

UNDERSTANDING DIGITAL ECO-INNOVATION IN MUNICIPALITIES: AN INSTITUTIONAL PERSPECTIVE

Complete Research

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Abstract

Municipalities consume over 67% of global energy and are responsible for over 70% of greenhouse gas emissions (GHG). The Intergovernmental Panel on Climate Change warns that rapid adjustments need to happen at a global level, or the effects of climate change will be irreversible. The contribution of municipalities is therefore vital if GHG emissions are to be reduced. Our research is timely in its exploration of the ways in which municipalities institutionalise environmental sustainability practices in and through Green digital artefacts. Using mechanism-based institutional theory as a lens, the paper presents the findings of three contrasting case studies of large municipalities in the United Kingdom in their respective programmes to leverage the direct, enabling and systemic effects of Green ICT in order to reduce GHG emission and achieve their eco-sustainability goals. The case sites are also regarded as exemplars for further research and practice on digital eco-innovation. The mechanism-based explanations illustrate how a social web of conditions and factors influence eco-sustainability outcomes. We conclude that the digital technology-enabled grassroots-based initiatives offer the best hope to begin the transition to sustainable climate change within municipalities. The contributions of our study are therefore both theoretical and practical.

Keywords: Institutional theory, Mechanisms, Green ICT, Green IS, Digital, Eco-sustainability.

1 Introduction

In 1992, the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro concentrated on vital issues of sustainability, natural resources and development. Agenda 21 focused on implementing the various agreements arrived at the conference. This mandates signatories to develop and implement national strategies for sustainable development. Local Agenda 21 (LA21) is the umbrella policy implemented by governments, it reflects the ‘Think global, act local’ emphasis in translating policy into action (Devine-Wright, 2013). While LA21 funded initiatives are underway across signatory nations, the related concept of eco-municipality received early attention in Scandinavia, particularly in Sweden (Lafferty and Eckerberg, 2013) and, recently, in the US (Silberstein 2010). Furthermore, the exploitation of digital eco-innovation within municipalities in addressing the overwhelming problems of environmental sustainability and climate change is also noted (Evans et al., 2013). Consequently, our research helps overcome the paucity of studies which consider the role of information and communication technologies (ICT) in enabling eco-municipality (Bengtsson and Ågerfalk, 2011), and Green ICT (Hilty and Aebischer, 2015; OECD 2009, 2010) or Green IS (Watson, Boudreau, and Chen, 2010; Loeser, 2013).

The Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report in 2014 provides the most comprehensive assessment of climate change yet—and the most starkest of warnings. Change needs to happen at a global level and fast, or the effects of climate change will be irreversible—although some argue that it is already too late (Lovelock, 2009). Acting locally has never been more important, as cities consume over 67% of global energy and are responsible for over 70% of greenhouse gas emissions (GHG). This brings the municipality into sharp focus, as it is here that the biggest reductions in greenhouse gas emissions are required.

The objectives and motivation for our research is to deepen our understanding of the various ways in which municipalities institutionalise environmental sustainability practices in and through digital artefacts. It employs three theoretically-informed and contrasting case studies of large municipalities in the United Kingdom to illustrate the institutional mechanisms responsible for change. The first case is limited in its contribution due to the approach this municipality has taken in leveraging the direct and enabling effects of Green ICT (OECD, 2009, 2010) to reduce its environmental impact. In the second case, local politicians and public administrations deploy Green ICT in a broader municipal context with greater impact. The third case illustrates how eco-municipal policies can have dramatic effects at local level with lessons for the institutionalisation of Green digital technologies for eco-sustainability that are global in their impact. The contributions of this study are both theoretical and practical. The mechanism-based explanations illustrate how a web local and global factors influence outcomes. At a practical level, it was apparent that while the existence of policy and funding mechanism are vital, we found that grassroots-based initiatives offer the best hope to begin the transition to digital technology-enabled sustainable municipalities.

The remainder of this paper is structured as follows. The next section presents this study’s theoretical lens. The next, describes the research methodology. The three cases are then described and the transition to eco-municipality explained in the context of the institutional environment in which they are embedded. The final section then discusses the findings and offers insightful and compelling conclusions.

2 Theoretical Background

Institutional theory explains how the *regulative, normative, and cultural-cognitive mechanisms* shape society, organisational fields, and individual organisations (Scott 2001). In her recent paper on the use of mechanism-based IS research, Avgerou (2013, p. 407) concludes that “[s]ocial mechanisms abound

in IS theory but, like causal claims more generally, they are rarely explicitly identified and mentioned as such.” At a macro-level institutional change results from, and can be explained by, the action of *coercive, normative and mimetic (cultural-cognitive) mechanisms* (Di Maggio and Powell 1983; Scott 1995). However, a range of other mechanisms, operating at different levels, are at play. Take, for example, that actors apply mechanisms in an institutional environment to influence the formation and structure of organisational fields: these actors include governments, industry associations, dominant organisations, and social movements. An organisational field is typically defined as consisting of organisations with similar business, commercial, or public service interests: also included are suppliers of services, resources, and/or products, customers and consumers, government agencies, and other stakeholders (DiMaggio and Powell 1983; Scott 1995, 2004).

2.1 An Conceptual Overview of Social and Institutional Mechanisms

Social mechanisms take the form of structures, social artefacts, or processes (Hedström and Swedberg, 1998). They have the characteristics of being both observable and unobservable and formal or substantive in nature (Gross, 2009). We adopt Gross’ (2009) conceptualization of social and institutional mechanisms as configurations of actors, their habits of cognition and action, related resources, and the responses they make when faced with problems, such as developing eomunicipalities using digital technologies. Researchers illustrate that mechanisms operate at macro-, meso- and micro-levels to bring about institutional change (cf. Campbell 2005; Davis and Marquis 2005; Gross 2009; Hedström 2005; Hedström and Swedberg 1998). Hedström and Swedberg (1995) build three categories of social mechanisms: (1) *situational mechanisms* that are macro- or meso-level structures, artefacts and processes that shape individual *commitments*; (2) action-formation micro-level mechanisms as structures, artefacts or processes that link desires, beliefs, and opportunities with *commitments* to actions; and (3) transformational mechanisms that incorporate individual and collective *commitments to action* to social construct meso- or macro-level outcomes (cf. Selznick, 1947). Thus, it has been observed that mechanisms operate in tandem/cascade/combination to bring about institutional change (Campbell 2004; Hedström 2005).

2.2 Social and Institutional Mechanisms and Institutional Change

Institutional theory focuses on “the formal and informal rules, monitoring and enforcement mechanisms, and systems of meaning that define the context within which individuals, corporations, labour unions, nation-states, and other organisations operate and interact with each other” (Campbell, 2004, p. 1). Scott (1995, p. 35) argues that *coercive mechanisms* may be found in “regulatory processes involve the capacity to establish rules, inspect another’s conformity to them, and as necessary, manipulate sanctions – rewards or punishments – in an attempt to influence future behaviour. These processes may operate through diffuse, informal mechanisms, involving folkways such as shaming or shunning activities, or they may be highly formalized and assigned to specific answers, such as the police or the courts.” *Coercive mechanisms* are typically employed by governments, dominant organisations, social movements, groups and dominant social actors, as do *normative* and *cultural-cognitive mechanisms*. *Normative mechanisms* typically draw upon values and norms that “introduce a prescriptive, evaluative, and obligatory dimension” to social or organisational life (Scott 1995, p. 37). Values designate what is preferred or desirable, while norms stipulate the means by which what is desirable should be achieved. *Normative mechanisms* typically originate in and are applied by actors in professional and standards bodies, non-government organisations (NGOs), consulting organisations, professional associations, academic institutions and publications etc. *Cultural-cognitive* (usually referred to as *mimetic*) *mechanisms* originate in socially-constructed symbolic systems, cultural rules, and shared perceptions and socially-shared understandings. *Cultural-cognitive mechanisms* emanate from societal actors, NGOs, social movements, community groups, investors, and other stakeholders. Di Maggio and Powell (1983) argue that over time organisations in a

field tend to become homogenous in terms of both their processes and structures—this they term isomorphism. In terms of the present study, while institutional isomorphism will occur as local governments socially construct digitally-enabled eco-municipalities through *coercive, normative, and cultural-cognitive mechanisms* (Di Maggio and Powell 1983; Scott 2004). Campbell (2004, 2005) and Selznick (1947) employ macro-, meso-, and micro-level social and institutional mechanisms to help explain institutional change in a variety of research contexts. Table 1 illustrates these constructs presented as a conceptual framework to aid our empirical analysis.

Mechanisms	Description
Political Opportunity Structure	Formal and informal political conditions that encourage, discourage, channel or otherwise influence the activities of entities in an organizational field. Monitoring and Enforcement are two complementary coercive mechanisms.
Strategic Leadership	Institutional Entrepreneurship is exercised by social actors who decide on which direction a social, institutional or organizational entity should take.
Commitments	The norms, values, and world views of actors at all levels shape commitments to organisational, sectional and individual objectives.
Network Cultivation	Involves creating social and institutional movements and associations.
Framing	This involves the use of metaphors and symbols which influence how issues are perceived and which inform social action in the context of socially constructed realities.
Diffusion	Refers to the dissemination of concepts, social structures, and practices, mainly through social networks.
Translation	Refers to how diffused concepts and ideas are transformed for application in new social contexts.
Bricolage	Involves the recombination of concepts, practices, etc. from other social contexts to produce new forms of social activity.

Table 1 Institutional Mechanisms (adapted from Campbell, 2004, 2005 and Selznick, 1947)

We posit these mechanisms as being active in the eco-innovation in digital technology-enabled eco-municipalities. In the context of our study, we argue that such mechanisms help institute social and organisational change towards digital technology-enabled eco-municipalities. It is useful to note an important research question at this stage viz. “How do we characterise or conceptualise the observed outcomes?” Research by the Organisation for Economic Cooperation and Development (OECD, 2010) conceptualises the application of Green ICT for environmental sustainability in terms of its direct, enabling and systemic effects. The OECD (2010, p. 192) argues that the “resulting environmental impacts [of ICT] are...difficult to trace but need to be part...categorised in a framework of three analytical levels: direct impacts (first order), enabling impacts (second order) and systemic impacts (third order)”. Given the widespread practical use of this framework, in that it forms a common frame of reference for policy makers, we adopt it to categorise and discuss the progress made to eco-sustainability in the case studies. In brief, the outcomes of the application of social and institutional mechanisms for eco-sustainability are as follows:

- **Direct or First Order Effects:** This refers to positive and negative impacts due to the physical existence of ICT products (goods and services) and related processes.
- **Enabling or Second-order Effects:** Green ICT applications can reduce environmental impacts across economic and social activities.

- **Systemic or Third-order Effects:** These promote and underpin behavioural change in individuals, business enterprises, and society these changes are fostered by Green ICT applications.

Institutional Environment and Organisational Field of Municipalities

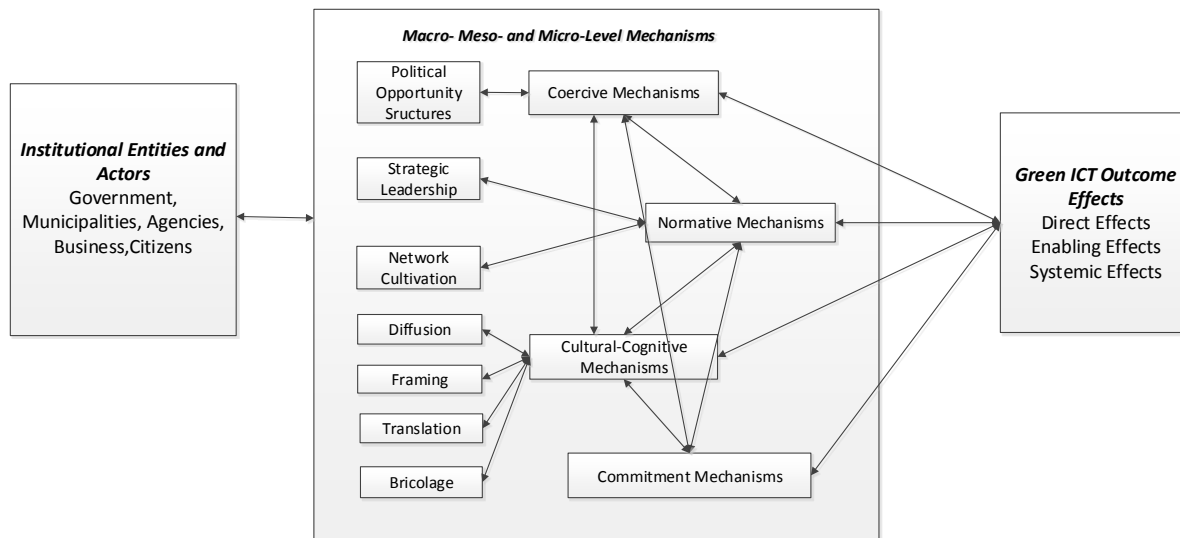


Figure 1 A Mechanism-based Theoretical Model

Our research objective is to identify and determine the role of social and institutional mechanisms in bringing about these effects. Figure 1 presents a theoretical models which posits that institutional entities and actors apply a variety of macro-, meso- and micro-level mechanisms to achieve the eco-sustainability objectives of Direct, Enabling and Systemic Effects. It is unclear from the literature how such mechanisms might be applied by specific actors act, whether in concert or in tandem, to produce the desired outcomes. That is the objective of this study. The next section describes the research design and method which helps realise this objective.

3 Research Design

This study forms part of a larger longitudinal, multiple case study design (Yin 2003) of the UK public sector’s application of Green ICT. Two period of interest characterise this research: The first from 2008 to 2011 and the second from 2011 to 2013. We first conducted a systemic review of extant research and practitioner literatures to help understand the state-of-practice in both public and private sectors (cf. Cooper, 1998). The entire relevant corpus of UK government policy documents and reports were included. Data gathering in the study was carried out by the researchers through attendance at 5 public sector-oriented and industry-based conferences, 4 in London and 1 in Brussels: The Green IT Expo 2009; Government ICT Goes Green Conference 2010; Efficient ICT: Greener Government 2011; Efficient ICT: Greener Government 2012; and the European Commission’s ICT for Energy Efficiency (ICT4EE) 2010 conference. These conferences were well-attended by a cross-section of UK public servants at all levels, particularly the Government ICT Goes Green and Efficient ICT conferences, which were government sponsored. 52 conference presentations and seminars were attended and key presentations and follow-up Q&A sessions were digitally recorded (approx. 30 hours). 7 informal interviews were conducted with purposively selected key informants, with 5 formal follow-up telephone interviews. At the end of the first phase (2008-2011), three UK public sector organizations were subsequently chosen for more in-depth study—The Borough of Hillingdon,

Manchester City Council and Bristol City Council. The latter cities are deemed exemplars in the UK and Europe due to their use of Green policies and the use of ICT to make the transition to Smart Cities. Key informants were formally interviewed and informal discussions took place with their team members. Extensive field memos were also taken and/or digitally recorded (Yin 2003). Data analysis involved the use of constant comparative analysis and coding procedures using the mechanism-based conceptual model as an interpretive lens for the identification and coding of the different categories of mechanisms and iterative interpretation of findings. The following case studies report our findings.

4 Institutional Environments, Eco-municipalities and Green ICT in London, Manchester and Bristol

Local government organisations play a vital role in developed economies: indeed, the aphorism that “all politics is local” reflects the fact that central government policies are often driven by local issues (Blom-Hansen, 1999). This section illustrates how local government policy in the UK often led, and in many cases transcended, central government strategy. Certainly, the UK government’s adoption of Agenda 21 acted as a *political opportunity structure mechanism* in shaping the institutionalisation of the Local Agenda 21. The Local Government Act 2000 places a duty on local authorities to *‘improve or promote the economic, social and environmental wellbeing of their areas and contribute to the achievement of sustainable development’*. Thus, 2000 also saw over 200 local authorities/municipalities (e.g. Metropolitan and London Boroughs, UK City and County Councils) to institute and sign the Nottingham Declaration, a *political opportunity structure mechanism*, whose objective is to have local authorities develop plans and implement actions to address climate change and reduce GHG emissions in their area of governance in partnership with local organisations and communities. Also acting as *framing mechanism*, the agreement created structures for the application of other mechanisms, such as *network cultivation* (by and among public administrators and private actors), diffusion (of concepts and solutions), *translation* (of solutions from nodes in the network, particularly from public-to-public, private-to-public, and public-to-private) and *bricolage* (where actors could innovate around, for example, digital technologies toward eco-sustainability).

The European Union’s emphasis on fostering the development and use of Green ICT led to the institution in UK law of the Waste Electrical and Electronic Equipment Directive (WEEE) and the Restriction of Hazardous Substances Directive (RoHS), and the Energy Using Products (EuP) Directive. These new environmental laws, with their concomitant *monitoring* and *enforcement mechanisms*, impacted on local government approaches to the development of eco-municipalities in surprising ways. Take, for example, as *political opportunity structures* they provided mechanisms for local politicians to advance the ‘Green’ agenda at local level. So too did the UK’s Climate Change Act and the Energy Act by Parliament in 2008. However, of direct impact was the institution of the Sustainability on the Government Estate (SOGE) strategy in 2006 and the Greening Government ICT Strategy in 2008. While the former had tangential impact on the municipal structures and processes of local authorities, the latter government strategies had a direct impact in their role as *political opportunity structure, monitoring* and *enforcement mechanisms*.

A report by The Society of Information Technology Management (SocITM) in 2007 on the role of Green ICT in local government organisations and presaged central government strategy. This report acted as *political opportunity structure, commitment, framing* and *diffusion mechanisms* in that it illustrated the actions that government organisations should be adopting to reduce carbon emissions. Specifically it described primarily direct effects, but only a subset of *enabling* and *systemic effects*. There is evidence to suggest that this document influenced the formation of government strategy in 2008, particularly in the UK Government’s CIO Action Plans—this is an example of *cultural-cognitive/mimetic mechanisms* of *translation* and *bricolage* at work. However, as we discovered when we went to research the use of Green ICT in local authorities, several city councils were involved in

wider community-based ICT-enabled initiatives that have the promise to deliver greater GHG emissions savings. A change of government in May 2010, from the left-of-centre Labour Party government of Tony Blair and Gordon Brown, to a right-of-centre Conservative Party/Liberal Party coalition Government led by David Cameron, led to the institution of a new Government ICT Strategy in 2010, which signalled a change in scope in that local authorities and other non-central government institutions were excluded from its scope as a *political opportunity structure mechanism*.

Three exemplars were chosen for inclusion in the study as they contribute different but complementary 'grassroots' perspectives (Selznick, 1947) on the influence of social and institutional mechanisms and Green ICT-based effects. The first organisation, the London Borough of Hillingdon Council, is an acknowledged exemplar on the use of Green ICT to leverage *direct effects* mainly, but also some *enabling* and *systematic effects*. The other two organisations, Manchester and Bristol City Councils are members of the UK's Core Cities Group which includes Birmingham, Bristol, Leeds, Liverpool, Manchester, Newcastle, Nottingham and Sheffield. They are also participants in the EU Intelligent Cities initiative and signatories to the *Eurocities Green Digital Charter* along with Birmingham, Genoa, Ghent, The Hague, Lisbon, Murcia, Nantes, Reykjavik, Tallinn, Stockholm, Vienna and Zaragoza. This charter commits (*normative mechanism*) them to (a) Deploy five large-scale Green ICT pilot projects before 2015; (b) Decrease ICT's direct carbon footprint by 30% before 2020; and (c) Create a partnership of cities on ICT and Energy Efficiency to work until 2011.

4.1 The Emergence of Green ICT at Hillingdon Borough of London

Perhaps the most capable and mature of the UK's local government organisations in the application and use of Green ICT within the municipal estate is the London Borough of Hillingdon Council. The second largest of London's boroughs, Hillingdon employs over 3,000 public administrators and has a sizable IT function. Hillingdon's performance in realizing the many of the benefits of *direct, enabling* and *systemic Green ICT effects* is due to the *strategic leadership mechanism* in that it's CIO, Steve Palmer. Palmer became SocITM President in 2010 and his involvement in SocITM was an example of *network cultivation* and *diffusion mechanism* that saw Hillingdon *translate* Green ICT concepts and practices into the organisation. However, Roger Bearpark, Assistant Head of ICT at Hillingdon, also stated the pragmatic issue of an inability to add new servers to its data centre due to a lack of space, was a business driver. In 2006 it was one of the first government organisations to virtualise its servers using VMware, and exercised a *strategic leadership* role, in terms of this study's theoretical perspective. The savings in energy costs from the application of the above mechanisms were noticeable; accordingly Roger Bearpark stated that from 2006 "we measured IT [power consumption] and we managed it. And we convinced the authority not to do [Green ICT] piecemeal...So, we looked at the desktop environment...took out CRTs, and replaced them with TFTs...We took a [carbon] lifecycle approach to desktop purchasing...then we tackled printing...we have power-managed multifunction printing devices and we moved to double sided printing... We looked at telephony, albeit we had IP telephony, but that drew power: How much power? We measured it. So we asked ourselves why are we powering it over weekend? Why after 6 or 7 in the evening when people go home? Working with Cisco we can be smart about what we are turning on and when." Hillingdon employed Cisco's EnergyWise to manage the power consumption of all network IT, while Cisco's Orchestrator was used to power manage PCs and laptops.

Hillingdon's data centre was also the subject of a Green overhaul: "Compellent provides our Storage Area Network...now we only spin any disk that we need to use...and we don't have trays and trays of disks we need to use in 6 months... plus, we now run our temperature in there at 27° Celsius, whereas before we were into the high teens...This combined with the virtualized server environment in our data centre saved us 97% of our power consumption every year." (Roger Bearpark). Green ICT-enabled 'new ways of working' meant that SOGE targets could be met by divesting property. Likewise, it radically altered Hillingdon's purchasing strategies in several ways: e.g. planning ahead

so that ICT assets could be shipped using low-carbon logistics. Bearpark concluded that “ICT is a catalyst for greater change...its is about enabling people to work from home, work on the road, it is about enabling the authority to look at the need for the property it currently has.” He also provides insights into the behavioural changes in the IT function: “Our IT support staff think Green and they act Green.” The outcome of these measures is a 14% reduction in power consumption and a saving of 162,900 Km in staff travel.

It is clear from the above, that Hillingdon Borough Council is exemplary in its application of Green ICT and the achievement of *direct* and certain *enabling effects*. The UK government is using Hillingdon as an exemplary case and is using its *strategic leadership position* to diffuse best practice and have other councils and agencies apply *translation* and *bricolage mechanism* to emulate its application of Green ICT. A Green Flag award for its open spaces aside, this digital eco-sustainability work does not seem to have been *diffused* outside the IT function into the social fabric of the community, or other stakeholders in the Borough, which reaches into Heathrow Airport.

4.2 Manchester City Council's Smart City Initiative

The Climate Change Action Plan for Manchester City Council (MCC) was instituted during Easter 2010: this policy commits Manchester to a 41% decrease in GHG emissions by 2020 (cf. Manchester City Council 2009). This *political opportunity structure mechanism* is much more ambitious than the others mentioned above. MCC's *commitments* to achieving the *enabling* and *systemic effects* of Green ICT was born out of a web of factors that centered on its plans to develop the city's economy through the ICT initiatives. Since 2002, Dave Carter, Head of Manchester Digital Development Authority (MDDA), provided the *strategic leadership* that saw widespread *commitments* to these initiatives. In 2004, political change in MCC saw Carter find political support from a like-minded member of the council. Together, they instituted the MDDA and implemented several community and industry-based initiatives using digital innovations to advance their policy agenda on social inclusion and eco-sustainability—i.e. *political opportunity structure mechanisms*. Pivotal to the success of this was access to funding from EU programmes (e.g. Interreg and FP 6). The most influential of these EU initiatives was the Intelligent Cities project, which saw MCC engage in *network cultivation* with 20 EU cities and 20 universities to conduct research on how ICT could make cities more energy efficient—this later evolved into the Smart Cities movement. Thus, *translation* and *bricolage mechanisms* played an important role for the MDDA, in importing new knowledge from other municipalities across the EU.

MDDA also built on the institutional network that MCC had already in place with private sector industry locally and nationally with the UK's Core Cities Group. As indicated, the external network of relationships with EU cities was to prove a fertile source for MDDA to apply *translation* and *bricolage mechanisms*, in concert with the University of Manchester Business School and the Built Environment Centre at the University of Salford to institute Living Laboratories, following on from a model developed in Helsinki. Dave Carter indicated how the above *mimetic mechanisms* were triggered: “Look what is happening in Helsinki, with buildings management and environmental management, and new ways of sensing and actuating and automatically building the kind of holistic buildings management systems that in methodological terms was not a million miles away from holistic e-governments systems. It just happened to be about energy efficiency and issues like that. At the time it really catapulted us into thinking “we ought to have some kind of Green IT strategy and we ought to start thinking of practical ways we do this... *we nicked ideas from everywhere else and just put them all together.*” (Emphasis added to indicate the use of *mimetic mechanisms*.)

One the first significant projects was targeted at domestic households in the community: The European Union-funded Digital Environmental Home Energy Management System (DEHEMS) investigated how ICT and Smart Meters could improve domestic energy efficiency. The project partnership included a mix of European local authorities (three in the UK, including Bristol City and two in

Bulgaria), private business and universities. The intention was to develop and test DEHEMS for the home market using a Living Laboratory of 50 homes in each participating city, including Manchester. This project researched and developed the technology and applied it with moderate success, as the MDDA DEHEMS project manager opined: “I think there is a fair bit of evidence from the early kit that once people have got information that yes, they would change their usage patterns ... Really it is just about getting a picture of how your home operates.” Rebadged *energyhive* the latter is one of the first Green ICTs that leverages the *enabling* and *systemic effects* in the European Platform for Intelligent Cities (EPIC) initiative: “The EPIC platform will combine the industrial strengths of IBM’s ‘Smart City’ vision and cloud computing infrastructure with the knowledge and expertise of leading European Living Labs.” Another related project is the EU *Energy Save* initiative which targets non-residential buildings using the Living Lab approach. MDDA has piloted and implemented energy save technologies in the Old Town Hall and the Art Gallery in Manchester. The Town Hall energy saving pilot found fruit in 2014, when the council could monitor the energy consumption characteristics of the Town Hall where heat and electrical energy is provided by the new the combined heat and power system. Granular metering and a Green IS was installed to maximise the impact of the metering by monitoring the energy-related behaviours of staff. The overarching *political opportunity structure* for the eco-efficiency energy-saving agenda is the EU-wide Green Digital Charter, which has, since 2008, been employed as a “framework for cities to use ICT as a main driver to improve energy efficiency”. Thus, *political opportunity structure mechanisms* gave birth to Manchester Digital Strategy, which encompasses Green ICT for energy efficiency and digital innovations for social and economic inclusion.

In 2008, the expansion of Manchester Science Park to facilitate the growth of Green data centres ran into problems due to energy supply and capacity problems: “So that really got us to the question of why is it that this exponential growth in IT (and the nature of the way IT is structured in buildings and the way buildings are thought about)...nevertheless it was the first time that you could go to the powers that be and say “future expansion of Manchester Science Park at risk”...what is it at risk from? The fact that you need to mitigate the *direct effects of IT* in terms of energy use being unsustainable” (Dave Carter, MDDA). This “wake-up call” and MCC’s *commitment* to becoming a Smart City led to institution of the New Economy initiative, which looks to public-private partnership models to bring about ICT-related change to Greater Manchester. The MDDA is participating in a pilot project as part of this initiative that is applying Smart Grid ICT to retrofit what is known as ‘The Corridor’: MDDA’s project lead on the New Economy initiative indicated “One of the big smart grid pilots is here on the Oxford St Corridor and that has got a lot of the big energy users and big estate holders – National Health Service, BBC, two universities, so there is some big organisations that we are working with. In fact we are calling that a Living Lab as well.” This is seen as one of the first significant steps to lower GHG emissions across the city of Manchester toward the 2020 targets. Another New Economy project co-funded by Carbon Innovation, the Northwest Regional Development Agency (NRWA) and participating businesses looks to apply the DEHEMS ICT to small-to-medium sized businesses in Manchester City. Each of these projects is characterized by the use of normative mechanisms (social obligation to be good citizens or corporate citizens) underpinned by network cultivation, and the use of translation and bricolage mechanisms at an EU and local level to translate policy into action.

The Head of Policy at the Society of Information Technology Management (SocITM) explained to the delegates of the Efficient ICT conference in 2011 that local government transactions accounted for over 3 billion of the approximately 4 billion on-line transactions hosted by public sector organisations annually. This has stimulated local government organisations such as MCC to focus on e-government solutions for the specific purpose of carbon emissions reductions in travel to council offices. However, MCC is also promoting e-commerce to local business through its ‘Selling on the Web’ initiative, in the hope of making retail shopping more energy efficient.

MCC is applying *network cultivation* and *diffusion* mechanisms through the Environmental Business Pledge, which is a free service and award scheme, whose aim it is to help over 1,600 local member organisations in Greater Manchester to improve their environmental performance and generate cost savings. Members can access, free of charge, information on environmental resource efficiency reviews and efficient business process design with the goal of reducing carbon emissions and cutting utility costs. There is an explicit focus on Green ICT (*enabling and systemic effects*) for energy savings. Another MCC initiative is the use of Green IS as *diffusion mechanisms* for environmental sustainability practices through the Carbon Literacy Project. This digital innovation provides an online library of resources and a matching service which acts as a *network cultivation mechanism*. Finally, MCC employs the Smart City Consortium-based GreenITNet as a *diffusion mechanism* for its digital innovations locally, nationally and across the EU through. This Green IS disseminates knowledge, best practice, and policies on Green ICT's role in achieving energy efficiency.

4.3 Bristol City Council: The Green Digital City Strategy

Bristol City Council's (BCC) has instituted several *political opportunity structure mechanisms* on the use Green ICT in both the local authority and across the city, which are considered exemplars by the CIOs in the Core Cities Group, of which Bristol is a member. It is also a signatory of the Eurocities Green Digital Charter, in which it participates in the EU Smart City initiative. As with MCC, Bristol hosts a Digital Environmental Home Energy Management System (DEHEMS) Living Laboratory on the use of Smart Meters, and other projects, and is a member of European network of Living Labs. Bristol's Smart City Programme *political opportunity structures mechanism* employs *strategic leadership*, *network cultivation* and *diffusion mechanisms* in tandem to achieve its objectives. It is led by the Bristol Futures Team at BCC, with members from the city's universities, businesses and community partners. Its objective is to innovate in the development of smart digital technologies (through fundamental research and *translation* and *bricolage mechanisms*) to reduce carbon emissions and achieve other socio-economic objectives, as well as social inclusion.

Bristol City Council has created several structures (*network cultivation* and *diffusion mechanisms*) at a local level whose aim it is to help implement its Green Digital City Strategy. The overarching institutional structure and *political opportunity structures mechanism* in Bristol's organisational population is the Connecting Bristol initiative which supports and helps develop Green ICT projects in Bristol City that are aimed at making both an economic contribution to, and GHG emissions reduction in, both communities and businesses. This initiative provides BCC with a structure to apply other mechanisms—*network cultivation*, *framing* and *diffusion*—that help shape the beliefs and desires (i.e. commitments) of social actors regarding eco-sustainability. The Green Addict and Carbon Makeover projects are specific mechanisms instituted to achieve its goals—these are not *coercive political opportunity structure mechanisms* as such. They can be categorised as a chain of mechanisms consisting of *framing* and *diffusion mechanisms* that lead to *network cultivation* and on to social action by applying knowledge and capabilities through *translation* and *bricolage*, all underpinned by *commitment* to eco-sustainability.

The Green Addict (<http://www.greenaddict.eu/>) is significant in that it Bristol City's carbon footprint *dissemination mechanism*. Connecting Bristol Programme Director described this initiative: "We came up with a foot-printing methodology for measuring CO2 in Bristol and it is partly about doing the research, but it was partly about the process of bringing those partners together...we did a lot of workshops and it was the first time that the Energy Manager met the IT Manager at the University of Bristol... getting people together, commercial organisations and the universities is important. It evolved into a series of case studies and a database of practical action that different organisations have been taking to reduce electricity bills or carbon emissions." Funded by the Carbon Trust in 2008, Bristol became one of the first of the Smart Cities to measure comprehensively its GHG emissions. The Connecting Bristol Programme Director argued that in order to determine where the greatest

improvements could be made across the city, the Council needed to know how much GHG emissions were being generated and where. The findings were surprising in that ICT accounted for 3% of the city's emissions: of this, 38% of ICT-related emissions came from the public sector. However, it was discovered that 20% of the council's own emissions came from ICT. This prompted a change in direction of Bristol City Council, which was then in the process of executing its Business Transformation Strategy. It is intended that *strategic leadership* here will help generate *mimetic responses* in the wider community in this municipality.

Connecting Bristol's carbon accounting exercise highlighted the need to help communities and business across the municipality to reduce GHG emissions (this involves the application of *network cultivation, diffusion, translation* and *bricolage mechanisms*). However, it would have to lead by example (i.e. *strategic leadership*). The Business Transformation Strategy was underpinned by the new Green ICT Strategy, which sought to consolidate and rationalize hardware and software architectures, while supporting transformed business processes and New Ways of Working (NWOW). These were innovative political structure opportunity mechanisms. A new CEO coupled with executive leadership from the council, who had a major interest in both Green ICT and Open Source Software, saw 50% change in the top two tiers of management. The new CIO, was also of a similar mind-set, having come from the Environment Agency. Together with Connecting Bristol Programme Director, the CIO and the councillor provided BCC with the *strategic leadership* to ensure that the internal Green ICT-enabled transformation of the council's business operations was married with the external transformation of the municipality.

The Connecting Bristol role in measuring and reducing GHG emissions across the community is underpinned by the use of *network cultivation, framing* and *diffusion mechanisms*. Take, for example, the GHG accounting exercise helped build relationships with business organisations in the Bristol municipal area. Connecting Bristol publishes on its award winning Green Addict Solutions Database that explains how businesses large and small can realize the direct, enabling and systematic effects of Green ICT. As the Connecting Bristol Programme Director notes: "There is quite a lot of sharing you can do as organisations have similar ICT infrastructures and issues, although the scale of it can be different". However, the same website frames the issues through related information and by publishing case studies from Green ICT Champions: the case studies provide the opportunity for mimetic mechanisms—translation and bricolage to be exercised by adopting organisations. At a local level, the success of the DEHEMS Living Laboratory gave rise to the EU funded 3e Houses Project which leveraged Green ICT technologies in social housing in order to make them more energy efficient. Bristol City is piloting 3e in 100 council houses, following initial pilots in Germany and Spain. However, BCC also supports several locally funded community-based initiatives aimed at enabling and systemic effects, principally using web technology to disseminate Green information to tenants in disadvantaged areas. The Local Agenda 21 plays a key role here.

The Green ICT Lead Officer for BCC liaises with Connecting Bristol to *diffuse* Green ICT practice to business organisations. His main role is to lead the Green ICT element of the Transformation Strategy. Focusing mainly on the *direct effects*, his team concentrates on delivering energy efficiencies in ten key areas, from energy measurement, to printing, workstation power management, telecommunications, server virtualization, data centres, sustainable procurement, ICT reuse and recycling, and so on. In relation to the latter, BCC engages with a local recycling company that has refurbished over 2,500 PCs and installed Open Source operating systems, Open Office, Mozilla and so on. These are subsequently distributed by Connecting Bristol to disadvantaged tenants in social housing estates in order to have them go online, bridge the digital divide, and shift their channel of engagement with BCC from walk-in centres to online service delivery options.

Thus, BCC's CIO stated "We have some quite clear strategies to take our emissions down by 20% over the next 18 months...it ranges from a new data centre we put in, which does some innovative things like using the water from the moat. Server virtualization, printer consolidation, PC power

management...there are some interesting challenges around using Open Office and Star Office products and PC power management, they don't work very well compared to the Microsoft products...we are having some challenges around that, but nothing we can't handle. We've also got a strong push to drive Open Source, Open Standards quite hard, we are looking to bring the Green and the Open together...both within BCC and across the city." All of this was, subsequently, achieved in the transformation and rationalization of BCC's business process using ERP, Shared Scheduling Software, New Ways of Working, Shared Transaction Services, Employee Self Service, and Customer Channel Shift Strategy. While shared software brings obvious direct effects in the consolidation of servers, the new Shared Scheduling software reduced the carbon footprint of mobile staff by, for example, helping to optimize site visits for service and repair calls to social housing, to businesses, and to enable route management. According to the Green ICT Lead BCC "24% of the workforce move[d] to home-working...[he calculate] that this save[d] approximately 11 kg of CO₂ per person per day". Another objective here was to reduce the number of council buildings in the estate, while transitioning staff to 'hot desks.' The Green ICT Lead pointed to the fact that "I work from home 2 days per week...in fact we have hot desks in our Romney office for teleworkers." This approach was not without problems as the CIO indicates: "We have a number of Housing Benefits Agents using a virtualised desktop and IP telephony from home, so we have several full-time agents from our call centres now home-based." It is also significant that, all BCC buildings are fitted with Building Management Systems (Green IS) that record electrical energy readings every 30 minutes and also help building managers manage gas and water resources.

The forgoing offers evidence of the scope of BCC's activities and mechanisms employed to make Bristol City an eco-municipality and Smart City. As of March 2015, the Connecting Bristol website continues to frame BCC's strategic leadership role, and its application of *network cultivation, framing, and diffusion mechanisms*. It also provides evidence of the application of *translation and bricolage mechanisms* to institutionalise digital innovations from private industry, signatories of the Green Digital Charter, and stakeholders in BCC's municipality to help make their organisations more energy efficient and environmentally sustainable. Its achievements in with respect to the Smart City Programme was recently recognised by the EU Green Digital Charter Award, which acknowledges the efforts of the 43 cities in delivering on the EU's climate change objectives using digital technologies.

5 Discussion and Outline Findings

A locally governed municipality is the fundamental point of contact with the citizenry. In OECD countries, environmental regulations are typically implemented through and by municipalities on behalf of central government. Consequently, this level of analysis, as opposed to national or international perspectives, is critical for instituting realistic behavioural change around climate issues within local communities. Interestingly, two of the three municipalities studied have achieved a large measure of success here. Certainly, Hillingdon is acting in accordance with government policy (i.e. on Greening Government ICT), and is implementing the Local Agenda 21. However, Manchester and Bristol are subject to the influence of *normative mechanisms* at national (e.g. Core Cities, Nottingham Declaration, and SocITM) and EU level (e.g. Intelligent Cities/Smart Cities/ Eurocities Green Digital Charter/Living Labs).

We note that the UK government employs a mixture of *political opportunity structure mechanisms* (Greening Government ICT Strategy), *normative mechanisms* (CIO/CTO councils and other associations/committees/fora (e.g. SocITM) as *network cultivation mechanisms* and to exercise *strategic leadership*) and *cultural-cognitive/framing mechanisms* (e.g. through various government publications, conferences, etc) to institute policy change at a local level. This was the case with the first Greening Government ICT Strategy (2008-2010), but not the second (2010-2014). The reasons for this related to the complexity of bringing the entire UK public sector in line with government objectives—the focus is now on central government departments and agencies. However, other

government *political opportunity structures* remain in place, which include the Sustainability of the Government State. Nonetheless, we note that the *coercive mechanism* that is the UK CRC Energy Efficiency Scheme had little impact on policy making at municipality level, in either Hillingdon, Manchester or Bristol. Yet while this *coercive mechanism* applies to all at the municipal level, it was not found to be explicitly related to the outcomes achieved, or in the process of being achieved, in the application of Green ICT. This may be explained, in part, by the relative progress being made by these municipalities in key eco-sustainability areas, through grassroots initiatives that institutionalise commitments to eco-sustainability (cf. Selznick, 1947). Each of the organisations studied are exercising *strategic leadership* in key areas of Green ICT where local events or wider social policy provided the impetus for action. At an individual level, we discovered actors in key positions with strong commitments to Green ICT who availed of, or created, the opportunities to act strategically to achieve the objectives of the *direct, enabling and systemic effects* of Green ICT in their organisations and in their local communities.

We found that Hillingdon, Manchester and Bristol imported concepts from industry through *translation and bricolage* with the help of ICT companies and equipment providers (*diffusion and network cultivations mechanisms*). Take, for example, the dialogue between SocITM and Hillingdon, with the latter applying *translation and bricolage mechanisms* in the application of Green ICT. In contrast, Manchester and Bristol applied the same mechanisms using a wider network across the EU, including local universities and international ICT organisations. Manchester and Bristol imported leaders in eco-sustainability and Green concepts. However, they also employed *network cultivation and diffusion mechanisms* to promote Green ICT concepts to small, medium and large business enterprises in Greater Manchester and across Bristol City, while doing the same for eco-sustainability practices to wider social and community groupings. Thus, our study found ample direct and indirect evidence that the institutionalisation of digital technologies for eco-sustainability in the municipalities of the London Borough of Hillingdon, Manchester City and Bristol City had achieved a significant measure of success in the *enabling, direct and systemic effects* of Green ICT.

6 CONCLUSION

Our research transcends the limitations of many previous IS studies by identifying with greater specificity and granularity the social and institutional mechanisms that led to the eco-sustainability outcomes in the municipalities studied. We have, therefore, made a theoretical contribution in applying our mechanism-based explanations of cause and effect. At a practical level, we have described and explained how municipalities can transition to eco-sustainability using digital technologies and help address the challenges of climate change. The current structure of institutional environments, at least in the EU, ensure that the necessary and sufficient macro- and meso-level situational mechanisms—coercive, normative and cultural-cognitive—are present to engender commitments in organisational actors to eco-sustainability. This, however, does not occur naturally—the institutional challenge is to trigger the process of institutional change that shapes the commitments of all social actors—local politicians, public administrators, business managers and citizens alike—to action on eco-sustainability. This, as Adger et al. (2009) indicate, is the core problem across all political institutions, societies and cultures. The digital technologies exist to achieve the direct, enabling and systemic effects of Green ICT, the problem is commitments to action. The exemplars we describe herein and their achievements in leveraging the enabling, direct and systemic effects of Green ICT provide rich examples for other municipalities. Thus, we have important insights into the mechanisms required to apply digital technologies (i.e. Green ICT) to achieve eco-sustainability objectives across EU municipalities and beyond.

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