Low-Cost, Monitoring-Based Commissioning for Small- to Mid-Sized Commercial Buildings

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AIA Quality Assurance

Learning Objectives

1. The significant, yet untapped commissioning opportunities in the small to medium sized existing building market

1. Challenges in delivering existing building commissioning services to this market

1. Technology, resources and processes which enable an innovative, low-cost commissioning approach on existing buildings

1. Quantifying the energy savings associated with commissioning efforts for the existing building market

Agenda

- Overview of energy savings program approaches
- MBCx Savings Summary
- Low-Cost MBCx
  - What's Different?
  - Process Overview
- EIMS functionality used for MBCx
- Utility Incentives
- Questions

Focus of Energy Savings Programs

Primary goals of energy-related program activity are to identify and implement energy savings measures that:

- **SAVE MONEY!!**
- **Persist over time**
- **Can be quantitatively measured**
- **Contribute to the overall "building mission"**
    - Enhance safety/security
    - Improve sustainability
    - Bring equipment to its proper operational state
    - Reduce tenant complaints
    - Decrease equipment life-cycle costs
    - Improve indoor air quality
    - Improve tenant satisfaction
    - Enhance facility operation and maintenance

Generate Energy Savings Measures (ESMs)

Various methods are used:

- Engineering Evaluations/Retrofits
  (Including Performance Contracting)
- Tune-Ups
- Retro-Commissioning
- Monitoring-Based Commissioning (MBCx)
- Many more unique and/or hybrid approaches that combine parts of the above methods…and/or add to them.

Engineering Evaluations/Retrofits

A capital, project-based approach to ESMs. Projects usually consist of the following three activities:

- Engineering analysis of the energy use characteristics of equipment, systems, processes and buildings.
- Designing/assessing equipment replacement and upgrade strategies.
- Managing the construction project to implement the upgrades.

Step 2.5 is typically: Funding!

Capital improvements can take a variety of forms—customer funded, performance contract, utility incentives, etc.

Retro-Commissioning (RCx) [PECI]

- Retro-commissioning (RCx) is a systematic, documented process (event) that identifies low-cost operational and maintenance improvements in existing buildings and brings the buildings up to the design intentions of its current usage.

- RCx typically focuses on energy-using equipment such as mechanical equipment, lighting and related controls and usually optimizes existing system performance.

- Although RCx may include recommendations for capital improvements, the primary focus is on using O&M improvement, activities and diagnostic testing to optimize the building systems.

Building Tune-Up [PNNL]

- An event with the goal to improve the building's energy efficiency through low-cost and no-cost operational improvements (mostly control changes).
- Implemented primarily through the building control system, generally at no cost other than the labor required to perform the tuning process.
- Recommendations and analysis typically rely on a building audit/survey and short-term monitoring (AKA "Trending") using building control system.

More detailed monitoring than typically done during RCx.

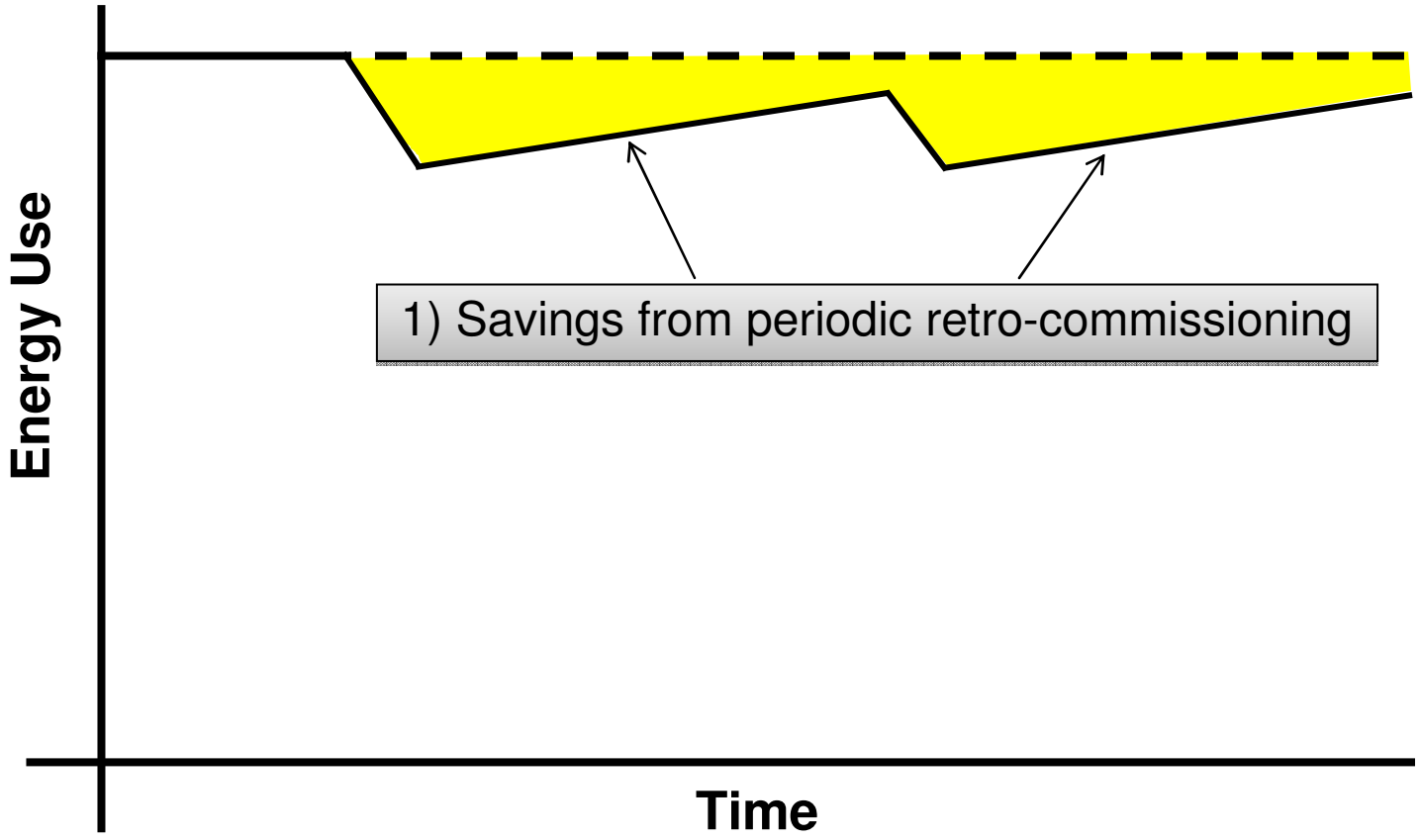
Monitoring-Based Commissioning [LBNL]

- Monitoring-based commissioning (MBCx) is a continuous process that combines ongoing building energy system monitoring (Tune-Up) with standard RCx practices with the aim of providing substantial, persistent, energy savings.

- There are three primary streams of additional energy savings from MBCx relative to RCx alone:

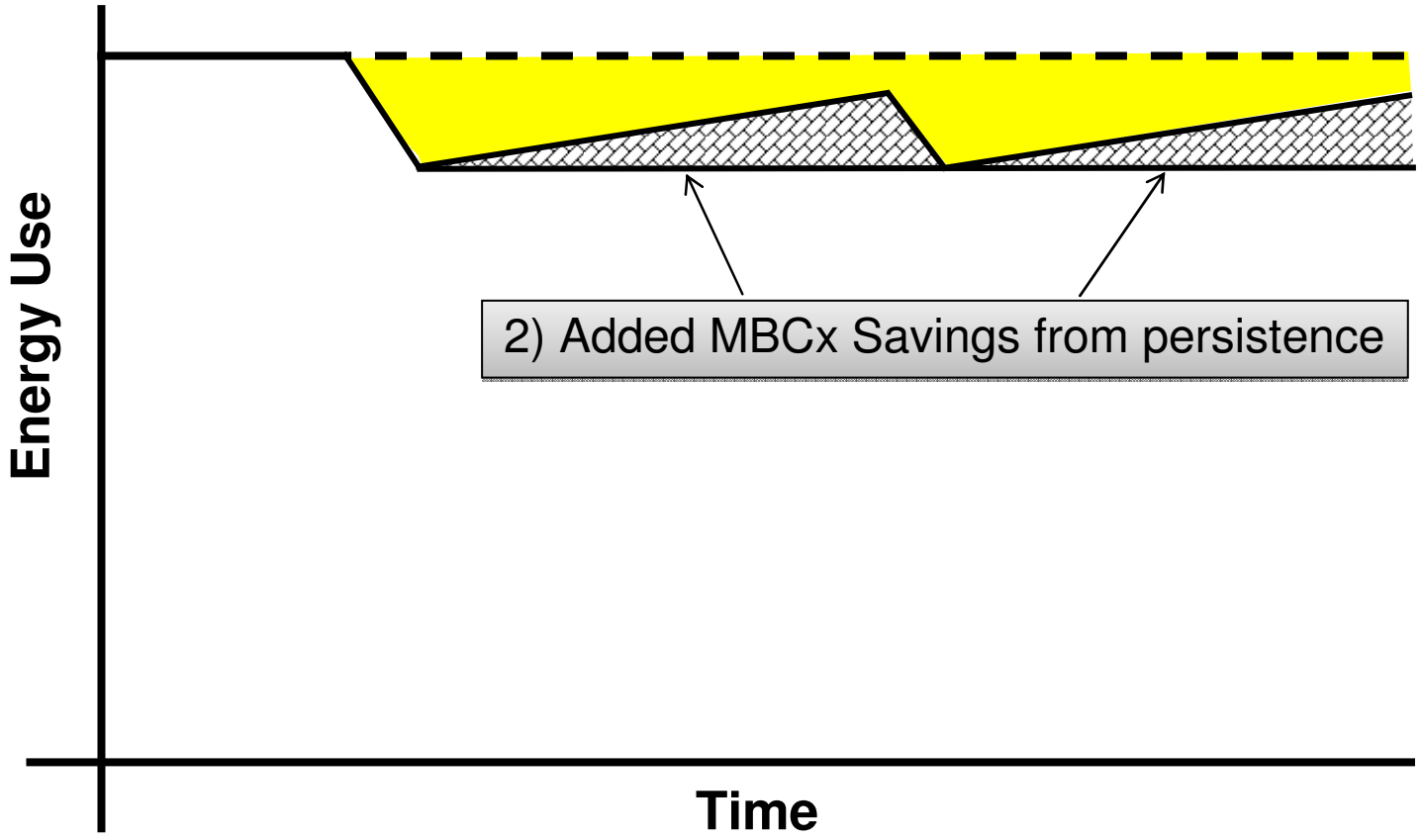
    1. Savings from persistence and optimization of savings from RCx
    2. Savings from measures identified through metering and trending (Tune-up)
    3. Continually identified new measures

Additive Savings for MBCx—RCx



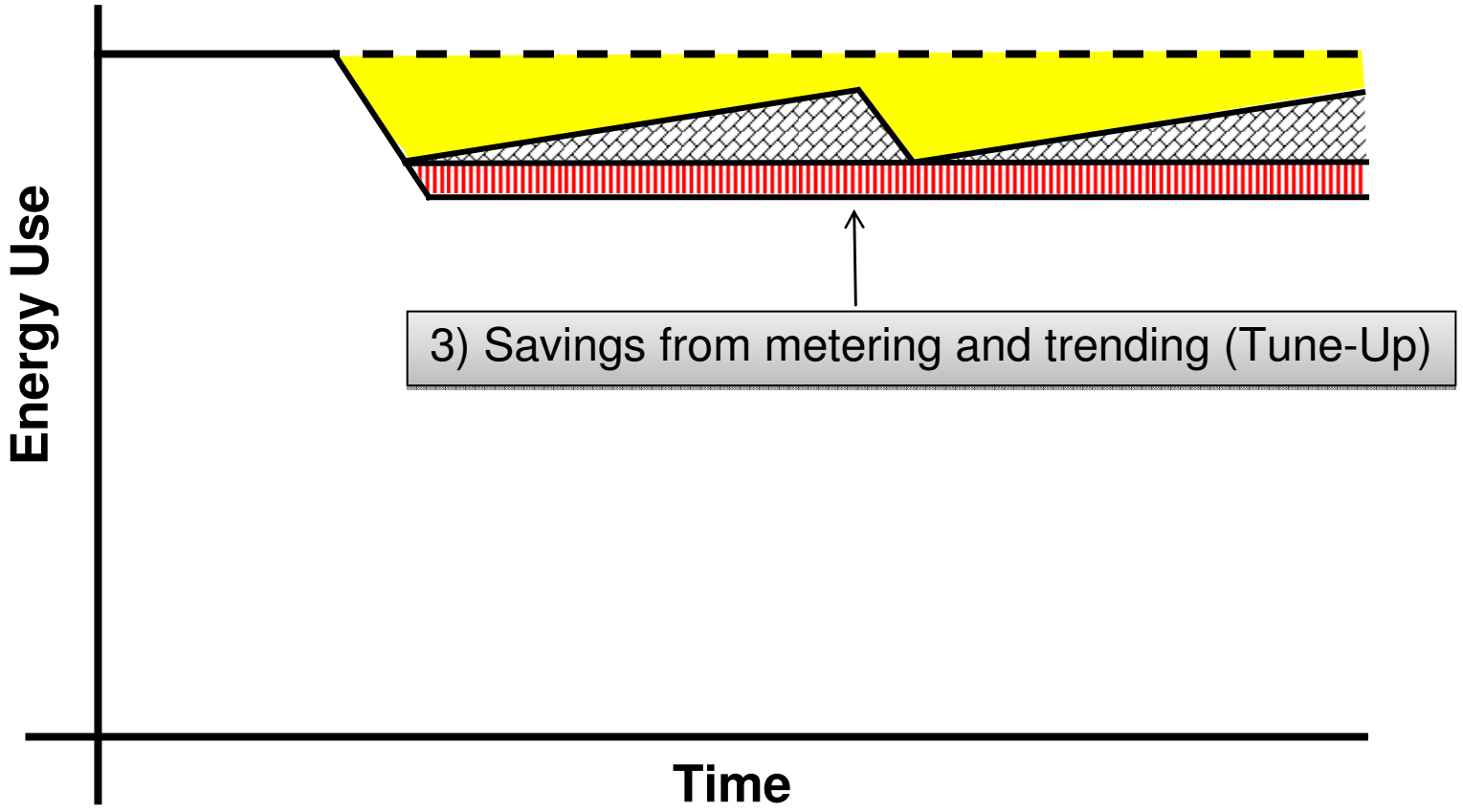
Source: LBNL-1972-E. "Monitoring-Based Commissioning: Benchmarking Analysis of 24 UC/CSU/IOU Projects

Additive Savings for MBCx—Persistence



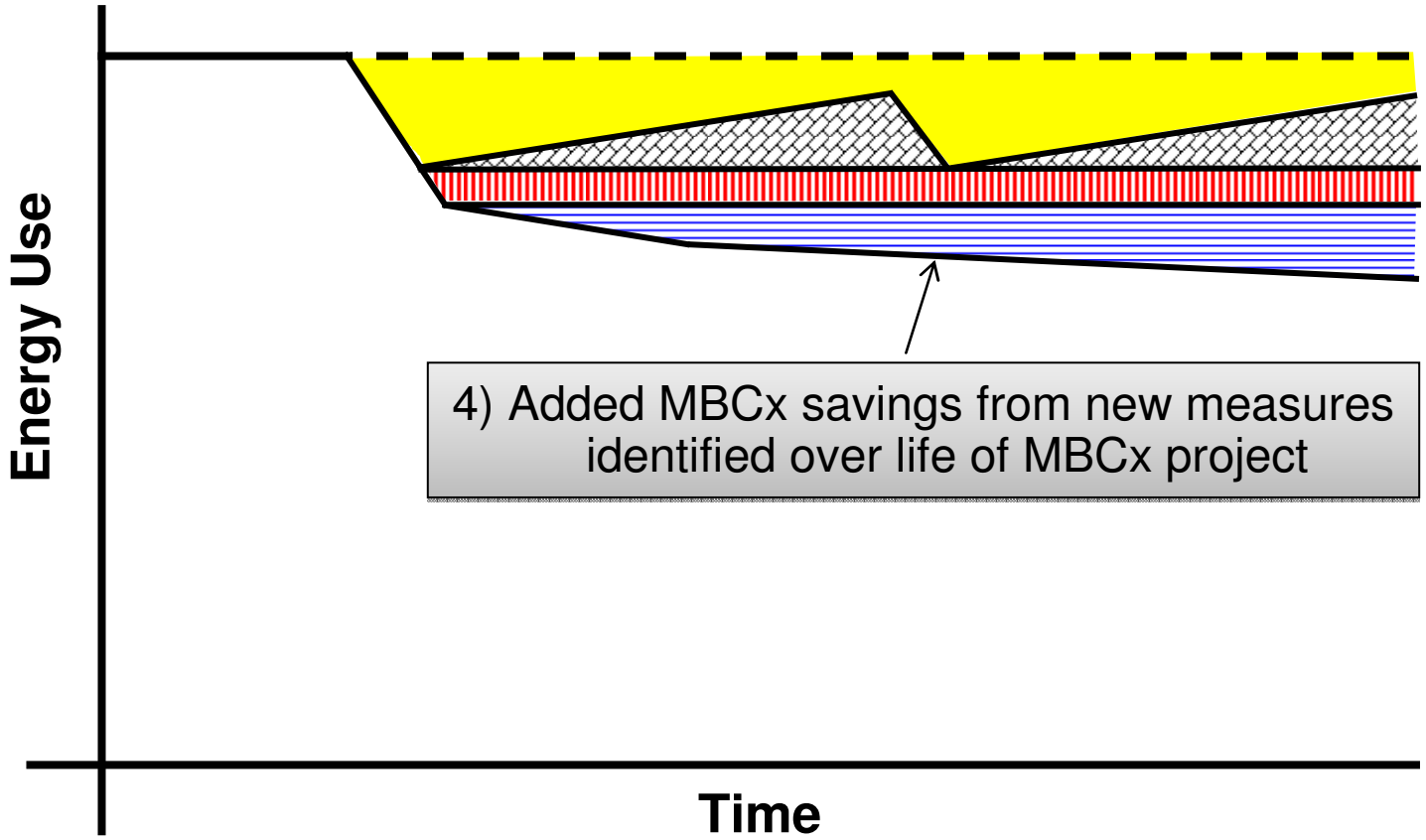
Source: LBNL-1972-E. "Monitoring-Based Commissioning: Benchmarking Analysis of 24 UC/CSU/IOU Projects

Additive Savings for MBCx—Trending/Metering



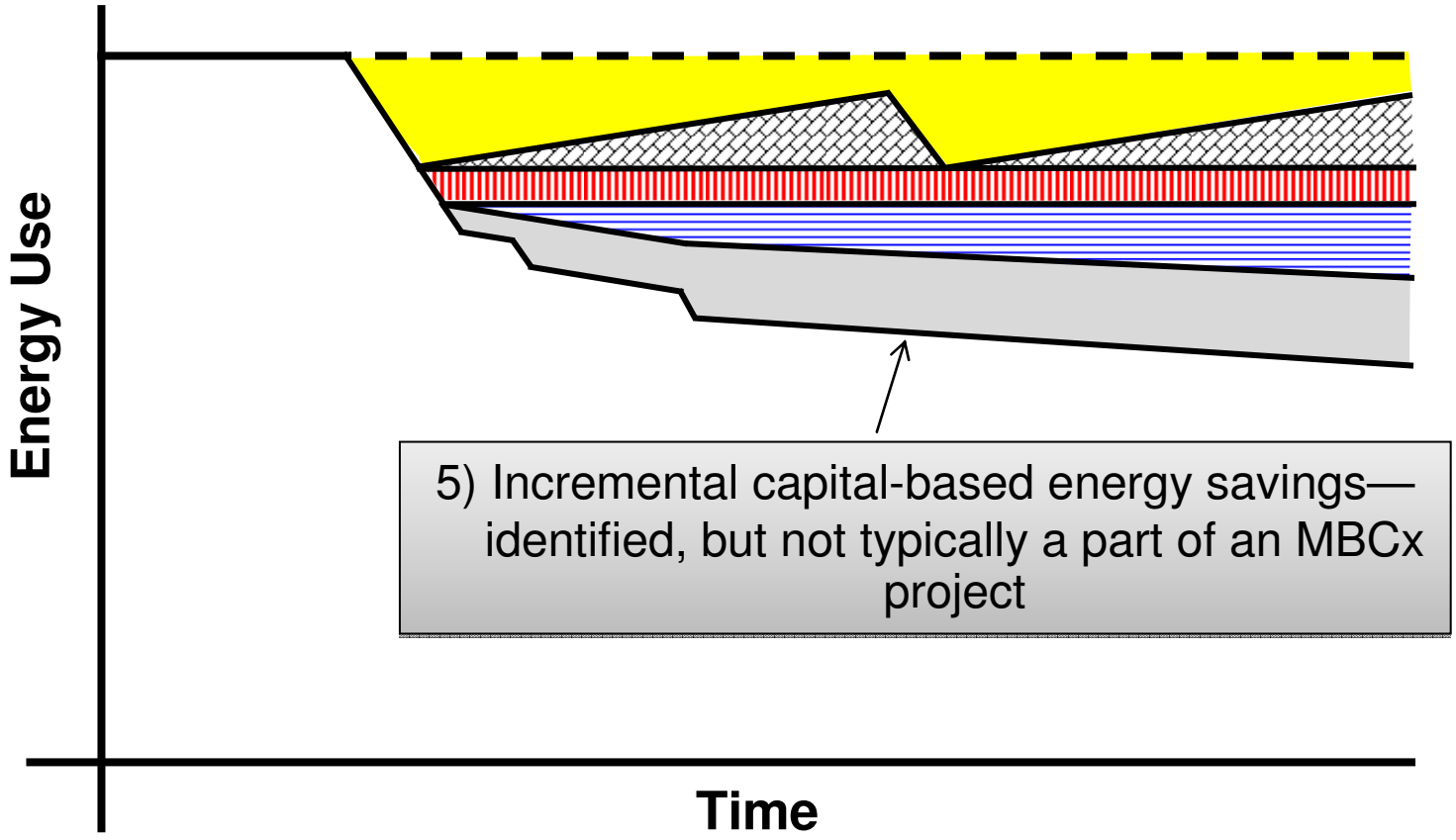
Source: LBNL-1972-E. "Monitoring-Based Commissioning: Benchmarking Analysis of 24 UC/CSU/IOU Projects

Additive Savings for MBCx—New Measures



Source: LBNL-1972-E. "Monitoring-Based Commissioning: Benchmarking Analysis of 24 UC/CSU/IOU Projects

Additive Savings for MBCx—Capital Projects



Source: LBNL-1972-E. "Monitoring-Based Commissioning: Benchmarking Analysis of 24 UC/CSU/IOU Projects

Primary MBCx Issue

MBCx appears to have many benefits, yet it is still not common. So, what's the catch…?

It isn't cheap! Where does the cost come from?

- Data Collection and Analytics (ongoing)
  - Detailed submetering and/or BMS Interface
  - Energy Information Management System
- People/Labor:
  - Intensive onsite visits/audits (days or weeks per location)
  - Analysis of hundreds/thousands of data streams
  - Project management, training, reporting, etc.

Low-Cost Approach to MBCx

NorthWrite MBCx:

Innovative, low-cost approach to provide monitoring-based commissioning.
Ideally suited to small- and medium-size commercial buildings, but applicable to all building sizes.

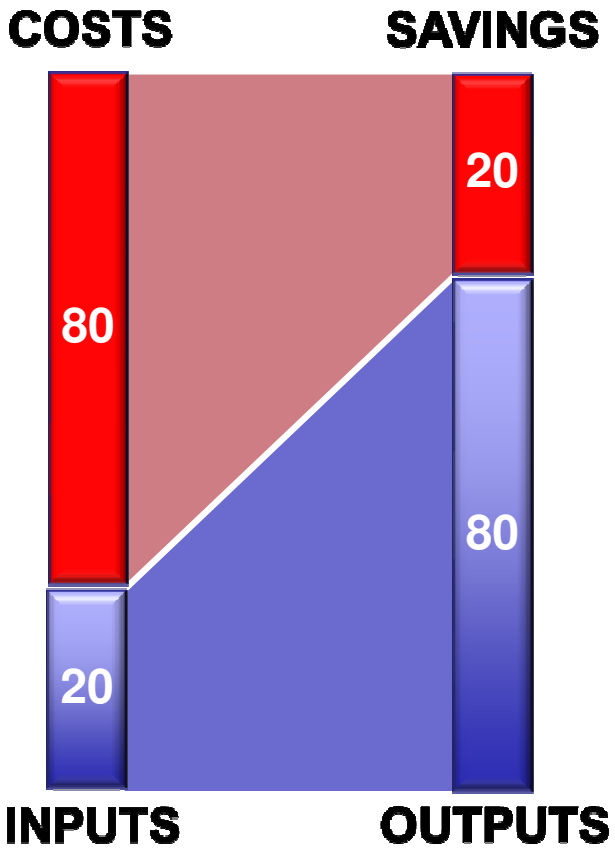
Target for a typical building is:

10-20% Energy Savings

Pareto Principle

20% of the effort in MBCx produces 80% of the results*

So, which 20%....?

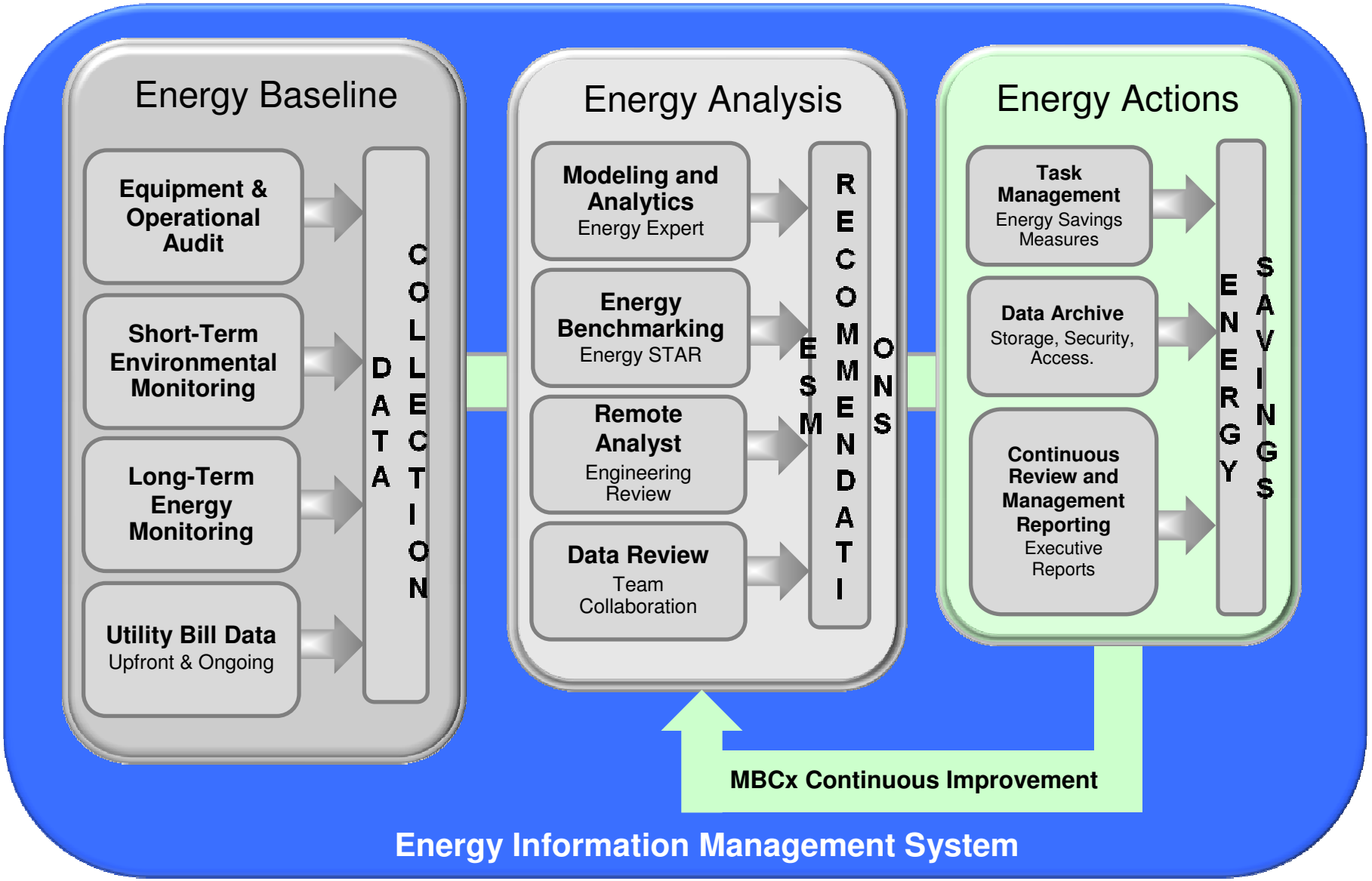


*Based on approximately 1,000 buildings where we've applied this approach

Innovation – Low-Cost MBCx

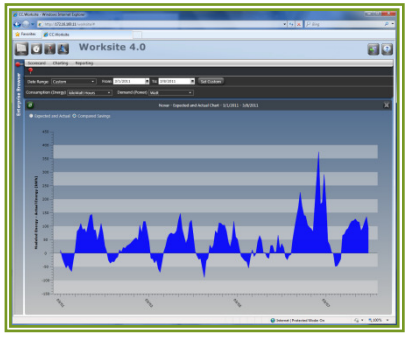
	Traditional MBCx		NorthWrite MBCx
	Detailed submetering	✓	Whole-building metering (Wireless)
	BMS interface	✓	Periodic portable environmental monitoring (Wireless)
	Continuous analysis of hundreds/thousands of data streams	✓	Periodic analysis of several dozen data streams
	Extensive onsite surveys/audits	✓	Web-based surveys/audits
	"Best effort" ESM implementation	✓	Automated ESM tracking with alerts/escalation
✓	Energy information management system	✓	Energy information management system

Process Flow Diagram



Process—Long-Term Energy Monitoring

- Whole-building, meter-based interval data used for:
  - Initial Assessments
  - On-going M&V/persistence tracking
- System comprised of:
  - Web-based/wireless monitoring hardware
  - Power meter (or pulse output)
  - EIMS



EIMS Software

Wireless Data Logger

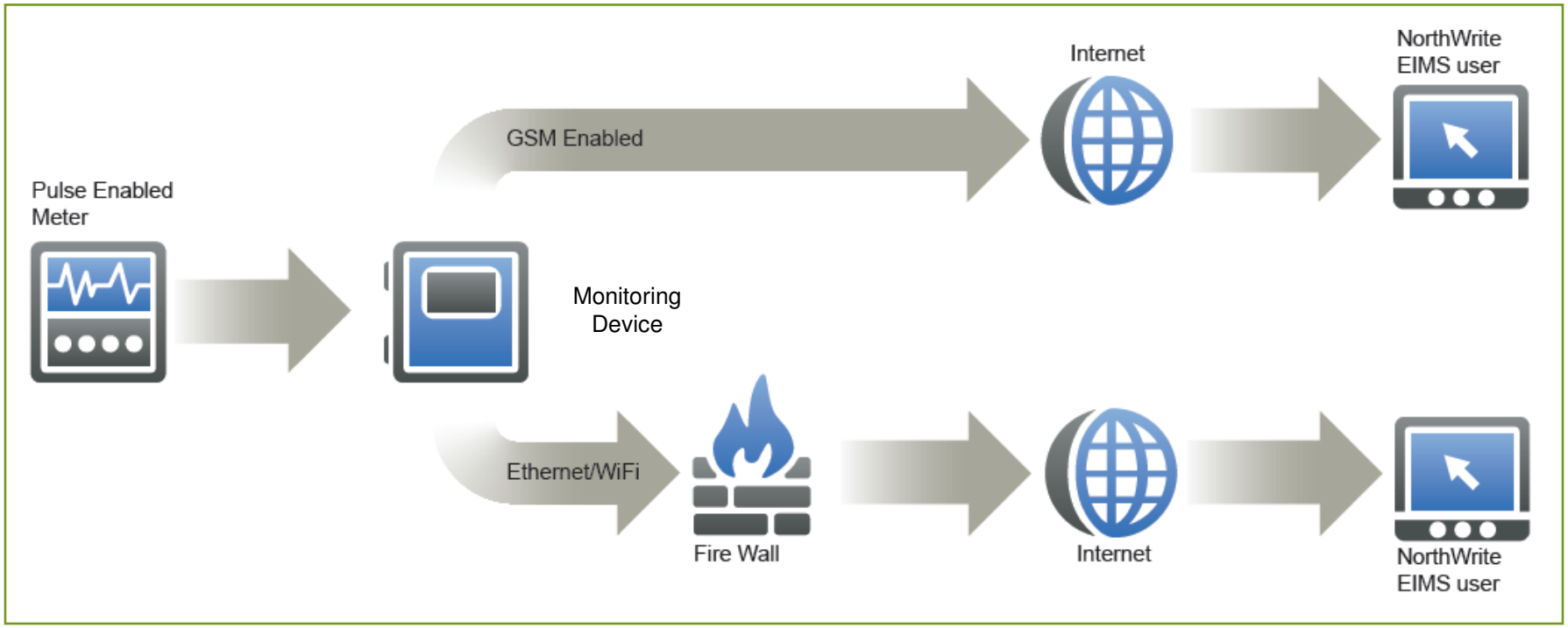
Pulse Output/Power Meter

Hardware

Process—Long-Term Energy Monitoring

Typical Meter Data Flow

Other mechanisms are available (e.g. FTP, XML, etc.)



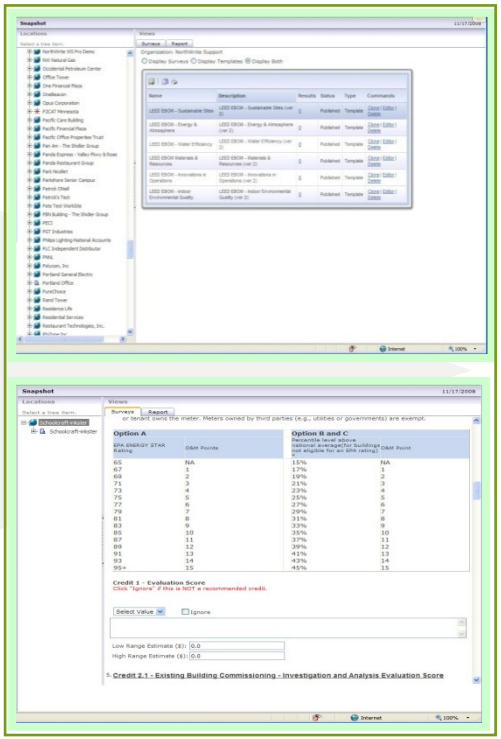
Process—Short-Term Environmental Monitoring

- Frequency
  - At program launch
  - As needed (seasonal variations, troubleshooting, etc.)
- Collected data used for:
  - Evaluating “as is” operation of building
  - Primary input used to generate recommended ESMs
- System comprised of:
  - Wireless “satellites” that monitor:
    - Temperature
    - Lighting Level
    - Humidity
    - CO2
  - Cellular gateway for local and long distance communications (real-time data collection)

Process—Equipment/Operational Audit

Basic Information

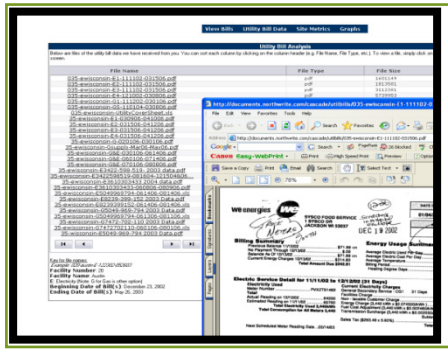
- Square Footage
- Building Type
- HVAC Equipment
- Lighting
- Controls
- Misc. Equipment
- Operational Info
- Schedules
- More…



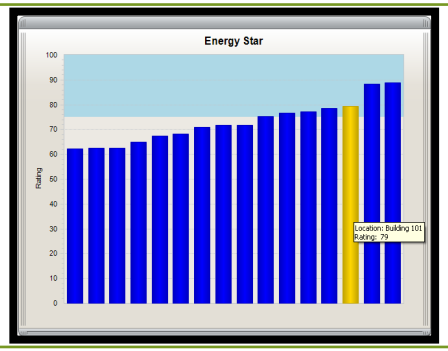
SnapShot Online Survey Application

Process—Utility Bill Data*

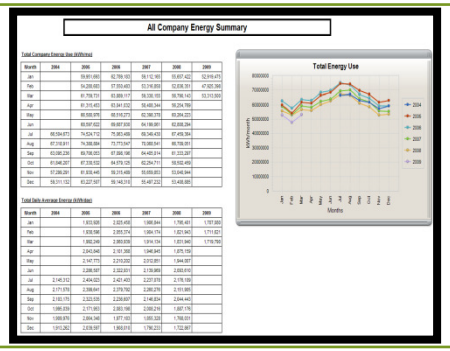
- Data Entry of Utility Bills
- Energy Star Benchmarking
- Utility Bill Manager Tool
- Supports Various Benchmarking Metrics



Data Entry



Energy STAR Benchmarking



Utility Bill Management Tool

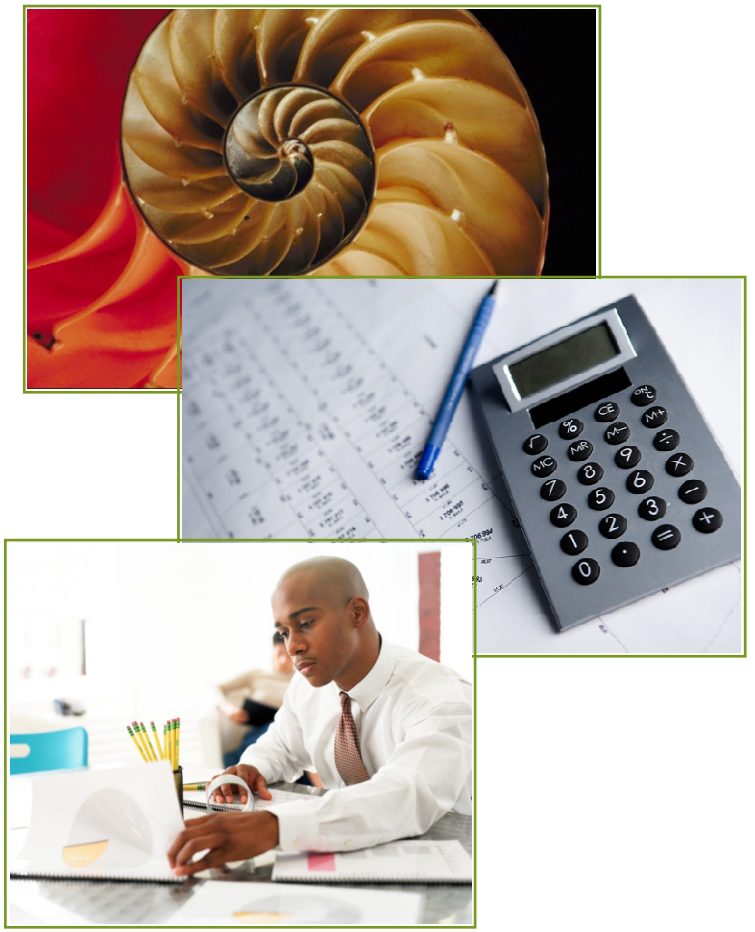
Portfolio Benchmarking

*2-years historical and ongoing throughout life of project

Process—Expert Analysis/Recommendations

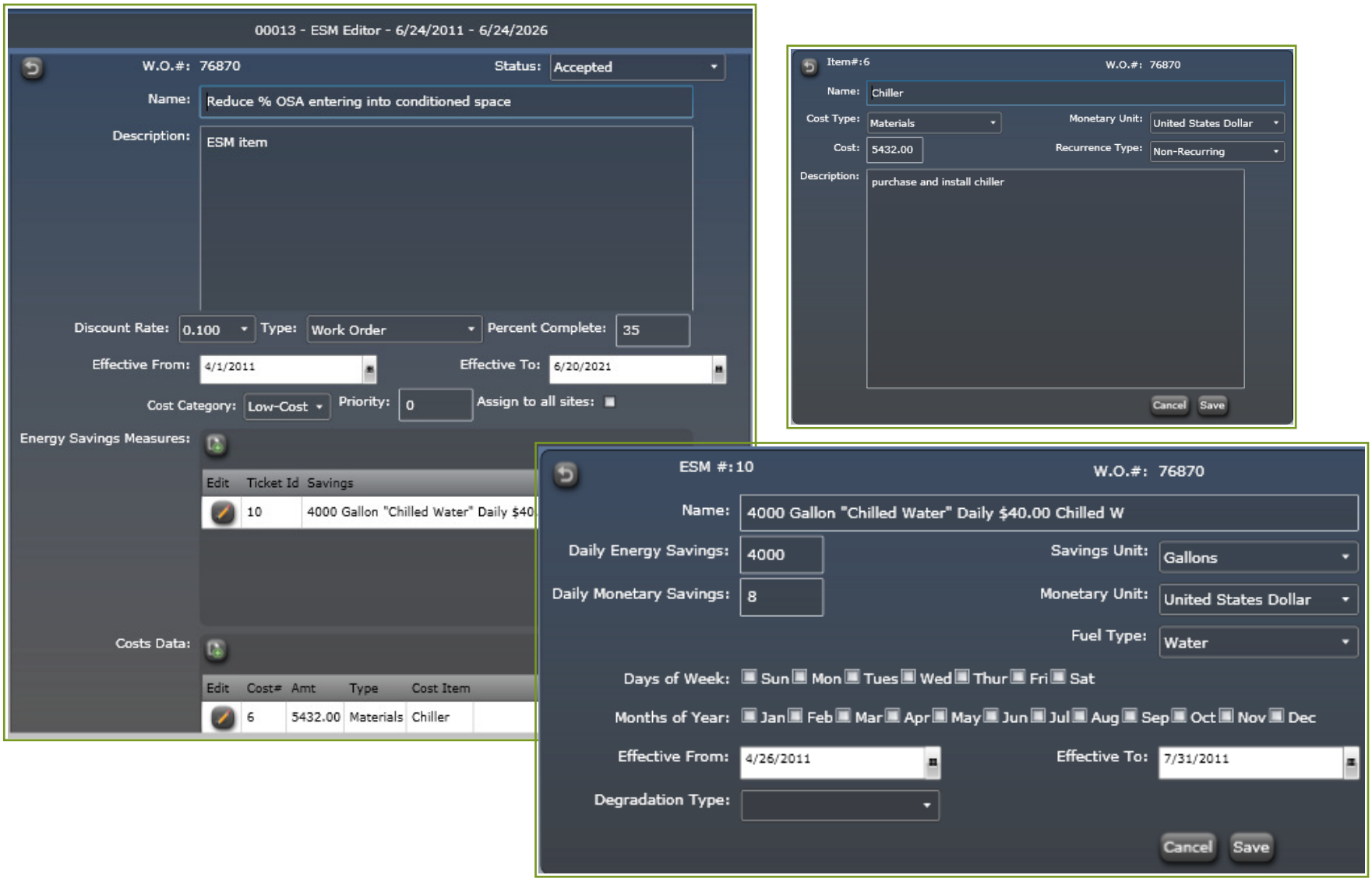
- Recommendations are submitted to customer via “Energy Savings Measures” software tool
- Customer/analyst interact via EIMS
- User activity is tracked/logged
- Users receive notifications (text messages, email, etc.)

- Each ESM includes the following:
  - Estimated energy, demand and cost savings
  - Cost to implement (materials/labor/etc.)
  - Persistence of measure
  - Degradation of measure
  - Recurring measure? Schedule if so.
  - Measure cost category (capital, no-cost, etc.)
  - Discount rate for the category of ESM

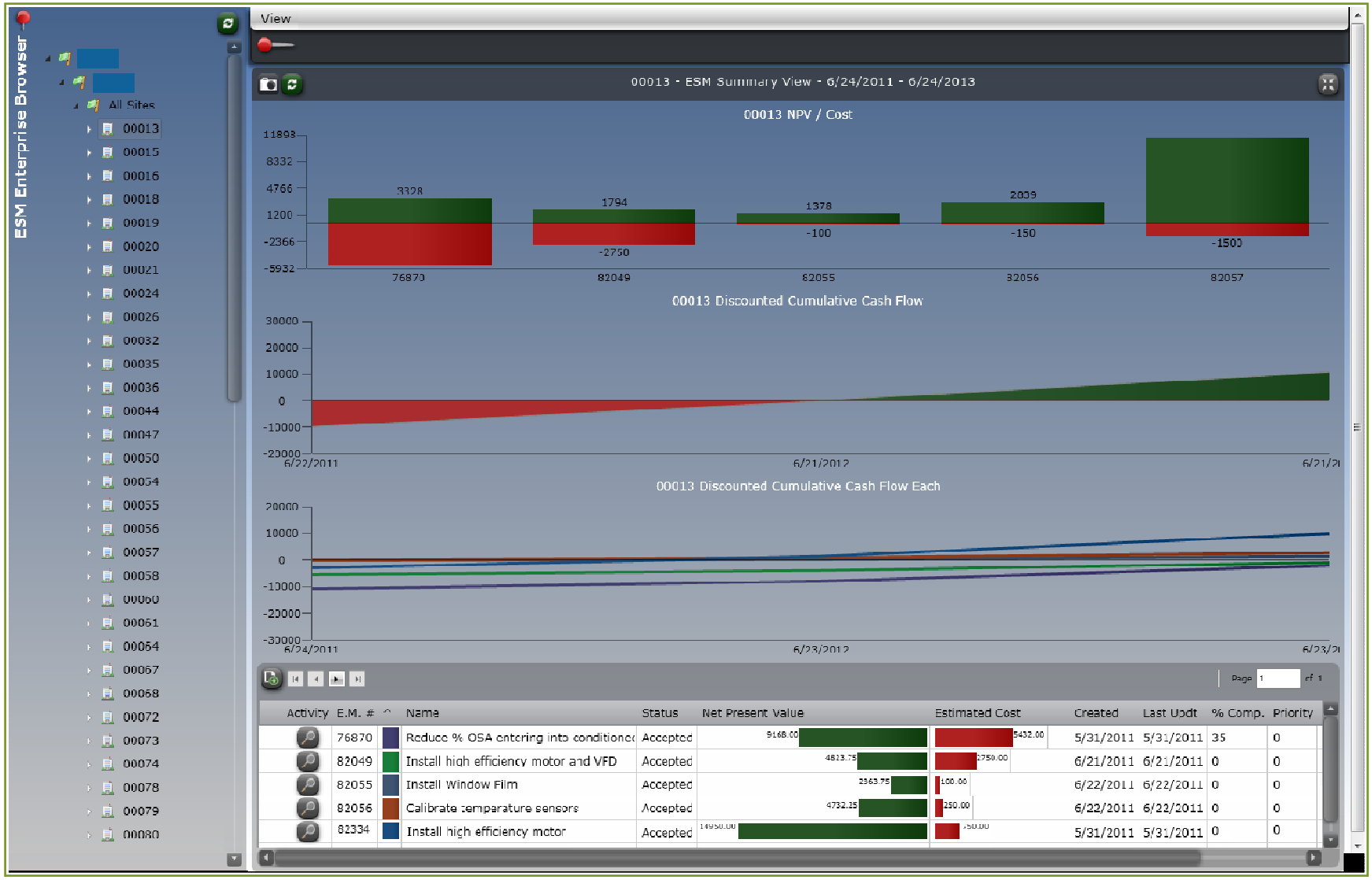


Analyst uses collected data, EIMS tools and simulation model to create recommended measures, energy savings estimates, and enters them into the EIMS.

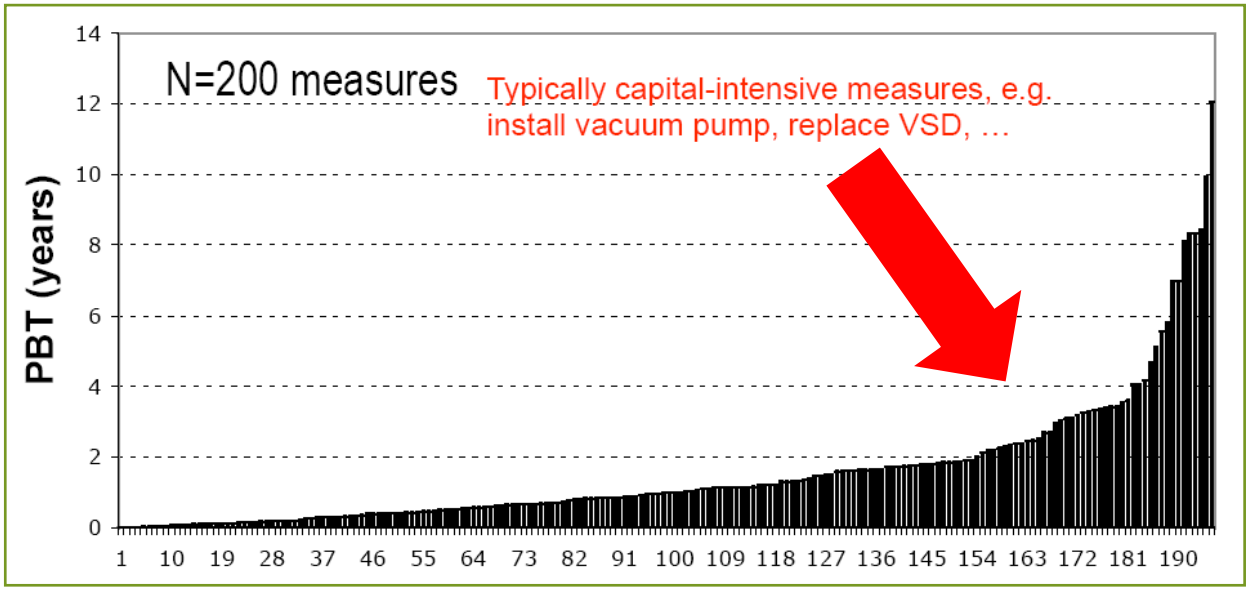
EIMS—EMS Setup

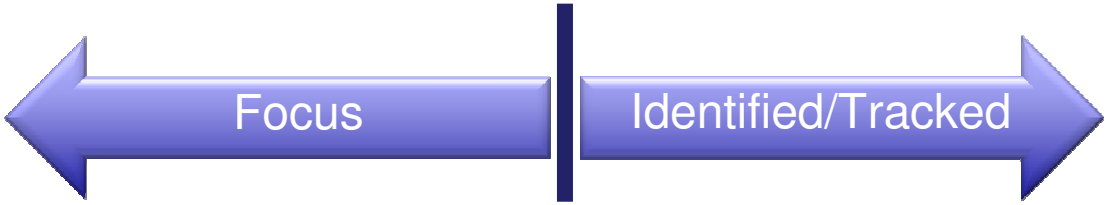


EIMS—Energy Savings Measures (Summary)



Paybacks for Energy Savings Measures





Source: US DOE, CEC

“Typical” Energy Savings Measures

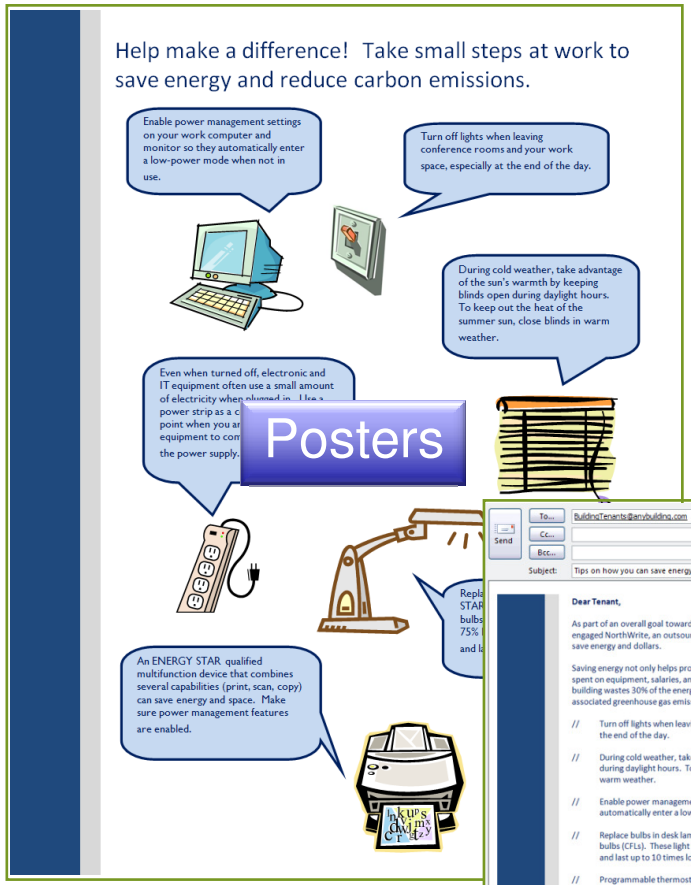
Example Energy Savings Measures:

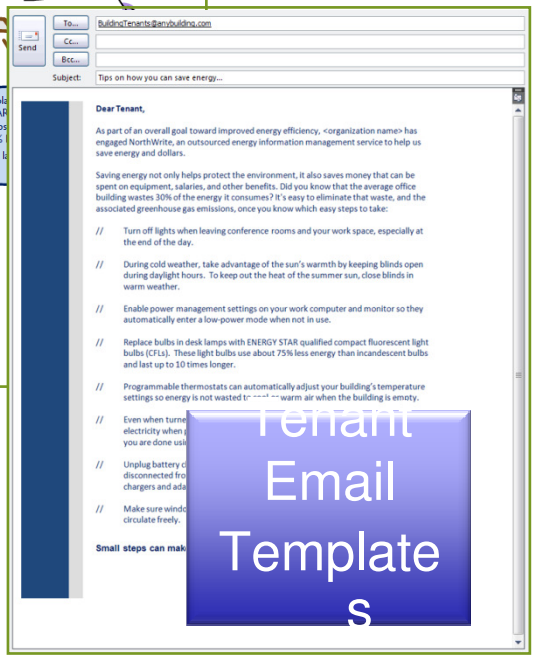
1. Optimize start-up time and equipment scheduling
2. Coast the last hour of operation
3. Outside air temperature lockout
4. CW/HW supply resets
5. Supply air resets
6. Economizer tune ups
7. Lighting occupancy sensors
8. Daylight control on perimeters
9. Adjust dampers
10. Adjust ventilation
11. Static pressure reset
12. Adjust temperatures
13. Calibrate thermostats
14. Equipment tune ups
15. Etc.

+

Behavior-Based Recommendations

Behavior-Based ESMs





Energy Kiosk

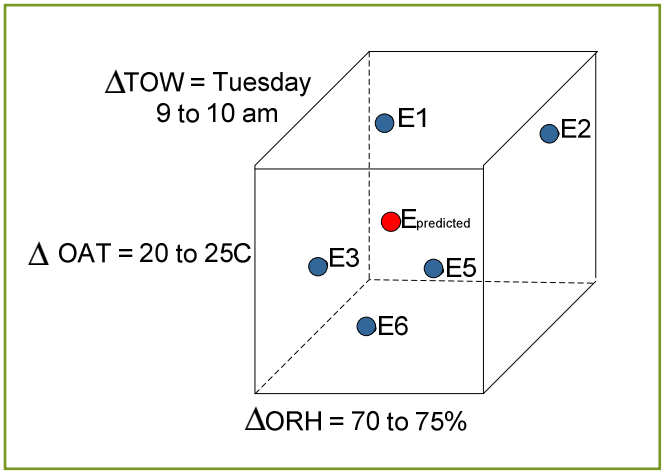
- Energy Information is visible and intuitive
- Forum for communicating with employees, visitors, etc.
- Foster friendly competition
- Get public recognition for your energy programs
- Increase energy savings through awareness

Energy Prediction Model

Data fusion engine used for predicting energy use and tracking/verifying savings.

Technology developed by:

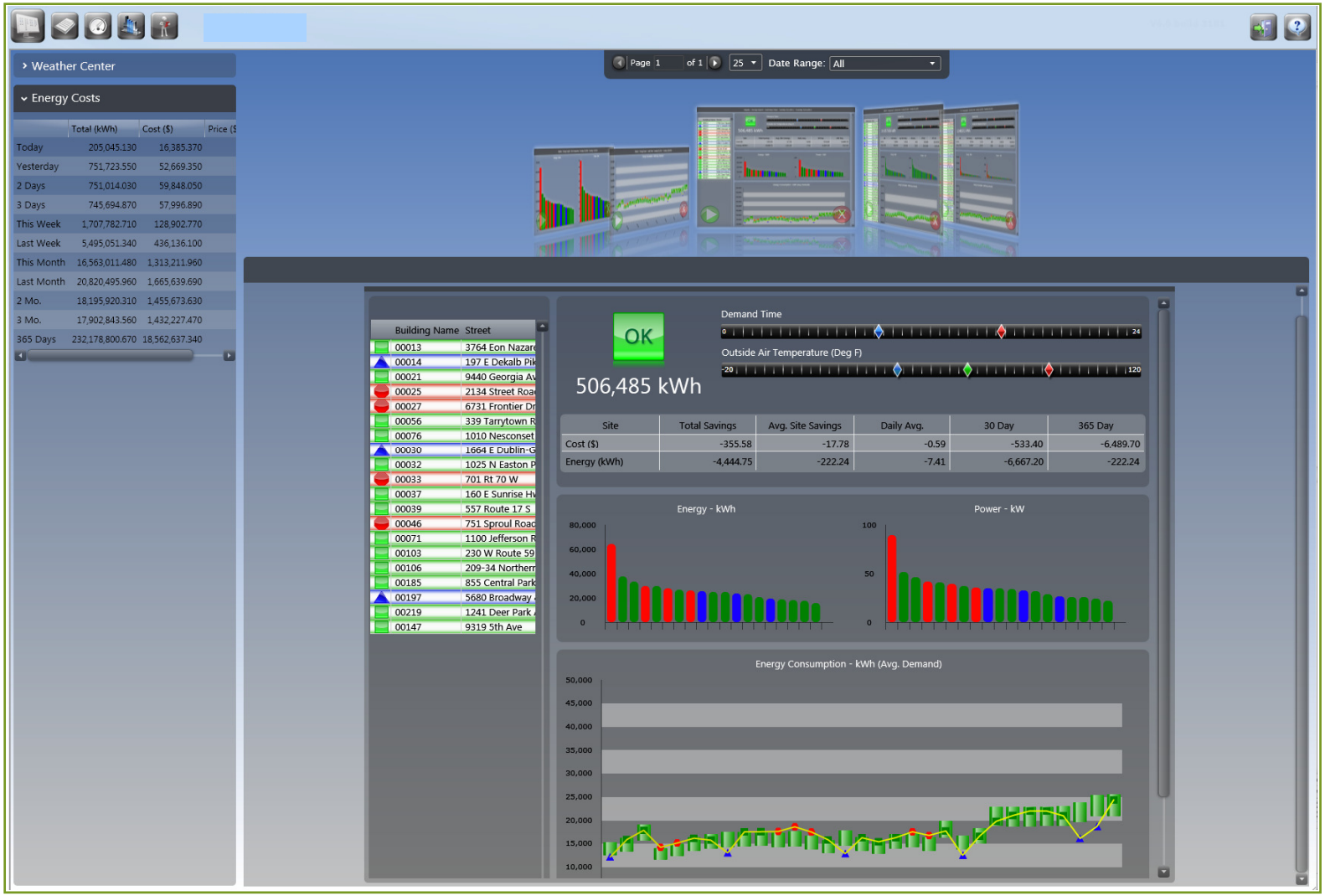
- U.S. Department of Energy and
- Pacific Northwest National Laboratory



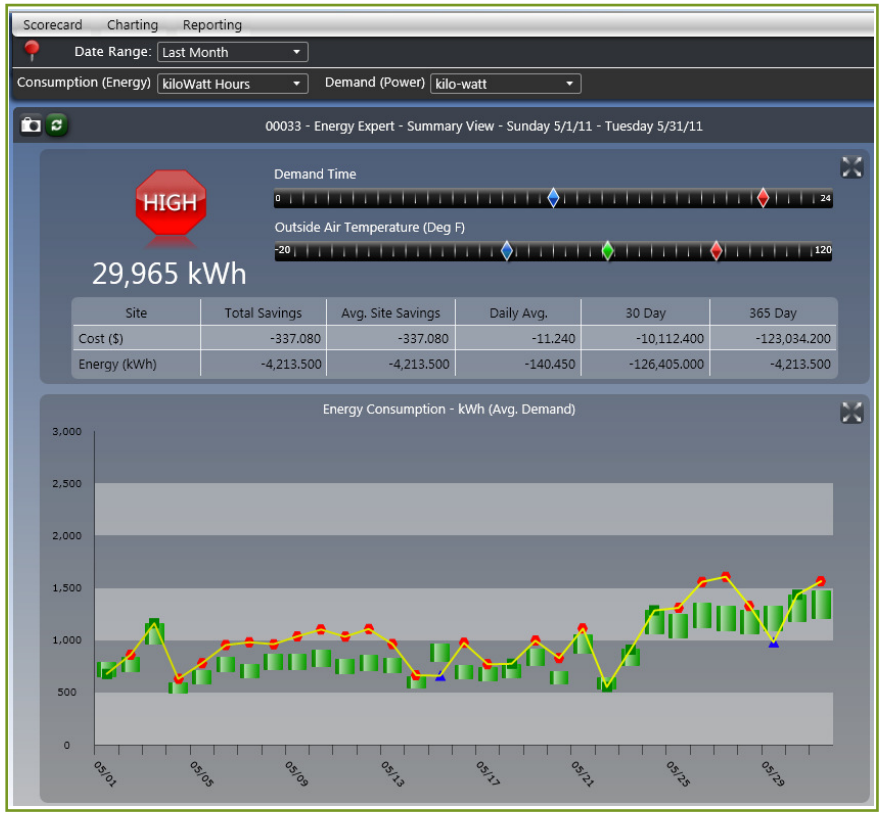
Energy Prediction Model Attributes

- Model assigns a representative value of the dependent variable to each bin defined by ranges of values of the independent (explanatory) variables—$E_{predicted}$
- Effectively identifies energy efficiency degradation
- Controls for impact of variations in explanatory variables
- Flexible: explanatory variables can be customized to a building's unique characteristics and use
- Can be trained with historical data sets or while data is collected in real time
- Bin sizes are adjustable and can be used to tune the model
- Captures both linear and non-linear relationships

EIMS—Energy Dashboard (Portfolio)

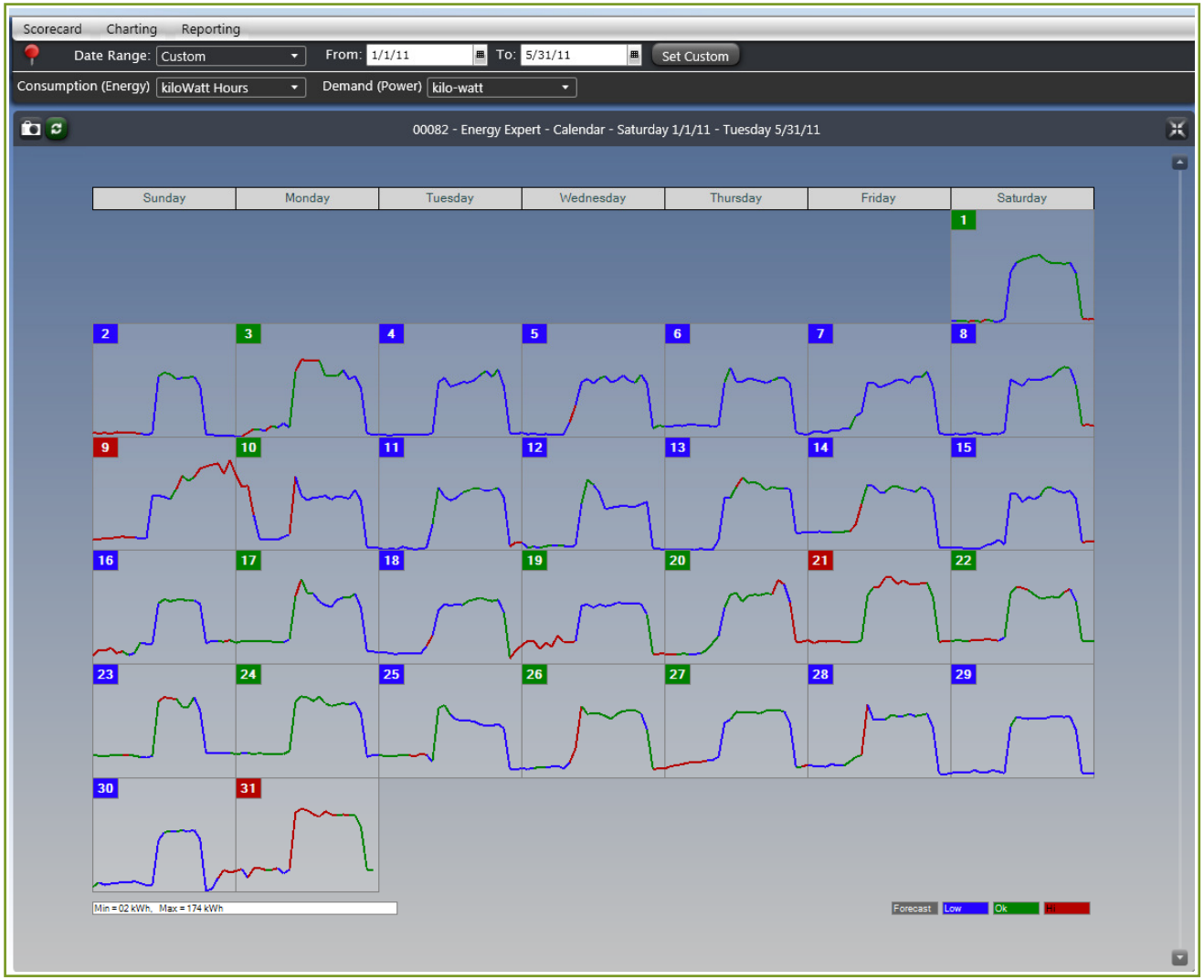


EIMS—Energy ScoreCards (One Month)

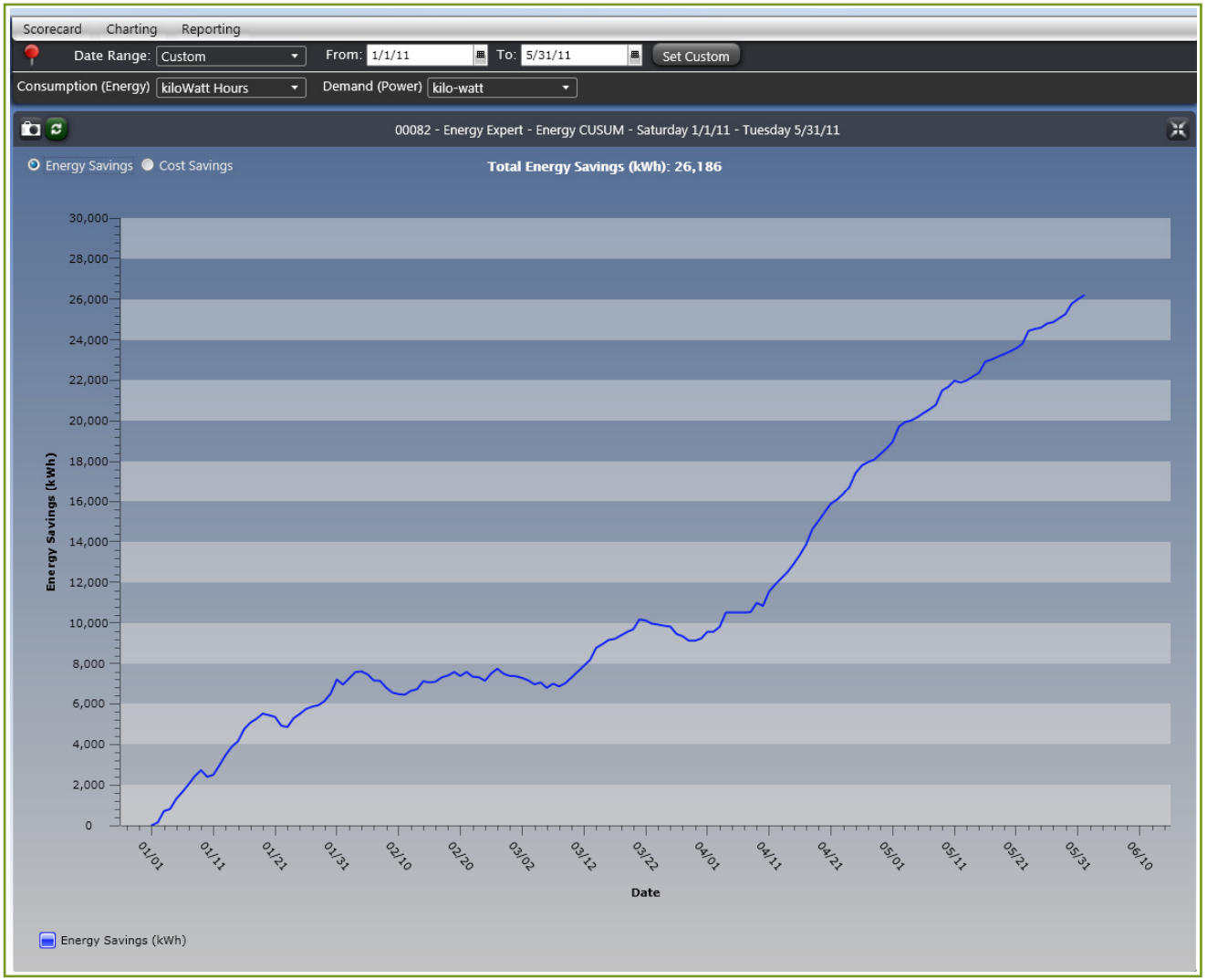


EIMS—Energy ScoreCards (One Day)

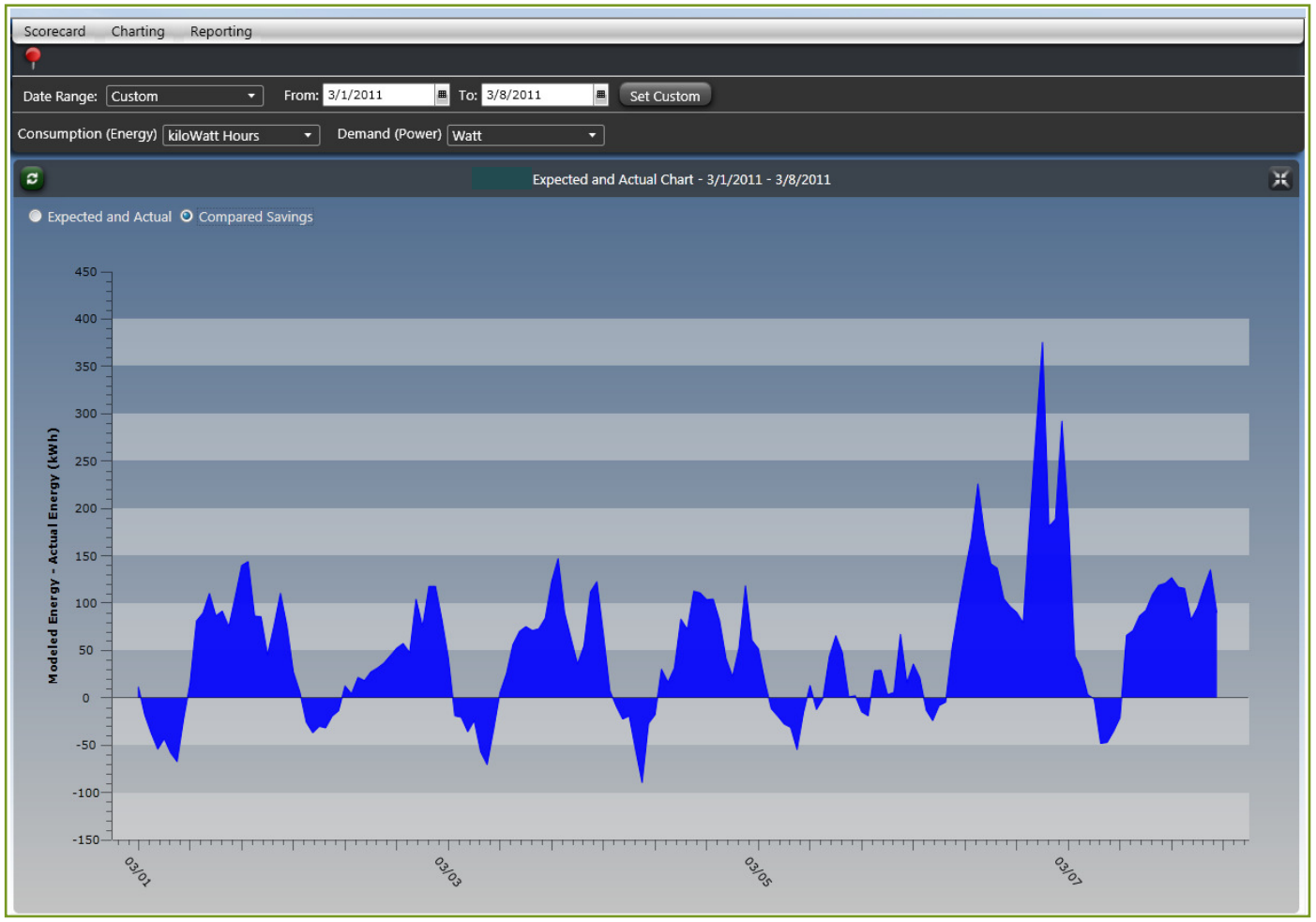
EIMS—Load Profile Calendar



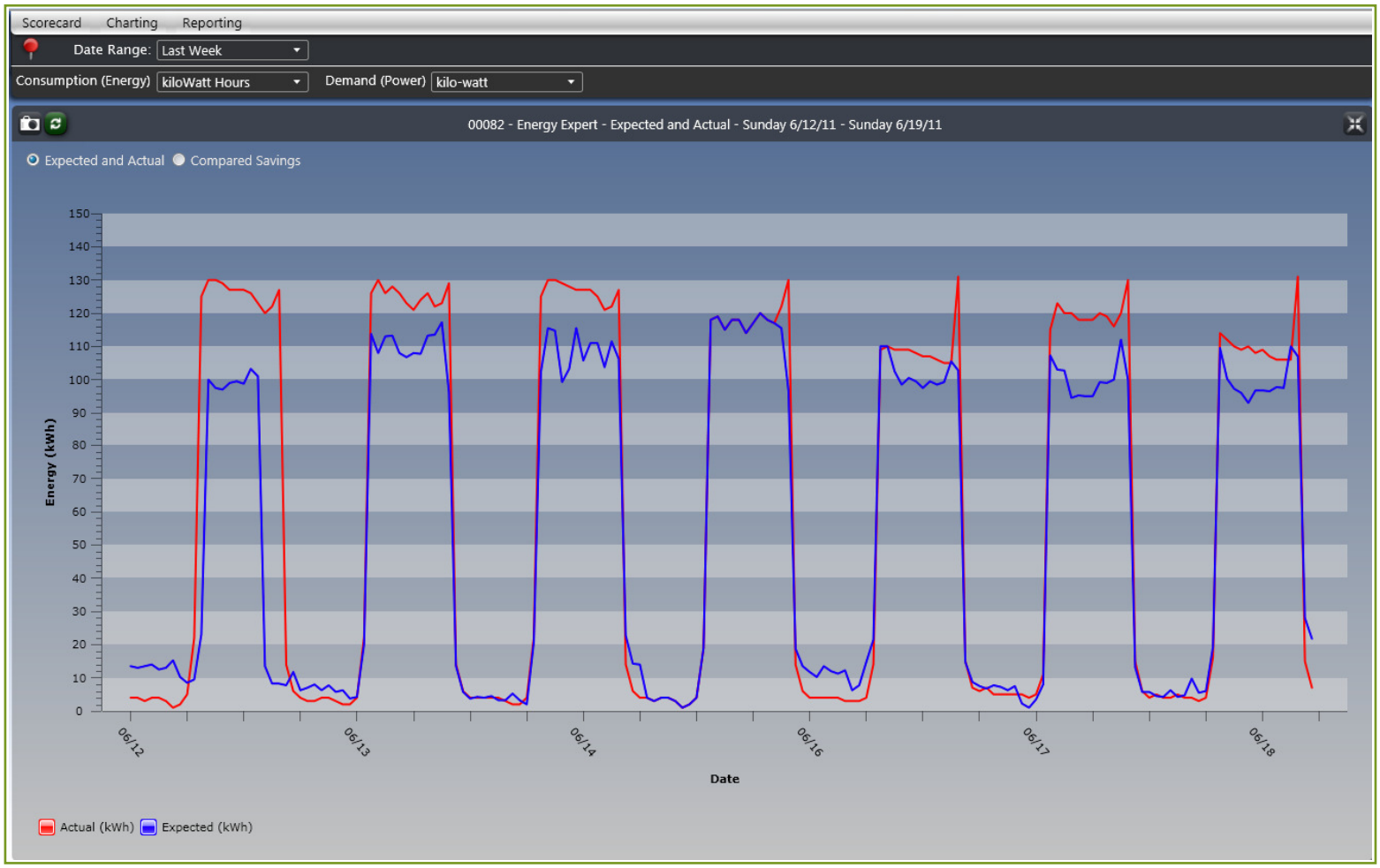
EIMS—Single Site Cumulative Sum (CUSUM)



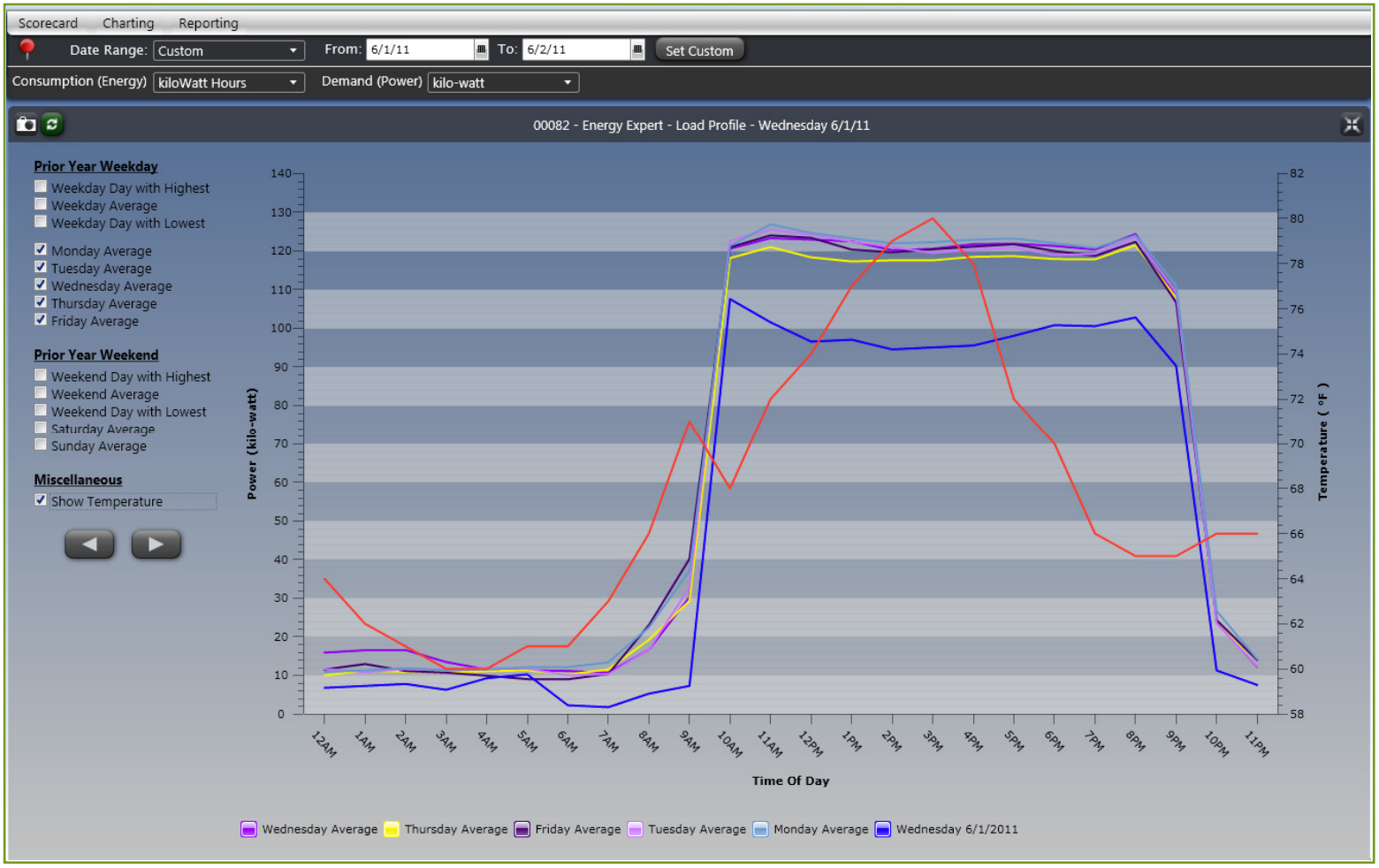
EIMS—Single Site Daily Savings Variation



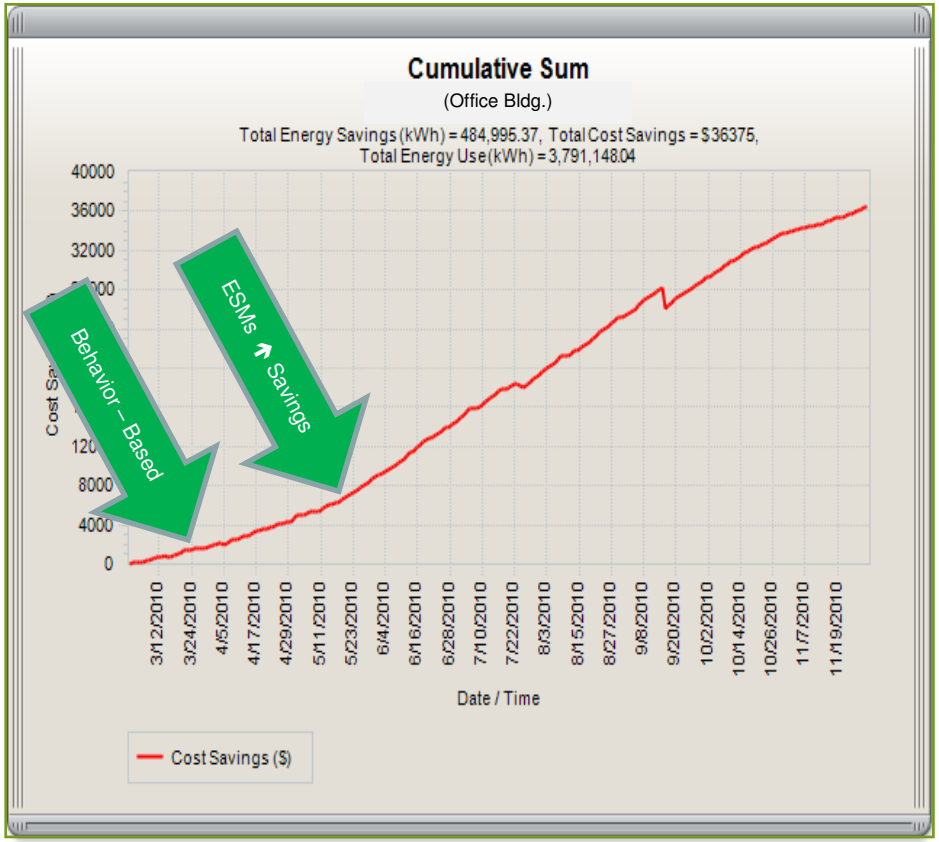
EIMS—Actual Vs. Expected Load Profiles



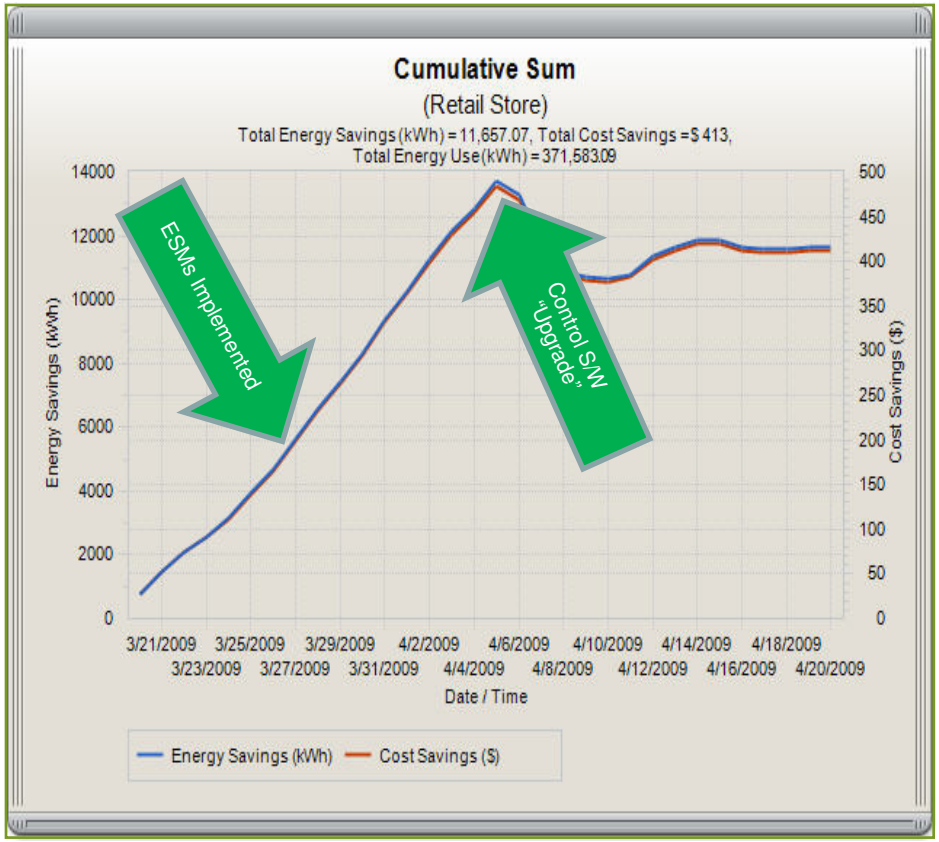
EIMS—Load Profile Comparisons



Example CUSUMs

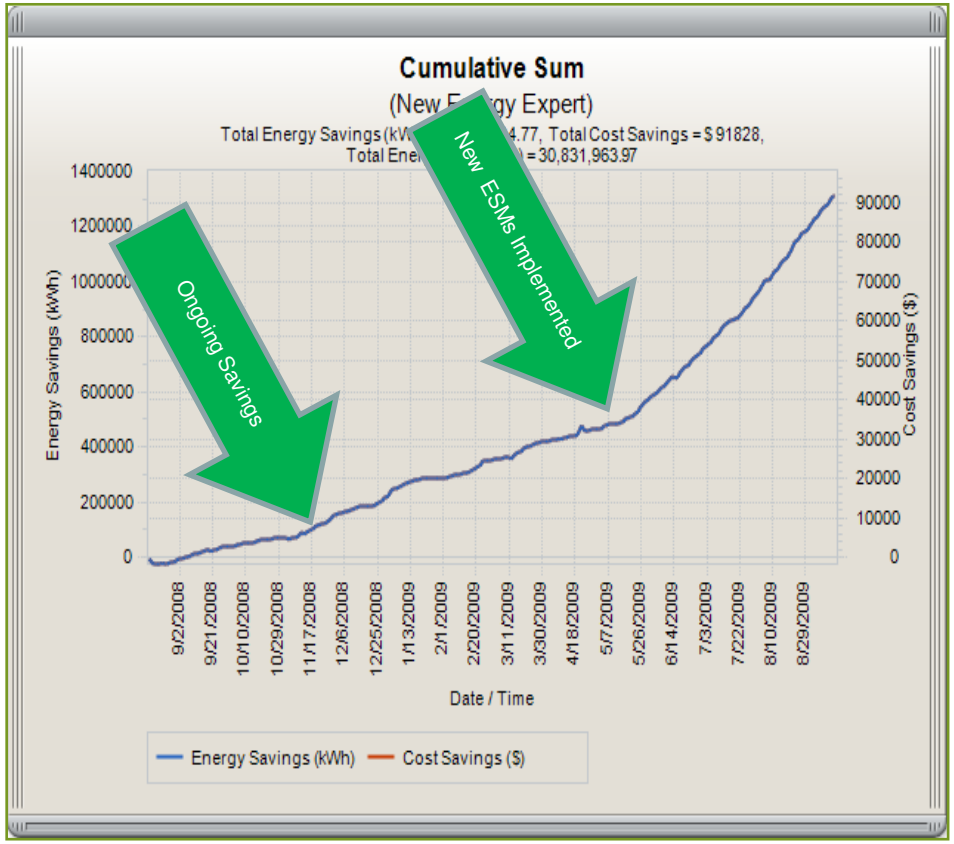


Office Bldg.

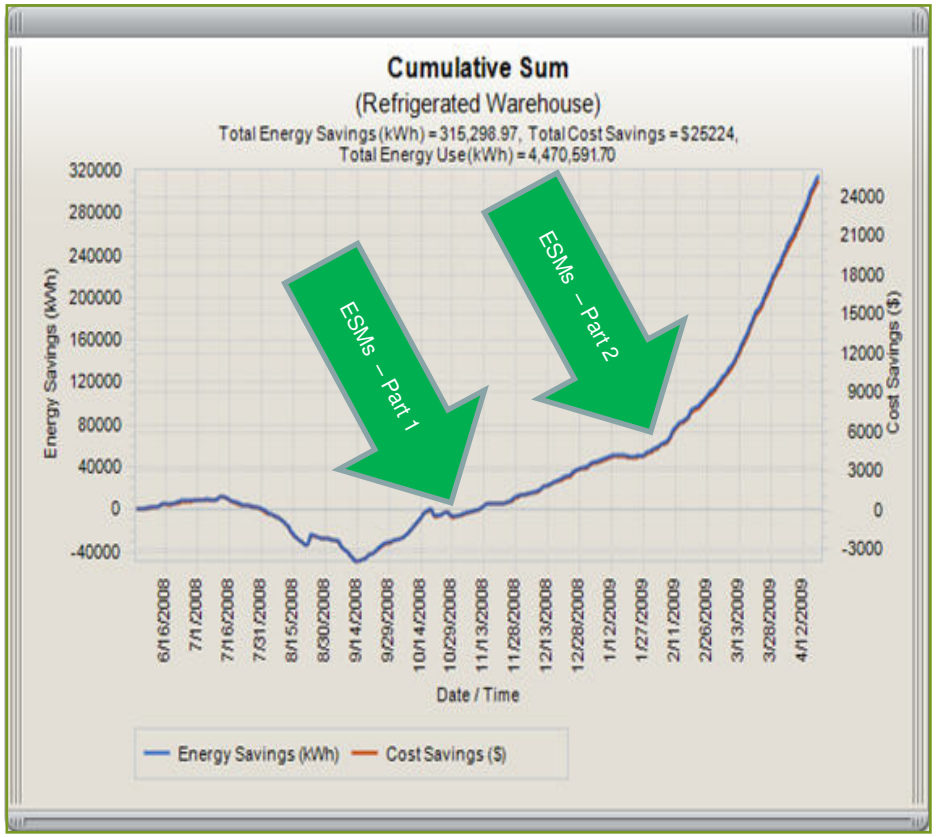


Retail Store

Example CUSUMs



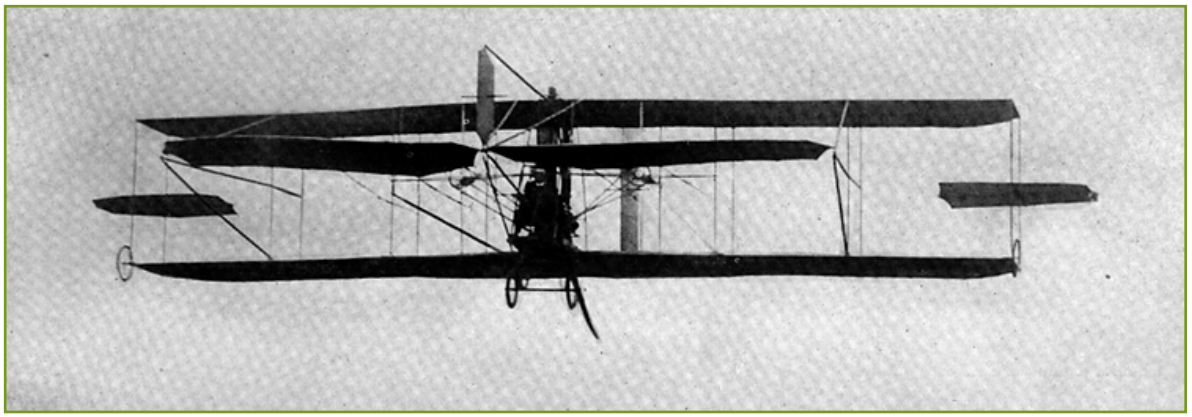
Hospital



Warehouse

Monitoring-Based Commissioning Incentives

- Most utilities are at the early stages
- A few utilities have formal incentives
  - National Grid
  - NYSERDA
  - PGE
  - BC Hydro (Continuous Optimization)
- Many more are piloting, evaluating or “thinking about it…”



Summary

- Not an “event”
- Low-cost relative to alternatives
- Target savings of 10-20%
- Applicable to a wide-range of building sizes (addresses market gap in smaller buildings)
- Instant and continuous tracking of results
- Approach ensures persistence of savings
- Approach identifies problems in real-time
- Results not solely dependent on individuals at each location

Thank You!

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