CalFlexHub
Advancing Dynamic Energy Management

Stakeholder perspectives on the role of standards in establishing a load-flexible ecosystem

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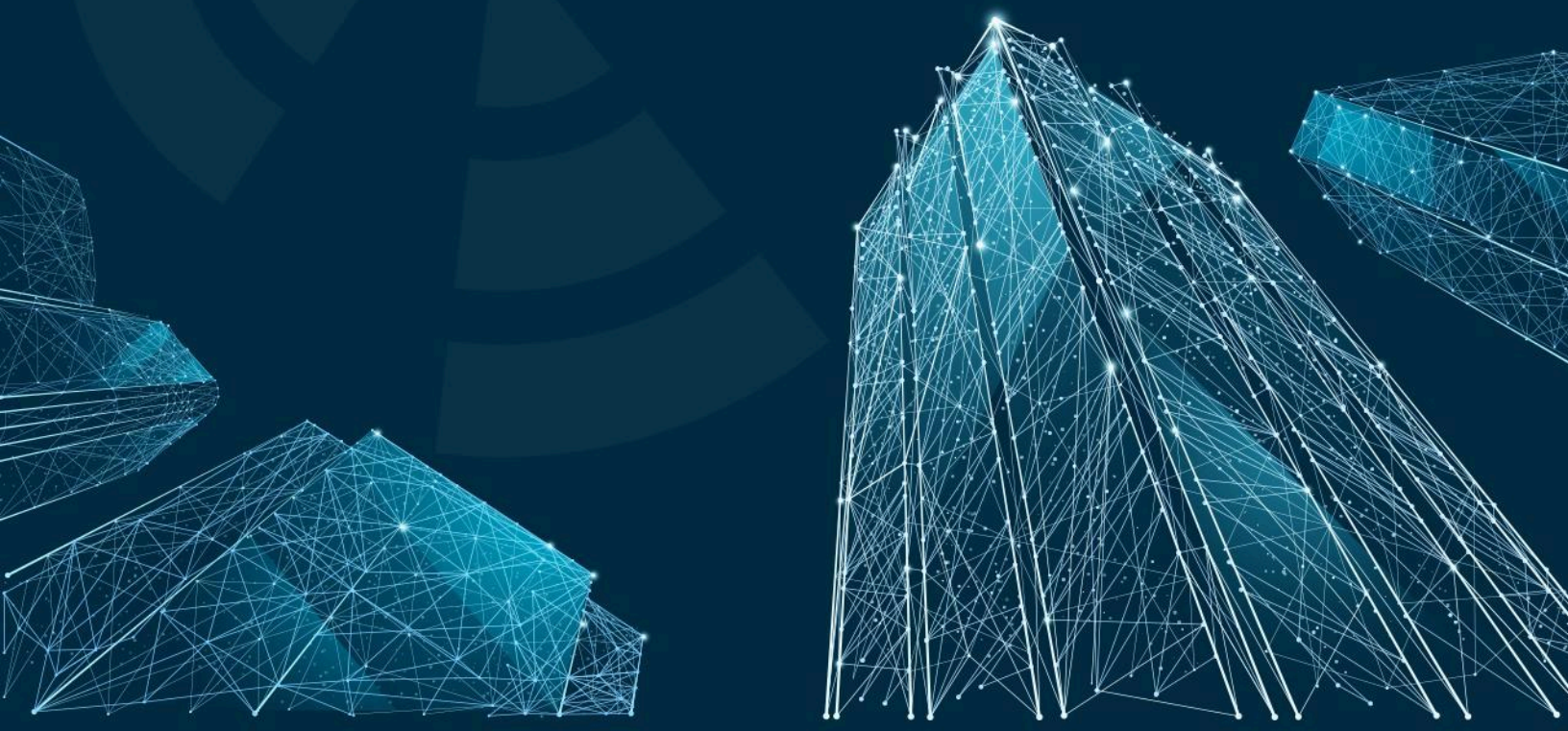

UCDAVIS Western Cooling Efficiency Center

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Stakeholder perspectives on the role of standards in establishing a load-flexible ecosystem

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ABSTRACT

Effective integration of load-flexible devices into residential and commercial buildings is integral to the success of California's vision for continuous load management. As part of a larger project, researchers are examining stakeholders' priorities, constraints, and needs with respect to a transition to highly dynamic prices and automated load flexibility. In-depth interviews were conducted with 95 individuals across four stakeholder groups—energy service providers, technology providers, large commercial customers, and energy/environmental interest groups.

Technology standards emerge as a key driver with regard to market stimulation, innovation, and widespread adoption of interoperable load-flexible technologies that enable grid-interactive energy-efficient buildings. This paper explores the "chicken and egg" issues related to the widespread adoption of load-flexible devices in the face of uncertain technology standards. Stakeholders warn that lack of standards creates uncertainty, causing manufacturers to take a "wait and see" approach, while overly prescriptive standards would unfairly create 'clear winners,' thus stifling technological innovation. Manufacturers hesitate to integrate load flexibility into their products while at the same time, utilities are slow to develop programs to promote load flexible technologies because few exist. In addition, competing standards and mandates across states and regions pose a fragmented market. Stakeholders report that transparency and open dialogue are critically important in the standards development process and emphasize the importance of balancing prescriptiveness with innovation, eliciting manufacturers' feedback, and collaborating across sectors.

Introduction

California is committed to an integrated resource planning future in which significant grid incorporation of renewable energy is balanced by electricity demand that is flexible throughout the year's 8,760 hours (sometimes referred to as "8,760 load flexibility"). In spring 2023, the California Energy Commission (CEC) approved an official "load shifting or load flexibility goal" of 7,000 megawatts (MW) by 2030, the same year the State projects it will require 38,000 MW of "new clean energy resources" (CEC, 2023). Fostering load flexibility beyond the State's existing event-based demand response (DR) efforts to a more continuous approach to flexibility will support several public purposes including promoting grid reliability, curbing rising electricity costs, utilizing renewable energy resources, and reducing greenhouse gas (GHG) emissions.

Standards will play a critical role in shaping 8,760 load flexibility in California as they will help to ensure performance, interoperability, and scalability. Several types of standards will be relevant, many of which are currently under development. These standards, like many others,

can loosely be grouped by whether they are (1) *government-led*, typically – but not exclusively – as authorized by statute and implemented by administrative agencies, with associated legal penalties for non-compliance; or (2) *industry-led*, typically as set through collective action by groups of industry players, such as trade or professional associations, and with incentives for compliance that do not have the force of law but may not be fully voluntary (e.g., standards tied to professional credentials).

The California Energy Commission's (CEC's) Load Management Standards (LMS) Rulemaking is one example of a government-led standard of relevance to California's efforts towards 8,760-load flexibility. The LMS Rulemaking applies four primary requirements to the State's large investor-owned utilities (IOUs), large publicly owned utilities (Munis), and large Community Choice Aggregation (CCA) service providers, as well as any CCA that provides more than "700 GWh of electricity to customers in any calendar year."[1] These requirements are: (1) "maintain the accuracy of existing and future time-varying rates in the publicly available and machine-readable Market Informed Demand Automation Server (MIDAS) rate database"; (2) "develop a standard rate information access tool to support third-party services"; (3) "develop and submit locational rates that change at least hourly to reflect marginal wholesale costs"; and (4) "integrate information about new time-varying rates and automation technologies into existing customer education and outreach programs" (CEC, 2024).

In addition to the LMS, which applies a standard set of requirements to energy providers of different types in order to support 8,760 load flexibility, California is also setting a very different type of *government-led* standard of relevance to the manufacturers of certain appliances. In keeping with its long-standing efforts to set minimum efficiency performance standards (MEPS) – efforts which predate federal MEPS and continue concurrent to these federal standards – California is developing "flexible demand appliance standards" (FDAS) that mandate a default setting of price and GHG responsiveness. One category of new appliance "sold or offered for sale, rented, leased, or introduced into commerce in California" is currently subject to regulation under FDAS, namely pool pump controls. In addition, pre-rulemaking draft language has identified the following product categories as under consideration for regulation: compact and standard electric clothes dryers; compact and standard dishwashers; and low-voltage system thermostats.

The most prominent example of an *industry-led* standards effort supporting 8,760 load flexibility is probably OpenADR[2], which "standardizes the message format used [by] utilities, ISOs [i.e., independent system operators], and energy management and control systems" for Automated Demand Response (Auto-DR) and distributed energy resource management so it is uniform, interoperable, open, and secure (OpenADR Alliance, 2024). Auto-DR is defined by the OpenADR Alliance, a "mutual benefit corporation created to foster the development, adoption, and compliance of the OpenADR Smart Grid standard," as "fully automated signaling from a utility, Independent System Operator (ISO), Regional Transmission Operator (RTO) or other

[1] California's large investor-owned utilities are Pacific Gas and Electric, San Diego Gas and Electric, and Southern California Edison. Its large publicly owned utilities are Los Angeles Department of Water and Power and Sacramento Municipal Utility District. California's large CCAs are Central Coast Community Energy, CleanPower SF, Clean Power Alliance of Southern California, East Bay Community Energy, Marin Clean Energy, Peninsula Clean Energy Authority, Pioneer Community Energy, San Diego Community Power, San Jose Clean Energy, Silicon Valley Clean Energy Authority, Sonoma Clean Power Authority, Valley Clean Energy.

[2] https://www.openadr.org/about-us

appropriate entity to provide automated connectivity to customer end-use control systems, devices and strategies." Note that the OpenADR Alliance stipulates that "Auto-DR does not require full automation on the customer end." The OpenADR communications standard is currently available in a 3.0 version released in November 2023 and designed not to replace but "to complement older versions of the standard," such as OpenADR2.0. The OpenADR Alliance, which originated in 2010, is now "a global ecosystem of software/platform providers, device manufacturers, operators, and [electric vehicle (EV)] service equipment companies" with 200 members, with considerable recent membership growth driven by a "wave of innovative EV business models" such as payment systems.[3]

This paper explores stakeholders' perspectives on these and other standards applicable to 8,760-load flexibility in California.

Background

The paper's findings draw from two needs assessments conducted to better understand stakeholders' perspectives regarding load flexibility technology development. These assessments were conducted as part of the California Load Flexibility Research and Development Hub project (CalFlexHub, funded under grant EPC-20-025). CalFlexHub, managed by LBNL, which brings together actors from across the California load flexibility innovation ecosystem to identify, evaluate, develop, fund, and demonstrate cost-effective and reliable load-flexible and flexibility-enabling technologies. One of CalFlexHub's tasks is to use social science methods to gain a better understanding of the broader context of these technologies, including identifying what stakeholders report as their most pressing priorities, constraints and needs related to the implementation of highly dynamic (i.e., "real time") electricity prices and development and adoption of automated load-flexible technologies.

In conducting these needs assessments, we engaged a broad spectrum of the many California stakeholders who play a role in the 8,760 load flexibility ecosystem, including (1) *government agencies and policy-makers*; (2) *utilities and other energy service providers*; (3) industry, in the form of *industry associations* and *technology providers*; and (4) *environmental groups* and *researchers*. Here we provide more context on these stakeholders, whose insights into government-led and industry-led standards are the subject of this paper.

Government agencies and policy-makers are pivotal in spearheading initiatives aimed at integrating renewable energy sources and establishing regulatory frameworks. In the California context, the most prominent government agencies involved in the government-led standards of LMS and FDAS are the California Public Utilities Commission (CPUC) and California Energy Commission (CEC), respectively. In addition to providing insights of direct applicability to these standards, government agency and policy-maker perspectives of particular note draw from knowledge gained by navigating regulatory landscapes and shaping energy policy frameworks to align sustainability goals with the interests of California taxpayers.

Utility companies and other energy service providers like Munis and CCAs are another set of very important stakeholders in 8,760 load flexibility who have a unique perspective on standards. As mentioned above, these companies are regulated entities under the government-led

[3] https://www.openadr.org/index.php?option=com_content&view=article&id=215:openadr-momentum-2024&catid=21:press-releases&Itemid=121

LMS Rulemaking; they also directly influence a range of energy distribution and consumption practices.

Utilities and other energy service providers are also part of industry-led standards such as OpenADR. The OpenADR Alliance is a form of *industry association*, in this case an association that brings together many different private sector perspectives in the effort to support Auto-DR and distributed energy resource management. Note that in the context of California's emerging 8,760 load flexibility industry "ecosystem", government agencies anticipate that many types of private sector "third parties" will develop to play important roles. In the CPUC staff report which recommended that the agency initiate the LMS Rulemaking as part of its proposed vision, principles, and roadmap for load flexibility (the CalFUSE framework), the envisioned third parties may include, either separately or in some combination of roles that can serve "as a one-stop service to customers … [to manage] the customer experience and value proposition":

> *"(1) application developers focused on making the CalFUSE price signal accessible to customers and devices; (2) device manufacturers integrating the necessary functionality to enable the devices to interact with the CalFUSE price; (3) automation service providers layering intelligent algorithms or artificial intelligence to optimize device behavior in response to the CalFUSE price; (4) energy management service providers offering services to customers for managing multiple smart devices and optimize customer's bills; and (5) DER operators or aggregators pooling together and leveraging multiple customers and their devices as a resource and offering services to LSEs or UDCs, etc.*

In the stakeholder needs assessments, we engaged with many existing private sector third parties, with a particular focus on *technology providers*. Figure 1 is a sketch of the Auto-DR system envisioned by the OpenADR Alliance. It depicts the communications and coordination context of 8,760 load flexibility, which both government-led and industry-led standards support. Figure 1 illustrates the interactions between the Virtual Top Node (VTN) "servers" of utilities, ISOs, and DR aggregators (i.e., flexibility service providers), which "transmit signals to end devices or other intermediate servers." It also depicts energy-using Virtual End Nodes (VENs), which are inclusive of many different device types, such as an "'Energy Management System' (EMS), a thermostat or other end device" that accepts the signal from the VTN and responds accordingly. VENs can be present in residential buildings, small-to-medium size businesses, or large commercial and industrial buildings. They can also play a role as both a VEN and a VTN, for example in the case of a DR aggregation server that acts "both as a VEN for a utility DR signal, and as a VTN for end devices." We engaged with stakeholders involved in both VTNs and VENs.

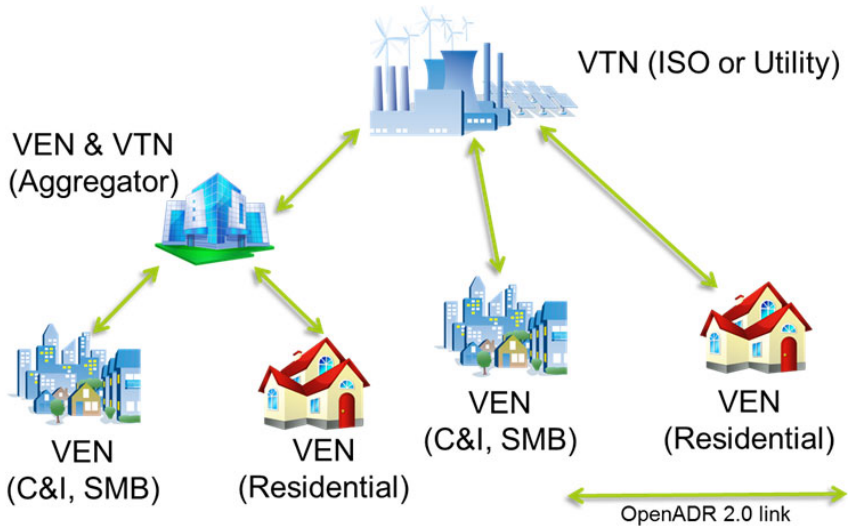


Figure 1: OpenADR illustration of the communications pathways underlying Auto-DR.

Finally, we engaged with *environmental groups* and *researchers* as part of the stakeholder needs assessments. Environmental groups are actively involved in advocating for measures to reduce greenhouse gas emissions and accelerate the integration of renewable energy sources into the grid. Researchers studying energy systems and technology standards contribute valuable insights and advancements in grid coordination concepts and technologies, supporting informed decision-making and policy development.

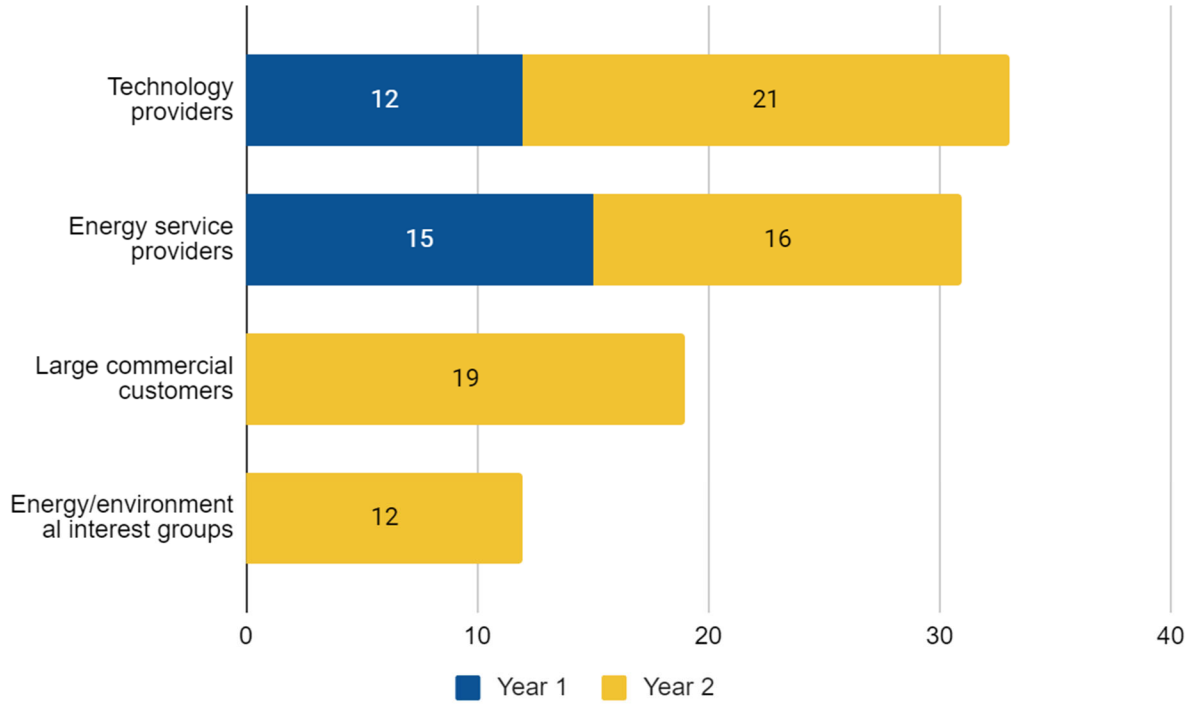
In future work, we hope to round out our stakeholder needs assessment research by talking with two additional groups: (1) technology installers, especially those who advise customers on equipment selection, who will be critical "middle actors" in load flexible technology adoption; and (2) utility customers across all sectors (residential, commercial, industrial).

Methodology

This section describes the methods used to collect and analyze the data reported in this paper. Data was collected through two rounds of interviews, the first between August 4 and September 14, 2022, and the second between June 15 and September 15, 2023. Interviews were conducted via Zoom, with content captured via recording, transcript, and detailed notes. Interviews lasted approximately one hour.

Recruitment for the first round of interviews was limited to CalFlexHub project partners, affiliates, and members of the CalFlexHub Technical Advisory Committee, to glean insights from stakeholders close to the policy developments. As shown in Figure 1, the 27 subjects interviewed in Year 1 (2022) represented two broad stakeholder types: (1) "energy service providers," including IOUs, CCAs, and firms that provide load management energy services for grid support, and (2) "technology providers," including manufacturers/developers of load-flexible and flexibility-enabling technologies.

Figure 1. Interviews by stakeholder group and year



Interview questions in the first year explored the topics of electricity rates, stakeholder value propositions, barriers to the transition to dynamic prices, and technical aspects of communications technologies. An important source of information related to standards was stakeholder responses to questions related to the communications architecture needed to facilitate fully automated load flexibility in response to highly dynamic prices.

The aim of the second year of interviews was to collect data from a range of stakeholders not affiliated with the CalFlexHub project, in order to gain a broader perspective on the relevant needs and priorities. To inform the stakeholder needs assessments for the second year of CalFlexHub, we convened a Delphi panel to inform the interview protocol and list of potential respondents. The Delphi technique is a scientific method used for iterative, structured group (i.e., panel) communication to gain consensus-driven insights into current or future challenges when information is limited (Beiderbeck et al., 2021). Experts from the CalFlexHub research team and beyond comprised our Delphi panel. From the Delphi process, standards emerged as an important topic for the second year's interviews. The interview protocol created by the research team based on the input of the Delphi panel of experts therefore included standards in addition to other questions related to California's vision for load flexibility, technology development, customer issues, and organizational changes needed to prepare for dynamic prices and devices that optimize responses to them.[4] The Specific Year 2 question related to standards was: "Tell me about the role of standards (e.g., appliance, industry) in bringing load-flexible technologies to

[4] The beginning of each interview included a level-setting statement drafted by the research team with guidance from the Delphi panel experts. The goal of this statement was to ensure all interview participants had a common understanding of the current state of policy and technology developments.

market. What about other policies like mandates?" In both rounds of interviews, a semi-structured interview approach was used to ensure consistency and maintain flexibility.

In total, we analyzed data collected from interviews with 95 individuals. Interview transcripts were independently coded by two team members to ensure thoroughness and reliability. In addition, a codebook was developed according to emergent themes and sub-themes. Themes that emerged from coding included 11 parent codes: customers, device/appliance, economics, energy history, key players, policy, social/environmental, priority/need/constraint, technology characteristics and technology/intelligences. There was also a code for "other." Each parent code had associated child codes. For example, the child codes under the parent code "policy" included building codes, demand response, energy efficiency, goals, load flexibility, mandates, pilots, programs, standards, and time of use. In all, there were 86 child codes.

Upon the completion of coding, the research team ran queries in NVivo based on the application of single or multiple codes, specific keywords, or jargon. The results of queries included portions from all interviews where the code(s) of interest were applied, which were then analyzed by members of the research team. In some instances, open-ended responses were pile-sorted and coded, and then frequencies were calculated to convey the prevalence of a given view.

While multiple parent and child codes were applied throughout the interviews, and multiple codes could be applied simultaneously to any specific portion of the interview, all of the standards-related interviews discussed in this paper had the parent code of "policy" code.

Results

The following results draw on data collected from 52 interviews coded with the parent code "policy"; of these, 47 interviews had one or more responses to which the code "standards" was assigned. In all, 323 unique/direct references to standards were compiled. Stakeholders' responses vary in specificity within the domain of technology standards, given the broad nature of the interview questions. In some cases, the discussion did not distinguish between the various subjects of standards (e.g., appliances, utilities, industry ecosystem) or the entities that led the standards (e.g., government, industry). To the extent possible, we have clarified these distinctions based on the broader context provided by the respondent's statement.

Given the small sample size from several of the stakeholder groups, this analysis does not include a systematic comparison of responses by group. However, when a sentiment differed notably across groups, this is noted and quotes were chosen to illustrate different stakeholder group perspectives. When sentiments were similar across stakeholder groups, the quotes[5] that were most illustrative were chosen to represent the sentiment, while we do not report the group to which the speaker belonged.

[5] Note that when we present a stakeholder quotation longer than two lines of text, we follow a social science and humanities convention of using so-called "block quotes." These block quotes are formatted in italics with left- and right-indents, and do not use quotation marks.

Negative effects of lack of standards or mandates

Most stakeholders across groups agreed that the current lack of standards related to load-flexible devices was partly to blame for slowing stakeholders' actions, stifling progress, and "inadvertently not achieving California's goals."

> *There's been a really challenging chicken and egg situation with smart grid or flexible demand deployments in general, where manufacturers don't build in the capabilities, or the devices don't ship with the capabilities enabled or present at all, because there aren't a lot of utility programs that would use them. So it's not worth doing. And the utilities aren't running programs because there aren't devices to go talk to. So codes and standards come into play to help address that problem.*

To stimulate the supply of new technology, several respondents argued that "really clear requirements of what's necessary to be a load-flexible compatible device [are] important." This was seen as necessary for a top-down approach to creating a market for load-flexible devices in which stakeholders' initiatives "trickle down" to customers.

Standards also play an important role in ensuring interoperability across manufacturers. As one manufacturer explained, "if we end up with every vendor having their own proprietary protocols and trying to make that work, forget about it."

For example, several stakeholders cited the lack of standards for grid-interactive capabilities in electric vehicle (EV) charging as a missed opportunity. As one stakeholder put it, in the absence of a technology standard, EV charging infrastructure has been widely installed without communication technology and "no eye to the future." Several stakeholders expect the inability to control EV charging loads in response to highly dynamic prices to be a significant problem in the future given the number of EVs entering the market in the near term.

Uncertainty about the standards or mandates that will be adopted also creates problems for technology providers. They are using a variety of strategies to cope with the uncertainties associated with the evolution of California policies and programs; these strategies have implications for the communications technologies they incorporate into their products. As mentioned above, some technology providers opt to wait and see what California will decide before making new investments. Also, as mentioned above, other stakeholders are installing multiple communications technologies to, in essence, hedge their bets. For example, one technology provider chose to enable the company's devices to receive signals via both Wi-Fi (utilizing OpenADR) and CTA-2045 ports "because of lack of direction from utilities as to how they want to control devices." He expressed hopefulness that his company would reap the benefits of a competitive advantage if either technology communication mode ultimately dominates the market. The respondent noted that it is currently expensive to include both technologies in his firm's products but felt the investment could pay off if his company can capture early market share. Some stakeholders are looking carefully at the evolution of other States' policies. For example, one technology provider cited a newly adopted standard in Washington[6] as the reason his company installed CTA-2045 ports in its hardware; his company interpreted the new standard as a potential clue to the future actions of California policymakers.

[6] Washington House Bill 1444 requires electric storage water heaters to incorporate CTA-2045 ports to ensure grid interactive capabilities effective January 1, 2022 (NEEP, 2021).

While many stakeholders seem confident that certain communications platforms will eventually edge out others through economic advantage or policy mandates, it is currently unclear which will dominate in California. One interviewee compared the situation to the "VHS vs. Betamax" saga in the development of Video Cassette Recorders.[7] Another described the communications technology landscape as the "Wild West," with potential challenges regarding future incompatibility across systems, stranded assets, and barriers to large-scale collaboration.

Mandates

A minority of stakeholders felt that industry-led standards would not be a strong enough mechanism to ensure the emergence of load-flexible devices at the scale required to implement California's vision for 8,760 load flexibility. As one said: "if you make it optional, then you may not get all these device makers to come along with you and meet the goal or achieve the vision." Stakeholders favoring government-led standards or mandates believed they would be necessary to stimulate the market adequately. As one succinctly put it: "Mandated it has to be." Another argued that California should "pick a winner… otherwise, all standards are just going to be competing."

However, several stakeholders warned there were risks to the "we tell them to do it [and] they will come" approach. First, complying with mandates can require complex modifications to, or developments for, load-flexible technologies, which can be difficult for equipment manufacturers, as this quote illustrates:

> *You're asking us to completely revolutionize the business model, right? We are not set up to do this today. It would take a huge lift on our part to do this, and …there has to be a reason to make this commercially attractive.*

In addition, a number of stakeholders argued that at this stage in the development of a load flexibility ecosystem, imposing standards could have the effect of hindering innovation, as this quote describes:

> *I think we're trying to push standards on a product class that is too new… I don't think it's been out there long enough to really figure out exactly what's best. We have a lot of exploration to do, a lot of testing, a lot of build applications. So standards are kind of getting in the way of innovation from the implementation side of things.*

Several stakeholders complained that manufacturer compliance with equipment mandates is not always met with the intended customer response. For example, one stakeholder noted with frustration that the building code requires heat pump water heaters to have smart controls (which drives up costs), but few customers have reason to use them under current electricity rates (though that could change if rates become more dynamic). Similarly, the JA13 protocol, which specifies performance credit criteria for electric storage water heaters, has hardly been used since

[7] From 1975 until 1988, a competition between analog video cassettes used in Video Cassette Recorder systems ended with VHS becoming the dominant format (over Betamax) due to its compatibility with a wider array of machines.

a mandate took effect in Washington (WA HB 1444).[8] Several stakeholders recalled that about a decade ago, ZigBee radios were required in all smart meters installed in California to enable the use of home energy management systems (HEMS). Ultimately, however, the market for HEMS did not materialize in response to the availability of the communications technology. Ever-evolving equipment mandates leave some weary: "It would be really nice to see the utilities use the protocols that the team already worked on before they start asking for another one."

Mandates have consequences for manufacturers. As one stakeholder stressed, it is important to consider whether "the timeline of the mandate [is] realistic or [does it] push folks out of the market?" It is not just industry laggards who can be negatively affected by mandates. Leaders in load-flexible technology development are also impacted by the timing of mandates, as the following quote illustrates:

> *At some point, one or a small number of standards becomes dominant, and that's fine. It's probably not the role of standards-making bodies like the CEC to pick a winner prematurely. But at some point, a winner emerges naturally, that's how this goes… you could say it's fair, but it makes it hard to be an early adopter because every building designer has to pick something. They're gonna put it in their building, and they hope it still works in five years.*

Outcome-based standards

Most stakeholders advocated for "intent-based" or "outcome-based" standards – where clear definitions outline the intended functions and performance of technologies without being too prescriptive. The ideal approach is described as: "'water heaters shall be able to do A, B and C', but … it's not overly explicit on exactly what it should do…". Some stakeholders advocated for this approach as one that allows the market, rather than regulators, to decide which technologies work best, a situation that is more suited to the rapid pace of technological change. "Everyone says standards help, and I don't disagree, but in a world that's changing as fast as this is, putting down stakes too early is hindering the market." A technology provider warned:

> *If you allow technology providers to innovate on behalf of the grid and the customer, you're going to get a lot further than if you just say 'you've got to do this.' [In the latter case, I'd] just put some poor real-time pricing algorithm on [the device] that meets the basic requirement and hope our customers never turn it on.*

Outcomes-based standards, it is argued, foster progress, as this quote illustrates:

> *I think outcome-based standards give flexibility that can sometimes spur innovation and creativity in how to get there. And I think sometimes it can also result in products and solutions that go beyond the expected, our standards-based targets.*

[8] See https://neep.org/sites/default/files/media-files/grid_final_formatted.pdf and https://app.leg.wa.gov/billsummary?BillNumber=1444&Year=2019&Initiative=false for more information on Washington House Bill 1444.

The downside of less prescriptive standards, stakeholders warned, is that they may be open to interpretation, creating inconsistencies across technology providers' products, which undermines their purpose. For instance, one respondent noted, "We have the JA13 standard, but how that's interpreted in practice…What I'm seeing in conversations with manufacturers and stakeholders in our industry is everyone has a slightly different expectation or understanding of what those things mean."

To address this, stakeholders suggested that certification testing and established compliance criteria can help streamline the application of device standards. One warned, however, that this approach would require a mechanism to ensure compliance:

> *There needs to be some testing and certifications with [a load-flexible device] so that everyone can be confident when it goes to market. [For example, the JA-13 standard is] not actually doing what everyone said it was going to be doing. Certain things, like how it responds to certain commands or how well it reports back its actual power consumption or state of charge…. Every manufacturer is slightly different. So it's… still very nascent, I think.*

Finally, stakeholders argued that standards represent a commitment by policymakers, which can help technology providers feel more secure when investing in developing load-flexible technologies, as this quote illustrates:

> *If a device maker is going to develop the device to meet this [standard], they need to know that there's going to be a throughline— [that] in all likelihood it would continue forward, that California has a track record of this. I think that getting the buy-in inspires the confidence that we [will] move forward with all of this.*

Collaborative approach

Across groups, stakeholders agreed that the industry should inform industry and government-led standards and/or related efforts. Several respondents noted the importance of transparency and collaboration between technology providers and other industry stakeholders. As one argued:

> *The dialogue is critical. The more dialogue you have with the industries, the easier it's gonna be to see the true path of how to get there. Whereas if you try to prepare a mandate or a standard with minimal industry input or feedback, that's going to be problematic.*

Indeed, two stakeholders cited as a cautionary tale an example of "a technically illogical requirement" (for pool pumps) created without industry input. The standards and/or other actions also need to work for utilities.

> *If the policymakers are coming up with a mandate or a standard that the market can't support, or the utilities can't integrate into a rate, it's just not gonna work, or it's gonna take a lot longer.*

However, a few stakeholders acknowledged that there are challenges associated with collaborating on standards development.

> *I think what happens in reality sometimes is the standards are created without fully incorporating input from all parties... Sometimes there are disagreements, and maybe one side is taken over the other and that may not be the best side.*

A collaborative standards development process could also help to streamline requirements across jurisdictions. Setting standards or mandates that were too "California-specific" was noted as a problem by stakeholders, especially technology providers. They noted that compliance is challenging when there are differences across regions as it forces manufacturers that serve multiple markets to develop specialized product lines. Some technology providers reported trying to ensure their products meet as many requirements as possible by keeping abreast of building codes and product certifications across the United States. As one stakeholder noted: "We are attempting to fit as many standards into our product offerings as we can, unfortunately, to address the very fragmented market that it is today." To encourage more market entrants, one stakeholder lobbied for federal standards to be set and adopted by individual states:

> *We want national standards, not something that's California-specific. That's going to be really hard for us. …So, whatever standards you use, make sure they're kind of a national standard that we have to comply with, as opposed to trying to do something really unique for California.*

Standards for system architecture and communications technologies

Beyond signal conveyance, stakeholders felt that the broader system architecture that will support 8,760 load flexibility should exhibit a number of important attributes. These desirable characteristics include system reliability, cybersecurity, compatibility, broad applicability across jurisdictions – and ideally, interoperability – of communications across different devices, protocols, etc. Note that cybersecurity includes both protection from criminal/unauthorized interference and assured data confidentiality and integrity, the latter of which will be particularly important given the large volumes of data generated by dynamic prices and load flexibility. Ideally, the system architecture should support building-level optimization, as opposed to device-level optimization, something that the development of energy management systems in residential and small commercial buildings would enhance.

Some stakeholders observed that from a systems perspective, it is "messy" when many signal providers have their own time resolutions, forecasts, and schema for data management. Stakeholders reported the need for communications technologies to be compatible: "What you want are systems that can work independently of what network is deployed." In particular, this interviewee emphasized the need for communications technologies to be compatible with BACnet[9] "because it's already in so many existing buildings." This would mitigate stranded

[9] According to the BACnet Committee, "BACnet is a global data communications protocol standard for building automation and control networks that provides a vendor-independent networking solution to enable interoperability among equipment and control devices for a wide range of building automation applications such as heating, ventilating, air-conditioning, lighting, access control, elevators, security and fire detection systems. BACnet

assets in the existing building stock when upgrading or adding systems to be compatible with load flexibility.

As mentioned above, OpenADR supports compatibility and interoperability by standardizing the message format used to communicate dynamic price and reliability signals. Stakeholder opinions about OpenADR varied widely, ranging from acceptance to disdain. The lack of a residential protocol was noted as a limitation, leading one technology provider to state that her company "hates OpenADR" for residential customers. Another pointed to the topic of timeliness, stating at the time of our interview – before the launch of OpenADR 3.0 – that even for commercial and industrial customers, OpenADR is outdated:

> *We do not use OpenADR. OpenADR is not necessary for [load flexibility] projects, and should not be a requirement. It's too heavy, too slow, too ponderous to get certifications, too limiting in the process by which you develop products… We need to use better, newer ideas that could become new standards rather than lean on old standards just because they're there.*

In addition to compatibility, stakeholders stressed that communications technologies need to have longevity and applicability to other markets; this will help ensure that business investments can be recovered over time and across jurisdictions. One stakeholder urged California regulators to consider "what's good for the country, the world, not just California" and to work with other states to establish common mandates based on the needs of all regions. A technology provider echoed this sentiment, saying it would be helpful if CalFlexHub could "consider how to scale so that other utilities and states can adopt the same protocols [and] market construct." As another pointed out, however, "It's going to be hard to get the whole world on one standard… [Technology providers] have to learn to be flexible since it's a global market."

Several stakeholders worried that the proprietary communication systems favored by many manufacturers could hinder optimization at the building level, which they felt was more useful than optimizing at the equipment level. While building energy management systems in industrial and large commercial buildings were seen as critical to the success of load flexibility, several stakeholders noted that the lack of analogous energy management systems in most residential and small commercial buildings will hinder optimization across end-uses in these buildings. In support of this worry, several technology providers stated that they, and other technology providers, do not allow outside access to their devices, particularly for the purpose of control.

Discussion and conclusion

This paper presents key findings from our investigation into the critical role of standards in shaping 8,760 load flexibility in California. Two types of standards are developing in support of this vision for California's energy sector. Prominent government-led standards, which are typically authorized by statute and implemented by administrative agencies with associated legal penalties, include the CEC's Load Management Standards (LMS) for energy providers and Flexible Demand Appliance Standards for appliance manufacturers. Prominent industry-led

enables interoperability among these systems by defining communications messages, formats and rules for exchanging data, commands, and status information." (BACnet, n.d.)

standards, which are typically set through collective action by groups of industry players with compliance incentivized in various ways that do not have the force of law, include OpenADR. Stakeholders recognize uncertainties in the regulatory context to be a particularly significant obstacle to California's energy goals, although there is also much debate about the connections between industry-led and government-led standards, the tradeoffs between mandates and outcome-based standards, and the implications for industry of different aspects of the evolving standards ecosystem around load flexibility.

There was general consensus across stakeholder interviews that uncertainty around the technology standards governing load flexible technologies is hampering progress toward California's 8,760 demand flexibility goal. Some technology providers are hanging back, awaiting clarity before making significant investments in developing load-flexible technologies. Others are making an educated guess as to which load flexibility-enabling mechanisms will meet future standards and developing technologies with one (or more) of those to try to capture the first-mover advantage. Both approaches pose risks for technology providers, whose investment in load-flexible technologies is vital to achieving California's load-flexibility goals. Programs to promote innovation will need to be carefully designed to reward early entrants without penalizing later entrants, which are necessary to stimulate competition.

Most stakeholders agreed that standards are needed to establish guidelines for load-flexible devices to stimulate the development of more interoperable load-flexible devices and ensure they will deliver the needed capabilities. Most stakeholders favored performance-based (i.e., outcomes-based) standards that allow technology providers to determine the optimal approach for achieving the required outcome. For example, the system architecture that will support 8,760 load flexibility should, according to stakeholders, ensure system reliability, cybersecurity (including data confidentiality and integrity), compatibility, and interoperability across different devices and protocols. Stakeholders generally argued that performance-based standards stimulate innovation and give developers flexibility to choose the precise ways their devices interact with the system architecture.

A potential downside to performance-based standards which stakeholders acknowledged, however, is that such standards may leave room for differing interpretations and, therefore, divergent (and perhaps incompatible) outcomes. To counteract this, compliance criteria may be required to ensure consistent interpretation. Most stakeholders agreed, however, that compliance criteria would be preferable to prescriptive standards (i.e., mandates) that specify the mechanisms technologies must use to enable load flexibility. Most felt that mandates would be an overreach in the regulatory standards context and would advantage technology providers that had made early investments in the chosen mechanisms while punishing those that made different choices. Stakeholders also worried that mandates could select suboptimal mechanisms or lock in mechanisms that later become outdated. A small minority of stakeholders argued that mandates would be necessary to stimulate the market at the scale required to establish widespread load flexibility. However, mandates are not always effective in stimulating markets, as the Zigbee/HEMS example illustrates.

Stakeholders expressed frustration with the patchwork of technology standards across the U.S. market. Stakeholders warned that adopting standards unique to California makes it difficult for technology providers to serve the national market. They advocated for state policymakers to align their requirements with those of other states and/or with federal standards. With respect to California's Load Management Standards, this might occur through inter-state discussions held

directly or via third-party groups like the National Association of State Energy Officials (NASEO). With respect to California's Flexible Appliance Standards, however, alignment prospects are likely to involve concerns about preempting state authority or impeding interstate commerce. Nevertheless, stakeholders expressed a preference for transparency to whatever extent possible, and while weighing litigation risks.

Given the complex and changing policy and technology landscape, as well as tradeoffs described above, many stakeholders advocated for an (even more) collaborative approach to standards development - i.e., involving industry representatives - than current administrative processes support to ensure that regulations are practical and realistic. Stakeholders emphasized that collaboration is the appropriate way to address difficult questions on load flexibility standards and some saw collaboration as the only way forward. This quote reflects that sentiment:

> *The biggest need is for increased collaboration… you've gotta have equal involvement upfront from the policymakers, the utilities, the technology providers. And those engagements have to be really robust, because it's not gonna work unless everything is aligned, or at least in support of one another. …We have to make sure that everyone's staying in touch with one another so we can capitalize on everything. So, when the technology providers are ready and have the proven technology, policymakers and utilities can jump on it and say, 'Okay, let's do this now. We can develop the rate. We'll do XYZ." We all have to be in concert together.*

Future research

In this paper, we have allowed stakeholders to speak for themselves with respect to their perceptions of the role of technical standards in the evolution of 8,760 load flexibility. Future research will turn to the relevant academic literature on government-led standards versus industry-led standards in order to pull out resonant insights for load flexibility. For example, the literature on government-led standards and environmental innovation debates the role of federalism (i.e., the interplay between the federal government and state governments) in market transformation, considers the tradeoffs between prescriptive versus performance-based standards in "technology push" versus "demand pull" aspects of market transformation, and provides insight into what it means for a standard to be "performance-based" given the evidentiary requirements of regulatory impact assessments (RIAs) conducted by agencies in government-led standards-setting processes. Similarly, the literature on industry-led (e.g., voluntary) standards provides useful insight into governance processes which can balance proprietary interests; a famous example is the "humming" used instead of voting by the Internet Engineering Task Force so the organization's technical work is not run by a "majority rule" philosophy, and instead by "rough consensus." This latter governance research is relevant to finding additional opportunities for a balanced, collaborative, and inclusive approach to communications standards development, which is crucial to meet California's ambitious goals.

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