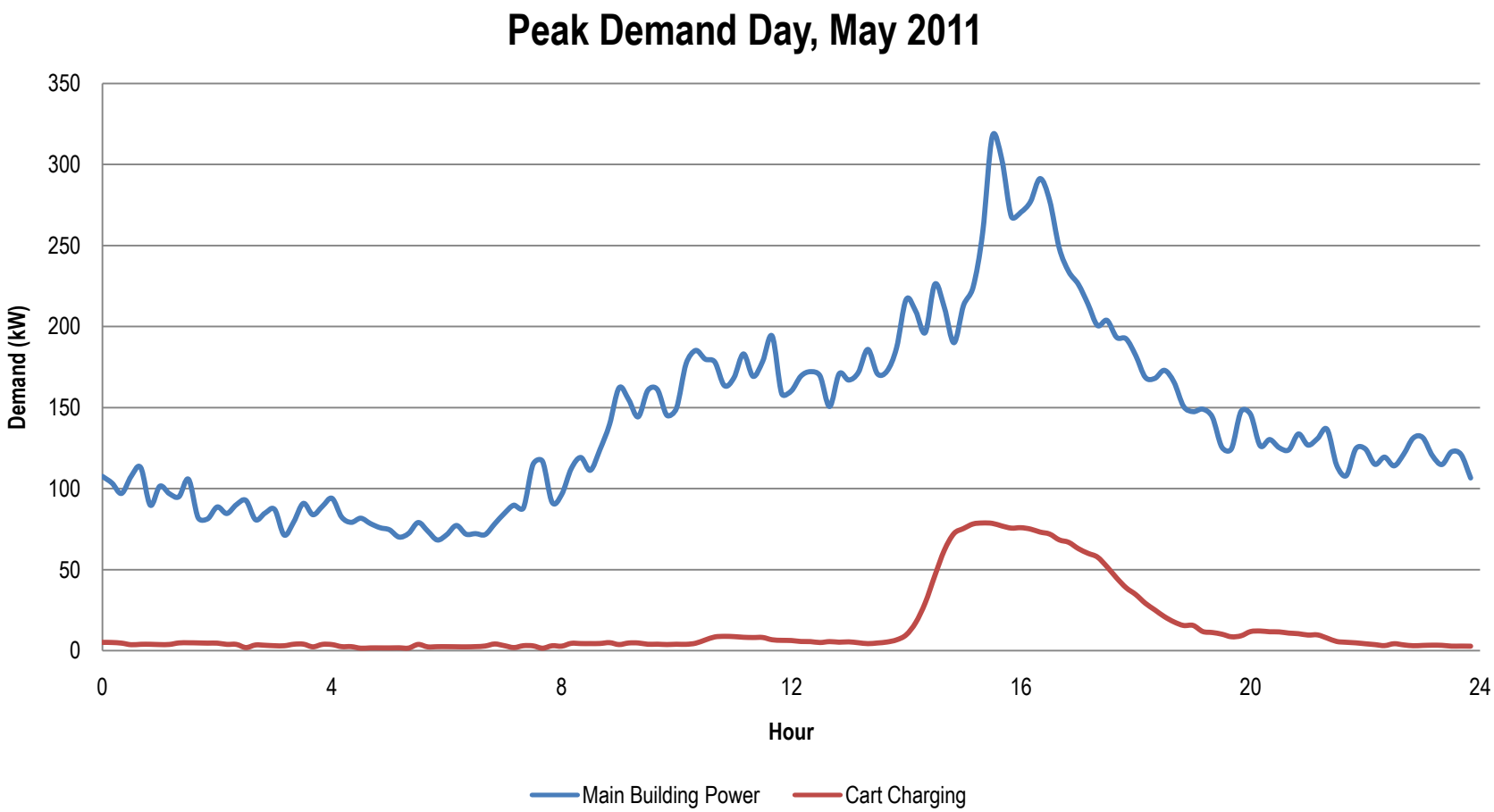
% Energy Savings

Temp (deg F)	Occupied	Unoccupied
60	7.7%	12.3%
70	19.3%	25.8%
80	17.3%	19.9%
90	7.4%	8.8%
Average	12.9%	16.7%

© 2010 Eaton Corporation. All rights reserved.

Evaluating Electrical Demand

Submetering Electric Cart Charging



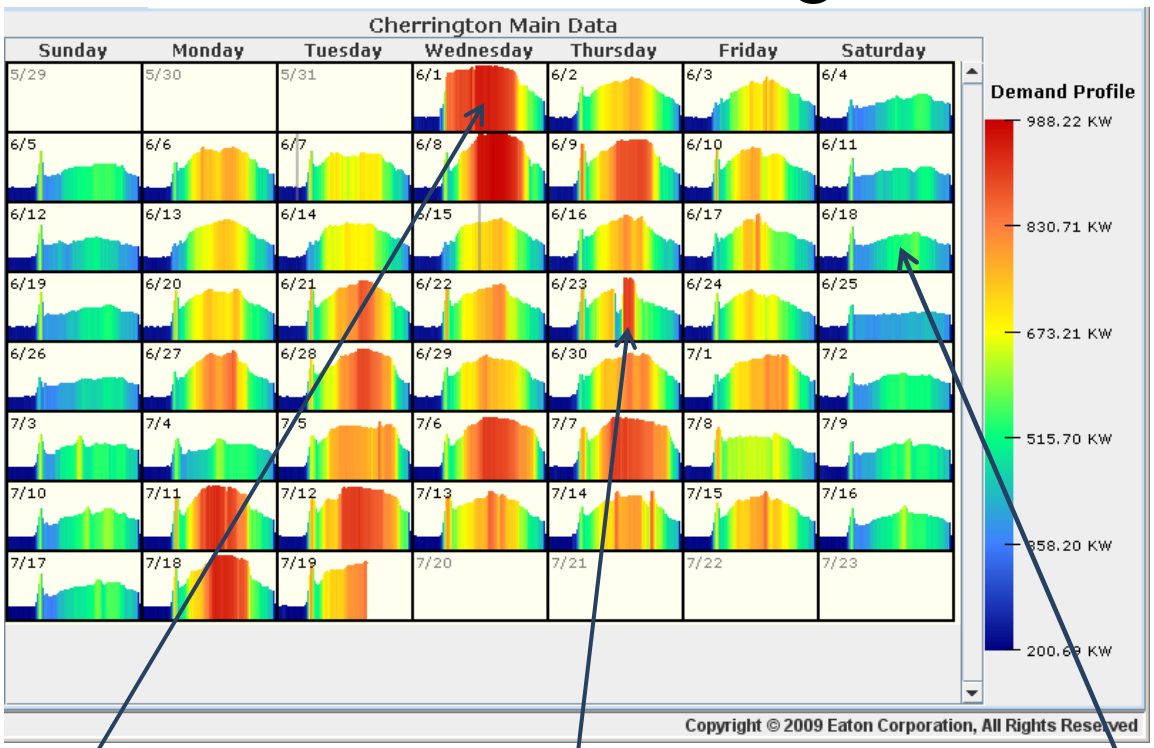
GovEnergy
www.govenergy.gov

Evaluating Electrical Demand

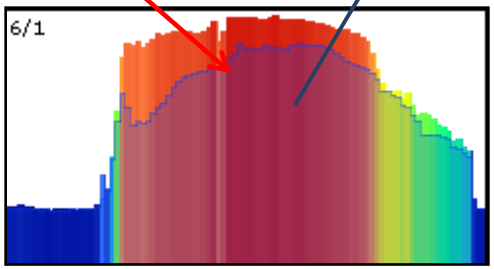
Submetering Electric Cart Charging

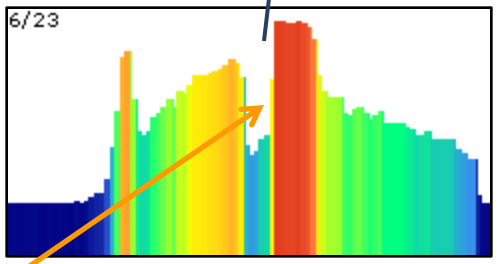
- "Short-term" sub-metering to evaluate electrical loads
- Submetering of electric carts indicated cart charging add 56kW to the month's kW demand peak.
- Recommend shifting this electric cart charging until after midnight, lowering the kW demand peak
- Annual savings $11,800

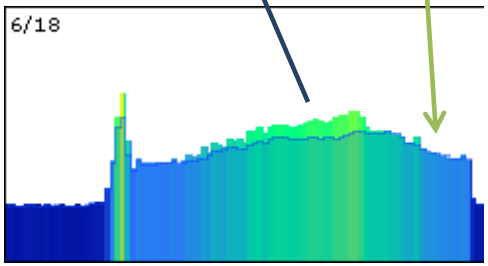
Meter Profiling



High demand







Extended usage on weekends

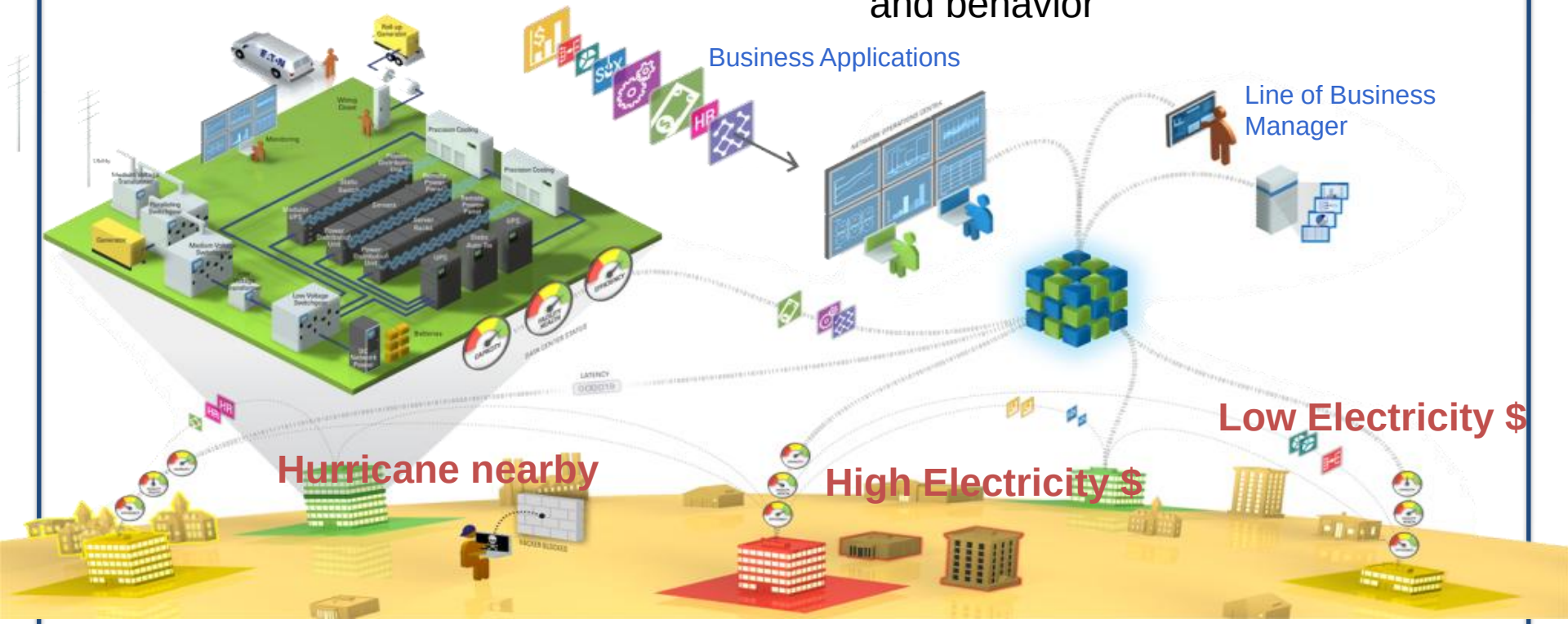
Demand response

GovEnergy
www.govenergy.gov

Data Centers operating in near-real time with utility dynamic pricing

- Example – Internet provider data center business evaluating computer operations, metered data, real-time pricing, and other factors.

- Optimize energy rates, load response, weather and other
- Technology is not the limiting factor, rather organizational structure and behavior



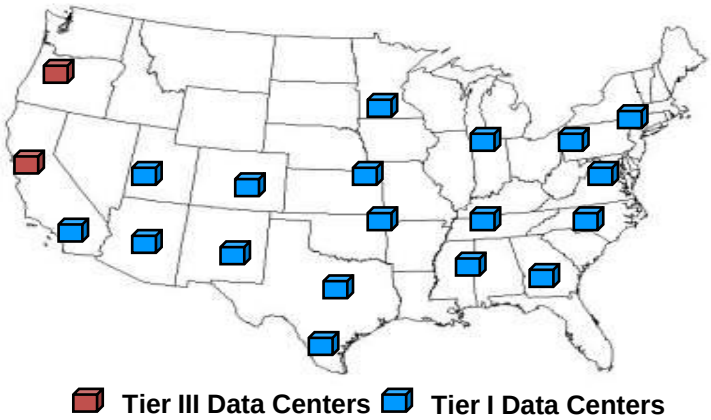
GovEnergy
www.govenergy.gov

Internet Provider - Data Center Example

Monetize the Cloud Opportunities

Profile

- 20 Data Centers in USA, each 10 MW+
  - 2 Tier III - Redundant, UPS, Generation
  - 18 Tier I – The network is the redundancy for lowest energy and cost per search
- Fully Virtualized Environment
  - Basic searches are done in Tier I DCs for cost
  - If Tier I DC is lost, instantly migrates to other Tier I
  - Financial transactions are migrated to Tier III DCs



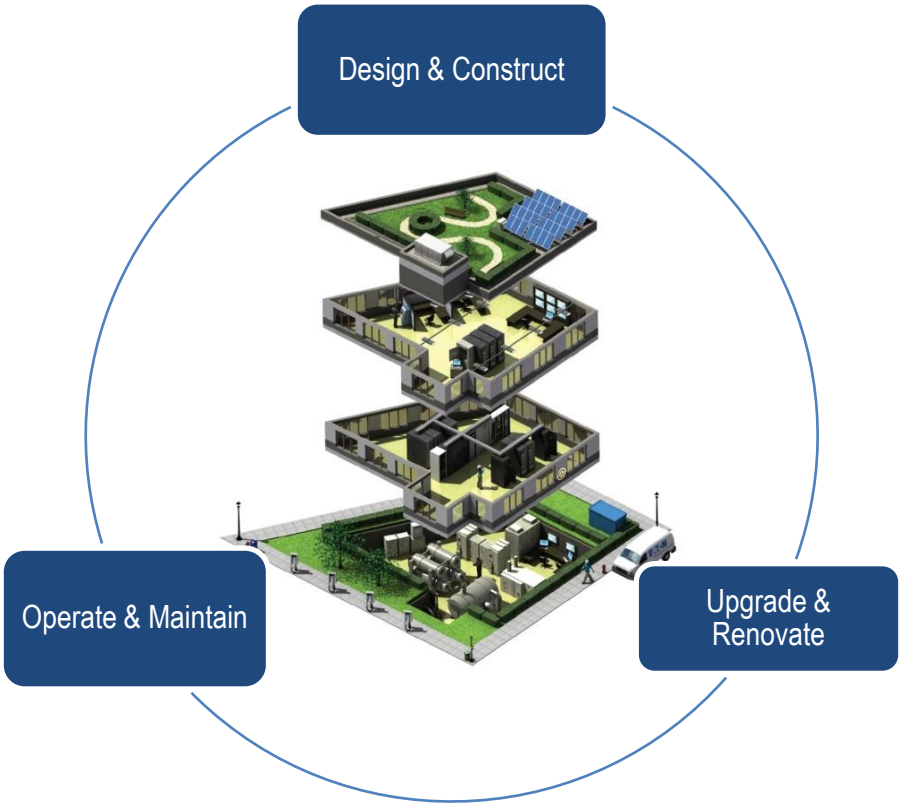
Real-time Utilities	Demand Response	Synchronous Reserves
• Electric, Gas and Water rates • Current Utility GHG emissions • Weather and drought situations • Grid interrupts	• Enroll in DR program • Respond to DR event within 1 hr • PJM - $40,000/MW-Yr 2011	• Enroll in SR program • Proactively manage utility rates • Place SR bid and respond within 10 minutes if called upon

Energy Service company: Energy audits, DR / SR systems integrator, raised floor services, products
Utility: National energy contracts, demand response, synchronous reserve programs
Systems Integrator: Integration to manage IT loads to meet business objectives

CONTACT INFORMATION

Carl Lundstrom, PE, CCP
Federal Solutions Manager
Eaton Corporation
Energy Solutions Group

4550 North Point Parkway, Suite 300
Alpharetta, GA 30022
Phone: (678) 254-1221
Fax: (678) 254-1239
CarlELundstrom@eaton.com
www.eaton.com/energysolutions



EATON
Powering Business Worldwide

Making Buildings Work. Better®