Building Energy Information Systems: State of the Technology and User Case Studies

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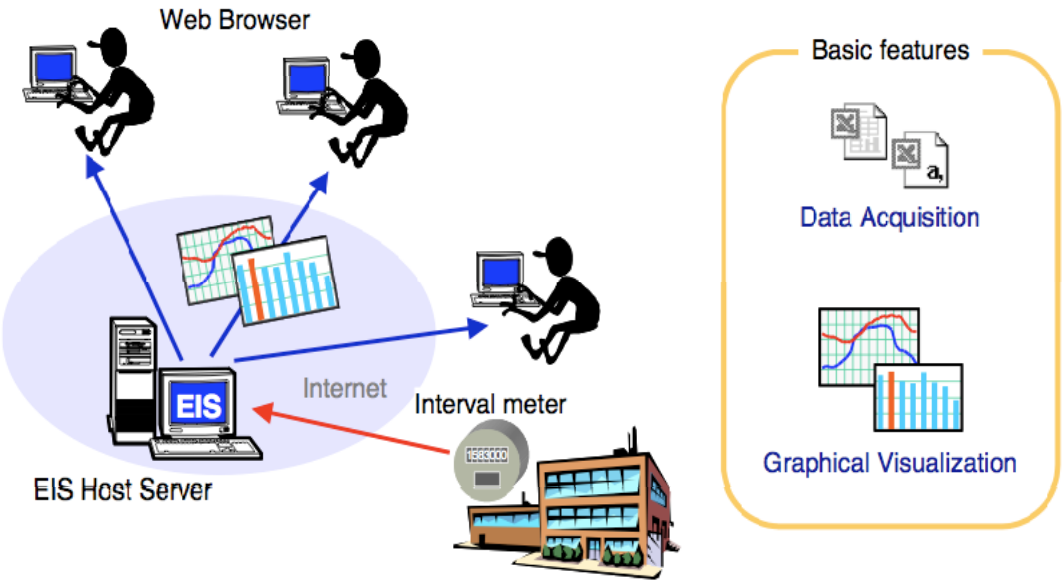
Outline

- Energy information system definition
- Study motivation and goals
- State of the technology findings
- User casestudies
- Additional visualization examples
- Remaining questions and future work

EIS Definition

- Energy information systems (EIS) comprise
  - Software, data acq. hardware, and communication systems
    - To collect, analyze and display building energy information

- EIS are NOT
  - Information dashboards
  - Batch analysis tools
  - GHG footprint calculators
  - Environmental monitors
  - Most building automation, control systems

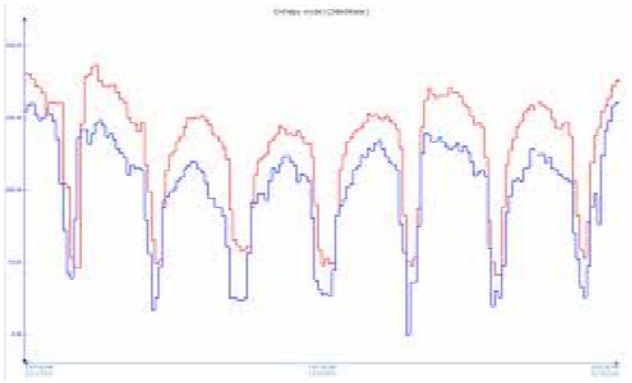


EIS Definition

- EIS provide
  - Web-accessible hourly whole-building electric data
  - Graphical/visualization capabilities
  - Weather, energy price signals, and demand response (DR) information
  - Automated building energy analyses

Motivation

- Current interest in
  - Energy displays and information dashboards
  - Role of feedback in reducing energy use
- Growing evidence of the value of permanent metering and continuous monitoring
  - 10% source energy savings, 25% energy cost savings
- Optimal performance requires higher granularity data, more timely analysis than monthly utility bills



Study Goals

1. Define a characterization framework that provides
   - A common terminology for technology features and capabilities
   - A detailed technical understanding of what the tools do/not offer
2. Understand the overall state of the technology
   - Advanced, common, distinguishing capabilities
   - Robustness of embedded energy analyses
3. Conduct user case studies to identify
   - Actions that are taken based on the information provided in an EIS
   - Energy savings that can be attributed to the use of an EIS

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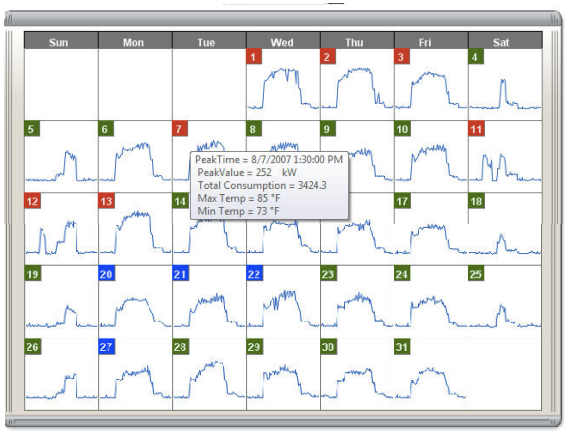
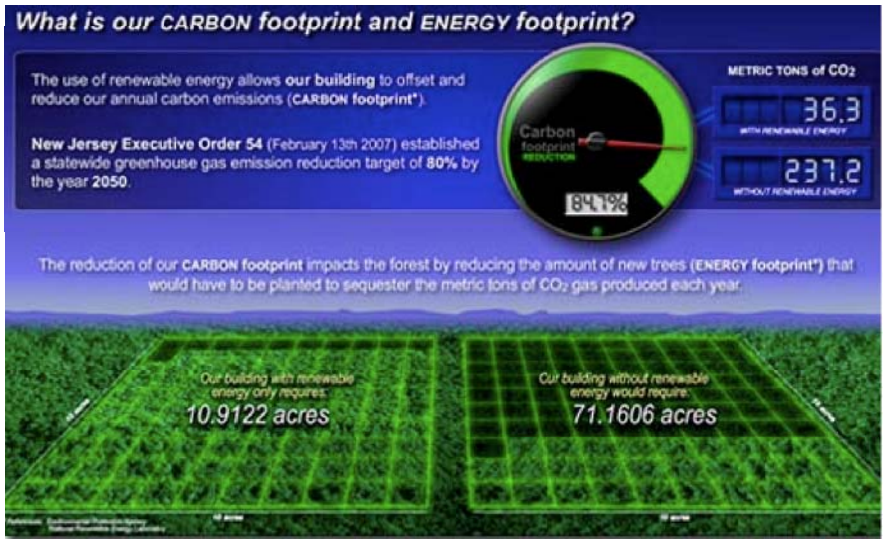
Technology Characterization Framework

- 8 categories of capabilities, 5-10 features each
- Data collection, transmission, storage and security
  - Storage capacity, security measures
  - Sampling and upload frequency
  - Supported protocols and interoperability
- Display and visualization
  - Daily, summary, calendar plotting views and intervals
  - 3D plotting
  - Mulitpoint overlays
  - X-y scatter plotting



Technology Characterization Framework

- Energy and advanced analyses
  - Averages, high/lows, normalization
  - Carbon tracking
  - Cross-sectional and longitudinal benchmarking
  - Forecasting
  - System efficiencies
  - Renewables, on-site generation



Technology Characterization Framework

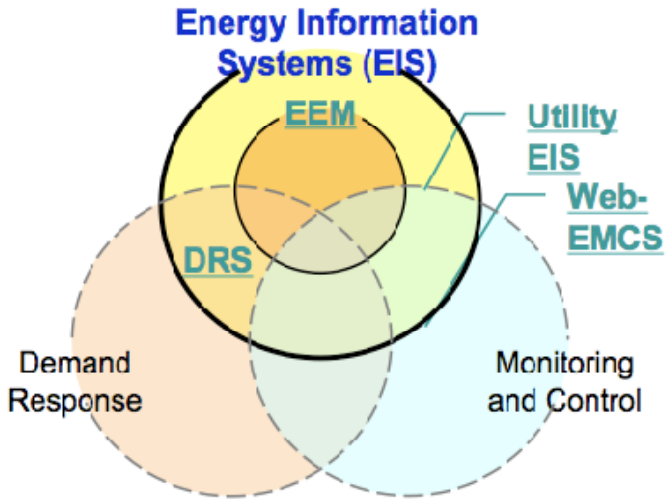
- Financial analysis
  - Simple and tariff based energy costing
  - Meter/bill verification
  - Savings estimation (operational or capital improvements)
- Demand response
  - Event notification and response recording
  - Opt out, black out
  - Load shed forecasting and quantification

- General info
  - Costs and licensing
  - Targeted verticals
  - Number of users

EIS State of the Technology

- Process
  - Identify ~30 representative commercial EIS
  - Apply framework to each tool, based on vendor interviews and software demonstrations
  - Analyze findings as a whole to evaluate overall state of the technology

- Vendors from controls, purely software, DR providers, utility tools



State of the Technology Summary

- Carbon tracking, DR features, baselining and anomaly detection are new or more sophisticated in last ~7 yrs
- Many features have converged to a common set
- Flexibility is a key distinguishing factor
  - alteration of trending, plotting, and reporting parameters, and automated calculations
  - changes dynamic and on-the-fly or hard-coded
- Robustness of analyses also distinguish EIS
  - Baselining
  - Anomaly detection and alarming
  - Load prediction
  - GHG accounting

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EIS User Case Studies

- Motivating Questions
  - How are EIS utilized in organizations that have them?
  - Which features have proved most useful?
  - What actions are taken based on the information provided?
- 4 cases
  - Wal-Mart, Sysco, UC Merced
  - UC Berkeley as a contrasting case

Wal-Mart

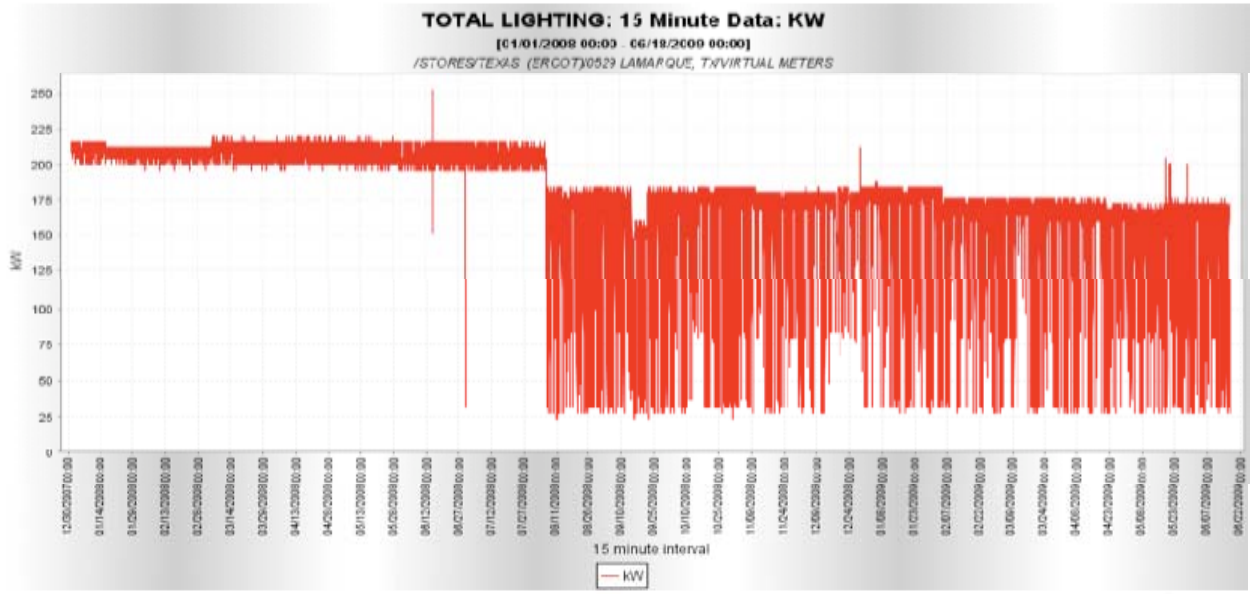
- 675M sf portfolio, EIS implemented in 2003
  - building and submetered electric: HVAC, ltg, refrig mains
  - subscription weather feed
  - some stores meter gas and water
- EIS philosophy: with $B utility expenses, 60-90dy billing cycles is insufficient
  - Don’t base retail decisions on 60dy sales data - energy considerations are just as critical
- Case illustrates:
  - Siloed use by specific groups or individuals for a few key purposes
  - Regular use not yet widespread vertically or horizontally within the enterprise
  - Even more sophisticated EIS may not satisfy all organizational energy management needs

Wal-Mart, Common EIS Uses

- Measurement and verification by specific project teams
- Power procurement and DR: forecasting and normalization features for week-ahead predictions - high accuracy, large expenditure decisions
- Individual stores: gauge the performance of new designs, particularly at 'High Efficiency' supercenters 1 report that EIS data used in simulation tools
- Portfolio tracking: benchmarking analyst exports data for custom model-based calculation of weather and sales normalized EUIs
  - 20 poorest performing sites IDd monthly, referred to op/maint

Wal-Mart Examples

- 2 examples from M&V and benchmarking
- High store consumption: 225 kW static lighting load due to a failed dimming control module
- $35K/yr avoided energy cost
- Identified failed VFD installation causing zero retrofit savings



Walmart
Save money. Live better.

Wal-Mart

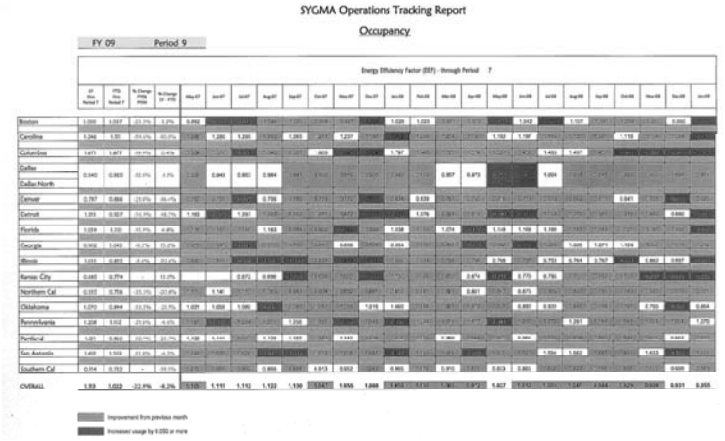
EIS Challenges

- Mostly independent of the EIS technology itself
- Submetering
  - Cost prohibits submetering to the extent desired by EIS champions
- Integrating regular EIS use into standard daily activities
  - particularly during the current economic downturn
  - 1 person benchmarks monthly vs. benchmarking *group* daily
- Custom models for portfolio benchmarking and High Efficiency performance tracking not easily accommodated

Sysco

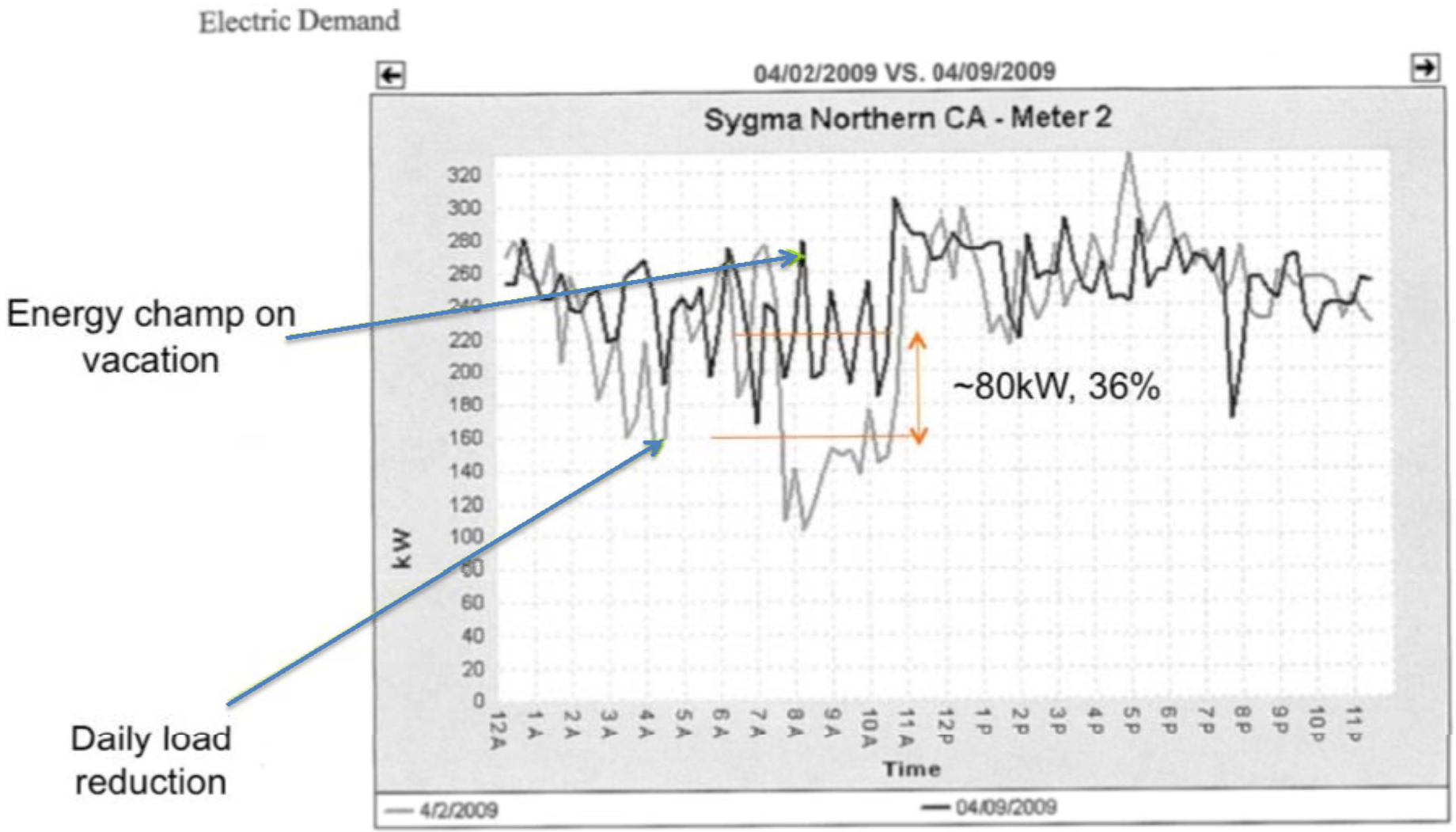
- Corporate energy efficiency program
  - Goal of 25% savings enterprise wide in 3 yrs (108 ctrs)
  - Leveraging EIS + HVAC engineering services
    - EIS used on-site, and throughout corporate enterprise
    - 'Energy champion' responsible for performance at each site
  - Expert audits + EIS data →low/no-cost measures
  - Capital improvements over time
  - 28% savings achieved after 2.5 yrs (18% low/no)
- Case illustrates
  - Enterprise-wide EIS use and information sharing
  - Limited yet powerful on-site use of the EIS
  - Use of EIS to ensure persistence in savings and accountability

Sysco – Stockton Sygma



- Metering
  - Interval data from 5 utility meters, for 3 warehouses
- Metrics
  - Unit-less ‘efficiency factor’ for each site
  - Monthly benchmark ranking tables across regions
  - Color coded tables to show up/down from prior month
  - kWh/ksf for the portfolio
- Daily EIS Use
  - 95% of use dedicated to 1 meter (refrigeration), 1 view
    - Today/this week vs. last week, % change in use, temperature change
  - Daily, manual load reduction at 10 units

Sysco – Stockton Sygma



Sysco – Stockton Sygma

Monthly EIS Use

- Ensure loads drop as expected off-hours (lights)
- Reports to generate site rankings based on efficiency factor
  - Review meetings w/ project mgr and energy champions
  - Accountability mechanism
- Automatically generated utility reporting

General EIS use

- Large initial savings, monthly accountability, culture of competition = no perceived need to use more powerful EIS features
- EIS most valued for supporting accountability and staff motivation for persistence in efficiency gains

UC Merced

- Campus Features
  - 2005 opening, newest UC campus, 4 main buildings, central plant, housing/dining
- Energy Targets
  - Efficiency, measurement, prioritized in design stages
  - Dense monitoring, 10K points upon opening
  - Goals: 20% better than benchmark, ramping to 35%, 50%

UC Merced

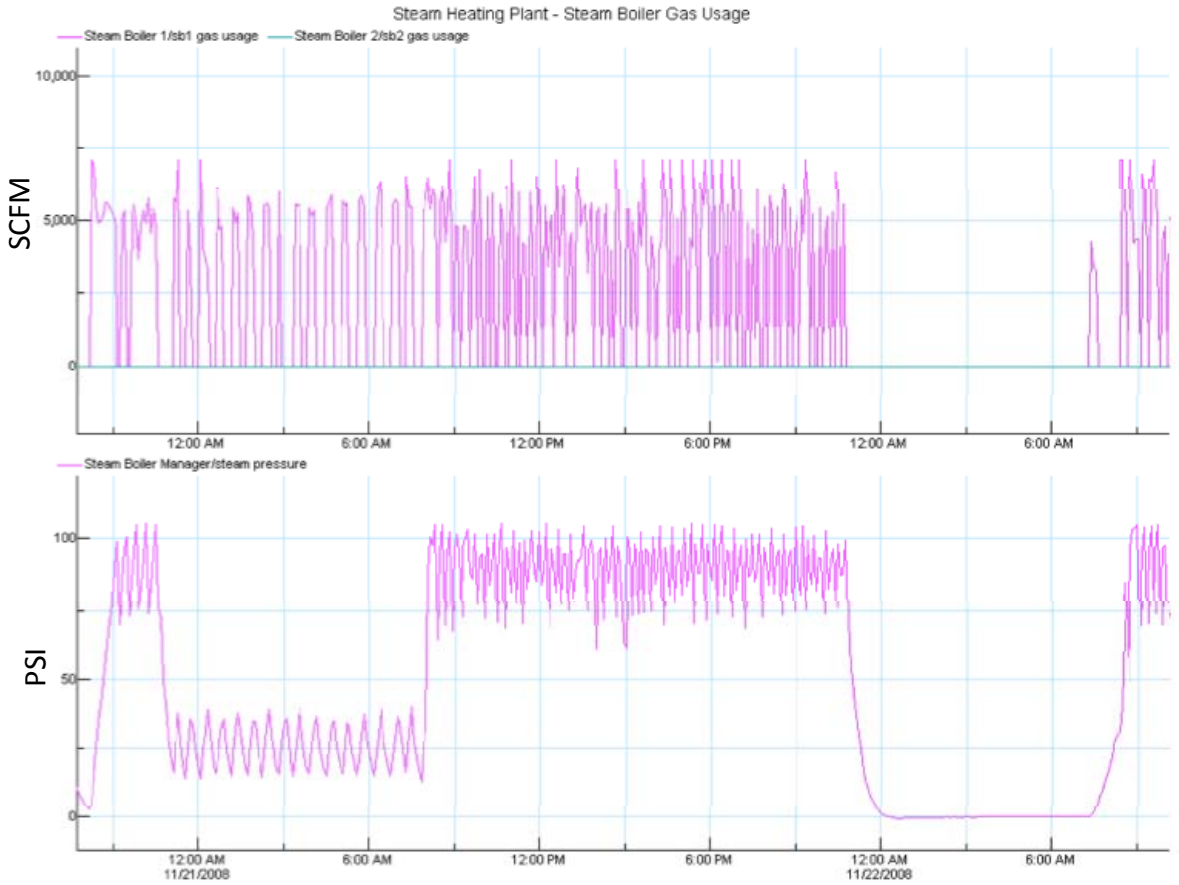
- Case illustrates
  - Challenges, successes in using a web-EMCS for intensive data collection, monitoring, energy Dx
  - The web-EMCS as enabling critical information links to meet low energy goals
  - Realization of the campus as a living laboratory
- Automated Logic Web-CTRL
  - Uses: energy performance tracking, assessment of utility recharges, building andequipment troubleshooting

UC Merced Examples

- Steam plant trends to identify excessive overnight steam plant pressure
- ~35% gas reduction

$2500/mo est. savings

- Gas trends and local steam measures to confirm steam plant efficiency



UC Merced

- 2007-2008 Energy Performance

	Campus Gas	Campus Electric	Campus Pk. Demand	Building Electric	Building Pk. Demand	Building Pk. Cooling
Improvement vs. benchmark	27%	34%	37-52%	42-45%	52-55%	15-36%

- Challenges
  - EMCS (logic) and instruments not configured for energy analyses
  - Intensive monitoring requires close attention wiring, system programming, network architecture and hardware selection

Case Study Conclusions

- Data quality is increasingly important with submetering, component/system monitoring, and non-electric energy sources
- Resources and staffing were constraints in every case
- Many EIS features are underused or not used
- Common uses: M&V, schedule verification, benchmarking, inefficient operations, persistence in low-energy performance, goal tracking
- External software common with custom analyses and performance metrics
- EIS as critical technology enabling savings and low energy performance

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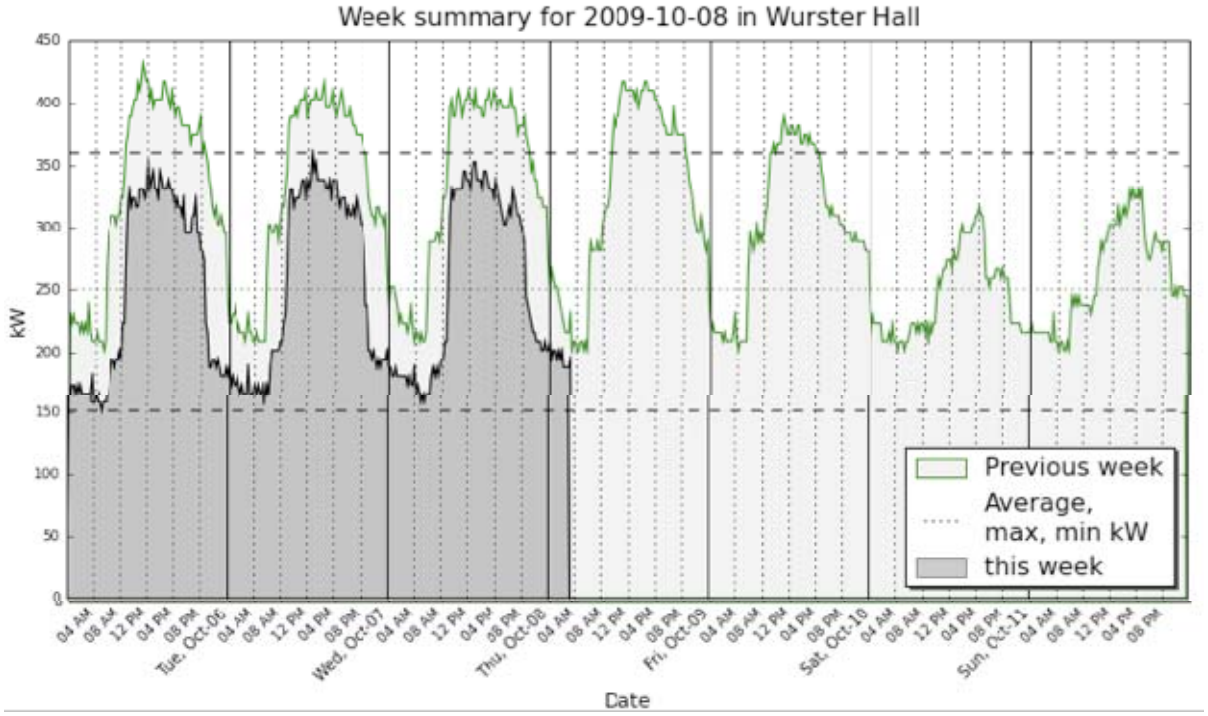
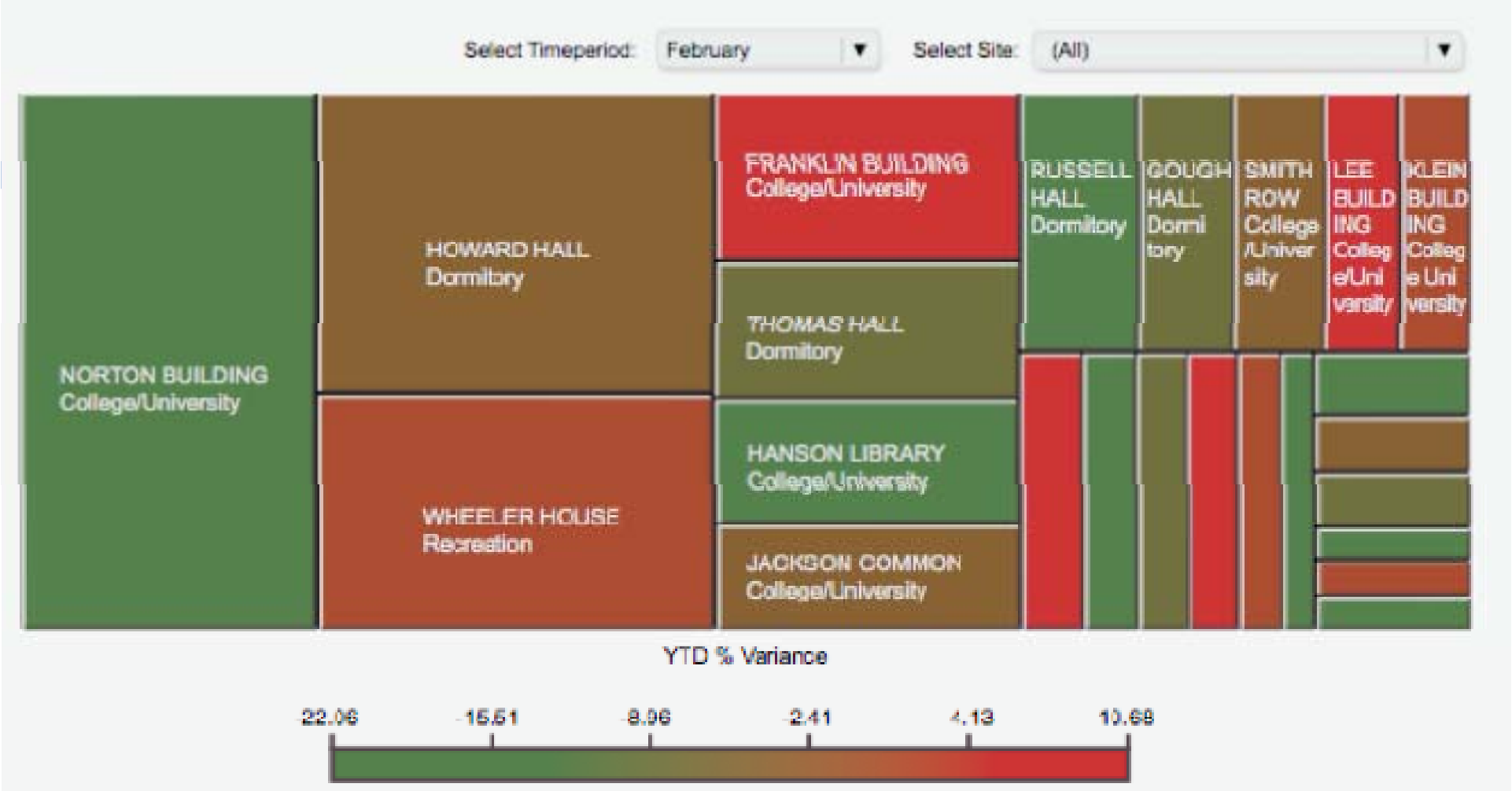
UCB *Building Energy Dashboard*



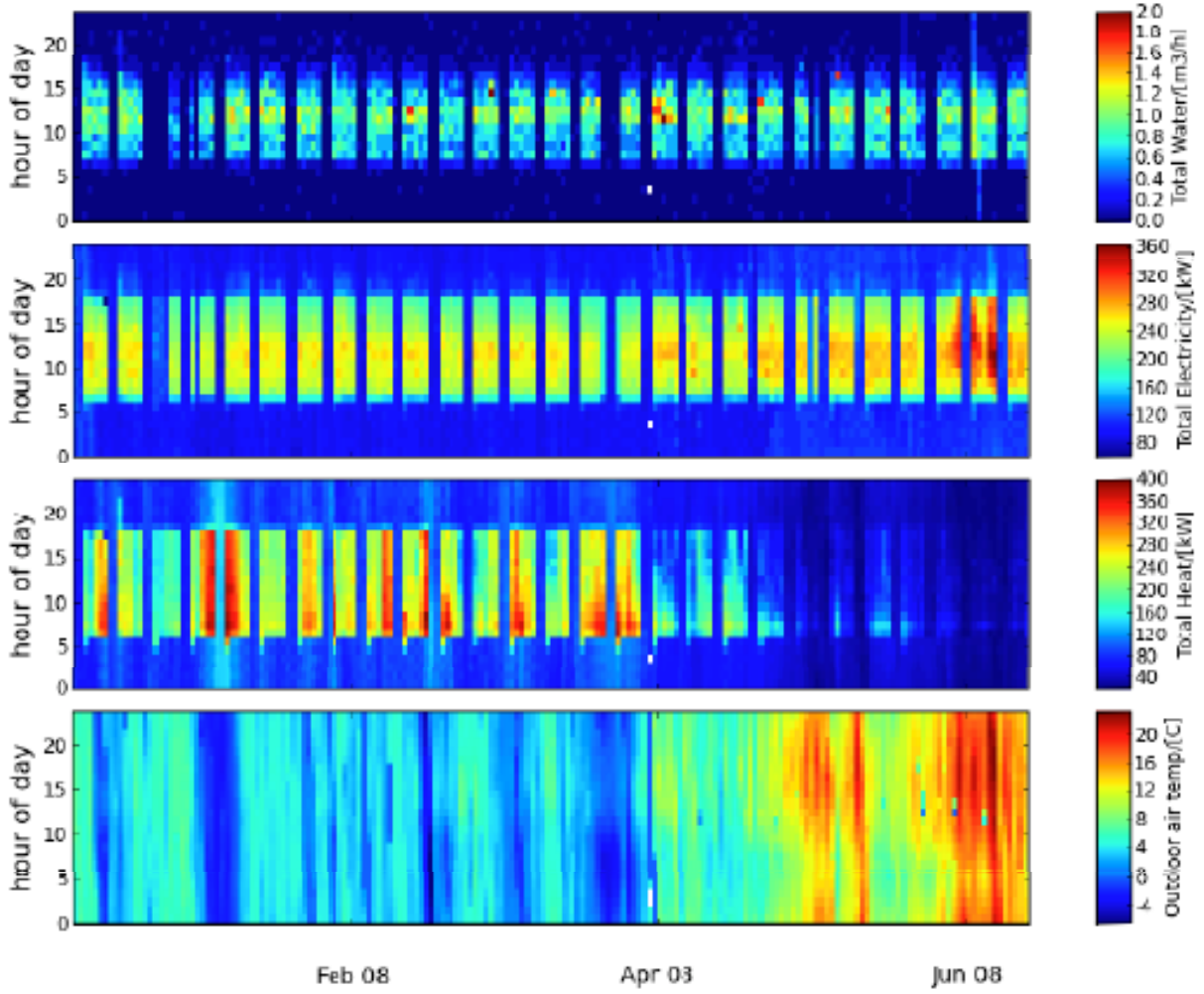
'detailed building plot', this week's consumption plotted against the previous week, with min, max, avg demand

student trials IDed excessive ventilation ops and over illumination

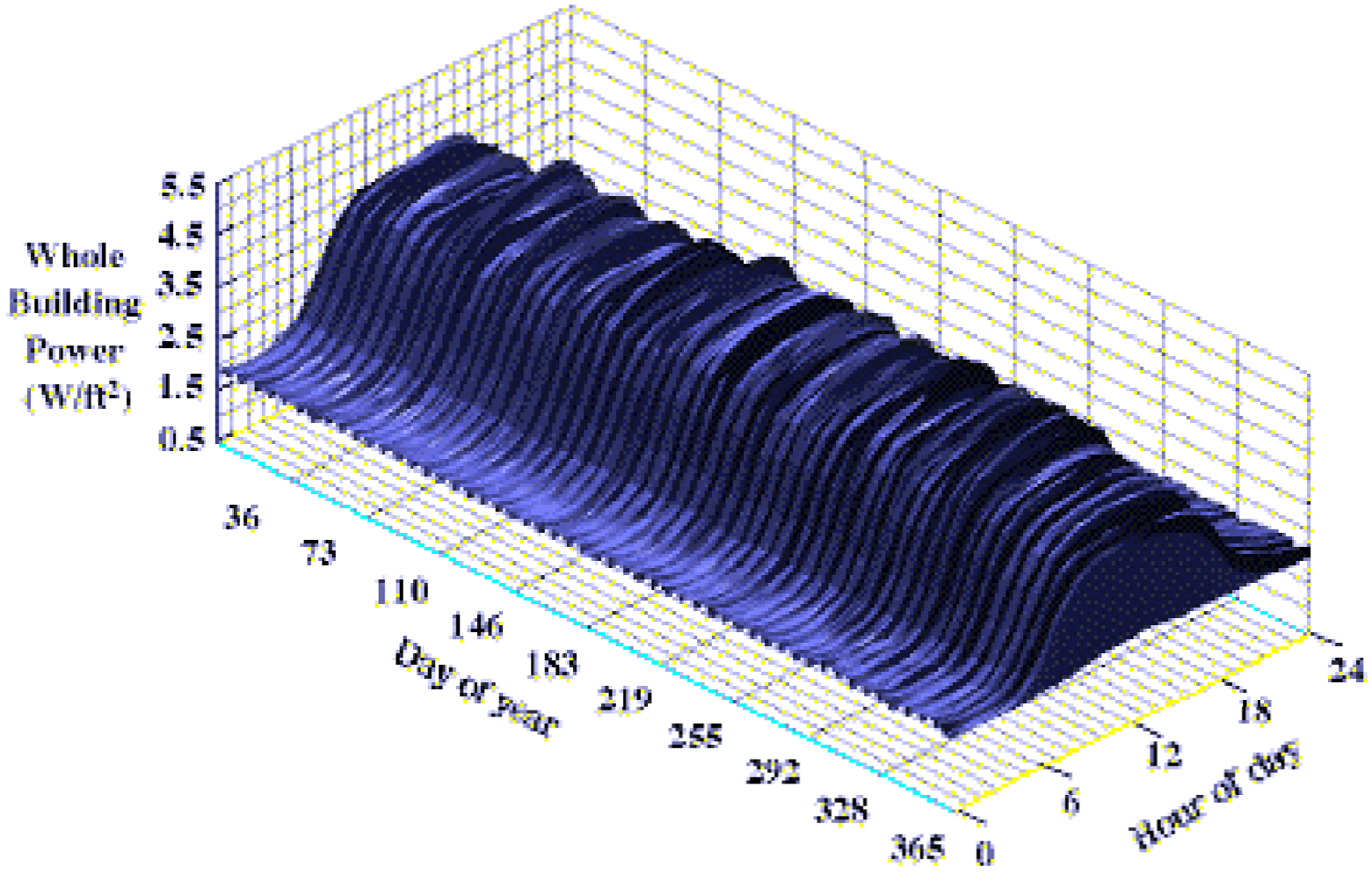
ventilation was reduced 6h, lighting retrofit conducted, resulting in a 30% reduction in total energy use



Color-coded floor map of current use relative to YTD average (Enernoc)



Carpet/raster plot: water, electric, heating load, outside air temp (BuildingEQ Project)



3D Load profile for a Northern CA office building

Dashboard view of critical HVAC performance indicators for a hospital surgery room

Remaining Questions and Future Work

- How can tools such as EIS be specified and selected?
- What analyses are useful and what data is required?
- What are the expected costs and benefits of the technology?
- What organizational practices will ensure maximum impact?

- Develop an EIS guide specification
- Develop a handbook of analysis methods
- Conduct a large-scale generalizable analysis
- Identify business processes to institutionalize the use of energy information

Thank you for your attention!

Questions?