

University of Galway Research Repository

Energy Management Information Systems: An Exploratory Study Of Implementations Using Adaptive Structuration Theory

Title	Energy Management Information Systems: An Exploratory Study Of Implementations Using Adaptive Structuration Theory
Author(s)	Molloy, Pdraig;Golden, William;Kirwan, Orla
Publication Date	2008-11-26T15:43:39Z
Publication information	Kirwan, O., Golden, W., Molloy, P. Energy Management Information Systems: An Exploratory Study of Implementations using Adaptive Structuration Theory. ICEIS Conference, Madeira Portugal, June 14-16th 2007.
Item record	http://hdl.handle.net/10379/71

ENERGY MANAGEMENT INFORMATION SYSTEMS: AN EXPLORATORY STUDY OF IMPLEMENTATIONS USING ADAPTIVE STRUCTURATION THEORY

Orla Kirwan, Dr Willie Golden

*Department of Information Systems, National University of Ireland Galway, Ireland.
o.kirwan2@nuigalway.ie, willie.golden@nuigalway.ie*

Dr Padraig Molloy

*Department of Mechanical Engineering, National University of Ireland Galway, Ireland.
padraig.molloy@nuigalway.ie*

Keywords: Adaptive Structuration Theory, Grounded Theory, IS Implementation, Energy Efficiency, Research in Progress

Abstract: This research is focusing on the implementation of an Information System (IS), more specifically a building energy management system (BEMS) within several organisations. One of the EU's 7th Framework Programme's (FP7) objectives is to "transform the current fossil fuel based energy system into a more sustainable one combined with enhanced energy efficiency (EE)". This research is concerned with the use of information systems to achieve the latter of these objectives; enhanced energy efficiency. The research is being undertaken using a multi methodological approach incorporating case study methodology and grounded theory. Advanced structuration theory (AST) will provide the conceptual model that will help to capture the longitudinal change process. A modified AST model is proposed which will provide a theoretical framework that further investigates and explains the implementation process, using several organisations at different stages of BEMS implementation. The researcher has confirmed access to these organisations and data collection commenced on October 1st 2006. The paper concludes with an overview of how the research will progress.

1 INTRODUCTION

Technological advances, increased environmental awareness, rising energy costs, legislation, and end-user perceptiveness has given rise to this investigation of building energy management systems. This research is specifically looking at the Information Systems that are available to improve the energy saving potential of end-users, by

investigating the implementation of such systems into several organisations.

The components of the technology that can increase EE are the actual building management system (BMS) and the commercially available monitoring and targeting (M&T) software packages that integrate with the BMS. Together they make up the BEMS. The BMS is the basic control system that

is contained in a building, managing the heating, cooling, lighting, ventilation and most other energy needs that an organisation has on an everyday basis. M&T is a structured approach to energy management that provides a simple yet powerful technique for identifying inefficient performance and eliminating waste.

Savings of between 5% and 20% from the annual energy bill have been realized as a direct result of the purchase, correct appropriation and implementation of this software (Lowry, 2002). The significant factors associated with the success of BMS installations are: end-user involvement in the specification, the user's perception of the performance of the BMS vendor, and satisfactory commissioning of the system. It is widely reported that BMSs are not fully utilized (Lowry, 2002). The failure to exploit the potential of these systems leads to the sub-optimal performance of building plant, both in terms of energy consumption and the maintenance of ambient internal building conditions. End-user dissatisfaction and the inability to understand and exploit the reports generated are other reasons for system failures (Levermore, 2000).

2 RESEARCH MOTIVATION

Energy-related research shows that the most fundamental indicators: energy consumption, fossil fuel dependence, import dependency, CO₂ emissions, and energy prices are moving in the wrong direction (Forfás, 2006). This is occurring on an Irish, a European Union (EU) and a global level. Present energy consumption patterns are showing an unmistakable increase in energy usage, and there is a clear consensus that sustaining continued growth in the world's economy will require a growing supply of oil (Forfás, 2006). The factors that are driving this research can be classified in the following categories: environmental, political and regulatory, economic or corporate social responsibility and are outlined below.

Environmental factors

The world remains largely dependent on fossil fuels, which are projected to continue to be the dominant source in energy supply, meeting 80% of the

projected increase in demand to 2030 (Green Paper on Irish Energy Policy, 2006).

Under the present Kyoto Protocol agreements, the EU must implement reductions of 330 million tonnes of greenhouse gas (GHG) emissions between 1990 and 2010. It is estimated that CO₂ emissions will cost the Irish state €1.45bn in penalties by 2008 and up to €4.3bn by 2012, as emissions are currently running 17% over the agreed carbon allowances. This is the highest in Europe. As a proportion of greenhouse gas emissions overall, energy related CO₂ emissions accounted for 51% in 1990 compared to a projected 66% in 2010, with energy use in buildings being at present 30% of this total.

Political and Regulatory factors

Legislation, such as the EU Energy Performance for Buildings Directive (EPBD), is forcing the marketplace to look at demand side management (DSM) and energy efficiency (EE), in a focused effort to offset the potential future problems outlined above. The directive takes account of the energy performance of buildings, and places demands on building stakeholders (e.g. owners, designers, operators, occupants, etc.) to quantify energy usage throughout the building's lifecycle. The European building sector constitutes over 40% of the total European energy consumption to date (European Commission, 2001), therefore this is an area of much significance if energy conservation and sustainability is to be achieved.

According to the Green Paper on Future Irish Energy Policy (2006), the potential savings dividend will be considerable and the objective is to deliver cumulative improvements in EE of 20% by 2020. Increasing the levels of EE must become a key priority for Ireland according to the government, and it is one of the answers to the energy problem that exists today.

Economic factors

Oil prices have risen from an average of just over \$23/barrel in the fourth quarter of 1999, to a high of \$72.40 per barrel in May 2006. Since early 1999, oil prices have risen about 360%. The annual rate of inflation rose to 3.8% in April 2006 as the effects of higher oil prices spread across the country (Irish Times, 11/05/2006). In the past 12 months, fuel and electricity prices have risen by 13.2%.

The European Union Emission Trading Scheme (EU ETS) commenced on Jan 1st 2005, and it relates to carbon allowance trading between the EU member states. The Directive, 2003/1987/EC, provides that key implementation decisions for the trading period 2008 to 2012 are to be taken by Member States in the course of 2006, namely submission of national allocation plans and adoption of final national allocation decisions (European Commission, Oct 2006).

Corporate social responsibility

Until now, relatively few organizations have implemented a climate change policy, and the asymmetry between the importances of for example, increasing energy efficiency, and the lack of corporate commitment may be explained by the widely shared perception that environmental action entails costs that impact productivity (Boiral, 2006).

The questions under consideration are: should organizations be responsible for “Environmental Issues”? Should they worry about energy conservation and carbon emission reductions if their competitors are not? Many managers are at a loss concerning the strategy that they should adopt to deal with these issues (Boiral, 2006).

This research will look at the implementation and subsequent use of information systems to manage energy components, monitor energy usage and implement potential energy efficiencies within organizations. A BEMS is a complex system from the perspective of the firm, and as such the chosen investigative framework will have to encompass each perspective. The chosen framework is AST, and it is developed in the next section.

3 PROPOSED CONCEPTUAL FRAMEWORK AND OBJECTIVES

IS implementation has been a research topic of interest for the past three decades, and remains a high priority due to the level of investment in, and reliance upon these systems by the organisations. It is also of importance due to the conflicting results from existing research into IS implementation. As IS become increasingly intertwined in the operations,

products, strategies, and infrastructure of corporations, it is critical that the implementation be successful (Alavi & Joachimsthaler, 1992). The organisational complexity of large IS implementations bring the problem of how to conceptualise the relationship between, on the one hand, IS development, and on the other hand, ultimate system use and associated organisational change (Alvarez, 2003).

A large body of implementation studies have investigated the relationship between user-related factors and implementation success (Alavi & Joachimsthaler, 1992). Their research analysed user-related factors (cognitive style, personality, demographics and user-situational variables), and contextual factors (decision-making tasks, organisational factors and external factors).

Management support is considered to be a critical factor in the successful implementation of IS innovations (Sharma & Yetton, 2003). This success remains a theoretical as well as a managerial issue. Successful systems are defined by those which have a significant uptake by the intended users. The systems that are actually used by the users are most likely to eventuate from a design process that embraces a user-centred design (UCD) approach. (Parker & Sinclair, 2001; Finlay & Forghani, 1998). Implementation success refers to realising the intended benefits of the IS (Zmud & Cox, 1979). The difficulty associated with achieving this aim is that it tends to be directly related to the complexity of the IS, which is comprised of both technical and organisational aspects.

Galliers (1991) states that if one takes a sociotechnical perspective of IS, it can be argued that IS are as much concerned with human activity and the organisation as they are with technology - if not more so. If this argument is accepted, it follows that IS strategy should contain not only IT strategy, but also such organisational issues as change management and a human resource strategy. The proposed AST model incorporates all of these aspects (see Figure 1).

AST provides a conceptual model that helps to capture the longitudinal change process (Schwieger et al, 2004), and also helps to describe the interplay between advanced information technologies (AIT), social structures and human interaction. AST extends current Structuration models of technology-triggered change to consider the mutual influence of

technology and social pressures (DeSanctis & Poole, 1994). This research proposes a modified AST model which provides a theoretical framework that further investigates and explains the IS implementation process, using several organisations at different stages of implementation all using the same AIT.

The act of bringing the rules and resources from an AIT or other structural source into action is termed *structuration* (DeSanctis & Poole, 1994). Giddens (1979) uses the term “structuration” to describe how structure enters into social action. Appropriation is the manner in which structures are adapted by the systems users for their own use through a process called structuration (Gopal et al, 1992). A measure of faithfulness is how the user is utilising the system compared to the systems actual aims and objectives.

System success is a multidimensional trait and cannot be described as a single measure, so clearly the success of any IS implementation is founded on addressing a broad spectrum of both technical and organisational issues (Dhillon, 2004). With this in mind, and taking the complexity of the system and the complexity of the organisation into consideration, AST is a suitable framework in which to investigate the implementation as it incorporates both aspects. The dearth of research on AST may be attributed partly to its complexity (Chin et al, 1997), and this research aims to add to the current body of AST knowledge by applying it in the context of energy management information systems, as there is no current research which focuses on this aspect. As DeSanctis and Poole (1994) point out “A critical challenge is to systematise the research so that technologies and interaction processes can be meaningfully assessed and comparative analysis is possible” (Chin et al, 1997).

Figure 1 has been adapted from the framework that was proposed by DeSanctis & Poole (1994). The researcher has extended the “other sources of structure” aspect of the original framework. As outlined below, the researcher will now also be able to discover what effect the external imperatives for adoption have had on the choice of the technology and on the process of appropriation of the AIT. Will one implementation be more successful than a second one that is occurring with stricter imperatives? The framework will also take the nature of the task into consideration. The researcher will

look at what exactly the organisation is trying to achieve, and its impact on the overall process, if any.

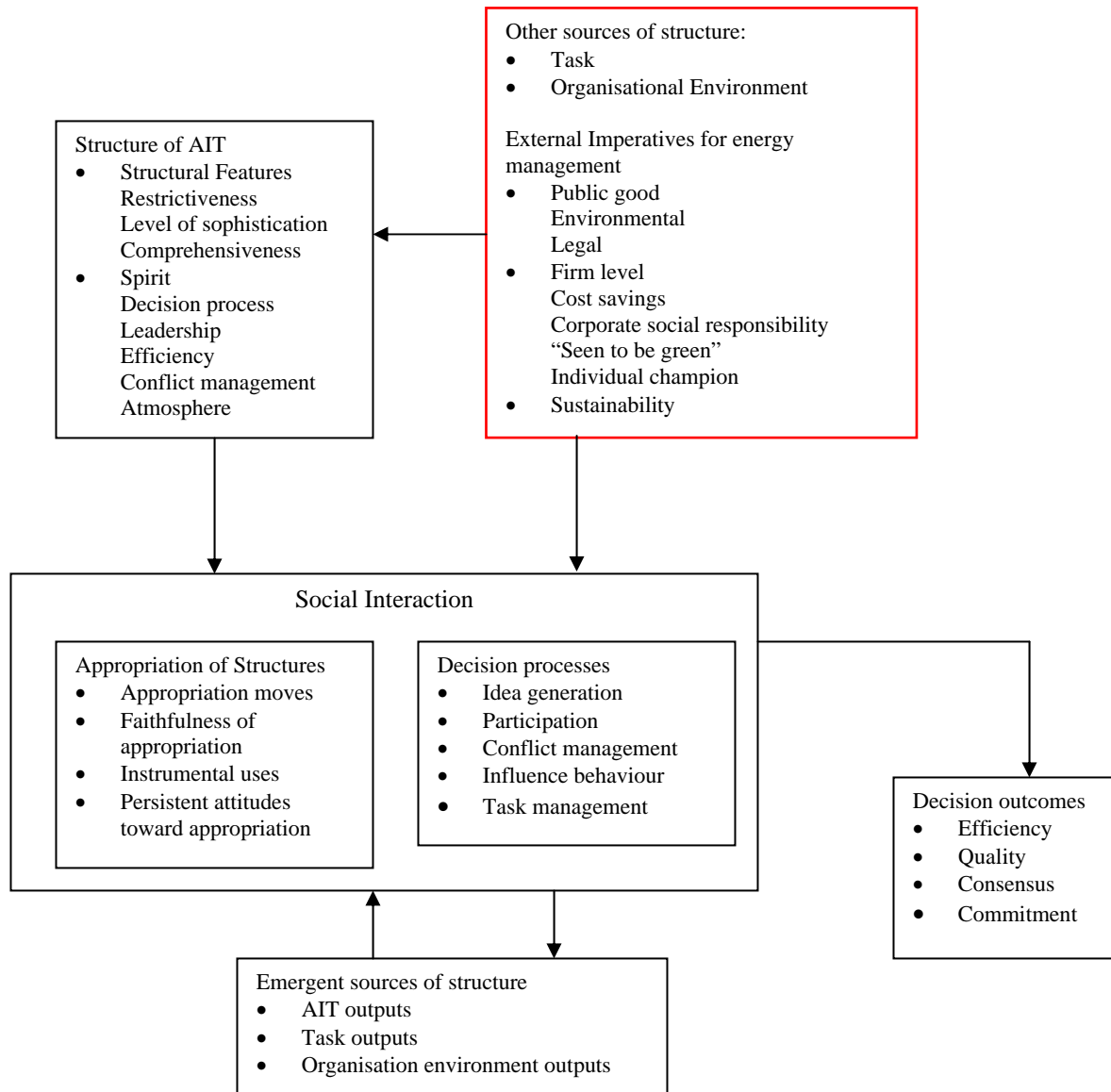


Figure 1: Proposed conceptual AST model for evaluating successful IS implementations, adapted from DeSanctis & Poole (1994).

The questions that the researcher would like to ask as a result of the implementations are as follows:

1. Pre-adoption Decision Process: Are companies aware of the present energy situation? What are these companies doing in relation to it? If they are adopting energy management information systems, how are they being implemented into the organisations? What impact do differing reasons for adopting energy management have on the implementation process?
2. Implementation Process: Impacts of the implementation at an organisational level. Was it appropriated in the correct manner? Does correct appropriation of the technology take place during IS implementation? Does a successful appropriation of the system (faithfulness of appropriation) lead to a successful implementation?
3. Post-implementation Process: Efficiency and effectiveness. Is the organisation more efficient as a result? Are the employees making more effective decisions as a result? Has it impacted the annual energy spend?

4 RESEARCH APPROACH

After carefully examining all possible research approaches for the research topic, the researcher decided that a multi methodological approach incorporating both case study and grounded theory would be the most appropriate due to the nature of the research area and also because the research is concerned with theory building not theory testing (see Figure 2). Benbasat et al (1987) has shown that the goals of the researcher and the nature of the research topic influence the selection of a research strategy. In making this decision, the researcher took into account the qualitative nature of the research, the extent of available resources, the type of information required and the suitability of each research approach.

The researcher is also conducting short interviews with approximately 20 organisations, covering both the public and private sectors, as the imperatives to adopt may be quite different across

the sectors. This data will help to define the problem space further.

The researcher would like to investigate the effect that the reasons for adopting energy management has had on the appropriation of the system. For example, what is the degree to which the imperatives influence the outcomes of the implementation?

With a grounded theory approach, theory emerges from the process of data collection and analysis. This means that the researcher does not commence such a study with a defined theoretical framework. Instead the researcher identifies relationships between the data and develops questions and hypotheses or propositions to test these (Saunders et al, 2003). However, this type of approach needs to commence with a clear research purpose. The grounded theory approach of Strauss and Corbin (1998) is structured and systematic, with set procedures to follow at each stage of analysis. These set procedures include the identification of codes, concepts and categories from the analysis of the data. Data collection commenced in October 2006, and the analysis is ongoing.

The chosen case studies are as follows:

Case Study #1 (Pre-implementation): A private hospital in the West of Ireland. The hospital is two years old and has a BMS installed. There is currently no M&T software installed and the hospital is currently trying to justify further spend on energy related matters.

Case Study #2 (implementation): A large third-level educational institution in the West of Ireland. There is a BMS installed, and M&T software is currently being installed. This is a large scale installation as 28 buildings will be integrated as part of the new BEMS.

Case Study #3 (implementation): A private pharmaceutical company in Dublin. They have a cross-divisional energy team in place, and are in the process of implementing a BEMS.

Case Study #4: (post-implementation): A private pharmaceutical company in Kerry. They have a BEMS in operation for the past two years, and are currently achieving cost savings as a result.

Layer	Exploration Phase	Explanation Phase
1. Research Philosophy	Interpretivistic	
2. Research Approach	Inductive/Deductive	
3. Research Strategy	Case Studies (20 companies)	Case Studies (4 companies) Grounded Theory
4. Time Horizon	Cross sectional	Longitudinal
5. Data Collection Method	Interviews Questionnaires	Interviews Questionnaires Documentation Secondary data Observation

Figure 2: Research philosophy, approach and strategy for this study.

5 CONCLUSION AND NEXT STEPS

The PhD commenced in October 2005. The case studies commenced in October 2006, and the primary data collection will take place for 12 months and conclude in October 2007. The case studies will run concurrently. The primary data is being collected from questionnaires, interviews and observation by the researcher. The researcher is onsite with each organisation once a month, depending on the schedule of the organisation. Interviews are taking place with the energy managers to get a view of the overall energy situation with each case study.

With the use of grounded theory, strict guidelines on how to do rigorous research using this approach will be strictly adhered to, in line with the leading experts in the area. Some academics have concerns and doubts regarding the apparent lack of a systematic approach and rigour in grounded theory (Allen, 2006). With this in mind, the researcher will ensure to adopt and complete the data analysis methods which must be systematically followed in grounded theory research projects to reach reliable findings which lead to meaningful conclusions.

The research will give rise to an insight into, and analysis of, effective implementations of energy management systems in organisations. This may engender an organisation with the following capabilities: an increase in EE, effective DSM, a decrease in energy use, a lowering of emissions, a lowering in potential carbon tax trading costs, help in achieving the Kyoto targets set by the agreement, and an overall decrease in the annual energy budget.

ACKNOWLEDGEMENTS

The researcher would like to thank the Irish Research Council for Science, Engineering and Technology (IRCSET) for the current PhD funding in the form of an Embark Initiative Scholarship.

REFERENCES

- Alavi, M. & Joachimsthaler, E. (1992). *Revisiting DSS Implementation research: A Meta-Analysis of the Literature and Suggestions for Researchers*. MIS Quarterly, March 1992, pages 95-116.
- Allen, G., (2006). *Keynote presentation: The legitimacy of Grounded Theory*. European Conference of Research Methodologies, July 17-18, 2006.
- Alvarez, A., (2003). *Towards an interpretive integrative framework to conceptualise social processes in large information systems implementations*. Information Technology for Development, Volume 10, pages 233-247.
- Benbasat, I., Goldstein, D., & Mead, M., (1987). *The case research strategy in studies of Information Systems*. MIS Quarterly, September 1987, pages 368-386.
- Boiral, O., (2006). *Global Warming: Should Companies Adopt a Proactive Strategy?* Long Range Planning, Issue 39, Pages 315-330.
- Chin, W., Gopal, A. & Salisbury, W., (1997). *Advancing the Theory of adaptive Structuration: The Development of a Scale to Measure Faithfulness of Appropriation*. Information Systems Research, Volume 8, number 4, pages 342-376.
- Department of Communications, Marine and Natural Resources, (2006). *Green Paper: Towards a*

- Sustainable Energy Future for Ireland*. October 1st 2006, pages 1-112.
- DeSanctis, G. & Poole, M. (1994). *Capturing the Complexity in Advanced Technology Use: Adaptive Structuration theory*. Organisational Science, May, Volume 2, Number 5.
- Dhillon, G., (2004). *Dimensions of power and IS implementation*. Information & Management, Issue 41, pages 635-644.
- European Commission, (2001). *Environmental 2010: Our Future, Our Choice*. 6th EU Environmental Action Programme.
- European Commission, (2006). *Building a global carbon market – Report pursuant to Article 30 of Directive 2003/87/EC*.
- Finlay, P. & Forghani M., (1998). *A classification of success factors for decision support systems*. Journal of Strategic Information Systems, Volume 7, pages 53-70.
- Forfás (2006). *A Baseline Assessment of Ireland's Oil Dependence: Key Policy Considerations*. April 2006.
- Galliers, R., (1992). *Information Systems Research Issues, Methods and Practical Guidelines*. Blackwell Scientific Publications.
- Giddens, A., 1979. *Central problems in social theory. Action, Structure and Contradiction in Social Analysis*. The Macmillan Press Ltd.
- Glaser, B. & Strauss, A., (1967). *The Discovery of Grounded Theory: strategies for qualitative research*. Walter de Gruyter Inc.
- Gopal, A., Bostrom, R., & Chin, W. (1992). *Applying Adaptive Structuration Theory to Investigate the Process of Group Support System Use*. Journal of Management Information systems, Volume 9, Number 3, pages 45-69.
- Levermore, G (2000). *Building Energy Management Systems*. Second edition, London: E & F Spon.
- Lowry, G (2002). *Factors affecting the success of building management system installations*. Building Services Engineering Research and Technology, Volume 23, Issue 1, pages 57-66.
- Parker, C., & Sinclair M., (2001). *User-centred design does make a difference. The case of Decision Support Systems in crop production*. Behaviour & Information Technology, Volume 20, Number 6, pages 449-460.
- Parker, J., (2000). *Structuration*. Open University Press.
- Saunders, M., Lewis, P., & Thornhill, A., (2003). *Research Methods For Business Students*. Prentice Hall.
- Schwieger, D., Melcher, A., & Wen, H., (2004). *Appropriating electronic billing systems: Adaptive structuration theory analysis*. Human Systems Management, Volume 23, pages 235-243.
- Sharma, R., & Yetton, P., (2003). *The contingent efforts of management support and task interdependence on successful information systems implementation*. MIS Quarterly, Volume 27, Number 4, pages 533-555.
- Strauss, A. & Corbin, J., (1997). *Grounded Theory in Practice*. Sage Publications.
- Strauss, A. & Corbin, J., (1998). *Basics for Qualitative Research: Techniques and Procedures for Developing Grounded Theory*. Sage Publications.
- Sun, (2001). *Energy Demand in the Fifteen European Union Countries by 2010 – A forecasting Model based on the Decomposition Approach*. Energy, 26, pages 549-560.
- Sustainable Energy Ireland (2005). *Energy in Ireland 1990 – 2003: Trends, issues and indicators*. January 2005.
- Zmud, R. & Cox, J., (1979). *The Implementation Process: A Change Approach*. MIS Quarterly, Issue 3, Number 2, pages 35-43.