Cutting-Edge Information and Telecommunication Technologies Meet Energy: Energy Management Systems and Smart Web Platforms

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Abstract. Green consciousness is a prerequisite for environmental protection. Renewable Energy Sources and Energy Efficiency seem to be the only way to reduce harmful greenhouse gases like CO_2. Cutting-edge technologies could be a driving force in the energy sector, covering issues that are vital for energy production, consumption and management. With rising energy costs and the move toward more sustainable buildings, increasing energy use in buildings has both financial and environmental consequences. So it is critical for building owners and facility executives to determine if their buildings are operating as efficiently as they can and if not, having the ability and control to do so. Aiming at a new era of energy, Build-IT provides energy monitoring solutions and innovative applications for energy data analysis.

Keywords: Automated Metering Infrastructure, smart meters, energy Monitoring & Targeting, energy saving, energy analysis.

1 Introduction

The vast majority of energy management activities are based on the financial impact they will have on the company. Today's rapidly evolving energy markets are forcing organizations to consider new ways to centrally manage the energy portfolio of the company. These two real-world conditions are causing building owners and energy managers to search for solutions to integrate and coexist with the rest of the enterprise building information network [1]. Energy managers are looking for an Internet friendly, smart platform that manages the "X" factor of energy.

Build-IT, having the technological know-how resulting from a 3-year Research and Development program, provides modern, reliable solutions in the field of energy Monitoring and Targeting (M&T). Incorporating the global energy trends, Build-IT creates innovative systems for M&T, smart homes, focusing on the energy management of large buildings and industries.

The cost of energy has to be incorporated in the operating cost of any company and should not be assumed as a fixed cost. This is especially critical in times of economic instability, where reduced energy costs can be considered as a profitable investment.

N. Hatziargyriou et al. (Eds.): E-Energy 2010, LNICST 54, pp. 153–162, 2011.

With adoption of energy efficiency practices, total energy consumption increases with lower rates or even remains the same. As a result, energy efficiency and saving come hand in hand with a plethora of benefits (environmental, commercial, financial), becoming a really vital process. The following figure presents the integrated solutions of Build-IT. This paper focuses on Smart Metering Systems and Energy Monitoring & Targeting [2].

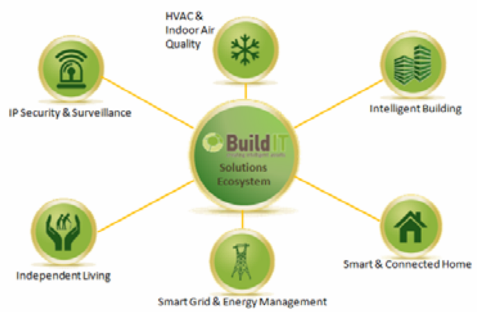

Fig. 1. Integrated solutions of Build-IT

2 Advanced Metering Infrastructure (AMI)

In partnership with E-sight Energy (UK), Build-IT provides the AMIplus solution, a fully integrated solution for energy metering, monitoring, targeting and management. As a real-time integration platform and automation infrastructure, it enables users to deploy optimal energy and environmental management strategies, allowing notification of events before they occur.

The technology also enables users to collect information and benchmark buildings so as to expose operational inefficiencies. From a green building perspective, AMIplus allows users to capitalize on accurate and concise intelligence relating to the energy performance of a building in order to achieve lower energy consumption and enhanced efficiencies.

The whole AMI system, as shown in figure 2, combines telecommunication technologies, data base principles, web based programmable logic controllers (Tridium), smart meters and sensors. The users are able to login the system from anywhere, just by using an internet connection.

Fig. 2. AMIplus system architecture

2.1 System Architecture

Focusing on the system's architecture, the metering system consists of smart meters, autonomous sensors (temperature, lux meters, humidity sensors, occupancy sensors etc) and programmable controllers – data collectors. The following figure presents the energy management installation for a typical large building [3] [4].

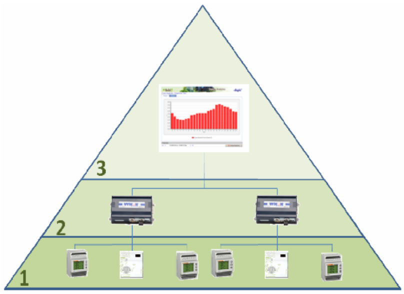

Fig. 3. Build-IT AMI system

The **first level** on the above figure consists of smart meters and sensors. It is crucial to collect plenty of values which constitute the input data that will be considered in further energy analysis. Smart meters are divided into two categories. The first category includes the energy meters, whereas the second one the power analyzers. Energy meters record only energy values (kWh) but they are considerable in special load metering and sub-metering. Power analyzers are complicated and have the ability to record power quality values such as Power, Current, Voltage, Total Harmonic Distortion (THD), Harmonics, Frequency, Energy (Real, Apparent) and Power Factor (cosφ). They are usually applied in the main installation to depict the whole energy profile.

The **second level** consists of the data collector. These powerful controllers, with a web based communication philosophy, are the most important components of the whole automated procedure. They use the internet as a gateway for data transport, using a new, secure, fully automated protocol oBiX (Open Building Information eXchange). oBix leads the new era of Machine to Machine (M2M) communications in buildings.

The **third level** of the above figure is the tool of energy monitoring and analysis. It is a software platform which is developed with sources of E-sight Energy (UK) and Build-IT. The use and benefits of this software are analyzed in paragraph 3.

2.2 Open Building Information eXchange (OBIX)

Standards in the device network industry have attempted to define "models" for every potential type of known device. This exercise continues to produce brittle models which do not capture the reality of smart devices. As a result, devices have an extremely variability between manufacturers. oBIX embraces this reality by using a model based on a simple, flexible type system backed by real computer science. First of all, oBIX defines a "kernel" model based on a few key primitive types such as integers, strings, etc. Secondly, defines an open ended type system for both standards organizations and individual vendors or integrators to build up their own custom models. This is not much different from how a programming language like Java allows people to build up their own class libraries. Furthermore, oBIX sets a simple, elegant mechanism to combine the models from different organizations into one system based on prototype inheritance. This is the critical missing piece in most alternatives to oBIX. Finally, identifies all information using URIs, making it ideal for developing the Web of Things.

2.3 Networking of Things

Although vertical industries have been networking smart devices for decades; they implement their own solid solutions [5]. The following figure illustrates a small sampling of the solutions in use today:

Residential				Commercial		Lighting	Industrial				Automotive	Metering	Verticals
X10	Zigbee	Z-Wave	Konnex	BACnet	Lonworks	DALI	Modbus	ProfieBus	DeviceNet	ControlNet	CAN-Bus	M-Bus	Proprietary

Fig. 4. The variety of protocols and their usage

Each industry tends to have hundreds of protocols, most of them proprietary to the manufacturers. Despite the fact that many things are networked today, very few of them are IP networked. However, efforts tend to this direction.

2.4 Internet of Things

Over the past two decades, there has been an explosion of standardization around the Internet Protocol (IP) [5]. The elegance of IP is that it defines a common interface between application protocols and the heterogeneous networking technologies used to transmit those protocols. As new networking technologies become available such as Wifi, all our old protocols continue to work.

Telemetry applications such as energy management have been using cellular communications for years. The value-chain required to build cellular solutions is quite complicated, but as the industry matures, it is becoming simpler and more cost effective to create cellular enabled devices. This has huge implications for the Internet of Things – manufacturers can sell devices to the field with automatic, built-in connectivity. The cellular enabled device simply finds the network and reports itself when powered up. As new protocols are invented, they can be carried over existing networks. The following figure depicts this procedure.

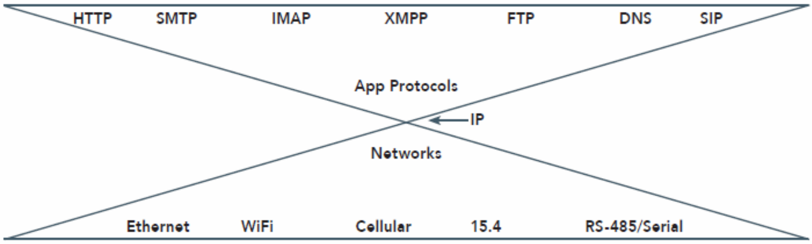

Fig. 5. New protocols are carried over existing networks

The only real problem today for using IP to network devices is lack of a standard for running IP over wired media.

For the foreseeable future, many categories of smart devices will lack an Ethernet port. Wifi will continue to drop in cost and will see its way into more devices. But the explosive growth in the Internet of Things will likely come from IP over cellular, 6LoWPAN, and wired serial communications. The Internet of Things is still in its infancy (today a very small percentage of microprocessors are IP enabled) but in the future, it will become a new communication skin through devices.

3 Energy Monitoring and Targeting

Energy Monitoring & Targeting helps both small and large organizations integrate, measure, manage and reduce their energy consumption [4]. AMIplus solution based on the MAIE methodology (Measure, Analyze, Improve, Evaluate) is a recurring process that should be repeated continually in the company, in order to allow rational use of energy [6]. Figure 6 shows the four interrelated steps of MAIE method:

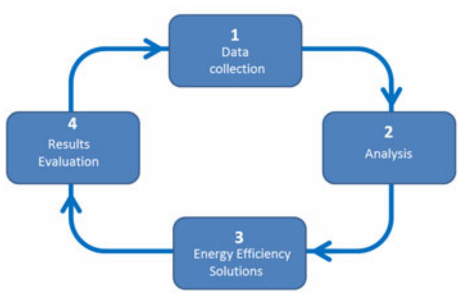

Fig. 6. Energy efficiency methodology

These four steps analyzed in the following paragraphs:

- *Data collection*

The first step of the MAIE method applies to the automated collection of energy data such as energy, temperature, lighting, production etc. Measurements are made from special digital meters and sensors at regular intervals e.g. per half hour or at smaller intervals (if necessary). The data generated from the meters and sensors are collected wirelessly or wired to a central controller which formats and sends them via the Internet to a secure database for further processing. The uninterruptible transfer of large data volumes with accuracy and security is a strong feature of the AMIplus solution.

- *Analysis*

The data analysis starts with the conversion of large data volumes into tangible and useful information for the user. The graphical representation of the energy data is able to display potential problems in the energy function of a building. Such problems may be caused by bad planning and bad energy behavior of the personnel, as well as problems of faulty management and waste of energy.

- *Energy Efficiency Solutions*

When problems arise from the energy profile of the building, improvement solutions for minimizing or avoiding the energy waste are proposed. As a next step, an attainable energy optimization target is applied that should be supported by all employees. In many cases it is not possible to save energy solely by improving energy behavior. In these cases, it is important to apply systems which automate the energy – inefficient procedures like heating, cooling, ventilation, lighting etc. Consumption parameters are carefully analyzed in combination with other factors (e.g. external temperature) and various corrective actions are proposed.

- *Results Evaluation*

The fourth step of the methodology is the most important one, since it is dedicated to the calculation of the level of achievement of the energy saving target.

Energy is a value that lacks visualization and therefore the location and the amount consumed cannot be determined absolutely. The solution is to focus on energy monitoring. The visualization of energy brings the revolution in energy management [7]. The debriefing measurements of the past seem to be an inefficient way of energy monitoring in comparison with the live display of a variety of electrical values. The existence of a system which collects, processes and analyzes energy data is necessary in the era of excessive energy consumption.

The following figures show two important ways of energy analysis and monitoring [2]. Raw values are transformed into useful diagrams to give an accurate sense of the energy consumption for each installation.

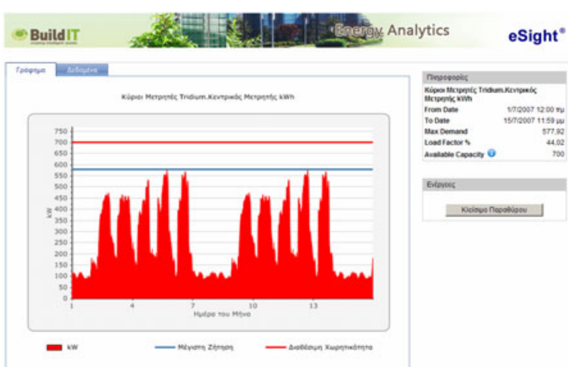

Fig. 7. Load factor analysis

Load data analysis depicts the characteristics of the load. This analysis focuses on the average, minimum and maximum load. It represents the consumption of the building, in any time intervals and finds the peaks and the valleys.

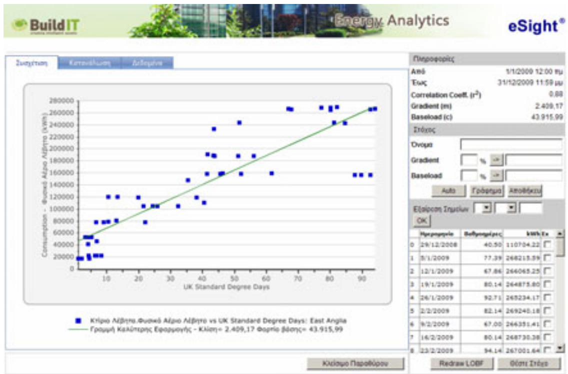

Fig. 8. Regression analysis

Regression analysis constitutes an extremely useful tool for energy managers. It presents the correlation between two values. Regression analysis is known from the diagrams of degree days and energy. Generally, it depicts any value (energy, gas) in regression with a force factor (temperature, degree days).

By managing energy and facilities as investments, companies gain control of energy use and achieve high rates of return in the form of energy savings and better performance of their buildings [8]. Benefits from this investment approach can include double digit energy reductions, as well as improved building performance, lower operating costs and increased environmental responsibility.

4 Energy Benefits from Monitoring and Targeting – Case Studies

With a huge portfolio of companies that have applied an AMI system worldwide, monitoring and targeting procedure becomes a new necessary component of energy efficiency in buildings and utilities. The following case studies emphasize the advantages of AMI systems in two huge European companies.

4.1 CDF Suez

GDF SUEZ possesses a broad portfolio of energy supply customers, from manufacturing companies to service providers. With many clients requesting access to energy data on a regular basis, GDF SUEZ identified the need for an energy management suite [9]. Customers would be able to view energy data thus allowing full autonomy of energy management.

Having identified the need for such a system, GDF SUEZ had a number of specific requirements such as Web-based architecture and allowing access across the internet from any PC, at any location for both GDF SUEZ staff and customers. The second need was a scalable system which can be expanded at any time and finally a comprehensive functionality covering a multitude of analyses.

The Solution

GDF SUEZ selected a 100% web enabled energy management suite for the following reasons:

- Complete web-based architecture: Using any browser, users are able to log on from any PC, to check the status of their energy data.
- Individual profiles can be set up, allowing the personalization of the platform for each independent user regardless of their location.
- Scalability: the platform is a fully expandable system and is ideal for any company dealing with growing numbers of metering channels.
- Functionality: energy M&T platforms include a wide range of energy analysis techniques enabling the user to perform a multitude of functions; from simple energy graphs to complex calculations, simplifying the sometimes difficult task of managing energy.

Customer Benefits

Utility customers can view energy data from any PC at any location, equipping them with a mean to monitor and manage their own energy consumption. By offering this facility, the supplier empowers the consumer to be responsible for their own energy use, thus increasing customer loyalty and retention.

4.2 Carlsberg

Carlsberg UK Leeds is a Brewing and Packaging Site [10]. Some of its annual operational characteristics are shown in the following table.

Table 1. Important operational data of Carlsberg

Name	Value
Employees	150
Production output	2.6 million Hectoliters beer
Gas energy consumption	57 million kWh
EU ETS Phase II allowance	14,254 tones
Water consumption	900,000 m^3
Effluent produced	600,000 m^3
Production CO_2, N_2	8,000 tones

The Solution

For the implementation of an AMI system 6 utilities accounting areas created consisting of Brewery Site KPI centre, Energy Centre plant, Brewing Process plant, Bottling plant, Canning plant, Large Pack Keg and Cask plant.

For purposes of energy monitoring and targeting used 142 meters, 25 calculated meters and 104 energy and performance analysis templates. The energy strategy included:

- Weekly Key Performance Indicators (KPIs) which calculated and compared to targets.
- Weekly meeting is held with user departments reviewing diagrams for previous 7 days, and any exceptions are discussed.
- Hourly dashboards are used at department operator level to monitor usage when the plant is running, stopped, shutdown or during maintenance periods.
- Email alarms range and average are used for alerting high usage of specific meters which can have a major impact on utilities costs, environmental compliance, and production output.

Results

The AMI system reduced site overall energy consumption in 2009 by 10% by understanding consumption loads and matching with production periods. Furthermore, utilized CHP plant and the recovered heat by matching to process demands, improved recovered energy from brewing process which uses 60% of site usage and opened a window into shutdown opportunities when production ends.

The whole process reduced site water consumption by 10% and effluent cost by 16%. It used alongside continuous improvement as a measure in root cause analysis and generated automated email systems to all production allowing early reaction and intervention to process losses.

5 Conclusion – Further Fields

Build-IT merges automation systems and real-time integration into a single, extensible platform that monitors, manages and controls the power consumption, drives energy efficiency and reduces energy costs. The AMI system is a scalable platform that delivers measurable Return On Investment (ROI) enabling users to capture the benefits of integration, automation and energy control of their buildings and maximize the value of information contained within them in real time.

An additional field of practice in which Built-IT focuses on is the development of Building Management Systems (BMS). BMS manage all building systems taking into account all critical areas and subsystems that make a building functional, including lighting, heating, ventilation and air-conditioning (HVAC), security, and energy management. It allows devices to share information with each other and streamlines them into a common system where management can control and monitor the buildings' operations [1].

The new era of technology and energy needs a bridge between systems and devices, simplifying the process of connectivity and integration that makes building and facility management easier. In addition to integrating energy consuming devices and systems within a building and getting them to work together to be managed, controlled and operate at optimum levels, Build-IT includes energy measurement and verification tools that allow users to implement the most efficient and sustainable energy strategies in a building today.

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