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Regional sociotechnical imaginaries and the governance of energy innovations

Anthony M. Levenda[a,*], Jennifer Richter[b,c], Thaddeus Miller[b], Erik Fisher[b]

[a] Department of Geography, University of Calgary, Calgary, AB, Canada
[b] School for the Future of Innovation in Society, Arizona State University, Tempe, AZ, United States
[c] School of Social Transformation, Arizona State University, Tempe, AZ, United States

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ABSTRACT

Discourses surrounding the design, development, and implementation of contemporary energy innovations variously promise to enhance the reliability of the energy grid, incorporate renewable energy, enable low-carbon transitions, and lead to greater convenience and lower costs for customers. Such wide-ranging visions are constructed and reinforced by sociotechnical imaginaries, or collectively held social beliefs and values that shape and are shaped by innovation processes. In order to understand how national sociotechnical imaginaries interact with social and technological order within smaller locales, we comparatively investigate the development of energy innovations of smart grids and distributed generation in two United States regions – the Pacific Northwest and the Desert Southwest – and two metropolitan areas within those regions – Portland, Oregon, and Phoenix, Arizona. Our findings indicate that the multi-level governance of innovation in energy systems is shaped not only by imaginaries at the national level, but also through imaginaries at the regional level. Our cases of Portland and Phoenix illustrate how different socio-cultural and political-economic contexts interact with and produce variations of national sociotechnical energy imaginaries and how these in turn shape sociotechnical configurations of energy innovations, often as alternatives to national imaginaries.

1. Introduction

Portland's reputation as a hub of sustainability innovation (Owley & Hirokawa, 2015) contrasts sharply with Phoenix's reputation as an unsustainably sprawling city (Ross, 2011). Nevertheless, politically active communities in both cities have pushed for transitions towards more innovative and "smart" energy systems. Their sharply contrasting cultural beliefs about the role of energy innovations in delivering public benefits, however, point to the interaction of local and national contexts in producing divergent sociotechnical governance arrangements. In this paper, we investigate "sociotechnical imaginaries" of energy systems innovations—smart grids and distributed energy generation—at a regional scale as illustrated in public discourse and policies. Sociotechnical imaginaries are defined as "collectively imagined forms of social life and social order reflected in the design and fulfillment of nation-specific scientific and/or technological projects" (Jasanoff & Kim, 2009, p. 120). Accordingly, they elucidate the "hidden social dimensions of energy systems," and are important "cultural resources that shape social responses to innovation" (Jasanoff & Kim, 2013, pp. 189–190).

Through a comparative analysis of the Portland, Oregon, and Phoenix, Arizona, metropolitan areas, we trace the historical

* Corresponding author.
E-mail addresses: anthony.levenda@uclagary.ca (A.M. Levenda), Jennifer.Richter@asu.edu (J. Richter), thad.miller@asu.edu (T. Miller), efisher1@asu.edu (E. Fisher).

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trajectories of sociotechnical imaginaries to understand how they influence conceptions of social progress and social order in the pursuit and development of energy innovations. While regional sociotechnical imaginaries articulate and resonate with national energy imaginaries of security and modernization, divergences occur due to distinct differences in histories, geographies, political identities, and cultural beliefs. To account for this divergence, we employ the analytical concept of "energy values" – the sometimes contested public values and expectations related to energy systems and their transformations in a given context. In Portland and Phoenix, we find two major energy values that shape energy discourses and innovations: stability connected to reliability, and democracy linked with independence. Through comparative analysis, we identify the ways in which innovations become politically salient, how policies respond to sociotechnical change, and how they may shape and respond to such change in the future. This brings to the fore contestations over the definition of public good, and how discourses over energy innovations relate to collective well-being as imagined and articulated in both national and regional energy policy discourse. The broader implications of our analysis suggest that variation in sociotechnical energy imaginaries between places within a shared national political and economic context are important resources in governing and shaping energy systems innovations.

In the next section, we discuss the theoretical framework that integrates sociotechnical imaginaries and our conception of energy values. Then we discuss our methods, results, and conclusions in subsequent sections.

2. Theoretical framework

The concept of sociotechnical imaginaries has increasingly gained attention as a way to frame, analyze, and critique the co-production of science and technology and political power. Our understanding of sociotechnical imaginaries builds upon Jasanoff and Kim's (2009, 2013) work, which examines sociotechnical imaginaries at the national level. Jasanoff and Kim (2009) explain that "promises, visions and expectations of future possibilities are embedded in the social organizations and practices of science and technology" (Jasanoff & Kim, 2009, p. 122), and that these expectations are not bound only to the organizational bodies that shape and engage with them, but are entangled with social values as well. These "technoscientific imaginaries are simultaneously also 'social imaginaries,' encoding collective visions of the good society" (Jasanoff & Kim, 2009, p. 123). Sociotechnical imaginaries, then, are collectively imagined forms of social life that are "almost always imbued with implicit understandings of what is good or desirable in the social world writ large" (Jasanoff & Kim, 2009, pp. 122–123), which is elucidated by Jasanoff and Kim (2009) in a study of nuclear energy as a state-level activity that required a national imaginary focused on modernization and security.

Recent studies have utilized the concept of sociotechnical imaginaries focusing on comparisons of national energy policies in the US, Germany and South Korea (Jasanoff & Kim, 2013), the role of sociotechnical imaginaries in shaping education in the smart city (Williamson, 2015), and comparisons of international policy-making institutions' visions of future bioenergy technologies (Kuchler, 2014). Methodologically, studies of sociotechnical imaginaries often rely on comparison of multiple cases across similar scientific or technological domains in different social, political, and cultural contexts (Jasanoff & Kim, 2015), but also usually involve historical explanation or a focus on representations of future societies. These studies demonstrate the diversity and robustness of the concept. Still (Jasanoff, 2015, pp. 322–3) suggests some overarching methods for studying the "formation of collective belief formation in scientifically and technologically engaged societies" with the sociotechnical imaginaries framework: first is examining the origin of new scientific ideas and technologies; second is an inquiry into "imagination as a social practice;" third is the analysis of competing imaginaries, or the emergence of new imaginaries that confront the old; and, last is the tracing of the way "unconventional ideas gain traction, acquire strength, and cross scales," through the "phenomenon of extension."

We argue that the governance of energy systems, including policies, and practitioners' practices, is influenced by sociotechnical imaginaries operating both nationally and regionally. This contributes to the development of the concept by elucidating how sociotechnical imaginaries "scale" between national and regional sites of cultural and historical imagination. We also analyze what this scaling means for variability in imaginaries and the development of competing imaginaries. We suggest the concept of "energy values" is one mode of explanation for this variation, specific to energy systems, and may also help identify areas where new ideas for energy innovations gain traction and broader public appeal through extension.

We understand values from a socio-cultural approach as historically and culturally variable social ideals that guide action and plans for action (Hitlin & Piliavin, 2004). Our conception of energy values builds on Langdon Winner's idea of "technology as legislation" (Winner, 1978, p. 317) as "an interpretive tool for understanding the meanings that drive people to favor certain choices of technological systems over others" (Laird, 2001, p. 5). Broader than public perceptions, interests, desires, wants, attitudes, or preferences, energy values are heterogeneous, historically specific, socially rooted, culturally shared ideals regarding the role of energy technology in (re)creating public good. This builds from the understanding that technological systems are always socio-technical, and that energy systems innovations in particular are co-productive of particular societal futures (Hughes, 1983; Miller, O'Leary, Graffy, Stechel, & Dirks, 2015; Miller & Richter, 2014; Miller, Richter, & O'Leary, 2015). While some scholars have articulated various understandings of public or social values associated with energy technologies, energy values here are articulated in relation to sociotechnical imaginaries and cultural discourses.

In relation to energy systems innovations, some scholars have sought to address values through ideas of public acceptance of technologies (Devine-Wright et al., 2017; Upham, Oltra, & Boso, 2015) wherein values are treated as implicit and non-specific to energy technologies. Scheer, Konrad, and Wassermann (2017) link stated individual preferences for energy technologies from focus groups in Germany to broader values such as power, autonomy, fairness, justice, self-reliance, and self-determination. Closely related to our idea of energy values, Demski, Butler, Parkhill, Spence, and Pidgeon (2015) describe a set of social values (efficiency and wastefulness, environment and nature, security and stability, social justice and fairness, autonomy and power, and processes and change) in the UK as related to preference formation regarding energy system change from a "whole-system view." We extend these analyses into our conception of energy values, which operate societally, informed by and related to broader sociotechnical imaginaries of energy innovations.

Values operate across scales and "provide the possibility for drawing links between individual, social structural, and cultural levels of analysis" (Hitlin & Piliavin, 2004, p. 383). This is central to understanding linkages between sociotechnical imaginaries across scales, and to actions of regional actors in the governance of energy systems innovations. We do not claim energy values determine change or individual decisions. Rather they serve as background, entrenched ideals of what energy systems should be, should do, and how they should help deliver socially desirable outcomes. The scale and scope of energy systems is often regional which suggests further attention to regional cultures and political communities is needed, especially as energy futures and innovations are increasingly shaped by local and regional policies and political action. In the US context, this is particularly salient as federal funding is utilized differently in state-level projects and policies, and each regional context has different ownership arrangements, different market structures, and different historical legacies that influence both infrastructures and institutions. In this paper, we trace the federal programs that both shape, and are shaped by, the ways that state and local governments deploy and take up imaginaries around specific energy technologies: distributed solar and smart grids. Our analysis of energy values provides a way to disentangle the historically, culturally, and regionally specific social responses to these energy innovations.

3. Methods

This paper analyzes policy and cultural discourses at the US national level, and the regional level, focusing on Portland, Oregon in the Pacific Northwest US, and Phoenix, Arizona, in the Desert Southwest US. Discourses are expressions of both energy values and sociotechnical imaginaries, defined as "a specific ensemble of ideas, concepts, and categorizations that is produced, reproduced, and transformed in a particular set of practices and through which meaning is given to physical and social realities" (Hajer, 1995, p. 60; see also Jager, 2001; Waitt, 2005). Variance in discourses helps elucidate divergent sociotechnical imaginaries, at both regional and national scales, and allows us to uncover social energy values.

3.1. Data collection and sampling

Data collection consisted of document review including national, state, and local policies, media articles, planning documents, and white papers from a variety of organizations including national, state, and local government offices, utilities, regulators, industry groups, non-profit organizations, citizen groups, and planning agencies. We generated a database listing the actors, policy issues, scale of the organization, and keywords, importing them into MaxQDA software for coding and theme generation. Document collection focused specifically on national energy policy discourse (2005–2017), community energy solutions and smart grid development in the Portland region (2007–2017), and on solar energy innovations and smart energy initiatives in the Phoenix region (2006–2017). We analyzed 152 documents amounting to over 1400 pages of text: 57 documents at the national level ranging from policies such as the Energy Policy Act of 2005 to Department of Energy's promotional smart grid materials; and 95 at the regional level, including 34 documents in Phoenix and 61 documents in Portland, focusing on discourse actors involved in smart grid and solar energy policy and activism.

3.2. Data analysis

Our analysis proceeded in two phases: discourse analysis followed by comparative analysis. We used an inductive coding analysis to generate themes according to frequent, dominant, and significant categories. Following the Gioia methodology (Gioia, Corley, & Hamilton, 2013), we reduced our original 1st order descriptive codings into similar categories leaving approximately 30 categories. These were then gathered into more abstract 2nd order theoretical themes, aggregate dimensions, and larger narratives after reaching "theoretical saturation." We found a series of issues related to energy values and sociotechnical imaginaries—such as public good, visions of technological progress and innovation, democratic decision-making, reliability, efficiency, etc.—and information specific to innovative aspects of energy systems change—distributed generation, renewable energy, and smart technologies. Once we developed these themes and aggregate dimensions, we began to consult the literature on energy innovations, sociotechnical imaginaries, and public values to position our findings.

Next, we used a comparative analysis for understanding how national imaginaries are refracted by local stakeholders through regional energy discourses. Comparison highlights how different social, political, and cultural contexts may impact visions of public good tied to science and technology. We found a number of salient and similar themes in Portland and Phoenix that we abstracted into more general concepts of stability, reliability, democracy, and independence. By stability and reliability, we refer to ideas both technical and social, aggregating themes that referenced ideas of continuation, lack of failure, resiliency, steady-state operations, and path dependency. We focused specifically on how particular energy innovations were described as threatening or enhancing stability and reliability. For democracy and independence, we aggregated themes of public engagement, decision-making processes, regulatory oversight, customer input, participation, decentralized energy production, energy autonomy and control. To compare these discourses, we looked for the meaning ascribed to these ideas in relation to energy innovations of smart grids and distributed solar generation. We did so using narratives as described by (Gioia et al., 2013, pp. 23–24), in order to "'zoom in' on the key emergent new concepts or themes and hold them up for examination as the core ideas of a given paper" and to highlight "those emergent concepts that are new and/or those existing concepts that have new twists that produce new insights."

The emergent concepts emphasized in our analysis were conceptualized as energy values, as described above. Comparing energy values across contexts helps us answer key questions: What values underlie smart grid and distributed solar policy, and how are these contentious issues? Within seemingly stable regional systems governed by regulated monopolies, how are publics envisioned, by whom, and how does the public react? What new political, institutional, and technological arrangements do smart energy systems and distributed generation (DG) make possible?

4. Findings: sociotechnical imaginaries at the regional scale

In both the Northwest and Southwest US, national sociotechnical imaginaries of modernization and security have shaped public expectations and values regarding energy innovations. These imaginaries were solidified in large institutions in the regions and reaffirmed through policy narratives and decisions. After first detailing the national and regional sociotechnical imaginaries and energy values that we find to be tied to smart grids and distributed solar technologies, we discuss the results of our comparative analysis.

Analyzing national policy discourse demonstrates the tight coupling between energy technologies and the sociotechnical imaginaries that Jasanoff and Kim (2009) describe as fueled by public desires for modernization and security. Recent national discourse on energy transitions and smart grids spanning two US administrations illustrates how modernization, growth, stability and security underpin support for energy technologies and innovations. On August 8, 2005, President Bush signed the 2005 Energy Policy Act (EPAct, 2005), which repealed the Public Utility Holding Companies Act of 1935, eliminated corporate structure and governance restrictions, and enabled holding companies to tap a broader array of sources of capital for investment (FERC, 2006). The Act resonated with a desire for action on national security in a post-9/11 world by placing an emphasis on developing domestic energy resources, including coal and renewables, that were seen as key to "reducing our reliance on energy from foreign countries," and helping the "economy grow so people can work" (Office of the Press Secretary, 2005). While much of the 2005 EPAct had provisions for fossil fuel resources, its provisions for renewable energy solidified an era of deregulation and competition, and signified a federal interest in developing renewable energy to increase national security and officially support transitions in energy resources. Just two years later, the Energy Independence and Security Act of 2007 (EISA, 2007) articulated a "smart grid" as a national goal for modernization of the electricity grid. EISA 2007 described how smart grids would utilize "digital information and controls technology to improve reliability, security, and efficiency of the electric grid" (EISA, 2007). For example, the EISA 2007 emphasizes energy security and independence through vehicle fuel economy, increased production of biofuels, and advancing research and development, all while creating green jobs. The central idea was that new energy technologies could deliver both economic benefits and environmental benefits—a form of "ecological modernization" (Hajer, 1995) that could garner widespread public support (EISA, 2007). For example, the EISA 2007 emphasizes energy security and independence through vehicle fuel economy, increased production of biofuels, and advancing research and development, all while creating green jobs. The central idea was that new energy technologies could deliver both economic benefits and environmental benefits—a form of "ecological modernization" that could garner widespread public support.

Similarly, in 2009, President Obama signed into effect the American Recovery and Reinvestment Act (ARRA), which was meant to alleviate the worst conditions of the incipient American economic recession and which appropriated funding for "job preservation and creation, infrastructure investment, energy efficiency and science, assistance to the unemployed, and State and local fiscal stabilization" (ARRA, 2009). It also provided bonds and credits to incentivize businesses to invest in green technologies and "clean renewable energy," as well as $750 million for competitive grants for training and placement in "high growth and emerging industry sectors" with two-thirds of that amount designated for programs "prepare workers for careers in energy efficiency and renewable energy industries" (U.S. Department of Labor, 2008). Smart grids, energy efficiency, and renewable energy were cast as fundamental technologies for the stable growth of the American economy, providing that boost of technological modernization that was described as having widespread social benefits. ARRA designated $2.9 billion for development of smart grid programs spearheaded by the US Department of Energy (DOE) and the DOE's Office of Electricity Delivery and Energy Reliability (OE), who stated in their report, *Jumpstarting a Modern Grid*, that the OE:

> provides national leadership to ensure that the nation's energy delivery system is secure, resilient, and reliable […] works to develop new technologies to improve the infrastructure that brings electricity into our homes, offices, and factories in partnership with industry, other federal agencies, and state and local governments […] [and] works to bolster the resiliency of the electric grid and assists with restoration when major energy supply interruptions occur (DOE, 2014).

While the wider discourses surrounding the policies of Bush and Obama may frame modernization and security according to their differing political commitments, they both pay tribute to these two dominant values, underscoring the enduring nature of national sociotechnical imaginaries.

Though national policy and federal institutions provide the means for funding new innovations, they stop short of mandating universal forms of implementation. This allows for regional development of energy innovations that is in line with more localized and often alternative sociotechnical imaginaries. Analyzing these abstractions at the regional level can help unpack how they come to be collectively held and expressed by publics and experts, scientists and policymakers, and political communities. To do so requires both empirical and theoretical analyses for understanding how energy innovations are governed.

4.1. Portland: smart and sustainable

The regional development of energy systems in the Pacific Northwest (PNW) played an important role in Portland's economy and culture. Today, the region has natural gas, hydropower, coal, wind, solar, and biomass facilities, although Portland General Electric (PGE), Portland's vertically integrated and investor-owned utility, recently agreed to close its one remaining coal plant by 2020 (Sickinger, 2017). In 2016, a new Renewable Portfolio Standard (RPS) was developed for Oregon, advancing the previous 2007 version. This mandated large utilities to source 50% of their portfolios from renewable energy by 2040 (Oregon Senate Bill 1547). While the State's energy mix is already nearly 50% renewables, largely hydro (42.88%) and wind (5.62%), the two utilities serving the Portland Metro area are still far behind this goal, relying largely on coal and natural gas (BPS, 2015).

While Portland pushes for an urban sustainability transition, governance of existing large-scale energy systems is largely controlled by entrenched organizations, limiting feasible options for the city. The Northwest Power and Conservation Council—responsible for regional energy planning since it was developed in 1980—has placed an increased reliance on grid modernization to enable greater demand response and energy efficiency (NW Council, 2016). Demand response refers to a variety of programs designed to shift the time and magnitude of energy demand, making demand more flexible and responsive, expressing energy values of reliability, stability, and democracy (Cappers, Goldman, & Kathan, 2010; Higginson, Thomson, & Bhamra, 2014). Demand response is seen as a way for "consumers to play a significant role in the operation of the electric grid by reducing or shifting their electricity usage" (DOE, 2017). This vision of smart energy systems is shaped by the legacy of the PNW's commitment to "least-cost" planning and conservation (Hirt, 2012; Pope, 2008). The NW Council explained that "energy efficiency is the primary action for the next six years," and that, given the uncertainties surrounding climate change and its impacts on the region's hydropower resources, "demand response resources, which have low development and 'holding' costs are best-suited to meet this need" (NW Council, 2016). Smart grid innovations that "deliver" these efficiencies and fit with the least-cost approach promise to make the grid more reliable and stable while modernizing it with smart technologies. In this way, smart grid technologies that deliver efficiency and enable demand response are tied to broader public values, held by utilities and communities alike, of reliability and stability, and regional approaches to energy governance.

Portland's dedication to becoming a "national model for sustainability" (BPS, 2012, p. 11) has emphasized community energy solutions and energy efficiency for reducing greenhouse gas emissions and mitigating climate change, exemplifying energy values of democracy and independence. In the 2012 Portland Plan, one strategic goal for "public and private urban innovation" was to "grow the local market for energy efficiency and solar improvements to homes and businesses" in order to "increase Portland's long-term affordability and resiliency and to reduce carbon emissions" (BPS, 2012, p. 54) and make clean energy access more equitable. City-level discourse, and associated policies and narratives, emphasized the ways in which energy technologies could provide wider public benefits of urban resiliency and climate action. However, Portland's utilities focused more on achieving stability and reliability of grid operations through efficiency and modernization efforts, but still relying on coal and natural gas. This underscores the utilities' emphasis on maintaining control over energy futures, stability in relation to long-term investments in power generation facilities, and reliability of the grid even as more distributed and intermittent renewable energy sources are integrated.

4.1.1. Reliability and stability

While the transition to a smart energy system often includes discussions of environmental impacts and consumer choice, the dominant discussions in Oregon have also focused on security, reliability, and stability. In the Portland region, stability and reliability are upheld as public goals to which utilities and regulators take responsibility, and non-profits such as the Citizens Utility Board (CUB) find to be a part of their missions of ratepayer protection and advocacy. For example, the Oregon Public Utility Commission (PUC) asked "How will the investment reduce customer costs, improve customer service, improve reliability, facilitate demandside resources and renewable resources, and convey other system benefits?" (OPUC, 2012, p. 6). PGE's smart grid vision explicitly focuses on "the potential to improve reliability, operational efficiency and to ease the integration of renewable resources as energy storage and smart appliances become more common" (PGE, 2013, p. 6).

Considerable attention to the innovation of energy systems in the PNW was spurred by national ARRA funding and the development of the Pacific Northwest Smart Grid Demonstration Project (SGDP). The SGDP brought together 11 utilities, two universities, and five technology firms from Oregon, Washington, Idaho, Montana, and Wyoming to test smart grid technologies over a five-year period, from 2010 to 2015, building on the 2006 DOE-funded Gridwise™ Demonstration Project which focused on demand response programs (Battelle, 2017; Hammerstrom, 2007). PGE served as one of the primary utility partners in the SGDP, spearheading an energy storage project demonstrating a five-megawatt lithium-ion battery system in the state capital of Salem, Oregon. The battery project allowed testing of local microgrid concepts that integrate energy storage with customer standby generators and distribution automation to allow the grid to "heal itself" (BPA, 2014). PGE's CEO and President promoted the project thusly: "PGE and its partners are demonstrating new technologies that hold promise for building a more efficient, sustainable, and reliable grid" (BPA, 2014). In short, PGE's innovative project and commitment to smart grid modernization has contributed to a regional effort to develop "one of the most advanced electrical systems in the nation, and as such, has inspired the imagination of a region" (BPA, 2014).

4.1.2. Democracy and independence

Portland was the first local government in the US to adopt a Climate Action Plan (CAP) in 1993, subsequently revised in 2009 and 2015. The 2015 CAP laid out goals and strategies for reducing GHG emissions that would help generate prosperity, create more access to mobility, develop healthy and resilient communities, and enhance equity. Oregon law mandates that by 2025, 25% of all electricity sold by PGE and Pacific Power must be from renewable energy sources. The City of Portland also encourages renewable energy generation in urban settings (BPS, 2015, p. 68). Programs such as Solarize Portland demonstrate a commitment to local community solar programs, offering an alternative to state-level policy action or regional portfolio standards for existing utilities. Solar Forward, a model for community solar based on crowdfunding campaigns, was launched by the Bureau of Planning and Sustainability (BPS) to enable donation-based campaigns for solar installations on community buildings, such as schools or libraries (BPS, 2017). This allows individuals who are interested in contributing to community energy solutions to fund projects and receive reimbursements on their energy bills, even if they do not have the opportunity to install solar at their residence (i.e. renters or those without adequate roof space).

The Solarize Portland program exemplifies Portland's ground-up vision of energy transition. Solarize Portland was based on a joint volume-purchasing program for solar panels, balance of system components, and installation services via a single contractor. Bulk or volume purchasing reduces costs for individual homeowners yet they still get individual systems at their homes. In Portland, neighborhood associations led voluntary community action to bring solar to nearly 1000 homes over three years, from 2009 to 2012. The Solarize Guidebook, a resource and how-to guide developed on Portland's experiences, explains the importance of community-based marketing for adopting solar:

> Solarize is a classic example of community-based social marketing: Information reaches people through face-to-face encounters with friends and neighbors, house parties, and other social interactions. Although the campaign uses the web and other traditional media, the thrust of the marketing appeal is personal. In contrast to a plea from the government or the utility, the appeal comes directly from a friend or neighbor (NREL & City of Portland, 2012, p. 16).

In this model, solar energy systems are not only a way to address carbon emissions, but also to develop local community and enable community governance of climate change (Aylett, 2013). Democracy and independence are goals that are to be achieved by local community action, not just participation in utility programs.

In another attempt to shape Portland's energy future, a resolution was adopted by City Council in 2015 explaining that "that the City Council will actively oppose expansion of infrastructure whose primary purpose is transporting or storing fossil fuels in or through Portland or adjacent waterways" (City of Portland, 2015a). Portland's then Mayor, local climate groups, and concerned activists saw the fossil ban as a way to shape Portland's energy future, showing a commitment to renewable sources of energy (Sickinger, 2016). Yet, the fossil fuel infrastructure ban encountered pressure from the Western States Petroleum Association and the Portland Business Alliance who led a lawsuit challenging the ordinance in 2017. In response, the Conservation Director of the Columbia Riverkeeper, a nonprofit environmental organization in Portland, explained that "people in Portland and throughout the Northwest will fight tooth and nail to defend what we love from dirty fossil fuel projects and their climate-wrecking impacts. The City of Portland made history when it adopted the fossil fuel ordinance. Today we stand in solidarity with the City and will work to defend the groundbreaking ordinance against industry attack" (Columbia Riverkeeper, 2017).

The historic fossil fuel ban is positioned as a message to powerful industry lobbyists, as Wysham (2016) notes, "Portland is showing where its future lies: Not in the all-too-literal 'boom and bust' fossil fuel economy, but in a more equitable low- to zero-carbon economy. No matter how many climate deniers occupy positions of power in Washington, DC, cities can and will lead the way on climate." Former Mayor Charlie Hales confirmed this stance, explaining that the City has "acted for future generations" and built on previous actions to reduce direct use of fossil fuels, limit City investment in fossil fuels, and reduce fossil fuels in the City's electrical supply, all actions that "make sure new fossil fuel projects aren't built, protecting our planet and our people" (City of Portland, 2015b). The rejection of fossil fuel infrastructure demonstrates the City's vision of democracy and independence tied to renewable energy technologies and ground-up sustainability efforts.

4.2. Phoenix: chasing the power of the sun

Phoenix is a metropolis carved out of the Sonoran Desert by the Salt River, receiving only 11 inches of rain a year. Despite its aridity, Phoenix saw high settlement rates during the 1990s, as people flocked to the low-cost area, lured by swimming pools and unlimited air conditioning (Needham, 2014; VanderMeer,2010). Powering the movement of water and energy through the Salt River Valley has required immense planning, investment in infrastructure, and organizational finesse, and energy and water systems to Phoenix were funded by federal investment into large-scale infrastructure. These include the construction of the Roosevelt Dam on the Salt River in 1911, funded by the Federal Reclamation Act of 1902, and the Glen Canyon Dam on Lake Powell, which was completed in 1966 by the Bureau of Reclamation. It is located on federal land bounded by the Navajo Nation, which hosts three other coal-fired generation stations (Needham, 2014).

Federal investment was driven by a sociotechnical imaginary that viewed the development of the West as synonymous with the modernization of the country in the mid-1900s. The establishment of large-scale energy infrastructures are indicative of a specific set of sociotechnical arrangements. Energy investments are now controlled by large utilities, including Arizona Public Service (APS), who is regulated by the Arizona Corporation Commission (ACC), and the Salt River Project (SRP), which was established in the 1890s to adjudicate water for agriculture in the Valley, and electricity distribution during the 1920s (Luckingham, 1995). SRP is governed by an elected board of directors, many with long ties to the region, and is not regulated by the ACC. These two utilities are the main arbiters of electricity production for the Phoenix area, and have contributed and controlled the energy fortunes of the city by supplying electricity to the metro area, often using the periphery of tribal and rural lands to host generating facilities (Needham, 2014).

Yet Arizona is haunted by the opportunities of solar energy. Solar energy is currently at a cross-roads in the state of Arizona and its fortunes reflect myriad energy values at play Phoenix, drawing attention to the different forms of governance and histories informing stakeholder characterizations. Solar energy is a lens through which energy values at the regional level are negotiated. Arizona's most recent foray into solar production is driven by the establishment of a renewable portfolio standard (RPS) in 2006 by the ACC. The 2006 RPS mandated that by 2025, 15% of electricity produced by regulated energy utilities must be produced from renewable resources, and 30% of that must be from DG. Similarly, to Portland, these policies were driven by federal incentives from the EPAct 2005, such as the Solar Investment Tax Credit which gave a 30% credit on rooftop solar systems to homeowners. Both APS and SRP supplied additional incentives such as net metering at a retail rate for DG residential customers to meet the goals of the RPS, leading to a boom in solar production that has been difficult to manage for both the state, utilities, and the public.

Controversies over the appropriate role of DG in Arizona are indicative of sociotechnical imaginaries around stability and reliability, as well as independence and democracy. For utilities, predictability in investments, rates and costs, long-term stability, the reliability of the grid, and control over the energy system were paramount concerns that could not be meshed with customer beliefs that DG systems would be a good long-term investment, defray the need for costly new plants, and serve to reduce carbon emissions. Exploring these discourses allows for greater insight into why negotiations over the appropriate role of solar broke down in favor of cancelling new regulations that were meant to propel solar energy production into mainstream energy systems.

4.2.1. Reliability and stability

For both APS and SRP, a prevailing discourse over energy is utilities' unique ability to provide reliable and stable electricity to consumers at a low rate of cost. Security and modernization are emphasized in the yearly reports from Pinnacle West, the parent company of APS. In 2015, their yearly report focused on modernization and security, discussing energy innovation as a means of retaining reliability and competitiveness: "At APS, we are at the forefront of utilities studying and deploying advanced infrastructure to enable reliable and cost-efficient integration of emerging technologies, both into the grid and with customers. As we integrate these new technologies and approaches with our current solutions, we enhance reliability, increase productivity and better serve our customers" (Pinnacle West, 2015, 14). APS has its own solar non-profit, Arizona Goes Solar, with a webpage that states: "As an Arizona home or business owner, you can take advantage of our state's abundant sunshine, today's advanced solar technology and incentives and rebates to save on the purchase and installation of a new solar system. Solar power offers many advantages including energy independence, energy cost stability, helping the environment and increasing the value of your home or business" (Arizona Goes Solar, 2017). SRP emphasizes these values of stability and reliability, claiming: "SRP is proud to be forward-thinking in creating strategies to protect Arizona's water supply, provide reliable energy and reduce greenhouse gas emissions...We helped the Valley grow, and today continue to drive its development as one of the most vibrant regions in the country" (SRP, 2017). Both utilities are long-standing organizations in the Valley, contributing to not only electricity and energy needs, but also water needs for a parched desert area. As such, they are products of, and contributors to, a sociotechnical imaginary that emphasizes discourses of modernization and security in the Desert Southwest.

The sudden adoption of DG caught utilities off-guard, and their concerns about predictable flows of energy, managing peak demand, and over-paying customers for energy production, caused utilities to challenge the practice of net metering (Brandt, 2013). But customers had taken advantage of federal and state incentives to invest in DG units, assuming that utilities would continue paying retail prices for energy produced by solar customers. For DG customers, the withdrawal of net metering policies seemed like an underhanded excuse to increase profits and keep energy production centralized. How to appropriately regulate and govern the introduction of solar energy to maintain stable and reliable energy systems, while also allowing consumers to produce energy, remains the most contentious issue for utilities and consumers alike. While both APS and SRP initially supported the build-up of DG, they began to challenge their own policies in 2011, claiming that the boom in solar DG customers adversely affected the stability and reliability of energy flows, because solar customers produced more energy during peak hours, but that energy could not be stored effectively to be released when energy was needed at peak hours. By 2013, they were warning of a cost-shift to non-solar customers and the utility, causing non-solar customers and utilities to effectively subsidize the use of the grid by solar customers. For APS and SRP, this contributed to unpredictable and non-useful electricity production during off-peak which could affect their ability to keep electricity prices stable, and potentially create a systemic lack of security for the grid itself.

4.2.2. Democracy and independence

While utilities had been historically producing reliable and stable electricity for their consumers, customers actually have little discretion in choosing their utility provider, and have had little input into choosing the source of their electricity, whether it be from coal, nuclear, or gas. As solar grew, local energy discourses were informed by concerns of securitizing retirement incomes, safeguarding the health of residents by transitioning away from fossil fuels, and allowing consumers to engage in energy production in new and direct ways, perhaps event to achieve energy independence from utilities. These discourses are informed by the same discursive aims as higher levels of governance of modernization and security, but are framed by local values that make DG an attractive means of achieving social and environmental goals.

The opening of DG solar offered more choices for customers, including the ability to produce their own electricity, and to make money by being a producer through net-metering practices. This was an attractive policy for retirees who were able to invest in rooftop systems, who could supplement their retirement pension by lessening their electricity costs and making money by selling back surplus electricity to the utilities. One organization co-founded by Barry Goldwater, Jr. (son of an influential former Arizona senator) called Tell Utilities Solar Won't be Killed (TUSK), framed their discourse in a thoroughly conservative political slant:

> "As a son of Arizona, I know we have no greater resource than the sun. Republicans want the freedom to make the best choice and the competition to drive down rates. That choice may mean they save money, and with solar that is the case. Solar companies have a track record of aggressively reducing costs in America. We can't let solar energy – and all its advantages and benefits it provides us – be pushed aside by monopolies wanting to limit energy choice. That's not the conservative way and it's not the American way" (TUSK, 2015).

The explicit message is one of regional political and economic opportunity, and that through the development of DG, new and different economic and political arrangements are possible. Local branches of the Solar Energy Industries Association (SEIA) called AriSEIA, also promoted the economic and local advantages of rooftop solar: “Lower energy bills that will never go up. Reducing our dependence upon fossil fuels. Ensuring a cleaner environment for future generations to enjoy. Creating quality jobs for Arizonans in an expanding global industry” (AriSEIA, 2016). Here, solar energy is an intensely local enterprise that is advantageously suited to Arizona. The underlying discourse is one of securing the economic and environmental future of the city, the state and the region, solidifying its potential as an energy-producer. As a parched desert city with a reputation for unsustainable sprawl and water use (Ross, 2011), solar is used discursively to challenge this perception of the desert metropolis, beneficially situated as a technological innovation, geographical suitable, and accessible to the public.

For local residents in urban areas in poorer neighborhoods of Phoenix, the opening up of the energy system presented new opportunities to create local energy systems that would be less polluting to environmental and human health. Chispa, an environmental justice activist group sponsored by the national non-profit League of Conservation Voters, agitated for avenues to access and invest in, DG units in poor and Latino neighborhoods across the Valley: “Our communities are exposed to pollution and toxins on the job, in our homes, at schools and in our homes. Often the first and worst hit by the effects of climate change, it’s no surprise that Latinos are also some of the strongest advocates for climate action, strongly advocating for and supporting government action to protect *la Madre Tierra*” (Chispa, 2016). In Phoenix, Chispa’s chapter promotes alternative energy as a grassroots movement for environmental justice in relation to the specific toxins produced by fossil fuel generation and its systemic effects on marginalized poor and Latino families historically and in the present, as politically- and environmentally-marginalized communities make up about 40% of the Phoenix’ population. Energy alternatives represent a possible transition that addresses historical marginalization from decision-making about energy production, as well as to redress a history of redlining that left minorities in industrial and polluted spaces (Bolin, Grineski, & Collins, 2005).

At a more regional and local level, energy values are refracted through expectations of an energy transition away from fossil fuels and centralized control of utility-scale production. Without a new political process for incorporating voices from previously unheard factions of society, groups like TUSK, AriSEIA, and Chispa raise concerns that solar will be produced, controlled, and distributed in exactly the same ways as coal and nuclear, in areas where the effects are displaced onto marginalized communities. Critics of utilities point to the power and control of regulated monopolies to fund the propositions they want, and in the case of APS, to fund their own candidates for the ACC, as well as funnel money for anti-solar ads through PACs against their own customers (Sheppard, 2013). Local groups are also raising concerns that there will be unequal access to high-quality energy, where wealthy neighborhoods will be able to access DG on their own rooftops, but rural, elderly, poor, and minority neighborhoods will not be able to access these same benefits.

In 2015 and 2016, APS and SRP held contentious public meetings where hundreds of protesters gathered to express their displeasure at the restructuring of net-metering, rate hikes for solar customers, and claims of cost-shifting (Randazzo, 2015; Richter, Tidwell, Fisher, & Miller, 2016). In December 2016, the ACC decided on their “Value of Solar” ruling (ACC, 2014), which allowed APS and other state-regulated utilities to discontinue retail net-metering policies, as well as offer lower set times for guaranteeing buyback for solar energy and decreasing credit for excess energy produced by DG customers, who would become their own class of customers (Pyper, 2016). The decision was met with mixed reactions. Brandon Cheshire, president of the Board of AriSEIA noted that, “The future of Arizona's solar industry was very much on the line in this case and while this settlement doesn't help Arizona solar grow, it allows solar to remain a viable option for some Arizonans” (AriSEIA, 2016). Corey Honeyman, associate director of US Solar at GreenTechMedia Research, commented that, “[T]his reform sends a clear signal that the future of residential solar growth in Arizona will rest on optimizing self-consumption and pivoting towards a solar-plus-storage solution sooner rather than later” (Pyper, 2016). Even the ACC noted that this wasn’t a “‘perfect decision,’ but a step in the right direction” for valuing DG production in a more nuanced fashion (Shallenberger, 2016). While discourses around the appropriate role of solar in Phoenix’s energy system continue to circulate, the ACC ruling provides evidence that even as there is a new recognition of the potential power of the “prosumer,” utility-scale solar is still a primary goal for utilities looking to create predictable and reliable energy production. Local discourses challenge this uni-directional flow of decision-making, by emphasizing the independence from utilities that DG could bring, as well as more democratic access to the benefits of solar, and more equal distribution of risks from energy production.

5. Discussion: comparing energy values and discourses

The discourses described above signify action at sites of local government, where governing “closer to the people” is positioned as a response to a sense of inaction at more regional settings of government and as a way to meet public needs and values through local actions. In the examples of Portland and Phoenix, we deliberately focus on particular “publics” involved in sociotechnical imaginaries, suggesting that energy technologies resonate not only with the nation-state, but also with more local political collectives. In the context of regional energy systems, we suggest that sociotechnical imaginaries can be identified and critiqued through comparison, highlighting the ways in which regional innovation practices and regulation of technologies express and illustrate sociotechnical imaginaries at work. Central to our analysis is the notion that imaginaries are never purely about particular energy technologies, but also about values and public expectations that energy technologies are positioned to fulfill. Thus, we find that comparison across regional contexts is useful for identifying the ways in which national imaginaries might influence local and regional policy, and also for illuminating how sociotechnical imaginaries are expressed differently across regional contexts.

In our analysis of Portland and Phoenix, we focused on two major sets of themes: reliability and stability, and democracy and independence. In Portland, reliability and stability are upheld as goals that serve the public interest, with utilities identified as public servants, providing necessary services to the region, especially large and growing urban areas. Stability is also expressed through discourses of continuity that are evident through discussions of slow transitions to renewable energy. Yet, this utility and regulatory rhetoric is sharply contested by local leaders and activists who argue for swift movements away from fossil fuels. Where reliability is received as a more agreeable discourse, stability is challenged. Similarly, in Phoenix, utilities and regulators agree that energy innovations should be pursued in the interest of greater reliability and stability. While the subtext of stability as a keyword for stasis in the industry is also expressed; the challenge of solar DG is far more prevalent in Phoenix; causing disagreement and legislative changes at the local level over who should be able to make decisions about the implementation and pricing of DG; and how it should be valued. In the case of Phoenix; stability is pursued through centralized control of technological change (through utilities and regulators); and action by individuals is seen as a threat and challenge to the existing systems of electricity provision; reducing stability and reliability.

We also identified democracy and independence as key values underpinning regional energy imaginaries. In Phoenix, the controversies over net-metering and how individual users produce and connect to the grid are disrupting the existing utility model, and as such distributed solar is being met with resistance from traditional energy providers. Alternatively, in Portland, there are similar controversies, but collaborative community projects seem to circumvent the utility pressure as do stricter standards for renewables, and lower residential DG adoption overall. Technological innovations related to distributed generation and smart technologies have led to possibilities of energy production at individual and community scales, yet the dominant social and political organization of energy systems has positioned "consumers" in more limited roles. In both urban settings, these roles are limited by participation in predefined utility programs and pilots for TOU pricing, for example. Yet both are influenced by citizen action groups that challenge the status quo, with differing levels of acceptability by government and regulators. In Phoenix, the adoption of DG by "prosumers" has created contentious issues for net-metering policies as the legislation has been reworked to favor more centralized, utility controlled solar power. In Portland, the City government supports a community-driven approach to enhance a transition away from fossil fuels, placing Portland's values of climate action and sustainability at the fore.

While local discourses in both Portland and Phoenix express themes of modernization and security, they "refract" differently through the lens of local concerns and relationships among publics, the state, and science and technology. Accordingly, frictions among national, regional, and local contexts highlight the emergence of durable and local variations of national imaginaries under which competing discourses are encompassed by broader visions of modernization and security.

6. Conclusion: regional sociotechnical imaginaries and the governance of energy innovations

In this paper, we demonstrate how regional and local contexts of energy innovations express differing versions of more general discourses of stability and reliability, and of democracy and independence. Our central claim is that sociotechnical imaginaries around energy innovations articulate differently at local and regional scales, as local cultural, historical, geographical and political-economic contexts translate into discernibly unique expressions of energy values. The multi-layered issues informing energy values in Portland and Phoenix position particular technologies and corresponding governance arrangements as capable of delivering on culturally and collectively held visions for desirable and attainable energy futures.

This paper provides evidence that durable sociotechnical imaginaries diverge at the regional level, even as they maintain close connections to national sociotechnical imaginaries. Thus, in the governance of energy innovations, local and regional sociotechnical imaginaries both refract and reflect overarching national imaginaries of modernization and security. At the local sites of both Portland and Phoenix, we demonstrate that imaginations of modernization and security are developed through energy innovations that are framed as enhancing regional energy values of stability and reliability, and democracy and independence. In Portland, these values are refracted through historically embedded themes of efficiency, least-cost planning, and demand response, which were achieved through smart grid technologies that could support local and regional articulations of modernization and security. As in Portland, Phoenix's desert contestations over sociotechnical configurations of solar technologies are also expressions of regional energy values of democracy and independence, where solar advocates demand more control over decision-making and policy regarding local solar, while utilities advocate for historically reliable and stable centralized solutions that could potentially close out new kinds of decentralized producers. Reliability and stability are, on the surface, less-contested themes, but their different expression in each locale again suggests they are refractions of broader national imaginaries. In Portland, reliability and stability discourses are tied to smart grid modernization efforts, while in Phoenix, the discourses focus on the regulatory impacts of disruptive sociotechnical configurations resulting from innovations in distributed solar energy generation. Additionally, in Portland, solar generation seems to focus on community visions of democracy and independence while, in Phoenix, a majority of efforts focus on specific political visions such as conservatism and environmental justice, actions showing how energy values are expressed differently in relation to broader imaginations of modernization and security.

Our analysis has important implications for understanding the governance of energy innovations at different scales. Since largely undisputed energy values such as reliability, stability, democracy and independence operate as central discourses that shape energy innovations in cities as different as Portland and Phoenix, it is easier to overlook the fact that they can do so in sharply different ways. Thus the same energy technologies—in our case, smart grids and distributed solar generation—can develop differently based on particular historical, institutional, infrastructural, cultural, and political-economic contexts. Other studies of energy values reflect a more scaled approach to comparisons energy values in energy transitions, such as Moore's (2013) examination of local values across the Mediterranean region, specifically focusing on local and regional energy values in rural Morocco. Studies in the Europe are also focused on national discourses and imaginaries in relation to low-carbon futures and smart grids, such as energy efficiency measures and sociotechnical change in the UK (Bridge, Bouzarovski, Bradshaw, & Eyre, 2013; Walker & Cass, 2010), "energy citizens" in

Denmark (Hansen & Hauge, 2017) and developing smart grids in Norway (Ballo, 2015). The Energiewende in Germany, as one of the most planned and developed energy transitions also offers fruitful considerations concerning shifting and reified energy values over a regional and national scale (Fischer, Hake, Kuckshinricks, Schröder, & Venghaus, 2016; Joas, Pahle, Flachsland, & Joas, 2016). Urban sustainability studies also offer discrete cases of energy values in relation to sociotechnical transitions (Luque-Ayala & Silver, 2016) and identifying and including relevant stakeholders in urban transitions (Nevens, Frantseskaki, Gorissen, & Loorbach, 2013). Not only does attending to these contexts help show how energy values are expressed differently in relation to shared sociotechnical imaginaries, it also helps reveal how policy decisions are made and unmade, how some publics are included and others excluded, how some technological innovations are deemed beneficial versus threatening, and what new sociotechnical configurations are nurtured and made possible. Yet the benefit of looking at intra-national contexts, especially comparisons between major urban areas that are shaped by discrete and varying environmental, political, and economic imperatives and values, add more nuance and depth to national studies. Understanding technological transitions in relation to energy values through localized case studies allows for insights into how national policies can be directed to more local goals by acknowledging energy innovations and smart grids as inherently sociotechnical. The implications of this analysis suggest that energy futures are enabled and constrained through a variety of dynamic socio-technical factors that reflect and refract differently through local, state, and national prisms. Recognizing the shifting role of otherwise stable imaginaries in patterns of multi-level governance can thus help reveal opportunities for alternative visions to take root and flourish as they refract broader culturally held beliefs and values that connect science, technology, and innovation to the public good.

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