Interval Data Systems, Inc.

– WHITE PAPER –

Defining the Next Generation Enterprise Energy Management System

2nd Edition

By the staff of Interval Data Systems, Inc.

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1 Introduction

The challenge is simple: how do facility organizations find new and innovative ways to ensure maximum operational efficiency, reduce deferred maintenance budgets by extending the life of systems and equipment, be good stewards of the building assets, forecast energy needs more accurately, and achieve the lowest energy purchase?

The answer is an Enterprise Energy Management System.

This paper highlights the key functional requirements of an Enterprise Energy Management System (EEMS) and describes how this functionality can be used to reduce costs, increase efficiency, and improve energy planning and cost allocation, all while improving or maintaining building comfort.

Today, large campuses and facilities typically have one or more building automation and control systems, campus metering systems (automated and/or manual read), a lighting management system, and some form of space management system. In addition, they deal with several utility companies, each of which has changing rates and rate structures. These systems generate an enormous amount of valuable operational information—which is nearly all thrown away without even being looked at because it is difficult to capture and access data.

While historically organizations have attempted to control energy and building maintenance costs by managing each individual energy source and energy consumer (e.g. building automation system), without a comprehensive 360° view of the facility's current energy consumption true energy optimization cannot be achieved.

An EEMS provides actionable insight through the consolidation of data from all of the institution's disparate energy and building management systems and the interactive access to that data, providing the facility's operations and engineering departments with an accurate picture of operations. With facts in hand, they can steward their assets, lower total energy consumption and operational costs quickly and effectively, and have the ability to verify and measure results.

2 EEMS Defined

At the most simplified level, an Enterprise Energy Management System consolidates *all* energy related data (sources, costs, control and monitoring points) into a data warehouse and provides tools to access and truly *interact* with the data. Conceptually straightforward, but today's energy management systems just do not do it.

It is worth noting what an EEMS is not. It is not a control system and should not be confused with building automation systems (BAS). An EEMS is much broader in scope than control systems, reaching well beyond the BAS. It provides data collection, data access, diagnostic and monitoring capabilities, a historical data warehouse, and a lot more as detailed throughout this paper. Similarly, an EEMS should not be confused with utility billing systems. It encompasses billing and meter data, but extends far beyond and connects billing information directly to the related operational data.

The EEMS makes data available so that the end user is able to perform in-depth diagnostics, analysis, and monitoring in a small fraction of the time it took with earlier methods. This, in turn, provides facilities' staffs with actionable information; i.e. information that enables them to make informed decisions to reduce energy consumption, accurately identify energy costs by cost center, or forecast energy costs in the future.

A true Enterprise Energy Management System is based upon five simple, but crucial, principles:

1. All energy related data must be consolidated into a centralized data warehouse.
2. The collected data must be 'normalized' and 'structured' to be usable.
3. Access to data must be 'interactive' and the information presented must be 'actionable.'
4. The system must measure and verify results.
5. The system must provide a platform that embraces industry standards for data collection, management, analysis, and publication.

3 EEMS Design Principle 1: Consolidate All Energy Related Data into a Data Warehouse

Energy data comes from purchased utilities, generated utilities, building automation systems (BAS), metering systems (both advanced and manually read), weather, and space planning systems. (There is also calculated data, but that will be dealt with later, in sections 4.3 and 5.3.3.) Additionally the EEMS must manage rate and billing data, users, and organizational information.

In order to be able to utilize energy data, the first step is to identify and collect the right data into a data warehouse so that accurate and actionable information can be available. The EEMS needs to collect *all* data, as one cannot optimize the whole by optimizing each component.

This section identifies the different data sources and attributes that define an EEMS and populate its data warehouse.

3.1 Purchased Utilities

For each utility within a campus or hospital, consumption data and billing information is generated.

Consumption information is typically time-based, regardless of the type of utility. For example electric utilities use 15 minute intervals, natural gas utilities use a daily time interval, oil uses time between tank fill-ups, and water uses monthly or quarterly intervals. Other utilities such as steam or chilled water often use 15 minute to hourly interval data. Eventually these different time series need to be “normalized” (an issue that is discussed later in this white paper) so that information can be presented in consistent intervals.

Billing information is equally complex: for large campuses, there are often multiple vendors for each utility type, each with differing rates, billing cycles, and pricing structures.

An EEMS must manage both consumption and billing information, and present this data in an intelligible, clear, and actionable format. The diagram below is a simplified view of the issues related to collecting utility data.

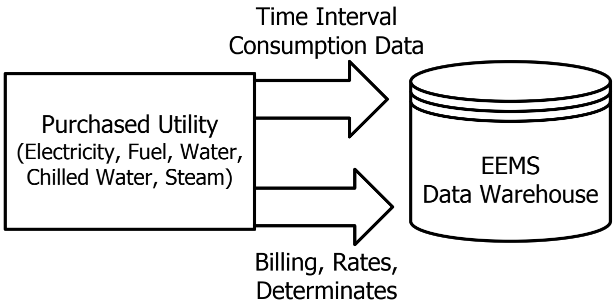


Fig. a) Billing & consumption data must be collected in tandem.

Time Interval Consumption Data: Many utility companies do not offer a way to track interval consumption data as it happens. The interval data is made available at the end of the billing cycle through reports or spreadsheets, which leaves the EEMS without current consumption data for a month at a time (with water being much worse). Other companies provide interval data through Web-based reports, which although more current, are far from ideal for populating the EEMS data warehouse.

The best option for collecting consumption interval data is for the meter to provide the data directly at regular intervals, or to attach a reading device that can provide the consumption data to the EEMS.

Bills, Rates, Determinants: The EEMS must understand and track the hierarchy of meter data that comes from a purchased utility. The data hierarchy goes from utility type, to supplier, to account, to meter and rate. A single rate is typically used for multiple meters spanning multiple accounts.

A large facility will have a significant amount of billing data to collect and manage. For example a university may have 1,000 – 3,000 utility bills per year. Today this is often captured in spreadsheets—limiting the accessibility and usability of that information. The EEMS should consolidate all the billing information, including the bill’s underlying determinants.

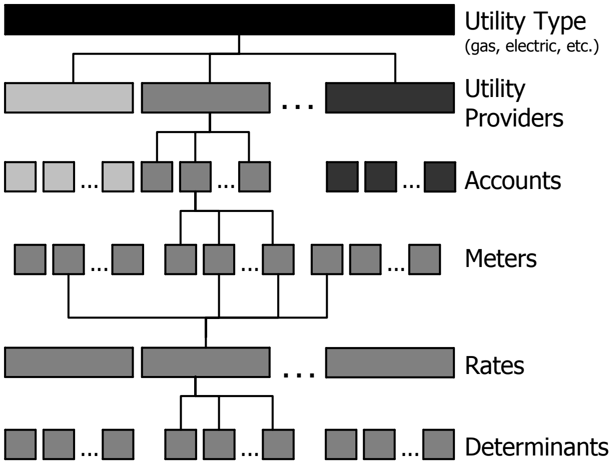


Fig. b) The EEMS must understand the hierarchy of utility meter data—from utility type, down to meter, and then to rates and determinants.

The bill is made up of a varying number of determinants. It is not uncommon for a large campus to have a dozen or more different rates from a single utility company. As an example, below are the billing determinants for three different rates in use at a university from a single electric company.

Billing Determinants

Determinant	Data Type	Rate 1	Rate 2	Rate 3
Start Date	Date	■	■	■
End Date	Date	■	■	■
Total kWh	Integer	■	■	■
Billed kWh	Integer	■		
Total kW	Number	■	■	■
Billed kW	Number	■		
Rate Billing	Money	■	■	■
Customer Charge	Money		■	
Fuel Charge	Money	■	■	■
Sales Tax	Money	■	■	■
Municipal Franchise Adj.	Money	■	■	
Total Current Bill	Money	■	■	■

Fig. c) The EEMS must have the flexibility to handle multiple rates with varying determinants.

3.1.1 Electricity

Today most electric utilities quantify consumption by averaging the demand over a 15-minute period (standard interval). The majority of electric utilities make the interval data available electronically to the customers, although again, not always in convenient ways to collect it.

Both 15-minute average demand and month-to-date consumption are required for the EEMS. Similarly, electric bills with determinants must be stored in the database too (for reasons discussed later) and, because billing rates change over time, it is important that the EEMS can accommodate this dynamic data and propagate these adjustments.

3.1.2 Natural Gas

Due to the fact that natural gas utility companies rarely bill based upon readily obtainable standard time intervals (a fact which has led many institutions to install their own gas meters to validate billing), it is important that the natural gas meters installed throughout the site are connected to the automated metering or building automation system for data collection. It is also critical that the meter configuration and BAS point configuration collect running totals of consumption flow, etc. as well as instantaneous readings. Running total data is required to make it possible to reconstruct the inevitable gaps and missed readings.

3.1.3 Chilled Water

While many organizations generate their own chilled water for air conditioning, etc., some chilled water is purchased from third-party utility companies. Similar problems exist concerning metering, again leading some organizations to purchase their own meters to validate bills. Because chilled water generation is tied to electric consumption, suppliers are increasingly moving towards more accurate time-series billing.

3.1.4 Steam

Like chilled water, steam is often produced by an organization itself, but, when purchased it is typically billed based upon time intervals ranging from 15 minutes to one hour.

3.2 Generated Utilities

Many large campuses/facilities have their own power plants that generate chilled water or steam that is subsequently distributed to the buildings. The EEMS must collect data from the control system(s) of the power plant as well as from the distribution network and end users of the energy.

Billing information must also be collected, much the same as it is for purchased utilities. Facilities that generate their own chilled water, steam, or even electricity will have their own rate structure and determinants and bill internally based on consumption.

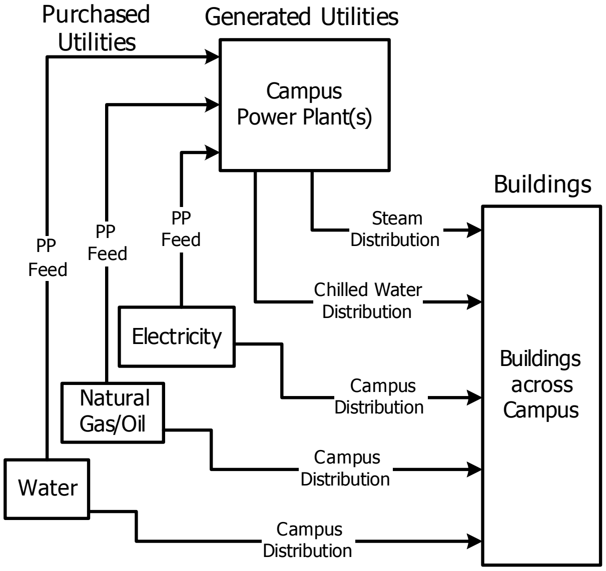


Fig. d) Institutions typically deliver purchased & generated utilities to the campus.

3.2.1 Chilled Water

Chilled water is distributed throughout the campus to different buildings. Typically a building automation system will control the chiller plant (chillers, cooling towers, primary distribution loops etc.).

The EEMS system must collect data from both the generating plant and the distribution network (buildings). In some cases the chiller plant will be run by a different BAS than the building and an EEMS must be able to display chiller plant efficiency as well as allow the user to determine how the chilled water is being used in the distribution system. Operating the chiller plant at maximum efficiency does not necessarily mean that the distribution system can benefit from a high delta T chiller operation, for example.

3.2.2 Steam

Like chilled water, steam is distributed throughout the site to different buildings. In order to determine the steam usage of a building, both a steam flow meter and condensate return meter are required: where the steam meter measures the energy delivered to the building while the condensate meter measures that which is returned. An EEMS then accesses the steam and condensate return meters via the building automation system that is normally used to monitor and control this equipment.

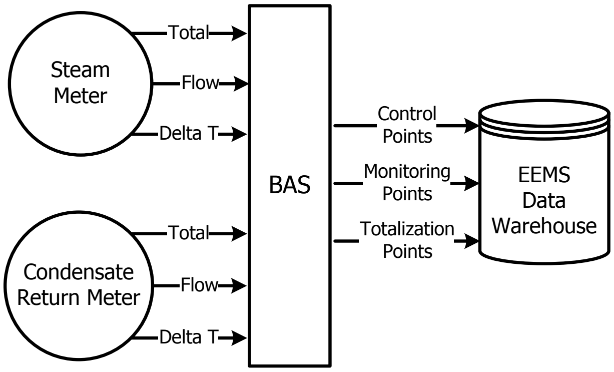


Fig. e) The path of data from steam meter to EEMS.

3.3 Building Automation Systems

First, an important point of distinction between a Building Automation System (BAS) and an Enterprise Energy Management System (EEMS) should be noted—BAS controls the HVAC equipment, lighting, security systems, etc. whereas the EEMS provides management information derived from the BAS, as well as all other energy systems across the site. An EEMS is not a control system.

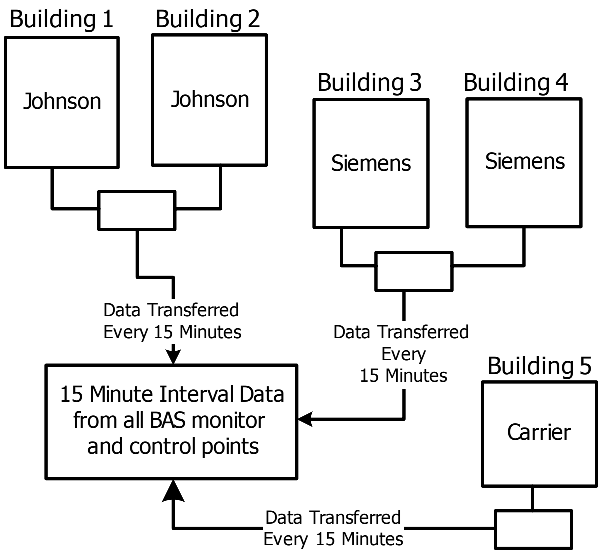


Fig. f) EEMS collecting data from multiple building automation systems.

Many institutions operate more than one BAS and so an EEMS provides a complete, holistic view by collecting data from all systems and overcoming the limitations of relying on the BAS for data. It is this comprehensive 360° view that enables organizations to more quickly and effectively diagnose energy usage.

As important as data collection is, it is equally important for the EEMS to provide fast access to the data, and to present a holistic view in a comprehensible form. This is covered in greater detail in “EEMS Design Principle 3.”

3.3.1 Extracting Data from the BAS

Virtually all BASs (particularly modern systems) allow external applications to collect data without negatively impacting performance. To provide a comprehensive picture, an EEMS requires data at 15 minute intervals from control and monitoring points.

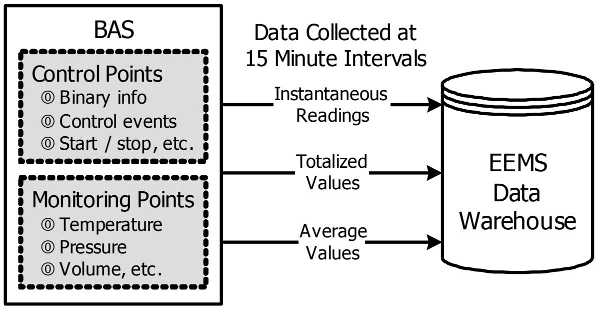


Fig. g) The EEMS collects various kinds of data from control and monitoring points every 15 minutes.

It is important to recognize that gathering data only from monitoring points means that, while you may identify something to improve, it is unlikely that you’ll gather sufficient information to know with certainty how to improve it. (This is what happens when advanced metering systems are installed instead of an EEMS.) Control points must also be gathered to be able to monitor any changes and understand how control changes affect behavior throughout the systems.

For operations at a fairly large facility or campus, it is not unusual to have 20,000 points or more. With such a large number of data collection points, each generating one record every 15 minutes for 365 days a year, the total data set comprises over 700 million records per year. From a user’s data-handling perspective, 700 million records are overwhelming, and without an EEMS, much, if not all, of this information was thrown away.

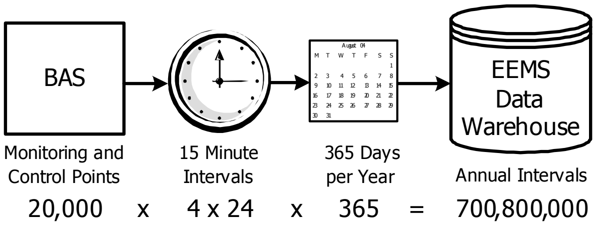


Fig. h) The ability of an EEMS to store, manipulate, and display very large volumes of data in an efficient manner is mission critical.

3.3.2 The Importance of Trend Data

Trend data is the foundation of diagnostics, monitoring, measurement and verification, and building a historical record of facility operations. While BASs typically contain a function called Trend Logs, they are a poor mechanism to collect trend data for the EEMS to operate against.

Trend Logs provide an excellent medium for viewing real-time BAS data, particularly where a known problem exists. The operator simply identifies the points required for the trend log and initiates data collection. However, there are several issues that severely limit their ability to serve as a useful data collection device or as a diagnostic or monitoring tool:

- All data is not collected. At any point in time, Trend Logs are typically only active for a few hundred points out of the thousands within the BAS.
- Trend Logs cannot collect all data. They were not designed to be active for all data points, and attempting to do so severely impacts the performance of the BAS server, affecting its ability to properly execute control functions.
- Data is limited to the BAS. Trend Logs have no ability to combine data from multiple BASs or other energy data sources critical to facilities operations.
- There is no meaningful historical data. With no constant data collection, there is no ability to look back in time at points of interest. Logs are turned on and then facilities staff must wait until enough data is collected. Earlier data is lost forever.

Fortunately there are approaches to collecting trend data without relying on Trend Logs. The EEMS needs to access the BAS monitoring and control points directly or through an independent server that does not impact the primary function of the BAS—to control the building and energy system operations. How this is done will be discussed later, under “Design Principle 5.”

3.4 Meters and Metering Systems

Meters and metering systems are typically located at buildings and throughout the distribution system to measure usage of electricity, steam, chilled water, fuel, etc. Different energy types will require different approaches to move the data from the meter into the EEMS warehouse.

Most electric meter manufacturers have software applications that consolidate the data and display consumption demand and power quality data. In effect, metering systems are designed to simply collect and display data needed to understand usage. The EEMS requires this data to also be present, necessitating a connection between the metering systems' databases and the EEMS data warehouse.

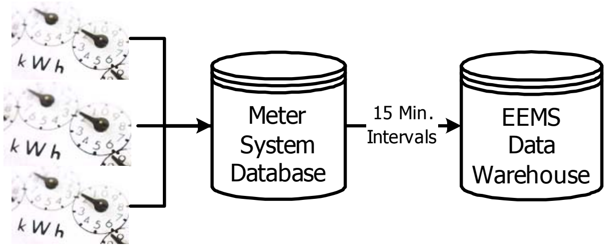


Fig. i) A connection between the metering databases and EEMS must exist.

For electricity, access to metering data via the metering database is a relatively straightforward process, but for those utilities that do not leverage advanced metering systems, data can be obtained and transferred through the building automation system; i.e., the BAS collects the data from the meter and the EEMS acquires the data from the BAS system. In reality, however, this connectivity is not a simple task. Meters must be reconfigured to collect and total the data, and the BAS points must be configured to access and deliver the required data to the EEMS.

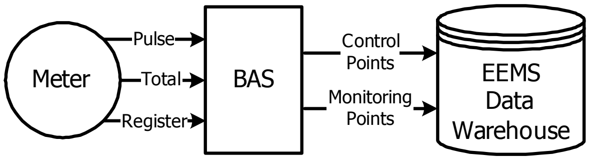


Fig. j) Data can be obtained & transferred through a building automation system.

In addition to the automated data collection described above, there is also the information from manually read meters that must be added to the EEMS warehouse in order to provide a complete picture for error diagnosis and identification. Many organizations already do this at some level, but the data is typically put into spreadsheets where there is limited access and no connection to other operational data. For manually read meters, like other meters, a configuration is required; i.e., the data being collected by the meter reader must be the right data for the EEMS.

3.4.1 Considerations for Meter Data Collection

Whenever meters are used for EEMS data collection there are a number of important considerations to make certain the right data are collected, even in the event of network failure. A decision must be made concerning the type of data needed. This can then be used as the basis for selecting the most appropriate collection device.

For example, if the desired information pertains to energy used over time, such as kWh, the device must be configured with a totalization function. While it is possible that the building automation system can total energy, it is not prudent since a network failure would mean the data was gone for good. With the meter configured to contain the total energy, one can go back and "fill in the data."

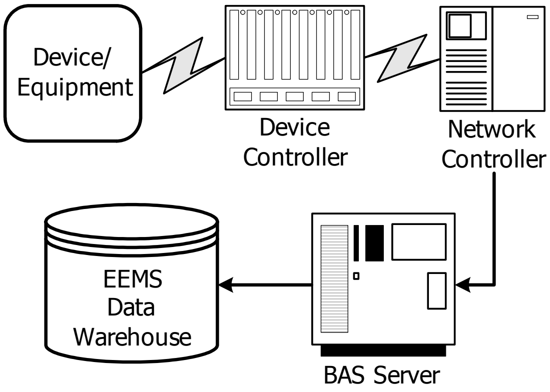


Fig. k) The communication path of data from device to EEMS.

The diagram above shows the path of data from the device to the EEMS database. It is important to recognize that there are a number of potential points of failure—at each hardware device and each network link. One must plan for a loss of data and ensure that the data collection process incorporates the appropriate safeguards to minimize data loss.

As the diagram shows, data can be collected at the device, device controller, network controller (sometimes referred to as the panel board), or the BAS server (via OPC). In selecting and specifying data collection points it is crucial to consider the goals and objectives for the project. For example, if you need to know the total amount of energy consumed you must configure the meter for register data *and* pulse data.

One other consideration when collecting meter data is deduct meters. This occurs when there is a main meter and then a series of sub-meters that cover part, but not all, of the energy consumption through the main meter. In this case the EEMS will want to collect interval data directly from the sub-meters, but then must deduct their consumption from the main meter before apportioning energy usage to other spaces.

3.5 Weather Data

To enable accurate energy forecasting, it is important to understand the context within which energy usage occurs. Weather is possibly the single biggest factor in this equation. For the most accurate results, weather data from a local airport (official METAR—Meteorological Terminal Aviation Routine Weather Report) should be used in the EEMS. While BASs typically have temperature and humidity sensors, invariably they do not provide quality reference information necessary for a number of reasons: temperature sensors may be located too close to the building, in the sun, on a roof, on the south side of the building; humidity sensors may be broken, etc.

An EEMS therefore should be configured to receive a weather feed from a local airport so that actual weather data can be used in energy forecasting applications and in assessing building performance characteristics. At a minimum, weather feeds should include the following data:

- Hourly temperature and dew point
- Wind speed and direction
- Barometric pressure
- Sky conditions (clear to cloudy)

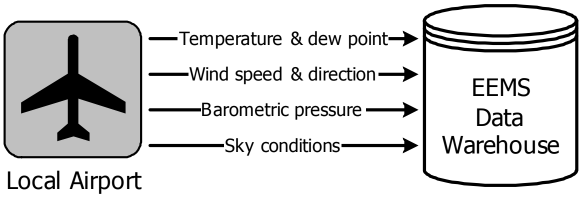


Fig. l) Weather data from a local airport should be used within an EEMS.

3.6 Space Planning Data

Space planning data is required by the EEMS in order to identify energy costs at the space level. Space planning systems (SPS) contain information concerning the use and allocation of all areas within a campus or facility. They map the hierarchy of the campus by site, zone, building, floor and room.

Space planning systems also understand the relationships between space and cost centers. Both SPS and EEMS have distinct, complementary roles. Space Planning's role is to maintain the space relationships (since occupancy and cost centers change) and to transfer cost center information into the general ledger. The role of the EEMS system is to deliver accurate energy costs down to the space level where the SPS can roll up the costs by cost center.

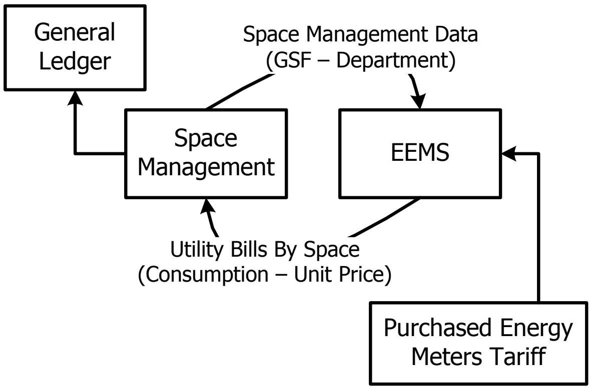


Fig. m) The EEMS and SPS work to combine energy and space data and write costs to the General Ledger.

Maintaining space planning data is an important discipline so that campus utility organizations, facility operations, planning and engineering functions can access common reference information. Today each of these distinct groups creates their own variation of a standard building name (for example) which makes their information useable only to themselves rather than many departments.

3.7 Organizational Information

Organizational information is required for the EEMS so that it can roll up cost center information. Once the EEMS allocates costs to each space, organizational information is required that can relate space to department (or cost center). It is incumbent upon the EEMS to adapt to any hierarchical structure and to the constantly changing organizational structure of the institution. The EEMS system should not burden the space management system nor the personnel maintaining space planning data with this task. In essence, the EEMS functions increase the value of the investment already made in existing space planning systems.

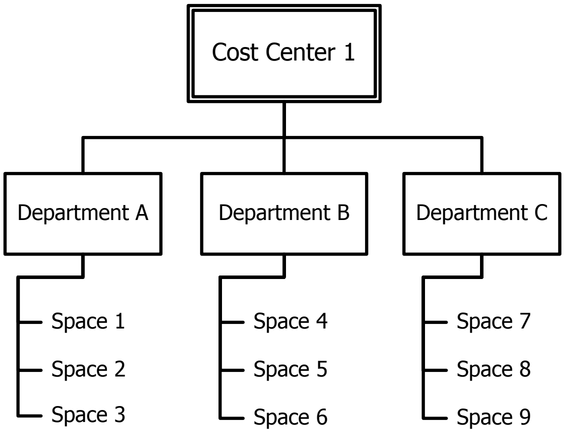


Fig. n) The EEMS needs to understand the dynamic nature of the relationships between organizational hierarchy and space.

3.8 Market and Pricing Data

For any purchaser of large amounts of energy, purchasing at favorable rates can make a significant impact on the bottom line. This is difficult to do since prices, pricing structures, and regulations are constantly changing. The role of the EEMS in purchasing energy is threefold:

- To display past and future energy usage patterns
- To convert and present utility billing and consumption usage into an equivalent real-time price
- To present real-time pricing information

All of this needs to be accomplished within the same interface.

Easy access to actual and predicted usage patterns enables the organization to make more informed utility purchasing decisions than ever before. For organizations that have secured the services of a third party to assist in making utility purchasing decisions, access to the EEMS must be made available to those individuals.

3.9 Don't Throw Data Away

Most large facilities and campuses spend millions of dollars annually on energy, millions on systems like building automation systems, and tens of millions for HVAC equipment. Yet the data that they generate is thrown away largely because there is so much of it, and it is difficult to access, manipulate, and interpret.

An EEMS captures this data and leverages it to provide a complete picture of utility consumption and an organization's energy infrastructure over time so that the most expeditious analysis can take place to reduce the total cost of ownership and operation.

4 EEMS Design Principle 2:
Normalize and Structure Data

EEMS Design Principle 1 focused on the importance and requirements of getting data into the system. EEMS Design Principle 2 constructs the data warehouse of historical trend information based upon the least common data denominator, a standard time interval. Once all data is normalized to this common standard, one can utilize it for a variety of applications.

4.1 Optimal Time Interval

There are a number of considerations in selecting a standard time series interval used by the EEMS, the most significant of which is ensuring that it is able to display sufficient data to identify transitions—this means that there should be enough data points gathered to discern performance fluctuations across transition time periods such as between day and night, 'office hours' and non-working hours, etc.

With this information, behavior patterns and problems become apparent quickly. For this reason, and because electricity is frequently metered within the same time interval, 15 minutes is an appropriate time series upon which an EEMS can be normalized. Longer intervals do not provide sufficient data granularity to always see behavioral changes. Shorter intervals can increase the data storage and processing requirements for the EEMS by 300% (or more) while increasing the information value very little.

Additionally, because capturing data at 15 minute intervals does not require a great deal of storage space to house the data records, data can be stored for the lifetime of a piece of equipment—20 years or more.

4.2 Normalized Time Series Data

Normalizing the data means that data from all sources is stored in the warehouse in the same time series interval. As discussed earlier, not all data sources provide data in the same time series, so an EEMS system must reconcile these differences. In some cases the actual time interval of the data source is one per day so the EEMS system must automatically convert this data into the normalized times series data. This problem isn't always due to the time series specified by the utility provider; it may occur for a number of reasons, including equipment failure.

The problem of time series inconsistencies is a fact that must be acknowledged and addressed. A well-implemented EEMS accepts these inconsistencies and "fills the gaps" with estimates that, when totaled, account for the total energy consumed and represent the pattern of that energy usage in a precise and accurate manner.

4.3 Data Calculations

Part of the function of any data warehouse is to provide access to the data in the most efficient means possible. This includes calculating and storing certain commonly needed values.

Once the data has been normalized, you can calculate additional trend data at each interval. For example, a Delta T calculation, simply the difference between supply and return temperatures, can be computed and stored as another monitoring point at each interval, making it available to the user as a Trend Line.

Storing calculated values is important to the overall data warehouse structure because it dramatically speeds up access by the user. The small amount of storage space used by the calculated data is more than made up for by the performance gains. (See more on calculations in section 5.3.3.)

4.4 Naming Conventions

There is a complete lack of uniformity in how buildings and systems are labeled within an institution. Today's facility organizations use building automation systems, store utility bills and meter readings in Excel or some utility system, generate their own utility bills for steam and chilled water, create campus maps, engineering drawings, maintain space planning systems, and work with many outside engineering and construction firms. Each group has their own systems for their own specific tasks, each with a different nuance to the same information.

This is unlikely to be prevented or be brought under control—hence the EEMS should be able to present to each specific user group the naming convention they are familiar with, while providing the cross reference information required.

4.5 Data Warehouse Structure and Hierarchy

It is clear that an EEMS handles and stores an enormous amount of data from many disparate systems. In order to derive value from such a large data set, a defined structure and hierarchy must be implemented to make the data readily consumable. The structure of the data must be flexible too, since physical configurations are constantly changing. Buildings may be added, equipment may fail unexpectedly, and space may be modified to accommodate organizational changes. The design of the EEMS system must be flexible to adapt and keep pace with this dynamic environment.

4.5.1 Warehouse Objects

Structuring of data should mirror the manner in which that data is to be used to gain insight. For example, it should parallel the physical facility so that data can be viewed either in aggregate or in isolation when focusing upon an individual building or piece of equipment.

The EEMS warehouse needs to support logical objects—sets of information and relationship hierarchies—that allow for this structure. The following list shows six warehouse objects and the hierarchy that needs to exist within them. The warehouse structure also must support the way different elements within the object inter-relate, for example, the way meter interval data must connect to billing rate data and physical building data.

Facility Objects

- Site
  - Zones
    - Buildings
      - Floors
        - Rooms
- HEGIS group
- HEGIS classification

Interval Data Collection Objects

- BAS & OPC point data
- Calculations
  - Balance efficiency calculation
  - Cooling efficiency
  - Cost calculations
  - Delta T
  - Theoretical water loss
  - Etc.
- Weather data

Issue Objects

- Issues

Organizational Objects

- Departments

Meter Objects

- Utility type
  - Utility information
    - Account information
      - Meter information
      - Rate information
- Billing information

User Objects

- User privileges
  - Users

5 EEMS Design Principle 3: Provide Interactive Access to Actionable Information

5.1 Defining Interactive and Actionable

Interactive access allows the users to work with the data in a dynamic fashion, moving seamlessly through the data with tools that provide near instantaneous response. This allows users to “work the way they think” rather than being limited to a series of static queries and reports. The EEMS must address both usability and performance issues to successfully provide interactive access to the data.

Actionable information can be used as the basis and rationale for effective decision-making, as opposed to merely indicating “status.” To create actionable data the EEMS must collect *both* monitoring and control points. With monitoring data alone (without control information) it is difficult to verify or quantify the savings opportunity. Monitoring data and control data should be viewed in tandem to become “qualified” as actionable information.

5.2 Time Matters

It is crucial when collecting tens of millions of records per month that insight can be gained within minutes rather than days. The use and operation of an EEMS cannot be an arduous and time-consuming task. Users must be able to derive insight about the data (useful, actionable information) in a very short period of time if the system is to become embedded within the facility’s management operations.

To accomplish this, data must be accessed and presented to the user at the *speed of thought*—able to view hundreds of thousands of data intervals in 15 or 20 minutes. In essence, if the user has to wait for information, their thoughts will wander. If they continually have to wait—if they are not constantly engaged—then their reaction will be that the EEMS is wasting their time. Once that point is reached, the EEMS will not be used and any potential value will be lost.

Currently, most facilities personnel waste an enormous amount of time collecting and distributing data. Due to the historical lack of availability, this wasted time is culturally accepted as “part of the job,” when in fact, instead of spending days manually gathering and piecing together data, a well-implemented EEMS can deliver it in seconds. When you have immediate access to the data, staff is freed up to devote time to the real engineering work of diagnostics, analysis, and planning.

5.3 Usability Matters

The amount of time required to gain insight is directly related to the usability of the system. With such vast amounts of data stored in the EEMS warehouse, it is essential that data can be assembled dynamically by the user via a simple, intuitive interface. The elements of the interface include the data organization and presentation, data display, and the program interface itself. The EEMS also needs to support other aspects of the facilities staff’s workflow, such as tracking identified issues or interacting with external analysis tools.

5.3.1 Data Organization and Presentation

As discussed in “Design Principle 2,” the data must be structured in a manner that is inherently useful. This needs to happen not only at the data structure level, but also at the user presentation level.

With such large volumes of data, the EEMS must allow it to be categorized in meaningful ways, such as organizing within the facility hierarchy (zones, buildings, floors, rooms), organization (departments, rooms), or systems (chiller system, air handling system, etc.). In many cases data must be accessible through multiple views so that, for example, a building manager has access to the building information while a plant engineer can look at chiller operations facility-wide.

The EEMS must make the presentation simple by providing a master organizational structure that offers a mechanism for users to select which data they see. Users must be able to “drive through the campus” from their desktop viewing thousands of data intervals per minute. The EEMS must also provide a method for users to define their own organized views.

5.3.2 Trend Lines

Section 3.3.2 discussed the importance of collecting trend data as the basis of diagnostics, monitoring, M&V, and more. The EEMS must use the trend data to provide *Trend Lines* as the primary mechanism to display and interact with the EEMS data. These are very different from BAS Trend Logs—a difference that elevates, by orders of magnitude, the effectiveness of an EEMS for diagnostics, monitoring and other applications.

Trend Lines provide insight into operational data over extended time periods and permit the expeditious identification of problems—problems spanning multiple BASs and inefficiencies that arise suddenly due to changing circumstances such as weather, equipment degradation over time, or system configuration adjustments. In contrast to Trend Logs, Trend Lines:

- Contain all the data from every monitoring and control point
- Do not impact BAS control performance at all
- Combine data from multiple BASs and other data sources such as meters, utilities, and weather data
- Capture all data from the moment the EEMS is turned on, so it is constantly available
- Create a historical record of building operations—both monitoring points and control settings

BAS Trend Logs do have their place in providing needed information—where their ability to collect real-time data is useful—as shown in the table below:

Application of BAS Trend Logs and EEMS Trend Lines

Criteria	BAS Trend Logs	EEMS Trend Lines
When to Use		
Diagnosing operations	After problem has been identified as under the control of the BAS and further data is needed for final diagnosis	Always—far superior tool for nearly al diagnostics and all cases where historical data or data outside the BAS must be considered
Monitoring operations	When real-time data for a small number of BAS points needs to be watched	Always—provides the ability to monitor hundreds of trends in minutes, combining data from any and all sources
Typically used by	BAS control engineers and technicians	BAS control engineers & technicians, energy engineers, facility managers, performance monitoring contractors, commissioning agents, HVAC design engineers
Technology Perspective		
Data storage	Stores point data for trends defined	Stores data for all points from all systems
Time interval of data	Captures data in increments from milliseconds to minutes	Captures data from all systems every 15 minutes
Displays data from	Native BAS	Multiple BASs, metering systems, utilities, weather, billing
Display time period	Typically a few days or weeks	Between a day and a year, with historical data going back years
Data storage	Up to a few months and data is discarded	Up to 20 years

Fig. o) Some of the uses, users, and differences between BAS Trend Logs and EEMS Trend Lines.

5.3.3 Calculated Data

Section 4.3 discussed how calculations are often done ahead of time and stored in the data warehouse. The efficiency gains in having commonly desired calculations available for monitoring and diagnostics are tremendous—having a dramatic impact on usability. A visual display of an ongoing trend built on a calculation can provide insight instantly that would otherwise take hours of number crunching and charting in Excel.

A Delta T is a simple calculation example commonly viewed as a basic performance measure of a chiller system. A Delta T is even more effective when the EEMS displays the supply and return temperatures used in the calculation at the same time. This way, if the Delta T fluctuates, the user can immediately see if the change was affected by a supply or return temperature rise or drop.

More complicated calculations can provide users with an overall operational efficiency rating, or, applying billing rate data, even a Trend Line that shows at every 15 minute interval the total energy cost for that 15 minute period. Calculations of this complexity rely on the EEMS's ability to fully integrate data from all sources and present it in a normalized fashion.

The EEMS should support calculations of any complexity, although it is appropriate to restrict the creation of calculated points to a system administrator who understands how calculations fit into the underlying data warehouse.

A sample of desired calculations—calculated every 15 minutes—include:

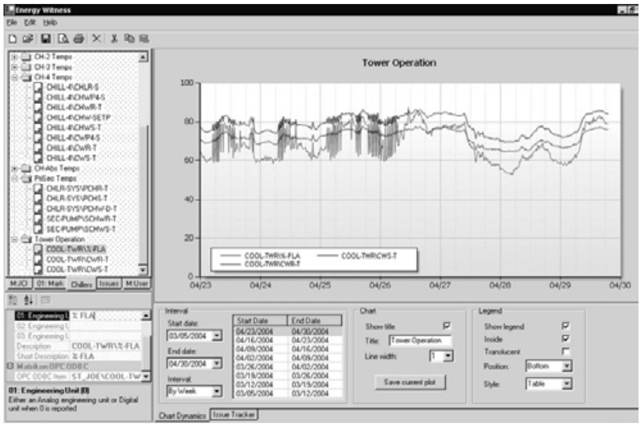
- Balance efficiency
- Chiller efficiency
- Chiller total cost
- Chiller plant total hourly cost of operations
- Cooling tower cost & efficiency
- Cooling tower make-up water cost & efficiency
- Delta T (primary & secondary)
- Pump break horsepower
- Pump efficiency
- Pump kW
- Theoretical water loss
- Tons output
- Tower total cost

5.3.4 Application Interface

All of the usability factors mentioned must come together in the software user interface (UI). It is how end users interact with the data—through mouse clicks, menu selections, etc.

The EEMS should use interface conventions already familiar to its users, such as expandable data trees to display available points and hierarchies, tabs for organization, contextual menus, drag and drop, etc.

Users should be able to take an iterative approach with each action building on the last for diagnostic purposes. Monitoring should be fast and efficient, allowing the user to quickly cycle through hundreds of Trend Lines—hundreds of thousands of intervals—in minutes. Trend Lines are the source of actionable information, but it is the UI and system performance of the EEMS that allow the user to work at the speed of thought.



01: Engineering U: % FLA
02: Engineering U
03: Engineering U
Description: COOL-TWR\%-FLA
Short Description: %-FLA
Matrikon OPC ODBC
OPC ODBC Item: ST_JOE\COOL-TW

01: Engineering Unit (0)
Either an Analog engineering unit or Digital unit when 0 is reported

Start date: 03/05/2004
End date: 04/30/2004
Interval: By Week

Start Date	End Date
04/23/2004	04/30/2004
04/16/2004	04/23/2004
04/09/2004	04/16/2004
04/02/2004	04/09/2004
03/26/2004	04/02/2004
03/19/2004	03/26/2004
03/12/2004	03/19/2004
03/05/2004	03/12/2004

Show title ☑
Title: Tower Operation
Line width: 1

Show legend ☑
Inside ☑
Translucent ☐
Position: Bottom
Style: Table

Fig. p) *An EEMS should allow interaction with data, such as drag & drop capabilities to add more Trend Lines onto an existing chart, one-click scanning back through time, and zooming in or out.*

5.3.5 Tracking Issues

As an expert reviews the data within the Trend Lines, they are able to identify areas of concern or highlight known problems. For each problem discovered, the EEMS should take a snapshot of the Trend Line(s) at that point in time, which can be annotated by the expert and sent to the appropriate building control technician. That technician is then able to take action and modify settings within the BAS as appropriate. The technician can then log the fix while the expert can verify that the change is working appropriately before closing out the issue.

Issues must be accessible by a variety of personnel that need the information to put together the action plan and ultimate resolve the issue. It is appropriate, however, to have controls that limit some users' scope of what they can see or modify.

5.3.6 Interact with External Analysis Tools

As good of a diagnostics tool as an EEMS is, there are many types of data analysis that are best performed by tools created for that purpose. For example, Excel can do curve fitting, regression analysis, and many other calculations that would be wasteful to duplicate within the EEMS.

To make using external applications an easy process, the data from the EEMS should be easily exported into Excel or other analysis software. This allows engineers who have built their own analysis routines in Excel (or other packages) to continue to use them.

5.4 Present User Specific Information

An EEMS must support a variety of applications and users. Data must be pertinent for each user while providing the ability to conduct additional investigation and access data not typically made available via other systems. Users of an EEMS may be BAS engineers and technicians, energy engineers, HVAC design engineers, facilities engineers and managers, commissioning agents, energy purchasers, and/or performance contractors.

Users of information from an EEMS extend well beyond that group to building managers, zone maintenance groups, department heads, finance personnel, and anyone who has occasional needs for some facilities information.

5.4.1 Information Publishing

In many cases, this second tier of users do not need interactive access to the data at the individual point level. Their interests are mostly static and may be better served by periodic reports.

An EEMS needs to provide a variety of output options that enable everything from detailed reports with data tables and charts of multiple Trend Lines, to summary reports that roll up information into cost breakdowns and overall operating efficiency ratings. The output needs the flexibility to be delivered via paper, electronic documents, or the Web.

6

EEMS Design Principle 4:

Measure & Verify Results

All too often performance measurement and verification (M&V) ends up neither measuring nor verifying performance. It is a simple case of not having access to data to do M&V properly[1]—a problem an EEMS solves.

In measuring and verifying results it is first important to define terms often used to justify and quantify the impact of investments in utility operations.

6.1 Real Savings versus Stipulated Savings

Real savings is proving cost savings via actual dollar savings, while stipulated savings is based upon savings of equipment. For example, new lighting fixtures may consume 40% less electricity while generating the same amount of lumens and, while the savings per lumen are real, the heating costs may have increased because the new lighting now produces less heat. An EEMS is required to view both the data for the electricity consumed by equipment type and for the utility consumed to heat (or cool) the area, all within the context of a specific space if a real savings assessment is to be made.

6.2 Energy Savings versus Dollar Savings

The EEMS must be able to account for both energy savings and cost savings (actual dollars). For example, just because the utility bill has dropped does not necessarily indicate that money/energy has been saved; rather it confirms only that less was spent. It confirms nothing about reduced energy consumption.

Factors like price, weather, a new construction coming on line, and consumption rates are required to understand whether actual dollar savings have occurred. Consumption savings occurs because of the way energy usage is being controlled and this can only be validated through monitoring and control points that highlight energy consumption changes.

To understand the dollar savings realized, one must account for variations in the price of energy, the actual weather versus the planned weather for the time period, and the change in the amount of energy used.

To realize true energy savings, which in turn lead to dollar savings, consumption must be reduced independent of the

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[1] IPMVP Volume I: Concepts and Options for Determining Energy and Water Savings,2001, Sect. 5.6

factors above and this can only be achieved when energy usage is being controlled more efficiently.

6.3 Use Life Cycle Costing

An important philosophical concept to adopt is “Life Cycle Costs.” It is the most appropriate way to assess equipment and building costs. The initial purchase of HVAC equipment is a significant capital investment, but its true costs lie in this number plus the cost of its operation, service, maintenance, and total life span. The dramatic impact of an EEMS on life cycle costs is discussed later, but it is important to highlight this “real cost” assessment as a true measure of the total cost of equipment ownership.

7 EEMS Design Principle 5:

A Platform that Embraces Industry Standards

Using industry standards and an open architecture is the right way to build an enterprise-class application. This has been proven repeatedly at all levels of technology and business where broad support and interoperability are significant benefits. A platform architecture and the use of standards protects the organization by minimizing dependency on any single vendor, even allowing functionality to be added outside the vendor’s development cycle.

There are standards in several areas that an EEMS should adhere to:

Operating system: There are three platforms, sufficiently open and standardized, that an EEMS could run on. The first, and by far the most popular, is Microsoft Windows. It offers the greatest availability of tools and options, and is already installed and supported nearly everywhere. The Microsoft .NET platform is excellent for developing and integrating application components. Other options include Linux, which has strong server support and tools such as J2EE, but is a limited end-user platform; or a Web-based platform, which is typically made up of Windows or Linux servers using the Web for network communications and a browser for the application front end (which instills limitations on the UI).

Database management: Equally important is that the data stored within an EEMS is housed in a manner that is open, accessible, and interoperable with other systems such as a standard relational database (i.e. SQL Server, Oracle, etc.). Proprietary data managers will handcuff users to rely on the vendor for everything.

Data collection: As discussed within “Design Principle 1,” data is the lifeblood of an EEMS, and access to this data is a complex and arduous task. The mechanism for ensuring that this data extraction/transfer takes place can be both cost prohibitive and extremely difficult without adherence to standards such as OLE for Process Control (OPC), BACnet, LonWorks, and Modbus.

Analysis: Data analysis tools range from the most general purpose and broadly available, Microsoft Excel, to highly specialized analytics. Ideally the EEMS will provide direct support for Excel, allowing users to take advantage of analysis routines already developed. Minimally the EEMS will allow data to be exported into any analysis program through cut and paste or by using an intermediate file.

Space planning and classification: The EEMS should support HEGIS groups and classifications for space planning. It should also interface with the leading space planning system, FAMIS.

Publishing: Making information available throughout the organization is an important function that saves significant time. There are four document formats an EEMS can consider publishing to—Microsoft Office, PDF, HTML, and XML. Office, which includes Word, Excel, and PowerPoint, is ubiquitous in business settings. The other formats are also nearly universally readable, although they require less common tools or special skills to edit.

8 Business Applications of an EEMS

The EEMS has many business applications, each with different benefits to the campus. Some of these applications deliver benefits that are operational savings (reduced energy consumption) and some of the applications enhance the infrastructure. The most common applications of an EEMS are:

- Operational diagnostics & monitoring
- Empowering efficient building control strategies
- Enabling continuous commissioning
- Chiller plant efficiency calculations
- Controlling building comfort
- Accurate energy cost allocation
- Capital request justification
- Information publishing
- Providing more accurate budgeting & forecasting
- Purchased utility accounting
- Vastly improved performance measurement & verification

8.1 Operational Diagnostics & Monitoring

Operational diagnostics is the process of reviewing operational energy data and identifying targets for energy savings, highlighting engineering design deficiencies, and alerting staff to malfunctioning equipment, to name just a few. While these tasks sound familiar, it is important to contrast the manner in which an EEMS performs this function with that of today’s technology and processes.

In short, an EEMS streamlines the process. It provides a complete picture that can be explored quickly and easily to identify problems, validate improvements, and test hypotheses—all without the technical literacy and timescales required by today’s approaches. With an EEMS, this process simply involves a straightforward visual analysis of the data, quickly digging deeper into the information where anomalies are evident to uncover problems and gain real insight.

An engineer diagnosing a problem using the data in an EEMS can typically resolve the issue to its root cause in one fifth to one tenth the person-hours than with standard approaches. Also, the elapsed time from the first indication that something is wrong to resolution can be reduced by a factor of 100 or even more. Appendix A shows a case study where this was the situation.

Once an issue has been resolved, the results should be verified and measured. This is to ensure that any actions taken had the intended result, and also to be sure that no unintended side effects occurred. Trend Lines provide the ability to start verifying results as soon as 15 minutes after the change has been made.

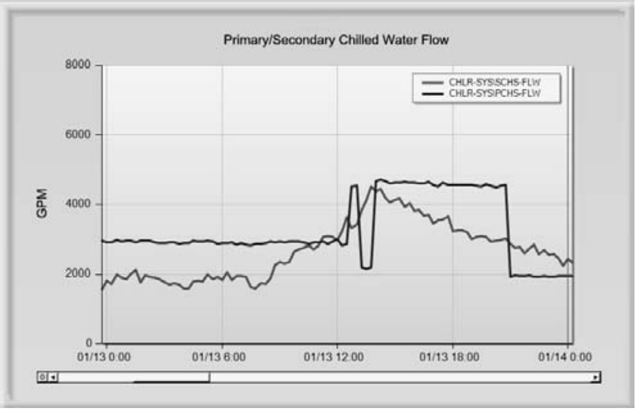

Fig. q) An example of a chart used in the process of identifying a problem. Here the diagnostician has identified significant differences between the BTU output of different chillers even though they should be producing equal amounts.

When not diagnosing specific issues, an EEMS is the ideal tool for ongoing monitoring of operations. The data organization, performance, and Trend Lines allow engineers to monitor as many as a half million interval data points in 20 minutes. Instead of watching unconnected real-time monitors and waiting for BAS alarms to sound, an EEMS's monitoring capability provides far more in-depth information about how systems are operating and reveals issues at their earliest stage.

8.2 Efficient Building Control Strategies

A great deal of effort is expended programming building automation systems to meet the disparate comfort needs of building occupants. Since seasons and weather change constantly, the strategy used to control the building will need to change accordingly.

A key role in the development of efficient building control strategies is the EEMS Trend Lines function. They show how the change in the control strategy is working, or highlight areas where the strategy should be adjusted. Importantly, by using a data collection interval of just 15 minutes, control strategy change requirements and the results of implemented changes will be apparent almost immediately.

8.3 Continuous Commissioning^{SM}

Continuous Commissioning[2] is an ongoing process for monitoring systems, diagnosing and resolving issues, and making energy consumption as efficient as possible while maintaining or improving building comfort. It includes anything from physical maintenance, to control strategies, to prioritizing and implementing retrofits.

While other forms of commissioning on existing buildings have initial design specifications as their goal, continuous commissioning seeks to optimize the current operations—how the building is occupied and used today, taking into account changes since the original design.

An EEMS provides a continuous commissioning engineer the information to perform many of the steps and meet the objectives of a successful continuous commissioning program:

- Document the existing state of operations, space comfort, and energy consumption
- Locate system issues, diagnose, and develop a plan to resolve them
- Create new recommendations for control settings, setpoints, etc.
- Identify and prioritize retrofit projects that will have the greatest impact
- Measure and document improvements in system performance and energy consumption
- Monitor ongoing operations to ensure all benefits are sustained

8.4 Chiller Plant Efficiency Calculations

A true EEMS must enable holistic utility performance measurement and management, including the frequently neglected chiller plant data. Chiller plant efficiency calculations provide simple to understand graphs that show the cost of running the chiller plant; accounting for energy usage by each chiller, cooling tower, and primary and secondary distribution loops. As the control strategies change operators can assess the true overall impact on costs.

8.5 Building Comfort

In addition to all the operational efficiency and energy cost related applications of an EEMS, it is important to remember that the real purpose of HVAC systems is building comfort. Well-maintained systems will improve the comfort and health of the building occupants through properly controlled temperature, humidity, and ventilation.

Improving comfort levels and maintaining their consistency can be accomplished while lowering energy consumption and its associated costs. This was proven by the Energy Systems Laboratory at Texas A&M University where their Continuous Commissioning efforts resolved major comfort issues while reducing energy consumption by 15 – 30%[3].

An EEMS provides the data to see exactly how building or room conditions change and what the control settings are to try to maintain comfort. For example, a large meeting room filled to capacity will typically experience a rise in temperature during a long meeting. The solution of "cranking up the AC" halfway through does not work very well, yet is often what is done in response to occupant complaints. With an EEMS, engineers can use the data to determine the proper control settings to manage temperature, relative humidity, supply air static pressure,

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[2] Energy Systems Laboratory, Texas A&M University, Continuous Commissioning In Energy Conservation Programs, www-esl.tamu.edu/cc

[3] U.S. Department of Energy, 2002, "Continuous Commissioning Guidebook, Maximizing Building Energy Efficiency and Comfort," ch. 2, pp. 1.

terminal damper position, etc. This is a more complex control, but maintains comfort better and is often more energy efficient.

8.6 More Accurate Energy Costs Allocation

By integrating all energy sources and consumers across the campus along with space planning information, organizations can identify specific energy consumption by space. Once space consumption is determined, the rates can be applied to generate accurate costs for each space. These can then be rolled up to assign costs by department or other organization structure.

Today, energy costs per space are typically allocated by a combination of approximation and averaging, producing an inaccurate cost allocation. In essence, the high energy consumers are being subsidized by the low energy consumers, resulting in cost centers being billed inaccurately.

8.7 Capital Request Justification

Large capital requests tend towards two categories: replacing old worn-out or out-dated equipment, and doing major overhauls resulting from design flaws or changing requirements that render the design obsolete. Replacing old equipment is part of a normal cycle, even if only done every 20 years. Proving the need for an overhaul is much more complicated and requires proof to show that the investment is needed.

Today, engineers design systems and specify how they should be operated. However, they receive very little feedback as to how a particular piece of equipment performs in the field, under load, supporting usage patterns that may be different from when the original design was done. EEMS Trend Lines can be used to “instrument” the equipment and provide verification of air handling system performance, distribution loop efficiency, and overall system performance under various loading conditions, to name just a few.

Many design engineering firms build various computer models to simulate operations, but now, Trend Lines provide real feedback, based upon live data for the first time. The information is based on actual operations, not original design intent.

While building automation systems cannot provide this feedback due to the large volume of data created, and the inability to look outside itself, an effectively implemented EEMS is able to perform this function with ease.

In short, an EEMS can be used to identify and verify design flaws, whether from bad initial design or due to changing requirements or equipment upgrades. This capability gives facilities personnel the information needed to justify the capital budget requests needed to fund system overhauls.

8.8 Information Publishing

The current approaches to publishing operational data fall into two categories: the ad hoc, “that information should be here somewhere” approach, and the comprehensive reporting approach. Both consume vast amounts of time from engineers, technicians, and other facilities personnel because the data is not readily available, and what is available is not organized. It is a giant exercise in manually compiling and distributing spreadsheets.

The EEMS provides the starting point where all data is present. It is organized so that building-specific, departmental, or system-centric views of data can easily be reported. Reports can be financial or consumption based, or correlate the two with ease. The EEMS makes more information available at a fraction of the effort and associated cost.

8.9 More Accurate Budgeting and Forecasting

An EEMS should also show deviations from budget in terms of causes (consumption, weather, price and new construction).

Through the EEMS, individuals can view daily updates versus budget on a graph, thereby preventing month-end budget shortfalls. By providing this insight concerning current status on an ongoing basis, the EEMS provides opportunities to prevent budgetary overages before they blossom, while at the same time providing the vehicle through which the most effective cost savings can be realized should a budget overrun actually occur.

8.10 Purchased Utility Accounting

Today, at their own significant expense, many organizations install their own meters in parallel with those of the utility company for the purpose of verifying the utility bills. However, there are other techniques to verify utility billing without requiring additional meters.

An EEMS can summarize energy usage from all of the consumers of energy, identify losses, and provide supporting documentation to reconcile discrepancies with the utility. Furthermore, an EEMS can do this in a fraction of the time and cost.

8.11 Vastly Improved Performance Measurement & Verification

In the past, the first phase of a performance contract required that the contractor collect baseline information regarding the status of the building. This labor intensive and expensive task invariably only provided small samples of data from locations across the campus. Attempts to collect more data through BAS Trend Logs will have a negative impact on the BAS’s ability to control operations. With such a random data collection process, it is simple to understand why this form of baseline information is inadequate for use to make significant investment decisions.

EEMS Trend Lines, discussed earlier, can significantly improve performance contracting for both the customer and contractor. With an EEMS, all the point data can be collected (with zero impact on the BAS) to provide a complete and accurate baseline as a matter of course, rather than as an expensive manual task, and the subjectivity can be removed from performance contracting. As improvements are implemented, their impact can be measured and verified quickly and easily.

9 Financial Benefits of EEMS

It is clear that an EEMS is able to provide the infrastructure to support many different business purposes. Importantly, these applications of EEMS technology are also able to deliver a rapid return on investment in a number of areas including:

- Lowering operational costs
- Positive cash flow
- More effective staff deployment
- Greater indirect cost recovery
- Reducing equipment maintenance costs and increasing equipment life
- Improving the efficiency of energy purchasing

9.1 Lowering Operational Costs

EEMS Trend Lines provide the insight necessary to identify and achieve operational savings. Today, organizations typically identify operational savings targets by engaging a seasoned HVAC engineer to tour the campus, every building, and each piece of equipment to determine what is happening. Decisions are made based on a tiny fraction (often just one or two percent) of the data and many problems are not found until long after they appeared or are completely missed.

With an EEMS, this process can be accomplished within days instead of months, without leaving the office, through the rapid visual analysis of data. Unlike a manual campus tour, an EEMS uses all of the operational data to quickly identify common operational problems that, when addressed, lead to a reduction in operational costs. Below are samples:

- Fans running constantly when they do not need to
- Chillers and air handling systems unable to keep up with setpoints
- Over controlling of the building
- Operation of the equipment that deviates from the instructions of supervisors

Furthermore, using an EEMS the operational changes and the financial benefits derived from them are instantly measurable and verifiable through simple monitoring of the data.

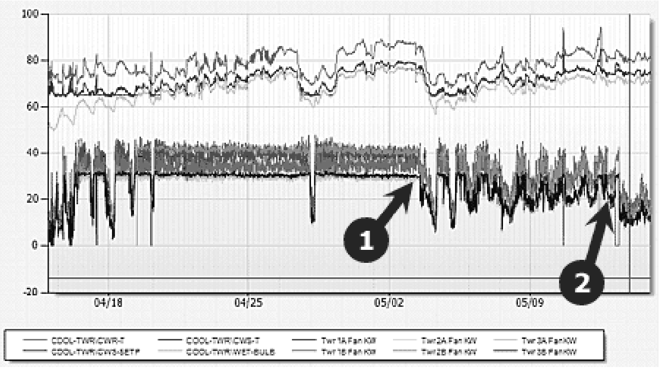


Fig. r) Electrical consumption in six cooling tower fans is reduced by (1) employing new control strategies for cooling tower approach offset, and further reduced by (2) setting fans to run in unison at lower rpm.

9.2 Positive Cash Flow

A typical retrofit project involves replacing dated components with new, efficient equipment. Such projects require a huge up-front investment to fund a few months of design and planning, followed by 6 – 24 months of installation/construction. It can be multiple years of negative cash flow before the project is complete and stipulated savings begin, and much longer before the return on investment is fully realized.

With an EEMS, savings start after just a few weeks. The initial investment is typically recovered in 5 – 6 months, and thereafter generates a positive cash flow. The realized savings and additional cash could even fund other projects once the operational issues are resolved.

9.3 More Effective Staff Deployment

Most facilities staffs are operating on guesswork due of the lack of data. Energy and control engineers may study real-time monitors and run BAS Trend Logs, often taking weeks to correct an operational defect.

With the data provided through the EEMS, facilities staff prioritizes the right problems and resolves them in far less time. Less time is spent on firefighting and more on improvements that upgrade campus/facility physical assets in line with the master plan.

9.4 Equipment Maintenance & Life

Access to Trend Lines and comparison data between the weather, like-equipment, and facilities can serve as a powerful tool to reduce maintenance costs and prolong the life of equipment.

For example, cooling tower fans are often run at 100% capacity unnecessarily when the dew point is too high for the environment to accept the heat that the towers are attempting to transfer. In this example, running the fans at 50% or less would be equally beneficial as running at 100%. Access to this data via an EEMS can extend the life of the fans, reduce the service call frequency, and reduce overall costs dramatically. The same approach can be applied across other equipment types.

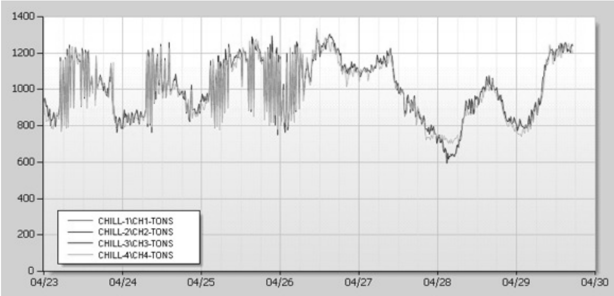


Fig. s) Equipment trashing was stopped when the chiller setpoint was set to a fixed value, resulting in an expected increase of life and reduction in repair/maintenance.

9.5 More Efficient Energy Purchasing

Whether an organization makes energy purchasing decisions alone, or with the help of consultants, an EEMS can have a positive and profound impact on the energy purchase process.

Purchasing energy is a complex task that requires a thorough understanding of demand. In addition, if energy costs are to be minimized, it requires an insight into how to manipulate the timing and height of peaks in demand.

Also, because energy pricing structures change regularly, effective purchasing requires a sound knowledge of the energy market's price drivers so as to "lock in" the best price. Organizations frequently buy extra energy, locking in prices via futures contracts. When decisions concerning contracts of this magnitude are made, organizations, like people, make better choices when presented with all of the facts. Without a robust knowledge of an institution's consumption patterns, the drivers of these patterns, and the impact of the weather on operations, an energy purchase is being made without visibility of the whole story.

9.6 Indirect Cost Recovery

9.6.1 Allocation

By accurately identifying energy cost for research space, rather than using an estimated allocation approach that invariably falls below the actual energy cost of the space, institutions are neglecting access to government funds.

Through the use of an EEMS, energy cost for space can be accurately and verifiably attributed to ensure that all of the institutions revenue opportunities are maximized and an institution's low energy users do not necessarily have to subsidize the high energy consuming departments.

9.6.2 Productivity

When examining financial benefits and focusing on cost savings, it is easy to overlook the impact of having space comfort. Studies have shown that maintaining a consistent, comfortable environment has a positive impact on attention span and productivity, and lowers time lost due to illness. Also, fewer comfort complaints mean that facilities engineers and technicians are not forced to spend time servicing comfort complaints.

10 Conclusions

When implementing a true EEMS, the following criteria must be specified:

- The EEMS must collect data from all monitoring and control points from all sources—building automation systems, utilities, metering systems, weather, and space planning systems. It must gather consumption data (in instantaneous, totalized, and average forms as appropriate), control settings, billing and rate information to provide a holistic view.
- It should structure the data within a data warehouse in a manner that provides the flexibility to handle complex relationships, hierarchies and calculations, and adjust to meet evolving requirements. Data should be normalized so that it may be more easily compared and contrasted, and so that problems can be pinpointed more precisely.
- It must present actionable information and Trend Lines so that data is represented in an informative manner. Performance and user interface must combine to provide interactive access to the data that can then be manipulated, supporting detailed investigation and efficient monitoring.
- The EEMS must deliver real savings that can be measured and verified, and demonstrate these returns over time.
- The EEMS should be more than an application—it should be a platform for energy management and other facilities operations that is expandable. It must conform to open standards so that integration and interoperability between related systems is a seamless and straightforward process.

An effectively implemented EEMS provides unparalleled insight into the day-to-day, week-to-week, and month-to-month operation of an institution's utilities. It nearly eliminates the time wasted by facilities staff gathering needed data. It provides individuals with the ability to rapidly find and address inefficiencies (fixing the root cause, not just treating symptoms) that can result in immediate cost savings and an ongoing financial return—often when these problems have gone undetected for many months or even years.

An EEMS also reduces the total cost of ownership of equipment by reducing maintenance costs and extending its life, all while providing the most actionable data to effectively secure lower utility rates and both improve and expedite master planning. It makes it easy to publish operational data to constituents within and outside the facilities staff.

An Enterprise Energy Management System presents the opportunity to span all existing building automation systems and energy related data so that assessments can be made in the context of the whole facility, environment, and billing climate. Complete information leads to better decisions—decisions that address building comfort, energy consumption, operational costs, capital investments, and stewardship of the assets.

Appendix A: Case Study

Diagnostic Process using EEMS

This case study is from a hospital in North Carolina. The data shown is real, taken from a live EEMS.

Problem

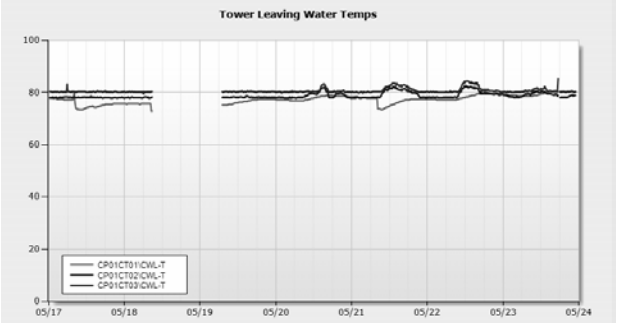
The water temperature leaving the cooling tower was not meeting setpoint. Based on traditional data and investigation, all that was known was:

- The first indication of the issue from the BAS was an intermittent alarm
- Alarms came from cells 2 and 3 of the 3-cell system
- The problem had been going on for over a week without being able to identify the cause

With no prior knowledge of the systems or operations at this facility, the diagnostician using the EEMS set out to find the root cause of the problem.

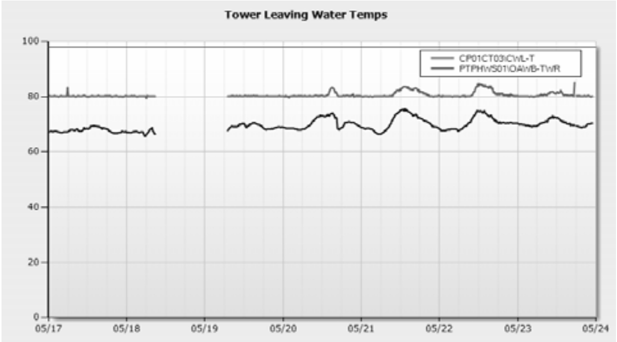
Process

The first step was to look at the water temperatures leaving the cooling towers for each cell. Tower 3 had the most difficult time achieving setpoint (80°F).



Pic. A-1) Bumps in trends show where setpoint is not held, causing BAS alarm to sound.

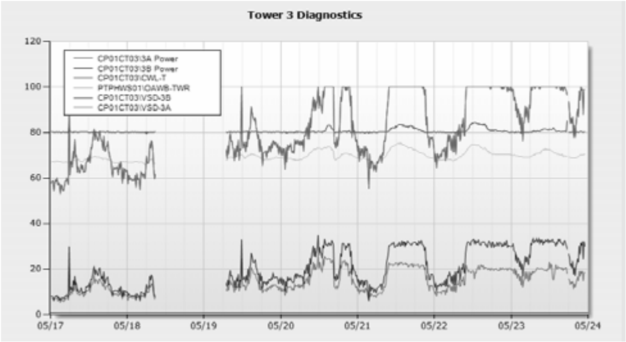
A correlation with weather was investigated by overlaying wetbulb with Tower 3's water temperature.



Pic. A-2) Each time the wetbulb exceeded 73.4°F, the tower could not maintain setpoint.

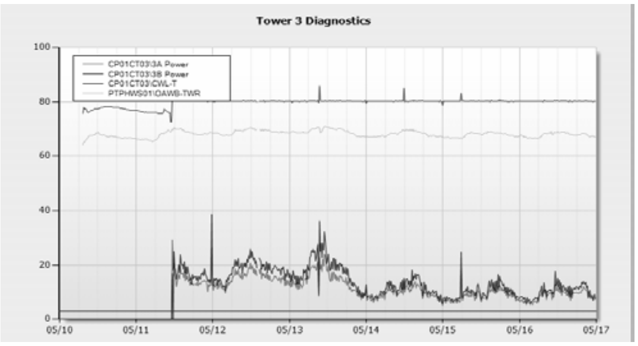
Scanning back through time verified that the behavior was related to weather. This was the first time in several months that wetbulb reached that high.

The next area of interest was the power consumption of the two fans in the tower. The EEMS immediately showed that two identical fans were using very different amounts of power. Adding control information to the monitoring data showed the exact same signals being sent to each variable speed drive (VSD).



Pic. A-3) The bottom two lines show the separation in power when wetbulb rises. The upper line that follows the same shape is actually two lines—the control signals.

Another scan back in time shows the fan behavior starting about the same time the BAS alarms started. Earlier, the fans run in unison (although wetbulb was not as high).

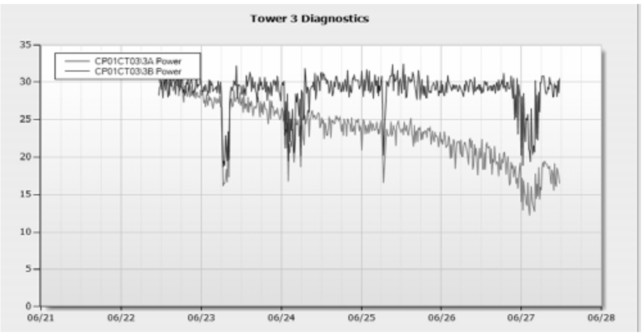


Pic. A-4) The fans first started to split a week earlier.

Diagnostics Conclusion

The conclusion was that a fan belt was likely slipping because it was a VSD, causing the problem. It only took about 30 minutes to complete the diagnosis.

The fan belt was checked and found to be loose. It was tightened and the EEMS verified the result.



Pic. A-5) After the belt tightening, the fans ran properly again. But, monitoring showed slippage again a month later.

Although the problem was properly resolved, its return suggests that the equipment ultimately needs replacing, not adjusting. The EEMS provided the facilities manager with the data to prove that this was a necessary expense.

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