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END-USE EFFICIENCY (Y WANG, SECTION EDITOR)

Overview of State Policies for Energy Efficiency in Buildings

Yu Wang [1,2]

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Abstract

Purpose of Review This paper introduces the major state-level regulations and policies for improving energy efficiency in buildings. The purpose of the review is to discuss the challenges and issues in policy implementation and the latest trend in adopting innovative instruments.

Recent Findings The implementation of customer efficiency programs increasingly incorporates non-price instruments to encourage participation and deep savings. States pay attention to not only code adoption and update but also compliance and evaluation. Many states have adopted innovative policy instruments, including decoupling mechanisms and performance incentives to make energy efficiency a good business model for utilities, dynamic pricing to reduce consumption and peak load, flexible financing to provide incentives, and green labeling and benchmarking policies to increase information transparency.

Summary State governments continue to be the primary decision-makers for improving energy efficiency in buildings. Combined efforts on code/standard compliance and innovative policies are the leading strategy to promote energy efficiency.

Keywords Energy efficiency · State policies · EERS · Decoupling · Dynamic pricing

Introduction

State governments are key decision-makers in improving energy efficiency (EE) of buildings. Unlike the federal regulations that provide uniform solutions, state governments have the flexibility to enact regulations and establish targets that reflect local circumstances and considerations. Local energy efficiency markets are driven by customer efficiency programs and state standards and regulations, which may exceed the stringency of federal standards. States take pro-efficiency actions because of multiple internal factors, such as public awareness and environmental movement, pressure for job creation, and requirement for grid stability and energy security [1, 2]. States also learn from their neighbors, peers, and leaders in adopting new policies for clean energy [3, 4]. Sometimes the federal government sets up targets and provides incentives that frame and guide state actions. For instance, the American Recovery and Reinvestment Act (ARRA) of 2009 provides large amount of grant funding to state and local governments, conditioning on their adoption of the most stringent building energy codes. Overall, policy design and implementation for energy efficiency needs to take into consideration of utility planning [5], stakeholder involvement [6], and indirect cost, consumer perception and other behavioral barriers [7].

This paper provides an overview of the state-level regulatory, financial, and information-based policies that aim at improving energy performance for products, equipment, appliances, homes, and buildings. Special attention is paid to the issues and challenges with policy design and implementation, as well as the recent trend in the adoption of innovative policy instruments. Massachusetts and California are selected to showcase how leading states take the strategy of combined efforts to promote energy efficiency.

This article is part of the Topical Collection on *End-Use Efficiency*

✉ Yu Wang

[1] Department of Political Science, Iowa State University, Ames, USA

[2] Ames, USA

Ratepayer-Funded Energy Efficiency Programs

All states have customer efficiency programs funded through public benefit funds, which are collected through charges wrapped into customer rates or other charges that appear on customer utility bills. Ratepayer-funded programs are administrated either directly by utilities in most states, or by third parties in some cases.[1] Customer efficiency programs have fast growing budgets—increased from $3.2 billion in 2010 to $7.6 billion in 2016 [8]. Program budget is spent primarily on electricity efficiency measures, with expenditure on natural gas efficiency improvements. CA, MA, and NY are the states that have large budgets for EE programs [8–10]. Budgets for EE programs are lower in smalle r states; but some of them, such as RI, VT, and D.C., have budgeted high percentages (about 6%) of their utility revenues on energy efficiency [8].

Ratepayer-funded programs typically combine financial incentives with energy audit and training/educational services. Some utilities design separate programs to target specific consumer sub-segments with fine-tailored offerings. For instance, the Efficiency Vermont and Vermont Gas Systems provide generous financial incentives for new homes constructed in compliance with stringent building energy codes. The Northwest Energy Efficiency Alliance runs a program to accelerate the adoption of ductless heat pumps by developing marketing strategies to increase customer awareness and supply chain capacity. Recent trend in designing EE programs focuses more on tackling information and behavioral barriers by incorporating non-price instruments [11], such as social media marketing, relationship building, process simplification, and quality assurance [12].

The estimated energy saved by customer efficiency programs has more than doubled since 2010: increased from 10.6 GWh to 25.4 GWh in 2016 [8]. From 2014 to 2016, EE programs have realized on average 25.9 GWh of electricity savings (0.69% of retail sales), and 353 MMTherm of natural gas savings (0.42% of retail sales) each year [8–10]. The top performing programs can save up to 3% of electricity [13]. The estimated cost of saved electricity was $0.030/kWh for residential customers and $0.053/kWh for non-residential customers, based on a study of EE programs in 20 states from 2009 to 2013 [14]. Many of the programs have also reduced peak demand and achieved non-energy benefits, such as health benefits, job creation, and water savings [15].

Customer efficiency programs are frequently criticized for the program effectiveness, the incomplete and inconsistent data, and the discrepancies in measurement of energy savings [16]. A review estimates the average savings is merely 0.9% from ratepayer-funded EE programs between 1992 and 2006 [17]. The estimated energy savings delivered by the programs may not reflect sustained load reduction over long time. The evaluation, measurement and verification (EM&V) of energy savings are critical, but methods always vary from case to case. Study suggests that third-party evaluations tend to generate lower verified savings than self-reported savings by customers programs, while the selection of the third-party evaluator also affects the estimate of energy savings [14]. But EM&V procedure is increasingly standardized and automated [18], with tools emerged for measuring and verifying energy savings from EE projects.[2] Benchmarking the baseline or pre-participation consumption is a key first step. The accounting of free-ridership [19] and the rebound effect [20, 21] also affect program performance and evaluation.

Nevertheless, research on behavioral science provides new opportunities to save energy by using non-price instruments to tackle the behavioral barriers in the EE market. Multiple behavioral nudges have been tested in pilot studies, such as framing and psychological cues [22, 23], tailored information, consumption feedback, goal setting, and commitment [24, 25], as well as in large-scale projects [26••]. Novel design features and behavioral "nudges" become popular with EE programs to target the "hard-to-reach" customers and encourage deep, sustained, and long-term savings.

State Regulations and Policies on Energy Efficiency

Investor owned utility (IOU) companies are not interested in energy efficiency due to the throughput incentive for energy sales. State governments attempt to better engage utilities in energy efficiency through mandatory energy savings requirement, decoupling utility revenue from sales, and providing performance-based incentives. Policies are also enacted to improve efficiency performance for products and buildings and motivate consumers through dynamic pricing of energy and flexible financing.

Energy Efficiency Resource Standard (EERS)

States adopt EERS to set up mandatory energy-saving targets, which are binding targets for utilities and non-utility program administrators to reach certain levels of savings through end-use efficiency. Most of the EERS targets require long-term energy savings with specified incremental annual savings in either percentage or quantity measures. For instance, CA's target requires on average 1,738 GWh electricity savings, 440 MW peak demand reduction, and 54.3 MMTh natural gas savings every year from 2016 to 2024 (see CA Public Utility Commission Decision 15-10-028). Some states set EERS targets to pursue deeper savings in later years, such as MI's target starting from 0.3% in 2008 and ramping up to 1% in 2012 through 2012 (Public Act 495 & SB 438). EERS is

[1] In DE, D.C., HI, ME, NJ, NY, OR, VT, and WI, customer EE programs are funded through public benefit funds and run by third parties.

[2] The International Performance Measurement and Verification Protocol is one of the most important tools that are widely used by EM&V processes.

popular among states, and efforts have been devoted toward a federal target.[3]

As of January 2017, 20 states have statewide mandatory targets for energy efficiency, and six other states have set up non-binding efficiency goals [27]. Seven of these states have specified cost-effective efficiency measures. Some of the states impose efficiency targets for all utilities, while others only mandate energy savings for IOUs. The coverage of the EERS targets ranges roughly from 57 to 100% of total energy sales [28•]. In addition, NV and NC have classified energy efficiency as an eligible resource (with caps) in their Renewable Portfolio Standards. The design of EERS targets also varies in funding method, baseline setting, incentive/penalty setting [28•], and demand-side technology eligibility [29]. See Palmer et al. [28•] for a summary of the EERS policy design and implementation.

The energy-saving requirements of EERS vary substantially; if normalized into annual saving, EERS targets are 0.7% per year on average [8]. MA and RI require the highest energy savings, which are over 2.5% incremental savings each year. EERS targets of OH, AZ, and NY are considered to be more stringent than others, based on the converted % savings of impacted entities with consideration of future population growth [28•].

Mandating energy savings provide some level of legislative certainty that greatly encourages market actors to invest in energy efficiency [28•]. Evidence has shown that EERS are more successful at driving energy-efficiency improvements than regulatory tools affecting utility business models [30]. The implementation of EERS may lead to electricity rate increase, but this customer rate impact can be alleviated when utility business model is adjusted [31]. A comprehensive strategy is recommended to achieve high efficiency gains—"getting the business model right and setting specific efficiency targets" [30].

Decoupling

Decoupling utility profits from electricity sales is designed to ensure that utilities are "indifferent" to demand-side efficiency versus supply-side investment. Decoupling can be accomplished by using periodic rate reconciliations to cover cost. Allowed rate adjustments are commonly calculated on a per-customer basis to compensate for under- or over-collection of revenues. Another decoupling approach is "lost revenue adjustment mechanism" (LRAM), which allows utilities to recover lost contribution to fixed costs by redistributing it over all sales by class. Lost revenue can also be remedied by using straight fixed variable rates (SFVR). The SFVR mechanism recovers all fixed costs through a flat charge, and recovers variable costs through a volumetric rate.

Allowing recovery of direct program cost and lost revenue is not enough to make utilities "indifferent". IOUs are subject to the Averch and Johnson effect that they tend to expand investment to earn more profit for the present stockholders [32]. Demand-side efficiency will reduce the rate bases for utilities and lower the return on equity for stockholders, but this disincentive cannot be 100% offset with decoupling [33]. Many states provide "additional" performance-based incentives to reward utilities for achieving pre-established goals so that they can earn an extra stream of revenue from energy efficiency. Performance incentives are popular with decoupled utilities, and mechanisms based on "shared benefits" are the most common type [34]. The shared savings is calculated based on a share of the net benefits from approved efficiency programs. Other types of incentives include an allowed percentage of program costs and an allowed rate of return on program spending.

Evidence shows that utilities have increased their expenditures on energy efficiency when decoupling policies are in place [35]. Brown et al. study the decoupling mechanism in the southeast—LRAM combined with direct program cost recovery and shared benefit incentives based on program administrator cost test. This business model has largely increased the rate of return on equity to exceeding the authorized rate of 11.25% [36•]. However, studies show that allowing rate adjustments through decoupling leads to the disproportionate distribution of the efficiency benefits. That is, participating customers enjoy savings from efficiency improvements, but non-participant may face with increased rates and costs [36•, 37]. Great scrutiny should be given to minimize the rate impact for customers when altering utility business models [36•].

Dynamic Pricing

The cost of power production varies significantly from hour to hour. Dynamic pricing is the idea to provide accurate price signals to customers so that they can cut down usage during high-rate peak times. Mechanisms for dynamic pricing include time-of-use pricing (TOU), critical peak pricing (CPP), and real-time pricing (RTP). Dynamic pricing enables utilities charge different rates for electricity based on time, generation cost and conditions of the grid. Dynamic pricing can remove subsidies to peak users embodied in flat rates, encouraging customers to shift load to non-peak time [38, 39].

Time-of-use Pricing sets and publishes electricity prices for peak and off-peak periods in advance. Electricity prices in peak periods are higher than off-peak time, which encourages load shifting and reduces peak demand. The rates for each time block are usually adjusted two or three times each year; however, TOU pricing does not address unforeseen weather

[3] A Senate bill was introduced in 2015, proposing a 20% electricity savings and 13% natural gas savings target by 2030.

conditions or equipment failures that can unexpectedly drive up generation costs. CA utilities implement Critical Peak Pricing, which adds one more rate in "critical" summer peak hours to recover the full generation cost. There can be a number of CPP event days in a year, and utilities usually notify customers ahead of time. Real-time pricing disseminates price singles in much smaller time intervals: typically hourly or even sub-hourly. RTP can reflect the changes in marginal costs and capture most of the cost variation in electricity generation. Technology improvements have helped enhance customers' ability to respond to real-time prices [40].

The implementation of dynamic pricing does not always lead to electricity savings [41], because not all customers have the capability or willingness to reduce peak demand or shift load [42]. Dynamic pricing is recommended to be combined with demand response or other demand-side solutions to achieve great savings [43, 44]. However, load shift may save money but increase CO_2 emissions due to the heterogeneity in hourly CO_2 intensity for electricity generation [40]. Another challenge to the use of real-time price and usage data is data security and privacy. States are beginning to set requirements regarding the use of metered-data. TX, for example, has determined that all meter data belongs to a customer; however, energy providers can be granted access to the data with customer authorization [45].

Other Policies Targeting Market Sub-Segments

Building Energy Codes Many states have adopted building energy codes to ensure efficiency improvement in new homes and commercial buildings. Imposing minimum energy performance requirements for new and renovated buildings can reduce energy consumption and save building owners and occupants money. Model codes are developed and updated periodically by independent organizations.[4] In the U.S., state governments have the authority in building code adoption and modification. Some states have decided to directly adopt the model codes, and many states have adopted revised versions of the model codes tailored to address location climate conditions. A few of the states draft codes using their own knowledge, capacity, and resources. As a prerequisite by the 2009's stimulus package, many states adopted building energy codes around that time so that they are qualified to receive funds from the federal government. Building energy codes have been found to be effective in a wide range of countries (see a review by Evans et al. [46]), and more attention has been paid to code compliance and implementation [46, 47]. Effective strategies for code compliance include performance testing, independent testing and review, professional accountability, incentives, training, and streamlining processes [46]. Automated tools are also in development for checking code compliance [48].

Appliance Standard The federal government has implemented minimum energy performance standards (MEPS) to phase out the least efficient models of appliances and equipment in the marketplace. Different from design standards mandating particular technologies or processes, appliance standards mandate performance outcomes, which provide design flexibility and motivate innovation. Currently, nationwide MEPSs cover 42 product types in 13 major end-uses, including refrigerators, HVAC, lighting, laundry equipment, cooking equipment, water heating, distribution transformers, and motors [1]. MEPSs are effective in improving product efficiency and stimulating R&D. But implementing uniform national standards is frequently criticized. States intending to set more stringent standards may find the US federal standards to be a barrier since the application for exemption tends to be slow and tedious. Currently, state governments take the lead in developing minimum efficiency standards for portable electronic devices, such as compact audio equipment, DVD players, pool pumps, portable electric spas, etc. [49]. The new technologies of smart appliances and Internet of Things impose new challenges to the development of appliance standards [50, 51].

Flexible Financing Innovative financing approaches, particularly on-bill financing, are beginning to take hold in the building sector. On-bill financing provides opportunities for end-users who want to adopt efficient technologies but have limited access to financing options. On-bill financing offers low- or zero-interest loans, with short payback time (typically less than 3–5 years). Utilities sometimes provide free products and installation, but customer monthly bill stays at the same level as pre-installation consumption [52]. Utilities get the investment back by capturing the savings—the differences between customers monthly bill and their actual consumption. On-bill financing tackles the split incentive problem because the monthly payment stays with the meter even if tenants moved out [53].

Benchmarking and Green Labeling States have taken the leading role in running information-based programs [54], such as energy audits and green labeling, home energy rating [55], building benchmarking, and the "Lead by Example" program for public buildings. Some states lead by example though setting up savings requirements for public buildings to demonstrate efficiency improvement opportunities. Benchmarking information is increasingly available for public and commercial buildings, as more and more states and cities adopted policies to require utilities and building operators to make their energy use data

[4] The International Energy Conservation Codes (IECC) for residential buildings developed by the International Code Council are widely adopted. For non-residential buildings, codes developed by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHREA) are used by many states in the USA and by other countries.

publicly available.[5] According to the estimation by the Institute for Market Transformation, these policies affect over 10^9 sf of floor space in major real estate markets [56]. Empirical studies demonstrate energy savings for certified efficient buildings [57, 58], and in return, energy performance labels and certificates provide price premiums for efficient homes in the real estate market [59, 60].

State Case Studies

MA and CA are widely recognized for their outstanding performances and leadership in energy efficiency due to strong and innovative policies, large customer efficiency programs, and significant energy savings. Short case studies of the two states are provided to exemplify the policy options for energy efficiency that are at state legislator's disposal.

Massachusetts

MA economy is driven by non-energy-intensive service industries, with energy consumption per capita lower than the national average [61]. MA also has some of the highest electricity rates in the country [13], a factor that tends to lead to high overall efficiency performance [1]. The state passed the "Green Communities Act" in 2008, requiring electric utilities to first exhaust all cost-effective energy-efficiency resources prior to utilizing other supply-side resource options. The legislation also requires utilities to meet escalating annual savings targets, ramped up to 2.94% of electricity, and 1.24% of natural gas by 2016. The energy savings targets are higher than most targets of the states that have adopted EERS. Large budget (over 6% of utility revenue) is planned for the customer efficiency program, "Mass Save," which has realized electricity savings for over 2.5% of retail sales for multiple consecutive years (calculated using data from EIA from 861 [13]). One of the most successful programs, the "Small Business Program's" direct install model has been recognized as one of the best delivery mechanisms, which got adopted by other states. According to program evaluation, the benefit/cost ratio is 3.14 for electricity and 9.6 for natural gas based on the total resource cost test. Three key elements for the success of the program are the turnkey approach, the generous incentives, and the on-bill repayment option [12].

To make efficiency a business model for utilities, Massachusetts allow them to propose decoupled rate structures and collect supplemental revenue (less than 1%) with rate adjustments. Utilities are also offered incentives through shared savings and performance targets. The shared savings incentive is particularly rewarding because participating utilities are able to receive a return on benefits on top of the net benefits that result in "double earning" [1]. Massachusetts is a restructured market, which allows for consumer choices for competitive electric suppliers. Electric utilities (Eversource and National Grid) also offer time-of-use rates to residential consumers.

State government is obligated to lead by example (Executive Order 484), by setting aggressive energy savings targets for its public buildings—35% by 2025, and support efficiency improvement with government funding. For residential and commercial buildings, energy-performance codes are updated to the most stringent codes, which are estimated to be 10% more efficient than the baseline codes. To ensure savings, analysis and compliance studies have been conducted and a "strategic compliance plan" has been developed. Massachusetts is also the only state that has more stringent minimum efficiency standard for gas furnace that is granted a waiver of federal standard. Information about home energy audits has mandatory disclosure to homebuyers throughout the state. There is no comparable information-based policy for commercial buildings, but the city of Boston and Cambridge have adopted benchmarking policies for their public, commercial, and multifamily buildings.

California

Over the last 4 decades, CA's per capita energy use has remained steady as the result of a sustained emphasis on energy efficiency. CA's customer efficiency program has the highest budget of all states—over $1364 million in 2016 [13]. CA's energy efficiency industry is strongly motived by its long-term savings targets, decoupling utilities, and performance incentives. All IOUs (74% market share) are decoupled to allow revenue requirement being adjusted for customer growth, productivity, weather, and inflation. Critical peak pricing is default for large commercial and industrial customers, and an option available for small customers on voluntary basis. Critical peak events happen 5–15 days for different utilities, and estimated demand reduction is higher for large customers (over 5%) than small-sized customers (about 2%) [62].

Code and standard development has been a very important driver for efficiency improvement in CA. The Golden State has arguably the most advanced code program in the country, with the latest residential code being estimated to exceed the IECC 2015 by 29% and the commercial code exceed the ASHREA 2013 by 13% [63, 64]. The latest code expands the capacity of demand response (DR) by requiring large commercial buildings to be designed with the capability to reduce lighting energy use when utilities issue a DR signal. CA has also promulgated minimum efficiency standards for 17 appliances that exceed federal standards, including computers,

[5] The U.S. Department of Energy is promoting the Energy Star Portfolio Manager, an online benchmarking and data management tool, for energy and water usage information.

televisions, faucets, showerheads, small-diameter directional lamps, and toilets.

CA is currently the only state that requires public, commercial, and residential multifamily buildings to disclose energy use data. California is also the first state in the nation to implement a mandatory green building standards to design standards that exceed the mandatory codes and standards for zero net energy buildings. State-owned buildings not only have water efficiency requirements, but also have a target to reach zero net energy for 100% new construction and 50% existing square footage.

Conclusions

States have been running ratepayer-funded efficiency programs, and have enacted energy savings targets, building energy codes, and appliance standards to improve energy efficiency for appliances, equipment, and buildings. More attention has been paid to the challenges to the implementation of such regulations and programs, particularly behavioral barriers and issues. Innovative policy instruments are gaining popularity with state governments, such as decoupling mechanism to engage utilities, dynamic pricing and innovative financing to incentivize customers, and benchmarking and other information-based programs. New concerns associated with the innovative policies include consumer behavior and data security, which are to be solved with future technology improvements and the passage of new legislations. Study of the leading states—MA and CA—suggests that combined efforts on compliance to codes and standards and adoption of innovative policy instruments strongly motivate end-use efficiency.

Compliance with Ethical Standards

Conflict of Interest Yu Wang is a section editor for Current Sustainable/Renewable Energy Reports. She declares no other conflicts of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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