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URBAN LIVING LABS FOR THE SMART GRID

Experimentation, governmentality and urban energy transitions

Anthony M. Levenda

1. Introduction

A variety of urban actors are increasingly experimenting with smart grid technologies to simultaneously address climate change, environmental, economic and sustainability concerns. Reconfiguring urban electricity systems to allow for more renewable energy integration, increased reliability and new forms of consumer engagement have been seen as a vital ingredient for a smart, and low-carbon, energy transition. In attempts to govern energy transitions, sociotechnical interventions are being tested out in experimental venues where new knowledge can be gained on how cities are best to react to pertinent energy sustainability issues. On the one hand, experimentation offers opportunities for radical alternatives and innovations, and on the other, it may serve only to further support existing socio-technical regimes.

This chapter engages with the concept of urban living labs (ULLs) to investigate how experimentation impacts the city and its citizens. ULLs are seen as normatively ambiguous modes of technological implementation in the “real-world”, forms of experimentation that facilitate learning and experiential knowledge production, and social arrangements that interlink various actors from research and development to government and industry (Karvonen & van Heur, 2014; Evans & König, 2013; Voytenko, McCormick, Evans & Schliwa, 2016). The burgeoning literature and emergent policy attention to ULLs suggest that they can serve not only as one-off projects for demonstration but sustained socio-technical changes that help cities achieve goals for sustainability and low-carbon transition more broadly. At the same time, however, ULLs are often only ephemeral, mapping particular pathways and materializing visions, but not generative of systemic change.

ULLs have been implemented to address a variety of challenges, especially relating to climate adaptation, urban sustainability and more recently, “smart” technology. At the intersection of these challenges is the urban smart grid, which promises to allow for decarbonization of energy supply, increased grid reliability, and electrification of transport all while saving consumers money. The growth of smart city and smart grid projects has made integration of digital information and communication technologies (ICTs) a prominent part of the urban electricity system (Marvin, Luque-Ayala & McFarlane, 2015; McLean, Bulkeley & Crang, 2015).

The smart grid integrates ICTs with the electricity system to provide data on the use, distribution, supply and demand of electricity on the electrical grid. Equipped with sensors, monitors and internet-enabled digital communication devices, data circulates alongside electrons to provide information on outages, time of use, variations in loads, and energy consumption in fine-grained detail. But the smart grid is much more than an array of networked technologies. As Luque (2014, p. 160, emphasis added) explains

> the smart grid is an assemblage of networks, technologies, and users interacting through telecommunications platforms. It is a socio-technical intervention that relies on utility networks,

technological equipment and digital software as well as knowledge networks and an emerging set of user practices.

As a socio-technical intervention, smart grids offer a jumping off point for new relations of production and consumption, but also further investment and public buy-in for larger smart city projects including implementation of smart, networked technologies for transportation, environmental monitoring, water, waste, government operations, etc.

In Austin, Texas, an urban smart grid experiment known as the Pecan Street Project (PSP, named after the non-profit organization, Pecan Street, which organized and implemented the project) was developed to demonstrate and learn from various socio-technical interventions including high concentrations of electric vehicles and distributed solar, smart home technologies and advanced smart grid infrastructure. Fueled by local political leaders, a private–public partnership, and a national smart grid demonstration program (funding stimulus), the PSP was said to have created "the most innovative neighborhood" and the "world's largest database on customer energy use" (Frangoul, 2015). By engaging environmentally concerned and/or technologically savvy residents of the Mueller neighborhood (where the PSP is located) with incentives to adopt electric vehicles, solar panels, home energy management systems (HEMSs) and numerous other smart technologies, Pecan Street was able to get considerable participation and access to collect fine-grained data on energy usage of consumers. This data resource and development project has garnered attention from numerous city officials, technology companies and researchers interested in the smart energy transition and all of its possible benefits, including "jolting up the green economy" (Frangoul, 2015).

Austin's urban smart grid experiment discussed in this chapter configures governance through experimentation (Bulkeley & Castán Broto, 2013b; Castán Broto & Bulkeley, 2013a). However, experimentation is not solely about infra- structural change or urban entrepreneurialism. Rather it implies new possibilities for relationships between producers, consumers, infrastructures, and practices. This presents a need to investigate the way in which "participants" of experiments are enrolled in experimentation and how their activities, practices and conduct are as much the subject of experimentation as is infrastructural or policy changes. Decisions that shape and become embedded in ULLs, and the forms of experimentation they facilitate, influence the activities and practices of urban citizens. Therefore, we must consider the politics of ULLs design, their material and discursive construction, the forms of experimentation they facilitate, and related knowledge claims that are supported by them. This chapter suggests an analytics of governmentality helps us understand the power relations embedded in ULLs and how urban experimentation works to reconfigure everyday practices through smart grid technologies and infrastructures.

The chapter starts by unpacking the metaphor of the ULL to understand the epistemologies underpinning urban experimentation, with particular attention to the ways in which ULLs are created materially and discursively as particular places for technological demonstration and testing, so called urban test beds. Urban test beds are more limited than ULLs in that they focus exclusively on technological testing and demonstration, but often claim the same moniker of a "living lab". Then I discuss the development of a smart grid experiment in Austin highlighting how the project facilitated demonstration and test-bedding approaches with aims for attracting technology companies to the city, and embedding new logics and rationalities for organising energy practices and conduct.

2. Laboratorising the city: A smart grid experiment in Austin, Texas

The City of Austin has been recognized as a leader in sustainability. Austin is known for an environmentalist ethos that emerged most prominently in the actions to preserve Barton Springs and the Edwards Aquifer during the 1970s and 1980s, an issue that aligned various actors on two sides of a long-term environmental and political struggle (Moore, 2006). Since the early 1990s, the city has worked to tackle energy and climate issues through green building programs, energy efficiency strategies, and implementation of clean energy production. With the growth in Austin's economy – focused on creative and tech industries – the city is positioned as a leader for innovation in clean tech and clean energy solutions. The large research university – the University of Texas (UT-Austin) – has also positioned Austin as an important hub for knowledge-based industries, often leveraging university partnerships for research and development. Austin's organizational structure of energy provision also helps to foster an engaged citizenry: Austin has one of the largest municipal utilities in the nation, Austin Energy, responsible to Austin's City Council. These characteristics of Texas's most liberal and progressive city created a favorable environment for the smart grid demonstration project implemented by Pecan Street, a non-profit research and development organization.

The smart grid project, originally known as the PSP, aimed to research and learn from the implementation of various smart grid and smart home technologies—including solar panels, electric vehicles, various HEMSs, smart meters, control and visualization technologies and energy storage technologies – implemented in an urban neighborhood. The project started at the Mueller Development – a private–public redevelopment project that commenced in 2004 on a nearly 700-acre defunct airport base just three miles northeast of downtown Austin and the University of Texas. The redevelopment project was a source of political contestation during development and more recently during disputes over afford- ability and density (Clark-Madison, 2002; King, 2015; Reeves, 2008). As the LEED (Leadership in Energy and Environmental Design)-certified neighborhood was celebrated for its sustainability, it was able to gain the political momentum needed for implementation of the development plan. The "clean slate" of the new development project also served as an ideal location for the Pecan Street ULL project.

The demands of the smart grid experiment required a physical infrastructure that was already "modernized", or in this case, built from scratch. This included the development of Austin Energy's smart grid platform (Carvallo & Cooper, 2015), new green-built homes, and Pecan Street's own information and communications or smart grid network. In addition, to test various smart grid technologies, the research participants needed to acquire various smart grid technologies – everything from solar panels and electric vehicles to smart appliances and HEMS equipped with visualization and control technologies. The new development project in central Austin was the ideal location for this ULL also because it served as a way to recruit participants for the research Pecan Street would conduct. As one of the studies based on the demonstration project describes it: "Mueller was selected as the test-bed for this research project because of its location, the relative uniformity of new homes, and the developer's requirement to build energy efficient homes and buildings" (Rhodes et al., 2014, p. 463).

The ULL project started as a partnership with the University of Texas, the Mueller Development, the City of Austin, Austin Energy (the municipal utility), the Austin Technology Incubator and industry partners led by the non-profit umbrella organisation, Pecan Street, Inc. Now known simply as Pecan Street, the organisation has been leading research and implementation of smart grid technologies on "the consumer-side of the grid" (Pecan Street representative, Interview, October 2015). The smart grid experiment started as an "energy internet demonstration" project, spurred and supported by a Department of Energy Smart Grid Demonstration grant part of the larger American Recovery and Reinvestment Act (ARRA) of 2009. An initial chairman described the genesis of the project and explained its initial purpose and goals:

> We started working and focusing on the data acquisition and manipulation side of energy, energy efficiency, renewable energy, electric vehicles and so forth. [. . .] Through that grant we were able to focus on a mass deployment of both electric vehicles and solar. We had the highest concentration of

> electric vehicles and solar in any neighborhood in the country. [. . .] One of the arguments we made for them was that there was plenty of capacity for the electric vehicles because people would be charging at night. Well, we actually didn't know that [laughter] and if everyone was plugging in their vehicles and charging them in the afternoon, then that adds to the problem rather than relieving it. Fortunately, the research has shown the charging is spread out pretty evenly throughout and we were able to document that and show it.
>
> (Former Austin Energy Executive, Interview, May 2016)

As the interview quotation above suggests, the project was aimed at proving that smart grid technologies would allow integration of electric vehicles and distributed solar generation reliably. The data collected through the smart grid project also helped show the efficacy of interventions, with granularity providing greater insights. Just two miles northeast of downtown on of data power nderstand the impacts on privacy or equity. But these technologies are no. By focussing on energy monitoring and data collection, Pecan Street's database, analysis and sharing wiki, Dataport, the group has built a fundamental resource for energy research in smart grids. The dissemination of information via Dataport on energy consumption and production has influenced numerous lessons and possible research trajectories on energy management both by consumers and utilities (inter alia Alahakoon & Yu, 2013; Ranganathan & Nygard, 2011). This ever-growing dataset is informing research on a variety of issues positioned as solutions for numerous energy and environmental problems (such as climate change) and technical problems for utilities (such as demand side management and peak load shaving). This focus has positioned this smart grid experiment as a place for learning about how to create a viable and profitable smart energy transition.

Austin's smart grid experiment is an example of the way cities are increasingly made the node for experimentation with socio-technical interventions for sustainability and low-carbon transitions through so-called living laboratories (Evans & König, 2013), urban laboratories (Evans & Karvonen, 2013; Karvonen & van Heur, 2014) and ULLs (Reimer, McCormick, Nilsson & Arsenault, 2012; Voytenko et al., 2016). The concept of the laboratory invokes the idea of a sterile, enclosed and exclusive space for knowledge production wherein scientific experiments are run separate from society (Allen, 2011; Evans & Karvonen, 2013; Gieryn, 2006; Gopakumar, 2014; Heathcott, 2005; Strebel & Jacobs, 2014). But classic work in science and technology studies (STS) – especially laboratory studies in the late 1970s – examined and unpacked the "hard core" of scientific work: its technical content and the production of knowledge (Knorr-Cetina, 1995).

The laboratory itself, as Knorr-Cetina (1995) posits, is an important theoretical notion in the social studies of science because it reveals "the power of locales in modern institutions and raise[s] questions about the status of 'the local' in modern society in general". At the same time Livingstone (2010, p. 3) suggests that the laboratory is a privileged place of knowledge production, where a concerted effort was made to create it as a "placeless place" to do scientific activities and where local contingency has no impact on those activities. A laboratory here is the same as a laboratory anywhere. This "placelessness" was also key to securing the credibility and objectivity in the production of knowledge.

The concept of placelessness poses practical difficulties for ULLs, however, because they are situated in urban contexts that have histories, cultures and economies that bleed through porous boundaries presenting a complex mix of endogenous and exogenous factors contributing to observed changes. At the same time, the place of an ULL tends to influence the legitimacy and credibility of knowledge claims within and about the city (Gieryn, 2006). For example, early Chicago School urban sociology used the city variedly as a field site – an uncorrupted reality – and a laboratory – a controlled environment providing the ability for generalisations true for other cities. ULLs tend to draw on the virtues of both lab and field, wherein the city becomes both the object (what) and venue (where) of study, allowing multiple modes of inquiry to make "valid" claims while "creating a discursive situation in which location, geography and situated materialities get foregrounded as ratifiers of believability" (Gieryn, 2006, p. 28). Sites where knowledge claims are made about the efficacy of urban sustainability or low-carbon transitions thus have a bearing on how urban sustainability or low-carbon transitions are defined and legitimated, and how they gain wider acceptance as models and exemplars producing "best practices" for any other place.

As a mode of governing urban socio-technical systems, such as the smart grid, ULLs facilitate forms of experimentation that utilise place-based claims and claims to placelessness simultaneously. This central tension filters through the two modes of governance examined in this chapter: governing by experiment and governing energy conduct. First, governing by experiment relies on place-based claims to demonstrate the efficacy of urban experiments to provide material manifestations of possible futures, and to show how novel socio-technical configurations work in the real-world. At the same time, knowledge generated from these experiments is supposed to be useful in other places, providing a real-world "truth-spot" that attests to the legitimacy of claims. The design and siting of the ULL are important political resources for giving authority to experiments and building momentum for transitions. As Gieryn (2006, p. 28) notes, "political pronouncements have different consequences when uttered from the street corner – or from the floor of an official parliamentary space". So, while experimentation may harness the radical contingency and messiness of cities, ULLs provide a structured and politically powerful space for protecting and nurturing socio-technical interventions.

Second, governing energy conduct refers to a specific form of urban governmentality that rests upon an imagined smart consumer subject. Instead of using place or placelessness to support claims, this form of governing uses the discursive space of the "laboratory" to attempt to shape actions and behaviours through appealing to particular rationalities based on neoliberal conceptions of homo-economicus, or economic man. Similar to Strengers (2013, p. 51) "resource man" – "a data-driven, information-hungry, technology-savvy home energy manager" – homo-economicus captures the economic and entrepreneurial subjectivity of energy users implied in many ULL strategies. The critical perspective of governmentality helps us locate and potentially confront the dominant neoliberal political rationality shaping urban smart grid experiments.

These forms of governing are important because they become embedded in the materiality of the urban and in the technologies and infrastructures of ULLs. In particular, technological systems generate certain forms of "user scripts" – sets of "normal" and acceptable use for various technologies – which govern the way people use technologies (Oudshoorn & Pinch, 2005). These technological inscriptions are of course contestable and open to change. Technologies have "interpretive flexibility" but often are locked-in over time (Bijker, Hughes & Pinch, 1987), becoming part of larger socio-technical systems, sets of practices and political economic rationalities that make them resistant to change. As smart technologies are implemented in the context of ULLs, they configure particular sets of user practices normal and acceptable, while also creating new path dependencies and reconfigurations of urban infrastructure.

3. Governing through experimentation: Technological demonstrations and test bed urbanism

Experiments are "purposive and strategic but explicitly seek to capture new forms of learning or experience . . . they are interventions to try out new ideas and methods in the context of future uncertainties serving to understand how interventions work in practice" (Castán Broto & Bulkeley, 2013, p. 93). They offer the "means through which discourses and visions concerning the future of cities are rendered practical, and governable" (Bulkeley & Castán Broto, 2013b, p. 367). The way localities respond to and govern energy challenges such as climate change and sustainability are, in part, choreographed and mediated through the experimental landscapes and infrastructures of ULLs.

Thus, ULLs not only require consideration as spaces of knowledge production and innovation, but also as places where (the future of) cities are governed.

While experiments offer opportunities for learning and radical innovation, they also may simply reinforce existing regimes. Experiments are often driven by the motivations of powerful actors – profit, a sense of urgency to act, a desire to expand authority and express ideologies. These are all clearly visible in the ways cities are responding in experiments, and in the visions they express discursively and manifest materially (Hodson & Marvin, 2009b; While, Jonas & Gibbs, 2010). At the same time, experiments can be exclusionary, technological "fixes" for issues that are inherently social and political, reflecting particular visions of powerful actors and interests reinforcing or creating new injustices (Swyngedouw, 2011; While, Jonas & Gibbs, 2004). Experimentation offers opportunities to "open-up" the city for private investment and control of urban infrastructures. Fitting with the dominant form of neoliberal urban governance, governing through experiment aligns with the entrepreneurial role of local governments (Davidson & Gleeson, 2014; Hall & Hubbard, 1996; MacLeod, 2002). As Harvey (1989, p. 5) argued, with the turn from managerialism to entrepreneurialism in urban governance, "investment increasingly takes the form of a negotiation between international finance capital and local powers doing the best they can to maximise the attractiveness of the local site as a lure for capitalist development". Opening up the city as a test bed or a demonstration site for new smart technologies provides an opportunity to attract highly mobile capital. However, this may have "splintering" impacts in the city (Graham & Marvin, 2001) that create spaces of high value while simultaneously excluding and marginalising other spaces and communities.

In Austin, for example, the Mueller redevelopment project has struggled with the problematics of meeting and sustaining affordable housing requirements guaranteed in the original partnership and development agreement. This problematic stems from the Travis Central Appraisal District (TCAD) methods for taxation, appraising affordable housing at market rates, sometimes 100 per cent over the purchase price (King, 2015). While the rising attention to the Mueller redevelopment as a model of sustainability has captured the attention of so-called new urbanists and sustainability officers of cities around the world, it has also contributed a growing unaffordable housing market and the correlated issue of greater displacement of communities of color in east Austin (Long, 2016).

While the affordability issue of "losing properties to the market" (Representative of Mueller Development, Interview, November 2015) was battled with a non- profit organisation, the Mueller Foundation, considerable taxation increases based on market-rate appraisals were creating un-affordable conditions for many homeowners. The program's commitment to a sustained affordable homes program is laudable, but the struggle to keep housing "off the market" will likely continue as the redevelopment project continues to add new housing units into the future. And while many of the initial homeowners benefitted from the subsidies and tax breaks organised by the PSP, state government and federal government, the access to smart grid technologies (including EVs (electric vehicles), PV (photovoltaics) systems, HEM (home energy management) systems, smart appliances, etc.) may not reach the broad growing community of affordable homes buyers. The affordability issues are not only tied to the improved infrastructure of the redevelopment and the technological innovation spurred by the ULL project, but it also signals a larger trend in the political economy of Austin's urban development with the creation of "ecological enclaves" (Hodson & Marvin, 2010) for well-off sustainability-minded citizens and urban "technological zones" (Barry, 2006) for the testing and establishing network and connection standards for new ICT infrastructures.

As a sustainability-focussed development with a "clean-slate" of green-built homes, and a newly modernised electrical grid, the smart grid experiment and demonstration was thought to "logically" fit at Mueller. In the new redevelopment project, infrastructures were designed to be amenable to smart grid technologies, the newly built homes were developed with a sustainability focus, and the larger vision for Mueller was to be an icon and demonstration for urban sustainability. This vision and context facilitated the demonstration and test bed approach to the ULL at Mueller, which may have foreclosed opportunities for more radical socio- technical innovations producing more just and sustainable outcomes.

3.1. Demonstrating the potential of urban smart grids

Providing vision and leadership is essential to governing in a democracy (Ezrahi, 1990). ULLs test out competing visions of urban energy futures that align various actors around extensive reconfigurations of urban infrastructures (Bulkeley, Castan Broto & Maassen, 2013). These visions reflect broadly shared values and beliefs about technologies and their social impacts (Jasanoff, 2004; Jasanoff & Kim, 2009). ULLs offer ways to produce, reinforce, and strengthen particular visions of technologically mediated urban futures (Bulkeley & Castán Broto, 2013b; Hodson & Marvin, 2009a; Reimer et al., 2012). At the same time, they provide opportunities to address global climate and energy concerns with particular "testable" or demonstrated solutions in localised places (Bulkeley & Castán Broto, 2012; Castán Broto & Bulkeley, 2013a). Alternative conceptions of urban experimentation offer different and often competing modes of knowledge production about urban sustainability that provide a different set of norms and rules by which communities can respond to climate change.

In the case of the Pecan Street smart grid demonstration project, it was cast both as a demonstration and a place of learning and experimentation. Given the context of the project – the Mueller development – the Environmental Defense Fund (2014) ardently promoted it:

> The Mueller neighborhood, the locus of Pecan Street, is a laboratory of ideas and technologies that will move the nation's $1.3 trillion electricity market toward a future in which energy is cheap, abundant and clean. If Pecan Street is successful, every neighborhood in America will look like it in 20 years.

Creating knowledge in ULLs has an intense focus on learning and demonstration. Thus, the way people view the ULLs and the knowledge they generate or demonstrate is integral to the activities conducted within. By focussing on energy monitoring and data collection, the Pecan Street database, analysis, and sharing wiki, Dataport, is a fundamental resource for energy research on smart grids. This database serves several purposes. First, it offers researchers data on energy usage where smart technologies have been implemented. This influences research findings and possibly, future policies regarding smart grid systems. Second, it offers companies opportunities to see how effective their technologies are, both in terms of energy efficiency or reliability, and in terms of customer acceptance. As one Pecan Street representative explained:

> We're always happy to exchange information with people. It really helps that we are a non-profit. I talk to cities; I talk to for-profit companies. We meet with them and they say, what have you learned, and I'll be happy to tell the for-profit company that is trying to build a product that this is what we've learned, this is what's failed, and this is what's succeeded. [. . .] My job is to make sure we can get as much data as possible to give to people so they can utilize it and learn from it.
>
> (Interview, October 2015)

ULLs, thus, can be viewed as a "theatre of proof " (Simakova, 2010; Smith, 2009) for ways of configuring smart technologies in urban space to achieve sustainable, low-carbon outcomes. Stemming from work in STS around the role of demonstrations and public engagement with technology (Laurent, 2011; Marres, 2011; Marres & Lezaun, 2011; Rosental, 2014), especially in contemporary practices of the product "launch" in high-tech industries, this notion of the theatre of proof typically is framed by the situation where an organisation “offers a “novel” product to “the market” (Simakova, 2010, p. 549). ULLs are not only places of knowledge production, but venues for linking technological artefacts and publics. In this sense, ULLs serve as mediators between possible socio-technical futures and a wider public who might adopt the knowledge or technological systems emanating from the living lab.

3.2. ULLs and test-bed urbanism

Connecting local, place-based “experiments” to broader urban transitions has been the subject of much research on urban sustainability transitions. As protected niches, ULLs might serve as mediators in urban energy transitions, but they are also geographical configurations that leverage local and regional assets to address more than local concerns and influence broader global audiences. The conception of test-bed urbanism (Halpern et al., 2013) helps to explain how urban spaces are configured for technological testing, as “platforms” for ICT and smart city technology development. The rise of so-called “platform capitalism” (Morozov, 2015) makes information infrastructure central to the provision of urban services, from transportation to energy, marked by the growth of the knowledge-based and sharing economies.

The platform metaphor is popular in the electricity industry. In Austin, Pecan Street’s conception was formulated around the idea of an “energy Internet” – an open platform for testing a variety of smart grid technologies. The group developed their own open platform that fits with the broader movement towards creating an “information technology platform that makes possible a wide range of new products and services that provide customer value” where “mobile phone app stores and the Internet provide powerful examples of how a grid operator can earn more revenue and catalyze significant private sector opportunity by structuring its grid as a platform for a broad range of private sector activity” (Pecan Street, 2011, p. 7). The obvious allusions to the platform services such as Facebook, Amazon and Uber are discussed here as models for the electric grid.

This allusion to cell phone apps provides a vision of a radically decentralized electricity system where grid operators supply a platform and utilities and new energy companies offer energy services to customers in a highly competitive electric marketplace. This vision has captivated a whole array of private sector actors operating on speculative future scenarios to capture the growing smart grid and IoT markets. Cities operating in financially restricted positions with limited budgets and pressures to develop and meet a variety of public needs find this opportunity to attract capital enticing, thus creating entrepreneurial strategies to retain large smart grid and IoT companies.

In Austin, the Chamber of Commerce has a specific strategy to attract start-ups with potential to receive venture capital for growing their companies. Start-ups working on clean energy and power technology, creative and digital media technology or data management are able to add to the key industries in Austin, all of which relate to smart grid technology and development. The Austin Chamber of Commerce boasts the municipal utilities commitment to renewable power, the Pecan Street’s research potential, and ERCOT (Electric Reliability Council of Texas)’s willingness to integrate clean energy companies into their electric grid as drawing points for energy companies. Supportive of these efforts is the University of Texas Clean Energy Incubator, the CleanTX cluster development organization, and the already large clean tech industry located in Austin. But the city more largely is thought of as an experimental space for these companies, nurtured by the various resources the city offers. As one Chamber of Commerce representative explained:

> We were tasked with bringing the industry, bringing the clean industry. [. . .] What’s the future of clean energy, clean tech? Its that efficiency piece, right. So, clean energy has grown into from renewables, natural gas, whatever into this “how can we do things better, cheaper, faster”? Pecan Street is a great example. [. . .] There are a lot of software engineers here, there are a lot of people

who know how to analyze data. Austin is a good fit for those companies. This is a natural place for them to be. [Clean tech] is going towards devices that communicate to create efficiencies. Austin [has a] lot of software engineers, and there is an incredible quality of life. You've got the Pecan Street Project where companies can test their sensors.

(Chamber of Commerce Representative, Interview, November 2015)

ULLs seem to be far from neutral technological niches, but strategic resources for cities to attract capital. The generalized version of this approach to governance suggests that these spaces aren't merely "niches", but important parts of a strategy to transform the urban fabric into a platform for socio-technological experimentation. This implies that social practices and infrastructures are malleable rather than obdurate and structured. But this fails to account for social divisions and social structures that shape everyday practice. In Austin, for example having a large public–private redevelopment project provided the opportunity for the smart grid demonstration project to flourish in a community of so-called "early adopters": largely upper middle class residents that are motivated to save energy or participate in new technology testing.

Like, these incubator companies will come up to us, I have this product, I need to get it field tested. We have three hundred volunteers in this neighborhood who will let us install it in their house. And, I would say, more than half of them want it in there, and the other half you usually have to convince a little bit with a financial incentive [. . .] and most of them will say yes, but more than half will jump at the fact to become a test-bed. So I would wholeheartedly agree with that synopsis of Mueller [as a living laboratory]. It's a really great test-bed of people that are, you know, early- adopters.

(Pecan Street representative, Interview, October 2015)

This points towards an area for further research on governance experimentation: the role of citizens. While there are examples of grassroots approaches to urban transitions that promise greater democratic engagement (Blanchet, 2015; Seyfang & Haxeltine, 2012; Smith, Hargreaves, Hielscher, Martiskainen & Seyfang, 2016), this Austin ULL utilises a top-down approach where residents are encouraged to install technologies, receive incentives or benefits for doing so, and in return, participate in the research that monitors energy consumption and performance. This approach relies on "early-adopters" who are willing to participate in already designed programs, unlike a grassroots approach that focusses on collective visioning processes and collective ownership to govern energy system change. The focus of approaches taken in Pecan Street research, instead, is on individual energy consumption behaviors and technological efficiency, fitting with the existing regime of energy provision. Certainly, ULLs are useful for understanding the technical limits of the smart grid; however, this approach contributes to the lock- in of particular pathways for smart grid development without broader consideration of the various concerns of citizens or with structural limitations to managing energy consumption and production.

In addition, governing by experiment in demonstrations and test-beds suggests that a particular governable subject already exists. However, in ULLs and other urban experiments, urban citizens are the engaged customer, active participant, technology adopter. The literature on urban experiments has treated these urban socio-technical interventions as projects applied to existing urban landscapes and populations. However, as suggested with urban smart grid experiments, the governing of energy use is enacted through particular imagined subjects.

4. Making smart consumers and governing demand

ULL projects offer new opportunities for various actors to participate in urban energy and sustainability transitions. If ULLs take on test-bed or demonstration approaches, what are the roles of participants and other actors? Do test-bed approaches suggest citizens are just consumers awaiting more sustainable technologies, or are they passive observers of demonstration projects, waiting to lend their approval for new technological solutions? As smart grid experiments proliferate, customer-utility relations are being reconfigured. The consumer, or household, is positioned as an engaged and active consumer, making decisions about energy consumption throughout the day. The smart grid enacts a set of relations and practices, both materially and discursively, wherein the conduct of end users is governed through "technologies of government" guided by particular political-economic rationalities. Smart grid experiments reconfigure familiar domains and categories – the household, the consumer – to govern how everyday practices are performed.

For example, smart grid demonstration projects have increasingly used the vocabulary of customer engagement and empowerment (Gangale, Mengolini & Onyeji, 2013). The customer moves beyond the role as a passive consumer and becomes an active participant in the electricity grid with new responsibilities, choices and opportunities (Naus, van Vliet & Hendriksen, 2015). Yet, as this discourse becomes pervasive, there is still little evidence that households are afforded autonomy or agency for engaging in energy transitions, with existing regimes playing dominant roles in shaping the implementation and standardisation of smart grid systems (Goulden, Bedwell, Rennick-Egglestone, Rodden & Spence, 2014).

The growth in attention to demand response, time-of-use pricing, and other "customer side" interventions have been celebrated by utilities and electricity providers as potential opportunities to shave or shift peak demand while increasing customer awareness and engagement. Yet, these practices rely on significant changes in energy consumption that have not been realised (Hargreaves Nye & Burgess, 2013). Underlying much of these programs is a conceptualisation of the end-user as a rational economic actor, or what Strengers (2013, p. 51) calls "resource man" – "a data-driven, information-hungry, technology-savvy home energy manager". These depicted end users are imagined as smart subjects, conscribed by social norms, expected to perform scripted uses for smart technologies with the encouragement to act rationally and responsibly. Governmentality helps us analyse how power operates beyond consensus or violence, linking technologies of the self (self-regulation) with technologies of domination (discipline), while also providing a linkage between the state apparatus and the constitution of the subject. Foucault posited that power was about "governing the forms of self-government, structuring and shaping the field of possible action of subjects" (Lemke, 2002, p. 50), or in other words, the "conduct of conduct".

Foucault also suggested that political rationality creates a discursive field wherein the exercise of power is made rational, "examining how forms of rationality inscribe themselves in practices or systems of practices, and what role they play within them, because it's true that "practices" don't exist without a certain regime of rationality" (Foucault, Burchell, Gordon & Miller, 1991, p. 79, italics added). Thus, if we take governmentality as a way to understand governing of urban energy systems, we must understand the way governing operates through the practices of those being governed (i.e. subjects), and the political rationalities informing these technologies of governance.

For example, Bulkeley, Powells and Bell (2016, p. 20) argue that governing energy use in the smart grid "works through the disposition of socio-material configurations through which conducts unfold and accompanying processes of normalising what constitute both acceptable and optimal forms of conduct", and that smart grids entail a specific governmental program that works through "recomposing the ways in which everyday practices are conducted". It is in this sense that the reworking of relations of consumption and production in smart grid experiments can be understood through the notion of governmentality.

Smart grid experiments, as a governmental program and specific locale (i.e. in a ULL), suggest a proper and optimal form of energy conduct for their participants. The idea of "self as enterprise" (McNay, 2009) is central to the implementation, political legitimacy and "success" of smart grid experiments. The promise of smart grids relies, in one part, on behavioural changes of users, expecting “smart users” to become active participants in the smart grid, performing their part as solar pioneers, eco-energy misers or flexible energy users adjusting consumption to the dynamics of a time-of-use rate structure. In this sense, smart grid experiments “success” presupposes (rational and individual) market actors who manage their everyday practices in a careful, calculative and reflexive way.

But as the experience in some of the households in Austin’s smart grid experiment show, people do not necessarily act “rationally”. A Pecan Street representative explained this point directly with a story of a multi-family tenant and research participant:

> We found crazy stuff occurring. You know, we showed up to one unit. And, the guy knocks on the door, our technician, and he’s like “Oh I’m here to diagnose, there is a problem with our monitoring device,” and the guy goes, “Oh yeah what’s going on?” And he’s like, “well it always shows your oven’s on”, and the guy goes, “yeah, my oven is on,” and our technician was like, “no no no no, we show that your oven is on” and the guy’s like, “yeah yeah yeah, my oven’s on.” And it turns out this guy just like left his oven on all the time.
>
> (Pecan Street Representative, Interview, October 2015)

Similarly, a representative from the Environmental Defense Fund explained that from his research in the smart grid experiment in Austin, and on energy more generally, people just don’t think or care about energy enough to change their behaviour or their practices.

> It’s a very wonky subject, its not necessarily the most interesting conversation material for a lot of people so one barrier is just peoples interest levels. There is a statistic that is widely quoted that people think about their energy bills and electricity six minutes a year. For most people its not something that you choose to focus on. [. . .] Even if they don’t think about it that much, they think about ways to save money, if something is a no-brainer, then you make that choice.
>
> (EDF Representative, Interview, October 2015)

As energy researchers engage with smart grid users, they often seem to get dismayed by the irrationality of human energy decisions. As the quote above illustrates, the researchers involved with smart grid experiments understand that end users don’t necessarily think about energy very often, but they still feel they can be persuaded economically. However, this logic is changing the nature of smart grid implementation. Lessons learned from early studies on energy efficiency impacts of smart meters and in-home displays suggest little evidence of sustained behavior change (Hargreaves, Nye & Burgess, 2010; Hargreaves et al., 2013). Studies on voluntary demand response and time of use pricing have indicated that these options may work (Dyson, Borgeson, Tabone & Callaway, 2014; Muratori, Schuelke-Leech & Rizzoni, 2014), but the trend towards automating decision making to maximize energy and economic efficiency seem to be the dominant trend. As one EDF representative explained:

> In terms of energy efficiency and smart grid and how they are related, its just sort of the next evolution. It’s using machines and technology that doesn’t have the human error element or the human interest level. You have these items programmed to be more efficient and at scale that will take a lot of the human element of being more efficient with energy out of the equation. [. . .] I mean, humans might want to act with the environment in mind, but they have their priorities and they have a lot of other things to do that day, and some things slip through the cracks, and if you want to be a good environmentalist but that’s a low priority for you that can slip through the cracks and the technology can make it a lot easier.
>
> (EDF Representative, Interview, October 2015)

While automation may provide energy and cost savings for end users, it also rationalizes and normalizes the deep integration of smart technologies in everyday life most probably without deliberation over end users concerns or values. Putting in place of a technological fix for the seeming inflexibility of energy demand and the irrationality of human behavior frames these problems as purely technical ones. But, these problems are more than technical. Energy demand is structured by the rhythms and patterns of everyday life (Walker, 2014). Consumption is not for the sake of consumption, but rather for aiding in everyday practices shaped by social norms, habits, economic demands, and other conventions (Shove, Pantzar & Watson, 2012; Shove & Walker, 2014). The limitations of the techno-economic approach exemplified by the forms of experimentation discussed in this chapter explains, however, that the design and implementation of ULLs – whether for smart grid experiments or other purposes – need to be questioned along axes of social and political concern. Who shapes the agenda and vision of a living laboratory, what are the planned outcomes and impacts, and who benefits? All of these questions require further consideration in the study of ULLs.

5. Conclusion

In this chapter, I have highlighted how a specific ULL was constructed materially and discursively as a place of demonstration for public approval and a test bed for smart technologies. Although there are certainly positive benefits from smart grid implementation and demonstration, the role of citizens in determining or influencing the pathways to a smart energy future seem to be limited to very narrow realms of participation through consumption. I suggested that the approach of neoliberal governmentality helps explain how the actions of users of ULLs are governed – proper forms of conduct that adhere to particular governmental rationalities described by techno-economic concerns. However, a contradictory trend towards automation and algorithmic, market-minded decision making – a technological fix – is progressing such that the "empowered" consumer no longer needs to act on information provision, they simply adopt technologies and enrol in programs, reinstituting a passive consumer role.

Therefore, while the current approaches to smart grid experiments rely on reshaping the "conduct of conduct", there is a trend towards automation and a techno-economic fix which vastly diminishes the potential for democratic engagement with planning or shaping energy systems. Just as smart city strategies that promise safer, healthier, more democrati, and sustainable cities, urban smart grid projects promise greater roles for consumers and place responsibility on citizens to facilitate change under a constrained environment and set of conditions. Yet, the agency of users is limited to consumption habits, preferences and technology adoption. As ULLs for smart grid projects serve as demonstrations for particular pathways, there is risk that lock-in will occur without engagement of a broader public sphere (Verbong, Beemsterboer & Sengers, 2013). Experimentation must account for alternative visions to avoid furthering the notion that users and citizens are just barriers to smart grid implementation.

With the ever-greater entrenchment of smart technologies, greater amounts of data are also being collected and analysed. With the smart grid, this offers opportunities for the deepening of surveillance in everyday life (Klauser & Albrechtslund, 2014), while at the same time strengthening the opportunities for "corporate storytelling" to further normalise unequal social relations in the smart grid and the smart city by placing the private corporation – with profit motives – at the centre of the construction and implementation of smart urban technologies (Söderström, Paasche & Klauser, 2014). The governmental rationalities of these projects must also take into account these private interests and the prescribed roles for urban citizens – now as smart-users, Resource Men or neoliberal consumers. By highlighting how particular governmental rationalities enable particular technologies to arise as solutions to urban problems, the problematics of "smart" user subjectivities in smart grid experiments, and the limitations of demonstration and test-bed approaches to ULLs, this chapter has raised several critical issues for future scholarship on ULLs. First, although ULLs promise ways to test-out and experiment with solutions to climate change and urban sustainability, they are in large part shaped by existing socio-technical regimes with political economic interests and goals of developing technological fixes to urban problems. This may contribute to the creation of pockets of sustainable development in the city where only small portions of the population benefit. However, ULLs together with bottom-up, citizen driven action can facilitate more radical and alternative changes,

a point which should not be discounted.

Second, as demonstrations, ULLs are significant opportunities to enrol public support for addressing key issues in transitions to urban sustainability or renewable energy. Yet, these approaches seem to have a limited conception of how users can interact with and participate in energy transitions. The Austin case study demonstrates that techno-economic approaches seek to regulate the conduct of individuals through economic incentives, but this limited approach fails when people act irrationally. Thus, a less democratic option of centralised automation and control is being pursued in smart grid implementation as a technological fix for the barriers of active human and user participation. These trends point towards the necessity of reinvigorating experimentation in ULLs with a radically democratic agenda. We should take seriously the role that seemingly one-off experiments have for possible co-production of more sustainable and just urban futures.

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