

Custom block rate design: a policy innovation to accelerate the rate and scale of energy efficient technology adoption in facilities

Eric Mazzi, Mazzi Consulting and New York Institute of Technology

Sunny Brar, Hollyburn Properties Limited

Ken Tiedemann, Research 4 Results

Patrik Thollander, Linköping University and University of Gävle, Sweden

Iris Sulyma, Research 4 Results

ABSTRACT

To meet aggressive carbon and energy reduction goals for facilities, the required rate and scale of technology deployment are unprecedented. We propose a policy innovation for energy utility rates, which is a custom block design. With this concept, energy utilities would provide every customer on a recurring basis (including where split incentives exist): facility-specific assessments, financial incentives, and financial resources to implement all measures which meet jurisdiction-specific benefit-cost (B-C) test criteria. Although we analyze energy efficiency measures, the instrument could also be applied to other distributed energy resources. The novelty of this inclining block rate design is that tiers are defined based on a facility-specific energy assessment, and not by a fixed quantity or percentage of energy consumption. This policy was introduced in a previous paper, and here we update the design, examine energy equity, and present three illustrative case studies: 1) 5-storey, new multi-unit residential building (MURB), 2) 23-storey office/MURB built in 1968, and 3) 9-storey MURB built in 1963. For the 23-storey MURB assessment, one natural gas and five electric measures met the hypothetical B-C criteria so that this customer would be presented the option to: a) implement the measures with an offer of on-bill financing of \$1,778 monthly for 10 years; or b) pay a premium rate (Tier 2) estimated to average \$3,813 monthly for the forgone and avoidable energy savings. The facility would be reassessed during the next cycle. Our main conclusion is that this rate design warrants further assessment and consideration for pilot testing.

Introduction

Due to concerns about climate change, there is wide recognition of the need to reduce greenhouse gas (GHG) emissions to net-zero by mid-century, followed by a transition to net negative emissions (NAS 2021; Larson et al. 2020). Some credible experts argue even further the need for more rapid transitions, such as achieving a carbon negative economy prior to 2050 (Kammen et al. 2021). These goals are widely considered to be infeasible without rapid scale up of energy efficiency activity (Global Commission for Urgent Action on Energy Efficiency 2020). While the need to rapidly adopt efficiency and steep GHG reductions is clear, the current pace and scale of energy transitions for buildings and industry would require several decades to centuries to complete (Nadel and Hinge 2020; IEA 2021). At the same time, there are inequities along income and racial lines to be solved (Graff and Carley 2020; Tong et al. 2021). Energy utilities are recognized as being critical to support an equitable transition to net-zero GHGs (Specian and Gold 2021). The custom block rate design described in this paper provides a policy innovation intended to support a rapid and more equitable transition to net-zero GHG emissions.

We previously published a paper introducing this concept of a new rate design to enable an accelerated rate and scale of energy and GHG reductions for residential, commercial, and

industrial facilities (Mazzi et al. 2020). In this paper we overview the rate design, describe important aspects of the concept which have changed, emphasize how this rate design can contribute to reducing inequities in energy services, and provide three new case studies to illustrate how this rate design concept would work. In our previous paper we reviewed key literature on barriers to energy efficiency, on-bill finance, mandatory energy audits, and tiered energy rates. The issues as we previously described remain essentially the same today, and we refer readers to our previous paper for those issues.

Previously we described the policy instrument as the “minimum barrier rate design” as it was developed to reduce energy efficiency barriers to the minimum practical level. However, to avoid confusion with a common two-tier (or multi-tier) inclining block pricing scheme, we now describe the policy as a “custom block rate design.” Block rates comprised of two or more tiers have been researched and adopted by energy utilities for decades. These rate designs have produced mixed results, with some finding that these designs are inequitable, confusing, and cause welfare losses (Shaffer 2020; Borenstein and Davis 2012). The key difference with our proposed rate design is that the blocks are defined based on a facility-specific energy assessment, and not based on a fixed quantity or percentage of metered consumption. As such, the blocks are not fixed and can vary widely to deliver equitable and economic energy services tailored for the specific customer and facility. To our knowledge, a custom block rate design as described here has never been proposed, let alone pilot tested or implemented at full scale.

While this paper presents the rate design based on energy efficiency measures (EEMs), we expect the rate design could be applied to facility-specific measures for other distributed energy resources such as: distributed generation (e.g. solar photovoltaics), behind-the-meter energy storage (e.g. electric batteries), demand response measures (e.g. grid-connected water heaters), or fuel switching (e.g. electric heat pumps replacing gas furnaces). B-C tests are integral to the design, and B-C test methods have been established for all DERs (NESP 2020).

Custom Block Rate Design

Here we update elements of the rate design, describe the general framework, and explain the proposed rules. Figures 1 and 2 provide an overview of the rate design process. The key steps for the process are summarized here, with further details below:

- All customers begin with an energy assessment which is used to identify EEMs.
 - To address privacy concerns, residential customers have the choice to opt-out of an in-person site visit as part of the energy assessment. In these cases, the residential assessment is completed 100% using remote and virtual auditing techniques.
 - Non-residential customers would not have an opt-out choice for the site visit.
 - Energy assessments can be performed on new buildings or industrial plants, which is already a common practice for new construction subsidy programs.
- Identified EEMs undergo due diligence review to assess pass/fail with respect to criteria for delivery of minimum level of service, accuracy of energy saving estimates, accuracy of implementation cost estimates, and technical performance. EEMs passing the review are tested using a B-C test. The test could be a resource cost test, societal cost test, resource value test or other prevailing B-C tests used in the applicable jurisdiction (NESP 2017).
- For EEMs passing the B-C test, the customer is presented a choice to implement each EEM using either an offer of guaranteed on-bill finance, or their own financial resources (e.g. cash, loans, subsidies). The utility would offer subsidies to eligible customers at this step, applying

the jurisdiction-specific eligibility criteria (e.g. income or other criteria linked to equity). Customers could opt to implement none, some, or all of EEMs passing the B-C test. It is noted that the B-C test threshold could be 1.0 (i.e. benefits equal costs), or as a risk mitigation strategy use a value greater than 1.0 (e.g. 1.15 where estimated benefits exceed costs by 15%).

- If customers implement all EEMs, then their billing rate is the standard, prevailing rate structure (called Tier 1 in this paper) adopted by the utility (e.g. flat rate, time-variant pricing).
- If customers opt not to implement some or all EEMs, then the customer pays higher pricing (called Tier 2 in this paper) for the quantity of avoidable energy. The total energy consumption, less the avoidable quantity, is priced at the prevailing (Tier 1) rate structure.
- If the utility account holder does not have legal decision authority to implement an EEM which passes the B-C test, then split incentives exist. In these circumstances, the utility identifies the party with authority (e.g. property owner or landlord). This option is diagrammed in Figure 2. Assuming regulatory authority to do so, the utility creates an account for the party which owns the EEM system. Then the party responsible for the EEM has the choice to implement the EEM with an offer of guaranteed finance (and a subsidy offer, if eligible) or forego implementation and pay Tier 2 for the avoidable energy consumption.
- The facility undergoes a recurring assessment on a frequency appropriate for the sector and/or facility type. For example, single family homes might be reassessed on a 5 year frequency, while a 3 year frequency might apply to industrial plants. Reassessments could be triggered by other events such as change of ownership, major renovation, or industrial process retooling.
- Measurement and verification (M&V) would be conducted based on a utility-specific evaluation plan (i.e. EM&V), which generally would employ sampling.

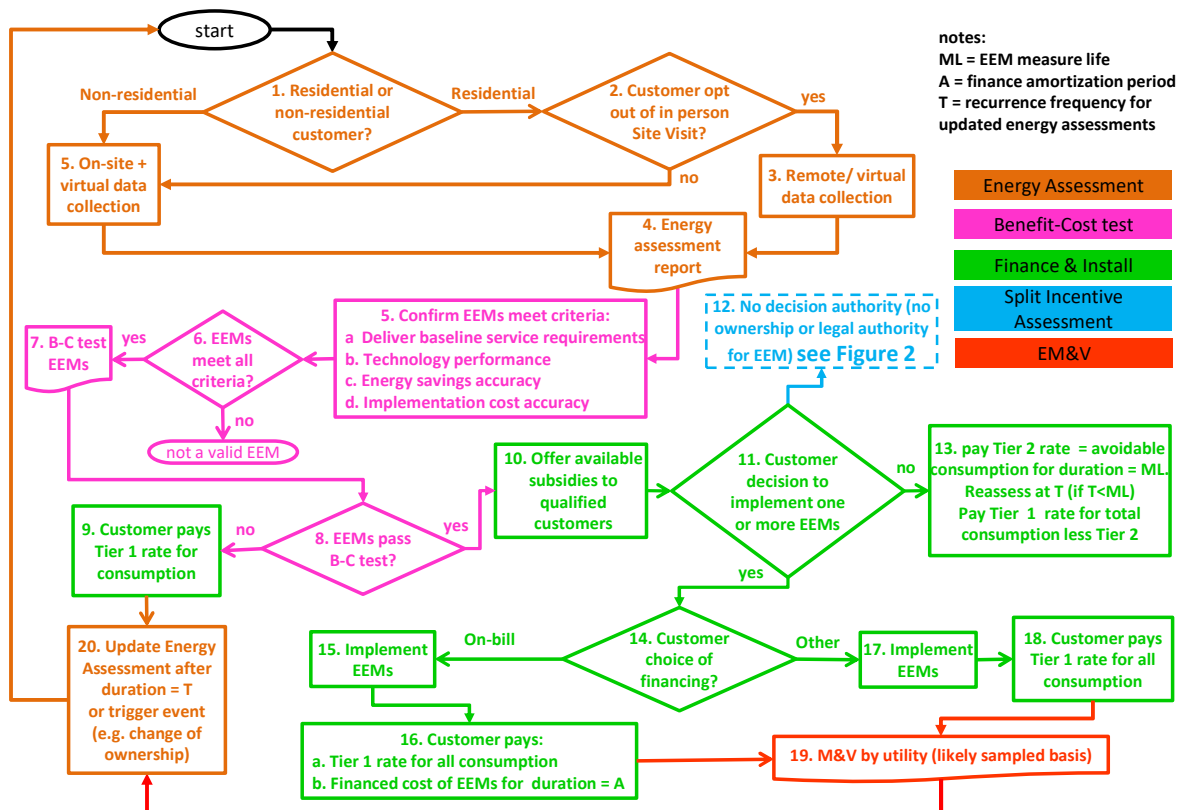


Figure 1. Flow chart illustrating process for custom block rate design.

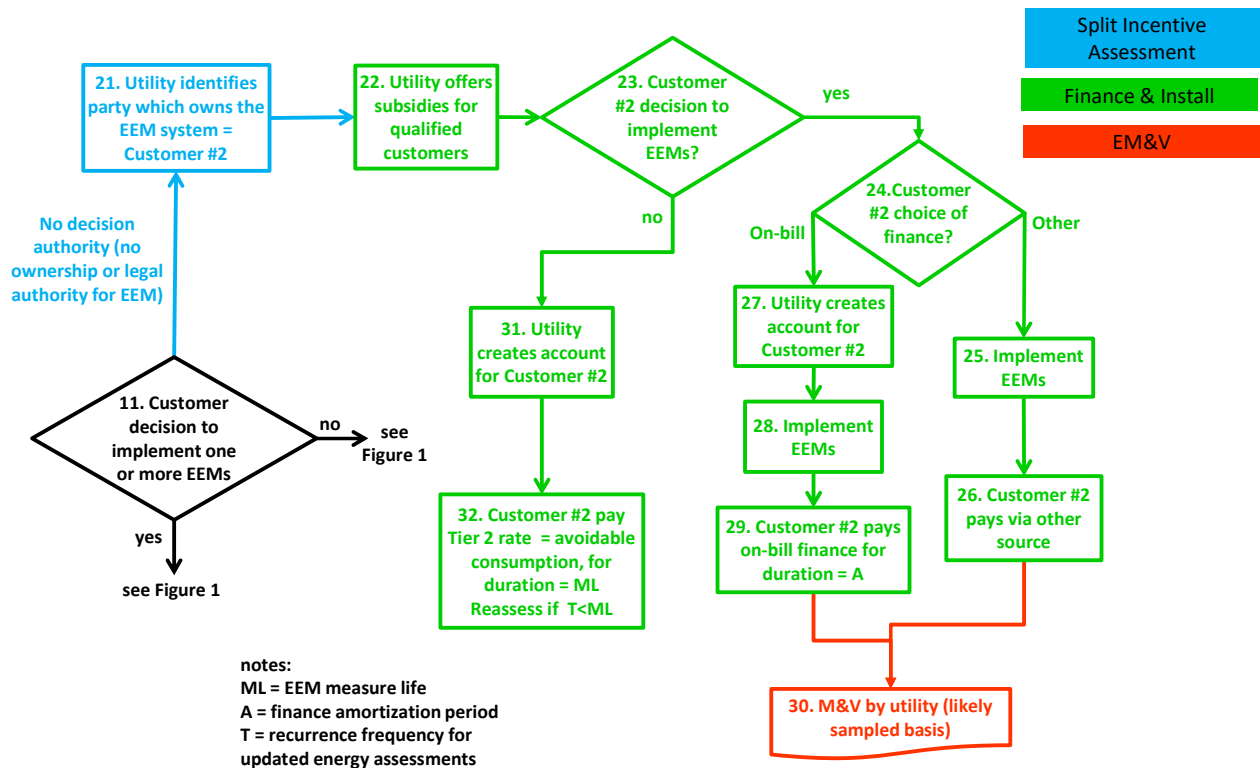


Figure 2. Flow chart for custom block rate design where split incentives exist.

We highlight that the rate rules and sequencing diagrammed in Figures 1 and 2 were developed considering best practices for effective choice architectures such as described by Thaler and colleagues (Thaler, Sunstein and Balz 2013). For example, there are a few key decision points which are best described as “mandated choice.” One example is the residential customer decision to opt-out of having in-person site visit for the facility energy assessment. Behavioral economics encourages choice architects to “expect error” which is why processes such as due diligence review, robust EM&V, and contingency funds are critical elements of the rate design concept.

Defining Savings and EEMs

We posit that the foundation of an effective rate design which minimizes barriers and avoids unintended consequences is to clearly define *energy savings*. Our definition follows:

Energy savings are defined as a reduction in energy consumption for a specified system over a defined period of time due to an intervention, and adjusted for direct rebound effects where applicable. Savings are quantified relative to a baseline system including the baseline technology as well as baseline quantity and quality of energy services. After the intervention, the quantity and quality of services delivered by the new system should equal or exceed the baseline, or otherwise be deemed acceptable (e.g. based on a best practices standards, regulation, or stakeholder requirements).

In our framework, a careful definition used to identify and qualify EEMs is essential to minimize common barriers and criticisms of past and present energy efficiency programs such as

hidden costs, imperfect substitutions, and related barriers and failures which we previously summarized (Mazzi et al. 2020). The definition above is also in agreement with ASHRAE (2011) that energy assessments should explicitly consider the level of energy services to avoid negatively impacting facility users. It is furthermore aligned with California's definition of energy savings which explicitly incorporates the level of service in both quantity and quality (CPUC 2020). In our framework, a proposed measure which is estimated to fall short of meeting baseline quality or quantity of service is not a valid EEM. An EEM which exceeds the baseline service in quantity or quality would provide non-energy benefits.

Mandatory Energy Assessments (with Residential Opt-out for Site Visits)

An essential element of the custom block rate design is that all facilities undergo energy assessments on a recurring basis, and that the cost of the assessment is built into the rate structure as a basic service¹. In general, these costs could be allocated to fixed elements, variable elements, or both in the utility bill. In our previous paper we overviewed the rationale, proposed procedures, energy assessment recurrence frequency, energy assessment costs, and the importance of rigorous accuracy requirements for both the energy savings estimates and the implementation costs. For a more detailed discussion, readers are referred to our previous paper (Mazzi et al. 2020).

In our current framework, we present that all customers² would undergo an energy assessment and there would be an opt-out provision for site visits only for residential customers. Previously we argued that residential customers have an opt-out for energy assessments to address anticipated privacy concerns (i.e. not just an opt-out for a site visit). However, we have revised this in our current concept on the basis that residential facilities can be adequately audited using remote or virtual procedures and tools. Many such tools have been proven, with ongoing efforts to improve further (e.g. NYSEDA 2022). We find no evidence that remote or virtual audits can produce energy assessments of equivalent scope and accuracy as assessments involving a site visit by a qualified auditor. However, we envision that allowing an opt-out of a site visit would be necessary to address residential customer privacy concerns.

Cost Effective Energy Savings

In practice, the cost effectiveness of energy efficiency measures is assessed using B-C tests such as total resource cost, utility cost test, and societal cost test (NESP 2017; NESP 2020). In this study, we illustrate the screening of EEMs using a simplified B-C method. We define cost effective energy savings (CEES) as the sum total of annual energy savings due to the bundle of EEMs which meet a cost threshold (CT). EEMs are included as CEES based on a) calculating the levelized cost of energy savings (LCES) for each EEM, and b) if the LCES is equal or less than the CT. This simulates screening using a B-C threshold of 1.0. The LCES is calculated using the usual outputs of an energy assessment. An interest or discount rate must be assumed, which we suggest would be the applicable interest rate for on-bill financing. The duration of the levelized cost analysis should be less than or equal to the expected measure life for each EEM. In our

¹ We assume some customers would have energy assessment costs subsidized as per current practice, especially low-income.

² By "all customers" we refer to all utility accounts which meet basic criteria, such as non-trivial consumption. An electric utility account for a street sign is an example of an account that could be exempt from an energy assessment.

previous paper (Mazzi et al. 2020), we included some additional discussion of the complexities of B-C analysis which is not repeated here.

Two-tier Custom Block Pricing

With the custom block rate design, customers have the choice to either: a) opt to implement some or all EEMs that meet the CT, or b) opt to forego the avoidable energy consumption and pay a Tier 2 rate for EEMs not implemented. The goal of the rate design is that all EEMs passing a B-C test get implemented such that typically there is no Tier 2 energy. However, where customers opt not to implement qualified EEMs, the goal is to establish Tier 2 energy in the most accurate and fair method we can envision. Tier 2 energy would be set equal to the estimated savings for unimplemented EEMs.

Critical to the effectiveness of this rate design is that the Tier 2 price be greater than the CT. This would effectively be the demand-side management (DSM) incentive for customers to implement EEMs or not. The greater the difference between the Tier 2 price and the CT, there is then a greater incentive for customers to choose to implement EEMs. In our case studies provided below, we assume the Tier 2 rate would be 5% greater than the CT³. The Tier 1 quantity of energy would be set equal to the total energy consumed for a billing period, less the Tier 2 quantity. In our vision for the custom block rate design, the Tier 1 price would be a lower price established by the utility based on the direct cost of servicing. Tier 1 pricing could be flat rates, time-variant, or other rate structures commonly used today.

The simplest approach to Tier 2 energy billing would be to average the annual quantity of energy savings over all billing periods (e.g. divide the total by 12 if billing is every month). This is presented in the case studies below. However, this may not be always the most practical method. For example, if the unimplemented EEMs are all cooling measures, then the best practice may be to apply Tier 2 energy only to the billing periods spanning the full cooling season.

Disaggregating EEMs to Tenants and Owners to Address Split Incentives

Split incentives are a ubiquitous barrier for energy efficiency programs and disproportionately affect low-income customers (Sorrell et al. 2000; Bird and Hernandez 2012). To address this barrier, our rate design includes disaggregating the EEMs to the responsible parties – i.e. tenants and owners. The custom block rate design procedure is designed to ascertain ownership for every EEM which qualifies as CEES. This is shown in Figure 1 at the decision point where the utility customer is presented the option to implement qualified EEMs, or not. In some cases the customer will not have the legal authority to agree (or not agree) to proceed with an EEM implementation – we define these situations as split incentives. Figure 2 illustrates how the utility would proceed where split incentives exist, assuming the utility has regulatory authority to do so. We describe the party as Customer #2 which has legal authority to decide to implement a qualified EEM (or not), but which is not the primary customer. This would typically be a property owner, or property manager acting on the owner's behalf. As shown in Figure 2 we envision that Customer #2 would be presented with the same choice architecture as for the primary customer.

³ As the case studies below illustrate, the LCES is often much lower than the threshold value, so the difference between the Tier 2 price and the financed cost of implementing EEMs is usually much greater than 5%.

This element of the custom block rate design would effectively entail the creation of a new utility account for Customer #2 to pay for foregone energy savings⁴.

We are well aware that the process for addressing split incentives would require new and controversial regulations to enable energy utilities to enact this element⁵. The custom block rate design could still be adopted without any mechanism to hold parties accountable where split incentives exist, in the same way that current rate designs and DSM subsidy programs function without any such mechanism. Figure 3 illustrates the process utilities could carry out under such circumstances. In short, the utilities could make the effort to identify and voluntarily engage Customer #2, optionally even offer subsidies to implement the qualified EEMs. But without any regulatory authority to require Customer #2 to be accountable, the utility could only request Customer #2 to voluntarily implement the EEMs. Ultimately if Customer #2 declines, the result would be typical of what occurs today – Customer #1 (typically a tenant, often low-income) incurs higher utility bill costs for unimplemented EEMs for which they have no legal authority to implement.

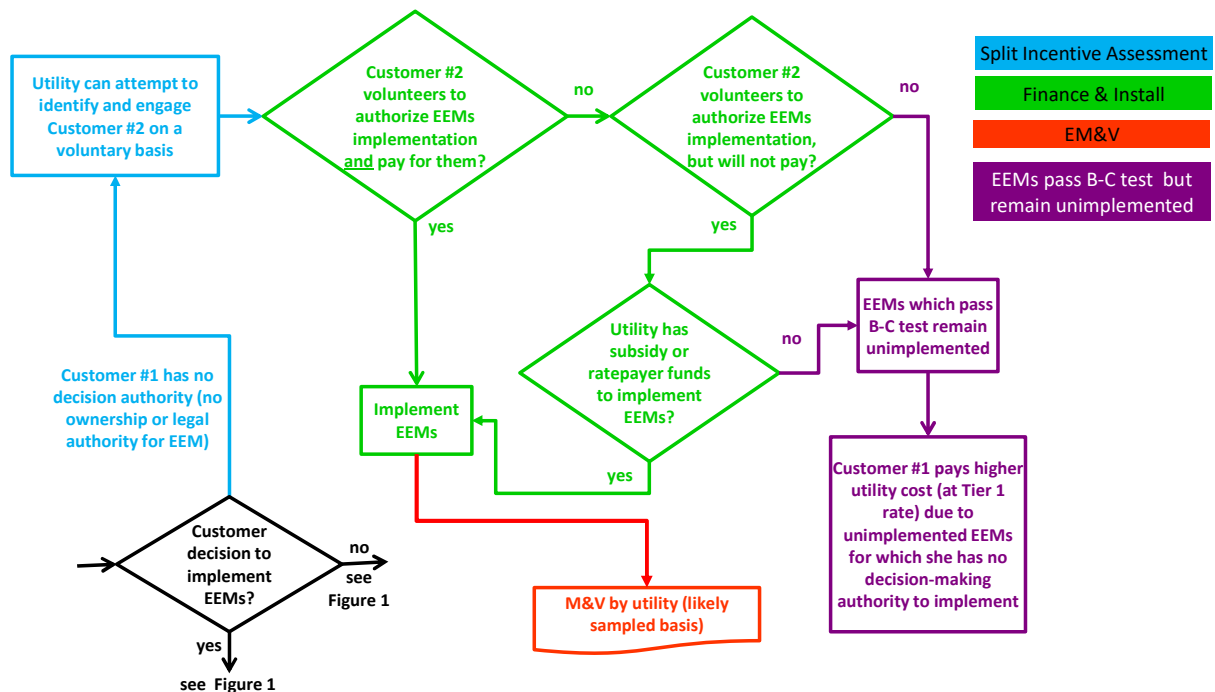


Figure 3. Flow chart illustrating process where split incentives exist without any regulatory authority to hold Customer #2 accountable.

Guaranteed On-bill Financing

With the custom block rate design, it would be mandatory that the utility offer on-bill financing. Guaranteed financing is critical to overcome the ubiquitous barrier of access to finance

⁴ If Customer #2 implements EEMs without using on-bill financing, creation of a new account may not be necessary.

⁵ There are precedents for regulatory change related to clean energy previously thought to be challenging if not impossible. One example in British Columbia was the exemption of the 1,100 MW Site C hydroelectric dam from oversight by the BC Utilities Commission. In the U.S., the roll back of lighting product efficiency regulations is an example demonstrating regressive regulatory change ([aceee.org/press/2019/09/doe-s-light-bulb-standards-rollback](https://www.aceee.org/press/2019/09/doe-s-light-bulb-standards-rollback)).

(Sorrell et al. 2000). Without a guaranteed offer of on-bill financing, the entire rate design process would not work in our assessment. Put simply, it would not be realistic to require a customer to implement qualified EEMs or pay a premium (Tier 2) price in the absence of a guaranteed offer of on-bill financing. Therefore, it is envisioned that every utility customer would be offered financing to be repaid on the utility bill⁶. The customer could opt to utilize their own financial resources such as cash savings, obtaining their own loan (e.g. municipal property assessed clean energy), utility subsidies (as identified in Figure 1) or subsidies from other sources (e.g. a federal grant). If on-bill financing is accepted, in the event of a transfer of ownership it would be linked to the facility (i.e. site identifier and meter) and not to the tenant or owner (i.e. similar to some property assessed clean energy loan terms).

The amortization period for on-bill finance should be, at maximum, equal to the expected measure life. Conservatively, the amortization period should be at least slightly less than the expected measure life. Once the on-bill financed costs are paid off, if an EEM continues to realize energy savings (i.e. if the realized measure life is greater than the amortization period), the account holder benefits with additional utility bill savings monetized at the Tier 1 rate. On the other hand, if the measure life of an EEM was overestimated, account holders could be paying for energy savings that are lower than estimated. Energy savings could be zero or even negative in cases of uncorrected equipment failures. This links back to the critical need during the energy assessment phase (see Figure 1) to rigorously screen and prove out EEMs, and estimate energy savings and implementation costs within the specified accuracy requirements. It is noted however, that this is not a new phenomenon in DSM. Subsidy programs face the same challenge, where ratepayers and program participants can end up paying for unrealized energy savings.

Implementing EEMs and the Utility Role

With the custom block rate design, energy utilities would have many critical roles. The custom block rate design, if implemented and successful, would result in an unprecedented level of activity in terms of energy assessments, equipment purchases, equipment installations, and behavioral interventions.

Overall, there are a number of functions and capabilities that energy utilities must be prepared to deliver under this rate design concept. Some of these capabilities should be in-house, but in some cases could be contracted out as is commonly done today. In either situation, the utility would have a key role to ensure success of the rate design. Utility company critical capabilities would include, but not limited to, the following list:

- Oversee energy assessments: set audit requirements for scope, accuracy, and recurrence frequency; qualify and manage energy assessors as trade allies; review/approve energy assessments to meet criteria for technical and cost accuracy.
- Set cost criteria and methodology for B-C tests and facilitate the B-C process through the regulatory approval process for regulated utilities (or oversight boards for cooperatives).
- Establish a process for implementation of qualified EEMs, such as clear rules and systems for retention of contract and project management services by the utility and/or reimbursement for such services contracted directly to the customer.

⁶ We envision on-bill finance could be financed by the utility or a 3rd party, but repaid through the utility account with either arrangement.

- Oversee implementers as trade allies: qualify and provide oversight of construction contractors, equipment vendors, and project managers.
- Site inspections: conduct site inspections of installed equipment (likely a sampling approach), which is the verification function under M&V protocols (IPMVP 2022).
- Financing: oversee financing; secure contracts with lending institutions; create and manage insurance or contingency funds.
- Manage split incentives: where split incentives arise, set up new utility accounts for Customer #2 to repay on-bill financing or pay Tier 2 charges.
- EM&V: develop and execute EM&V plans (e.g. sampling), implement M&V, and perform periodic rate design evaluations.
- Identify, assess, pilot, and vet emerging technologies.
- Arrange for credible dispute resolution processes
- Coordinate with other utilities: almost all facilities have electricity plus one or more utility accounts such as natural gas or district energy. Effective coordination between these utilities would be critical, such as combining resources for energy assessments, and to ensure full decarbonization.

Illustrative Case Studies

Here we provide three illustrative case studies. These case studies are for real facilities, based on a hypothetical scenario simulating how the proposed custom block rate design would work. Consistent with the scope of this paper, our case studies include only buildings and not industrial facilities. These case studies are based on actual energy assessments, although the utility externality and CT values are hypothetical. Some parameters have been simplified and only the end results are shown due to limited scope in this paper to expand on the analytical details.

23 Storey Multi-unit Residential Building

This case study is for a 50 year old, 23-storey multi-unit residential building located in eastern Canada in ASHRAE climate zone 6. The facility floor space is 177,000 ft² including 193 residential suites, parking garage, and common spaces. The facility is heated with centralized natural gas boilers, as well as central water heating and ventilation. One gas meter and one electric meter serve the entire structure, and tenants do not directly pay for their own utilities. Baseline natural gas usage is 15,800 GJ/yr (150,000 therms/yr) and electricity is 1,349,000 kWh/yr. Utility marginal costs are \$10.3/GJ for natural gas and \$0.117 for electricity (excluding carbon taxes).

The electric utility is a mix of nuclear, hydro-electric, natural gas, and renewables. In our scenario, the utility assessed externalities to be \$0.060/kWh comprised of both carbon and non-carbon externalities⁷, and set the CT at \$0.177/kWh. Tier 1 and Tier 2 prices for electricity were set at \$0.11/kWh and \$0.185/kWh (5% over the CT), respectively. The gas utility used \$100 per metric tonne CO_{2e} as the externality for carbon, and \$0.50 per GJ for non-carbon externalities.

⁷ One approach to Tier 2 pricing to reflect the social cost of carbon could be to include the prevailing cost of direct-air CO₂ capture and long-term storage (DAC) in the price. In principle, the utility could then invest part of Tier 2 payments in DAC projects.

The CT was set at \$15.9/GJ. Tier 1 and Tier 2 prices for natural gas were set at \$8.0/GJ and \$16.7/GJ (5% over the CT), respectively. An energy assessment was performed for both energy sources. EEMs were assessed assuming 5% interest. The results are provided in Table 1.

Table 1. Case Study: energy assessment results for 23-storey residential building (LCES $\leq$ CT for shaded cells, meaning these are EEMs which pass the B-C test)

	EEM	Electricity savings kWh/yr	Gas savings GJ/yr	Implementation Cost	LCES
Natural Gas, GJ	water system upgrades		150	\$47,710	\$25.5/GJ
	window retrofit		1,600	\$585,000	\$25.9/GJ
	chiller desuperheater hot water preheat		700	\$65,000	\$10.5/GJ
Electricity, kWh	in suite lighting	114,100		\$24,050	\$0.020/kWh
	upgrade building automation system (BAS) including garage CO control	58,100	90	\$32,500	\$0.054/kWh
	common area lighting	8,000		\$4,940	\$0.059/kWh
	VFD on booster pump	13,000		\$19,500	\$0.169/kWh
	VFD on cooling tower	11,400		\$18,750	\$0.186/kWh
	solar preheat hot water preheat	13,400		\$39,000	\$0.377/kWh
	fan coil motors	3,500		\$50,180	\$1.381/kWh
	Bundled electric EEMs ⁸	199,400	2,540	\$887,380	\$0.109/kWh

One EEM meets the CT threshold for natural gas, and five electric EEMs met the CT criterion for electricity. The customer would be provided the option to implement the CEES bundles for natural gas and electricity, or pay Tier 2 pricing for the foregone energy savings. Applying our scenario assumptions, implementing the CEES amounts to \$1,778 on-bill finance payment on utility monthly utility bills for 10 years (finance term chosen to be less than measure life), or pay for Tier 2 energy charge estimated to average \$3,813 monthly. The EEMs would then be reassessed during the next energy assessment cycle. The fixed customer charges would be increased to add \$738 per month⁹ to fund recurring energy assessments, which would be split between gas and electricity accounts.

5 Storey New Construction Residential Building

This case study is for a new construction design for a 5-storey multi-unit residential building located in western Canada in ASHRAE climate zone 5. The facility floor space is 16,000 ft². The facility is designed to be heated with natural gas. A new building energy modelling study was done to assess only natural gas energy savings. The baseline design was assessed for upgrades to reduce natural gas consumption. The marginal cost for natural gas was \$9.0/GJ (excluding carbon taxes). The gas utility used \$100 per metric tonne CO_{2e} as the externality for carbon, and \$0.50 per GJ for non-carbon externalities. The CT was set at \$14.6/GJ. Tier 1 and Tier 2 prices for natural gas were set at \$8.0/GJ and \$15.3/GJ (5% over the CT), respectively. The results of the model-based energy assessment are provided in Table 2.

⁸ Electric bundle includes EEMs meet cost threshold, adjusted for interactive effects. LCES amortized 10 years.

⁹ Assume \$0.25/ft² every 5 years for 177,000 ft².

Table 2. Case Study: Energy Assessment Results for Tenanted Commercial Building (LCES $\leq$ CT for shaded cells, meaning these are EEMs which pass the B-C test)

	EEM	Gas savings GJ/yr	Implementation Cost	LCES
Natural Gas, GJ	water system upgrades	16	\$1,600	\$13.8/GJ
	chiller desuperheater / preheat	120	\$8,500	\$12.6/GJ
	window retrofit	37	\$14,500	\$37.8/GJ
	Bundled EEMs	136	\$10,100	

Based on the CT for natural gas, two EEMs met the CT criterion. The customer would be provided the option to implement the CEES bundle for natural gas, or pay Tier 2 pricing for the foregone energy savings. Implementing the CEES amounts to \$95 on-bill finance payment every month on the natural gas bill for 12 years (finance term chosen to be less than measure life), or pay for Tier 2 energy charge estimated to average \$212 monthly and reassessed during the next energy assessment cycle. The fixed customer charges would be increased to add \$67 per month¹⁰ to fund recurring energy assessments. In this case study, the recurring energy assessment scope and frequency would likely be modified to reduce the ongoing cost of assessments.

9 Storey Multi-unit Residential Building

This case study is for a 56 year old, 9-storey multi-unit residential building located in eastern Canada in ASHRAE climate zone 6. The facility floor space is 54,000 ft² including 59 residential suites, parking garage, and common spaces. The facility is electrically heated with centralized domestic hot water. One gas meter and one electric meter serve the entire structure, and tenants do not directly pay for their own utilities. Baseline natural gas usage is 1,410 GJ/yr (13,400 therms/yr) and electricity is 888,000 kWh/yr. Utility marginal costs are \$12.2/GJ for natural gas and \$0.132 for electricity (excluding carbon taxes).

The electric utility is a mix of nuclear, hydro-electric, natural gas, and renewables. The utility assessed externalities to be \$0.060/kWh comprised of both carbon and non-carbon externalities, and set the CT at \$0.192/kWh. Tier 1 and Tier 2 prices for electricity were set at \$0.11/kWh and \$0.201/kWh (5% over the CT), respectively. The gas utility used \$100 per metric tonne CO_{2e} as the externality for carbon, and \$0.50 per GJ for non-carbon externalities. The CT was set at \$17.8/GJ. Tier 1 and Tier 2 prices for natural gas were set at \$9.0/GJ and \$18.7/GJ (5% over the CT), respectively. An energy assessment was performed for both energy sources. EEMs were assessed assuming 5% interest. The results are provided in Table 3.

Table 3. Case Study: Energy Assessment Results for Tenanted Commercial Building (LCES $\leq$ CT for shaded cells, meaning these are EEMs which pass the B-C test)

	EEM	Electricity savings kWh/yr	Gas savings GJ/yr	Implementation Cost	LCES
Natural Gas, GJ	window retrofit		400	\$51,519	\$12.4/GJ
	water system upgrades		120	\$19,800	\$13.2/GJ
	new domestic hot water heaters		170	\$52,500	\$34.8/GJ
	chiller desuperheater / preheat		280	\$196,794	\$91.0/GJ
	Bundled gas EEMs		520	\$71,319	

¹⁰ Assume \$0.25/ft² every 5 years for 16,000 ft².

Electricity, kWh	upgrade building automation system (BAS)	95,100		\$102,825	\$0.104/kWh
	programmable thermostats	36,600		\$21,000	\$0.074/kWh
	occupancy sensors heating	95,200		\$67,733	\$0.092/kWh
	common area lighting	3,600		\$4,548	\$0.122/kWh
	VFDs on makeup air units	1,200		\$13,800	\$1.297/kWh
	solar photovoltaic	12,200		\$60,000	\$0.474/kWh
	Bundled electric EEMs ¹¹	207,500		\$196,106	

Two natural gas EEMs and four electricity EEMs met the CT criteria. The customer would be provided the option to implement the CEES bundles for natural gas and electricity, or pay Tier 2 pricing for the foregone energy savings. Implementing the CEES amounts to \$2,886 on-bill finance payment every month on the utility bills for 10 years (finance term chosen to be less than measure life), or pay for Tier 2 energy charge estimated to average \$4,285 monthly, and reassessed during the next energy assessment cycle. The fixed customer charges would be increased to add \$224 per month¹² to fund recurring energy assessments, which would be split between gas and electricity accounts.

Accelerating and Scaling Up Energy Equity and Justice

Improving equity is now widely recognized as a centerpiece in DSM (Specian and Gold 2021). Energy justice is defined as “The goal of achieving equity in both the social and economic participation in the energy system, while also remediating social, economic, and health burdens on those disproportionately harmed by the energy system” (IEJ 2022). Evidence continues to accrue that unjust access to energy services and related environmental exposures are inequitable and warrant policies to correct current inequities, which are often linked to historical and current policies (Tong et al. 2021). However, the adoption of energy efficiency or climate-friendly policies does not necessarily ensure improvements in equity or energy justice. The design and implementation of policies intended to save energy and decarbonize systems can unintentionally exacerbate inequities if not carefully designed and implemented (Hall et al. 2021).

We suggest that our custom block rate design presents a policy instrument which potentially could improve energy justice and reduce energy burdens. While not assured or proven until such time as pilot tested and evaluated, we anticipate the following advantages:

- **Large scale customer engagement:** Subsidy programs intended to reduce inequity typically have limited uptake. For example, as a percentage of eligible customers, low-income programs in Canada have achieved uptake of less than 3% for self-install programs, 0.7%-1% for minor direct installs, and 1%-2% for direct major installs (Kantamneni and Haly 2022). Under the custom block rate design, there would be a mandatory “touch point” with 100% of utility customers (including low-income). Even for the residential customers who choose to opt-out of the site visit, the instrument still involves customer contact which presents an engagement opportunity. Customers experiencing low levels of energy justice are less likely engaged (e.g. perhaps because they are more likely tenants and not owners), so scaling up engagement could reasonably be expected to reduce energy burdens and alleviate injustices.

¹¹ Electric bundle includes EEMs meet cost threshold, adjusted for interactive effects. LCES amortized 10 years.

¹² Assume \$0.25/ft² every 5 years for 54,000 ft².

- **Facility-specific needs identified to overcome heterogeneity:** Customers with high energy burdens are known to have unique circumstances (e.g. poor facility quality to enable efficient equipment upgrades). Because essentially every facility would undergo an energy assessment, energy utilities would be able to offer the most cost-effective upgrades. Identifying and funding facility-specific EEMs is the most effective way of working with the heterogeneity of customer and facility needs. One of the ways that utilities can maximize the benefits of limited subsidy funds would be to preferentially offer subsidies to customers assessed to be subject to energy injustice, using the information obtained from facility-specific assessments.
- **Better service at reduced costs for low-income and vulnerable customers:** In our framework, customers who qualify for subsidies based on income or other vulnerability metrics would: a) have the cost of energy assessments subsidized, b) pay the cost of service for Tier 1 energy, c) receive subsidies for some or all EEMs passing screening criteria and B-C tests (see Figure 1, element #10) hence eliminating Tier 2 charges, and d) benefit from EEMs implemented through the proposed split incentive mechanism (see Figure 2). While the custom block rate design provides a rate structure, it does not dictate the magnitude of prices. In practice the magnitude of the rate design components (i.e. fixed charges, Tier 1 structure or rate, Tier 2 rate) would be established by each utility following jurisdiction-specific practices (Lazar et al. 2020). However, it is reasonable to expect that customers currently classified as low-income or otherwise experiencing energy injustice would generally realize increased quantity and quality of energy services at overall lower cost compared to current circumstances.

Discussion

There are a myriad of issues to consider in rate design which are beyond the scope of this paper, and which could be topics for further research. Here we list some of these key issues:

- **Contingency fund:** we envision that the proposed rate design would include contingency funding (essentially an insurance fund) to cover cost overruns and corrective actions (i.e. forensic analysis and re-optimization of EEMs). Contingency funds could also be disbursed to compensate customers for EEMs (or EEM bundles¹³) which underperform as determined by EM&V¹⁴. We highlight though that an effective rate design which routinely applies a conservative approach¹⁵ in estimating energy savings and is careful to apply accuracy requirements for technical performance and costs, then the vast majority of EEMs should overperform in delivering energy savings. Under these conditions, the inevitable underperforming EEM would be easier to manage.
- **Subsidies for energy efficiency:** while the basic custom block rate design framework could eliminate subsidies (and thus eliminate free ridership, at least theoretically), we assume that subsidies to qualified customers in all sectors would continue to be offered, based on income and other equity metrics. This is illustrated in Figure 1 (element #10) which includes explicit consideration of subsidies in the finance and install phase of the process.

¹³ Clear and consistent rules for allowing EEM bundles (or not) would be critical.

¹⁴ It is not necessarily the case that 100% of customer costs be reimbursed. One approach could be to reimburse customers to reduce their costs to the limit where the B-C test = 1.0 for an underperforming EEM or bundle of EEMs.

¹⁵ See IPMVP (2022) for the definition of “conservative.”

- Fuel switching: decarbonization actions such as electrification or change to low-carbon fuels are widely advocated as a necessary strategy to achieve climate goals. As noted in the Introduction, we envision this rate design could include all DERs, including fuel switching.
- Temporal and spatial patterns of energy consumption and savings: utilities could include an assessment of the temporal and spatial patterns of consumption and savings in the energy assessments. EEMs could be differentially valued based on a) measure temporal load shape (Frick and Schwartz 2019), or b) location under a “geo-targeting” strategy (Frick et al. 2021).
- Time-variant pricing schemes: time of use and other dynamic pricing strategies for electricity are adopted or targeted for adoption in many jurisdictions (Dutta and Mitra 2017). We highlight that with our rate design, time-variant pricing models could be used for Tier 1.

We emphasize that custom block rate design offers a vision for scaling up and accelerating energy efficiency and decarbonization. The potential scale can be illustrated by considering the U.S. where there are over 120 million residential electricity customers, and that a large fraction of these customers also have natural gas (and some district energy) accounts. Current estimates are that roughly 2% of U.S. households are audited each year, and it would take roughly 500 years to complete whole home retrofits at current rates (Nadel and Hinge 2020). If 120 million customers were to undergo recurring energy assessments every 5 years on average, this would mean 24 million residential energy assessments¹⁶ annually, with provisions that any EEMs passing B-C tests be implemented with guaranteed on-bill financing (or that Tier 2 pricing applies).

Finally, we want to emphasize that the custom block rate design presents potential risks and challenges. We have discussed some of the key risks throughout this paper. Underperforming EEMs are one of the key risks, which we emphasize can be minimized through careful and clear screening criteria for EEMs, due diligence reviews, robust EM&V, and creation of a contingency fund. Worsening or allowing present inequities to persist is a potential risk with any rate design. As we have discussed, we argue that equity can be improved through large-scale customer engagement, integration of subsidies to customers, and eliminating split incentives. The challenge of achieving regulatory change is another risk we have discussed in the context of split incentives. As we discuss, it is important to recognize the downside of not adopting worthwhile regulatory change is that current risks – especially climate change and inequities – can be expected to persist.

Conclusions

Current rate designs and related policies do not provide adequate incentives for customers to implement cost effective EEMs at the rate or scale necessary to achieve decarbonization policy goals. We conclude that our rate design offers reason for optimism that energy utilities can more economically and systematically identify and eliminate the energy efficiency gap on an ongoing basis to improve energy services and make the essential contributions to achieve net-zero and negative carbon emissions targets while improving equity. At the same time, we realize that no policies are guaranteed to be effective. A careful, phased approach carried out by experienced professionals will be needed to make any new energy rate design successful. Our key conclusion is that this rate design is worthy of further research and development including feedback via customer and utility staff engagement, refinement via relevant focus groups, and pilot testing in one or more utility customer segments.

¹⁶ It is emphasized that facility-specific assessments could, and arguably should, include decarbonization such as the technologies and costs for measures to achieve net-zero for Scope 1 and Scope 2 GHG emissions.

References

- ASHRAE (Association of Heating, Refrigeration, and Air Conditioning Engineers). 2011. *Procedures for Commercial Building Energy Audits*.
- Bird S. and Hernandez D. 2012 “Policy options for the split incentive: Increasing energy efficiency for low-income renters” *Energy Policy* 48: 506-514.
- Borenstein S. and Davis L. 2012. “The Equity and Efficiency of Two-Part Tariffs in U.S. Natural Gas Markets” *The Journal of Law & Economics* 55(1):75-128.
- California Public Utility Commission (CPUC) 2020. “Energy Efficiency Policy Manual” Version 6. cpuc.ca.gov
- Dutta G. and Mitra K. 2017. “A literature review of dynamic pricing of electricity.” *Journal of the Operational Research Society*. 68:1131-1145.
- Global Commission for Urgent Action on Energy Efficiency 2020. “Recommendations of the Global Commission” International Energy Agency. iea.org/reports/recommendations-of-the-global-commission-for-urgent-action-on-energy-efficiency
- Graff M. and Carley S. 2020. “COVID-19 assistance needs to target energy insecurity” *Nature Energy* 5:352-354.
- Hall S., Anable J., Hardy J., Workman M., Mazur C., and Matthews Y. 2021 “Innovative energy business models appeal to specific consumer groups but may exacerbate existing inequalities for the disengaged” *Nature Energy* 6:337.
- IEA 2021 “Industry direct CO₂ emissions in the Net Zero and Announced Pledges scenarios, 2000-2030” International Energy Agency iea.org/data-and-statistics/charts/industry-direct-co2-emissions-in-the-net-zero-and-announced-pledges-scenarios-2000-2030
- IEJ (Initiative for Energy Justice) 2022. <https://iejusa.org/section-1-defining-energy-justice/> Accessed March 14, 2022.
- IPMVP (International Performance Measurement and Verification Protocol) 2020. Core Concepts. EVO 1000 – 1:2022.
- Kammen D., Matlock T., Pastor M., Pellow D., Ramanathan V., Steyer T., Stokes L., and Ventura F. 2021 “Accelerating the timeline for climate action in California” UC Berkeley Previously Published Works <https://escholarship.org/uc/item/0hv777t0>
- Kantamneni A. and Haley B. 2022. “Efficiency for all: review of provincial/territorial low-income energy efficiency programs with lessons for federal policy in Canada.” Efficiency Canada.
- Larson E., Greig C., Jenkins J., Mayfield E., Pascale A., Zhang C., Drossman J., Williams R., Pacala S., Socolow R., Baik EJ, Birdsey R., Duke R., Jones R., Haley B., Leslie E., Paustian K., and Swan A. 2020 “Net-Zero America: Potential Pathways, Infrastructure, and Impacts, interim report” Princeton University. December 15, 2020.
- Lazar J., Chernick P., and Marcus W. (LeBel M. editor) 2020. “Electric cost allocation for a new era – a manual” Regulatory Assistance Project. raponline.org

- Mazzi E., Tiedemann K., Thollander P., and Sulyma I. 2020. “Minimum barrier utility billing rate design for scaling up energy savings in facilities” ACEEE Proceedings of 2020 Summer Study on Energy Efficiency in Buildings.
- Mims N. and Schwartz L. 2019. “Time-sensitive value of efficiency: use cases in electricity sector planning and programs.” Lawrence Berkeley National Laboratory.
- Mims N., Price S., Schwartz L., Hanus N. and Shapiro B. 2021. “Locational value of distributed energy resources.” Lawrence Berkeley National Laboratory.
- Nadel S. and Hinge A. 2020 “Mandatory building performance standards: a key policy for achieving climate goals” ACEEE white paper. [aceee.org](https://www.aceee.org)
- National Efficiency Screening Project (NESP) 2017. “National Standard Practice Manual for Assessing Cost-Effectiveness of Energy Efficiency Resources” nationalenergyscreeningproject.org
- National Efficiency Screening Project (NESP) 2020. “National Standard Practice Manual for Benefit-Cost Analysis of Distributed Energy Resources” nationalenergyscreeningproject.org
- National Academies of Sciences (NAS), Engineering, and Medicine. 2021. “Accelerating Decarbonization of the U.S. Energy System” Washington, DC: The National Academies
- NYSERDA 2021 “Remote Energy Audit Resources for Contractors and Energy Auditors” nyserdera.ny.gov/All-Programs/Become-a-Contractor/Home-Performance-With-ENERGY-STAR/Remote-Audit-Providers accessed March 24, 2022. New York State Energy Research and Development Authority.
- PNNL (Pacific Northwest National Laboratory). 2011. “A Guide to Energy Audits” Commercial Building Initiative PNNL-20956.
- Shaffer B. 2020 “Misunderstanding Nonlinear Prices: Evidence from a Natural Experiment on Residential Electricity Demand” *American Economic Journal* 12 (3): 433-461.
- Sorrell S, Schleich J, Scott S, O’Malley E, Trace F, Boede E, Ostertag K, Radgen P (2000) “Reducing barriers to energy efficiency in public and private organizations.” Science and Technology Policy Research report.
- Specian, M., and Gold R. 2021. “The Need for Climate-Forward Efficiency: Early Experience and Principles for Evolution.” Washington, DC: American Council for an Energy-Efficient Economy. [aceee.org/research-report/u2106](https://www.aceee.org/research-report/u2106).
- Thaler R., Sunstein C., and Balz J., 2013 “Choice Architecture” chapter 25 in *The Behavioral Foundations of Public Policy*. Princeton University Press.
- Tong K., Ramaswami A., Xu C., Feiock R., Schmitz P., and Ohlsen M. 2021 “Measuring social equity in urban energy use and interventions using fine-scale data” *Proceedings National Academies of Science* 118 (24).