WHAT IS RTEM?

Introduction

Real Time Energy Management (RTEM) is a term used by the New York State Energy and Research Development Authority (NYSERDA) to describe a combination of systems and services employed to monitor and identify building improvement opportunities. The system consists of hardware, software, and secure internet connectivity that continuously transmits a building's current and historical performance data to the cloud, provides automated fault detection and diagnostics (FDD), and supports demand response.

RTEM services are delivered by expert consultants to support building staff in using the RTEM system by delivering actionable insights to improve the efficiency and reliability of building operations. The combination of RTEM system and service has the potential to achieve 15% to 30% in energy savings (Katipamula & Brambley, 2005).

RTEM Benefits

- **Improve Equipment Operational Performance**. RTEM monitors the live operation of energy-consuming equipment and plants installed within commercial buildings, most commonly air conditioning, ventilation, air quality, and comfort heating. In some cases, lighting fixtures and hot water consumption are also included. Deviations from equipment's performance envelopes may be predicated using advanced analytics and prevented where possible. Performance degradations are detected immediately and remedies are often identified and recommended.

- **Increase Rigor of Routine Maintenance**. The rigor with which routine maintenance is conducted on all the major energy-consuming equipment and plants. Poor maintenance wastes energy and leads to shorter equipment life. RTEM detects conditions such as reduced air flow due to clogged filters and degradation of performance and provides data to assist in troubleshooting.

- **Optimize Control Schemes**. Equipment and plant control schemes optimization to match building occupancy or functions and weather conditions dynamicallyincluding set points, to use the least amount of energy. Building environment, functional usages, and occupancy change over time, while the set points, equipment scheduling, and control scheme tend to remain static. Manual overrides are often left in place while the original cause of manual intervention elapsed. RTEM communicates automation system adjustments detects errors and records fault resolution.

RTEM Enhancing Building Operations

RTEM shifts the focus of a building's operational staff from one of scheduled maintenance and chasing faults, to proactive performance-optimized strategies that apply predictive analytics to building automation. As a result, the organization migrates from treating energy as an operational expense to managing energy as a strategic metric in the health of millions of dollars' worth of capital assets, including the building itself.

RTEM enhances the productivities of the building's operational staff, focusing on prevention and optimization. When the unpreventable faults occur, RTEM consultants have access to critical data and the recommendations from advanced analytics vetted by experts to remedy the situation quickly.

The Role of the Cloud

The growth of cloud-based computing is undeniable and is a critical aspect of NYSERDA's definition for RTEM functionality. By rootingthe system in cloud-based computing, NYSERDA is focusing on the transformation of the RTEM marketplace beyond the impacts associated with the incentives.

Compared to building systems that reside within the four walls of a building, such as a Building Automation System (BAS), RTEM depends on the cloud for the delivery of servers, storage, data, and software applications in an "as-needed, pay-per-use" business model. RTEM is especially different from web-enabled or Internet-connected BAS where computing resources are still located within the building, which is not sufficient to satisfy NYSERDA's definition of an RTEM system. RTEM system providers are responsible for maintaining the cloud infrastructure, allowing building staff to focus on the system's capabilities rather than enabling IT foundation.

RTEM Solutions

The marketplace is rich with RTEM-like solutions. The U.S. Department of Energy (DOE), under its Better Buildings initiative, broadly classifies RTEM systems into technologies that are either whole-building or system-focused. Both whole-building and system-focused RTEM deployments provide visualization tools and reports through web portals hosted in the cloud and accessed through login controls.

Figure 1: Whole-Building vs. System Focused RTEM Systems

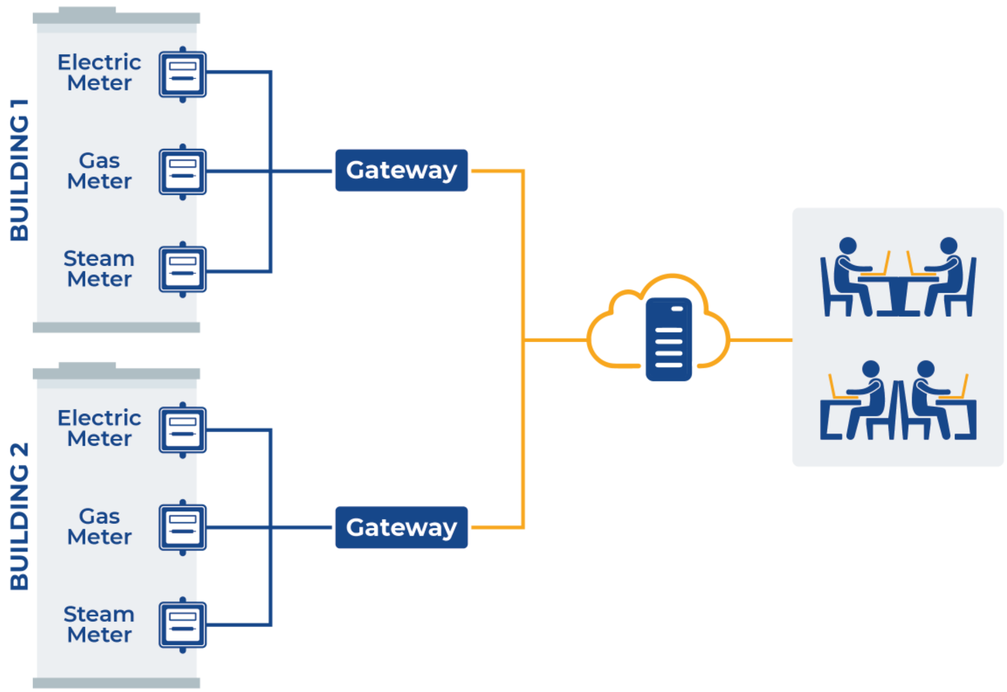
Whole-Building RTEM

The whole-building RTEM monitors incoming utility services (e.g., electricity, natural gas, steam, water, etc.), allowing for benchmarking and utility bill analysis. Although some functionalities can be delivered using monthly whole-building energy data, the efficacy and depth of analytics are dramatically better when 15-minute to hourly interval meter data are available. Options for data gathering include connecting to utility databases using a defined interface such as Green Button,[1] connecting to the pulse output of the utility meters and accumulating the consumptions in parallel with the utility, or when available, connecting to an onsite smart meter through a defined protocol.

Whole-building RTEM using monthly energy data is principally used to compare building energy performance within a single owner's or operator's portfolio, or compared to a national database through integration with EPA's Portfolio Manager. Additionally, weather normalization of historical building energy data allows for season-to-season and year-to-year tracking to identify trends. Identifying buildings that compared poorly to similar buildings is beneficial if it leads to determining the cause.

[1] http://www.greenbuttondata.org

Figure 4: Whole-Building RTEM



Whole-building RTEM using 15-minute to hourly interval energy data can be used to perform preliminary diagnostics of performance issues when analyzed with local weather data. When sufficient interval and weather data from multiple years are included in the analysis, a building's energy behavior can be modeled using a straightforward algorithm such as regression analysis, or with an advanced machine learning algorithm such as support vector machine. The model compares a building's actual energy usage against the predicted usage to create an alert when the building's energy consumption pattern deviates from the predicted ideal.

System-Focused RTEM

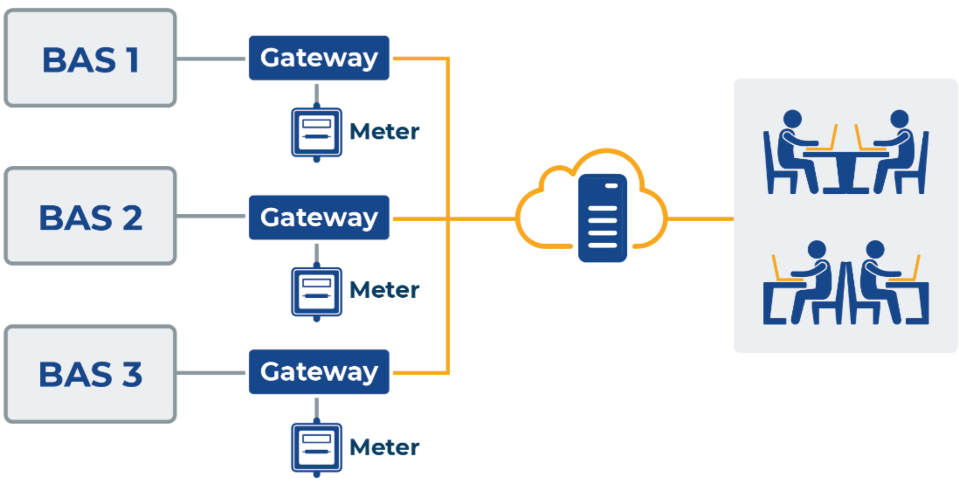
System-focused RTEM provides monitoring of major building systems such as air conditioning, ventilation, air quality, and comfort heating. Data are collected at the equipment and plant level, providing live insights into their operation and often supplemented with meter data, enabling energy consumption reporting by major building subsystems.

Data collection options include acquiring data from dedicated equipment and system controllers, such as variable-speed drives connected to fans/pumps or control panels for a chiller plant, using communication interfaces such as Modbus, Fieldbus, or BACnet. This interface type relies on dedicated controllers to collect data from the embedded equipment and sensors to be collected by the RTEM system. Additionally, in larger buildings, the existing BAS is a convenient aggregation location for system-focused RTEM to access data for all the systems and sensors controlled and monitored by the BAS.

Deployments are also available with standalone data collection sensors and meters outside of a BAS, ranging from temperature and humidity sensors to current-transformers and voltage probes installed inside electric distribution panels or major electrical junction boxes to monitor electricity used on a circuit-by-circuit basis. It is also important to note that system-focused RTEM also integrates data from systems outside of traditional BAS, such as networked lighting controls or submetering systems for tenant billing.

This system monitors a finer granularity of data, compared to the whole-building RTEM system, resulting in a comprehensive analysis available to building operators. It allows for fault detection and diagnosis at the system or equipment level, as well as performance monitoring, where slow degradation such as wear and tear due to aging or lack of maintenance can be detected. Additionally, the availability of fine-grain interval data over an extended period enables equipment and plant coordination to accommodate dynamic occupancy and weather conditions.

Figure 5: System-focused RTEM



Basic RTEM

The most basic RTEM system is composed of a data acquisition gateway or other hardware streaming live building data to a repository residing in the cloud. The difference between a basic and a more advanced RTEM system is whether additional meters, sensors, and controllers are included in the RTEM deployment. An example of a basic RTEM system is a data acquisition gateway connected to a BAS using BacNet.

Algorithms hosted in the cloud analyze and aggregate or summarize data into key performance indicators, which are presented graphically in visualization dashboards through a web portal to communicate energy performance. Depending on the data collected, whole-building or system-focused, the dashboard may present hourly and daily time-series profiles identifying peak load. This information would include sub-hourly interval data, where necessary, such as when fault conditions have been detected or alarms have been raised. Dashboards may also provide navigation to more granular-level data, access to specialized analytics and trend charts, or access to reports that communicate KPIs by user types. Thus, a building engineer and chief financial officer may each have uniquely summarized information. However, basic RTEM lacks the dataset required by advanced analytics and fault detection and diagnostics software to operate reliably.

Additionally, data sources such as time-series weather data, time-of-use energy prices, and demand-response information may be integrated into the algorithms to enhance the system's analytical capabilities.

Advanced RTEM

Advanced RTEM supplements basic RTEM systems with additional sensors and meters to deliver a more comprehensive view of a building's performance. This system also includes more sophisticated analytics that incorporate predictive algorithms where energy performance is mathematically modeled by cloud-based software to normalize key variables affecting energy consumption such as weather conditions and occupancy schedule. The models are continuously refined as additional data are collected to enable a higher accuracy of predictions of energy behavior over time. This modeling type is used to conduct automated anomaly detection by comparing actual vs. modeled values, predict energy costs using forecasted weather and market prices, and fine tune control schemes.

A suite of functionalities commonly referred to in the industry as automated fault detection and diagnostics (FDD) is often included. FDD is software with analytic capabilities that identify equipment problems and assist in locating the causes of the problem as well as identifies fault duration and frequency, determines cost impacts, and assigns priority levels. Additionally, FDD suggests probable causes for each fault, with recommendations for an immediate remedy. This software may also request additional data or request physical inspections to ascertain equipment condition information before a diagnosis is rendered.

Why are RTEM Services Valuable?

RTEM Services provide the expert consultants to translate the large amounts of data output by an RTEM system into actionable tasks for system maintenance, operational scheduling, or replacement planning. Without external expertise to help integrate an RTEM system into the ongoing operations of the building, the system can become "orphaned technology." Experts verifying the automated alerts and validating the upgrade recommendations is critical to the success of RTEM projects.

Additionally, NYSERDA also recognizes the human resource constraints of managing a facility. As the industry evolves, it is common that fewer dedicated facility staff are responsible for maintaining greater building square footage with more sophisticated building systems. Ideally, an RTEM system would focus specifically on those issues of importance to the building's staff, present information and identify opportunities in ways that are easy to understand, assist staff with troubleshooting problems, and avoid false alarms that waste time and resources. Nonetheless, an RTEM system has the potential to inundate existing personnel, which may render the system irrelevant. Moreover, staff turnover presents the risk that RTEM systems may be unused. NYSERDA seeks to avoid underutilized RTEM systems deployed under the RTEM Program by incentivizing the hiring of outside consultants focused on extracting the maximum value for the customer.

To this end, NYSERDA cost shares in the hiring of prequalified consultants to supplement building staff. The consultants are RTEM service providers with dedicated availability and expertise to work with the building staff to complete data extraction and analysis, verify automatic notifications such as provided by FDD, and deliver the human confirmation that is often necessary when interpreting automated outputs. RTEM service also provides additional proficiencies such as preparing financial analyses, preparing RFPs and bid documents, evaluating bid submittals, and helping manage energy efficiency implementation projects for customers.