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Customer-Side Energy Management: What Role Should Utilities Play?

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Abstract

Decarbonization of the electricity grid implies more variable and intermittent solar and wind generation. Intermittency response is the strongest motivation for customer-side energy management (CSEM)—that is, technology that allows a third party to monitor electricity availability and adjusts use to balance supply and demand. The question is the role of utilities in providing CSEM. Antitrust and regulatory policy have reflected a principle that regulated businesses' participation in unregulated markets creates opportunities to exploit market power. Tactics include excessive transfer pricing of unregulated inputs, cross-subsidization of unregulated services, and discrimination against unaffiliated rivals in obtaining the regulated service. Risks of utilities' involvement in CSEM can probably be mitigated through vigilance and safeguards. Moreover, a utility may be well placed to undertake CSEM because of its supply and consumer use. In addition, adverse selection may inhibit a direct-to consumer CSEM market from developing. A likely outcome is that the utility procures CSEM technology from a competitive market and provides CSEM directly.

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1. Introduction

1.1. Context

As interest grows in mitigating the harms of climate change by reducing fossil fuel emissions (Krosnick and MacInnis 2020) to decarbonize the economy, electricity provided by non-emitting renewable generators, particularly those powered by solar and wind energy, has gained importance. The transition to clean energy involves substituting renewable generation not just for generation from fossil fuels, particularly coal and natural gas, but also for direct uses of electricity. Lighting, air-conditioning, home heating, and hot water heating are examples, but the most consequential may be substituting electric vehicles (EVs) for gasoline-powered automobiles.

Increasing the use of renewable electricity, as a replacement for fossil fuel generation and an energy source for transportation and other uses that, up to now, have largely been powered by fossil fuels, requires integrating renewables into the overall electricity delivery system. This integration presents significant challenges. From an engineering perspective, the most significant challenge is that solar- and wind-produced power is intermittent—clouds may momentarily obscure the sun, and the wind may slow or stop.[1] However, electricity use is relatively constant as refrigerators, air-conditioners, lights, and computers keep operating.

Continuously matching the supply of electricity with nonintermittent demand requires some intervention. Currently, the main method for achieving balance is the use of natural gas–fired generators, whose output can be varied with sufficient speed to counter the variability in output from wind or solar generators. Energy storage is a second approach to supporting the integration of renewables. Although electricity can be stored in several ways, potential growth in this area involves batteries, both large-scale batteries in the grid and customers' "behind the meter" batteries, perhaps those in EVs or other batteries that store power from solar panels or as backup to cover short-term outages.

A third method is the adoption of controls that would vary electricity consumption to match variations in renewable output (Brear et al. 2020). Such controls might, for example, reduce electricity use for refrigeration, air-conditioning, space and water heating, and EV charging on a minute-by-minute basis to match solar and wind energy supply. Ideally, users may not notice these differences because, for example, the refrigerator will maintain a relatively constant temperature. However, even if the differences are noticeable, users might be compensated by the savings from avoiding

[1] To some degree, variation may be limited within renewable generation if power can be transmitted from locations where there are some times when it is cloudy in one location and sunny in the other, or if the wind is strong in one while still in the other (Van Horn et al. 2020). Absent perfect negative correlation, however, residual mismatches will still require interventions to ensure that supply and demand remain in balance.

the need for standby natural gas generators—and the costs of their carbon emissions—or batteries.

A second challenge in the integration of renewable electricity is improving the ability of users to take advantage of it when it is generally available. When the wind is blowing or the sun is shining, the cost of generating an additional kilowatt-hour (kWh) is essentially zero. If demand is also low during those times relative to supply, for example, wind blowing at night or solar power on sunny afternoons when home air conditioners are not being used, electricity from renewables may be plentiful. To the extent that electricity use can be shifted to these times, such that EVs are charged during hours of high renewable generation rather than when renewable power is less plentiful, demand for electricity from non-emitting renewable sources will be encouraged.

Both matching intermittency and shifting demand to times when renewables are plentiful requires some degree of management of electricity use. In principle, this could be accomplished through pricing that signals to buyers to increase electricity use when it is relatively plentiful and curtail use when it is relatively scarce.[2] However, for reasons discussed in more detail below, buyers may not be aware of prices or have the ability to alter use in response to changes in price.

This presents an opportunity for intermediaries that can provide the service of monitoring electricity availability and adjusting use, perhaps even moment-by-moment. If customers can thereby reduce their utility bills, they might pay these intermediaries; if the intermediaries take on the role of purchasing electricity and can do so at a lower cost than customers could do on their own, they might pay customers. In either case, these intermediaries could capture the savings realized from better integration of renewable generation.

I label here this possibility “customer-side energy management,” CSEM for short. One can think of CSEM as having two components: the communication and switching technology the enables control of electricity use at the point of use, and the actual active or automated application of that technology to manage electricity use. A single firm could provide either or both. The potential gains from CSEM have already attracted entrepreneurs.[3] Specifics on how CSEM might be designed, implemented, and marketed is largely outside the scope of this paper.[4] My focus is on the role of

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[2] Such pricing should also include an estimate of the cost of the greenhouse gas externalities associated with fossil fuel–powered generation.

[3] The Brattle Group Load Flexibility Symposium on October 20–21, 2020, included presentations from Siemens, Oracle, Uplight, Voltus, Arcadia, and Temix. There are many others as well.

[4] One such possibility is “energy as a service,” or EaaS, in which an intermediary both purchases electricity and provides CSEM, and the customer pays the EaaS provider for the services provided in part by the air-conditioners, water heaters, refrigerators, and other equipment that the EaaS provider controls and perhaps supplies (Cleary and Palmer 2019). A variant on this is a subscription service, where the customer pays the CSEM intermediary a fixed fee for energy services and the CSEM provider ensures that the customer’s energy use

distribution utilities—referred to throughout as utilities here—as CSEM providers. Specifically, my question is whether utilities should have a role.

This may be a surprising question. After all, utilities have a great deal of expertise to bring to bear on CSEM provision. More fundamentally, excluding them would exclude a competitor from the market, which in principle ought not be a good thing.

However, two kinds of arguments may give some pause to allowing utilities to provide CSEM. One is the relatively generic concern that when dominant firms in one market enter a second market, a situation known as vertical integration, competition in that second market may fall. Vertical integration has generically not been viewed as harmful. To perhaps oversimplify, vertical integration is largely about how firms decide to organize, whereas competition is largely about how many firms offer alternatives within a market—which vertical integration does not necessarily affect. In recent years many have raised concerns (Baker et al. 2019), and antitrust authorities have clarified when they might find that a vertical merger warrants scrutiny (DOJ and FTC 2020).[5]

That generic possibility does not motivate this discussion.[6] Rather, the concern arises because the prices that utilities can charge for electricity delivery, and sometimes electricity sales, are regulated. The concerns with the entry of regulated firms into related competitive markets are discussed below, but it is worth noting at the outset that they are neither new nor unprecedented in the electricity sector. These concerns, particularly potential discrimination in access to transmission, led federal regulations to insulate the control of regulated transmission from competing generation companies.[7] Similar concerns can apply to distribution utilities providing competitive retail services, such as solar panel installation (Brennan 2014). Regarding distribution, more in the control of states, New York, for example, has limited the role of distribution companies to facilitating, rather than imposing, programs to promote demand management and carbon emissions reduction.[8]

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stays below the subscribed amount (Cleary and Palmer 2020); in one possible arrangement, the customer might sell back unused electricity or purchase electricity beyond the subscribed amount. I do not address the specific pricing and business models for CSEM service; my focus is on the potential role of utilities in providing CSEM.

[5] The settings include foreclosure of rivals in one market from access to inputs, using its business in one market to obtain "competitively sensitive" information about its rivals in the other market, and facilitating collusion among competitors.

[6] For a recent assessment of how the burden of proof that a vertical merger is harmful should be greater than when one has a merger of competitors (a horizontal merger), see Brennan (2020).

[7] Federal Energy Regulatory Commission, Promoting Wholesale Competition through Open Access Non-discriminatory Transmission Services by Public Utilities; Recovery of Stranded Costs by Public Utilities and Transmitting Utilities, Order No. 888 (April 24, 1996); Federal Energy Regulatory Commission, Regional Transmission Organizations, Order No. 2000 (December 20, 1999) (Brennan et al. 2002).

[8] The New York State Planning Board, in Volume I of its 2015 "The Energy to Lead" report on implementing the state's Reforming the Energy Vision agenda, wrote, "On February 26, 2015, the PSC adopted a regulatory policy framework that will guide a transition for the utilities to

The story may not be negative. Concerns regarding regulated firms in competitive markets may be mitigated when it comes to utilities' provision of CSEM. Because they control distribution operation and know their customers' use patterns, utilities may be able to offer some aspects of CSEM more efficiently than other enterprises.[9] A perhaps important and generally neglected possibility is that potential CSEM providers may find it difficult to attract buyers. This may arise not only because of buyers' reluctance to deal with anyone other than the utility (Brennan 2007) but also because of adverse selection. A CSEM market directed at households might fail to develop because of an inability to convince customers that advertised savings on electricity will be realized.

Those considerations make it difficult to recommend or predict with confidence a CSEM pathway. One possibility is something of a hybrid. To facilitate decarbonization EV chargers, water heaters, and the like perhaps could entail, through regulation or subsidy, a standard CSEM technology that would enable a distribution utility to control their use in response to electricity price and availability. I suggest this scenario at the outset to indicate that a simple answer to this question is not likely.

The rest of this paper proceeds as follows. Section 2 provides a very brief description of the components of CSEM service, and what CSEM does not include in this paper, namely third-party control of distributed generation. To get a sense of where growth in renewables creates greater scope for CSEM, Section 3 discusses the various margins in the electricity sector where, in theory, prices could balance electricity production and use, and identifies which of those margins are most salient here. Section 4 is a reminder that although prices in theory can lead to efficient allocations, using them can be too costly, and alternatives can be (and are) employed instead—rationalizing CSEM and not just letting prices take care of it.

In Section 5, I turn to the concerns raised by utility provision of CSEM, starting from the general potential harms when regulated firms operate in unregulated markets. This assessment includes potential means for mitigating those concerns. Section 6 looks at potential benefits of utilities' involvement in the different components of the CSEM sector outlined in Section 2, especially control of electricity use through CSEM technologies. This section also includes a discussion of the adverse selection problem as a further reason why utilities may play a significant role in the adoption and

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play a new role as a distributed system platform (DSP) provider. Rather than choosing solutions and deploying them in a top-down approach, utilities will act as a market platform that enables third parties and customers to be active partners in building a cleaner, more affordable, and resilient energy system. Utilities will provide data, price signals, and system access to enable third parties to innovate and scale clean energy solutions where they can most benefit the system and customers." **https://energyplan.ny.gov/-/media/nysenergyplan/2015-state-energy-plan-pf.pdf**.

[9] Even going back to 2012, utilities' involvement in some form of CSEM was extensive. ABI Research, *Utility-Provided Home Energy Management Systems* (2012), **https://www.abiresearch.com/market-research/product/1009921-utility-provided-home-energy-management-se/**.

utilization of energy management, even if it is not marketed as a “service” to residents. Section 7 summarizes and offers some policy suggestions.

1.2. Caveats and Assumptions

Before I proceed, three caveats may be in order.

First, I begin with the assumption that many if not most residential customers are uninterested in active management of their electricity use. Although the prospect fascinates people interested in electricity provision and policy, it strikes me as unlikely, especially in a world where the only interaction between residential customers and their electricity provider is monthly payment of an online bill. For those with automatic bill payment, even that minimal interaction becomes essentially none. The market for CSEM is driven by giving customers the ability to manage their electricity use in an automated way that does not require ongoing examination of how much electricity is being used when and for what.

A second caveat is that zero or very low prices for electricity are not a problem per se. Where renewable resources are plentiful, particularly where solar power is widely produced at the customer’s location, the price of electricity can be zero, since the marginal cost of producing electricity from wind turbines and solar panels is negligible. That can be a good thing, justifying CSEM as a way to help customers use electricity when it is essentially free and avoid use when it is expensive. Some observe that frequent electricity prices of zero will deter new investment in renewables (or any other generation), but that is how markets are supposed to work. The market failure in inducing additional construction of renewable generation is not low prices as such, but that in the absence of a price of carbon, electricity prices are too low when fossil fuel plants are used, thus limiting the revenues renewable generators could get at those times and thus the return to new investment. Carbon pricing, however, is not the subject of this paper.[10]

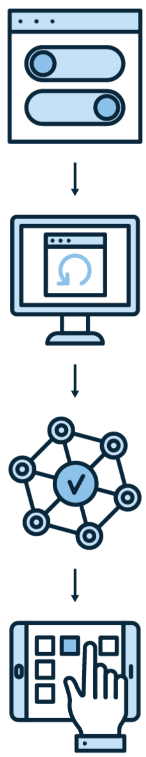
Third, the analysis of CSEM’s effect on consumer demand focuses directly on the use of electricity and the extent to which the benefits of that use match up to the cost of electricity provision. I will not treat a reduction in use as a form of supply based on use below some baseline: a diet is not a source of food. Getting customers to base electricity use at any given time on the cost of generating it at that time is, from an economic efficiency perspective, the end in itself. It does not clarify matters to treat negative demand as positive supply.

[10] Because of sunk capital costs, fossil fuel generators may still find it profitable to continue to operate at low prices that cover only variable costs. This also makes it hard to displace them and achieve full or nearly full decarbonization.

2. Customer-Side Energy Management Components

To assess the role utilities might play in CSEM, it may be worthwhile to briefly consider the four components of that service.

Figure 1. Components of CSEM



Device Manager: Equipment at the device allows remote switching to turn a device on and off or vary the amount of electricity it consumes

Management Software: Software enables device to respond to remote signals

Communication: Internet or proprietary communications network relays signals between device, software, and controls

Controls: Customer, utility, or other entity controls the device, perhaps in response to real-time electricity prices

The first is equipment at the device—water heater, EV charger—that permits remote switching of the equipment. This switching may be on-off, or it may vary how much electricity the device uses. The equipment may be external to the device itself, as a dimmer switch is to a ceiling light, or it may be built into the device itself. If the latter, the utility company's provision of the equipment would entail selling the water heater or EV charger—if not the vehicle itself—not just the remote switching device.

The second component is the software that enables the device to respond to signals to turn on, off, up, or down to save the customer money or help balance electricity supply and demand. This is likely to be bundled with the switching equipment, but it need not be. One could imagine having multiple apps with different interfaces and methods to allow the customer to tailor the response of the device to those signals.

Third is communication between the producer of these signals and the software, and between the software and the control equipment at the device. This would likely be provided by existing mobile and wireline communications companies using common Internet protocols. The touted “Internet of Things” envisions this sort of communication, with the remote use of apps to control how the device responds to signals. However, one can envision a communications system that, for cybersecurity reasons, uses proprietary protocols standing apart from the Internet.

Last is sending out the control signals. One possibility is that the customer controls the devices, perhaps in response to real-time information on prices. At the other end of the spectrum, the utility might do the controlling. The controlling utility could be the distribution utility, the focus here, but one could imagine that it could also be a regional transmission operator (RTO), using its information on wholesale prices and variation in output from renewable generation to use this control of customer equipment to balance the grid. In the middle, the distribution utility or RTO could send price signals to a third party—for example, an unregulated retailer—that does the controlling, perhaps with input from the consumer via the app.

It is beyond the scope of this paper to assess particular business models, other than in the context of assessing the potential benefits and costs of utility involvement. It is important to reemphasize here that distributed generation and, more broadly, electricity supply are not the subject of this paper. The focus is only on adjusting electricity demand, not on signaling the provision of electricity supply, e.g., using customer-side storage or generation to provide electricity or ancillary services, such as load balancing or voltage control. The overall thrust of the analysis is likely to apply qualitatively to customer production of energy, but that raises issues of integrating distributed energy sources into a two-way distribution grid, setting prices to pay for such electricity and ancillary services, and the legal determination of whether distributed energy production falls under state or federal jurisdiction—all important questions, to be sure.[11]

[11] The Federal Energy Regulatory Commission recently ordered regional transmission organizations to remove barriers to the participation of aggregated distributed generation resources in the wholesale energy, capacity, and ancillary services markets that the RTOs manage. Federal Energy Regulatory Commission, *Participation of Distributed Energy Resource Aggregations in Markets Operated by Regional Transmission Organizations and Independent System Operators*, Docket No. RM18-9-000, Order No. 2222 (September 17, 2020).

3. Relevant Pricing Margins

If the policy target is economic efficiency, then in principle, price should equal marginal cost. If so, and buyers can see and react effectively to prices—more on that in the next section—the good or service is used just up to the point where its value to the buyer exceeds its cost of production. One of the complications of electricity is that (at least) four margins are present that should affect customers' choices regarding their electricity use.

First and perhaps most familiar is that the cost of producing electricity can vary as demand varies over the course of a year. Because electricity has to be generated to meet that demand, generation used only during high demand periods will be expensive, since it has to cover its cost over a limited amount of time. Where demand peaks in only a small fraction of hours of the year, those prices may be as much as a hundred times the price when demand is at normal levels. This is the rationale for having buyers face real-time prices, especially at those critical peak-demand periods (Crew and Kleindorfer 1986; Brennan 2004).

A second and less recognized possibility is that the capacities of a distribution grid's substations, transformers, and other facilities have to be sized to carry the highest amount of electricity demanded along different paths in that grid. When a portion of the distribution system experiences high demand, more distribution capacity in some form must be added, raising the incremental cost of that electricity. This can justify demand charges—prices per kilowatt based on that highest amount (Faruqui and Bourbonnais 2020). In principle, like location-based nodal transmission charges (Hogan 1992), these demand charges will vary by time and place. Notably, the time of peak demand in a particular part of the transmission grid may differ from the time of peak demand over an entire wholesale power market, which is what would determine real-time and critical peak prices mentioned above.

Those two margins, peak generation and distribution capacity, were recognized long before renewables came to play such a large role in the electricity sector, whether brought about by prices or decarbonization policy. Although decarbonization may affect them qualitatively—particularly stresses on the distribution grid from widespread EV charging and use of electricity instead of natural gas to heat homes—they are not the margins that renewable growth has affected the most. Our focus here is on the third and fourth margins.

The third margin involves systematic variation in the output from renewable generation at different times of the day. This variation in *supply* differs from variation in *demand*, particularly during critical hours, that has motivated real-time pricing or variants such as critical peak or seasonal pricing. Distributed solar generation amplifies the price effects of this systematic variation, the leading example being the

California “duck curve” showing electricity prices near or at zero during sunny afternoons (Denholm et al. 2015).

The fourth margin involves momentary variation in output from wind- and solar-powered generators. The wind may die down and then come back up, or the sun may go behind a cloud, even as demand remains largely constant. This has typically required maintaining capacity of dispatchable and quickly variable generation—fueled by natural gas—to make up for the difference. Of increasing relevance is battery storage; this could include customer-side storage in EVs.

Another way to keep the system in balance, and the focus here, would be to match these momentary variations in supply by varying demand. In principle, one could reduce or stop charging EVs or heating hot water when renewable supply is unavailable and resume use when the sun comes back out or the wind picks up. One could adjust air-conditioning or refrigeration to respond to renewable output variation as well.

Those margins—predictable within-day changes and momentary variations in supply—are primary motivations for CSEM as a complement to renewable generation: it could help customers adapt their electricity use to the variations. For within-day changes, customers can save money by shifting electricity use to times of the day when the supply is plentiful. For momentary variations, CSEM could help avoid the need for backup natural gas generation—and the carbon emissions that come with it—or storage. Both options create potential profit opportunities for CSEM providers.

Table 1 summarizes these pricing margins.

Table 1. Pricing Margins

Margin	Price	Renewables relevance
Peak generation	Real-time pricing	Not novel, may mitigate or exacerbate
Distribution capacity	Demand charges	Not novel; demand-side generation or storage may mitigate
Intraday variation	Time of day pricing	Moderate relevance; day vs. night, wind patterns
Intermittent supply	Moment-by-moment pricing	High, as output varies with sudden changes in wind speed, cloud cover

The threshold question in looking at CSEM is why automated control may be necessary. In principle, customers could adjust demand by responding to variations in electricity prices associated with these variations in renewable supply. To understand the potential advantage of CSEM over price signals, a reminder of broad economic arguments on the limits of markets may be useful.

4. Bypassing Markets, in General and in Electricity

A general response of economists to an allocation problem, almost a caricature, is to say that prices can and should do all the work. To promote use of renewables for decarbonization, a combination of an appropriate price of carbon and prices along all the margins described in the previous section should suffice. Electricity producers and users would then adjust outputs and purchases in response to those prices until supply and demand come into balance.

The process in reality does not always follow the textbooks. The theory presumes that the costs of using the prices and markets are negligible. This will not always be the case. Buyers have to be able to determine prices, verify sales claims, monitor performance, ascertain breaches of contract, and obtain remedies. Sellers are in a similar position. If those transaction-related costs are large enough, the price system alone may not be the best mechanism for determining supplies and purchases.

In light of all of the attention given to the inadequacy of pricing in electricity markets, particularly the absence of real-time retail rates that reflect wholesale costs, inadequacy of relying on pricing may seem a radical idea. However, two enormous aspects of the economy reflect means of allocation that do not depend on market prices: one is administrative allocation within firms; the second is determining payments when someone is found liable for nuisances, accidents, or breaches of contract by common law courts.

Economists' appreciation of the need for these alternative institutions for resource allocation, as a response to the high costs of using markets, is due to Ronald Coase. Coase (1937), followed most notably by Williamson (1983), explained the boundaries of firms in terms of the relative benefits and costs of using markets, in that when costs are high, one will see allocations done inside the firm through vertical integration, labor promotion and reassignment, and the like. Coase (1960) applied the idea of high "transaction costs" to explain the use of common law to promote efficient outcomes by having courts respond to the high costs of defining property rights, inducing optimal levels of care, and specifying and determining compliance with contingencies in contracts.

Although Coase's insights show the limits of prices, a novel aspect here is that the high costs of using the price system are borne in large measure by final customers rather than, say, a firm deciding whether to hire permanent employees or acquire workers as needed in a temporary market. In Coase's terms, my skepticism regarding "customer engagement" in electricity use is an assertion that transaction costs are high enough to at least raise the possibility that customers' response to price signals may be inferior to other methods.

This is where CSEM, broadly, comes in. Abstractly, it allows customers to avoid having to make choices based on market prices and instead delegate that responsibility to someone who will administer their choices for them. This delegation is not total; for example, customers may want to override air-conditioner controls (or have their thermal comfort preferences built into any controlling algorithm) or continue charging their EVs if they need a full charge at a particular time.

CSEM relieves customers of having to base electricity use decisions on prices, but it is not devoid of prices—or at least not necessarily so. To the extent that CSEM is marketed to customers, either it will be offered at a long-term price for the benefit of expected reductions in bills, or CSEM providers will pay customers for the benefits of avoided costs from alternative means of balancing loads, such as fossil fuel generators or batteries. The CSEM providers, in turn, may base their algorithms on pricing information, either current or perhaps day-ahead wholesale prices.

On the other hand, if customers' involvement is sufficiently costly but the benefits of managing electricity use sufficiently great, CSEM may be marketed directly to the generator, wholesale market manager, utility, or retailer rather than the final user. An analogy might be "smart meters" that enable time-based pricing, by recording use at any given time, and direct communication between the customer and utility of outages. If CSEM is adopted by a regulated utility, the state public utility commission will judge whether it is a prudent expense. If CSEM is purchased by a generator or retailer competing with others, its benefits will show up as a price, reliability, or "green power" advantage in attracting customers.

A Coasian transaction costs view of the rationale for CSEM underscores an important difference between our two main rationales, systematic time-of-day price differences and intermittency in renewable power supply. For systematic time-of-day price differences, customers are likely to have access to price information in advance, through either established (and perhaps seasonally adjusted) time-of-use rates or, where real-time pricing is implemented, pass-through of day-ahead wholesale rates. With this notice, customers may be able to adjust their use in response to prices without the need for CSEM. They may choose a relatively simple CSEM solution if that level of attention to prices is sufficiently costly.

The intermittent supply context is radically different. Instead of predictable systematic price variation throughout the day, prices vary minute by minute with the supply from renewables. Whether prices could be set by suppliers and reacted to by customers is far from clear.[12] In one sector with very rapid price formation—Internet advertising—automation is required because prices vary far faster than humans can react (McAfee 2011). The automation equivalent here would be CSEM on the buyer

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[12] Leslie et al. (2020) have a more optimistic view on the role of prices. It may be possible to design an automated instantaneous auction market akin to McAfee (2011) for when intermittent supply is fixed temporarily at a low level because of variation in weather conditions.

side that in effect automates demand as a function of price, perhaps integrated with a similar supply bidding mechanism on the renewable generation side of the market.

For that reason, the ensuing assessment of the role of utilities and potential policy responses will focus on the intermittency context. This is where price formation is most problematic and hence where CSEM is likely to be most consequential for renewables integration and, consequently, decarbonization.

5. Regulated Firms in Competitive Markets: Utilities and CSEM

5.1. Precedents

Before getting to specifics, recall that concerns about utilities in regulated markets disrupting competition in unregulated markets are neither new nor purely theoretical. A precedent was *Otter Tail Power Co. v. United States*,[13] in which the Supreme Court ruled in 1973 that Otter Tail's refusal to deliver electricity to municipal power companies was an anticompetitive effort to eliminate municipal power providers as retail competitors (and that Federal Power Act jurisdiction did not preclude antitrust liability). This decision was closely followed in 1976 by *Cantor v. Detroit Edison*, which concerned the utility Detroit Edison's program to furnish its customers with light bulbs.[14] The Supreme Court ruled that this program violated the antitrust laws and was not otherwise protected as an action of the state regulator.

The bellwether for this concern was a US Department of Justice (DOJ) antitrust case against AT&T, which led in 1984 to a divestiture that separated AT&T's competitive long-distance, equipment, and information service markets from its then-regulated local telephone monopolies.[15] This outcome followed DOJ's effort to prevent oil companies from owning regulated oil pipelines used to ship oil (Mitchell 1979). The principles behind these efforts resurfaced in the electricity sector in Federal Energy Regulatory Commission (FERC) Orders 888 and 2000.[16] These orders, which set out rules for competition in open wholesale power markets, did not go as far as the divestiture in *United States v. AT&T*, but they did impose separation rules that limited the ability of those competing generation firms to control investments in and access to the regulated transmission networks they need to deliver their electricity.

Three main principles underlie the concern about regulated firms in unregulated markets: excessive transfer pricing of inputs to regulated enterprises, cross-subsidization of competitive offerings by revenues from ratepayers of the regulated service, and discrimination against unaffiliated competitors from access to the regulated sector (Brennan 1987; Brennan et al. 2002). Before describing these and assessing their potential relevance to utilities' provision of CSEM, it is necessary to highlight the importance of regulation, as in the regulation of transmission in Orders 888 and 2000. If transmission were not regulated, owners of transmission facilities could exercise market power and extract profits directly by setting monopoly transmission rates. They would not need to exploit that market power indirectly by

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[13] *Otter Tail Power Co. v. United States*, 410 U.S. 366 (1973)

[14] *Cantor v. Detroit Edison Co.*, 428 U.S. 579 (1976).

[15] *United States v. American Tel. and Tel. Co.*, 552 F. Supp. 131 (D.D.C. 1983).

[16] Federal Energy Regulatory Commission, Promoting Wholesale Competition.

entering unregulated enterprises and charging themselves excessive prices, cross-subsidizing the offerings, or discriminating against competitors. The purpose of all of these tactics is, in effect, to move the regulated price close to the price the regulated firm would charge if its ability to maximize profits were unfettered.

5.2. Excessive Transfer Pricing

This concern involves a regulated firm entering an unregulated market for something it buys, and then selling that item to itself at an inflated price. Under cost-of-service regulation, where the regulator bases price on the regulated firm's reported costs, this higher price could be used to justify a higher regulated rate for the utility. In the textbook example, from the era when regulation of the electricity sector generally included generation through transmission and distribution to final sales, a utility buys a coal mine and sells itself the coal at an above-market price. The higher price for that coal is then passed through to ratepayers in the form of higher electricity prices. The profits from doing so would show up on the books of the unregulated coal mine.[17] In addition, if other CSEM providers are more innovative or better at controlling costs, self-dealing by the utility to exploit an excessive transfer pricing opportunity would lead to less efficient CSEM service, compromising the ultimate decarbonization goal motivating CSEM.

The excessive transfer pricing opportunities for CSEM are limited but not totally absent. Because this concern involves a utility's selling something to itself, it applies only if CSEM is a utility function—for example, if a utility enters the business of providing CSEM technology, like smart thermostats, and sells the technology to itself at a higher price.[18] For this to happen, regulators would have to approve above-market prices for CSEM. Since the decision to provide CSEM technology will require approval by the utility's regulators, one might expect the regulators to scrutinize CSEM expenditures for prudence Self-dealing prices above those available in the market for CSEM technologies might be unlikely to survive such scrutiny.

My expectation, then, is that excessive transfer prices are unlikely to be a problem in the near term as regulators scrutinize CSEM expenditures. Similar scrutiny would be required to prevent inappropriate self-dealing over the long term if utility-provided CSEM becomes routine. However, if a regulator is concerned about its ability to police excessive transfer pricing, it could order the utility to procure CSEM technology on the open market, while still providing CSEM service.

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[17] By "unregulated," I mean the lack of regulation of prices or profits. The coal mine may still be regulated for worker safety and environmental protection.

[18] A numerical example might be helpful. Say a utility forms a CSEM technology subsidiary and sells that technology to itself at $500/house when the market price for equivalent technology is $300/house. The extra $200 per connection would be rolled into the distribution rates the utility charges to customers.

5.3. Cross-Subsidization

Cross-subsidization is another tactic for the utility to absorb costs in order to raise its regulated prices, but it works in a different way—by absorbing an unregulated affiliated enterprise's costs and passing those on to ratepayers (Brennan 1990). Here, a regulated utility enters a business that uses inputs similar to those the regulated firm uses. An example might be providing a local mobile telephone service that uses trucks, wiring equipment, and technical employees similar to those used by the utility. The utility tells the regulator that those trucks, wiring, and staff were used to provide the regulated service, and their costs should be counted in setting the utility's rates. Allocating costs of the unregulated service to the regulated service's account constitutes a subsidy of the former by the latter—hence the term "cross-subsidy." The rates for the regulated service go up, but the profits on the books remain constant. The added profits from the cross-subsidy show up as the difference between revenues and (non-cross-subsidized) costs of the unregulated affiliate.

The direct harm from cross-subsidization is that the price of the regulated service goes up. A second harm is that the subsidy gives the regulated firm's affiliate an artificial competitive advantage in the unregulated market, potentially increasing its share and inefficiently moving business to it from other suppliers with lower costs or differentiated products. Last, and in the extreme, potential competitors may see this ability to cross-subsidize as leading to prices below their costs, discouraging their participation in the market.

My sense is that in general, cross-subsidization is not likely. There are already so many entrants into the business that a distortion of competition does not seem significant. Any individual utility has too small a share of what is likely to be a national if not global market in CSEM equipment and software.

Three qualifications to that conclusion may warrant regulators' attention to cross-subsidization. The first is that if a utility can cross-subsidize its CSEM operations over its service territory, it could meaningfully distort competition in CSEM provision there, even if not nationally. In-region CSEM costs charged to the utility's ratepayers could cause their distribution rates to increase as well, although I suspect not by very much.

A second qualification is that, even if the regulator can distinguish physical CSEM-related inputs from distribution-related inputs, a major input that can be cross-subsidized is capital borrowing. If the utility's CSEM affiliate issues bonds and the utility as a whole can guarantee them, the ratepayers have to cover the cost of that risk through the rate of return the regulator allows to reflect that risk. CSEM sector participants presumably can speak to the likelihood and significance of this kind of cross-subsidy. If it appears significant, regulators may want to institute capital separation policies to ensure that ratepayers do not bear the utility's risk.

A third complication arises if policymakers want to subsidize CSEM, perhaps as a policy to encourage decarbonization. To do so efficiently would entail offering a subsidy to all CSEM providers and letting the market sort out how well each provider does. Funding this subsidy, however, requires taxes to pay for it. The political unpopularity of taxes invites legislatures to adopt a different funding mechanism—pay for it through electricity rates. One could design electricity rate increases to provide subsidies for all providers, but an administratively easier policy might be to have the utility provide CSEM, funded through cross-subsidies. Tax-supported subsidies to all CSEM providers, not utility-funded subsidies of its affiliated CSEM provider, would better preserve competition in the CSEM sector, but other policy considerations may outweigh competition.[19]

5.4. Discrimination against Competitors

Perhaps the leading concern about participation by regulated firms in unregulated markets, and the main motivation behind the separation rules in FERC Orders 888 and 2000, is discrimination against unaffiliated competitors in access to the regulated service. An example can illustrate this.[20] Suppose one has a regulated monopoly in hot dogs. Suppose further that this hot dog monopolist also provided mustard, the price of which is not regulated. Last, suppose that this hot dog monopolist has a way to prevent the hot dog consumers from using mustard other than its own—that is, it can discriminate against rival mustard companies in access to its hot dogs. It could then add the monopoly hot dog margin to the price of its mustard, thus avoiding the regulatory constraint and, essentially, forcing hot dog buyers to pay the monopoly price. Those profits show up on the books of the unregulated mustard affiliate. Along with this higher price, hot dog eaters are harmed by being deprived of different types of mustard.

The example underlying Orders 888 and 2000 is qualitatively similar. Suppose the owner of a regulated transmission grid also owned generation and could discriminate against competing generators that would use its grid. Since regulation prevents charging high prices, qualitative discrimination could be used. Such discrimination might take the form of less reliable, more congested, or delayed construction or expansion of transmission lines to rival generators. This would create an artificial competitive advantage for the transmission grid's generators, allowing them to take some of the grid's market power in the form of higher electricity prices.[21] To prevent this, FERC did not follow the AT&T divestiture model and break up integrated utilities to put generation and transmission in separate companies. Rather, its orders

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[19] One such consideration is that funding CSEM subsidies through rate increases approved by state utility regulators absolves state legislators of having to endorse taxes. A similar consideration may apply to having utilities administer energy efficiency policies (Palmer et al. 2013).

[20] The following example is from Brennan (1987).

[21] The discrimination concern with pipelines discussed in Mitchell (1979) was that oil companies who owned a regulated pipeline would reduce its capacity, to reduce the supply of oil at the terminal of the pipeline and raise prices there, which the oil companies would then capture.

prevented generators from controlling transmission grids by vesting that control in separate entities, originally independent system operators, some of which are now called regional transmission organizations.

If discrimination is a concern regarding utility provision of CSEM to customers, it is indirect. It is hard to see how a utility could discriminate against a CSEM provider in the provision of its regulated distribution service. Many of its rivals are likely to come from outside its service area, rendering discrimination impossible. One indirect possibility is that the utility may have information regarding the electricity use patterns of particular customers. Such information may be useful in marketing CSEM services. Preventing or limiting CSEM rivals' access to that information could constitute discrimination.

A remedy would entail devising a means for making such information available that is not yet available, possibly including a payment to cover the cost of gathering and providing that information. A system of information access would have to address privacy concerns by, for example, requiring customers' consent prior to disclosure of that information. If such means cannot be satisfactorily devised, this information may give the utility a genuine advantage in providing CSEM.

Table 2 summarizes the concerns and conclusions.

Table 2. Risks of Regulated Firms in Unregulated Markets

Risk	Harm	Remedy
Excessive transfer pricing	High rates to ratepayers	Prevent utility self-dealing in CSEM technology
Cross-subsidization	High rates to ratepayers, distortion of competition	Ensure utility does not cover CSEM costs, borrowing
Discrimination against competitors	High prices of unaffiliated CSEM	Allow CSEM rivals access to customer use data

Having discussed potential costs of utilities' provision of CSEM, we now turn to the potential advantages.

6. Potential Benefits of CSEM Provision by Utilities

6.1. Economies of Scope and Coordination

The principal argument for having firms supply multiple products, as is common in the economy, is "economies of scope": one firm can supply multiple products more efficiently than separate firms can each supply only one of those products. The usual reason is gains from exploiting a common facility or workforce over multiple products. For example, Toyota builds both cars and trucks because it can share costs of product development and production. In terms of sharing production facilities and workers, economies of scope between utilities and CSEM do not seem compelling, since the latter provider develops and employs customer-level information technology not typical of large-scale distribution.

However, as Coase (1937) observed in explaining the boundaries of what firms do in terms of the cost of using markets to allocate goods and services across those boundaries, a main benefit of providing multiple products is coordination. This benefit is particularly important when the goods and services are complements—that is, one is used to produce the other, or they are used together to produce something else or by final customers. A classic example of the difference is why an auto manufacturer produces both car bodies and the engines that go in them, but not the steel used to make both. The auto manufacturer can find and get the kinds of steel it wants from competing steel suppliers, but it needs to coordinate the design of engines with the bodies of the cars they are going into.[22] Restructuring of the electricity sector, particularly separating generation ownership from transmission control, is premised on the view that coordination within a firm provides negligible benefits, and that markets, along with regulatory rules, suffice.

Coordination, particularly in ongoing operation, provides a stronger argument for allowing utilities to provide CSEM—especially for responding to intermittent variation in supply from wind- and solar-powered generators. As noted earlier, systematic time-of-day variation can be mediated through prices. This allows customers to choose how much to respond to price variations and whether it is worthwhile to invest in equipment and communications connections that allow them to adjust consumption.

Using the price system to make relatively small but potentially very frequent adjustments in electricity use, however, is likely to be difficult at best. It may also incur

[22] Coordination is more important when one or both sides have to make long-term investments that lose value unless used with the other (Klein et al. 1978), leaving the firm making the investment vulnerable to opportunistic exploitation, such as refusal to honor commitments to use or pay for that investment (Williamson 1993).

needless cost. Using the price system implies translating frequent, rapid supply reductions into prices that, if responses can be quickly forthcoming, would then be translated back into demand reductions. A fair question is whether that translation stage is necessary, even if it could be effective.

That consideration suggests a potentially significant benefit in letting the suppliers of renewable energy provide and operate CSEM technology as well. One option would be for a generator using wind or solar power to produce electricity to supply the CSEM to make it reliable. One potential problem is that the reliability issues associated with renewable intermittency are determined by variation not from one generator but in the grid overall. This consideration suggests that CSEM might best be carried out by the relevant grid controller, either the distribution utility or perhaps the RTO, that controls the grid in regions where generation and transmission are separated.

A second consideration, whether renewable generators, distribution utilities, or RTOs provide CSEM, is how they would do it. It is unlikely that they would get into the business of providing water heaters or EVs, although they may (and in some places do) provide charging stations. They are not likely to have advantages in developing CSEM technology. For any of these entities to manage electricity use across many users, communications standards—what signals provide what adjustments—are likely to be necessary at some point to ensure that such control is effective.

6.2. Consumer Preference and Adverse Selection

A second reason why CSEM may require utilities' involvement may depend not on economies of scope and coordination but on how customers may respond to a CSEM market. A first consideration comes from one of the initial assumptions—that customers' engagement is costly (Brennan 2007). Residential customers in particular have been reluctant to search and choose new electricity providers. Instead, they have generally chosen to continue to procure their electricity from the incumbent distribution company, especially where state regulators continue to exercise oversight over the retail prices those incumbents can charge. In many ways, the situation for new entrants has gotten worse because online and automatic bill payment have enabled buyers to avoid thinking about electricity use other than paying a monthly bill. Evidence remains to be gathered, but one might expect that residential customers may be similarly reluctant to engage in the market for CSEM.

CSEM for residential users requires consideration of a particular market failure: adverse selection. For a CSEM market to work, consumers must be engaged and able to evaluate and monitor the performance of CSEM vendors, especially prior to purchase if commitments to a particular CSEM system last a long time. Those factors have prevented penetration by retail energy suppliers, in a setting where customers presumably would find choices easier than they would with CSEM, involving fairly arcane technologies with benefits impossible to promise. CSEM suppliers may find it difficult to overcome skepticism about claims of "savings up to X percent."[23]

The electricity market comprises large commercial, government, and industrial users as well as residential users, of course. These larger users may have the resources and ability to verify CSEM claims and compare costs to benefits. If large users continue to account for around two-thirds of electricity use, a customer-oriented market for CSEM without the utility's involvement may not suffer from residential customers' reluctance to choose and asymmetric information handicaps. One might reap most of the load-balancing benefits of CSEM without involving residential users at all. However, the growth of EVs and increased working from home (during and perhaps following the coronavirus pandemic) may increase the residential share of the electricity business (Cicala 2020). If so, efforts to promote decarbonization through widespread use of renewably generated electricity should not ignore this part of the market.

[23] Although the Internet might diminish the asymmetric information problem, such claims would remain hard to verify—a particular problem when savings are likely to vary widely across households as opportunities to adjust or shift energy use also vary. To help make this market work, perhaps a utility should be required to provide any customer's real-time demand information to any potential provider of CSEM service, as noted above in the discussion on discrimination. But even if people accepted that, the utility and CSEM provider still may not know how much of that demand came from technologies amenable to management.

7. Observations: What Might Policymakers Consider?

7.1. Summary

Mitigating climate change through decarbonization requires substituting electricity generated through renewable sources for electricity generated by the burning of fossil fuels. The consequent vast growth of renewable generation is likely to lead to or exacerbate two effects in energy markets. One is to increase the disparity in energy supply between times of the day when wind and solar power are generally available and when they are not. The other is moment-to-moment intermittency because of variations in wind speed or cloud cover.

At present, natural gas plants with quickly variable output and increasingly economical storage are ways to address those challenges, particularly intermittency. Another option is to shift demand from times when electricity is expensive to when its price is very low—perhaps close to zero—and to vary demand as energy output varies to match this intermittency. Adjusting demand to take advantage of low prices and respond to intermittency, customer-side energy management, or CSEM, has four primary components: technology to turn on and off or reduce load from hot water heaters, electric vehicle chargers, and other devices; software to instruct this switching; communications networks to send instructions to the devices; and controllers that are sources of instructions, in the form of either prices or direct commands to alter electricity use.

Business models exist that combine some or all of those functions. A threshold question is why not just use prices to convey information on the relative plentitude or scarcity of electricity, and let buyers respond to those prices. For systematic time-of-day variation, perhaps seasonally adjusted, prices may well work. Customers could then decide on the basis of cost and convenience whether and how to automate response to those prices. Intermittency of supply, however, makes price-based adjustment more challenging, if not impossible. This is not a unique or unusual circumstance; economic theories of firm organization and common law doctrines are premised on markets frequently being costly to use. Intermittency of response is consequently the strongest justification for CSEM.

The question here is what if any role utilities should have in providing CSEM technology. In electricity and other sectors, antitrust law and regulatory policy have been premised on the principle that regulated businesses' participation in unregulated markets creates opportunities to exploit otherwise constrained pricing power. The potential harms include higher prices for ratepayers of the regulated business and distorted competition in the unregulated markets. The leading tactics that could be used are excessive transfer pricing of unregulated inputs to the regulated enterprise, cross-subsidization of unregulated services (shifting physical or capital costs to the regulated accounts), and discrimination against unaffiliated, unregulated rivals in access to the regulated service. In all cases, the risks are fairly minor and can probably be mitigated through regulatory vigilance or, if necessary, safeguards.

On the other hand, utilities' provision of CSEM may deliver benefits, of which two stand out. One is that a utility may be best placed to coordinate CSEM with intermittent supply variation, in part because of its access to supply and consumer-use information. The second is that adverse selection may prevent an independent direct-to consumer CSEM market from developing. If these benefits are important, the likely outcome is that the utility procures CSEM technology from a competitive market and provides CSEM directly.

7.2. Potential Policy Considerations

If a distribution or transmission utility provides CSEM, regulators should be vigilant if it expands into production of CSEM technology and software. Economies of scope there are not likely to be large, and excessive transfer pricing, cross-subsidization, and discrimination remain concerns.

A second broad issue is the potential need for standards. Manufacturers of electricity-powered devices such as hot water heaters and electric vehicles operate in national, if not international, markets. Effective CSEM may require that utilities that undertake CSEM, and the suppliers of CSEM technology, be able to apply that technology to the broad range of such devices. This in turn may require adoption of a standard method for control that CSEM providers and practitioners can use. This is not unprecedented. If decarbonization through promotion of renewable generation becomes general practice, CSEM technology and management could be as much a part of devices as requiring that they be able to operate on 110-volt, 60-cycle alternating current.[24]

Implementing such a policy should come only after a benefit-cost analysis to determine whether the decarbonization and other renewable grid integration benefits exceed the costs of any CSEM standardization mandates. This analysis should cover both the costs of the equipment and any cybersecurity risks if CSEM requires connecting customers' appliances to the Internet. Part of this assessment is whether, after CSEM technology is installed, customers retain the right to adapt or even override it—for example, keeping the air-conditioner on when a utility, through CSEM, would turn it down or off. Whether in a CSEM environment utilities would charge fees

[24] A perhaps analogous policy is California's recent requirement that all new homes have rooftop solar panels or access to community-wide solar facilities. California Energy Commission, "California Energy Commission approves first community solar proposal under 2019 Energy Code" (February 20, 2020), https://www.energy.ca.gov/news/2020-02/california-energy-commission-approves-first-community-solar-proposal-under-2019.

to those who want to opt out, or pay customers to opt in, with revenues presumably coming from ratepayers as a whole, remains to be seen.

A fundamental question for regulators to assess as CSEM develops as a complement to renewable generation growth is whether it should be included in what distribution companies do. Utilities have already seen their responsibilities broaden beyond reliable supply of electricity to end users. In many states, utilities are charged with the implementation of mandates to improve energy efficiency (Palmer et al. 2013). In the not-too-distant future, it may become the norm for distribution utilities to have the ability to modify demand, just as they are now responsible for ensuring supply.

I end with a speculative caveat. If generator-scale storage becomes sufficiently inexpensive, the most economical way to handle momentary variation in energy output from renewables would be to pair a renewable generator with sufficient storage to smooth out that variation. That so many entrepreneurs appear willing to enter the CSEM business suggests that low-cost storage is not likely to price them out of the market. Until that prospect appears more likely, one should not use it to justify ignoring the potential need for standardization and other policies to facilitate CSEM as a means to reduce the cost of using renewably generated electricity and thus promote decarbonization.[25]

[25] CSEM would remain useful in a two-way system, instructing customer-side batteries when to provide energy to balance load with supply.

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