Putting it All Together: Leveraging Codes and Standards to Accelerate Integration of Demand-Side Resources

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ABSTRACT

As California approaches its various goals for energy efficiency, renewable generation, energy storage, greenhouse gas reductions, and zero net energy (ZNE) buildings, the relationship between electricity supply and demand is evolving and increasing in importance. The system-wide "duck curve"—the occurrence of net load dips in the non-summer months during the mid-afternoon followed by a dramatic ramp up—is an emerging grid operating condition resulting from increased use of roof top photovoltaics generation and increased use of photovoltaics by utilities to meet their renewable portfolio standard (RPS) mandates. Grid operators are looking for new mechanisms to manage supply and demand to maintain grid reliability. At the same time, it is increasingly cost effective and feasible for buildings to deploy strategies that integrate energy efficiency, on-site renewables, on-site storage, demand response (DR) capabilities, and/or innovative building controls. True markets for integrated distributed energy resources (IDER) are in infancy; policies are needed to achieve the scale and industry experience for it to be a dependable day-to-day tool for managing grid-level supply and demand. Reaching this IDER maturity will be necessary to achieve the multiple energy and climate goals.

This paper provides specific recommendations on how codes and standards (C&S) can be leveraged to accelerate the adoption of IDER solutions. We first summarize current initiatives that aim to encourage IDER, including C&S initiatives and voluntary programs. Market, technology, and cost barriers to wide-scale adoption are identified. Finally, we discuss new C&S opportunities for policy drivers, design specifications, appliance standards, and building codes.

Introduction

Over the next 15 years, the population of the United States (U.S.) is projected to grow by about 12 percent to 359 million people (Colby and Ortman 2015). This population growth will be accompanied by a forecasted annual increase of roughly 0.6 terawatts of electricity demand (EIA 2009). Given a larger portion of electricity is being supplied by renewable sources, which are less predictable and harder to control, it is important to consider how this load growth will impact grid operations. Will it exacerbate the current "duck curve" challenges, or can new loads act as a neutral or even beneficial flexible resource to the grid? With IDER, new loads could absorb renewable energy surpluses from the grid, or self-supply during peak hours. Leveraging demand-side flexibility to change when individual loads pull electricity from the grid could have a meaningful impact on the operation and reliability of the high-renewables grid.

The Rocky Mountain Institute (RMI) proposes that the shape of a utility customer's load on the grid is impacted by how a customer deploys the following strategies to meet electricity needs: buy it, make it, eliminate it, or shift it. Figure 1 illustrates how each of these strategies impacts load shape and grid electricity purchases. The "buy it" strategy is grid purchases. The "make it" strategy is achieved through distributed generation like solar photovoltaic (PV) systems, "eliminate it" is primarily achieved through energy efficiency, and the "shift it" strategy is achieved through demand flexibility, which RMI defines as follows, "Demand flexibility uses communication and control technology to shift electricity use across hours of the day while delivering end-use services … at the same or better quality but lower cost," (Bronski et. al. 2015).

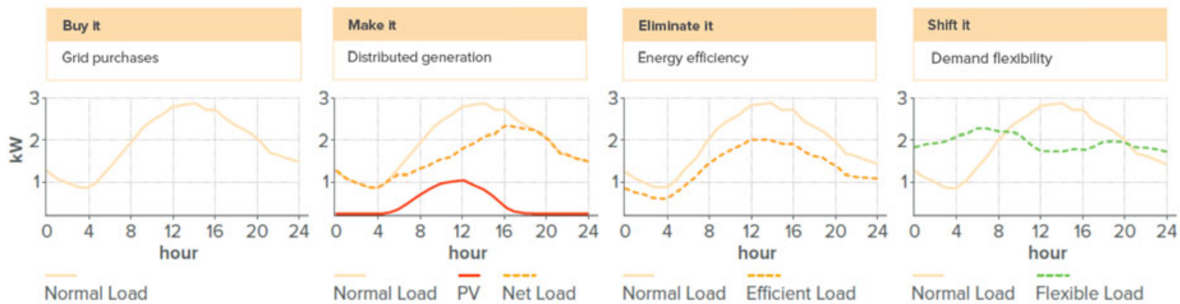

Figure 1. Demand-side Strategies to Change Load Shape. *Source*: Bronski, et al. 2015.

Historically, C&S have focused on the "eliminate it" strategy. However, as energy efficiency standards climb closer to theoretical maximum cost-effective efficiency levels, C&S have started to address the "make it" and "shift it" strategies. Following in spirit of policy goals and the California loading order[1] that prioritizes cost-effective energy efficiency before renewable generation, it is now appropriate to explore how C&S can expand efforts to help shape and accelerate the wide-spread deployment of IDERs to fully enable "shift it" and "make it" strategies. Doing so will lead to significant consumer savings and many system wide benefits such as: reduced utility capital investments in natural gas peaker-plants to meet the afternoon/evening ramp, enhanced confidence that grid operators can rely on IDER to adjust demand to meet available supply, and the ability integrate and absorb increasing amounts of intermittent renewable energy.

As discussed in the next section, there are many barriers to widespread participation in IDER markets. C&S have a role in shaping the IDER landscape, but IDER C&S should be deployed considering the market and technologies are changing and maturing and C&S need to remain sufficiently nimble to allow for transformation to occur.

Barriers to Reshaping Load Profiles

The vision of reshaping load profiles as a means to help manage grid-supplied electricity resources is clear. Determining how load reshaping can be implemented on the scale that will have a meaningful positive impact is less clear. There are a myriad of obstacles that need to be addressed for the vision to come to fruition. Table 1 presents several key barriers, though this is an incomplete inventory of all existing barriers. The entire industry is evolving to accommodate the emerging reality where electricity loads are smarter, more interconnected, dynamic, and responsive to grid; and data from energy loads is increasingly more robust and accessible. The electricity industry, from regulators to technology innovators to utility program managers, is working diligently to resolve these barriers. C&S cannot address all of the barriers that the industry is facing, but the C&S community has an important role to play. Through C&S, it can

[1] The California loading order consists of decreasing electricity demand by increasing energy efficiency and demand response, and meeting new generation needs first with renewable and distributed generation resources, and second with clean fossil-fueled generation. The loading order was first adopted in CEC's 2003 Energy Action Plan.

be ensured that new loads have the capability to contribute to load reshaping so when industry has addressed other barriers, customers have the option to participate in markets that value dynamic load management. C&S can also standardize IDER systems to ensure appropriate safety, reliability, reporting capabilities, and interoperability.

Table 1. Sample of technical, market, and cost barriers to wide scale deployment of IDER systems

Technical	System Integration / Optimization	How do all IDER components from different manufacturers using different control and communications protocols, communicate with each other to optimize building loads and the loads' interaction with the grid?
	Emerging Technology	Are smart inverters sufficient enough to increase grid reliability through reacting to real-time grid conditions (i.e. voltage levels and reactive power control, power factor adjustment, etc.)? (Emerson et. al. 2015) Are self-generation systems designed to maximize value when coupled with on-site storage or use?
	Information Technology	Can the 'internet of things' be fully realized to help implement load shaping strategies while maintaining consumer privacy and security? How can data be used to inform transformation?
Market	Consumer Engagement	Will customers be receptive to demand flexibility techniques and sharing information about their energy systems to third parties and utilities? Is cost savings significant enough and easy enough to understand and implement that a sufficient number of customers will want to participate?
	Market Actors	Will energy loads be managed by external providers or by customers that have access to robust control systems with simple user interfaces?
	Outreach / Awareness	How will homeowners know that their appliances are actually IDER components and will they know or care to "connect" them?
Cost	Rate Reform	How should utility rates be reformed so customers' electricity pricing induces load management practices that are beneficial to grid operation?
	Price Uncertainty	Will the price of on-site battery storage come down? How much can consumers expect to save from IDER and will that savings value remain reasonably constant over time?
	Equity	What is the most cost-effective and equitable way to update the electric distribution system to accommodate the emerging customer owned IDERs?

Current C&S and Incentives that Address "make it" and "shift it" Strategies

Current C&S Initiatives

The C&S instruments discussed in this paper are policy drivers, design specifications, appliance standards, and building codes. Table 2 identifies existing policy directives, codes, standards, and specifications and whether they currently contribute to the "eliminate it", "make it", and "shift it" strategies.

Table 2: Current C&S mechanisms that address IDER components that lead to load reshaping

Codes & Standards Instruments	**California Only**	**"Eliminate it"**	**"Make it"**	**"Shift it"**
Policy Drivers				
U.S. Energy Policy & Conservation Act: increases domestic energy supplies and availability, restrains energy demand, and prepares for energy emergencies.		●	○	○
California ZNE Goals: sets various goals and deadlines for ZNE buildings.	X	●	●	●
AB 802: increases access to energy usage data and increases energy efficiency in existing buildings.	X	●	○	○
AB 32: establishes targets for greenhouse gas emissions reductions.	X	●	●	●
AB 2514: increases incorporation of energy storage into the grid.	X	○	○	○

SB 350: increases renewable energy procurement goals and calls for doubling of energy efficiency savings goals for electricity and gas.	X	●	○	○
AB 793: increases energy efficiency through weatherization programs for low-income households and encourages energy management technology usage through incentive programs.	X	●	○	●
Appliance Standards				
Federal Appliance and Equipment Efficiency Standards		●	○	●
ENERGY STAR™ Specifications*		●	○	○
California Appliance Efficiency Standards (Title 20)	X	●	○	○
Design Specifications				○
UL, ANSI, ASME, IEEE		●	●	○
Building Codes				○
ASHRAE 90.1-2013		●	●	●
ASHRAE 189.1-2013*		●	●	●
2012 International Energy Conservation Code (IECC)		●	●	○
International Green Construction Code (IGCC)*		●	●	●
California Building Energy Efficiency Standards (Title 24, Part 6)	X	●	●	○
California Green Buildings Standards (CALGreen; Title 24, Part 11)*	X	●	●	●

● Addressed ○Not addressed * voluntary code or standard

Policy Drivers – Current. Policy establishes high-level direction and long-term goals. Current policy directs both California and federal government to pursue initiatives to ensure energy is used efficiently and the electricity grid is safe and reliable. Both the California Energy Commission (CEC) and the U.S. Department of Energy (DOE) have been administering initiatives that support these goals for decades. For many years, demand-side policy has been primarily focused on energy efficiency and reducing peak demand. Recently policy has provided clear direction that building codes should cover IDER strategies like load shifting and integrated controls. The 2015 California Integrated Energy Policy Report, a biennial report that the CEC publishes that discusses recent energy trends and policy recommendations, states, "Load shifting is likely to be a valuable strategy for achieving zero-net-energy code buildings, and the Energy Commission can develop compliance options that provide TDV [Time Dependent Valuation] credit for such technologies," (CEC 2015). This policy direction is leading to the adoption of IDER measures in building codes, as discussed later in this paper.

Policy direction on the state and federal level is transforming IDER markets and the regulatory framework under which they operate. For example, the Supreme Court's decision to uphold Federal Energy Regulatory Commission (FERC) Order 745, which stipulates DR providers shall be compensated for reducing electricity load at the same rates as if the demand were met with generated electricity, confirms that it is within FERC's jurisdiction to regulate DR programs in wholesale markets. State and regional regulatory structure and market drivers, such as regional energy availability, grid operation and grid reliability issues, are leading to variability in how IDER markets are evolving within the seven primary Independent System Operators and Regional Transmission Organizations[2] in the U.S. It is anticipated that IDER markets will move towards including DR as a component of long-term capacity planning and as a potential solution for short-term reliability needs, but it is outside of the scope of this paper to provide a detailed discussion of IDER markets and how they are transforming as a result of various market drivers.

[2] The seven ISO/RTOs operating in the U.S. include: California ISO, Electric Reliability Council of Texas, ISO New England, Midcontinent ISO, New York ISO, PJM Interconnection, and Southwest Power Pool.

This paper does not recommend revisions to the regulatory framework for IDER markets. As mentioned elsewhere in this paper, the C&S community should consider IDER market trends when considering new C&S opportunities related to IDER.

Design Specifications – Current. Design specifications establish design attributes to ensure product safety, reliability, and interoperability across the entire industry, regardless of the product manufacturer. These specifications are typically developed using a consensus process that allows participation from all interested stakeholders. Design specifications typically focus on safety and reliability, but some metric of energy performance is usually included. There are design specifications for most components of IDER systems (e.g., energy-using products, PV modules, inverters, batteries), but design specifications for integrated systems are lacking. The design specifications for communications protocols, which describe how communication between energy loads and grid operators should occur, are still evolving.

Industry is working on design specifications for smart inverters that could be coupled with on-site solar PV systems or on-site battery storage systems. Studies have shown that the grid could accommodate twice the distributed generation capacity if smart inverters are used instead of basic inverters (Coddington et al. 2012). Smart inverters that meet the forthcoming UL design specification[3] will be capable of performing beneficial grid functions such as the ability to: connect/disconnect, adjust power factor, adjust reactive power output, and report operation status (UL 2010). When the UL smart inverter standards is finalized, California interconnection rules[4] will require the use UL certified smart inverters (CPUC 2014).

In the absence of national consensus standards, utility incentive programs and California's buildings standards have developed their own design requirements. For example, the California Solar Initiative (CSI) Handbook and the associated CEC database of certified solar PV equipment provide guidance on design standards for solar PV systems. When the CSI program sunsets in 2016, a void will emerge for up-to-date design guidance and lists of certified products. Unique design specifications for incentive programs and state building standards is not desirable and can lead to compliance and enforcement (C&E) challenges.

Given the benefits of IDER depends on how customers interact with the IDER systems, there may be a benefit in standardizing how information from IDER components is conveyed to users. This could help consumers understand and trust their control systems and might lead to increased participation in active energy management strategies.

Appliance Standards – Current. Appliance standards set minimum energy performance requirements for products offered for sale in a given geographic region. Appliance standards have been effective at achieving energy efficiency. Federal standards currently apply to more than 60 product categories, representing about 90 percent of home energy use, 60 percent of commercial building energy use, and 30 percent of industrial energy use. DOE estimates that existing federal efficiency standards completed to date will save 132 quadrillion Btus (quads) of energy cumulatively through 2030 (DOE 2016). Existing DOE and CEC appliance standards

[3] *UL 1741 SA Supplement for Grid Support Utility Interactive Inverters* is currently under development.
[4] Distributed generation interconnection rules establish the requirements that utilities and customers must adhere to when connecting distributed generation resources (e.g., rooftop solar PV systems) to the grid. Interconnection rules are being updated to accommodate the growing saturation of distributed generation including requirements that IDSR components comply with new design specifications, such as the pending UL smart inverter requirements.

focus exclusively on energy efficiency. The U.S. Environmental Protection Agency (EPA) establishing ENERGY STAR® specifications that encourage "shift it" strategies.

There are five ENERGY STAR specifications that provide a five percent compliance credit if the product meets the Connected Product Criteria, which includes but is not limited to requirements for communications protocols, energy reporting capabilities, and minimum capabilities to curtail load if a DR signal is received.[5] At the time of writing, EPA is developing an ENERGY STAR specification for connected thermostats that would establish requirements for the thermostat itself and for service providers that use thermostats to help manage customers' heating and cooling loads. If the specification is approved, service providers will be allowed to bear the ENERGY STAR if they submit data to EPA that demonstrates the services they provide result in a reduction in heating system run times, and therefor energy use (EPA 2015).[6] This is a new approach to appliance standards that demonstrates one way a code-setting body is leveraging data from actual installations to establish a standards for an IDER components where the energy benefits depend on the user's behavior.

Building Energy Codes – Current. Building codes establish the minimum energy performance of newly constructed buildings as well as additions and alterations to existing buildings. Following the trend of other C&S instruments, building standards have been and continue to be effective at eliciting energy efficiency. Building codes are ahead of other C&S instruments in integrating requirements for other IDER components, in part because building codes can tailor requirements based on climate zone and building attributes.

In the 2005, California introduced Time Dependent Valuation (TDV) to assess the energy and cost impacts of potential code changes and to quantify the energy impacts of building systems and equipment when using the performance approach (whole-building energy simulation) to compliance. TDV assigns a unique cost and energy valuation factor to energy savings that occur during each hour of the year. Savings that occur during peak periods are valued more than savings that occur off-peak. Introducing TDV enabled CEC to quantify the value of measures that curtail loads during peak periods or shift loads away from peak times, thereby enabling the adoption of several "shift it" measures into California's Building Energy Efficiency Standards (Title 24) since 2005.

The 2008 Title 24 Standards, which took effect in January 2010, included mandatory requirements that HVAC systems in all nonresidential buildings be capable of shedding load by way of modifying temperature set points. Since the 2013 Title 24 standards that took effect in July 2014, lighting systems in nonresidential buildings larger than 10,000 square feet must be capable of shedding load by dimming lighting by 15 percent. The impacted HVAC and lighting systems must be equipped with demand responsive controls that are capable of automatically initiating the load shed in response to a DR signal. While these measure represent a significant "leap" for building code, there is room for improvement including establishing consistent communication requirements for all DR controls. There has also been a call for improved

[5] The ENERGY STAR specifications for the following products include a Connected Product Criteria credit: clothes dryers, residential clothes washers, residential dishwashers, residential refrigerators and freezers, room air conditioners. The credit can be traded against efficiency, meaning a manufacturer may choose to make their product "connected" instead of making it more efficient. There is a voluntary Connected Product Criteria requirement for pool pumps, but there is no credit available for pool pumps.

[6] Service providers would not have to achieve savings from every customer as long as they demonstrate savings from their entire customer base.

training and education to help improve compliance and encourage occupants of Title 24-compliant buildings to enrolling in utility DR programs.

As mentioned, TDV establishes a method to value “shift it” strategies through the performance approach.[7] The number of “shift it” measures that can receive performance credit are limited, however, because it is not desirable to allow efficiency measures, which have reasonably assured energy savings, to be replaced with DR measures whose savings are dependent upon whether building occupants choose to participate in DR programs. Instead the DR measures for nonresidential buildings are mandatory measures, meaning all applicable buildings must have DR capabilities and DR cannot be traded against efficiency. As IDER markets evolve and become more predictable and reliable, it might be appropriate to allow more “shift it” strategies to be used to meet the energy budget through the performance approach, but to maintain the loading order, only the most robust “shift it” measures should be allowed to replace energy efficiency (i.e., “eliminate it” strategies).

The 2016 Title 24 Standards include requirements that address the “make it” strategy. Buildings must comply with mandatory solar-ready requirements, and in residential buildings on-site solar PV can be used to trade off against high-performance attics and walls requirements; however, electricity generated from solar PV systems is significantly discounted. The 2016 California Green Building Standard (CALGreen or Title 24, Part 11) includes a voluntary ZNE Tier. To comply with the ZNE Tier, builders must meet minimum efficiency requirement then install a solar PV system to achieve a calculated whole-building Energy Design Rating of zero where the long-term value of solar generation is equivalent to the long-term value of building energy consumption that includes plug loads (both white goods and consumer electronics).

Model building codes such as ASHRAE 90.1, ASHRAE 189.1, IECC, and IGCC also include requirements that reach beyond energy efficiency. For example, the IECC has requirements for solar-ready roofs, and ASHRAE 90.1 subtracts electricity generated from on-site renewables from up to five percent of the required energy cost budget. The performance method of ASHRAE 90.1 also has the capability of crediting “shift it” strategies when the energy cost rates incorporate time of use rates or other rates that incentivize load shifting.

Current Incentive Programs

There are incentive programs for all components of IDER systems. Programs that promote energy efficiency across all electricity loads are well established and available everywhere in the country. Programs that encourage peak shaving are also available throughout the country. Programs that aim to shift load are limited, but some utilities, including the California Investor Owned Utilities, are piloting programs that would encourage customers to shift load to off of evening peak times towards in the middle of the day with abundant solar energy. Incentives for on-site solar PV are available in about half of the states. In some markets, notably California, the market for on-site solar PV has matured sufficiently where rebates for solar PV systems are no longer available. Incentive programs for on-site storage systems are emerging; California and New Jersey currently have incentive programs for on-site battery

[7] The 2016 Title 24 Standards provide compliance credit for thermal storage HVAC systems in nonresidential buildings.

storage in residential and/or commercial buildings.[8,9] Finally, there are many programs that offer incentives to buildings that deploy innovative technologies that exceed code-minimum energy performance. However, many of these whole-building incentive programs focus on the building's net energy draws from the grid and do not place high value on load reshaping.

Title 24 has required newly constructed nonresidential buildings to have DR capability since 2010 (the effective date of the 2008 Title 24 Standards). In theory, these Title 24-compliant buildings would be prime candidates for enrollment in utility DR programs. In practice, relatively few new Title 24-compliant buildings that have DR capability are enrolling in DR programs. This is problematic because there is a cost associated with complying with the mandatory DR requirements, but customers are not realizing the associated energy or cost benefits. Moving forward, it is critical that C&S teams work closely with incentive program teams to update both code requirements and incentive programs with the goal of encouraging more building occupants who have DR-capable buildings to participate in IDER markets.

C&S Opportunities to Encourage "make it" and "shift it" Strategies

This section identifies specific C&S opportunities for policy drivers, design specifications, appliance standards, and building standards. Since IDER markets are evolving, C&S that aim to enable and accelerate IDER needs to be carefully sculpted to allow for innovation and competition. When pursuing any code or standard related to IDER, the code-setting body should work closely with the market actors to ensure that well-intentioned proposals would not inadvertently inhibit progress. C&S can be revised over time to remain relevant and appropriate as the market matures. It is essential that C&S requirements are harmonized with other regulatory requirements such as rate design and interconnection agreements so C&S requirements can be achieved while also adhering to other regulations. It is also imperative that C&S is designed with the inherent goals of the loading order, which prioritizes cost-effective energy efficiency before load shifting and energy generation. Finally, many IDER measures will only result in energy benefits if people actually take advantage of their IDER devices and building capability to participate in IDER markets and manage their load profiles. Code-setting bodies should work closely with incentive programs and entities that provide training and education to help encourage people to participate in IDER markets.

Policy Drivers – Opportunities

Establishing ambitious yet achievable goals has been an effective means to drive change, as demonstrated by California's ZNE goals driving building codes. There are no specific goals related to increasing the availability of reliable, predictable, measureable, and verifiable flexible demand. State and federal policy makers might consider establishing such goals (e.g., a goal for participation in IDER markets by a given year).

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[8] In California battery systems (>3MW) are incentivized through SGIP. Incentives were first offered in 2009 and are expected to be offered through 2020. Batteries fall under the category of renewable and emerging technologies (R&ET) category and compete with other technologies for an allocation of the $57.75M annual budget. R&ET accounts for 75 percent of SGIP's $77 million annual budget.

[9] In March 2016, New Jersey opened a commercial and residential incentive program for on-site storage with a $3 million budget.

Current evaluation methodologies are insufficient to quantify all benefits of IDER, like the value that dynamic loads have on grid operation and reliability, particularly loads that can respond DR signals within minutes (or seconds in the case of frequency regulation). Methods that are capable of computing all benefits of IDER should be developed. Currently, CEC evaluates energy and cost impacts of proposed appliance standards on an annual basis; proposed changes to building codes are evaluated using TDV, which uses and hourly analysis of energy and cost impacts. A more granular minute-by minute methodology that also values grid reliability may be more appropriate to quantify the value of IDER measures.[10] Another factor to consider is that the benefits of DR measures is dependent on DR market participation rates, and estimating participation rates can be difficult especially as IDER markets evolve.

Code-setting bodies should be considering how they can use data to improve methods for evaluating the benefits of proposed C&S. Data is becoming increasingly more robust and available. Connected devices can collect data about how IDER systems are being used. Web crawlers can systematically pull data, like product cost and technical specifications, to inform comprehensive analyses for how product cost and functionality are changing over time. Data availability could become part of the solution to challenges associated with quantifying the benefits of “make it” and “shift it” strategies. As demonstrated by the ENERGY STAR connected thermostat specification, data from actual installations could also be used to demonstrate compliance with standards – a move towards outcome-based codes.

Design Specifications - Opportunities

Design specifications for IDER components are evolving as technology changes. It is critical that industry remain diligent in updating specifications frequently so they remain relevant as markets and technologies transform. It is also important for industry to start working on design specifications for IDER systems (not just IDER components) that will ensure safety, security, reliability, and interoperability. Once national consensus specifications are approved, they can be referenced in building codes, appliance standards, or interconnection rules thereby requiring compliance with the consensus standards. With standardization, consumers may find the market for IDER components and IDER systems less confusing and more approachable, which could then lead to increased participation in IDER markets.

Appliance Standards - Opportunities

Appliance standards apply to all products available for sale in a state or throughout the country. When considering new appliance standards, code-setting bodies should consider if the proposed change is appropriate throughout the entire region where the standards apply. IDER requirements can be incorporated into appliance standards over time as markets and technologies change. In the near term, it may be appropriate to establish energy performance requirements for smart inverters, battery storage systems (e.g., round trip efficiency and discharge capacity), and standby power use for a wide variety of connected devices. Connected devices have higher standby power draws than non-connected devices; requirements that establish maximum

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[10] Adding granularity to the evaluation methodology should be balanced with the practicality of running building simulation models for the performance approach where minute-by-minute calculations could slow simulation times without having a noteworthy impact on the results of the annual energy benefits analysis. The updated methodology might only be used to evaluate code change proposals, but not be used for building code performance approach calculations.

allowable standby power use could mitigate potential growth in electricity use as more devices become connected. This is particularly important in California as the building code requires the installation of connected devices.

In California, the building code includes requirements for IDER devices, but the building code's C&E (compliance and enforcement) processes is not well-suited to verify compliance with device requirements, which leads to compliance challenges. For example, Title 24 requires Occupant Controlled Smart Thermostats (OCSTs) to be installed in nonresidential buildings if more robust DR HVAC controls are not used.[11] CEC's Title 24 staff are responsible for certifying compliant OCSTs and posting a list of approved OCSTs on the Title 24 section of CEC's website. It does not seem logical for CEC's building code staff to be monitoring and enforcing compliance with OCST device requirements. Given the complexity and of the building code and the sheer volume of code requirements, a C&E process that requires code officials to navigate multiple lists of approved devices can lead to noncompliance.[12] One potential solution is to leverage the robust and effective C&E process in place for California's Appliance Efficiency Standards (Title 20) to simplify compliance with Title 24 device requirements. This could be accomplished if Title 24 staff continue to certify Title 24-compliant products and devices, but compliant products are listed in CEC's Appliance Efficiency Database instead of in addition to listing certified products on CEC's Title 24 website. Title 24-compliant LED lighting products are listed in the Appliance Efficiency Database using this approach, but other Title 24-compliant devices are not included in the database. Alternatively, Title 24 device requirements could be incorporated into the Title 20 purview by adopting test and list standards into Title 20 that would require manufacturers to test their products using a specified test method and submit the results to CEC by way of the Title 20 C&E process. The following devices could benefit from being incorporated into the appliance standards C&E process: PV modules, smart inverters, on-site energy storage systems, OCSTs, and other HVAC equipment.[13]

Building Codes - Opportunities

Mandatory requirements. The existing mandatory DR control requirements in Title 24 could be strengthened by harmonizing communications requirements for all Title 24 DR controls; currently communications requirements for OCSTs, which are specified in Joint Appendix 5, are very detailed and specific while communications requirements for DR lighting controls and more sophisticated HVAC controls are vague and non-specific. To ensure interoperability, it is desirable for all controls to adhere to the same minimum communications requirements. Existing requirements would benefit from a clean-up to make them easier to understand, which could lead to improve compliance. It may also be appropriate to require DR controls in more building, requiring OCSTs in all newly constructed residential buildings, for example.

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[11] OCSTs can also installed in residential buildings instead of the solar-ready requirements.

[12] Title 24 allows residential buildings to claim a solar PV credit to help meet the required energy budget if complying using the performance approach. The PV system must meet design and performance requirements detailed in the New Solar Homes Program Guidebook; compliant PV systems, modules, and inverters are listed on the Go Solar California website, which will be maintained until the conclusion of the incentive program in 2016.

[13] Title 24 staff currently oversee compliance with equipment, device, and product requirements for: air economizers, airflow measurement apparatus - forced air systems, airflow measurement apparatus - ventilation systems, air-to-water heat pump systems, economizer fault detection and diagnostics, intermittent mechanical ventilation systems, low leakage air-handling units, and OCSTs: http://www.energy.ca.gov/title24/equipment_cert/.

Other opportunities for mandatory requirements that could be incorporated in the near-term include expanding requirements for: plug load controls to applications other than office buildings (e.g., schools, retail spaces, and residential buildings); and acceptance tests to ensure IDER systems are installed and commissioned correctly.

Prescriptive Requirements and Compliance Options. Historically, "make it" and "shift it" requirements in Title 24 have been mandatory. This approach, in which there are no prescriptive requirements or compliance options for "make it" or "shift it" strategies guarantees that builders cannot pursue load shifting or on-site generation instead of efficiency, thereby maintaining the loading order. As IDER markets mature, code-setting bodies could explore adding prescriptive requirements and compliance options for IDER components other than efficiency to encourage broader update of IDER systems while maintain the loading order.

The performance approach provides builders with a flexible pathway to achieve the required energy budget, giving builders leeway to experiment with new technologies and design approaches. Although the performance approach is intended to provide compliance options, it is limited in that builders can only receive compliance credit for approaches that have approved modeling rules. Compliance credits for "make it" and "shift it" strategies have been limited to ensure the loading order is maintained.[14] Once a framework is in place to ensure efficiency is deployed first, prescriptive requirements and/or modeling rulesets could be developed or updated for: solar PV systems, on-site battery storage systems, thermal storage HVAC systems, building control systems that have default programing to optimize all IDER components within a building, controlled electric vehicle charging, and electric water heaters with DR capabilities.

Water heaters with DR capabilities have been gaining traction as a new untapped resource to enable load shifting and peak shaving. A January 2016 study from the Brattle Group found that both electric resistance and heat pump water heaters (ERWHs and HPWHs) with grid interactive capabilities can have significant positive impacts on grid operation and save customers money throughout the life of the water heater. Grid-interactive water heaters can be used to a similar effect as batteries—they can cut peak load, shift load to off-peak hours using thermal storage, and newer more advanced water heaters can respond quickly to short term requests thereby providing frequency regulation services to the grid (Hledik, et. al., 2016).

Acceptance tests. Acceptance tests can be an effective way to confirm that building systems have been installed and commissioned as intended. There are existing acceptance tests for control systems, but there are no requirements for solar or storage systems. As building codes add IDER measures, accompanying acceptances tests should also be considered.

Interim design specifications. If a building code is going to require IDER components or allow them to receive compliance credit, it is prudent to require those systems to adhere to minimum design and performance specifications. It is preferred that industry develop consensus standards. In the absence of a consensus standards, building codes can include their own design specifications. Existing design specifications in for controls systems could be improved, and new specifications for solar PV and on-site storage systems could be added.

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[14] The 2016 Title 24 Standards allow builders to install solar-PV to meet a portion of the required energy budget for residential buildings. Solar PV systems will contribute to the whole-building Energy Design Rating that is use to demonstrate compliance the ZNE Tier in CALGreen. The CALGreen requirements were crafted to ensure that buildings meet a minimum level of energy efficiency before applying credit from solar PV systems. There is also an approved modeling approach for HVAC systems with thermal (ice) storage.

Local ordinances. Constraints of the existing transmission and distribution infrastructure make IDER more valuable in locations where it can alleviate grid congestion or defer or eliminate the need for infrastructure upgrades. Local ordinances that are more stringent than the state-wide building codes can help encourage the adoption of IDER strategies on a more aggressive timeline in areas where IDER is valued the most. The adoption of local reach codes could be expedited by establishing more stringent IDER requirements in reach codes like CALGreen, ASHRAE 189.1, or the IGCC. Local governments could use reach codes as a template for local ordinances.

Energy reporting. The value of demand flexibility is not widely understood by customers, utilities, or grid operators. In this data-driven era, accurate information collected from a wide variety of customers that are deploying IDER solutions could be used to gain a better understanding of the value proposition. Data could be used to help utility customers understand the value of participating in IDER markets, inform incentive programs and future C&S proposals, and to improve energy management strategies. Code-setting bodies might consider adopting code requirements that would require newly constructed buildings to be capable of collecting and reporting information about how energy is being used on a granular time scale on the device level. The building would have the capability to collect and report data, but the building occupant would have the ability to choose if and how they share data with code enforcement bodies, utilities, grid operators, service providers, or others. Interconnection rules can also include energy reporting capabilities for distributed generation systems that are connected to the grid.

Conclusions

The C&S community has an important role to play in facilitating a market shift towards "make it" and "shift it" load management strategies that could be beneficial to customers and to the operation of the high-renewables grid. Although C&S cannot address all barriers to widespread participation in IDER markets, they can ensure that IDER components are available in the market and that those components are safe, reliable, reportable and interoperable. Since IDER markets are evolving, C&S need to be developed carefully with broad stakeholder input to allow and encourage innovation and competition. Table 3 summarizes opportunities for policy drivers, design specifications, appliance standards, and building codes. When pursuing these opportunities, code setting-bodies should:

- Establish C&S that respect the loading order;
- Collaborate with utility incentive programs and entities that offer training and education to encourage people to participate in IDER markets;
- Work closely with other regulators to ensure new C&S do not contradict with other regulatory requirements;
- Revise C&S periodically so they remain relevant as IDER markets mature; and
- Consider how data can be used to help establish new C&S and/or demonstrate compliance with C&S.

Table 3: C&S mechanisms that could enable and accelerate the adoption of IDER capabilities.

#	C&S Instrument	Description
1	Policy	Establish high-level IDER goals
2	Policy	Update methodology for quantifying benefits of IDER components
3	Policy	Clarify that appliance standards can address "make it" and "shift it" strategies
4	Design Specification	Develop design specifications for solar PV systems, and on-site battery storage systems
5	Design Specification	Update design specifications for communications hardware and communications protocols
6	Appliance Standards	Adopt test and list requirement for solar PV systems, battery storage systems, thermostats and other DR controls, on-site battery storage systems
7	Appliance Standards	Adopt energy performance standards for smart inverters, solar PV modules, on-site battery systems, and standby power for connected devices
8	Building Codes	Explore opportunities for: water heaters with DR capabilities, thermal storage HVAC, solar PV, battery storage, and integrated controls that optimize all IDER components (mandatory or prescriptive/performance if loading order is maintained, reference consensus design specifications or adopt interim design specifications in building code, establish associated acceptance tests)
9	Building Codes	Update mandatory requirements for DR controls (clean-up, harmonize communication requirements and acceptance tests, add or modify default load management strategies)
10	Building Codes	Adopt mandatory requirements for plug load controls and OCSTs in more building types
11	Building Codes	Local ordinance for IDER in areas in areas with transmission and distribution constraints
12	Building Codes	Explore opportunities for energy reporting

References

42 U.S. Code (Energy Conservation Program for Consumer Products Other Than Automobiles, U.S. Code Title 42). 2016. § 6291 and § 6201.

Bronski, P, M.Dyson, M. Lehrman, J. Mandel,J. Morris, T. Palazzi, S. Ramirez, H. Touati. 2015. *The Economics of Demand Flexibility: How "flexiwatts" create quantifiable value for customers and the grid.*

CEC (California Energy Commission). 2015. *2015 IEPR (Integrated Energy Policy Report).* Report No. CEC-100-2015-001-CMF. http://www.energy.ca.gov/2015_energypolicy/

CEC. 2016. Chief Counsel of the California Energy Commission, *Warren-Alquist State Energy Resources Conservation and Development Act of 2016*, P.R.C. § 25000 et seq. 2016. http://www.energy.ca.gov/2016publications/CEC-140-2016-002/CEC-140-2016-002.pdf

CPUC. 2014. California Public Utilities Commission, *Interim decision adopting revisions to electric tariff rule 21 for Pacific Gas & Electric Company, Southern California Edison Company, and San Diego Gas & Electric Company to require "Smart" inverters.* December 2014. http://apparent.com/wp-content/uploads/2015/01/CPUC-order.pdf.

Coddington, M., B. Mather, B. Kroposki, K. Lynn, A. Razon, A. Ellis, R. Hill, T. Key, K. Nicole, and J. Smith. 2012. *Updating Interconnection Screens for PV System Integration*. NREL/TP-5500-54063. Golden CO: National Renewable Energy Laboratory. http://www.nrel.gov/docs/fy12osti/54063.pdf.

Colby, S. and J. Ortman. 2015. "Projections of the Size and Composition of the US Population: 2014 to 2060." March 2015. Washington, DC. U.S. Census Bureau. https://www.census.gov/content/dam/Census/library/publications/2015/demo/p25-1143.pdf.

DOE (United States Department of Energy). 2016. *Saving Energy and Money with Appliance and Equipment Standards in the United States.* http://energy.gov/sites/prod/files/2016/02/f29/Appliance%20Standards%20Fact%20Sheet%20-%202-17-2016.pdf

EIA (Energy Information Administration). 2009. *Annual Energy Outlook 2009 with Projections to 2030*. http://www.eia.gov/oiaf/aeo/pdf/0383%282009%29.pdf

Emerson R., Ardani K., Margolis, R. 2015. *Industry Perspectives on Advanced Inverters for U.S. Solar Photovoltaic Systems: Grid Benefits, Deployment Challenges, and Emerging Solutions.* NREL/TP-7A40-65063. http://www.nrel.gov/docs/fy15osti/65063.pdf

EPA (Unites States Environmental Protection Agency. 2015. *ENERGYSTAR® Program Requirements for Connected Thermostat Products: Version 1 Draft 2.0.* https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Program%20Requirements%20for%20Connected%20Thermostats%20Version%201.0%20Draft%202.pdf.

Hledik, Ryan, Judy Chang, and Roger Lueken. 2016. *The Hidden Battery: Opportunities in Electric Water Heating.* The Barattle Group, Inc. http://www.nreca.coop/wp-content/uploads/2016/02/The-Hidden-Battery-01-25-2016.pdf

UL. 2010. *UL 1741: Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources.* http://ulstandards.ul.com/standard/?id=1741_2.