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Abstract

Data centre energy consumption is expected to increase organisational costs and CO^2 emissions. Greening data centres can decrease these negative impacts. As a result, examining the antecedents to approaches for greening data centres in order to facilitate their widespread adoption is critical. This study aims to identify the antecedents to the adoption of technologies and techniques (including those that are commonly accepted to produce successful outcomes, i.e. best practices) in greening data centres. A conceptual framework is proposed for explicating the conditions that might influence the adoption of the best practices in greening data centres. The conceptual framework is partially explored through two case studies. A series of theoretical propositions that are rooted in institutional, motivation-ability and utilitarian theories are proposed. The findings show that organisational propensity to adopt greening data centre best practices is based on institutional pressure, organisational and environmental efficiency motivations, organisational ability to take on greener practices and performance and effort expectancy.

Keywords: Data centre, green IT, energy efficiency, Green ICT, Best Practice

INTRODUCTION

The exponential growth in demand for computing and processing power has resulted in a subsequent rise in data centre energy consumption and carbon emissions (EPA 2007; Velte et al. 2008). This raises the issue of the sustainability of data centres. The Environmental Protection Agency's (EPA) ground breaking report on Data Centre Energy Efficiency (EPA 2007) revealed that data centre energy consumption more than doubled in the USA alone since the year 2000, amounting to about $4.5 billion in electricity costs (EPA 2007). Further, the study demonstrated that as of 2006, the electricity use attributable to data centres in the USA was estimated at about 61 billion kilowatt-hours (kWh), or 1.5 percent of total U.S. electricity consumption (EPA 2007). In Europe, the electricity consumption of data centres, enterprise servers, and information and communication technologies (ICT), cooling and power equipment constitutes a significant proportion of the overall electricity consumption of the European Union commercial sector (European Commission. 2008). Both the US and EU estimates act as a wakeup call to policy makers and the information technology (IT) industry. Therefore, it is important to address data centre energy efficiency in order to ensure that the associated impacts, such as strain on infrastructure and financial and environmental costs are mitigated.

Data centres represent all buildings, facilities and rooms which contain enterprise servers, communication networks and cooling and power equipment for providing data services (e.g. data processing, such as web hosting, Internet, intranet, telecommunication and information technology) (Barroso and Hölzle 2009; European Commission. 2008). A green data centre is the one in which the mechanical, lighting, electrical and computer systems are designed for a high-level of energy efficiency and minimal environmental impact (Sun and Lee 2006). It represents a data centre that has made a significant investment in technologies and techniques and in adopting best practices that are intended to improve both the energy performance and the environmental footprint of the data centre.

The IT industry, concerned about the environmental impact of ICT expansion and energy consumption on one hand and the availability of energy sources on the other, are strongly driving the adoption of green data centre practices. Amongst organisations, some of the main drivers for the adoption of practices to greening data centres are the rising cost of energy, capacity constraints, environmental concerns, impending regulation and good corporate citizenship (Winkler et al. 2008). More broadly, the adoption of Green IT is driven by the need for greater IT efficiency and the pursuit of tangible cost savings from IT operations (Molla et al. 2009b).

Examination of the extant literature reveals that reducing an organisation's data centre impact on the natural environment leads to long-term savings (Barroso and Hölzle 2009; Velte et al. 2008). Brill (2007) suggested that basic changes such as server virtualisation can be implemented with little or no capital investment and may actually defer the need for costly new data centre investment. Further, the increasing willingness of manufacturers and vendors to compete on the basis of energy efficiency suggests that there are efficiency gains to be realised without excessive initial costs (European Commission. 2008). However, there is a body of opposing research pointing to the factors that have prohibited organisations from implementing best practices to green their data centres such as lack of internal expertise, weak incentives, unwillingness to risk performance, lack of budget and the complexity of changing data centres (Bednar et al. 2009; Winkler et al. 2008).

Given the range of perspectives in the literature, it is important to examine the antecedents to organisational approaches to greening data centres. In order to identify the antecedents to the adoption of best practices, this paper proposes a conceptual framework that is drawn from institutional, motivation-ability and utilitarian theories. The framework is partially explored through two case studies. The remainder of this paper is structured as follows. First, we provide an overview of green data centre best practices. Next, a review of the organisational behaviour literature that informed the conceptual framework is presented. We then outline our methodology and provide the results of two exploratory case studies and a number of propositions. The paper concludes with some observations based on the case studies.

GREEN DATA CENTRE BEST PRACTICES

Best practice is an action performed by an organisation to a standard which is better or equal to that achieved by other organisations in similar circumstances (Hughes and Smart 1994) or an action that matches industry benchmarks and trends. It is therefore a practice that has been determined to produce superior results based on analysis of performance (Jarrar and Zairi 2000). In the context of green data centres, this can be refined to encompass practices that improve energy efficiency while maintaining or improving data centre operational performance.

Within the cumulative green data centre literature a number of technologies and strategies emerge as best practice. These are based on the available technology applied in conjunction with techniques and data centre management approaches that can be enforced throughout the lifecycle of the data centre. Not all energy losses can be circumvented; nonetheless, in most data centres opportunities exist for improving energy efficiency. Loper and Parr (2007) suggested that to improve energy efficiency data centre operators have four basic choices: (1) reduce computer power usage through efficient application management; (2) improve server efficiency; (3) improve the efficiency of power supplies and distribution; and (4) improve the efficiency of cooling systems. Table 1 outlines the established best practices as identified by the literature, key industry bodies (i.e. the Green Grid) and practiced by leading organisations (i.e. Google). These can be grouped into two categories: (1) The ICT Infrastructure, referring to servers, storage, and telecommunications and (2) Network-Critical Physical Infrastructure (NCPI), referring to lighting, UPS, cooling and other facility dimensions. These best practices are typically undertaken in conjunction with management and governance practices and processes such as energy efficiency measurements, ratings, itemised electricity bills and proper alignment of data centre staff (Chernicoff 2009; EPA 2007; Google 2010; Green Grid. 2007; Velte et al. 2008; Winkler et al. 2008).

Table 1: Green Data Centre Best Practice

ICT Infrastructure	Enable existing power saving features	(EPA 2007; Green Grid. 2007; Winkler et al. 2008)
	Rightsizing of UPS and IT equipment	(Green Grid. 2007; Info-Tech 2007)
	Efficient server consolidation and virtualisation	(Chernicoff 2009; Green Grid. 2007; Info-Tech 2007; Winkler et al. 2008)
	Optimise storage	(Velte et al. 2008; Winkler et al. 2008)
	Proper configuration of server software	(Green Grid. 2007)
	More efficient power equipment / Optimise power distribution	(Google 2010; Velte et al. 2008)
NCPI	Use free cooling	(Google 2010)
	Proper location of vented floor tiles	(Green Grid. 2007; Velte et al. 2008)
	Coordination of air conditioners	(Green Grid. 2007)
	Utilisation of air conditioner economiser modes	(Chernicoff 2009; Green Grid. 2007)
	Installation of a close-coupled cooling architecture	(Green Grid. 2007)
	Optimisation of data centre design	(Chernicoff 2009; Green Grid. 2007; Velte et al. 2008)
	Installation of energy efficient lighting, blanking panels, efficient plumbing	(Green Grid. 2007)
	Optimisation of data equipment floor layout	(Chernicoff 2009; Green Grid. 2007; Winkler et al. 2008)

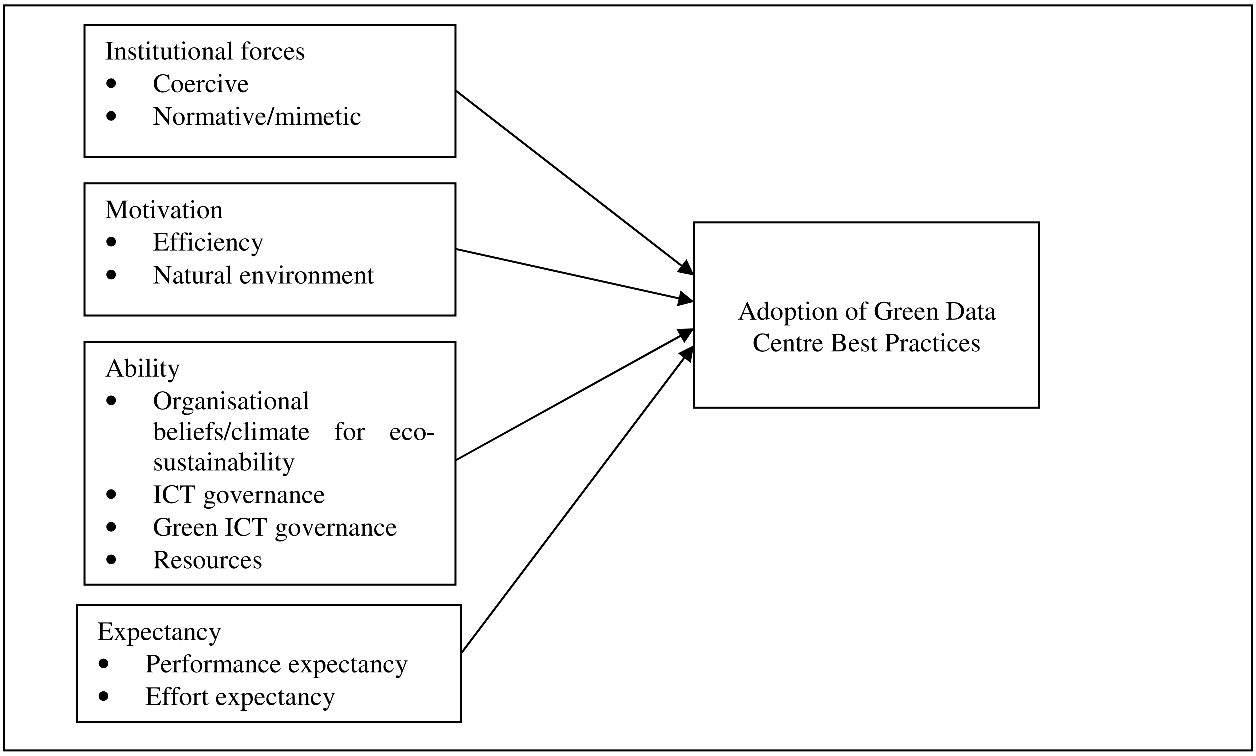
THEORETICAL BACKGROUND AND CONCEPTUAL FRAMEWORK

A number of studies have illuminated our understanding of the antecedent factors that can explain organisational behaviour in the adoption of green practices and strategies (Chen et al. 2009; Levy and Rothenberg 2002). However, few theoretical approaches have been developed for explaining organisational behaviour towards green data centre best practices. This is because many existing approaches have not accounted for broader environmental-social pressures that are the catalyst for change as well as the benefactor of it. In the context of green data centres this refers to environmental deterioration as a pressure for change and improved environmental sustainability as an expected outcome of the change, as well as the social imperatives such as improved efficiency and reduced cost. However, there is a growing interest among researchers to incorporate the natural environment in the investigation of information systems (IS) in organisations (Chen et al. 2008).

The underlying foundation for the conceptual framework in figure 1 is based on Institutional Theory (DiMaggio and Powell 1983), Motivation-Ability Theory (Merton 1957), and Performance-Expectancy Theory (Venkatesh et al. 2003). By fusing these theoretical perspectives, we are able to capture the potential institutional and organisational antecedents to the adoption of green data centre best practices. While the institutional theory helps to anchor antecedents external to organisations, the combination of motivation, ability and expectancy theories help to anchor antecedents that are internal to organisations. The individual components of the conceptual framework are discussed next.

Figure 1: A conceptual framework

Institutional Theory



Institutional theory is concerned with the influences that shape social and organisational structures, schemas, rules, norms, routines and, ultimately, the behaviour of social actors (Scot, 2007). It has been used extensively for understanding the sustainability and environmental issues in organisations (Jennings and Zandbergen 1995), Green IT adoption (Butler and Daly 2009; Molla 2009) and IT innovation (King et al. 1994). Institutions motivate social behaviour through mimetic, normative and coercive pressures (DiMaggio and Powell 1983). In adopting green data centre best practices, there are two main pressures on data centres, namely, coercive and normative pressures.

Coercive pressures are present when organisations act because of government laws and regulations (DiMaggio and Powell 1983). Regulatory pressures exert a negative influence on isomorphism and strategic homogeneity (Milstein et al. 2002) and may motivate organisational competitiveness and innovation (Porter and Linde 1999). While few countries have enforced regulations on data centre energy efficiency, clearly a new regulatory environment is emerging with carbon trading schemes likely to feature heavily in the near-future. Along these lines, a review of the literature reveals that impending regulations might influence the adoption of practices for improving data centre energy efficiency (Winkler et al. 2008) and more broadly green IS and IT adoption (Chen et al. 2009).

Mimetic institutional pressures are at work when organisational pressure to conform comes from other organisations and develops into an uncertainty-coping strategy (DiMaggio and Powell 1983). On the other hand, normative institutional pressures come into play when cultural expectations press organisations to act in a legitimate way (DiMaggio and Powell 1983). Further, when mimetic and normative pressures increase, isomorphic tendencies also rises and variation in organisational environmental strategies is reduced or eliminated (Milstein et al. 2002). There is clearly an overlap between mimetic and normative forces. For this reason we consider them together. Similarly, other authors have excluded normative pressure from the institutional theory framework in order to eliminate confusion and focus attention on mimetic and coercive pressures (Chen et al. 2009). Importantly, there is empirical support for the complementary effects between mimetic and coercive pressures in driving the adoption of green IS and IT (Chen et al. 2009).

Normative and mimetic influences usually emanate from Non-Government Organisations (NGOs) (such as Greenpeace), professional and standards bodies, consulting organisations, and society at large (Butler and Daly 2009). The success of large data centre organisations such as Google, Fannie Mae and Citigroup (GreenerComputing Staff. 2009; Stansberry 2005) in implementing green data centre best practices and the efficiency benefits that these organisations have realised can create a mimicking tendency among other data centres. However, some literature concerning the drivers of green data centre practices adoption suggest that normative and mimetic influences are not the major factors (Winkler et al. 2008). Given the early stage of the diffusion of green data centre best practices, this may come as no surprise. However, given the ever increasing recognition that "We (society, individuals and organisations) are obliged to minimise or eliminate where possible the environmental impact of IT to help create a more sustainable environment" (Murugesan 2008 p. 24) normative and mimetic pressures are likely to exert greater influence on organisations in the future.

Aside from the institutional forces, Merton (1957) postulated that a combination of organisational ability and motivation shape the nature and intensity of actions and outcomes. That is, organisational behaviour can be motivated because of the expectation of enhancing efficiency and attaining legitimacy as well as the internal human, managerial and technical capability to do so (Grewal et al. 2001).

Motivation

Organisational motivation to implement green data centre practices can emanate out of concern for improving efficiency, and out of care for the natural environment. The efficiency motive generally refers to the need for greater resource utilisation and reducing the cost of doing business (Grewal et al. 2001). Such motivation is in synch with the notion that organisations are bound to assure shareholders or owners that the company makes an adequate profit. Therefore, any decision concerning green practices is likely to be based on a cost–benefit analysis of the actions (Hendry and Vesilind 2005). However, as environmental performance and financial performance are associated (Menguc and Ozanne 2005), the definition of benefit might need to be expanded to encompass environmental benefits too. Data centre studies show that rising energy costs, cost savings and a desire to get more out of existing investments are the major motivators for adopting best practices to green data centres (Bednar et al. 2009; Winkler et al. 2008).

The natural environment is an important source of competitive advantage, and as such should be considered as a resource associated with organisational viability (Hart 1995). Within the context of data centres, this refers largely to availability and sustainable use of energy and the emission associated with sources of energy. While there is little evidence that indicates that corporate commitments to environmental goals are significant antecedents to greening data centres (Winkler et al. 2008), against the backdrop of the projected increase in the number data centres and associated energy consumption, concern for the natural environment may emerge as a motivation for the implementation of green data centre practices. Hart (1995) proposed three elements of environmental sustainable strategy: pollution prevention, product stewardship and sustainable development. Pollution prevention is relevant to data centres as the burning of fossil fuels for energy is a source of pollution (carbon dioxide and sulphur dioxide). Sustainable development in the context of data centres takes on similar meaning, referring to the efficient use of computing and energy resources in order to meet the needs of current and future generations (World Commission, 1987; Sahlin-Andersson, 2006). Product stewardship refers to the application of environmental considerations in the design, creation, operation and termination of data centre facilities and ICT, power and cooling equipments within those facilities for lower life-cycle environmental cost and impact.

Ability

The ability of an organisation includes its readiness, capability and learning (Molla and Deng 2009). In the context of improving data centre energy efficiency this is reflected through the attitude of an organisation towards the natural environment, the commitment of senior management to environmental performance, and the capability of the organisation for adopting innovative practices for improving the organisational environmental performance.

Organisational climate and attitude towards the natural environment is an important antecedent for the adoption of green practices in an organisation. This is dependent on the commitment of senior management to corporate environmental policy, along with active encouragement of environmental initiatives that emerge from lower levels of the organisation (Maxwell et al. 1997). Azzone and Noci (1998) found that only a small number of organisations consider the environment as an important factor of strategic change, and that they typically adopt three types of behaviour: a re-active, an anticipatory and an innovation-based pattern of environmental behaviour. Levy and Rothenberg (2002) argued that collective organisational interpretations about the nature of and solutions to climate change constitute important drivers of strategy. They articulated three dimensions to this (1) organisational perceptions towards climate change and environmental issues, (2) the history of the organisation (which influence whether changes/options are viewed as threat or opportunity), and (3) management in different functional areas adopting perspectives consistent with departmental interests. Others argue that environmental commitment may be associated with the realisation that methods for reducing environmental impact positively impact revenue (Hendry and Vesilind 2005).

Studies of green data centre drivers have demonstrated that a corporate initiative to be green is important in facilitating change (Bednar et al. 2009). From a broader perspective, green IT initiatives are more likely to be motivated from a sense of social responsibility from employees within an organisational environment capable of change rather than responding to external coercive pressures or pursuing competitive advantage (Kuo and Dick 2009).

Organisational ability can also include governance, which offers a framework for defining a complex set of relationships and activities in organisational relationships (Davies 2002). It is the operating model that defines the administration of IT decisions and green IT initiatives. Thus two dimensions of governance – ICT governance and green ICT governance are likely to influence practices in greening data centres.

Green IT Governance is the operating model that defines the administration (roles, responsibilities, accountability and control) of green IT initiatives. Governance also includes allocation of budget and other resources to green IT initiatives and defining metrics for assessing the impacts of green IT initiatives (Molla et al. 2009a). Lack of management priority (Emerson Network Power. 2007) and not knowing the energy costs of IT (Molla 2009) are cited as reasons for a lack of green IT initiatives in organisations. The latter is pertinent for data centre energy efficiency as it is generally considered that if energy consumption is not measured then it is difficult to change (Kaiser 2010).

Another common antecedent to any adoption or organisational behaviour is the resources available to institute change. Within the motivation-ability framework, this refers to the stock of resources, including technological, financial, and human capital in order to undertake change (Merton, 1957). While budgetary concerns are not a dominant obstacle to green data centre practices, lack of knowledge (Judge 2010) and capacity constraints (Winkler et al. 2008) are cited as obstacles in the path to moving to green data centres.

Expectancy

There are two utilitarian perspectives that are likely to influence organisations' adoption of innovation - performance expectancy and effort expectancy (Venkatesh et al. 2003). Performance expectancy refers to the notions of perceived usefulness (Davis 1989) and anticipated benefits (Venkatesh et al. 2003), that is, the return on investment and effort. This has emerged as an important factor in explaining adoption of information systems and technology. Likewise, amongst data centre managers, there is a clear lack of confidence that changes will lead to savings (Loper and Parr 2007), suggesting that green data centre practices are not perceived as useful. Effort expectancy refers to the ease of implementation of the best practices (Venkatesh et al. 2003); the perceived ease of use of the technology (Davis 1989) and its complexity (Rogers 1983). That is, how difficult the change is perceived to be. This is a key factor within the data centre domain, given that many have been built with large tolerances to change and the criticality of uptime. Therefore, it is no surprise that data centre managers and administrators are more concerned about performance uptime and not the energy usage (Mata-Toledo and Gupta 2010) and business continuity and 'not wanting to risk reliability' feature as a inhibitor for change (Emerson Network Power. 2007; Winkler et al. 2008). Further, given the rapid and heterogeneous nature of innovation, managers find it difficult to keep up with technology in order to keep optimising data centres according to best practice. Moreover, there are few rewards to do so, and data centre managers are concerned that new green data centre practices are untested (Loper and Parr 2007).

RESEARCH METHOD

In order to explore the conceptual framework two case studies of data centres were undertaken. The case studies were used to explore motivational and inhibitor factors behind the adoption of green data centre best practices. Interviews were undertaken with data centre managers or other relevant person and site visits were performed in order to attain direct observation. The use of case studies (Yin 1994) as an initial exploration of the conceptual framework allows for a better understanding of the antecedents to the adoption of green data centre best practices. Case studies can be based on a single or many cases. This is because the validity of the case study has more to do with the 'plausibility and cogency of the logical reasoning' (Walsham 1993 p. 15) and less with the number of cases. A potential weakness of relying on a single case study is that it may result in narrow theory (Eisenhardt 1989). Nonetheless, the external validity of case studies can arguably be enhanced by the strategic selection of cases rather than their number (De Vaus, 2001). The case studies sites were, therefore, selected as relevant cases for examining both the adoption of green data centres best practices and the antecedents. The first case, henceforth referred to as Case A, is a University with multiple data centres, including a newly built co-located facility. The second case study (Case B) was a co-located data centre organisation that focuses on the provision of data centre services for large organisations. The former represented an example of a conventional data centre with an evolving approach to greening its data centres, including moving operations to a purpose built centre, whilst the latter was selected as an example of a state-of-the-art data centre.

CASE STUDY ANALYSIS

The best practices undertaken by each organisation are outlined in Table 2. Following this, a synthesis of the key findings from the analysis of the case studies, in terms of institutional influence, motivation, ability and expectancy, is presented. Each case study has followed a separate trajectory in the implementation of best practices. Case A, in order to overcome limitations with its existing data centres, decided to move to a purpose built co-located data centre. The purpose built facility demonstrates the implementation of best practices. Case A envisions that all data centre activities will move to this centre in the future. In the instance of Case B, the data centre was built with energy efficiency, eco-sustainability and future proofing in mind, not only as a point of differentiation and added value for customers but also to account for a projected focus by its clients on energy consumption and government policy on emissions. Both data centres have the ability to directly draw renewable energy. Table 2 shows that both cases have or are undertaking the best practices listed in Table 1. However, Case B has also implemented a range of state-of-the-art practices such as a super intelligent cooling infrastructure and multi-density rack/server approach.

Table 2: Implementation of Best Practices

	Case A	Case B
NCIP	• Improving transformers & UPS • Water cooling is used in all data centres • Hot aisle and cool isles are utilised (the cool aisle is isolated, minimising the leakage, and improving the control of the air) • Improving efficiency of chillers, fans, and pumps • Free cooling used and expected to be used to a large extent in the short term future	• Modular design, clients assigned 'pods' that are purposely placed to maximise air flow and allow for expansion • 'Super intelligent' cooling infrastructure that adapts depending on the workloads and the equipment in the individual racks (cooling maintained at 21.5 degrees) • Latest UPS technology used • Worlds Best (APC) Hot Aisle Containment Solution utilised • Air cooled ultra high efficient 'free air chiller' technology making use of ambient air (saves 50,000 litres of water per day) • No raised floor design • Cabling positioned overhead to remove loss of cooling efficiency
ICT Equipment Infrastructure	• Consolidation has resulted in 60% less servers • Virtualisation process underway (20-30% complete) • Power management enabled • Storage consolidation underway and is expected to be undertaken to a large extent • New equipment purchased with automatic power down power supplies and CPUs • Moving towards automation of monitoring and control of temperature	• Consolidation and virtualisation is pushed onto clients (however, data centre can offer 50% reduction in the number of racks required) • Standardised IT equipment used, designed to work together in the most efficient way • High and multi-density approach unlocks a whole new world of computing outcomes for the clients through virtualisation • Fully automated real-time data on power usage, heat and humidity • Building Management System used to interface with the infrastructure monitoring tools

Institutional Influence

Case A: The main institutional influences come from the popularity of greening data centres within the industry and a broader IT industry understanding that energy consumption needs to be addressed. The IT Managers in Case A usually attend industry conferences and workshops in order to learn about and improve energy consumption. No industry standard guidelines or certifications (i.e. LEED, ISO 14001) are followed. Increasing public focus on data centre energy consumption was also an influence and there is a desire to be seen to be achieving environmental outcomes. Impending regulation was not a pressure felt. However, it was mentioned that the government is aware of the problem faced by research institutes concerning storage (and subsequent energy and capacity stress) and is considering building dedicated storage facility for research institutes.

Case B: The data centre was designed and built with energy efficiency in mind. Case B has taken into consideration the government and public focus on global warming and the spotlight on the data centre industry in the planning stage of the purposely built data centre. The implementation of green data centre practices have also been influenced by the actions of green-aware organisations and the IT industry, "*…suddenly efficiency has become very important…getting to the point where (clients) will start the conversation with what's your PUE (Power Usage Efficiency)"* (Data Centre Manager, 2010). The data centre welcomes, and is prepared for, regulations concerning Green House Gas emissions. "*…if there was a ETS (Emissions Trading Scheme) it would then reward efficient operators like me…If the cost of energy was to double this place would be so much more attractive to clients*" (Case Study B, 2010). This is based on the notion that an ETS will add value to the services of the data centre. Uncertainty surrounding energy prices in Australia and the influence this will have on the data centre industry is also a reason for adopting green data centre best practices. While, the organisation is conscious of the normative and regulatory environment a wait and see approach has been adopted concerning which industry standard guidelines to follow.

Based on this analysis our first theoretical propositions are as follows:

Proposition 1: Organisations that operate in an environment of impending or clear and enforceable energy efficiency regulations are more likely to adopt practices to green their data centres.

Proposition 2: Organisations that operate in an environment where green data centres are the norm and where green data centres are popularised by industry and the broader society are more likely to adopt practices to green their data centres.

Motivation

Case A: The decision to move part of the operations to a purposely built co-located data centre has to do more on capacity factors and less on energy efficiency. First, its existing data centres are housed in non-purpose built rooms that have a range of limitations such as inability to receive dual power feeds, cooling issues, lack of space for expansion and in the past have suffered from flooding. Second, other commercial co-located data centres were operating at maximum capacity and therefore few choices were available "*our options were extremely limited, because every data centre in town is full, there's no data centre space, its gone…you would think, given that all the rationalisation, server consolidation, virtualisation, there would be lots of data centre space, but it's not happening its actually gone the other way*" (Data Centre Manager, 2010). Third, current data centre infrastructure could not sustain 24/7 availability.

Increases in energy costs and awareness of energy consumption and its impact on the environment have also been part of the consideration, although to a lesser degree of importance. Importantly, cost of change (towards improving energy efficiency) and environmental benefits are considered on equal terms.

Case B: As a purposely built data centre, the initial motivation was to be as green as possible, and leverage this dimension to clients as a point of differentiation. By using the most state-of-the-art technology, the data centre maximises efficiency (offering power savings of up to 50 percent for clients and was designed to save up to 60,000 litres of water a day).

Proposition 3: Organisations that are concerned with efficiency (limiting cost, increasing capacity) are more likely to adopt practices to green their data centres.

Proposition 4: Organisations that are aware of the environmental issues related to growth in energy use are more likely to adopt practices to green their data centres.

Ability

Case A: A strong organisational environmental policy and philosophy towards reducing environmental footprint exists. Over the last two years, there has been increased focus on environmental concerns and environmental KPIs have been built into management reporting and the IT department is committed to green IT. IT management participate in industry discussions/forums concerning green data centres to ensure that skills are in place to improve energy efficiency. While no direct organisational incentives have been offered or mandates made by upper-level management, the IT department understands that energy efficiency needs to be addressed. Space and cost are considered obstacles to implementing green data centre practices.

Case B: Management are acutely aware of issues relating to environmental impact (the data centre consumes roughly the equivalent energy of up to 50,000 homes). Green is a theme that permeates all levels of the organisation. Improving energy performance is also something clients are advised on. Management measure/rate performance (and can even do this per rack and socket basis). Funding is an issue concerning improving energy efficiency; however this is based on the cost for the client. In the development of the data centre solar power was examined in order to provide energy; however, at a cost of five hundred million dollars it was clear that no client would afford the data centre services. Space is not an issue as the data centre has been built with expansion in mind. Initiatives are in place to make sure that employees are up-to-date concerning green practices.

Proposition 5: Organisations with a clear commitment to environmental sustainability are more likely to adopt practices to green their data centres.

Proposition 6: Organisations with well defined IT/Green IT Governance practices and necessary resources are more likely to adopt practices to green their data centres.

Expectancy

Case A: Moving to green data centre best practices has improved the environmental footprint but also increased reliability, service delivery and operational efficiencies. That is, there is an established coupling of investment and performance. Performance and availability remain the key operational considerations.

Case B: Investment into green practices was based on the assumption that it would lead to significant benefits in the form of clients and reduced impact on the environment. The data centre continues to expand its high-profile clients and improve environmental performance. Further, the data centre has positioned itself as a resilient high performing data centre, designed with future-proofing systems. Any change in data centre operations takes place against power, cooling and security considerations to achieve sustainability outcomes. "*Our business is underwritten by our ability to provide* *power cooling and security 100% of the time. That's our primary focus, but if you can do that in such a way that you are achieving much better sustainability outcomes, then you will be head and shoulders above other data centres in Australia*" (Case Study B, 2010).

Proposition 7: Organisations with a clear understanding of the benefit of green data centres (and do not perceive a negative impact on performance) are more likely to adopt practices to green their data centres

Discussion and Conclusion

In this paper we presented a conceptual framework based on the Institutional, Motivation-Ability and Performance-Expectancy Theories. The synthesis of these theoretical perspectives provided the basis for capturing the institutional and organisational antecedents of green data centre best practices. Two exploratory case studies were conducted in order to explore the conceptual framework and a series of propositions were offered.

The normative environment has emerged as a strong influence, in terms of a trend towards greener data centres driven by environmentally aware data centre managers and the IT industry. The regulatory environment was also a strong influence. In one case, Australia's impending Emission Trading Scheme is welcomed as it will be used as a form of service differentiation and added value proposition to customers. This supports the contention that environmental regulation can drive competition (Porter and Linde 1999) and that regulatory environment may exert a negative influence on isomorphism (Milstein et al. 2002). Unlike the literature which indicates that few organisations consider the environment as an imperative for change (Azzone and Noci 1998), both case studies indicated a corporate environmental policy and overarching organisational philosophy towards reducing environmental footprint. The availability of resources (budget, skills, space etc) was an important consideration for Case A. Nonetheless, for both cases any green decisions were taken against the backdrop of fundamental performance, availability and security considerations. Therefore, any energy efficiency decision takes place based on the range of performance consequences and effort (Emerson Network Power. 2007; Mata-Toledo and Gupta 2010; Winkler et al. 2008).

Based on findings presented in this paper a survey instrument has been developed to empirically validate the conceptual framework and test the propositions, as suggested by (Butler and Daly 2009). The survey instrument will be distributed Australia wide to organisations with a dedicated data centre, as per our earlier classification. A range of data centre sizes will be represented, from server closets within a conventional building to dedicated rooms housing servers, storage devices, and network equipment.

It is important to place some limitations on the preliminary work presented in this paper. First, the case studies carried out were exploratory and not designed to provide empirical validation but rather provide some coupling of the theoretical framework and reality. Second, the case studies, while representing one state-of-the-art and one 'typical' data centre, cannot be considered representative of data centres in Australia given the range of control factors (size, industry, and data centre classification) that were not considered in this research. Nonetheless, the case studies provided an empirical basis for discussion of the conceptual framework.

The study has both theoretical and practical significance. Organisations wanting to use green IT are now seeking greater understanding of how green IT generates value and improves their environmental and economic performance. Nevertheless, IS research is criticised for failing to provide meaningful assistance to "those organisations unsure about how, where, and when to respond to imperatives for their IT applications and practices to become green" (Elliot and Binney 2008) and for being slow to recognise the problem of climate change and take action (Watson et al. 2010). This study expands knowledge in the field of green IT, specifically data centres, by identifying the antecedents of green data centre best practices. The importance of the framework lies in its applicability to any data centre environment as the framework will provide the necessary conceptual tool to understand the factors that drive or inhibit the adoption of green data centre best practices. Further, the study will be of interest to scholars interested in how patterns of organisational environmental behaviour are influenced in the context of data centres.

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