Virtual Enterprises for Integrated Energy Service Provision

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Abstract. Holistic Energy Service Provision has the potential to provide new business opportunities for Facility Management Companies, Building Managers, Energy Providers, Maintenance Providers and many other stakeholders currently working in the area of building design, construction, building operation, energy management, maintenance, etc. since customers wish to get access to all services related to energy supply, energy consumption and building services maintenance through a "one-stop-shop".
Our paper describes how the concept of Virtual Enterprises/Virtual Organizations could be applied in the area of Energy Service Provision. The paper describes the context, the relevant stakeholders, required novel IT-services and finally the concept of "Extended Energy Profiles" to allow easy and standardised exchange of Energy Information amongst potential partners in an "Energy Service Company" established on the VO-paradigm.

Keywords: Virtual Enterprise, Service Provider

1 Introduction

According to the "World Energy Assessment" delivered by United Nations Development Programme UNPD (cf. UNDP 2004), the global average growth rate of energy use of primary energy is about 1,5% per year. If this rate is preserved throughout the coming years, the total energy use will double between 2000 and 2040, and triple by 2060. This growth rate can no longer be supported. Most importantly, we must reduce our dependence on fossil fuels because their usage leads to CO_2 emissions contributing to global warming. A substantial part of the energy (approx. 40%) is used to operate buildings. Therefore, the challenges for the construction sector are (i) to improve the energy-efficiency of buildings and (ii) to provide solutions which enable the optimal usage of renewable energy sources.

Sustainable energy and carbon neutrality are now major management issues for building owners and operators. Organisations in the area of Total Energy and Facility Management need to become Virtual because of the increased complexity of the required technical solutions. Virtual Enterprises may be created to investigate and utilise alternative forms of energy sources such as solar, geothermal, biomass, wind but to name a few. These sources of energy can be tied into an existing system provided for by the national grid.

2 Infrastructure for Energy Service Provision

Technologies for distributed energy generation provide an 'early action' approach to greenhouse-gas reductions because they are available now. They can be introduced into present-day BMS with moderate special network technology or market developments. Distributed energy refers to clean local generation and demand management at customer sites.

Domestic energy management is supported by Intelligent Building Management Systems (iBMS). They are being developed to help manage appliances efficiently, integrate renewable generation, and inform customers about options and consequences of different energy choices. Locally distributed controllers are part of iBMS. These controllers confer with the building occupants, to find out individual preferences, and accommodate these. They are also used to effectively manage the operation of (renewable) energy generation at the building or in a nearby district.

Mini-grids might combine heating, ventilation, air-conditioning, and refrigeration appliances; and receive energy generated from different sources; i.e. certain communities in an area of limited size can be independent of national energy grids, or achieve specific energy requirements while remaining grid-connected, by adopting local generation sources and new management and control technologies.

Smart Grids or Neighbourhood Management Systems (NMS) are based on the assumption that each house (or customer) has a controller that communicates with all major appliances, and with controllers in nearby houses in the network. The controllers also communicate with the electricity company, to find out when peaks in demand are expected.

All the infrastructure components described above are part of so called smart neighbourhoods where houses work together to ensure that they operate as efficiently as possible to minimise power drawn from the main grid, especially during times of peak demand. This means, home energy management will be coordinated across multiple households for aggregated benefits.

2.1 The Need for Virtual Enterprises

Over time changes have forced organisations and companies to review not only how they do business with others but also how they themselves are structured in order to become more competitive and profitable. Changes in technology, information systems, globalisation, economies and legal requirements have all played a part in how organisations act in today's world. In response to these changes companies have been forced to review and change their structures in order to not only comply but also to carry on as a viable business. Becoming part of a Virtual Enterprise within a Virtual Organisation will become the norm in order to service in an ever increasing competitive and technical world.

In terms of Energy Services the purpose of the Virtual Enterprise is to provide a new solution to a new scenario – the utilisation of independent energy services. This will mean that the Energy Services Virtual Enterprise will be based on the ability to create co-operation and to realise the value of business opportunities between the Energy Services partners. Energy Services also includes additional services such as inspection, maintenance, monitoring, decision support and retrofit. Katzy et al 1999 propose three goals of a Virtual Enterprise.

Applying these in the context of this paper the first goal is to create value from changing opportunities within the environment of the Virtual Enterprise. The Virtual Enterprise involving the Energy Services partners will show a distinct difference from the traditional monopolistic government owned energy provision. With the co-operation of the partners the Virtual Enterprise will be able to benefit from the changing opportunities within their environment.

For the second goal the Virtual Enterprise will also present an alternative way to the traditional form in so far as differentiating and integrating energy service provision under dynamic conditions. This will allow the providers to seize new opportunities rapidly through structured cooperation between providers.

In the third goal the Virtual Enterprise will be defined from its manoeuvres rather than its command structure and from the operations rather than from the organisation.

In the case of IT-supported Energy Service Provision (ESP) this will mean that the services of the Facilities Manager will co-operate with independent energy providers and users. Reasons are increased complexity triggered by additional components such as solar and geothermal power which may require local knowledge and expertise. Virtual Enterprises can be seen as a subset of these Virtual Organisations.

A further benefit from utilising Virtual Enterprises would be in the sphere of NMS whereby energy might be provided from a number of energy sources and managed through one central organisation, either the facilities manager or the Energy Service Company (ESCO). This would allow the various stakeholders to join forces and offer new value-added services for energy management.

3 Stakeholders for Energy Service Provision

Many decision makers are involved in producing and delivering various forms of energy, with different decision protocols, different time and space horizons, and different areas of concern. Utilities, regulators, and consumers need to know how to better use energy related information, since they all share the goal of maintaining service reliability while meeting necessary revenue or cost goals.

3.1 End Users – Occupants and Owners of Buildings

Occupants and owners of either residential or office buildings create an energy demand according to their energy usage profile. They have the closest control of the energy consumption. Therefore it is essential that energy management services can be delivered remotely and cost-efficiently in a mass market.

Furthermore building occupants are one valuable source to evaluate user comfort based on the performance of building systems and components. Measuring and documenting the user satisfaction with environmental factors such as air quality, thermal comfort, or lighting means this data could be used to determine and evaluate service level agreements with Facility Management and Energy Service Providers.

With increasing energy prices and increasing numbers and complexity of "consuming systems" (e.g. heating, lighting) and "producing" systems (e.g. solar panels, heat pumps) End Users and Owners of buildings have an increasing demand for expert Energy Management Services since the operation of such complex systems can no longer be managed by the user itself.

3.2 Energy Providers / Operators of Generation Facilities in NMS

The increased integration of renewable energy sources into Energy Grids leads to the fact that the grid operation becomes much more complex. Detailed information about the supply capacity of the individual (renewable) energy sources is essential to balance the grid operation and the overall capacity of the grid. Vice versa a more precise prediction of the energy demand is required to assist the grid operators in managing the different "generation sources" in the most sustainable way. This can create a position whereby energy providers may be able to purchase or trade-off in relation to the acquisition of the information produced through the use of iBMS.

As a major stakeholder the Energy Provider has much to gain from being part of the ICT Integration for ESP since they can facilitate more accurate information about user's needs and consequentially provide value added services to better support operation and maintenance of buildings.

3.3 Total Facilities Management Providers and Energy Service Companies

The provision of Facilities Management Services includes Energy Management and other forms of technical and infrastructural building management. Currently, Facilities Management Systems are insufficiently integrated with BMS. Therefore, the integrated planning of inspection and maintenance activities is not easily achievable. The availability of standardised data exchange formats and mechanisms would be of great help to improve the interoperability of the available systems, such as Building Information Modelling Tools (BIM), Building Management Systems and Computer Aided Facility Management Systems.

Furthermore, the information provided from energy audits would also allow the Facility Management Providers to make predictions depending on the course of action for retrofit and renovation determined by the Building Owner/Occupier/User as a result of that audit. Consultancy services to improve the energy efficient operation of buildings could be offered to users and owners of buildings.

Currently, so called Energy Service Companies are established to provide energy delivery from multiple sources, energy management, building operation, and equipment maintenance as a "one stop shop" to customers. Within this paper we consider these ESCO-scenarios as part of "Total Facilities Management" concepts

4 Novel IT Service and New Business Model for Energy Service Provision

The development of advanced IT-services for improved ESP addresses many challenges. The introduction of advanced BMS will lead to more energy efficient operation of buildings; the application of NMS will support the easy and efficient integration of renewable energy sources into existing energy networks. These IT-solutions will generate more data which document User Comfort and the Performance of systems and specify User Demands and available Supply Capacity from renewable energy sources. Energy Information could be used by Energy Providers, Facility Managers, Energy Experts and other stakeholders to offer so called Value Added Services to Owners and Occupants of buildings. Therefore, new business models in the energy sector are required to close the gap between the interests (cf. Kettonen 2007) of the different stakeholders in the energy sector, to enable the integrated usage of Energy Information, to support the development of 'Value Added Services', and finally to offer these services in new, innovative ways to clients (Osterwalder 2005). Novel IT services are required to support these new business models for ESP.

4.1 Energy Profiling

Like other commodities, energy prices are tied to supply and demand, making it critical to forecast energy requirements to better quantify future needs.

Currently, utilities use energy profiling to predict future energy requirements. Load profiles, an estimate of average energy patterns for a group of customers based on load research sample data, are used to shape a cumulative meter reading from 15 minutes to 60 minutes intervals. The profiles are regressions made up of calendar, weather and daylight variables. New technology, like automated meter reading will make more granular data available and allow utility providers to:

- Achieve more accurate profiles by conducting more in-depth statistical analysis on individual customers and customer groups
- Complete more frequent updates on profiles or even to create more profile groups by utilizing actual historical data as opposed to "shaped" data

4.2 Energy Information as 'Tradable' Good

In chapter 5 of this paper we argue that the introduction of additional energy profiles is required to support the exchange of relevant information for ESP in a standardised way (cf Gokce 2009). Advanced analytics and novel information technologies, such as Service Oriented Architectures, can enable the various stakeholders to reduce cost for information provided and exchanged, increase customer retention, and efficiently manage supply contract risk.

4.3 Demand Prediction

Demand, or load, modelling is a key planning tool. Under competition, and with increased consumer involvement in the market, demand side management (DSM) alternatives will also alter demand models as prices change with load and as consumers plan their own consumption more consciously, with their own energy profiles and demand models. This complex interaction of social and physical variables has the potential to produce significant nonlinear dynamics in local and regional demand for energy, such as electricity, gas, steam, or hot water. Energy Technology researchers are trialing intelligent, self-learning, interconnected controllers to manage energy demand and reduce greenhouse gas emissions by homes and businesses.

4.4 Supply Forecast

Some energy customers meet portions of energy demand with local co-generation. The economic and reliable operation of the renewable energy sources is especially demanding of accurate supply and demand forecasts and related tools for planning and operations management. Knowledge of accurate, location-specific weather, climate, and energy market information is necessary to model the supply capacity. Since retail energy prices vary with load, and other parameters, this calculation can be very complex.

Grid management involves many entities, and stakeholders with differing expertise all need the high quality information in forecasts and effective tools and decision support systems to integrate data, plan, and communicate their actions. New tools for supply forecast should combine the modelling and visualisation of the physical energy infrastructure with abstract notions of system performance. Emerging tools like probabilistic grid flow models seem to be well suited to integrate certain kinds of demand and supply forecasts.

When co-generation of heat (cold) is combined with distributed generation installation, the importance of the weather becomes crucial to economic performance. Optimal operation of the distributed generation depends, at a minimum, on accurate 1 to 2-day weather forecasts. These relationships must be studied and new tools for decision-making refined and developed.

4.5 Simulation as Part of iBMS

Models based on specific demographic, appliance, local generation, and social research data help to forecast the system behaviour of networks with large amounts of managed demand and local generation. Simulation tools use these models to provide the means to answer questions about scalability of large demand-side systems and the services they may provide to networks, retailers, and new businesses. The goal is optimal management of energy demand and consumption, taking into account individual consumer preferences such as: (1) comfort – for thermal comfort and (2) energy costs – ensuring that energy services are commercially viable and affordable.

5 Extended Energy Profiles for ESP

The problem of interoperability is usually addressed by specifying standardised information models. Energy Information is described partially in multiple standards, such as in BIM (e.g. IFC 2.x3), or BMS (e.g. using BACnet). However, most of these standards are very complex and not easily understandable. Therefore, we propose to define a format for the specification of "packages" or "containers" to support the exchange of Energy Information during the various phases of the building life cycle. These "packages" or "containers" should be called "Energy Profiles." Table 1 summarises the function of Energy Profiles to specify energy demand, energy supply capacity, required set of Performance Criteria, a certain level of User Comfort, and – if required – a set of proposed upgrades/improvements. Table 1 below gives an overview how energy profiles support certain functions of dedicated stakeholders.

Figure 1 illustrates the relationship amongst VE-stakeholders, functions performed under their responsibility, and energy profiles supporting or specified by these functions. The emphasis is on building operation and on performing real-time energy simulation using sensed and metered performance data ("as-is" Performance Profile).

Table 1: Proposed "Extended Energy Profiles"

Supply Profile	initial	This profile is used by the energy provider to inform a customer about the available supply capacity & energy tariffs. Optionally, the profile could contain information about available options in terms of Energy Mix.
	calibrated	
Demand Profile	ideal	This profile is used by end users to inform the energy provider about intended energy consumption and to optionally specify its preferred "Energy Mix".
	as is	
Consumption Profile	n.a.	This profile results from a negotiation process. It is used by the end user to inform the energy provider about the amount of energy to be consumed/purchased.
	customised	
Performance Profile	ideal	This profile is used by the Designer/MEP-Engineer to inform the Facility Mgr. /Bldg. Operator about the Performance Metrics of a Building & its Energy Systems.
	as is	
Control Profile	initial	This profile is used by the Facility Manager to inform the Building Operator about the "Control Scenario" of a Building and its Energy Systems.
	calibrated	
Maintenance Profile	initial	This profile is used by the Facility Mgr. to inform the Building Owner and Maintenance Staff about required maintenance activities.
	customised	
Retrofit Profile	initial	This profile is used by the Facility Mgr. to inform the Energy Expert about required replacement of Building Services Systems or proposed renovation activities.
	n.a.	

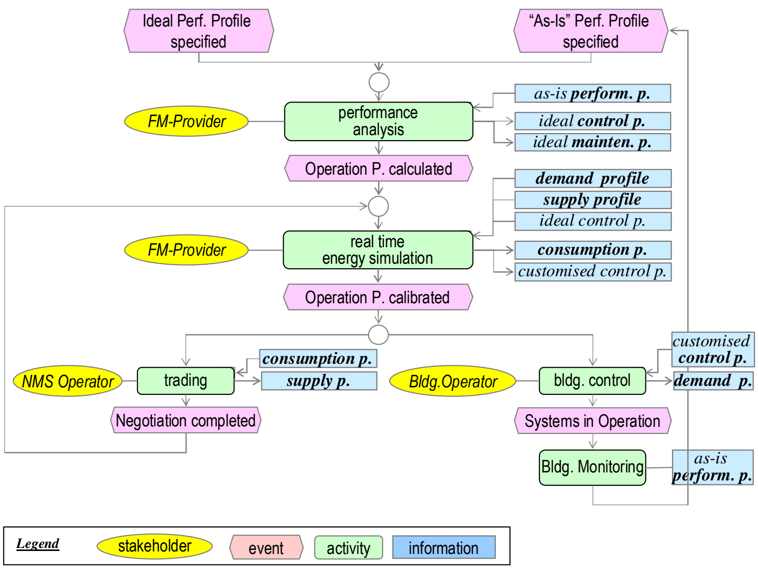

Figure 1: VE-stakeholders, Activities and Energy Profiles

6 Conclusions and Acknowledgements

By representing the sequence of activities using the ARIS-methodology (Architecture of Information Systems) it becomes possible to easily specify the relationship between "business function", "stakeholder", and "Energy Profile" (see figure 1 above). The clear, consistent, and holistic specification of these relationships is a key pre-requisite for the set-up of supporting IT-infrastructure for Virtual Organisations supporting the "trade" of relevant information required for ESP. These specifications are currently under development at University College Cork, Ireland as part of the EU-FP7 project intUBE (further details at http://zuse.ucc.ie/intube and http://www.intube.eu/). The work presented in this paper is supported by European Union (ICT-2007.6.3 ICT for Environmental Management & Energy Efficiency).

References

1. Ahmed, I., & Nunoo, C. (1999). Data Warehousing in the Construction Industry: Organizing and Processing Data for Decision Making. *8DBMC* (pp. 2395-2406). Vancouver: NRC Research Press.
2. Barrett P, Baldry D. Facility Management towards best practice. Blackwell publishing, 2003
3. Camarinha – Matos LM. Collaborative networks: a new scientific discipline. Journal of Intelligent Manufacturing, 16, 439-452, 2005.
4. Kister TC, Hawkins B. Maintenance Planning and Scheduling Handbook. Elsevier Inc, 2006
5. Lane, P. (2007). *Data Warehousing Guide, 119g Release 1 (11.1), Oracle Data Base, .* Oracle.
6. Lee, J., & Lee, H. (2002). Principles and Strategies for applying Data Warehouse Technology to Construction Industry. *ECPPM, eWork and eBusiness in Architecture, Engineering and Construction* (pp. 341-353). Slovenia: Swets & Zeitlinger.
7. Scheer, August-Wilhelm, ARIS - Business Process Modeling, Springer, New York, Heidelberg, 2000.