The Role of Informational Mechanisms in the Adoption of Green IS to Achieve Eco-sustainability in UK Municipalities

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This paper identifies, categorizes, and elaborates the *informational mechanisms* that governments and municipalities employ to become eco-sustainable. Specifically, it illustrates how municipalities are successfully reducing greenhouse gas (GHG) emissions using Green Information Systems (IS). The research involved a systemic literature review of both academic and practitioner publications in addition to two substantial case studies within UK municipalities (Manchester and Bristol). The findings are significant in that they demonstrate how Green IS can be *comprehended, adopted, implemented,* and *assimilated* in municipalities and organizational fields. The findings are also noteworthy in that they advance the use of mechanism-based Institutional Theory in IS research. Thus, our research inform society on how we can address its greatest challenge—the climate emergency.

Keywords: Green IS; Eco-sustainability; Informational mechanisms; Institutional Mechanisms; Institutional Theory.

Introduction

Green information systems (IS) are specific configurations of people, processes, and technologies (including software). *Inter alia*, Green IS shape and support individual, organizational, and societal commitments towards the reduction of greenhouse gas emissions (GHG) [1, 2, 3, 4].

There exists a growing body of research on Green IS [5, 6], with over 200 articles in major journal and conference proceedings [6]. Green IS are being studied using a diverse theoretical lens, at both the organizational and individual levels; however, institutional theory is one of the most used by Green IS researchers [6]. The prevalence of institutional theory is explained by the fact that it operates at multiple levels of analysis, from the institutional environment to organizational fields, to organizations, and on to groups and individuals [7, cf. 8]. Mignerat and Rivard [7] focus on how institutional theory can help explain the *comprehension, adoption, implementation,* and *assimilation* of IS. They also point out there is a scarcity of IS research focusing at the level of the organizational field—this is also true of research on Green IS, as will be seen in the next section. Swanson and Ramiller [9] indicate that the concepts of *comprehension, adoption, implementation,* and *assimilation* provide a much richer conceptualization of IS innovation than mere implementation or adoption. It is for these reasons, following Butler [2], this paper observes that if the eco-sustainability benefits of Green IS are to realized, then they need to be (a) *comprehended, adopted,* and *implemented* by an organization and then (b) *assimilated* by end-users and related actors across an organizational field. It is within this context that we address the dearth of Green IS research employing institutional theory at the levels of the institutional environment and organizational field [cf. 7].

On the Urgent Need for Green IS Research on Organizational Fields

The need for immediate action to address climate change by individuals, organizations, and society is clear from the IPCC's review in 2018 of 6000 scientific papers and its conclusions on the very real and immediate consequences for humanity [10]. Nevertheless, society has failed to respond to repeated warnings [11], despite the fact that "[t]he delayed response to climate change over the past 25 years has jeopardized

human life and livelihoods" [12]. In 2019, however, national and local governments declared that the world faced a climate emergency. [1]

Green IS researchers have noted the difficulties with changing individual, organizational, and societal commitments to environmental sustainability and climate change [13, 14, 15, 16, 17]. As with society-at-large, researchers also argue that the IS discipline itself does not recognize the magnitude of the problem of climate change nor has it embraced sustainability as an integral part of the IS research agenda [1]. Consequently, Green IS researchers cited above argue that there is a need to identify how commitment to climate change policies can be supported through Green IS. Furthermore, this needs to happen at all levels—individual, organizational and societal—so that sustainability goals and objectives can be met and a global catastrophe avoided [cf. 1, 2, 3, 4, 14, 15].

There is a dearth of cumulative, impactful multi-level IS research on the societal transition to a world with low GHG emissions. One promising area of interest to IS scholars is on the application of Green IS solutions to foster environmental sustainability in smart cities [18, 19]. However, smart cities are not always eco-sustainable cities [20]. This is problematic, as cities and urban areas generate over 75-80% of the world's GHG emissions and waste [21]. Thus, further research on Green IS in cities and urban areas—i.e. municipalities—is indicated. Given the critical importance of achieving eco-sustainability in municipalities and their organizational fields, this study, therefore, addresses yet another significant gap is the IS literature.

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[1] https://www.europarl.europa.eu/news/en/press-room/20191121IPR67110/the-european-parliament-declares-climate-emergency

On Informational Mechanisms and Institutional Change towards Eco-Sustainability

Researchers across the social and life sciences advocate the application of mechanisms in institutional and political contexts [22], particularly policy mechanisms [23, 24] in urban contexts [25], to trigger and/or accelerate a societal response to the climate emergency. In *Prosperity without Growth*, Professor Tim Jackson [21 p. 194], former Chair of the UK Sustainable Development Commission, states that "society has evolved a whole set of ***'commitment devices'***: social and institutional mechanisms which moderate the balance of choice away from the present and in favour of the future." What Jackson, the Sustainable Development Commission he chaired, and researchers across disciplines are arguing for are social and institutional *informational mechanisms* to be identified and applied in order to overcome the aforementioned problems and initiate and maintain a societal change to sustainability.

Our study focuses on this agenda, as the political, social, institutional *informational mechanisms* required to bring about change towards sustainability are not well understood [26, 27]. However, this paper argues that if *informational mechanisms* are applied to institute adaptive change towards eco-sustainability in municipalities, specifically by employing Green IS, then this increases the probability that the worst consequences of climate change may be avoided, through reductions in carbon emissions.

Prior to the advent of digital technology, *informational mechanisms* were analogue in form and function: however, the introduction of IS meant some analogue mechanisms could be manifested digitally or indeed the emergence of new digital mechanisms based on the affordances of Green IS [2, 16, 28]. We, therefore, argue that a combination of analogue and digital *informational mechanisms* acts as *'commitment devices'* [21] to

Green IS *comprehension, adoption, implementation,* and *assimilation* at the level of the organizational field of the municipality.

While the need for a strong response to climate change is clear, the ability of humanity to mitigate its detrimental effects is placed in increasing doubt. Therefore, society needs to make clear the accountabilities and responsibilities of all actors, particularly the response of businesses and consumers. Thus, if municipalities are to institute change, particularly where eco-sustainability is concerned, then the actors, the resources (informational) they employ, and the actions they take to achieve eco-sustainability initiatives require understanding [29, 30]. The motivation for this study is, therefore, to identify information-based social, institutional, and organizational mechanisms related to institutional and organizational change that can help enable municipal transformations to eco-sustainability. Thus, the paper's research question is: ***How do municipalities institutionalize environmental sustainability practices through Green IS?***

Empirical Focus and Contributions

The study employs two case studies of large municipalities in the context of the UK public sector to identify the *informational mechanisms* responsible for adaptive institutional change towards eco-sustainability. In the first case (Manchester City Council), local politicians and public administrations deploy Green IS in a broader municipal context with significant impact. The second case (Bristol City Council) illustrates how eco-sustainable municipal policies can have dramatic effects at the local level with lessons for the institutionalization of Green IS for eco-sustainability that are global in their impact. However, as both municipalities operate in a wider institutional environment, under the influences of UK government mechanisms, these are also enumerated and explained.

The contributions of our study are both theoretical and practical. The mechanism-based explanations presented herein operate at the level of the institutional environment, field and organization and illustrate how municipalities influence the social, institutional and organizational processes through which eco-sustainability outcomes are achieved using Green IS. The mindful application of such *informational mechanisms* by municipalities will, we argue, increase the probability of the attainment of eco-sustainability outcomes, such as the GHG emissions reductions, required to address the climate emergency.

The next section presents a short overview of relevant Green IS research. Following this, we present our theoretical 'lens' and then our research approach and method. The two cases are presented and their transition to eco-sustainable municipalities explained in the context of the institutional environment in which they are embedded. The final sections discuss the findings and offer insightful and compelling conclusions.

Green IS, Mechanisms, and Transitions to Eco-sustainability

As indicated above, there is an increasing interest in Green IS research [5, 6]; however, it is debatable if a cumulative body of research exists and its influence on practice demonstrated [1, 31]. Take, for example, that approximately 15% of studies focus on Green IS adoption [6]: however, the issues and problems related to the organizational *comprehension*, *adoption*, *implementation*, and *assimilation* of Green IS in the context of the adopting entity's 'organizing vision'[2] [32] have not been adequately addressed. Focusing, on the adoption phase of Green IS, Loeser et al. [8] argue that the adoption of Green IS can: (a) Reduce business costs, (b) Enhance corporate image, and (c) Enable eco-sustainable competencies. Loeser et al. and several other studies seek to identify the

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[2] An organizing vision is a focal community idea for the application of information technology in organizations [32, p. 360]

mechanism(s) responsible for producing these benefits. It is to this body of research that we now briefly explore.

Several IS researchers investigate the mechanisms that link organizational beliefs about environmental sustainability, the adoption of Green IS and the resultant benefits [33]. However, "[t]here is a lack of empirical studies analyzing the antecedents and outcomes of Green IS initiatives" [34, 14]. Take, for example, the study by Henkel et al. [16], whose focus is on identification of what could be classified as Green informational mechanisms to induce pro-environmental behaviour (PEB) in individuals: they argue that "To date, only a few studies have presented impactful Green IS designs on the third-order effect to mitigate climate change." Third-order effects are systemic in that they promote and underpin behavioural change in individuals, business enterprises, and society.

Previous research on the latter issues theorized that institutional mechanisms (*coercive, normative*, and *mimetic/cultural-cognitive*) influence the *comprehension, adoption, implementation,* and *assimilation* of Green IS for the purpose of helping to lower GHG emissions [2, 15, 35]. Related research also demonstrates that a combination of institutional *coercive, normative* and *cultural-cognitive* (*mimetic*) and related mechanisms that arise from functional affordances, whose presence produce and maintain environmentally sustainable behaviours, support sense-making, decision making, and knowledge creation in order to achieve environmental sustainability objectives [2, 16, 36, 37].

There are, however, issues with the extant conceptualization of mechanisms and their application and use in the IS field [2, 38]. Take, for example, a recent paper by Loeser et al. [8] states that its research finding *"clarifies the mechanisms that link organizational beliefs about environmental sustainability to Green IT and Green IS*

actions undertaken, and the organizational benefits that accrue from these actions."
Other studies include: (a) A recent paper by Henkel et al. [16] that identifies two specific *cultural-cognitive mechanisms* influencing Green IS outcomes—Priming and the Status Quo Bias; (b) Research identifying *mimetic/cultural-cognitive* pressures influencing Green IS outcomes [8, 10]; and (c) a study that explains the *normative* pressures that shape managerial decisions on Green IS adoption [39]. Studies on IS adoption provide support for the conjecture that all three influences—*coercive, normative* and *cultural-cognitive/mimetic*—shape IS adoption in organizations, but that influence is mediated by other factors [40]. It is important to note, as Bygstad et al [41] argue, that IS mechanisms may relate to, or be functions of, Green IS affordances, but they are not conceptually equivalent.

Thus, we argue that there are significant gaps in Green IS research, particularly studies that offer mechanism-based explanations of the *comprehension, adoption, implementation,* and *assimilation* of Green IS that operate at the level or the institutional environment, organizational field and organization.

Theoretical Background

Institutional theory explains how *regulative, normative,* and *mimetic/cultural-cognitive mechanisms* shape society, organizational fields, organizations, and individuals [42]. At a macro-level institutional change results from, and can be explained by, the action of *coercive, normative* and *mimetic (cultural-cognitive) mechanisms* [38, 43]. Scott [42, p. 35] argues that *coercive mechanisms* are typically found in "regulatory processes involve the capacity to establish rules, inspect another's conformity to them, and as necessary, manipulate sanctions … in an attempt to influence future behaviour. These processes may operate through diffuse, informal mechanisms." *Coercive mechanisms* are typically employed by governments, dominant organizations, social movements,

groups and dominant social actors, as are *normative* and *mimetic/cultural-cognitive*

mechanisms. *Normative mechanisms* typically draw upon values and norms that

"introduce a prescriptive, evaluative, and obligatory dimension" to social or

organizational life [42, p. 37]. Values designate, i.e. convey information, on 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 organizations (NGOs),

consulting organizations, 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/Memetic*

mechanisms emanate from societal actors, NGOs, social movements, community

groups, investors, and other stakeholders. Di Maggio and Powell [43] argue that over

time organizations 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,

institutional isomorphism is achieved as municipalities socially construct Green IS-

enabled eco-sustainable municipalities through *coercive, normative,* and

mimetic/cultural-cognitive mechanisms [2, 43].

In the realm of the human and social, all operative mechanisms may be classified as one

or other of these three high-level categories; furthermore, such mechanisms operate at

different levels and manifest themselves as structures, processes, or other social

artefacts [42]. Actors apply a combination of such mechanisms in an institutional

environment to influence the formation and structure of organizational fields: these

actors include governments, industry associations, dominant organizations, and social

movements. An organizational field is typically defined as consisting of organizations

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 [42, 43]. Thus, we conceptualize a municipality as a particular type of organizational field: This then is our study's unit of analysis.

Informational Mechanisms and Eco-Sustainability Outcomes

Social and institutional mechanisms take the form of structures, processes, or social artefacts. They have the characteristics of being both observable and unobservable, formal or substantive, in nature. We adopt Gross's [44] 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 eco-sustainable municipalities using Green IS. As indicated above, mechanisms convey information that is coercive, normative or cultural-cognitive [45, 46]. Furthermore, researchers argue that mechanisms operate at macro-, meso- and micro-levels to bring about institutional or organizational change [48, 47] and shape organizational and individual *commitments* [48]. *Informational mechanisms*, therefore, help explain cause and effect at several levels in our unit of analysis. They are also argued to stimulate, reinforce, or increase *commitment* to change by actors [49, 50]. In this study we theorize that such mechanisms operate in an organizational field and help in the comprehension, adoption, and implementation of Green IS [51] in order to achieve tangible eco-sustainability objectives of bringing about direct, enabling and systemic Effects [52, 53].

The Organization for Economic Cooperation and Development (OECD) [54] conceptualizes Green IS for environmental sustainability in terms of their direct, enabling and systemic effects. The OECD [54, p. 192] argues that the "resulting environmental impacts [of Green IS] are…difficult to trace but need to be…categorised

in a framework of three analytical levels: (1) Direct impacts (first-order effects including positive and negative impacts due to the physical existence of IT); Enabling impacts (second-order effects of Green IS applications that reduce environmental impacts); and (3) Systemic impacts (third-order effects fostered by Green IS on behavioural change). Given the widespread practical use of this framework, in that it forms a common frame of reference for policymakers, we adopt it to categorize and discuss the progress made to eco-sustainability in the case studies.

The central aspect of our research objective is to identify and determine the role of social and institutional *informational mechanisms* in bringing about these effects in municipalities. It is unclear from the literature how such mechanisms might be applied by specific actors, whether in concert or in tandem, to produce the desired outcomes. Our exploratory research provides, in this respect, much needed practical insights.

Research Design and Methodology

This paper's research question is: *"How do municipalities institutionalize environmental sustainability practices in and through Green IS?"* The previous section argued that social and institutional *informational mechanisms* are instrumental in producing first-, second- and third-order eco-sustainability effects or outcomes. According to Yin [55], 'how' questions may be answered through exploratory case studies. According to Gerring and Cojocaru [56] "a case study (a) focuses on one or several cases that are explored in-depth, (b) integrates diverse styles of (observational) evidence, and (c) potentially sheds light on a broader population, which it represents in an imperfect manner." While Yin argues that a single case study design is appropriate where researchers wish to perform a critical test to existing theory or to explore rare or unique events, multiple case studies in a multiple-case design involves the selection of "two or more cases that are believed to be literal replications, such as a set of cases with

exemplary outcomes in relation to some evaluation questions" [55, p. 59]. A multiple case study is, therefore, the most suitable to answer the above research question.

Case Selection

The organizational field of municipalities (local government) in the UK includes public sector organizations, business enterprises, social groups, and citizens. It has as its institutional environment the UK government and the UK Parliament in Westminster. During the period under study, the UK government operated within the broader institutional environment of the European Union (EU)—research data from EU organizations is, therefore, relevant and included in the study. Thus, the research approach incorporates a longitudinal, case study design of the UK public sector's application of Green IS, focusing on the implementation of central government policy and, specifically, two cases of the institutionalization of eco-sustainable municipalities—Bristol and Manchester. The research was conducted in two phases: The first involved field research from 2008 to 2011: as indicated, this consisted of three case studies, the UK Public Sector exploratory case study and the multiple case studies of two municipalities. The second phase examined the outcomes and evolution of the three case studies from 2012 to 2018. It was in the conduct of the first case study of the UK public sector that the two municipal cases were identified for research. It was clear that just as the UK Public Sector case was *representative* of how a national government can transition the public sector to eco-sustainability, so too were two municipalities— Bristol and Manchester—which were *typical cases* [57] of how local governments can transition to eco-sustainability.

This study adopted purposeful sampling as the overall approach for case selection and with-in case data collection. The cases were not only *representative* or *typical* [57], but selected using theory-based sampling, as they embody important theoretical constructs

in relation to the phenomena of interest [57]. Thus, theoretical sampling [58] saw cases selected on the basis that the *informational mechanisms* that were responsible for the institutional change to eco-sustainability and which produced the observed outcomes. As Seawright and Gerring [59] point out, *representative* or *typical* cases are selected by a researcher "so that he or she can better explore the causal mechanisms at work in a general, cross-case relationship. This exploration of causal mechanisms may lead toward several different conclusions." In the current context, we were seeking to identify cases that were representative of a sub-population of municipalities in the UK and Europe that made the transition to Green or eco-sustainable municipalities. Thus, this approach enabled the achievement of this paper's research objective and facilitated a cross-case analysis in the selected cases to develop this paper's theory of *informational mechanisms*.

Case Background

The UK is considered an exemplar in terms of its government's approach to addressing eco-sustainability. However, as the epicenter of the industrial revolution in the 1850s, the UK's per-capita emissions of GHG are comparable with that of the US. Accordingly, since 2000 when it instituted the Climate Change Programme, the UK Government enacted the Climate Change and Sustainable Energy Act 2006 and the Climate Change Act 2008 which shaped national and local government policies. It also instituted the Committee on Climate Change (CCC), which is a powerful NGO that advises the UK government, as did the UK Sustainable Development Commission during its short tenure. This focus on climate change policy was implemented by central government departments and agencies to make the UK the "greenest government ever"—as will be seen, *informational mechanisms* and Green IS played a key role as

instruments of policy in this transition. Thus, the UK national government provided the institutional context and environment for eco-sustainable municipalities to develop.

The two municipalities chosen for study are Manchester City and Bristol City. These municipalities are members of the UK's Core Cities Group, participants in the EU Intelligent Cities initiative, and signatories to the *Eurocities Green Digital Charter* along with 53 UK and European municipalities. As such they are representative or typical cases of the sub-population of municipalities globally that have been successful in implementing policies on eco-sustainably using Green IS across their eco-systems to include individual citizens and business enterprises, as well as their own institutions and others in their organizational field.

Data Collection

According to Eisenhardt [58], theory-building researchers typically combine multiple data collection methods, whether from archival sources, observations, and interviews. According to Hox and Boeije [60], these are sources of primary data in qualitative research. All three approaches were employed in the current study. Table 1 illustrates the data sources within the Public Sector.

Conference	Sample of Key Information Sources: Formal Presentations, Panels and Informal Discussions
The Green IT Expo 2009 ICT for Energy Efficiency (ICT4EE) 2010 Government ICT Goes Green Conference 2010 Efficient ICT: Greener Government 2011	*Institutional Environment and Public Sector Case* HM Government Green ICT Champion; WWF Climate Savers Speakers; EU Commission Representatives Information Society and Media Speaker & Representative; EC DG CONNECT. Communications. Networks, Content & Technology, Speaker & Representative; EC DG JRC Joint Research Centre; DigitalEurope Representative; UK Carbon Trust Speaker and Representatives; UK Department of Environment Speaker and Representatives; Cisco Smart Connected Buildings Engineer; Presentations from Microsoft, IBM, OVUM, BCS, Cisco, British Telecom, ITU. Socitm Society of Information Technology Management

	Members
	Local Government/Municipalities Case
	Smart Sustainable Cities Session: Presentation and Panel. Bristol City Council Representative; Connecting Bristol Speakers; Manchester City Council Speaker and Representatives; MDDA Speakers and Panel Members; Hillingdon Council Speaker & Representatives; NHS Speakers and Representatives; University of Liverpool Speaker & Representatives;

Table 1: Data Sources in the UK Public Sector

A wealth of archival sources, such as policy documents from the EU, UK national and local government sources, non-government organizations (NGOs), and private sector organizations were collected for analysis. Data were collected from other artefacts such as related websites but also Green IS. These either were *informational mechanisms* in-and-of themselves, and/or they referenced additional exogenous or endogenous *informational mechanisms*, or they referenced the actors responsible, and the first, second and third-order outcomes that were desired or achieved. The key archival sources are cited in the body of the text and in the references.

We also gathered a wealth of observational data from several of the key informants and other relevant actors from the UK and EU public sector and municipal organizational fields. This occurred at related conferences and conference workshops, where actors in government departments, agencies, EU directorates, NGOs, municipalities, industry organizations, and related business enterprises spoke and/or participated in workshops. See Table 1. Digital recordings were made where ethically possible, and field notes were taken throughout [56, 57]. 52 conference presentations and seminars were attended and key presentations and follow-up Q&A sessions were digitally recorded. Twelve informal unstructured interviews/discussions were conducted with participants using a combination of *convenience* and *purposeful sampling* at these conferences. These

included discussion on the institutional environment of the UK Public Sector and the Bristol and Manchester cases with some of the informants listed below.

The third strand of data collection applies the key informant technique described by Seidler [61: 816] to gather data from and on central actors. Seidler states that the key informant technique relies on "a small number of knowledgeable participants, who observe and articulate social relationships for the researcher." This approach was applied in the current study as a form of purposeful sampling in the selection of interviewees in both Bristol and Manchester, with due recognition to the problems of informant competency and bias articulated in the literature [62]. Table 2 catalogues the key informants interviewed in the Bristol and Manchester cases.

	Bristol Interviewees		Manchester Interviewees
BC1	Bristol City Council CIO	MC1	Head of Manchester Digital Development
BC2	Connecting Bristol Director		Agency (MDDA)
BC3	Climate Change & Built	MC2	MDDA Group Interview
	Environment Co-ordinator	MC3	DEHEMS Project Lead
BC4	Green ICT Lead	MC4	SMARTiP Project Lead (Smart
BC5	Printer Strategy Project Manager		Innovation and People project (Smart-IP)
BC6	Infrastructure Development	MC5	Principal Digital Development Officer
BC7	Manager Infrastructure Architect	MC6	Manchester Digital Lab MADLAB Lead
	Energy Management Officer	MC7	Manchester Digital Managing Director

Table 2 Key Informants in the Bristol and Manchester Cases
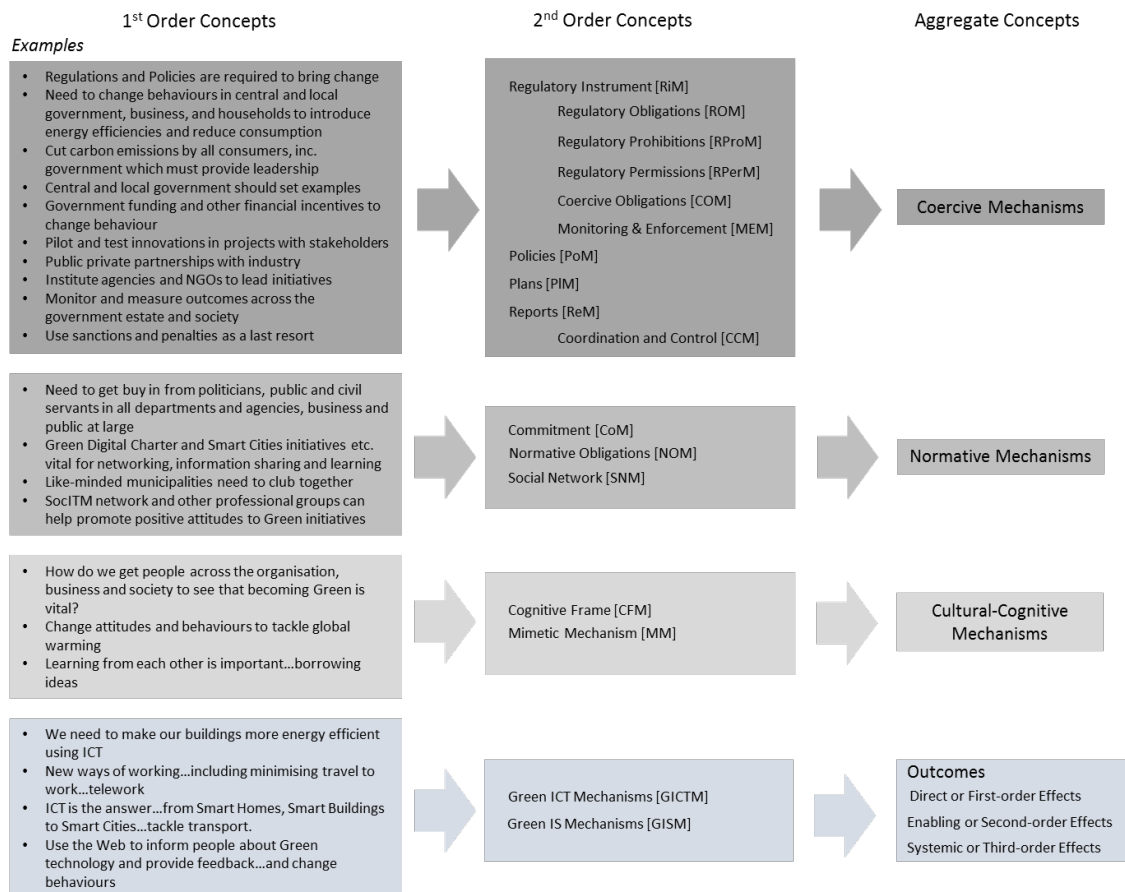
Figure 1 Data Categorisation of 1st and 2nd Order Concepts to Aggregate Concepts

In a general context, specific data collection activities were framed by the theoretical concepts, e.g. institutional theory, social mechanism theory, and their relationships within the context of the research question. The questions asked were aimed at eliciting information from actors on why, which, how, mechanisms were being employed in order to achieve desired outcomes. As actors were not homogenous in terms of their objectives, i.e. senior managers would have strategic goals, while specific projects would have tactical objectives, thus role-related questions were tailored, while general questions would have been similar. Of course, given the conceptual complexity of the theory, many questions were indirect, and the use of specific mechanisms inferred. As indicated, actors were also questioned informally in social contexts and observed at conferences presenting their views on sustainability activities, and outcomes. Inferences

were made regarding the existence or not of *informational mechanisms* using the researchers' *pre-understanding* of mechanism-based theory and mechanisms previously identified in the literature [63].

Data Analysis

Institutional theory and the mechanism-based perspective provided the data analysis with seed categories for coding [64] and pattern matching [55]. The initial categories/codes remained stable as they were applied across the UK Government Public Sector case and the two local government/municipality cases, due to the fact they had been corroborated in a cumulative body of research. Pattern matching on, for example, Gross's [44] theoretical conceptualisation enabled internal validity [55] to be ascertained.

There are a number of approaches proposed in the social science literature to ensure the quality, reliability, and validity of qualitative research [65], particularly case study research [55]. These span the entire research process, but they are especially important in the data analysis phase [65]. Gioia et al.'s [65] approach is particularly apposite since it helps answer the question: *"How then might we go about discovering and developing the kinds of concepts that might better capture the phenomena of organizing and organization?"* Their intention resonates with the overall goal of the present study. As they point out, they laid the groundwork for data analysis with their research question(s) and the data collection approach, particularly the interview protocol (see Appendix A), which reflects the initial theoretical categories developed from the literature [59]. However, Gioia et al's thesis of a theoretical or conceptual *tabula rasa* to avoid confirmation bias is effectively questioned as being cognitively or psychologically impossible [63]. The existence of bias, confirmation or otherwise, is

worked out by the *care*-full, *concerned* [66] researcher through the application of his/her *phronesis* (experiential knowledge) and *techne* (methodological techniques).

In performing our data analysis, we followed implicitly the interpretative research approach documented by the first author [67, 69]. This research approach was influenced by the seminal work of Winograd and Flores [68], and informed by phenomenological hermeneutics, and enables researchers to "explore social actors' embodiment and hermeneutic relations" to IS [69, p. 153]. Thus, we argue that while the affordance perspective referenced earlier would benefit researchers untrained in the *techne* of the phenomenological hermeneutics, and who do not possess research *phronesis,* scholars of the hermeneutic method have a much richer toolbox to work with [63, 67]. However, we followed Gioia et al. [65] in mapping from 1st order concepts in the research artefacts (archives, observations, interviews) to the 2nd order concepts, which in this study are the *informational mechanisms* that were theorized as being responsible for the relatively successful transition to eco-sustainability in the municipalities studied. These are noted in Figure 1 along with the codes for each mechanism (e.g. *policy mechanism* PoM, commitments, CoM, and so on).

The coding scheme was emergent in that it formed part of an interpretive approach that applied abduction, as formalised by David Rennie [70], to interpret and analyse the evidence from all three sources. In Rennie's [70, p. 391] methodological hermeneutics "the idea that extant theory can be used in the development of theory is accommodated because educing and conceptualizing the meaning of text allows for drawing on knowledge of any kind, including prior theory, so long as doing so is in keeping with the development of new understandings rather than merely the confirmation of old ones." As Butler and O'Reilly [63] have argued, *pre-understanding*, in the form of extant theory and research in a particular domain, is vital, if understanding is achieved.

Furthermore, it is logical to assume that not all research phenomena will possess the same degree of interpretive ambiguity or equivocality. In this study, institutional theory was chosen due to its proven ability to explain institutional and organizational change or transitions. The empirical evidence from the cases was relatively low in terms of interpretive ambiguity and equivocality, compared to that presented by Rennie [70] or Gioia et al. [65].

Thus, as Figure 1 indicates the Aggregate Concepts of *coercive, normative*, or cultural-*cognitive mechanisms* are well-known and their effects demonstrated in the literature, as previously discussed. However, in social contexts mechanisms operate at macro-, meso-, and micro- levels; hence, as the above mechanisms are aggregate concepts, their constituent operational mechanisms required identification. Again based on the literature, we made the conjecture that *informational mechanisms* would explain how eco-sustainability outcomes might be best achieved, whether in the implementation of Green IS or their roles and application to achieve the aforementioned outcomes. It is also the case that these outcomes are known and well-defined.

The data analysis process was conducted as follows. In the first phase, we analyzed the research texts and artefacts (archival texts, digital recordings, field notes, interview transcripts, and Green IS artefacts). In conducting the analysis, we began by reading the text to get a general sense of their content and to understand them. We then broke the text into passages or sections according to their meaning. These sections ranged from a few lines to two or more paragraphs. We interpreted the meaning(s) of the passage and used abduction to assign a mechanism that best represented the meaning and then categorised it as a coercive, normative, or cultural-cognitive mechanism. This process involved the use of existing categories or mechanisms, such as commitment or mimetic behaviours, but also created and categorised new mechanisms. Briefly, abduction is an

inference to the best explanation of empirical data, evidence or observations. Abductive inference is usually the simplest and most probable explanation (or categorisation) of an observation or data. Using this approach, we then assigned to a text segment each and every category of mechanism that we interpreted relevant using the conceptual categories indicated in Figure 1. Thus, we used the mechanism-based perspective to inform our identification and coding of the different categories of mechanisms and our iterative interpretation of data and findings. This involved the use of 'seed' codes [63] in an emergent approach, that saw the development of new codes as data collection and analysis proceeded, with all data collected being coded. The 'seed' codes were drawn from previously identified mechanisms documented in the Theoretical Background section, while our conceptualization of informational mechanisms helped us to identify and categorize additional mechanisms. Data collection continued until no new conceptual insights were generated. At this point, repeated evidence for our conceptual categories was identified. Following Eisenhardt [58], theoretical saturation was deemed to have been met, as data from the two cases and the background case of the UK Public Sector generated no new conceptual insights. As per Yin [55], our replication strategy ensured the resultant mechanism-based theory possessed empirical fidelity.

The identification of *informational mechanisms* in and of itself was, however, insufficient. As indicated in the previous section, mechanisms act in concert with other mechanisms, whether in series or cascade or parallel, to produce the observed outcomes. The second phase of data analysis focused on the task of the network effects of mechanisms. The following case study reports use of networked graphs and related explanations to capture and display these relationships (following Miles and Huberman [64]). The case studies present the findings using a concept-based rhetorical approach recommended for qualitative studies by Rennie [70].

Building Eco-Sustainable Municipalities using Green IS in Manchester and Bristol

Municipalities as local government organizations play a vital role in developed economies. This section illustrates how local government policy in the UK often led, and in many cases transcended, central government strategy, which forms the institutional environment of context for the former [43, 44].

The UK government's adoption of Agenda 21 acted as an *informational mechanism* in that as a *policy mechanism* [PoM][3] it signalled the intention to adopt and institutionalize the international Local Agenda 21 and have municipalities do likewise. The informational content of this co-created *policy mechanism* provided the normative stimuli that encouraged, channeled, or otherwise influenced, through its ability to *diffuse* [DM] information on the *commitments* [CoM] and actions of actors and stakeholders in UK municipalities. In its role as an *information mechanism,* it reduced equivocality about the consequences of climate change, among other sustainability issues, and also the uncertainty of which course of action actors should take. It *coerced* [CM]*,* through the imposition of *normative obligations* [NOM], and provided a *cognitive frame* [CFM], to engender *commitments* to action. Thus, we report that *informational mechanisms* have *deontic* (obligations, prohibitions and permissions) and *alethic* (necessity, possibility, and impossibility) *modalities* [71 , 72].

This *informational mechanism* triggered a cascade of related *mechanisms* (*Policies* [PoM], *Plans* [PiM], *Reports* [ReM]) as actors across the institutional environment committed to Agenda 21. However, the application of such mechanisms is not deterministic, as actors have agency and free will, as evidenced by the glacial pace of

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[3] In this section we apply the codes developed in the data analysis, indicated in Figure 1.

change and global inaction since Agenda 21. Nevertheless, the Local Government Act 2000, placed, and still places, an *obligation* on local authorities to *'improve or promote the economic, social and environmental wellbeing of their areas and contribute to the achievement of sustainable development'.* In 2001, over 200 local authorities/municipalities (e.g. Metropolitan and London Boroughs, UK City and County Councils) instituted and signed the Nottingham Declaration, which was a related national *informational mechanism* [PM], whose objective was to have local authorities *commit* to developing *plans* and implement actions to address climate change and reduce GHG emissions in their area of governance in partnership with local organizations and communities. Also acting as a *cognitive framing mechanism* [CFM] it influenced how key issues are perceived and informed commitment to social action.

The European Union's emphasis on fostering the development and use of Green IS led to the institution in UK law of the Waste Electrical and Electronic Equipment Directive (WEEE), the Energy Using Products (EuP) Directive and the European Energy Performance of Buildings Directive (EPBD). These new environmental laws were *informational mechanisms* that specified coercive *regulatory obligations* [ROM]*, prohibitions* [RProM], and *permissions* [RPerM], along with their concomitant *monitoring & enforcement mechanisms* [MEM], which collectively impacted on local government approaches to the development of eco-sustainable municipalities in surprising ways. The following comment by Paul Isbell, Energy Manager for Bristol City Council illustrates this:

> "Historically the requirement for an energy department or designated energy manager within the public sector was eliminated with the importance of the subject matter declining and the heightening of other priorities. Times have changed and an emphasis on energy, how and when we use it and the impacts that it has on the environment is now an imperative subject which is largely being enforced through government legislations such as the European Energy

Performance of Buildings Directive (EPBD), which has brought the requirement for building energy performance certificates."

Policy mechanisms, such as UK's Climate Change Act and the Energy Act by Parliament in 2008, were also pivotal in their impact on sustainability outcomes. However, of particular 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 also introduced mechanisms to trigger change, as one senior civil servant in Department for Environment, Food and Rural Affairs stated in 2008: "The wider public sector—local government, schools, the NHS—is explicitly not covered by the SOGE targets but there are all sorts of other mechanisms which other departments will be able to answer for on how they are, nonetheless, really driving through sustainability" down to local levels.

Background Case: Institutional Mechanisms on the UK's Greening Government ICT Policy and Public Sector Green IS

Three levels of *informational mechanisms* institutionalized the *comprehension, adoption, implementation,* and *assimilation* of Green IS in the UK Government, with the desired Green IS outcomes of GHG emissions reductions. We argue that a combination of EU-based *coercive policy mechanisms* and UK policies on the application of Green ICT, coupled with the application of *normative mechanisms* by the Society of Information Technology Management [73], as well as other social influences, focused the attention and generated *commitments* of UK policymakers and public sector CIOs towards environmental sustainability. The result of such pressures and influences led to the institution of the Greening Government ICT Strategy in 2008. This was the first formal policy document on the use of Green IS in the UK public sector. The *commitments* to action that resulted led to several Green IS.

A report by the Society of Information Technology Management [73] on the role of Green IS in local government organizations presaged the aforementioned government strategy. In 2009, Steve Palmer, CIO of Hillingdon Council and SocITM President stated that SocITM's intention was "to help shape policy that central government wants to implement, so our members feel they are part of it and not having it done to them…The economic downturn we face provides an enormous opportunity for maximizing the potential that ICT has for delivering high quality, low carbon services…Green ICT initiatives cannot just reduce travel, enable flexible working and reduce energy consumption; they can also improve the quality and delivery of frontline services,." SocITM's *report mechanism* informed IT professionals from CIOs down, across the UK public sector, on the *normative obligations* that government organizations needed to comply with to reduce carbon emissions. Specifically, it focused primarily on the *direct effects* and only a subset of *enabling* and *systemic effects*. There is evidence to suggest that this document influenced the formation of government strategy from 2008, particularly in the UK Government's CIO Action Plans, through *cognitive framing, diffusion, mimetic*-ism, and *commitment*. That is, the particular affordances that Green IS offer [74] were inscribed directly, or configured in local contexts, across government departments, agencies and local authorities.

Two exemplars were chosen for inclusion in the study as they contribute different but complementary 'grassroots' perspectives on the influence of social and institutional mechanisms and Green IS-based effects. The two organizations, 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[4] 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. In 2018, the charter committed (through *policy, diffusion* and *normative obligation mechanisms*) 53 European municipalities to the following:

- "working with other Green Digital Charter signatories to promote the best applications and results of ICT solutions;
- establishing local partnerships to implement the Green Digital Charter's commitments, and to make these central elements of the cities' wider strategies;
- deploying five large-scale and replicable ICT pilots per city within five years and communicating the impact of these to citizens and local stakeholders;
- decreasing the direct carbon footprint of the ICT sector by 30% per city within ten years."

It is clear from an analysis of current practice that municipalities have had mixed results in achieving these outcomes (see http://www.greendigitalcharter.eu/).[5] However, the two cases hold up well, as the initiatives described remain exemplars in late 2018.

Case #1: Manchester City Council's Smarter City Initiative 2010-2018

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. As of April 2018, MCC has updated its Climate Change Action Plan to act as both strategy and implementation plan (http://www.manchesterclimate.com/2050consultation). It also convened the Greater Manchester Green Summit on 21st March 2018 in order to become "one of the leading green city-regions in the UK and

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[4] The terms Smart or Intelligent Cities are synonymous. However, recent research has pointed out that A Smart City may not be sustainable and has argued for the term Smart Sustainable Cities (57).

[5] http://www.greendigitalcharter.eu/ Accessed April 2018/

Europe." These are classic *informational mechanisms* that signal the Council's intentions to the wider community.

For Manchester City Council, 2010-2018 was a period of steady, but perhaps less dramatic, institutional change towards eco-sustainability. During this time, Manchester's annual GHG/CO_2 emissions saw a decrease from 3.2 million tonnes in 2005 to approx. 2.5 million tonnes in 2015, a 22% decrease[6]. It is estimated that reductions are running at about 3% per annum, despite economic and population growth. The target is a reduction of 41% by 2020, over 2005 levels. Gavin Elliot, Chair of MACF (Manchester: A Certain Future) Steering Group states in the latest Strategic Report 2010-2017 that "Manchester will become a zero-carbon, zero waste, climate resilient city by 2050, or sooner, if necessary to make our full contribution to the Paris Agreement."

It is clear from our analysis of the data that the *policy mechanisms* MCC instituted were much more ambitious than those of other municipalities mentioned in the previous section. From the outset, MCC's *commitments* to achieving the *enabling* and *systemic effects* of Green IS were born out of a web of factors that centred on its plans to develop the city's economy through a raft of digital initiatives. In 2010, for example, the Head of Manchester Digital Development Agency (MDDA), provided the projects and related *informational mechanisms* that saw widespread *commitments* to this strategy. It was at this time that the Council 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. structural *coordination and control mechanisms*. Pivotal to the success of this was access to funding from EU programmes

[6]http://www.manchesterclimate.com/sites/default/files/MACF%20Annual%20Report%202016_0.pdf

(e.g. Interreg and FP6). The most influential of these EU initiatives was the Intelligent Cities Project, which saw MCC engage in developing *social networks* with 20 EU cities and 20 universities to conduct and *diffuse* research on how Green ICT could make cities more energy efficient—this later evolved into the Smart Cities movement. Thus, *mimetic mechanisms* played an important role for the MDDA, in importing new knowledge and Green IS/ICT from other municipalities across the EU.

MDDA also built on the institutional network that MCC had already in place with the 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 *mimetic mechanisms*, in concert with the 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. The Head of MDDA 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 to start thinking of practical ways we do this…*we nicked ideas from everywhere else and just put them all together*".

The use of the colloquial term "nicked" is indicative of the existence of *diffusion* and *mimetic mechanisms* at work.

One of 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 Green IS/IT 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 businesses, 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 developed the technology and applied it with moderate success, as the MDDA DEHEMS project manager noted:

> "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 IS 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. Information provided by this Green IS enhances human understanding, particularly when it comes to decisions about energy use. The following examples also possess such affordances.

MDDA 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 provided by a newly implemented combined heat and power system. Granular metering and a Green IS were installed to maximise the impact of the metering by permitting the *coordination and control* of energy-related behaviours of staff.

The overarching *policy mechanism* for the eco-sustainable efficiency energy-saving agenda was the EU-wide Green Digital Charter, which has, since 2008, been employed as a "framework for cities to use ICT as the main driver to improve energy efficiency". Thus, initial *policy mechanisms* gave birth to the Manchester Digital Strategy, which

encompassed the application of Green IS for energy efficiency and digital innovations for social and economic inclusion.

The expansion of Manchester Science Park, which enabled the facilitation the growth of Green data centres, ran into problems due to energy supply and capacity issues:

> "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" (Head of MDDA).

This development and MCC's *commitment* to becoming a Smart City led to the introduction of the New Economy initiative, which looks to public-private partnership models to bring about ICT-related change to Greater Manchester. The MDDA participated in a pilot project as part of this initiative that applied 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 organizations that we are working with. In fact we are calling that a Living Lab as well."

This was 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, applied the DEHEMS technologies to small-to-medium sized businesses in Manchester City. Each of these projects is characterized by the use of *normative obligation mechanisms* (i.e. social obligations to be good citizens or corporate citizens) underpinned by *social networking* and *diffusion mechanisms*, and the use of *mimetic mechanisms* at an EU and local level to generating *commitments* that translated *policy* into action. The Green IS that resulted from these projects acted not

only to institute the aforementioned *informational mechanisms* but also enacted *coordination and control mechanisms.*

MCC applied *social network 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 organizations 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. Here, there is an explicit focus on Green IS (*enabling and systemic effects*) for energy savings and *information mechanisms* that trigger behavioural change and *commitment*.

Another MCC initiative was the use of Green IS as *cognitive framing* and *mimetic 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 *social network* and *diffusion mechanisms*. Finally, MCC employed the Smart City Consortium-based GreenITNet as combinatorial *social network, diffusion* and *mimetic mechanisms* for its digital innovations locally, nationally and across the EU. This Green IS disseminates knowledge, best practice, and policies in achieving energy efficiency. Hence, it employs several *informational mechanisms* that shape the desires and beliefs of users, thereby instilling *commitment* to green objectives. This, as with other early projects above were pathfinders for the current raft of initiatives.

The Manchester Digital Development Agency transitioned into the Manchester Climate Change Agency (MCCA, a not-for-profit Community Interest Company), in 2015, with a new NGO called Manchester Digital taking over the general focus of the former MDDA. From 2015 on, the initiatives described above gave rise to 15 even more

significant and influential initiatives, from Building Energy Management Systems, as the forerunner of a heat energy transfer system for the city (a *mimetic response*), to SmartImpact which involves a network of cities, sharing best practice and developing tools to enable the development of smart city districts through *social network, diffusion and mimetic mechanism*s[7]. Thus, it is clear that there is a web of *policy mechanisms* and related *normative, diffusion* and *mimetic mechanisms* at play in ensuring that eco-sustainability goals are achieved in the face of a confluence of conditions and factors.

In 2018, the overall *policy mechanisms* for all initiatives in MCC is the *Our Manchester Strategy*[8] and the *Manchester: A Certain Future* (MACF) initiative, in which the MCCA plays a key role. The key stakeholders here are the Manchester City Council, the MCCA, and a range of business, academic and community leaders. Administrative leadership is now formally invested in the city's mayor, Andy Burnham.[9] It is worth noting the range of mechanisms that brought Manchester to this point in its evolution towards eco-sustainability were the formal mechanisms as described, but also informal *cognitive frame* and, in particular, *commitment mechanisms*, as Philip Selznick concluded in his seminal *TVA and the Grassroots* [48].

It is notable that in 2016 39.3% of Manchester's GHG emissions came from industrial and commercial sources, with 30.2% from the domestic sources, and 30.4% from transport. However, in the period 2005-2016, emissions from industrial and commercial sources were reduced by 42%, domestic homes by 35%, and those from transport fell by just 14%, despite the widespread use of public transport in Manchester City and its

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[7] http://wwwS.manchester.gov.uk/directory/120/smarter_city_case_studies/category/1160
[8] http://www.manchester.gov.uk/downloads/download/6426/the_manchester_strategy
[9] See https://www.greatermanchester-ca.gov.uk/news/article/290/ green_summit_heralds_bold_green_future_for_greater_manchester

environs. Current projections[10] indicate that Manchester will achieve a 37% reduction of GHG by 2020, as against the targeted 41%. However, in comparative terms, the following excerpt is instructive:

> "In 2014, Manchester's emissions fell by 15.8% – comfortably exceeding the UK average of 9% and the Core Cities average of 12.5%. This means that after lagging behind the Core Cities and UK national emission reduction trends for a number of years, Manchester has now closed the gap on our comparators."

GHG emissions per capita in Manchester were reduced by nearly three tonnes per person or an estimated 40% reduction from 2005-2017, with the period 2010-2017 witnessing an acceleration in reductions.

There was an overall success in many key areas; however, it is clear that the key area for improvement in Manchester City is transport. Nevertheless, On March 21st 2018 the MCC unveiled a UK-wide municipal-focused low carbon pathway model called SCATTER (Setting City Area Targets and Trajectories for Emissions Reduction). This is a Green IS developed by a public-private partnership to support cities across the UK to manage emission reduction targets and identify strategies to achieve them.

We infer from the above data that comparative success in reducing GHG emissions were, in all probability, the outcome of the application of formal and informal *informational mechanisms* and the related increase in *commitment* to eco-sustainability objectives. It is also clear, given the emphasis of the 15 projects, and the advances in Green IS and enabling technologies, that *direct*, *enabling* and *systemic effects* were being generated. Due to its institutionalized *commitment* to becoming a sustainable smart city, Manchester will lead the way in implementing this Green IS. We now turn to the second of the cases.

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[10] http://www.manchesterclimate.com/sites/default/files/2017%20MACF_Annual-Report.pdf

Case #2: Bristol City Council and The Green Digital City Strategy

In October 2017, Bristol City was ranked 4th in a study by Juniper Research on the top 10 Smart Cities in the UK. However, as indicated earlier, a Smart City is not the same as a Smart Sustainable City. Its relative standing here is indicated by the fact that Bristol attained the European Green Capital Award in 2015. As with Manchester City, Bristol's success as an eco-sustainable municipality did not happen overnight—this was the product of the application of social and institutional mechanisms over several years.

From the outset, Bristol City Council (BCC) instituted several *policy mechanisms* on the use of Green IS in both the local authority and across the city. In 2010, its approach was considered an exemplar by the CIOs in the Core Cities Group, of which Bristol is a member. It is also a long term signatory and active member of the Eurocities Green Digital Charter, in which it participates in the EU Smart City initiative. This is an important initiative, the contribution of which will become clear later in the case study.

As with MCC, Bristol hosted a Digital Environmental Home Energy Management System (DEHEMS) Living Laboratory on the use of Smart Meters, and other projects. Bristol is also a member of the European network of Living Labs. Bristol's Smart City Programme offered the city an opportunity to institute and leverage *policy mechanisms* to generate *normative obligations,* shape *cognitive frames, diffuse* knowledge*, and* evoke *commitments* in and across the *social networks* in the municipality. This project was led by the Bristol Futures Team at BCC, with members from the city's universities, businesses and community partners. Its objective was to innovate in the development of smart digital technologies (through fundamental research and related *diffusion* and *mimetic mechanisms*) to reduce carbon emissions and achieve other eco-sustainable and socio-economic objectives, as well as that of social inclusion in the digital age. In 2016,

Bristol Futures Global Ltd was established as a Smart City consultancy by principals of Bristol Futures Team to continue the work on a commercial basis.

In 2010, Bristol City Council created several *informational mechanisms*, such as *social networking* at a local level whose aim it is to help implement its Green Digital City Strategy. The overarching institutional *policy mechanism* in Bristol's organizational population was the Connecting Bristol initiative which supports and helps develop Green IS and related 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—*normative obligations, social network, diffusion, cognitive frame* and *mimetic*—that help shape the desires and beliefs (i.e. *commitments*) of social actors regarding eco-sustainability. The Green Addict and Carbon Makeover projects were specific *project mechanisms* instituted to achieve its goals—these are not *coercive mechanisms,* in that they mandate *regulatory obligations,* they achieve their objectives through *normative obligations*. Thus, the Connecting Bristol initiative resulted in a chain of mechanisms consisting of *normative obligation, social network, diffusion, cognitive frame* and on to social action by applying knowledge and capabilities through *mimetic mechanisms*, all underpinned by a *commitment* to eco-sustainability.

The Green Addict was a significant initiative here, in that it was, from 2012, Bristol City's Green IS that disseminated carbon footprint information and implemented and assimilated *social network, diffusion,* and *coordination and control mechanism* across the municipality. The Connecting Bristol Programme Director described this initiative:

> "We came up with a foot-printing methodology for measuring CO_2 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 organizations and universities is important.

It evolved into a series of case studies and a database of practical action that different organizations have been taking to reduce electricity bills or carbon emissions."

Bristol became one of the first of the Smart Cities to measure comprehensively its GHG emissions. From the outset, 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 it turned out 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 was recognized explicitly that *policy, social network, and diffusion mechanisms* here would help generate *mimetic* responses across the wider municipality.

Connecting Bristol's carbon accounting exercise highlighted the need to help communities and businesses across the municipality to reduce GHG emissions. However, as indicated, it would have to lead by example through policy and Green IS innovations. 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) at BCC. These were innovative *policy mechanisms* that shaped BCC's transformation to an eco-sustainable organization.

A new CEO who had a major interest in both Green IS and Open Source Software, coupled with executive leadership from the council, saw 50% change in the top two tiers of management in BCC's IT function in 2010. The CIO also held similar desires and beliefs to the BCC councillor committed to driving political change, having come

from the Environment Agency. Together with Connecting Bristol Programme Director, the CIO and the councillor provided BCC with the top-level *commitment* to ensure that the internal Green IS-enabled transformation of the council's business operations was married with the external transformation of the municipality.

Connecting Bristol's role in measuring and reducing GHG emissions across the community was underpinned by the use of *social network, diffusion,* and *mimetic mechanisms.* For example, the GHG accounting exercise helped build relationships with business organizations in the Bristol municipal area. Connecting Bristol published on its award-winning Green Addict Solutions Database *explanations* on how businesses large and small could realize the direct, enabling and systematic effects of Green IS. As the Connecting Bristol Programme Director notes:

> "There is quite a lot of sharing you can do as organizations have similar ICT infrastructures and issues, although the scale of it can be different".

Again, clear evidence of *informational mechanisms* at work. However, the same website provides *cognitive frame* and *diffusion mechanism* for issues through related information and by publishing case studies from Green IS Champions: the case studies provided the opportunity for *mimetic mechanisms* to be exercised by adopting organizations.

Reporting to the CIO, BCC's Green ICT Lead liaised with Connecting Bristol to have Green IS practice adopted by business organizations through *social network, coordination and control,* and *diffusion mechanisms*. His main role was to lead the Green IS element of Bristol's Transformation Strategy. Focusing mainly on the *direct effects*, his team concentrated 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. Summarising these efforts, 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 at BCC:

> "24% of the workforce move[d] to home-working…[he calculated] that this save[d] approximately 11 kg of CO_2 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…but not all are keen to work from home, as they like the social aspects of working in an office."

This is evidence of different institutional logics at play on an individual level. It was not

that the grassroots were not *committed* to eco-sustainability, the new modes of working had to be balanced with personal needs and circumstances. It is unlikely, however, that such individuals were travelling large distances and may have been availing of car-pooling.

It is also significant that during this period, buildings in the BCC estate were 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. This is an example of the use of Green IS as *diffusion* and *coordination and control mechanisms*.

In 2017, Green Digital Charter published its annual report which illustrated the lead role that BCC is playing in the cross-domain REPLICATE Project. The core innovation by Bristol in this is the development of the REPLICATE energy demand management system. This Green IS holistically monitors, *coordinates and controls* energy use in order to level out peak demand. Through related interventions BCC intends to: (a) tackle fuel poverty by reducing the cost and amount of energy consumed; (b) enable the switch to local renewable sources in order to increase local resilience; (c) enable greater sustainable mobility in transport; (d) inform citizens on how to change and control energy consumption and travel patterns; and (e) make a significant contribution to reducing CO_2 emissions. It is clear that *informational mechanisms* provided by REPLICATE proved vital in the achievement of these goals.

As with Manchester City Council, Bristol City Council's application of *informational mechanisms* realized positive outcomes in terms of Green IS' impact across the municipality. For example, BCC successfully achieved its target of a 50% reduction in carbon emissions from council operations (against a 2005 baseline) three years ahead of schedule, and delivered a significant 60% reduction in 2016/17. Encouraged by its achievements, BCC has proposed a new GHG reduction target of 65% by 2020 for its

operations. These figures are being achieved at a practical level through: (1) Energy efficient buildings in BCC's estate; (2) Investments in renewable energy sources such as wind turbines and solar panels; and (3) Energy-efficient street lighting. BCC also admits that milder winters over the past 5 years played a role in reducing emission levels.

In sum, BCC recognizes that its policies act as mechanisms (*policy, normative obligations*, *cognitive frame, diffusion,* and *social network mechanisms*) that inform in order to ensure continuous improvements in achieving eco-sustainability across the municipality. Thus, it states that it wishes to *"use its position as a large landowner, employer and consumer to influence the wider community to consider their environmental impacts"*.[11] Thus there was a cascade of *informational mechanisms* that led to Bristol City Council's success in its evolution as a smart sustainable municipality.

Discussion and Theoretical Contributions

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. It is evident that the dominant logic of 'lean' initiatives in the public sector has failed primarily through an overemphasis on technical issues, at the expense of organizational and institutional realities, leading to poor outcomes, with smart cities, but not smart sustainable municipalities. This may also be true of the use of Green IS in Smart Cities [see 18, 75]. Consequently, we conclude that a local level of analysis, as opposed to a national or international perspective, is critical for instituting realistic behavioural change around climate issues within local communities.

We note that at national level, the UK government employs a mixture of *policy*

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[11] http://news.bristol.gov.uk/council_achieves_carbon_reduction_target_three_years_ahead

(Greening Government ICT Strategy); *normative obligation mechanisms* (CIO/CTO councils and other associations/committees/fora, including, for example, SocITM); *social network mechanisms* (through workshops and conferences); *mimetic* and *cognitive frame mechanisms* (e.g. through various government publications, conferences, etc.) to institute policy change at a local level by fostering *commitment* to change and create its 'organizing vision' for Green IS *adoption, implementation* and *assimilation*. This was the case with the first Greening Government ICT Strategy (2008-2010), but not the second strategy (2010-2014). Table 3 notes the direct (or first-order), enabling and systemic effects of Green IS here. Interestingly, the two municipalities studied achieved a large measure of success in each of these categories.

It is apparent that Manchester and Bristol were 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). However, the success they achieved is unique. To be sure, other government-centred *policy mechanisms* influenced both municipalities: take, for example, the Sustainability of the Government State (SoGE). We also note that the *coercive regulatory obligation mechanism* that is the UK CRC Energy Efficiency Scheme had little impact on policy-making in municipalities, as in either Manchester or Bristol.

Yet while this *regulatory obligation mechanism* applies to all at the municipal level, we did not find it to be explicitly related to the outcomes achieved, or in the process of being achieved, in the application of Green IS. 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.

Effect & Description	☑	Examples of Green IS effects in UK Municipalities
Direct or First-order Effects		
Producers	☑	Compliance with RoHS, WEEE, Procurement policies, EPEAT etc.
Consumers and Users	☑	PC and Server Procurement to EPEAT/Energy Standard inc. Thin-client, Reusing PCs, Extending equipment life-cycle (e.g. PCs); EU Code of Conduct for Data Centres.
Enabling or Second-order Effects		
Optimisation	☑	Desktop and server virtualisation systems; PC power management systems; Building management systems; Smart grid system (Manchester Pilot); Transport and work scheduling optimization systems.
Dematerialisation and Substitution	☑	Switch to e-documents from printers; Tele-working; Teleconferencing.
Induction effects	☑	Smart meters induce the use of Web-based IS; New ICT help running data centres at higher temperatures.
Degradation Effects	☑	Procurement rules on packaging and ease of recycling to overcome effects.
Systemic or Third-order Effects		
Providing and disclosing information	☑	Smart meters; Smart grid; Green ICT Scorecard IS; Green ICT Tool/Procurement IS; Building Management Systems; Bristol Methodology for GHG Emission Measurement; Bristol GreenAddict IS & Cross Domain Replicate Project.
Enabling dynamic pricing and fostering price sensitivity	☒	
Fostering Technology Adoption	☑	Switch to thin clients and notebooks; G-Cloud; Government Application Store; Green ICT Outsourcing.
Triggering Rebound Effects.	☒	There is an absolute reduction in workstations, networking switches, and software applications; however, the increased use of Smart meters and other sensors may offset reductions in ICT elsewhere.

Table 3: Direct, Enabling and Systemic Effects Examples from the Cases

It is evident that Manchester and Bristol City Councils are exercising *policy* leadership

and strategic *commitments* in key areas where Green IS are being applied to make their municipalities eco-sustainable. It was clear to us as researchers that actors in key positions had strong personal *commitments* to applying Green IS to act strategically in order to achieve the objectives of the *direct, enabling* and *systemic effects* in their organizations and their local communities. Drawing on evidence in the cases, we present the eco-sustainability outcomes direct, enabling, and systemic effects in Table 3. It is also clear, in line with extant perspectives in institutional theory, that the institutional environment in the UK and EU provided primary *informational mechanisms* that legitimized, shaped and influenced the responses of these two municipalities.

We also found that Manchester and Bristol imported concepts from industry through *mimetic mechanisms* with the help of ICT vendors and equipment providers (*social network*). Take, for example, *informational mechanisms* applied in SocITM, chiefly *social network, normative obligation* and *mimetic mechanisms* that informed the application of Green IS. In addition, Manchester and Bristol applied the same mechanisms using a wider network across the EU, including local universities and international ICT organizations. Also, Manchester and Bristol imported leaders in eco-sustainability and Green concepts. However, they also employed *social network* and *mimetic mechanisms* to promote Green IS 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.

The current structure of institutional environments, at least in the EU, ensures that the necessary and sufficient macro- and meso-level *situational mechanisms—coercive, normative* and *mimetic/cultural-cognitive—*are present to engender *commitments* in organizational 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 research indicates [76], 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 IS, the problem is informing and generating the necessary and sufficient *commitments* to action.

Thus, our research found ample direct and indirect evidence that the institutionalization of Green IS for eco-sustainability in the municipalities of Manchester City and Bristol City had achieved a significant measure of success in realizing the *enabling, direct* and *systemic effects* of lowering GHG emissions through Green IS.

Theoretical Contribution

Our theoretical contribution is summarized in Figures 2 and 3. Together, these figures present the causal chain of *informational mechanisms* from the institutional environment to the organizational field, organizations that constituted it, and the Green IS that help achieve eco-sustainability targets, the most important of which is the reduction of Green House Gases/carbon emissions (GHG/CO_2). Previous sections have explained the operation of these *informational mechanisms* and their outcomes. Appendix B provides additional evidence for the empirical fidelity of our theorizing.

Unpacking this paper's contributions first requires an explanation of the mechanism-based theoretical model in Figure 2 The model focuses on the mechanisms responsible for the institutionalization of Green IS, not the institutional entities or actors responsible for employing them or being influenced by them. Hence, the model generalizes from the cases. While the context for the current explication is municipalities, the model can be

used to explain how a government department can, for example, institute a Green IS. Furthermore, the model indicates how Green IS can shape and influence actors' *commitment* in an organizational field due to the collective effects of the IS' constituent *informational mechanisms*, thereby producing desired changes in behaviour—i.e. principally third-order or systemic effects. This is indicated by the 'feedback' arrow in Figure 2. Thus, we propose Figure 3 to highlight specifically the role informational mechanisms of Green IS.

Figures 2 & 3 summarise and address our research question posed at the beginning of this paper; viz. *How do municipalities institutionalize environmental sustainability practices through Green IS?* As indicated, this involves the *comprehension*, *adoption*, *implementation,* and *assimilation* of Green IS [cf. 2, 7, 15]. Thus, Figure 2 indicates the mechanisms involved in *comprehension, adoption*, and *implementation*, while Figure 3 explains how Green IS related-mechanisms underpin the *assimilation* phase—the central aspect of which is attitudinal and behavioural—i.e. *commitment*-based.

Municipalities institutionalize Green IS in the context of their 'organizing vision' [9, 32], and, in particular, the institutional environments and organizational fields in which they operate, which are in turn structured by the *informational mechanisms* provided in government regulation. Such mechanisms, which are primarily analogue, are expressed in statutory instruments and regulatory rules published by environmental protection agencies. In the absence of strong grassroots pressures from social movements [77], regulatory instruments provide genesis mechanisms that trigger transitions to eco-sustainability. The purpose of all such rules is to change or maintain desired behaviour patterns. Regulatory instruments act directly on government departments, related agencies and local governments. General, citizen-specific instruments target the individual behaviours (i.e. *commitments* of social actors). However, silent in the present

study was the role of budgets and financial resources provided through taxation. These are effective mechanisms for translating policy into action and are generally taken for granted.
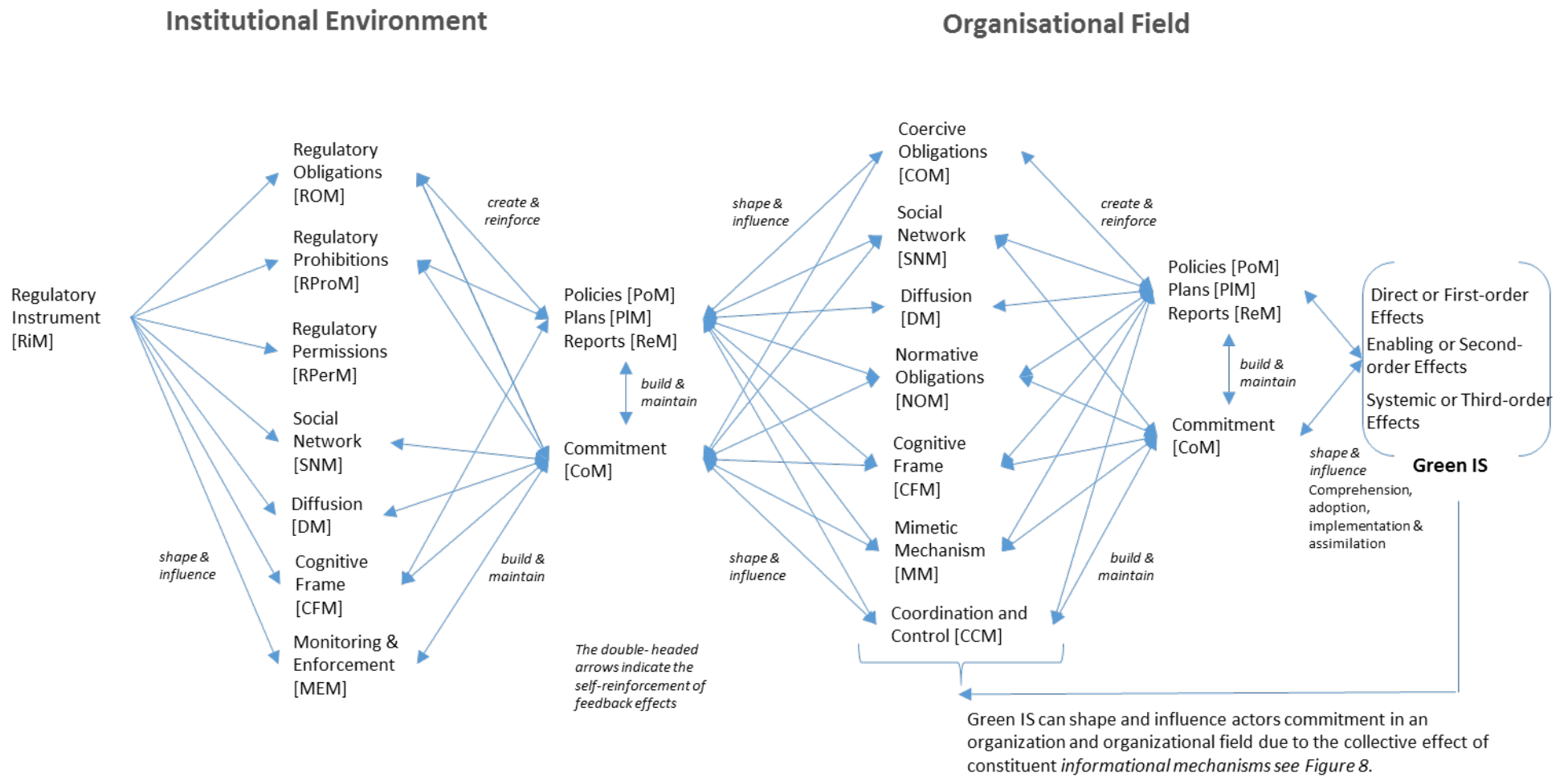
Figure 2: The Role of Informational Mechanisms in the *Comprehension*, *Adoption*, and *Implementation* of Green IS

In keeping with our research objective, the model in Figure 2 indicates that regulatory instruments, which result from wider policy or government research bodies, contain mechanisms that change behaviours through combinations of *obligation, prohibition,* and *permission mechanisms*. They also contain sanctions, in the form of *monitoring* and *enforcement mechanisms*. These *coercive mechanisms* trigger institutional responses, as local governments/municipalities institute *policies*, *plans,* and *reports.* These latter mechanisms act to implement government eco-sustainability objectives, but the outcomes achieved depend on the mediating influences of *institutional logics* and related *legitimating strategies* at play in local politicians and municipal officials. Such influences, and related logics, will be shaped by the aforementioned coercive influences, but also the *commitments* generated in the course of action, as Selznick demonstrates. Thus, *cognitive frames* of municipal agents may be influenced by *diffused* information in regulatory instruments, thereby engendering the desires and beliefs required to generate *commitment*, if it is not pre-existing. One can assume that government and local politicians from the same party will have shared *cognitive frames* and *commitments*, hence alignment of *institutional logics* and *commitment* is highly probable.

We make the conjecture that except in nations with highly polarised political contexts, this first stage in the causal chain is relatively unproblematic, due to the consensus on climate change in most democracies.

Thus, assuming appropriate budgetary provision and institutional commitment to eco-sustainability objectives, we make our first general theoretical proposition, which operates at the level of the institutional environment and organizational field:

> *If* governments integrate an appropriate mix of mechanisms in regulatory

instruments aimed at instituting eco-sustainability at a national level, including analogue- and digital-based mechanisms to diffuse information and shape cognitive frames, as well as appropriate monitoring and enforcement mechanisms, *then* there is an increased probability that municipalities will commit to instituting municipal policies, plans and reports to begin the transition to eco-sustainability.

Explicit in the model, but implicit here, is the role of Green IS to enable *diffusion mechanisms*, *social networks* and enable a change in *cognitive frames,* as well as providing mechanisms of *monitoring and enforcement*. This was evidenced in the Green IS instituted by the UK government. It is clearly apparent that Green IS influenced the 'organizing vision' and institutional logics of local government organizations as well as government departments and related agencies. Figure 3 indicates several *coercive, normative and cultural-cognitive mechanisms* at play in shaping policy responses and related mechanisms.

Organisational Field and Organisation
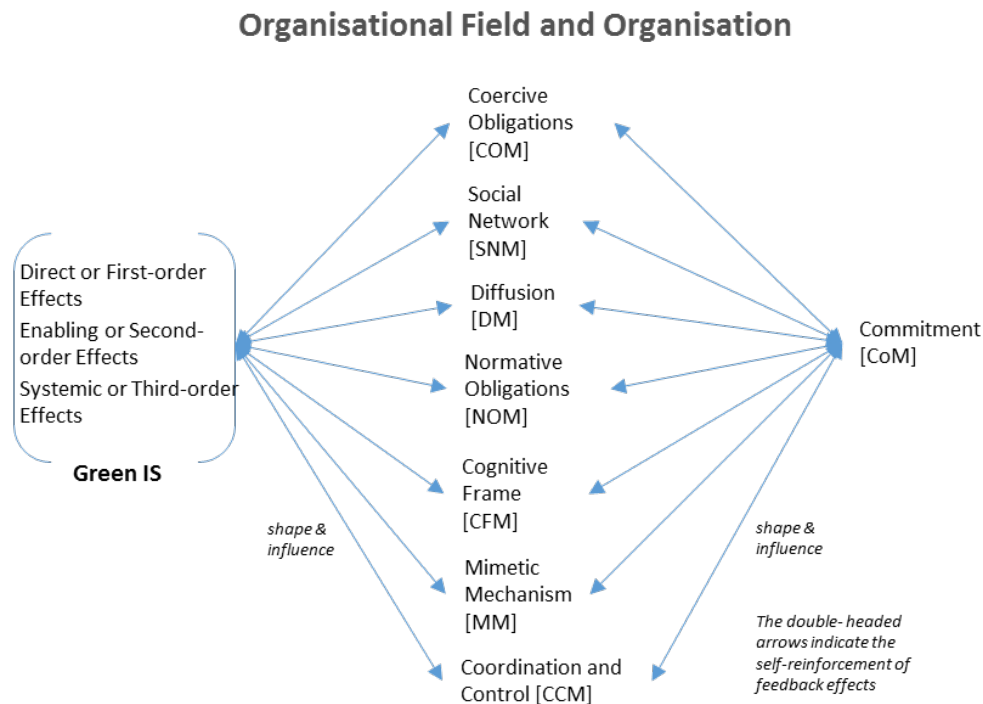
The *assimilation* of Green IS can shape and influence actors *commitment* in an organization and across an organisational field due to the collective effect of constituent *informational mechanisms.*

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Figure 3: Informational Mechanisms for Green IS Assimilation and Commitment to Behavioural Change

The organizational field of a municipality is highly complex due to the diversity of actors at business and citizen levels, with a greater level of variance in institutional logics than for example that which would exist in the organizational field of government or individual business organizations. Thus, the challenges in bringing institutional change in a municipality are daunting—but not insurmountable, as we have seen.

Coercive mechanisms from central government only partly explain the municipal response. Other mechanisms act collectively, these include *social network, diffusion, normative obligations*, *cognitive frame*, *mimetic* and *coordination and control mechanisms*. These help change or reinforce the *commitment* (institutional logics) of actors and the 'organizing vision' of the municipality. The tangible outcomes are related *policy, plans* and *report mechanisms*, which provide direct and indirect *normative* and *mimetic mechanisms* to begin the transition to eco-sustainability. Policy and plans may focus on *commitment* to the *comprehension, adoption*, and *implementation* of Green IS. If properly designed and implemented, then Green IS, as indicated by Figure 3, can also enact *social network, diffusion, normative obligations*, *cognitive frame*, *mimetic* and *coordination and control mechanisms* in the *assimilation* process to infuse eco-sustainability objective with value [42, 48] and shape institutional logics of actors to commit to eco-stainability objectives. Thus, we propose a second general proposition, which operates at the level of the organizational field and organization.

> *If* municipalities institute municipal policies, plans and reports to begin the transition to eco-sustainability, integrate an appropriate mix of informational mechanisms through analogue and digital (i.e. Green IS) media aimed at instituting eco-sustainability at a local level, including mechanisms to establish social networks, diffuse information and shape cognitive frames, as well as appropriate monitoring and enforcement mechanisms using Green IS, *then* there is an increased probability that municipalities will commit to and achieve a transition to eco-sustainability.

Contribution to IS Theory

The theoretical significance of mechanism-based explanations is new to IS scholars [2, 38, 41], but not to scholars in cognate or reference disciplines [44, 45, 47]. Thus, to understand the theoretical contribution of the current study demands a minor modification of the IS paradigmatic worldview, which focuses primarily on variance- or process-based explanations. To be sure, process-based explanations implicitly involve mechanisms to explain phenomena, but not the full range, and the dominant process-based approach could benefit from a full, explicit orientation. While we adopt a "causal mechanism" approach to theorizing, we follow Markus and Rowe [78, p. 12] in arguing that mechanism-based theory on IS phenomena does not imply "unidirectional, deterministic, and/or external influences and thereby radically oversimplifies and distorts what matters most in understanding human affairs." Social and institutional mechanisms are in-deterministic and probabilistic in that human agency and competing institutional logics or *commitments* mediate the outcomes generated by the mechanisms. Human agency in this context is informed by institutional logics or commitments that may run counter to the organizational objectives of eco-sustainability. Thus, the effect of *informational mechanisms* may be reduced as agents may not possess the required commitments and may wish to achieve alternative objectives, particularly if they doubt the findings of climate science or if it means a significant change to established social and organizational behaviours.

We argue that we have significantly advanced the mechanism-based approach to IS theory building, particularly for those wishing to apply mechanism-based institutional theory. The above discussion of our theoretical models highlights the 'problem driven' nature of our work, which according the Davis and Marquis [79, p. 340] makes a theoretical contribution as a "some-times true theory…not in the sense that [as a

problem driven study it] yield[s] useful insights for managers, but because [it is] oriented toward explaining events in the world rather than chosen purely as contexts for testing hypotheses derived from theory." We also believe that IS researchers interested in developing mechanism-based theory in critical realist studies will also find both our approach and findings of interest.

Our major contribution is, however, in the area Green IS research. This strand is especially in need of problem driven exemplars that operate at the level of the organizational field, rather than the organization. Our previous discussion indicates why this is so. However, of particular relevance is that by identifying digital *informational mechanisms* in Green IS (Figure 3) that help institute change to eco-sustainable practices, our findings provide a solid empirical foundation for further theory building on Green IS research, or on how to best ensure the *comprehension, adoption, implementation,* and *assimilation* of Green IS in organizations and organizational fields. The latter contribution will be of interest to design science researchers and those concentrating on functional affordances of Green IS.

Implications for Practice

In November 2019, the EU declared a *Climate Emergency*. However, this was only the latest development of global 'grassroots' pressures that saw approximately 1,261 municipalities across 25 countries declare climate emergencies.[12] The question confronting national and local governments is *'What is the most timely, efficient and effective way to bring about the significant degree of institutional change required to lower GHG emissions?'* This paper helps answer this pressing question.

[1212] https://climateemergencydeclaration.org/climate-emergency-declarations-cover-15-million-citizens/

Local Agenda 21 was instituted by the UN in 1993. Both Bristol and Manchester took their Agenda 21 obligations seriously; however, they took over 10 years or more of incremental change to see tangible results. Both municipalities also took another 10 years for progress to be made across all categories of direct, enabling and systemic effects and significant GHG emissions reductions to be made. To achieve GHG emissions reductions equivalent to those achieved by municipalities such as Manchester and Bristol in the required timeframe, municipalities can learn from their experiences, as documented herein, and apply that knowledge in a series of coordinated programmes.

In order to begin this process, central and local government organizations, particularly municipalities, will need to institute regulations, policies, and plans and to leverage other institutional artefacts or structures, such as social networks, professional associations, to ensure that the behavioural changes vital for the transitions to carbon-neutral societies take place. The Green IS described above will help enable the achievement of these objectives. However, Green IS will need to be *adopted*, *implemented* and *assimilated* successfully. The findings of this study provide guidance on this. Hence, Green IS that incorporate the *informational mechanisms* presented in this study will, if implemented properly, play a pivotal role in achieving climate emergency objectives.

Drawing on the empirical findings, municipalities could, in particular, deploy an integrative Green IS that inform, measure and provide feedback on energy consumption and reduction at various levels of granularity (home, building, and municipality) and across consumption categories such as heating, air-conditioning, IT, business, and transportation (road, rail and air) etc. These could be integrated with social networking applications.

In summary, our research provides a readily accessible road-map, with riched empirical examples and normative propositions, for government policy makers and municipalities embarking on the considerable and uncertain journey to institute Green structures, artefacts and behavioural change required to reduce GHG emissions.

Limitations

Case study-based interpretive research has clear limitations, particularly in providing clear evidence of causality or generalisability of findings [55, 57]. We acknowledge this by categorizing our work as 'sometimes-true theory'. Despite the obvious strengths of multiple case study approaches involving literal-replication, the two cases studied may not be representative of the wider population, as may the organizational field and institutional environment. Furthermore, we cannot claim that the phenomenon of Green IS enabled transitions to eco-sustainable municipalities was explored as exhaustively as it might be, particularly at the level of individual Green IS.

Then there are the limitations to research quality [55]. However, potential risks to research quality were mitigated as the overall interpretive case study design involved: (a) care in case selection and sampling; (b) integration of multiple viewpoints and interpretations from multiple sources of evidence (interviews, archival and observations); (c) care in ensuring a clear chain of evidence; (d) corroborated findings generated by the data analysis through the use of two researchers in performing and reviewing data coding and analysis; and (e) employing consensus-building discussions on the data analysis and theory building. Through these measures, we believe that we successfully collected sufficient amounts of data from multiple informants and different data sources to increase the confidence in the conclusions drawn from the analysis. Furthermore, during our analysis, a trend towards theoretical saturation suggested we

had collected sufficient data to explore relevant factors and interactions related to the role of information systems in sustainability transformations.

While research generalisability is always a challenging issue for qualitative researchers, we followed Yin [55] to perform analytic generalizations to extant theory and corroborations to other data and findings from institutional studies on organizations and IS research, including Green IS. This approach was strengthened using hermeneutically-informed abductions [70] to identify new informational mechanisms or explain particularly observations. Nevertheless, in the final analysis, our problem driven sometime-true theory has empirical fidelity and is generally corroborated by extant theory.

Conclusions

This paper unpacks the challenges and complexities for the use of Green IS to achieve eco-sustainability goals in municipalities. It identifies and elaborates several analogue and digital *informational mechanisms* that we argue are key to the process of instituting change in municipalities in the application of Green IS towards eco-sustainability objectives, specifically where the reduction of GHG/CO_2 emissions are concerned. While mechanisms provide explanations, they can also be used to predict. Take, for example, if a municipality wishes to lower its GHG emissions, then the application of the mechanisms presented in the graph models presented in Figures 2 & 3, increases the probability of, but does not guarantee, successful outcomes. The realm of the social environment is, however, uncertain—simply because all mediating mechanisms cannot be known in advance and of the role of human agency and conflicting desires and beliefs, i.e. competing commitments and institutional logics affecting outcome achievement. What we have here, therefore, is a tentative theory, or sometimes-true

theory [63] which will require error elimination, as Karl Popper points out [80]. That is the challenge this paper poses to the IS discipline and Green IS researchers in building on the findings of this study.

Our research transcends the limitations of previous Green IS studies by identifying with greater specificity and granularity the social and institutional *informational mechanisms* that led to the eco-sustainability outcomes observed in the municipalities studied. Furthermore, we fulfill the criteria articulated by Adamson et al. [81, p. 195] for studies that foster an *"understanding of social processes that unfold across extended temporal trajectories"* and that *"focus on the evolution of formal institutions with a responsibility for adaptation."* We have, therefore, made a theoretical contribution by providing qualified explanations of cause and effect using *informational mechanisms* in this longitudinal study.

At a practical level, we have described and explained how municipalities and organizational fields can transition to eco-sustainability using *informational mechanisms* that promote the use of Green IS and related digital technologies to help address the challenges of climate change. The exemplars we describe and their achievements in leveraging the *enabling*, *direct* and *systemic effects* of Green IS provide rich models for other municipalities. Thus, we have provided important insights into the *informational mechanisms* required to apply Green IS to achieve eco-sustainability objectives across municipalities. We accept, of course, certain limitations to our research, as the findings are based on an analysis of just two case studies. Clearly, more extensive research should be undertaken, perhaps internationally, to provide arguments supporting our highly qualitative in-depth methodological approach. Future research directions should concentrate on the application of Institutional Theory in contexts which represent a rich-complexity of agendas. However, as indicated at the outset of our

paper, time is not on humanity's side.

Appendix A: Typical Interview Questions

1. How eco-sustainable is your organization?

2. What evidence is there to back this up?

3. What is/has been done at a policy and practical context to achieve this?

4. What and who influenced the development of policy?

5. How influential was EU or government policy, directives or regulations?

6. How relevant was your organization's participation in initiatives such as the EU Smart/Intelligent Cities or the Green Digital Charter?

7. Was there committed leadership? Who was it? Would you describe them as charismatic?

8. Was this commitment to the green agenda visible at all levels externally and particularly within your organization?

9. Were there 'climate sceptics' or others who found this getting in the way of their day job?

10. Was their resistance to change in the organization or across wider stakeholder groupings such as business enterprises or citizens?

11. What mechanisms, hard or soft, do you think was most effective at changing mind-sets and ways of thinking?

12. What role did information technology (ICT) play in all this?

13. Was ICT most effective in producing direct effects, e.g. reducing energy consumption, without human involvement?

14. Or did it help change beliefs, attitudes and behaviours to make people lead more sustainable lives, whether in business operations or domestic/personal lives?

15. Can you give me examples?

16. How important was web based information, either on municipal websites, social media etc., in changing people's behaviours and commitment to eco-sustainability/lowering GHG emissions?

17. What role did professional bodies play in shaping beliefs and attitudes toward climate change and the need for Green ICT?

18. For IT professionals, How important was SocITM's role in shaping the IT mindset towards Green ICT?

19. What changes produced the greatest outcomes at the lowest cost or effort?

    a. Across the public sector?

    b. Across the local government sector?

    c. Within your municipality?

20. What role did the popular conception (i.e. beliefs and attitudes) toward climate change play in shaping the response to your organization's Green strategy and outcomes?

21. The government and your municipality have introduced a variety of web-based applications to either drive behavioural change or enable energy savings and GHG emissions reductions, 'Why and how do you think they are effective'?

22. Given your experience, could you briefly outline a change strategy that another municipality might employ to change hearts and minds and transform its organization and the business and citizen communities with the greatest effect at GHG reduction?

Appendix B: Informational Mechanisms and their Outcomes

Mechanisms	Instance	Evidence from Interviews
Regulatory Obligations, Prohibition and Permission	WEEE Directive RoHS Directive EuP Directive	UK municipalities need to "improve or promote the economic, social and environmental wellbeing of their areas and contribute to the achievement of

Mechanisms		sustainable development." LGA 2000.
Monitoring and Enforcement		"We've lots of reasons for what we are doing in Manchester…using digital technologies to help reduce waste and emissions…whether it's the UK's implementation of EU directives, WEEE and EuP, for example. But the government has its own strategies…but we have our own agenda, because it's good for the city… so we have our local policies." Head MDDA
Policy & Normative Obligations	Agenda 21 Local Government Act 2000 Nottingham Declaration EU Smart City UK's Climate Change Act and the Energy Act 2008 Sustainability on the Government Estate (SOGE) Strategy Greening Government ICT Strategy UK Government's CIO Action Plans Eurocities Green Digital Charter Our Manchester Strategy	
Commitments	Policy and Report mechanisms are formal statements of commitments. However, it is the responses to such commitments and their informal expression, usually unobservable, that make the difference. Objective evidence is found, in the context of this study, in the outcomes being achieved across the following agencies: Society of Information Technology Management (SocITM) Bristol City Council (BCC) Manchester Digital Development Agency (MDDA) Manchester Climate Change Agency (MCCA)	"In some ways I would say that what Bristol is doing is much more leading edge stuff in terms of focusing first and foremost on Green IT" Head MDDA. "We are leading the way with our Green ICT strategy. We focus on innovation and use of technology working in partnership with the local IT providers…examples are in procurement, energy efficient data centre, and re-use of computers and recycling. We also excel at working from home…other councils are doing some, but not all" BCC ICT Lead. "24% of the workforce move[d] to home-working…[he calculated] that this save[d] approximately 11 kg of CO_2 per person per day". "I work from home 2 days per week…in fact we have hot desks in our Romney office for teleworkers." Green ICT Lead, BCC. "We're committed as are other Green Digital Charter members to share best practice with business and the community to make Manchester more a more sustainable place to live and work." Head, MDDA.
Social	Green IT Expo	"I've been very active in Europe,

Networks and Diffusion	Government ICT Goes Green Conference Efficient ICT Greener Government Conference EC ICT for Energy Efficiency Conference UK Core Cities Group Greater Manchester Green Summit on 21st March 2018 Manchester Digital Strategy Environmental Business Pledge Bristol Futures Team Bristol Futures Global Ltd Connecting Bristol MDDA DEHEMS European Platform for Intelligent Cities (EPIC) GreenITNet SmartImpact SCATTER (Setting City Area Targets and Trajectories for Emissions Reduction)	whether it's in Green ICT or Smart Cities, there's a big overlap there…and lots to learn…so its all about building relationships." Head MDDA. Greater Manchester Green Summit commits Manchester City to be "one of the leading green city-regions in the UK and Europe." MCC "I'm a SocITM member, I use the society to reach out to CIOs and IT managers across the public sector, I learn from them and they from what we are doing in Bristol." CIO BCC. "We reached out to the university, to local businesses, to get Green innovation going here…I think that's one of our success. CIO BCC. "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." Head, MDDA "There is quite a lot of sharing you can do as organizations, have similar ICT infrastructures and issues, although the scale of it can be different". Connecting Bristol Programme Director.
Coordination and Control		
Cognitive Frame	There were a range of formal and informal *Cognitive Frame mechanisms* — each of the *Policy and Report mechanisms* framed the eco-sustainability agenda in regional, national or local terms.	"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" Head of MDDA. "Best practice in Green ICT is fine, but there has to be a context…that it is good for business and that is good from Bristol." Connecting Bristol Programme Director. "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." Head, MDDA
		"There is quite a lot of sharing you can do as organizations, have similar ICT infrastructures and issues, although the scale of it can be different". Connecting Bristol Programme Director.
Mimetic Mechanisms	These are triggered by the preceding Informational mechanisms; however, the degree of *social networking* determines the level and range of *mimetic mechanisms* in and across a municipality(ies). Key is that mimetic mechanism are those through which local entities socially construct or co-create eco-sustainability solutions locally.	"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 organizations that we are working with. In fact we are calling that a Living Lab as well." MDDA Project Lead
		"We came up with a foot-printing methodology for measuring CO_2 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 organizations and the universities is important. It evolved into a series of case studies and a database of practical action that different organizations have been taking to reduce electricity bills or carbon emissions." Connecting Bristol Programme Director.
		"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." BCC CIO.

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