European Association for the Development of Renewable Energies, Environment and Power Quality (EA4EPQ)

International Conference on Renewable Energies and Power Quality (ICREPQ'12)
Santiago de Compostela (Spain), 28th to 30th March, 2012

ENERCARE

Miguel Lagares-Lemos, Enrique Jiménez-Domingo, Ángel Lagares-Lemos and Juan Miguel Gómez-Berbís

Computer Science Department
Universidad Carlos III de Madrid
Madrid (Spain)
angel.lagares@uc3m.es, **enrique.jimenez@uc3m.es**, **miguel.lagares@uc3m.es**, **juanmiguel.gomez@uc3m.es**

Abstract. Households, factories, office buildings and communities can reduce their energy consumption, while maintaining the same level of activity and comfort, by identifying and avoiding unnecessary energy waste. Governments around the world are taking initiatives in this direction and also international coordinated initiatives such as the future ISO 50001.
To support these plans, the general goal of ENERCARE project is to design a new open information platform built on customizable, adaptive and open service-oriented architecture, providing connectivity to the energy grids and information to the users.
ENERCARE will provide an innovative platform for the development of a key piece in a new generation suite of Smart Grid products. Through the spread of services on energy management, will encourage more energy conservation at demand side and will contribute to the achievement of low-carbon society to come.
ENERCARE will work to increase the social awareness of the citizens in saving energy and the improvement in new and more efficient habits triggered by IT solutions.

Key words

Green, IT, energy efficiency, intelligence, artificial intelligence, SmartGrids.

1. Introduction

Importance of power monitoring in the industry, buildings or organizations is well known. However, in the last decade it has gained more importance due to a major awareness on the economic implications of saving and efficiently using energy and also because the existence of specific directives oriented to reduce CO2 emissions [1]. Therefore the energy market is tending to use the software-oriented solutions to improve energy efficiency in buildings and organizations [2].
Electricity marketplace is opening up in many countries. It means that current information systems need changes and there will be more actors on the market and more software will be used for data processing and analysis.
With the rise up in the prices of energy and the environmental concerns like climate change, global warming and CO2 emissions, the need for more energy efficient power network becomes a must. The old situation main problems with respect to energy efficiency are: power losses and un-needed generation/consumption of energy
The data that can be collected from the power network is coming from a lot of sources and the analysis of such enormous amount of data and building a real time system requires a lot of work towards software intensive methodologies especially when it comes to data mining algorithms as well as statistical algorithms.
For all these reasons, ENERCARE appears as a necessary system. Users of the different platforms modules will interact with the energy information through intuitive user interfaces that will help them to save energy, while maintaining the desired comfort levels. For companies, the system will support the execution of the energy policy of the company and the management of all processes included in the ISO 50001.
In addition, the system will monitor all possible elements of local production and consumption of energy, in order to generate energy saving advices, detail energy data are required such as: solar, fuel cells, micro-turbines, heating, cooling, lighting, ventilation, air conditioning, PC, etc.
The remainder of this paper is organized as follows. Section 2 provides a thorough state-of-the-art as a starting point for building the system. In Section 3 the different features of ENERCARE are presented. Section 4 captures the main innovations brought with the project. The architecture proposed for the system is provided in section 5, and in Section 6, the different outcomes and results for the system are presented. Finally, section 7 shows the future work and concludes the paper.

2. State of the Art

Several automation manufacturers have developed energy monitoring solutions, aligned with their business model, with enhanced visualisation, reporting and data management capabilities. For example, Power Logic ION enterprise (Schneider Electric) or SENTRON (Siemens) are focused on electric energy monitoring in general allowing hierarchical connexion of power meters for

monitoring and control with data access through corporate networks. On the other hand Corporate Energy Management Application (Wonderware) [3] is designed as an energy data integration platform capable to connect with ERP systems and it is addressed to all energy types including power, water, gas, chill, air, and steam at both main and sub-meters.
Schneider solution is designed to work with equipment (power meters) from the same firm, whereas Wonderware (SCADA provider) tends to be compatible with the most common industrial protocols and control automation devices through the Wonderware System Platform. These and other existing solutions are designed to deal with energy data and provide more or less integration with other company information systems for a further analysis to improve energy management. Also ABB offers products for this purpose, e.g. cpmPlus Energy Manager. The cpmPlus Energy Manager is winner of the 2010 Control Engineering "Engineers' Choice" Award, helping customers in all industries to monitor, manage and optimize their energy usage for maximum efficiency and cost savings. It addresses the business side of energy management by producing accurate energy demand plans and taking advantage of them in energy supply planning and optimization.

3. System Features

The features of the proposed project are:

- An open platform architecture for the management of energy data and processes in buildings, facilities and electronic devices.
- Contribution to standardization of efficient building monitoring by definition of an open source prototype platform.
- An intelligent energy management methodology for information systems and a set of software engineering best practices for companies to envisage a wise and forthcoming energy management policy face to the integration of Information Systems.
- Artificial intelligent algorithms to precisely define (in near real time)/predict the energy needs and the use of the various devices such as illumination, air conditioning/heating tec.
- Interfaces: Customer User Interface is capable of displaying real-time data on the Energy cost vs consumption and enables the smart planning/programming of the plant/building devices.
- Automatic mechanism for detection of abnormal situations and proposals of solutions.

4. Architecture

Figure 1 shows the conceptual system view for the ENERCARE platform.

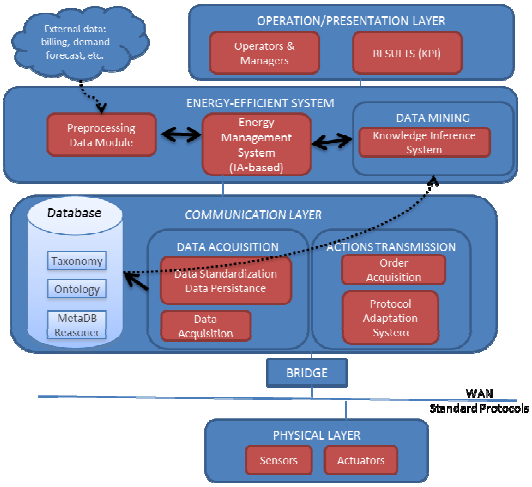

Fig. 1. ENERCARE Platform Conceptual View

A. Communication Layer

The aim of this component is to communicate all the different components of ENERCARE platform, skipping their particular protocols or languages, being able of provide a flexible and transparent data interchange through the whole system. To achieve this goal, the system makes use of communications elements and protocols that will address the needs of the overall system.

The system defines a standard solution to interact with the different sensors (smart meters and energy monitors) but also control elements in charge of assuring usability and comfort of buildings (HVAC, lighting and infrastructures and other instruments involved in energy efficiency monitoring campaigns). Interfaces have to provide a standardized set of connection methods to be integrated in the backbone communication network assuring scalability, with independence of predefined topologies, prepared for plug&play connectivity of both fix and mobile sensing devices.
Open communication protocols are needed in order to cope with the variety of subsystems and strategies involved in the control (HVAC, access control, lighting, etc.) of buildings, industries or any type of energy consuming organizations. Goal oriented and energy efficient protocols, adapted to technologies and dealing with probably asymmetric bidirectional communication are needed to link field devices and control systems and energy monitoring systems.
The system deals with the labour of handling the heterogeneity of real deployments where different technologies will have to coexist and interoperate in a transparent way and assuring the interoperability of existing control and sensing systems with additional sensing networks and the deployment of the efficiency energy monitoring system.

B. Energy-efficient System

This module represents the heart of the system and entails all the data processing and intelligent reasoning for achieve the main goal, an energy-efficient platform.

This goal will be reached by means of real-time actions to plan and distribute the energy consumption and also by learning based on past information and different simulations (Data mining module). This module is divided in three sub-modules:

Preprocessing Data Module. This module is in charge of exchanging data with other platforms and enterprise applications. For instance, this module could contemplate integration with systems that deal with economic processes (billing and settlements), energy demand forecast and energy purchases, etc. It should also incorporate advanced reporting and publication capabilities.

Energy Management Module. This module is the central processing core of the platform, where the system processing capabilities for energy monitoring will be residing. This module includes real-time management of energy devices; continuous sensor network monitoring: energy readings, current status of the network, energy alarms, sensor alarms, etc.; energy efficiency calculations for new developments: buildings, premises, etc.; andSmart HCI - Advanced representation of energy data

This module aims to optimize energy consumption life cycle by providing continuous monitoring and advanced analysis and visualization mechanisms capable to contextualize energy consumption to the usage of particular installations.

Data Mining Module (Knowledge Inference System). Data Mining is able to extract business intelligence information from large data sets, providing reliable information to have a better knowledge of the progress of the system.
Data Mining provide the system with the ability of foreseen results based on past actions. In this way the system increase its performance as is able to predict future actions or results, being able of changing the regular flow of the system. In conclusion Data Mining can be described as intelligent engine for the system, as it is learning from past events and from different simulations performed.

C. Operation/Presentation Layer

This layer is the interface for communicating with the different users of the platform. It can be divided in two modules depending on its functionality. The module which is in charge of presenting all the results to the user and the module for the operators who want to configure the settings of the system. The former module includes the following key performance indicators (KPI's):

- Energy balances according to different criteria: domain specific, geographic, seasonal…
- Energy losses
- Energy balance simulations.
- Energy visualization and reporting: Develop advanced reporting and visualization technologies to represent energy consumption behaviors and its relationship with other usage parameters and scenarios.

5. Conclusions and Future Work

In this paper, we have presented ENERCARE, an innovative system that allow to make a more appropriate use of the energy systems by means of artificial intelligence techniques that capture the necessary information from energy devices to manage the energy distribution decreasing the waste of energy and making a more efficient delivery of it.
The innovations brought with the development of this project have been clearly presented and appear to be a reference in the research lines of this scope due to the necessary change in this ambit to solve some of the most important environmental problems of today. Although the project is not finished, we think that the contribution can be very relevant and the initial studies have been promising.
Future research lines in the context of ENERCARE can be focused in the improvement in the process of capturing the information from the energy plants or devices to be more precise and develop better methods to distribute the energy reducing the emissions and increasing the efficiency in the whole process. In future, we will consider the possibility of make use of the power of Cloud Computing to reduce even more the CO2 emitted thanks to a better management of the workload and the enormous benefits of this trendy paradigm. With this we will be able to build a complete environment, fully configurable, for a better knowledge of the different situations taking into account aspects like fault-tolerance, load-balancing, business requirements and driven mechanisms to provide mature and real-world ready-to-use system releases, which can be build on the previously outlined advantages of the platform.

Acknowledgement

This work is supported by the Spanish Ministry of Industry, Tourism, and Commerce under the EUREKA project SITIO (TSI-020400-2009-148) and the Spanish Ministry of Science and Innovation under the INNPACTO TRAZAMED (IPT-090000-2010-7) project.

References

[1] R. Langari, W. Jong-Seob, "Intelligent energy management agent for a parallel hybrid vehicle-part I: system architecture and design of the driving situation identification process," in IEEE Transactions on Vehicular Technology, vol.54, no.3, pp. 925-934, May 2005.
[2] C. Shuguang, A.J. Goldsmith, A. Bahai, "Energy-efficiency of MIMO and cooperative MIMO techniques in sensor networks," in IEEE Journal on Selected Areas in Communications, vol.22, no.6, pp. 1089-1098, Aug. 2004.
[3] Wonderware (http://global.wonderware.com). Last visited in February 2011.

[4] A. Chervenak, I. Foster, C. Kesselman, C. Salisbury and S. Tuecke, "The data grid: Towards an architecture for the distributed management and analysis of large scientific datasets", Journal of network and Computer Applications, vol. 23, issue 3, pp. 187-200, July 2000.