ICT Industries as a Test Case for Practice-based Sustainability Research

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Practice-based research approaches to sustainability, which focus on the shaping of everyday life by infrastructures and systems of provision, are widely used in social science research (Evans, forthcoming; Rohracher 2008; Shove 2003; Urry 2010). Yet the impact of these ideas on public policies, campaigning groups and private industries has been minimal in the global north. Approaches to sustainability in business, government and environmental campaigning – with some exceptions, such as the New Economics Foundation (2010) – usually focus on individual behavioural change rather than systemic re-organisation. Elizabeth Shove (2010; 2011) has called for a paradigm shift in sustainability research, away from behaviouristic models and toward holistic, practice-oriented perspectives. Behaviourist approaches remain strong for many reasons that Shove (2010, 1280) elaborates on, including the political advantages of shifting responsibility for climate change onto individual citizens and away from governments and large corporate actors. Such approaches are also popular because they have an elective affinity (Weber [1905] 1992) with contemporary rhetorics of responsibilisation and neo-liberal valorisation of individual choice (Clarke 2005, 449).

High-profile case studies examining long-standing problems may help develop a wider audience amongst NGOs, governments and industry organisations for practice-based research. Information and communications technologies (ICTs) sectors, particularly data centres and online service providers, are excellent possibilities for such research. However their importance is not only due to urgent material reasons: resource use, pollution impacts from manufacturing and carbon dioxide equivalent (CDE) emissions (Schipper & de Haan 2005). ICT industries are a good test case because the structure, organisation and major ecological impacts of these industries present problems that *appear* to be best addressed with behaviouristic approaches. If useful practice-based solutions can be found for problems that seem unsuited to these methods, then a case like this could serve as valuable proof of concept for wider applicability. There are also political reasons to critically question rhetorics of and approaches to sustainability in these sectors. ICTs are widely used in monitoring and measuring schemes – particularly domestic energy use – that perpetuate behaviouristic models and inculcate consumer responsibilisation.

Within this sector, data centres and online services are a good research focus for several reasons. These facilities are central for ordinary computer users who rely on this infrastructure for everyday tasks, even though the overwhelming majority of users never set foot inside a data centre or have much knowledge about them. More important, however, is the role data centres are playing in the development of 'smart' networked technologies that assist in monitoring and allocating energy and resources for other sectors and the extent to which these facilities operate as testing grounds for energy efficient hardware and components. Data centres sit at the intersection of multiple energy-reduction pressures. Increasing energy costs were already a 'bottom line' problem before recent financial crises (Brill 2010) and since these events, the problem has only worsened. Moreover, for companies under pressure to adopt more stringent corporate social responsibility programmes, reducing ICT-related CDE emissions can be 'direct and relatively rapid to achieve' (Harmon et al. 2010, 2). Data centres workplaces are vital infrastructure for everyday uses of ICTs, but are also sites of innovation for ICT energy use reduction strategies and places where economic, social and ecological pressures generate a sense of urgency around decreasing energy consumption.

What could a practice-based analysis offer an industry that is oriented toward a behaviourist paradigm; whose climate change 'solutions' support behaviouristic models; and whose problems appear to be best conceptualised as issues of individual behaviour? Based on an analysis of technical white papers and reports, as well as pilot research with ICT professionals, I will also offer some tentative contributions that address current industry dilemmas: expanding demand for services (GeSI 2008) and rising energy prices (de Becker 2009; Green Grid 2007). An examination of normative practices in these industries, as explained in technical reports, white papers and industrial best practices, suggests that expansion is driven by a 'just-in-case' engineering paradigm (Green Grid 2010, 6) that encourages infrastructures built for peak, but more often excess, capacity. This paradigm is based on three problematic assumptions: boundless bandwidth and storage, boundless energy, and entitlements to permanence. These assumptions undergird the just-in-case paradigm but also support the fundamental illusion of our times: a magical belief in purely virtual services and commodities entirely decoupled from environmental impacts.

ICT sectors as an important test case

Much excellent practice-based scholarship has been published on visible sectors with damaging ecological impacts, such as transport (Featherstone et al. 2005) and the built environment (Rohracher 2008, Shove 2003). Like these other aspects of everyday life, ICTs – especially data centres and online service providers – are embedded in systems of provision that constrain sustainable practices and enable or facilitate resource inefficient ones. Conceptually, the structure and organisation of ICT industries, and the distribution of their CDE emissions, seem to present a perfect scenario for behaviouristic research (Steg & Vlek 2009, 310), with tens of millions of individual electronic devices whose users are engaged in bounded activities within an identifiable sphere of action. Industry professionals promote IT solutions to environmental challenges faced by other industries (GeSI 2008, 9–11; Koomey 2007; 2008), and these solutions take on familiar behaviouristic forms, such as energy use monitoring and metering. Information and communications technologies are used to sustain and reproduce behaviouristic solutions, and putative 'carbon savings' created in other industries become a justificatory rhetoric for ICT sector expansion (GeSI 2008, 10). Thus, interrogating sustainability rhetorics in ICT sectors calls into question the fundamentals of a particular environmental logic of contemporary society that relies on trade-offs rather than reductions and prioritises individual 'choice' and 'responsibility' rather than systemic change. Yet despite this elective affinity between ICT industries and behaviouristic perspectives, long-standing management and efficiency problems remain unsolved, leading some within these sectors and their allied academic disciplines searching for alternative approaches.

Industry structure, organisation and emissions

The structure of ICT industries and the ways these technologies are used in everyday life does not immediately suggest a systems-and-practices approach. Infrastructures upon which ICTs depend are very fragmented and decentralised (Abbate 2001, 157) and these technologies are integrated into everyday life through highly personalised devices and services. Though empirical data is somewhat sketchy on distribution and sources of CDE emissions by ICTs, the Smart 2020 Report (GeSI 2008, 17, 19) estimates that manufacturing, transport and disposal of electronic devices constitutes only 25% of global CDEs generated by ICTs. The other 75% of emissions produced by ICTs is generated in use through electricity consumption. Given these conditions, campaigns and research based on consumer behaviour change seem to be the most efficacious means of reducing climate impacts from this sector. From a behaviourist perspective, consumers appear to be 'at fault' for ICT emissions by using electricity to power their digital devices. Using an ABCs approach to ICT emissions, we can easily identify discrete behaviours, such as sending a Tweet, uploading images or watching videos, and associate these behaviours with particular attitudes about participation in social life, entertainment and information-seeking. The ostensible goal of such research would then be to change consumer attitudes about ICTs which would theoretically change electricity consumption. Conceptually, there seems to be a good methodological fit between the environmental problems presented by ICTs – consumer use that produces emissions through energy consumption – and a behaviouristic approach.

From a systems-and-practices perspective, if CDE emissions and pollution impacts from ICTs arise primarily through electricity consumption, then one of the key problem areas is how this energy is generated. Yet a strategy largely based on changing to renewable energy powered data centres – as suggested by Greenpeace (2011a; 2011b) – ignores a forty year history of rebound effects in digital technologies industries (Plepys 2002).

Hard drive prices provide an instructive example. Since 1980, the cost of digital storage has declined precipitously with more resource efficient designs and production processes (Grochowski & Halem, 2003, 341). This trend begins with small capacity magnetic hard discs and is today exemplified by pocket-sized storage media available from vending machines that can store more digital data than a supercomputer could in 1991. In the 1990s, digital storage was priced on a per-megabyte basis, but today IT professionals calculate with gigabytes or, more commonly, terabytes. As larger, cheaper storage media have been developed (and manufacturing has been re-located to countries with cheaper labour costs), the cost of storing data has decreased. New uses have been found for an excess of storage capacity: high definition videos and images, music and the return of the terminal under a new guise: cloud computing.

Graphics cards have followed a similar trajectory, from the combined sound and graphics units of the early 1990s to contemporary graphics cards with multiple on-board processors, heat sinks and cooling fans, while RAM has also become cheaper per megabyte. Computer software now requires massive storage media, large amounts of memory and storage. Users' ICT practices – streaming video, playing video games and internet telephony – also require this computing capacity as well as relying upon complex, often proprietary operating systems that are quite inefficient in terms of computing resources. From the most material aspects of producing digital devices, such as water waste in silicone wafer production, to the most virtual aspects of ICT use, inefficient memory allocation and computing cycle use in software, resource inefficiency or profligate overcapacity is an inescapable aspect of these technologies. When presented with increased efficiency, whether in terms of costs or computing resources – storage, memory, processing power or more recently, bandwidth – the response in designing and manufacturing digital devices, software engineering and user practices has been to leverage these efficiencies to produce and consume faster, cheaper, more resource-intensive machines, programmes and practices.[1]

This tendency within both ICT industries and consumer use and practices toward rebound effects casts current industry discussions about reducing sector CDE emissions in another light. The normative professional narrative about ICT climate change impacts tacitly relies upon offsetting increased sector CDE emissions with potential emissions savings provided by networked 'smart' technologies in other sectors (GeSI 2008). These possible 'savings' generated in other industries through use of ICTs provide an excuse for further development of excess capacity which will quickly be absorbed by new, increasingly resource intensive computing practices and software. With these trends in mind, an approach that seeks impacts reduction primarily by switching to renewable energy is laudable, but rather misses the point. Though this is a vital step, it fails to address the underlying causes of intensifying energy use in ICT sectors, which could be addressed with a systems-and-practices approach.

Monitoring, metering and missed steps

Practitioners position ICTs as ways to reduce CDE emissions and increase resource efficiency in other sectors through increased metering and monitoring of energy use through 'smart' energy grids, manufacturing technologies and so on (GeSI 2008, 9). From this perspective – which seems normative amongst industry professionals – climate change is a problem that can be solved through judicious application of minor technical 'fixes'. In the 'fight against dangerous climate change', ICTs are a 'key player' (GeSI 2008, 10), with networked monitoring technologies as the key plank in the anti-climate arsenal. The underlying assumptions of this logic are again behaviouristic. If companies, factories, families and individuals were only aware of the consequences of their decisions – if energy use was made more visible – then energy or resource use behaviour would change. This positioning of ICTs as crucial to global reduction of CDE emissions serves as an industrial regime of justification, based on 'efficiency of beings, their performance, their productivity and their capacity to (…) respond usefully to needs' (Boltanski & Thevenot 2006, 203–204).

The irony of this metering-and-monitoring role for ICTs in reducing climate impacts is that the energy efficiency approaches industry leaders wish to impose on other sectors are not standard operating procedure in most data centres (Blackburn & Hawkins 2009). Several metrics have been developed to assess energy efficiency in data centres, such as Power

Usage Effectiveness (PUE), Data Center Infrastructure Efficiency (DCiE) and Carbon Usage Effectiveness (CUE); PUE and DCiE express a relationship between total facility energy use and that used for ICTs, while CUE expresses the proportion of CDE emissions from a data centre arising from IT equipment energy consumption. Yet these metrics, unlike 'smart grid' technologies advocated by ICT leaders for use in other industries – which facilitate dynamic allocation of resources – only present a static representation of energy use rather than real-time monitoring of resource use. Unused server capacity, idle and forgotten machines are everyday problems in data centres that contribute to increased energy use. According to a Green Grid (2010, 2, 4–6) survey

> (...) only one-fifth of data center operators attempt to identify unused servers as part of their regular day-to-day operations. Those respondents who do look have an average of 10 percent unused servers in their data centers. Multiply that by the world's 44 million servers and the result is an estimated 4.4 million unused servers around the globe. (…) and the unnecessary emission of over 11 million tons of CO_2. (…)

Though software applications for monitoring server capacity exist, these applications are not widely used. The very idea of looking for idling machines or 'slack in the system' is an unfamiliar idea. In an industry that has historically been dominated by a 'just-in-case' peak-capacity-oriented business model and that has experienced strong growth along with declining hardware prices and, until recently, low energy costs, it seems quite reasonable (and consistent with business wisdom in the sector) to act on an assumption that if capacity is provided, it will be used.

Despite an apparent elective affinity between behaviourist approaches to climate impacts and ICTs, underlying problems arising from historical trends in these industries have yet to be satisfactorily resolved. This has led some practitioners to seek out different conceptual toolkits and adopt interdisciplinary approaches (Baker & Stocks 2007; Dedrick 2010; Jenkin et al. 2011; Watson et al. 2010) to re-think classic quandaries. This sense of openness to ideas from other industries, disciplines and so on, combined with a sense of urgency about reducing climate impacts – or being perceived to at least engage with 'green computing' issues –

creates an excellent opportunity for non-behaviourist social science approaches. With this in mind, what might a systems-and-practices perspective offer for ICT industries, particularly data centres and online services?

Changed priorities ahead

Perhaps the most important contribution a systems-and-practices approach could make would be a re-interpretation of sector problems with respect to their historical development. Though science and technology studies scholars have delved deep into science histories, computers and digital hardware are as yet unexplored territory. More study is needed to illuminate the developmental trajectories that have produced just-in-case thinking and engineering for peak in hardware, software and ICT services and infrastructures, but such an endeavour would be beyond the scope of this chapter. Instead, I will focus on what a systems-and-practices approach might contribute to what ICT professionals have identified as the key problem in the sector: energy efficiency. However, as previously mentioned, there is a historical tendency in this industry for efficiencies to be leveraged to produce rebound effects. This pattern is reiterated in contemporary narratives about ICT sector expansion which are justified or compensated for by possible emissions efficiencies achieved in other industries through 'smart' networked monitoring and resource allocation technologies. The main challenge for a systems-and-practices approach to ICT sustainability is to frame this problem of energy efficiency in a way that identifies the underlying practices and beliefs that generate this self-perpetuating dilemma.

From a practices perspective, the principal problem of ICT industries is not so much energy as *resource* efficiency, a challenge that spans the life cycle of digital devices from what Annie Leonard (2010) popularly calls 'design for the dump' to infrastructures designed for more-than-peak capacity. In data centres machines are 'spun up' for testing, then left running 'just to see how long they'll stay up', as Franklin, a security firm analyst said, while industry-wide there is a tendency to keep old machines running when no longer in use, to store and keep in operation servers set up for services no longer required by clients, and to keep physical machines running and connected to a network even after their tasks have been allocated to a virtual machine (Green Grid 2010, 3–4). To reduce excess energy usage to a matter of 'efficiency' in terms of facility energy use versus equipment energy use (as in PUE and DCiE metrics), or energy-at-the-plug versus manufacturer specifications (Brill 2010) or even virtualisation and virtual machines versus physical servers for each client or service, ignores everyday practices in these sites. These practices are rooted in a just-in-case mode of thinking that builds upon problematic, yet normative, beliefs about resources both material, such as servers, hard drives and energy, and virtual, like computing cycles, bandwidth and storage. There are three fundamental normative, problematic beliefs that contribute to a just-in-case mentality which is specific to data centres (even if we expanded our analysis to design and manufacturing or other stages of the ICT device and infrastructure life cycle these beliefs would remain relevant): boundless energy, boundless bandwidth and storage, and entitlements to permanence. I will consider each of these ideas briefly, and then explain how they come together in the resurgence of terminal-based computing.

Boundlessness and permanence

Though energy efficiency, the finitude of fossil fuels and problems with rising energy costs are often everyday concerns in data centre management, quotidian practices within facilities and commercial pressures illustrate underlying ambivalent assumptions. Commercial elements contribute to engineering for more-than-peak capacity (Green Grid 2010, 3) through standard Service Level Agreements (SLAs) between data centres and clients. These agreements can be financially punitive if required levels of service provision – which can include vague qualifiers such as 'poor user experience' or general service interruption – are not met by data centres. As data centre clients wish to provide reliable service for their downstream customers, or in-house employees in the case of outsourcing ICT needs, estimated technical requirements – bandwidth, server numbers, storage capacity – for SLAs are often padded, with clients requesting more-than-peak requirements. According to Franklin, it is not uncommon for data centres to slightly top up clients' estimated requirements as well: 'Hardware is cheap, and data centres usually have extra machines lying around anyway.' For Franklin, it is better to add a bit of extra capacity, 'just in case'. This mindset leads to engineering for excess and suggests a logic based on abundant energy and resources and scarce clients and money (in the form of unpaid service fees if SLAs are not met).

Though beliefs about energy abundance are made explicit primarily through ambivalent everyday practices, such as maintaining servers with older service configurations months after a client has migrated to new machines, and responses to commercial pressures, like padding service requirements to avoid violating SLA requirements, assumptions about boundless bandwidth and storage are more explicit. These two aspects of just-in-case thinking developed hand-in-hand. The past thirty years have seen a phenomenal decrease in computer hardware costs, particularly storage media. Though technological innovation plays a role in these decreased costs in terms of streamlined mass production techniques, use of cheap, often exploited labour in manufacturing and even device design has also brought down the bottom line for ICTs (SACOM 2010; CAFOD 2004), thus decreasing material costs for data centres. Storage media have become so cheap that unlimited storage is now taken for granted by users of online services and cost differences between data centre service plans are only rarely attributable to storage limitations. As a result of declining hardware costs there has been a rapid expansion of communications infrastructure over the same period, although telecommunications infrastructure costs have not declined at the same rate as hardware costs (Gray 2008, 66–67) – especially not when compared with the tremendous decline for storage media (Grochowski & Halem 2003).

Entitlements to permanence are more clearly articulated in user expectations, but these expectations are manifested in data centre storage practices. The proliferation of user accounts is an example of permanence entitlements, but commercial interests are also at play. Though only a few kilobytes are needed to store the details of an account – even if it includes credit card information – every transaction made, picture stored or song uploaded requires more storage. From a data centre or service provider point of view, user accounts are maintained as long as possible, 'just in case' the user decides to return. As users, we have an expectation that material stored with a given service provider will be there forever. After all, we have a user account. Yet we forget accounts and passwords, stop using an application or service, or sometimes even make a new account. The user account as a normalised practice is problematic, because it requires what is in effect perpetual storage – account deletion is quite rare, sometimes because online service providers make it quite difficult to find links to account termination – and thus reinforces a perception of boundless storage.

Normalised beliefs about storage and bandwidth abundance have enabled the return of terminal computing, now associated with pleasant images of fluffy clouds rather than glowing monochrome screens and text commands. Cloud computing is not a new idea, it is very similar to how computer networks used to function when storage was expensive, networks were small and permanence was attached to persons rather than user accounts. The main differences between today's clouds and central storage of the 1970s and 1980s are a fluffy image which conceals privacy and civil liberties issues, the size of files being stored and today's much vaster scale of users. Within a system where storage and bandwidth are treated as non-finite, and storage is expected to be permanent, the next logical step for a service is storing vast amounts of data and charging users for accessing it 'anywhere' – given users rely upon proprietary devices, file formats and operating systems for which they have also paid licensing fees. Cloud computing is an unsustainable practice which is splendidly facilitated by current systems of provision.

Some polemical thoughts

If cloud computing, which seems to be an increasingly necessary service given the highly mobile lives of affluent persons, and the proliferation of digital devices in consumer capitalist societies of the global north, represents a perfect blend of these three assumptions, how can we dismantle the practices that support it? The simplest answer, but the most difficult one in terms of operationalisation, is that the extent to which high levels of mobility and increasing quantities of electronics are framed as 'needed' for a particular kind of 'good life' requires urgent re-evaluation. Though these are good directions for sociological inquiry – and require more thought and research – my aim at the beginning of this chapter was to prove that a systems-and-practices approach could provide actionable ideas or solutions for ICT industries. Two sociological ideas that emerge from this analysis are a challenge to the notion of engineering for peak: just-in-case thinking and the idea of the user account in general.

Engineering for excess capacity is based on relatively static assessments of service requirements. Changes to SLAs and client demands would require an industry-wide discussion about the extent to which Panglossian beliefs about boundless bandwidth are not compatible with bounded ICT infrastructures. Practices in data centres that are built on assumptions of boundless energy – deactivating sleep or hibernation modes, leaving machines turned on after testing is finished – suggest that the level of resource allocation monitoring provided through ICTs with networked 'smart' technologies could be further deployed in data centres. Though some software tools have been developed for these purposes, they are not widely used.

Challenging the notion of a user account is rather radical from a computing perspective, but it is one possible first step toward changing a system of provision that assumes storage is unlimited by time or volume. Guest accounts, single use passwords, time-limited storage – a best-before date for digital goods – and shared accounts are all potential alternatives. Bandwidth or storage caps are also possibilities, but have proven unpopular. Attempts to impose metered network use in Canada by Internet Service Providers and the Canadian Radio-television Telecommunications Commission were met with strong citizen and consumer group opposition. Some massively multi-player online games delete character data if an account has not been used or fees have not been paid for six months. Yet these sensible policies are perceived as unfair by users, because a user account is something intangible yet perceptible, something that seems to convey certain rights (even when those rights are heavily limited by restrictive terms of service).

ICT professionals, even those nearing the end of their careers, have worked and lived during an era of abundance and declining material costs. The gradual reversal of these trends as a result of rising energy and 'spiking' hardware prices – hard drive supply shortages (Coldewey 2011) – and bandwidth metering debates, is difficult to harmonise with technological practices and approaches to problems that have developed under different circumstances with respect to resources.

From this point of view, the problems of ICT professionals are conceptually similar to those experienced in the consumer capitalist societies of the global north in which they are located: how can deeply entrenched practices and approaches that were built on a mentality of abundance, or alternatively phrased, boundless growth, be changed to reflect finitude? This chapter offers what engineers call a proof of concept, a demonstration of the feasibility of a practice-based analysis of energy and resource efficiency problems in ICT industries, particularly data centres. Though the suggestions offered are tentative, they offer a different way of conceptualising familiar sector challenges, and indicate that a systems-and-practices approach has something to offer for even an industry that might prefer behaviourist solutions.

Note

1 Transistor miniaturisation, which produces hotter-running processing units that require more energy for cooling provides another example of rebound effect in digital devices.

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