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# Nested logics and smart meter adoption: Institutional processes and organizational change in the diffusion of smart meters in the United States

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ABSTRACT

Using the rollout of smart meters in Washington State as a case study, this paper introduces the concept of "nested" institutional logics to explain how sustainable technology innovation occurs within a heterogeneous organizational field. Marshaling data from fifty-two key informant interviews and extensive document analysis, we analyze the institutional and organizational processes that are driving the deployment of smart meters. Combining work on institutional logics with innovation literature, we argue that nested logics create specific constraints and opportunities that condition the emergence of new organizational forms and behaviors. We discuss the implications of this analysis for energy research and sustainability policy.

## 1. Introduction

Industrial society faces massive energy challenges in the transition to a sustainable, livable future. Such transitions are inevitably a blend of political, economic, and technological processes [1,2], but an especially important feature of this transition is the electrical grid. The processes of power production and consumption in countries across the globe will require major investments in innovation and electricity infrastructure [3]. Although the grid can become a major part of clean energy solutions [4], a key sustainability challenge lies in the structure of national power systems and, in the United States at least, the electrical power field's organizational heterogeneity: in addition to electrical utilities, other municipalities, research labs, government agencies, technology firms, trade associations, and public and private power generators jockey to coordinate power production and distribution. Additionally, many national energy policies engage much larger questions of federalism, regulatory processes, and interest group politics, as well as legislative and executive priorities ([5] on the US; see also [6,7] on Europe [8]; on Japan) Organizational heterogeneity thus gives rise to diverse interests and agendas and can cause problems of coordination at the national, regional, and local level. These energy politics have spawned vociferous debate about the direction and goals of sustainable energy policy.[1]

In this paper, we focus on the diffusion of smart meters in the U.S. state of Washington to suggest that innovation and deployment of sustainable energy technology is best understood as nested processes in which multiple scales and types of organizations and institutions interact regularly and bi-directionally, if imperfectly. Too often in energy policy research, innovation and deployment systems are simplified to focus on just one level, scale or one set of interactions; this paper attempts to map and understand the complexity of a single phase of energy system innovation, focusing on the diffusion of smart meters and using institutional theory. Thus, we ask: how does sustainable tech deployment occur across a heterogeneous organizational field? We introduce the concept of "nested" institutional logics to explain the deployment and subsequent diffusion of electrical power innovations emerging from collaborations and interactions among public, private, and cooperatively owned utilities in Washington State, at different governance scales (local, state, and federal). Institutional logics are "practices and beliefs inherent in the institutions of modern western societies" ([9]: 230) that operate as cultural schema to shape organizational behavior ([10]: 1421). Marshalling data from fifty-two key

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[1] Some climate scholars have argued that a local "ground up" approach to sustainable energy technology is important given the variety of institutional arrangements across the country and the relative lack of coordination in the world [108,109]. Others argue that public organizations now fund most sustainable tech innovation (directly or indirectly) and that climate change is a border-less problem; thus, governance solutions also need to be global (cf [110,111,18,19,8].). In particular, electric utilities have abandoned many long-term research projects because reducing R&D expenditures is seen as an effective way to enhance short-term profits [112,113,108]. These reductions are particularly visible in clean tech areas like wind and solar; thus—the argument goes—larger coordinated systems are best suited to manage global energy challenges.

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informant interviews and extensive document analysis, we analyze the institutional processes and organizational changes that are "nested" across scales of organization and whose interaction drives the deployment and adoption of smart meters. We give particular attention to why and how cooperation among different types of organizations shape innovation outcomes. Our data show that nesting creates unique constraints and opportunities that condition the emergence of new organizational forms and behaviors, and that foster innovation across a range of organizational imperatives and levels of governance.

## 2. Method

### 2.1. Case study and background: utilities in Washington's electrical power field

"Smart" electrical power meters (also called advanced metering infrastructure, or AMI) are electronic devices installed in homes and businesses that allow two-way information flow between consumers and utilities. They relay electricity use data at much shorter time intervals than traditional metering systems (minute-to-minute rather than month-to-month), allowing electrical utilities to remotely coordinate power supply and demand, detect outages, implement time-of-use and dynamic pricing, and manage system efficiency and reliability. For these reasons, many see smart meters as a key that unlocks the promise of a decentralized and dynamic renewable energy system. As such, smart meters and associated technologies promise to have profound implications for how – and even whether – traditional utilities organize the storage, sale, and distribution of electrical power.

In Washington, as elsewhere, electricity generation, transmission and distribution are decoupled. In theory, energy can be produced by one entity, transmitted by a second, and distributed by a third. In practice, most of Washington's electricity is generated and transmitted by the Bonneville Power Administration (BPA) and distributed to consumers by any of 45 local public and private utilities. BPA is a nonprofit federal power marketing administration headquartered in Portland, Oregon and serving the Pacific and Inter-Mountain Northwest. Housed within the U.S. Department of Energy, it covers costs by marketing wholesale electrical power. BPA also controls a vast power infrastructure, operating and maintaining about three quarters of the high-voltage transmission lines in its service territory [11].[2]

Different electric utilities build and maintain storage, transmission and billing infrastructure for the power grid. Because they play a central role in moving electricity from power plants to homes and businesses, utilities are dominant actors in an otherwise heterogeneous organizational field composed of power generators, technology firms, university laboratories, state and municipal regulatory agencies, trade associations, labor unions and other professional groups, as well as consumer groups ([12]; see [13] on consumer groups especially). The US electric industry has historically enjoyed comparatively high levels of public ownership and continues to do so today. Public power utilities comprise 60% of electric utilities in the United States; rural electric cooperatives 26%, and IOUs 6%[3] [14]. The industry has also been the source of important power-related innovations [15,16]. However, scholars who study utilities have documented how, beginning in the 1990s [17], utilities' investments in R&D have shrunk dramatically as the sector privatized [18]. Other studies show that the decline in R&D spending has been steeper among private utilities, suggesting that innovation remains a favored model for publicly held utilities (but see [19,20]). To parse these dynamics, a small but growing body of research draws attention to innovation processes among non-profit and public organizations (see [21–24]).[4]

Three different types of electric utilities operate in Washington (See Table 1). Public Utility Districts (PUDs) are community-owned, locally regulated utilities governed by a nonpartisan elected commission. The twenty-four Washington PUDs serve approximately one million residential, business, and industrial customers in 26 of the state's 39 counties. Most PUDs purchase electricity wholesale from BPA and retail it locally, although a few own and operate their own hydroelectric dams [25]. Co-ops are a second type of nonprofit utility, in which customers set their own electricity rates, policies, and plans through elected representatives. Eighteen cooperatives operating in Washington serve roughly 280,000 customers [26]. The remainder of electricity distribution and sale is handled by Washington-based investor-owned utilities, or IOUs. These private utilities are profitmaking entities that are governed by the Washington Utilities and Transportation Commission, which sets electricity prices (more commonly known as "rates") that IOUs charge customers. There are just four IOUs in Washington State, but their service population is large: Avista Corporation, Pacific Power, Cascade Natural Gas, and Puget Sound Energy together provide electricity to nearly two million customers [27].

Utilities in Washington are legal monopolies within their established geographic service areas; they function at the state level as oligopolies within the electricity districts they serve. While not operating in the same highly competitive environments that private organizations in many industries face [28], utilities nonetheless face financial constraints that affect business and technological decisions. For example, IOUs must deliver profits to shareholders as if they operated in a private market. PUDs, on the other hand, are not allowed to earn profits, but they also are not allowed to charge too much or too little for the power they provide.[5] Additionally, the risks associated with technological innovation in electricity provision are very high: if not successfully designed and implemented, changes to the electrical grid could produce catastrophic energy loss, consumer dissatisfaction and a host of other problems [29,30]. Given the relative lack of competition among utilities, heavy state and federal regulation, and high risks of technological change, utilities have few obvious incentives for developing and implementing new, and largely untested, smart metering technology (see also [31]). Although the first generation of smart meters has, in some places, cut costs for public and private utilities alike by replacing high-cost labor-intensive meter-reading practices [32], the risks associated with piloting new technology remain present and significant. Yet despite these constraints, Washington utilities – public and private – are forging ahead with innovative technologies, business models, and organizational strategies raising the question: how does innovation occur across heterogeneous organizational fields?

### 2.2. Data sources and analysis

Our study begins with the assumption that the social, technological, and political environment shapes energy systems, and that actors' behavior is driven in large part by cultural norms (cf. [33]). Our analysis is based on evidence from semi-structured interviews with fifty-two respondents representing Washington-based advocacy groups, public

[2] In addition to Washington, this service territory includes Idaho, Oregon, western Montana and parts of eastern Montana, California, Nevada, Utah and Wyoming.

[3] The remaining 9% is a combination of federal power agencies and power marketers.

[4] Research suggests that, like private organizations, public organizations also can be regularly challenged by difficult problems that combine governance, economic, and social opportunities; they are relatively well-resourced and their funding is stable, even though public budget cycles are often contentious; and they are embedded within networks of public and private entities so much so that actively seeking out network ties is a crucial part of most public-organizational strategy. Intrinsic factors (such as experimentation) that are shown to be crucial for innovation abound in the public context.

[5] Regulation is explicitly designed to protect profits by setting rates that consumers pay and that, in turn, limit utilities' ability to turn profits and deficits.

**Table 1**
Utility Types in Washington State.

| Type of Utility | Number of Utilities | Customers Served | Source of Wholesale Electricity |
|---|---|---|---|
| PUD | 24 | 1 million | BPA; independently operated dams |
| Co-op | 18 | 280,000 | BPA/Various |
| IOU | 3 | 1.9 million | Independently operated dams/plants |

and private electrical utilities, technology firms, university and national laboratories, and consumer advocacy groups.[6] We achieved representation by drawing a stratified random sample of smart meter field actors. Derived from preliminary research, the sample included actors with different stakes and positions that structure cooperation, competition, and conflict in the field as well as those (dominant) actors that have played important roles in the field's development to date. The sampling frame of relevant organizations was generated by consulting various sources, ranging from state legislative records and patent data to trade association websites and participant lists for regional smart meter conferences. We also used preliminary interviews to identify less prominent actors (for example out-of-state technology supply firms or less formalized pockets of local opposition). We then grouped organizations by type and within each type order actors by geographic region, organization size, ownership characteristics (public, private) and demographic context (urban, rural). We drew a stratified random sample from this master list, which contained 261 actors. Interviews lasted between one and two hours. All were conducted in English and transcribed by a professional transcription service.

Our interview schedule sought to elicit information from respondents about organizational engagement in smart meter implementation and, to a lesser degree, sustainable tech innovation processes generally. There is a well-documented "valley of death" between R&D and deployment phases of innovation (cf. [34]); that is, the dynamics of energy innovation associated with deployment are often very different than the dynamics of innovation associated with R&D. Our concern here is primarily with the deployment phase. Interview questions were grouped into four major categories: origins of work and implementation, standardization and regulatory requirements, questions of network relationships and partnerships, and future outlooks. Within those categories, we asked about motivation to undertake work in the smart meter field, about the challenges and opportunities that organizations faced in pursuing them, about funding that shaped their decisions, and about the number and nature of inter-organizational collaborations. We discussed the regulatory environment in which organizations found themselves, as well as broader questions about consumer data and consumer reactions.

We took an inductive approach to data coding, beginning with empirical observations and seeking to generate new insights and hypotheses [33]. After transcribing the audio interviews, we conducted a content analysis of the resulting transcriptions to identify major conceptual themes (e.g. "collaboration", "culture" or "relationships"), which were subsequently refined to more precise themes and codes that permitted our emergent theory to remain tightly linked to our data [35]. To maintain confidentiality, we use pseudonyms, redact informants' specific job titles, locations, and, in some cases, the type of organization they represent.

Qualitative data, and particularly anecdotes or vignettes, are an important device in helping people from different disciplines better understand each other in working on applied environmental problems (cf. [36]). The quotes used in this article were selected because they were broadly representative of other similar actors' views, and occasionally because they provided clear insights into a specific mechanism or process.

In addition to our interview data, we conducted extensive secondary-source analysis of existing statistical data and documents [37]. We collected all publicly available and non-public documents we are able to locate and obtain. We prioritized analysis of materials produced by the sampled organizations. In addition, we sought government records, articles from newspapers, trade magazines and academic journals, transcripts of legislative hearings and commission meetings, and relevant websites to triangulate processes and findings within our interview data. We coded documents and secondary sources according to similar procedures as the interview data, with primary and secondary readings designed to elucidate social dynamics. This process helped us build a theoretical framework that both emerged from, and tightly linked to, our study data (Eisenhardt 1989; see also Charmaz 2006; [35]).

## 3. Conceptual framework

All too frequently, studies of technological innovation and innovation policy do not integrate a systems perspective (cf. [38–40]) and the complexities inherent within these processes are ignored [41]. The approach we develop here aims to add precision to "systems thinking" by drawing on institutional analysis from organizational sociology and management research, which is divided on the question of how innovation emerges. In one camp, innovation is thought to happen *within* organizations. Across a wide range of studies, researchers have identified characteristics of innovative organizations (cf. [42,43]) and innovative people within organizations (cf. [44]), as well as organizational decision-making [45] and practices [46,47].

Others argue that innovation is distributed across, and predicted by, inter-organizational networks and systems [48–54]. From this perspective, inter-organizational relationships and systems dynamics help organizations access knowledge and resources that are unavailable within their own boundaries; the locus of innovation is often found within a network, rather than a single organization ([54]; see also [55–57]). In particular, research on national systems of innovation responds to the ways in which globalization has reshaped national hegemony (cf. [58]), and further work has explored how innovation *within* nations—in regions and sectors—is also evolving ([59]; see also [60,61] on regional and sectoral systems).

In the context of sustainable technology deployment, inter-organizational relationships and the cultural norms that guide them matter a great deal. Deployment, by definition, implies the interaction of different organizations, and understanding the normative glue that holds such processes together is helpful to understanding the nature of the processes.

Our concern here is with the cultural norms and practices that exist within such systems, adding a cultural-organizational perspective to existing work on sociotechnical systems of innovation (cf. [62,63]). Further, recent research has shown that social relationships, political climates, and peer-to-peer influences figure highly into the adoption and deployment of technologies [64,65]. The nested logics framework we describe next builds on these insights about organizational culture and is derived from data analysis of institutional processes and organizational change driving smart meter deployment among different actors in Washington's crowded energy field.

[6] See Appendix A for a complete list of respondents.

### 3.1. A nested logics framework

The concept of institutional logics addresses the cognitive and symbolic dimension of social institutions and organizational behavior. The term refers to the shared practices, beliefs and values that govern "how a particular social world works" ([9]:101). Institutional logics are concepts for studying relationships among institutions, individuals, and organizations [9,66,67]; they are social orders that are distinct from geography or regional clusters (cf. [68,69]) in their attention to culture, norms, and social context. Institutional orders "shape how reasoning takes place and how rationality is perceived and experienced" ([67]: 2),[7] moderating organizational behavior and shaping variation in a field.

But what happens when multiple institutional logics operate simultaneously? Recent work explores how competing logics can provoke productive organizational change (cf. [10,70,71]) or, inversely, how incompatible institutional logics can stymy organizational change ([72,73]; see also [74]). We extend this general line of inquiry to examine how institutional logics that are nested across different scales of organization, "like a traditional Russian doll" ([75]: 9), can drive innovation and diffusion.[8]

Nesting is dynamic and bi-directional: each specific logic is embedded within a larger social context, but the larger social context is influenced by, and responds to, the logics within it as well. In this sense, nesting functions as a type of opportunity structure (cf. [76]) that either promotes or constrains organizational behaviors at different scales in response to the interaction of logics. For example, the Washington-based utility Avista is an organization composed of interacting internal offices and positions. But Avista is embedded within a statewide organizational field populated with many other kinds of organizations. In turn, Washington's energy field is embedded within a U.S. energy field – a vast field of organizational actors that includes multi-state regulatory commissions, Congress, the Department of Energy, and other federal agencies and programs. Empirically, this structure is important because, although utilities are the dominant actors in the Washington energy field, they do not act independently. Instead, their behavior is conditioned through relationships with other organizational actors at other levels, all of whom, we find, make decisions guided by institutional logics nested within each other.[9]

The tripartite structure of our framework corresponds to rough scalar levels (nation, state, organization). The dominant institutional logic operating at the broadest scale is characterized by the idea of *developmentalism*: that states should promote the common good and manage market failures in pursuit of that good (cf. [77,78]). Although the partisan nature of US politics has made these efforts virtually invisible to mainstream public debate, this "hidden developmental state" [21] has had major impacts on the structure of the U.S. national innovation system. Nested within a logic of developmentalism, an institutional logic of collaboration among Washington utilities is particularly visible primarily at the state level, and encourages partnerships and knowledge sharing, including among local government organizations [79], that works to ease the pressures for competition that might otherwise dominate markets. Because the locus of much US energy policy is at the state level, it varies a great deal across the country [80,81]. In Washington, the state-level patterns of energy resources, energy consumption, and the political and economic context is unique and, we argue, contributes to a unique meso-level institutional logic that both shapes and is shaped by the macro-level logic of developmentalism. At the organizational level, utilities that are characteristically innovative in terms of their network connections [54], decision-making, and behavior are influenced by the logics of developmentalism and collaboration, and by interaction between the two. As we will show, these nested logics harmonize and reinforce behavior across different types of organizations with different incentives and different positions in the (multi-scalar) field to produce the type of unexpected innovation that we describe below.

Our nested logics framework draws attention to how inter- and intra-organizational culture and norms may reinforce one another or produce interaction effects. This perspective enables us to engage recent debates about the effects of multiple institutional logics on organizations [10,70,82] and answers the call for institutional theory to elaborate how innovation in public sectors occur [83,84].

## 4. Results

Our analysis suggests that smart meter implementation happens in the context of nested institutional logics that govern longstanding inter- and intra-organizational relationships. We present the results of our institutional analysis in three parts, corresponding to the tripartate framework described above.

### 4.1. Public research funding and developmentalism

The institutional logic of the developmental state is historically rooted, and was first widely perceptible in the wake of the Great Depression. Originally designed to assure reasonable profits for industry and guarantee living wages for labor, the National Industrial Recovery Act of 1933 also included "New Deal" support for innovation: federal expenditures for research and development in the 1930s accounted for 12–20% of total R&D expenditures during that decade while industry backed about two-thirds ([85]: 132). More importantly, the Act also helped create formal and informal links between industry, state, and university research (and those links were partly conditioned by the decentralized funding and structure of US higher education) ([85]: 132). The New Deal, and stimulus programs generally during this period, established incentives "through which economic functions formerly shaped by market competition would be planned and regulated in the public interest" ([86]: 256). The idea behind these programs was to incentivize the market towards the public interest, and to jumpstart economic recovery—a logic that we identify with the developmental state. This logic gives cultural weight to support for and provision of collective goods, support for critical infrastructure, the resolution of social problems, and a social contract for science and technology, while heavily emphasizing relationships with market forces.

Today, a similar institutional logic underlies federal efforts in the wake of the Great Recession of 2008. With a national economy in freefall and investments sluggish, the Obama Administration sought to stimulate economic recovery in the private sector with an infusion of public money and resources. Like the New Deal before it, the American Recovery and Reinvestment Act (ARRA) emphasized innovation, particularly in the clean technology and renewable energy sectors. ARRA investments were a boon for power especially. The Act included the largest ever one-time investment in upgrading the U.S. electrical infrastructure, mitigated some of the risk of innovation, and supported utilities in sharing their experiences throughout the electric industry ([87]: 5). The program devoted over $50 billion to energy technology innovation, green jobs, and low-income energy efficiency assistance programs, many of them focused specifically on "shovel-ready" implementation projects.

Since 2007, funding for smart grid-related R&D from public and private sources has totaled more than $12.5 billion [88], including $4.5 billion allocated through the ARRA specifically in 2009 [29]. The

[7] Organizations, shaped by environmental imperatives, often engage "alternate" forms of rationality [114], that we call culture.

[8] Existing research has shown that innovation and diffusion dynamics differ more between small and large systems than amongst different technologies [40], suggesting that sustained attention to multi- and inter-scalar innovation processes is warranted.

[9] Indeed, other studies have found that the primary predictor of the diffusion of environmental policies is politics and political culture, rather than organizational structure [65]. See also Parag and Janda [115] on multi-level systems.

funding stream, in part, has been channeled into new research programs to develop smart meters and other "smart" energy-related systems and components. Across the country, ARRA funds have been used for research and pilot projects by electrical utilities, universities, federal research facilities, and large and small engineering and technology firms.

Washington-based utilities saw substantial benefits from this federal program. All utility-based respondents in our sample credited ARRA funds for helping propel them into smart meter use. For instance, a major IOU joined forces with other smaller regional utilities to demonstrate smart grid technologies, using matching stimulus monies—effectively creating an inter-organizational innovation network through incentives offered at the federal level (see also [54]). Combined, the utilities put up $18.9 million dollars to move one Washington city towards "Smart City" status. The goal was to create a regional smart grid that included updated and automated distribution systems, roll out AMI on homes and businesses, and to pilot a Smart Home project. For this utility, the ARRA resources permitted a test-drive that rendered their subsequent smart meter implementation projects more efficient:

> [We] deployed about 13,000 advanced meters in [the city]. [That demonstration project] was part of a federal grant we received from the American Recovery and Reinvestment Act back in 2009. We learned a lot from the […] pilot and […we are] applying those learnings to the current operations of our distribution system, and also as we plan ahead and anticipate the evolving needs of our customers and the energy future. —Larissa, Communications Manager,[10] IOU

As Larissa's comment shows, ARRA subsidies enabled the utility to explore and refine AMI programming, leading to more long-term thinking and improved programs elsewhere in the state. The Department of Energy considers this deployment of funds successful, for the same reasons that utilities do, arguing that the "investment in and large-scale deployment of these technologies has given utilities—and the industry—the opportunity to gain critical operational experience thus allowing us to move from the cycle of pilot projects to full-scale deployment in utility operations" ([87]: 2). For the DOE, funding a project like this is consistent with a logic of developmentalism, and has long-term, full-scale deployments as its end goal.

Elsewhere in Washington state, utilities jumped at the chance to experiment with smart meter installations, even though, as many of our respondents told us, the business case for AMI deployment remained weak.[11] This incentive helped the utilities develop a socially-desirable technology, despite weak financial incentives. As one research director recalls:

> Their [utilities'] business case—all it had to say was it [smart meters were] ready to go at that time, the technology was there, it will save them *x* amount of dollars on sending meter trucks out, and it will help with reliability. They didn't really have to make a big business case. —Nick, Research Director, Trade Group

In this case, the stimulus enabled private infrastructure to create what it understood as a public good, by helping pilot new technology and mitigate some of the financial risk of installing meters.

For another utility, the ARRA grants jump-started a more time-intensive and thorough reconfiguration of the grid towards "smart" status. Rather than funding smart meter installation projects as many other utilities did, "we took the approach that to get the maximum value, we had to do things on the grid—automate the grid to make it more efficient and more reliable—that would then add to that the customer experience [of a smart meter] on a more limited basis" (Cameron, Engineer, IOU). Cameron's utility saw the grants as a social and economic opportunity to pursue long-term investments and alterations to the grid because, as an IOU with a profit mandate, his company needed a financial incentive to be able to plan long-term. The federal stimulus created a social opportunity to begin rethinking the grid systematically; as a mechanism of development, it indirectly asked utilities to invest in that infrastructure by offering stimulus funds for upgrades, and to mitigate some of the financial risks of doing so.

The ARRA was one major recent instantiation of a logic of developmentalism in sustainable tech innovation. One engineer credits the ARRA's focus on smart meters with publicly funded research that was three decades old; while many of the ARRA projects were focused on deployment, those projects drew on basic research that had been publicly funded some years ago. He spent the first part of our interview recounting the development of smart meter concepts at his laboratory, linking them to emerging thinking elsewhere:

> [Engineers] actually had notions clear back in the 80 s of "wait a minute, energy efficiency is not just passive. It could be active!" That's very much a smart grid notion. As it turns out there was a couple of people in Bonneville [Power Administration] that, at the same time, were thinking about the "energy web", as they called it. At the same time, there was a few people at EPRI [the Electric Power Research Institute] in California, they called it something goofy […] Anyway, it kind of independently sprang up in these three places. It was clearly one of those things where if you just look at the world from the right angle, it's obvious. […] It was completely impractical then, but the notion was there.

This engineer traces the development of smart grid concepts back thirty years, to informal relationships among public and private institutions that predated most contemporary iterations of the technology. Public funding and public organizations put pieces into place of what would eventually become the ARRA smart grid program, well before smart meters themselves came online.

The broader point is that for many academic, government, and industry research labs, public funding represents an important opportunity to incentivize or support innovation. It also helps reinforce the belief that this kind of support is fitting and proper. Thus, many see public funding as a critical component of developing new technologies, whether the research itself is executed by public, private, or cooperative organizations. In this way, federal grant both embody and reflect a logic of developmentalism. In other words, research grants help to legitimate the idea that federal resources, and the grants that provide them, is worthwhile and proper role of government. A manager at a different lab sees state and industry support are necessarily codependent, working together towards a shared goal. For him, public funding of R&D itself is not simply an incentive, but rather a public good:

> I think there's a very critical role for government funded R&D, simply because a lot of companies, especially like a utility, simply does not have the risk profile to take on a lot of very risky R&D. That's just not who they are or what they should do. I heard one really good expression […of] what a federal lab researcher does: "we do the research that the private industry either couldn't do, wouldn't do, or shouldn't do". [….] The research we do is very early stage […] We rely on industry to take those ideas and then move them up that TRL [technology readiness level] scale to actually get them into commercial product and to test them. We *need* that relationship. We can't do it all by ourselves. –Pablo, Manager, Public Research Lab

Pablo sees developmentalism as a logic that infuses the state, and frames public financing of research as a public good that supports technological advancement generally. Explicit in his comment is the notion that state should assume (at least partially) the risk profile of

[10] All names are pseudonyms.

[11] For consumers, a weak business case referred to the limited impact that smart metering would have on lowering home and business energy bills which in Washington are already among the lowest in the nation.

technological innovation, and that this kind of sharing of funding and R&D responsibilities are a fundamental responsibility of a functional developmental state. By the same token, national labs do not have the relationships or the expertise to market and disseminate technologies, and therefore rely on private partners to scale and test new technologies—reinforcing a logic of collaboration at other levels.

Repeatedly, respondents in our sample suggest that both the ARRA and the ongoing federal funding for research fall within the purview of responsible government, pointing to an institutional logic of developmentalism. These findings help us understand how public monies affect innovation processes and broader economic trends over the long term. While existing literature has established a link between federal grants and R&D [89], our research suggests that an innovation ecology extends far beyond grant-making, and that respondents recognize public funding as a collective benefit (see also [90]).

### *4.2. Collaboration in established innovation infrastructure and feeder programs*

Washington utilities are also conditioned by a logic of collaboration that operates within the state. This logic is a more expansive cultural norm than what has been characterized elsewhere as an imitation process of "learning-by-copying" [16]. Rather, collaboration is a pervasive logic that shapes and structures behavior and cognition, both justifying and encouraging interaction and coupling among different types of organizations with different mandates and incentives. As we will see, in Washington, this logic is particularly clear among network partners (including utilities, funders, trade associations, and labor organizations), and is nested within a larger logic of developmentalism.

One of Washington's Centers of Excellence (a regional, public initiative) is an example of how a regional innovation system, operating with a logic of collaboration, can support the development of new technologies. Publicly-funded Centers of Excellence have popped up across the U.S., and are closely linked to federal initiatives that support technology and skills development. Usually located on campuses of public colleges and universities, they function as hubs for best practices, innovation, leadership, research, support and/or training for specific focus areas, such as homeland security or clean energy [91]. In Washington, these Centers are charged with narrowing the gap between employer workforce needs and work-ready graduates and are located on campuses of community and technical colleges rather than research-intensive academic environments. This model is designed to help new technology scale quickly, and the worker training program is understood as an important piece of the "state's strategy of sustaining an innovative and vibrant economy" by linking private industry and labor unions in an effort to harmonize worker skills and industry needs [92]. They represent an institutionalized form of inter-organizational collaboration embedded in a certain set of cultural expectations and norms, helping build an innovation "infrastructure" that explicitly links the public education system to other key actors in the tech economy:

> Washington had the state board for community and technical colleges come up with this model […] basically to be economic development drivers in the industries that were important to the state's economy to ensure that the workforce for those industries was being developed based on industry needs. – Bonnie, Program Manager

The program is designed to harmonize labor skills with production demand, and it takes this mandate seriously. In theory, this Center will allow the industry to adopt cutting-edge technology more quickly, because it has access to a consistent stream of well-trained young workers. As one labor organizer we interviewed described it, Centers of Excellence should operate as an integrated system of public-private workforce development: "In a perfect world any community college system would be […] churning out individuals that meet industry needs, because the industry is at the table, telling us what [they] need. That's the perfection I'm striving for" (Kay, Labor Organizer). Here, marshalling public resources to meet industry needs is treated as a public good.[12] Kay is describing an integrated system of relationships with a shared set of norms—a collaborative culture that is reinforced by economic incentives legitimated by developmentalist logic.

The theory of change enshrined in the Center of Excellence is fully dependent on public systems: the board selects a public college that is best suited to hosting the program, and outfits it with public support. In addition, these training programs are seen as critically important to the United States meeting its carbon reduction goals and maintaining a competitive edge in tech innovation internationally. Bart, an engineer with a government agency, links a lack of training to a climate of falling competitiveness in the tech industry:

> We have a challenge in front of us as a society to address the carbon issue and do it in a manner that doesn't hamstring our normal lifestyle and business and the economy. […] To do that, you're going to need a whole other generation of people to do the work […] Even if you can increase that [workforce] pipeline [through university programs], we still don't have enough, domestically, people coming through the university systems to meet the need. So we have to import people that have gotten that training or that orientation or the interest, from other parts of the world.

In this context, Bart sees part of the Center's mandate as preparing the workforce that would permit tech programs to hire locally, thus supporting the domestic labor market. This, however, cannot be accomplished without supportive logic of developmentalism that informs his collaborative approach:

> Meanwhile there's all this talk about exporting jobs. We should not be exporting jobs […in] manufacturing—high-value jobs! We should be taking people and retraining or training the next generation to do those jobs *from* our domestic population, *through* our education system. And to do develop those products here and then take that technology and market it, export it, just like what Boeing does with airplanes. – Bart, Engineer, Government Agency

Both Bart and Kay understand this kind of development as critical to establishing a scientifically fluent workforce that supports robust domestic innovation. The entire skilling system is based on relationships between labor, public subsidy, and industry needs. Critically, however, state-level initiatives like these that span organizational forms and mandates require the supportive national logic of developmentalism to render them plausible.

Additionally, the unique nature of the utility field—specifically, the lack of direct competition among utilities—is often cited among utilities themselves for supporting an environment of collaboration, and through that, innovation. This finding emerged repeatedly in our interviews and resonates with other studies showing how collaboration can generate innovation [93], whereas competition can impede it [94]. As one manager for a mid-sized PUD observed:

> One of the unique things about the electric industry is that in general we don't compete against one another. We have our service territories that we serve, and so it's really collaborative. Everyone wants to learn from one another. There's no trade secrets. […] Ninety-nine percent of utilities share that and that's how it's a little bit different than other industries that are much more competitive in nature. – Walter, Project Manager, PUD

Walter continues, explaining that the lack of competition in the environment helps foster more rapid innovation through information

[12] The relationship, however collaborative, also raises provocative questions about who is driving the direction of job growth; as private, profitmaking entities are deeply engaged collaborators, they have an outsized voice in the use of public funds for the development of jobs, while accountability mechanisms remain limited.

sharing and a general ethic of collegiality. In other words, the normative culture of sharing is in part *enabled* by the non-competitive structure of the industry, but by no means *determined* by it:

> You look at these different trade conferences and utilities always are drafting white papers and presenting them and just sharing their knowledge of their experience. We've done that a bunch with all of our projects, our smart grid projects […] "This is what we did, this is the problems we had, these are the solutions", and just try to share that knowledge out to the industry.

The monopolistic nature of the electrical power field, infused with, informed by, and informing a national logic of developmentalism, yields a highly unusual climate of cooperation among organizational actors in this case. Another manager reflects specifically on how this cooperation fosters new ideas, even for private utilities. For her, the noncompetitive nature of utilities—even investor-owned ones—is precisely the characteristic that permits the partnership, risk-taking and experimentation that can lead to innovation:

> We're [utilities] all in this together. Our service territory and our returns are defined. I say that from 18 years or so experience being one of the engineers that would do that kind of collaboration between service territories. It might go faster *after* someone takes a risk, but that's because the rules are so well-defined.

In this example, the logic of collaboration facilitates relationship-building, unification, and information-sharing, even absent an explicit financial incentive. An engineer, Alec, from a county-level PUD reflects:

> I think the challenge that we have, here at the utility, is that we tend to see things pretty short, in a short time frame […] Where we have a challenge is looking beyond today, and to 3, 5, even 15 years down the road. What would the services be? What would customer expectations be? What would regulatory compliance look like? What are all the things that might impact us in the future? Trying to forecast some of that. That's my job, I travel a lot, interacting with other utilities, or technology conferences, to try to understand the trends that utilities are moving down and try to align our technologies to be able to be as future proofed as possible.

Alec continues, describing his utility's motivation for deploying smart meters in the first place:

> [Our] PUD is pretty unique in the sense that we generate about 2000 MW of power, and we sell about 80% of that onto the market. We don't have a problem with our generation resource. We use about 18% on average. Whereas many public utilities do have a source issue. Things like demand response or critical peak pricing. Customer load control, those things are of interest to people in the public sector. Our model is quite opposite of that. […] Today the focus has shifted into, "all right, now that we've got all this great data, how can we organize it to make good business decisions around value to our customers, around reliability, around being able to co-exist with renewables on the systems".

Importantly for our argument, Alec's utility deployed smart meters not because they had an immediate financial incentive to do so—it generates a great deal more power than it needs to meet demands. Alec contrasts his utility's situation to "a traditional utility [that] is able to–because of the value of the energy–a traditional utility, through demand response, could generally end the reduction of meter reading costs, could generally have a positive ROI [return on investment] in a relatively short period of time", this PUD deployed smart meters as a part of a collaborative effort to "future-proof" the grid – a decision that is enabled and legitimized by a culture of cooperation. Alex offers a final, telling comment:

> Not all of our decisions are going to be cost based. […] We recognize this technology is a long-term investment […] This goes beyond cost benefit analysis. It goes directly to the customer, I think is what I want to emphasize. Value to the customer, that doesn't always make dollars and sense.

Value to the customer, for Alec, is generated through the adoption of a new technology in keeping with the expertise and movement of the field. In Washington state, this logic of collaboration is enabled and reinforced by (and in turn, reinforces) a national logic of developmentalism (investment in the public good, knowledge production, and infrastructure). It also, as we shall see, enables and legitimizes the development of inter-organizational network partnerships. Together, these nested logics bolster innovative efforts and the long-term development of both new technologies and skilled workers.

### 4.3. Organizational-level: network partnerships

The institutional logic of collaboration operating among Washington utilities reflects not just the importance of federal funding, but also reinforces network ties among organizations. Among our respondents we see not only that public organizations are heavily networked, but also that their network connections are strategic. This is consonant with predictions from prior research [52,53]. One of the leaders of the Center of Excellence described in the previous section discusses the Center's educational success as a direct outcome of tight, functional, and highly intentional decisions about building collaboration:

> We did not [develop our program] by ourselves, but with all of our major utilities in Washington. […] It's just about the partnership. [It] drive[s] it at every level.[13]

As we learned from several interviews, many young nonprofit or private organizations strategically surmounted their "liabilities of newness" [95]—such as an inability to find funding—through partnerships with well-established organizations. Under the right conditions, partnerships can also help public organizations overcome legitimacy challenges they may face because of their not-for-profit status. Pablo, an engineer at a public research lab, reflects on this trend:

> We're seeing more and more large projects that are funded by the [Department of Energy] where they want an industrial partner that is a co-lead. […] I think they do that because they want to demonstrate that these projects have some real-world merit, and it's not just a science experiment […] DOE does get sometimes criticized for all the money they invest in the national labs, and it's like "how many jobs has that generated for us lately?"

For him, the network partnerships reinforce a public focus on deployment, combatting the perception that labs simply undertake "science experiments". Pablo continues, exploring how this pressure to produce jobs has manifested in his lab's focus on marketization, and its approach to organizational partnerships:

> The DOE has started to show a lot more interest in making sure that they're [demonstrating] some real tangible benefits that come from these R&D investments. Having an industrial partner kind of demonstrates that, yes, […] there is a path to commercializing these technologies.

As Clemens [96] has shown in a different case, state or public organizations compensate for perceived inadequacies through the strategic use of partnerships, often with private organizations that are perceived to be leaner and more efficient. For Pablo, private organizations, motivated by profit, are less likely to collaborate with a public utility absent a "real world application" that promises market value.

[13] This statement resonates with findings by Chan et al. [116] regarding the necessity of collaboration.

Pablo also told us that forming network partnerships are a conscious and ongoing part of his lab's research and innovation strategy. This strategy, often referred to as "multiparty innovation" [97], prioritizes creating and maintaining relationships, to have them ready when a social opportunity (such as an RFP) appears. For example, networks are frequently accessed in efforts to capture funding and related research opportunities. The approach represents strategic and intentional organizational decisions over and above simply having network connections. Pablo continues:

> The way we've learned the way to do that is […] to set up these relationships early […] We always like to say you need to have a lot of these relationships in place way ahead of that time. If you wait until the FOA [funding opportunity analysis] comes up—because now they're expecting a proposal within 90 days—it's almost too late to start developing relationships at that point in time. We like to try to develop long term relationships so that we kind of have them on tap.

As this excerpt suggests, having relationships with other organizations "on tap" helps the organization pursue funding or project opportunities on much shorter notice than it otherwise might—ongoing and collaborative partnerships within an ecology that help the organization take advantage of social opportunities on short notice. In that sense, the *possibility* of funding opportunities is often the initial impetus for creating inter-organizational relationships, but the fact of these "long-term" relationships creates ongoing normative conditions in the field. Kay, a labor organizer, describes receiving an ARRA smart meter training grant in almost identical terms:

> We knew […] that this money was going to be coming down. […] A much smaller group of the advisory committee got together and was very strategic in "what do we want to do? Where do we want to go? What's going to be our focus?" And we developed our almost strategic plan informally and sort of like, "Okay, now we're locked and loaded. Now we'll see what money comes down to see how that idea, we know we can do, we're all committed to doing, we'll see if a funding grant opportunity comes down for those dollars." It did.

Kay continues, discussing how the funding partnership has shifted the dynamic among organizations in a much more permanent way:

> [The collaboration] made me rethink how the industry works. When I very first met some of the utility folks within the company, they were sort of like—industry and labor have, at times, sat across the table from each other. […] This grant opportunity created this situation where there *was* give and take. We're […] all rowing in the same direction. […I] don't know that many people within the labor community that can also call the president of a power plant and go, "Hey, you want to go grab a glass of wine and talk about this?", which is what happened. We're still acquaintances. Some of us are still very good friends.

As a labor advocate, these collaborations have helped Kay rethink her network partnerships and even alter her longstanding wariness or suspicion of industry. This, despite the fact that "grabbing a glass of wine" produces no immediate, tangible benefit; the logic of collaboration is more durable than a one-off project. Her experience of inter-organizational networking reinforces the driving logic of the field (the norms of collaboration), and eased some of the historical tensions between different actors.

Respondents in this section directly credit their networks and partnerships with the development of new programs and technology incubators such as Washington's Centers of Excellence. The characteristics of their organizations, and particularly the relationships that exist, are supported by a state-level institutional logic of collaboration, within the context of a national innovation system that supports the development of new ideas through funding, seeing it as part of the role of the developmental state. Organizational actors can justify these relationships and collaborations precisely because organizational-level decisions are culturally supported by positive views on public infrastructure, ideas, and collaboration at other levels in the social system; network relationships also serve to mitigate some of the legitimacy issues that public organizations face.

## 5. Conclusions

The development and deployment of new technologies such as smart meters will be critical to society's ability to transition to a renewable energy system in the context of climate change. Using a nested institutional logic perspective, we have shown how relationships across different institutional levels and different organizational forms facilitate deployment of new technologies such as smart meters by legitimizing organizational forms and behaviors (such as collaboration among private firms) that might otherwise be considered deviant or nonconformist. This paper has explored the complexity of the energy innovation process. Our findings affirm the value of qualitative approaches in studying complex systems that are structured by interactions among diverse actors and at different, interactive scales. This is especially so given the large empirical literature on energy service provision that is derived from survey research – a method that is less well-suited to generate insights about institutional processes and organizational change (see, e.g. [98–100]). Our findings also suggest the need for more sustained network science research about energy innovation generally. To conclude, we note three points that follow from our study and that have important practical and theoretical implications for the future of energy research and energy transitions.

The first point is that field conditions can have lasting effects on organizations' long-term planning. *Extant* field conditions forecast the inter-organizational dynamics of the energy transition. In the United States, institutions like the law, corporate governance, and the stock market encourage for-profit companies to take the short view (compared, for instance, to many places in Western Europe where the laws encourage longer-range thinking). Tech companies working in the electrical power field complain of this orientation; one argues, for instance, that "more efficient long-term plans are needed to coordinate future generation and transmission investments" [101]. Even in this context, public organizations are well-suited to the long-view because they are not subject to the same short-term profit pressures. A comment from an engineer provides insight into how this mechanism may work: "I am enamored with public power. […] They're innovative thinkers, so I think a lot of it is where they sit." Public organizations are tasked with long-term service provision, and "where they sit" is envisioning products that may only yield fruit much later. Our study show that public organizations can afford to be early adopters precisely because the lack of profit motive insulates them against market failure, while the institutional logic of developmentalism, encompassing a logic of collaboration, legitimates organizational decisions made with the future in mind.

This study also speaks to the importance of inter-organizational collaboration for different stages of innovation, our second point. While existing research has shown that collaboration can (and often does) drive innovation, popular narrative remains firmly attached to the notion that organizations innovate when they compete, because competition forces efficiency. Yet, in Washington's electrical power field, innovation emerges through collaborative networked partnerships among like organizations, because regulation largely *prohibits* competition. For instance, these findings suggest that arguments to privatize utilities, often based on the grounds of efficiency [102], may be shortsighted.. However, collaboration also can lead to risk-taking that might not otherwise occur; industries that privatize arguably miss these opportunities. Rather than assuming that privatizing is always better, we must remember that there is a critical role for public organizations, and the state, in the energy transition.

Finally, this study has implications for the future of publicly-funded research. Governments in the US have always had problems with legitimacy as a consequence of the weak-state configuration and political ideology [96,103,104]. However, scholars have suggested that a potential source of legitimacy for imperiled states is successful entrepreneurship ([105]; see also [106,107]). If correct, government and public organizations should take more vocal credit for spurring innovation of forward-looking technologies that improve citizens' lives. Many organizations that play a key role in innovation are public, as we have seen. Yet, in many other contexts, private and for-profit firms typically claim an outsized portion of the credit [22,77]. Even in our data, partnerships often seek the legitimacy of market actors. Failing to recognize the public role in innovation could lead policymakers to cut funding and undervalue public investment in research; this would likely have the undesirable effect of making the United States significantly less innovative and competitive, and potentially slow the country's energy transition.

As societies transition away from fossil fuels and toward energy systems based on renewable sources, innovation takes on new political and social urgency. Understanding the ways in which new ideas come about has never been more important. Evidence from this study suggests that robust innovation can and does happen at multiple levels, and it is strengthened through the nested logics that we describe here. The case of smart meters demonstrates that innovation need not always be hamstrung by a profit motive or lack thereof—indeed, this study shows there are robust public programs and institutions that can help society achieve its critical goals. It therefore remains vitally important to support and protect them.

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**Appendix A. Interview Respondents**

| | Organization Type | Job Title |
|---|---|---|
| 1. | Activist | Activist |
| 2. | Activist | Activist |
| 3. | Activist | Activist |
| 4. | Activist | Activist |
| 5. | Activist | Activist |
| 6. | Activist | Activist |
| 7. | Activist | Activist |
| 8. | Activist | Activist |
| 9 | Consumer Association | Associate Director |
| 10. | Consumer Association | President |
| 11. | Government Agency | Engineer |
| 12. | Government Agency | Engineer |
| 13. | IOU | Outreach |
| 14. | IOU | Media |
| 15. | IOU | Communications |
| 16. | IOU | Engineer |
| 17. | IOU | Marketing Director |
| 18. | IOU | Technology Director |
| 18. | IOU | Planning & asset manager |
| 20. | IOU | Communications |
| 21. | IOU | Products & Services Director |
| 22. | IOU | Engineer |
| 23. | IOU | Administration |
| 24. | IOU | Operations Manager |
| 25. | IOU | Program Manager |
| 26. | IOU | Policy Manager |
| 27. | IOU | Administrator |
| 28. | IOU | Engineer |
| 29. | Labor Union | Apprenticeship Manager |
| 30. | Municipal Utility | City Council |
| 31. | Municipal Utility | Electrical Engineer |
| 32. | Municipal Utility | Utilities & Public Works Director |
| 33. | Municipal Utility | Marketing/Outreach Director |
| 34. | Public-Private Tech Partnership | Director |
| 35. | Public-Private Tech Partnership | Executive Director |
| 36. | PUD | Technology Innovation Office |
| 37. | PUD | Net Metering Coordinator |
| 38. | PUD | AMI Project Executive |
| 39. | PUD | Chief Technology Officer |
| 40. | PUD | Customer Services Director |
| 41. | PUD | Marketing/Outreach Director |
| 42. | PUD | PUD manager |
| 43. | PUD | Chief Information Officer |
| 44. | Research Laboratory | Engineer |
| 45. | Research Laboratory | Technology Director |
| 46. | Trade Group | Energy Services Director |
| 47. | Trade Group | Environmental Group |
| 48. | Trade Group | Executive Director |
| 49. | Trade Group | Project Development Manager |
| 50. | University | Electrical Engineer/Professor |
| 51. | University | Engineer |
| 52. | University | Engineer |

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