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"Night of the Living Dead" or "Back to the Future"? Electric Utility Decoupling, Reviving Rate-of-Return Regulation, and Energy Efficiency

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RESOURCES FOR THE FUTURE

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Abstract

The distribution grid for delivering electricity to the user has been paid for as part of the charge per kilowatt-hour that covers the cost of the energy itself. Conservation advocates have promoted the adoption of policies that “decouple” electric distribution company revenues or profits from how much electricity goes through the lines. Their motivation is that usage-based pricing leads utilities to encourage use and discourages conservation. Because decoupling divorces profits from conduct, it runs against the dominant finding in regulatory economics in the last twenty years—that incentive-based regulation outperforms rate-of-return. Even if distribution costs are independent of use, some usage charges can be efficient. Price-cap regulation may distort utility incentives to inform consumers about energy efficiency—getting more performance from less electricity. Utilities will subsidize efficiency investments, but only when prices are too low. Justifying policies to subsidize energy efficiency requires either prices that are too low or consumers who are ignorant.

Key Words: Decoupling, price caps, electricity, energy efficiency, conservation

JEL Classification Numbers: L51, L94, Q41

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Timothy J. Brennan*

Introduction

Forty-five years of regulatory economics have been devoted to exposing the flaws of cost-of-service or, equivalently, rate-of-return regulation. Those criticisms initially focused on input distortions due to errors in setting the rate of return, followed by concerns that such regulation created incentives to exploit market power through integration into similar, unregulated sectors and then cross-subsidization of services to raise rates, and perhaps create credible predatory threats. The main focus of attention over the last twenty years has been that, to the degree a regulator succeeds in holding prices to cost, the regulated firm is stripped of incentives to be efficient.

These concerns apply to electricity distribution. As evidenced by the concerns of Maryland regulators (State of Maryland Public Service Commission [MDPSC] 2006, 6–10), holding prices to cost may remove incentives for distribution utilities to shop for bulk power at least cost and put together an efficient portfolio of contracts. These utilities have also been accused of being slow to make repairs following storm-created outages, such as those following Hurricane Isabel in 2003 (Office of People's Counsel [OPC] 2003). In principle, any such delay could have been a consequence of distribution utility divestiture of generation as part of the implementation of restructuring. If a utility no longer suffers losses from foregone electricity sales, it has less incentive to restore power quickly after a storm (like Hurricane Isabel) because it did not produce energy.

The main theoretical contribution to addressing these problems has been to suggest mechanisms that set prices without regard to realized cost, e.g., price caps (Brennan 1989). Under such a scheme, regulated firms have incentives to be efficient because they keep the money. By divorcing prices from reported costs, price caps also remove incentives to cross-subsidize by

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misallocating costs of providing competitive services to the regulated sector. Expected productivity gains can be shared through programmed price reductions set *ex ante*, maintaining marginal incentives to be efficient.[1] Even a relatively small savings in production cost can outweigh losses from prices above average costs (Brennan 1996), with prices typically converging to Ramsey-like levels that maximize welfare, subject to profits achieved by the regulated firm (Brennan 1989).

Price caps have some disadvantages as well. When the average price of a bundle is capped, the mechanism can be manipulated to give regulated firms the ability to set low prices in markets where entry is anticipated. Those firms depend on a regulatory commitment not to adjust prices in light of realized losses or excess profits. To the extent that such a commitment is not credible, price caps revert to a form of lagged cost-of-service regulation, mitigating but not eliminating the problems of error and induced inefficiency outlined above. In addition, incentives to evade the price constraint by discriminating in favor of unregulated affiliates remain. Nevertheless, allowing firms to profit by divorcing prices from costs has become a guiding principle of regulatory economics and, increasingly, policy.

A new movement in electricity policy called "decoupling" is challenging this consensus (Mufson and Rein 2007).[2] Although sometimes described as decoupling revenues from quantity sold, in practice it is usually defined as decoupling a distribution utility's profits from the amount of electricity it delivers to users. There can be some ambiguity in the definition of decoupling. A recent detailed statement by the Maryland Energy Administration (MEA) mentions decoupling in terms of revenues and of profits (MEA 2008, 7 [profits], 44 [revenues, and "revenues per customer"]). If, as modeled below, we treat the costs of a distribution utility as independent of use, i.e., that costs are fixed, then the definitions are the same—as long as other factors affecting cost, notably the number of electricity users, are held constant. A measure of the salience of decoupling is that a former president has cited it in a speech (Clinton 2007). The rationale for decoupling comes from conservation advocates, who believe that allowing utilities to charge a positive

[1] Original forms of price caps labeled adjustments at RPI – X, where RPI was the change in a suitable price index and X was a "productivity"-related rate reduction. In theory, this latter term was based on expected rather than realized productivity. In practice, it represents the division of the expected gains between the regulator and regulated firm in reaching the political bargain necessary to move from rate-of-return regulation to price caps.

[2] Hirst and Goldman (1990, 1160) mentioned "decoupling electricity sales and earnings" in a much earlier article on integrated resource planning predating the restructuring movement. They did not explore the implications of their suggestion and its relation to ongoing analyses of the economics of regulation.

price for distribution based on use induces them to encourage consumers to buy more power, which thwarts efforts to limit energy consumption. To the extent that decoupling would imply charging flat fees rather than use-based fees for distribution, one might expect it to promote efficiency, in that facilities with no marginal cost attached to use should not require a marginal price. In contrast, for most forms of decoupling, conservation advocates support usage-based charges—but with automatic rate increases to users in general when any individual user reduces electricity use in order to maintain utility profits.[3]

Hence, we are left with the following question. Is decoupling like the horror film "Night of the Living Dead," where rate-of-return regulation comes back from the grave to haunt regulators and regulated industries? Or is decoupling like an example of going "Back to the Future," where ideas from the past are shown to bring unforeseen benefits and have been rejected too soon? We find a little bit of both. We show first that if non-usage based charges equal to the marginal cost of adding an additional consumer fail to cover total costs, making up some of the shortfall through usage-based charges can improve efficiency. This analysis applies equivalently to decoupling that fixes revenues-per-consumer, as these are tantamount to fixed fees for connection to the grid. Other specific rationales of conservation advocates for decoupling may fail to pertain. Absent real-time pricing, utilities that buy energy at wholesale and sell at retail already have incentives to limit use at peak periods, when wholesale prices exceed costs. However, the decoupling argument raises the possibility that price caps could possess effects and even disadvantages that have not yet been duly recognized.

We examine two of these effects here. The first involves the provision of information. We find that when prices exceed marginal cost, a price-capped firm will supply only information that boosts demand and will suppress information that reduces demand. This effect is reversed when price is less than cost, as would be the case for distribution utilities selling energy at averaged rates during peak periods when wholesale prices are at their highest. This result is akin to the often-voiced concern that price caps reduce quality, as discussed in Weisman (2005). From the perspective of the regulated firm's profit, information that boosts demand is formally equivalent to increasing quality. With respect to decoupling generally, evaluating distortions in infor-

[3] If profits are not independent of use, decoupling will not have the effect of removing utility incentives to promote use that advocates of decoupling espouse. In addition, if a distribution utility's costs are independent of use, then fixing revenues and fixing profits (which equals revenues less costs) are equivalent, if the number of users of electricity remains constant.

mation provision from a welfare perspective is complicated by the need to decide which set of information is appropriate.

The second effect considered here is whether a price-capped firm would want to subsidize electricity substitutes, e.g., energy-efficient appliances, in order to decrease demand. We find that it might, but in some settings its incentive to do so is less than warranted by the "theory of the second best." This result also suggests that, to some degree, discriminatory cross-subsidization of unregulated affiliated complements may be appropriate, contrary to considerable research regarding the application of antitrust law to regulated firms.

Moreover, the case for an incentive to subsidize substitutes, like second-best arguments generally, depends on electricity being underpriced. This may well be, particularly during periods of extreme peak demand and if environmental effects are not incorporated into electricity prices (e.g., through tax or marketable emission permit programs). Because much of the electricity policy discussion takes the view that electricity is overpriced, we investigated a general model to see if energy efficiency should be subsidized. We found that if electricity is priced too high, then a necessary condition for subsidies to improve efficiency is if consumers are failing to make efficiency choices that are in their own individual (as differentiated from collective) interest.

In evaluating any of these results, it is crucial to keep in mind that the behavior of rate-of-return regulated firms is inherently unpredictable to the extent that decoupling successfully renders profits constant, regardless of conduct. Fixing profits regardless of what a firm does eliminates the ability to use profit maximization to predict what that firm would do. That said, arguments made by decoupling advocates can illuminate otherwise neglected effects of incentive-based regulation. Recognizing these limits, we find that decoupling makes sense only if utilities possess information—not otherwise available to consumers—on efficiency investments that can reduce demand or if consumers lack the information or the wherewithal to make such investments themselves even when the benefits each would realize exceed the costs each would bear. We conclude by noting that the rationale for decoupling may be political—defusing potential utility opposition to efficiency policies—rather than specifically economic in nature.

Rationales by Decoupling Advocates

Carter (2001) set out the basic rationale for decoupling. She began with the premise that "utilities have long had the responsibility of delivering least-cost, reliable energy services to customers," indicating a perspective that utilities should go beyond reliably providing *energy* to providing the services for which energy is used. She further observed that "price cap regulation discourages the most economic investments if they are likely to reduce throughput." To provide such incentives, "the sales-revenue link in current rate design must be broken"—in other words, decoupling.

The Regulatory Assistance Project (RAP 2005) offered more detail on how this works, noting that under "traditional ratemaking…utilities lose revenue and profits from sales not made as a result of successful energy programs." It advocated decoupling (which it termed "adjustable revenue caps") over an alternative system of "lost revenue adjustments," claiming the latter is narrowly targeted to compensate specific programs and fails to "remove[] the utilities' incentive to promote new sales." Canine (2006) and Darbee (2007) promoted decoupling on similar grounds—in Darbee's words, "making utilities catalysts of reductions in consumption makes sense because they're the companies that consumers pay for their electricity every month."

Whether or not decoupling is adopted may not depend solely on conservation effects. Sotkiewicz (2007) pointed out that decoupling, by providing "revenue stability," shifts risks from utilities to consumers. If distribution utility profit rates remain unchanged, this shifts wealth from consumers to the utility. The adoption is likely to depend on the relative political influence of these groups, in conjunction with environmental advocates of decoupling. Revisiting concerns raised by alleged utility failures to make repairs promptly after a hurricane, we might add that such risk reallocation could reduce utility incentives to mitigate delivery risks under their control.

Little if any academic work has discussed decoupling as a policy for conserving electricity in the electricity sector.[4] Within the policy community, support for decoupling is not unanimous. An assessment by the Rutgers University Center for Energy, Economic, and Environmental Policy (CEEEP 2005) identified a number of operational concerns, including how, whether, and how frequently to adjust revenue requirements in light of changes in weather, customer base, and other potentially relevant factors. CEEEP also asked if decoupling should be done overall or by customer classes, and which rates should be decoupled.

A perhaps less disinterested assessment comes from the Electricity Consumers Resource Council (ELCON), an association of large industrial electricity users. ELCON finds decoupling "blunt" (ELCON 2007, 3), that is, not optimally tailored to address the concerns motivating its

[4] Tschirhart (1995) appears to be a rare exception.

proponents. In line with academic arguments supporting the replacement of rate-of-return regulation with price caps, ELCON claims that decoupling "promotes mediocrity" by eliminating efficiency incentives, when profits become independent of use. It objects to shifting the risks from utilities to consumers as noted above.[5] It recommends instead that efficiency be induced by pricing electricity appropriately.

John Perkins, the Iowa Consumer Advocate, identifies numerous reasons for rejecting decoupling (Perkins 2007). Most of his points, although made in the context of natural gas sales, apply to electricity as well. One reason, in his view, is that decoupling is a "significant departure from proven regulation" because it allows automatic rate adjustments without a chance for the public to intervene. In saying this, he makes the point that it reduces utility incentives to "manage sales risk." A second reason, as noted above by ELCON, is the shift of risk to the consumers. Perkins also suggests that decoupling discourages consumers from making conservation efforts by reducing usage costs. It is important to note that holding profits or revenues constant overall is consistent with having any individual's use increase that individual's distribution charges; other users will see a reduced overall cost for distribution.

Usage Fees When Costs Are Fixed

Although some forms of decoupling retain usage-based fees, which are adjusted to keep utility revenues or profits fixed (RAP 2005, 3; ELCON 2007, 2), decoupling in some ultimate sense would eliminate usage-based charges altogether (Sotkiewicz 2007), such as fixed revenues per customer.[6] One obvious argument for decoupling distribution payment from usage is that the costs of distribution are largely, if not entirely, independent of use. These costs are essentially those of constructing and maintaining the local wire grid, conduit, transformer, and pole system. Costs depend on the number of customers, as one needs more parallel connections to add each new household or business to the mix. Other than perhaps transformer wear and tear (if any), the costs would seem to be independent of use.

The logic of setting prices for fixed assets independent of use has come up in regulatory contexts before. The costs of providing a wireline telephone connection to a customer's premises

[5] Such an appraisal is also shared by some consumer advocates, e.g., Noël (2007).

[6] As noted above, decoupling refers only to fixing utility profits or revenues—which presumably are the same if costs are fixed—not perconsumer charges. One could decouple but still recover fixed distribution charges on a per-unit basis. We argue below that some usage charges are likely to be efficient, even if all costs are fixed.

are largely independent of use ("non-traffic sensitive," in earlier jargon for telephone service). Through long-standing policies—despite extensive criticism from many economists—the fixed costs of these landlines were recovered through "traffic sensitive" charges on long distance use. This was based on court and regulatory decisions that the costs of the fixed lines had to be allocated into separate local and long distance service, under separate state and federal jurisdiction, respectively. In this case, the pricing policy was also costly because it used surcharges on a relatively elastically demanded service (long distance telephony) to subsidize a less elastically demanded service (local dial-tone) below marginal cost (Griffin 1982).

These arguments make an analogous case for allowing distribution utility revenues to be independent of use. Sotkiewicz (2007) also noted that separate fixed charges can reduce the need for rate hearings and open the door to innovate rate designs. Fixed charges, however, are likely to be unappealing to decoupling advocates. By reducing the per kilowatt-hour price of electricity, it would presumably stimulate rather than stifle use. As we elaborate below, whether for reasons of political expediency or genuine expectation, controlling demand by raising prices is understandably unpopular among decision-makers, so the flip side—that cutting prices will not increase demand—is unlikely to cause much concern. In addition, moving charges from usage to a fixed fee is likely to be unpopular for the same reason 20 years ago, when it was proposed in the telecommunications sector: it raises overall payments for those who use electricity the least, presumably those toward the bottom of the wealth distribution.

Even on narrow efficiency grounds, one may not want to have the costs of distribution covered solely through distribution revenues, even if all costs are independent of usage. This will be the case if the fixed fee necessary to cover costs exceeds the marginal cost of connecting an additional user to the grid. Essentially, average costs of distribution have to exceed marginal cost, which is what one would expect under natural monopoly conditions normally required to justify regulation. In such circumstances, using fixed fees alone would result in too few users, creating a potential overall efficiency gain from reducing fixed fees and imposing usage fees to recover costs.

To show that optimal fees for a service with no usage costs nevertheless may require usage charges, one posits a continuum of N users, where $Q(i, p)$ is the quantity demanded by consumer i at price p. For analytical ease, we assume that consumers are indexed in reverse order of use with non-crossing demand curves, so that if $i > j$, then $Q(i, p) \leq Q(j, p)$ for all p. Given that consumer i is on the system, consumer i's surplus is given by the standard measure:

Consumer *i's* surplus = $\int_p^\infty Q(i,z)dz$.

Because there are no usage-related costs, the total gross surplus from consumer *i's* use includes the payments consumer *i* makes, *pQ*(*i*, *p*).

Total gross welfare is the integral of the individual consumer surplus over all *N* consumers. The cost of the grid depends on the number of users, hence we represent this cost as *C*(*N*). Total net welfare *W*(*N*, *p*) is then:

$$W(N,p) = \int_0^N \left(\int_p^\infty Q(i,z)dz + pQ(i,p) \right) di - C(N). \tag{1}$$

Choosing *N* and *p* to maximize *W* gives the first-order conditions:

$$W_N = \int_p^\infty Q(N,z)dz + pQ(N,p) - C' = 0. \tag{2}$$

$$W_p = \int_0^N pQ_p(i,p)di = 0. \tag{3}$$

The first of these, from equation (2), is that the grid should be expanded to the point where the total surplus from adding the marginal user just covers marginal cost of adding that user. The second, from equation (3), implies that the usage price *p* should be zero, equal to the marginal cost of additional use. Putting these together implies that *p* should be zero, total surplus equals consumer surplus, and one would get the efficient outcome with a fixed per-user fee *F* for connection to the grid equal to:

$$F(N) = \int_0^\infty Q(N,z)dz. \tag{4}$$

This neglects a requirement that revenues from electricity fees cover the costs of the distribution grid. If the revenues from charging this fixed fee covered total cost, i.e.,

$F(N)N \geq C(N)$,

then this condition would be met. If it is not the case, then the optimization problem requires a constraint that revenues from usage and connection cover the cost of the grid.[7] The fixed fee will be the surplus reaped by the N^{th} user at price *p*, and revenues from use will be the integral of the amount each consumer uses at price *p*, $Q(i, p)$. The constraint that revenues cover cost will then be

$$p\int_0^N Q(i,p)di + N\int_p^\infty Q(N,z)dz = C(N). \tag{5}$$

This constraint implicitly defines a function $N(p)$, the number of users from whom one will get a fixed fee sufficient to cover costs if *p* is charged for each kWh (kilowatt-hour) of use.[8] Given this function, we can then choose *p* to maximize welfare $W(N(p), p)$ given by (1). This gives the first-order condition

$$W_N N' + W_p = 0, \tag{6}$$

where W_N and W_p are given by (2) and (3). For the optimal usage fee *p* to be positive, the derivative of $W(N(p), p)$ given by the left hand side of (6) needs to be positive when *p* is zero.[9] Because W_p is zero when *p* is zero, we have that the optimal usage price is positive when $W_N N' > 0$ at $p = 0$, or

$$N'[F(N(0)) - C'(N(0))] > 0, \tag{7}$$

where $F(N(0))$ is given by (4) for $N(0)$ as given by (5).

At $p = 0$, no revenue is collected through a usage fee, hence $N(0)F(N(0)) = C(N(0)$. If average cost exceeds marginal cost, $F > C'$ in (7), the optimal usage fee is positive if $N' = 0$. To see this, we apply a more general formulation. Let $R(N, p)$ be the revenue collected by charging a

[7] We neglect here the possibility of price discrimination. Charging different users different fixed fees,based on their surplus from using electricity,could allow cost recovery without prices based on use.

[8] We derived the result on optimal prices in this fashion rather than calculate it through a Ramsey-like constrained optimization. Since the demand to get service at all (*N*) and the demand for units of service based on price are interrelated, a general tractable calculation of the optimal *p* is difficult if not impossible.

[9] We assume whatever is necessary for a unique solution, e.g., that the welfare function is differentiable and the second derivative is negative.

usage price of p and a fixed fee that N users will pay, given p. The constraint that revenues cover costs that depend only on N, a generalization of (5), is just

$$R(N, p) = C(N).$$

Differentiating gives

$$R_N dN + R_p dp = C' dN,$$

which gives

$$\frac{dN}{dp} = \frac{R_p}{C' - R_N}.$$

At $p = 0$, R_p is positive. Presumably, the revenue constraint (A5) implies that at $p = 0$, the number of users N is greater than that which a monopolist would choose, implying that marginal revenue is less than marginal cost. This makes the denominator positive as well. Hence, $N' > 0$. The optimal usage fee is positive in the absence of marginal usage costs when the unconstrained optimal fixed fee generates insufficient revenues to cover total cost.

Price Caps and Information Provision

Proponents of decoupling argue that utilities lack the incentive to encourage conservation. Since conservation is first and foremost a matter of demand, we look first to see if a price-capped utility would have an incentive to withhold information, particularly that which would lead consumers to reduce demand. This does not imply that a decoupled, rate-of-return regulated utility has more or less incentive to supply information than a price-capped firm. If decoupling works as its advocates expect, it leaves utilities with the same profit whether customers conserve. Consequently, one cannot predict that with decoupling alone, any particular utility would meet the objectives set out by policy makers—although they might if profits are affected indirectly, e.g., if unwillingness to follow policy creates political unpopularity that leads to greater regulator scrutiny.[10] We do not model here the effect of additional incentives on utilities or consumers, such as subsidized energy audits, to induce conservation.[11]

Let us focus, then, on a price-capped utility that charges for electricity on the basis of use. Let p_r be the per-kWh cap on distribution charges, with no marginal cost associated with distribution of an additional kWh of energy. We assume first that the utility sells only distribution services. Particularly for residential users, it may also supply energy as well, which is purchased at retail and sold at wholesale. This model could be easily adapted to that setting by allowing p_r to be the cap on energy sales, including distribution charges, and adding a marginal cost c to reflect wholesale electricity costs.[12]

Let I be the quantity of information the utility can supply. The cost of supplying information (including procurement and dissemination) is $h(I)$. The demand for electricity is $Q(p, I)$, where Q_I can be positive or negative, i.e., additional information increases or reduces demand at price p. For modeling ease, we assume that the cost of information h is independent of p, in particular, that more demand does not make information more or less costly to distribute. The basis for the effect of information on demand, e.g., directly changing the benefits consumers receive from energy use, fostering environmental awareness, or letting consumers know how they can get the same level of service with less energy, is immaterial. However, some forms of information thought to induce conservation, such as publicizing the existence of energy-efficient appliances may in fact induce greater energy consumption, if demand for the appliance's services (such as home cooling) is elastic.13

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[10] One might think of this as weakening a claim for surplus in a process based on the exercise of regulatory clout (Peltzman 1976; Becker 1983). It may be worth observing that Baltimore Gas and Electric, a leading utility in Maryland, has stated that "Customers **expect** BGE to promote efficiency; BGE is viewed as the 'energy expert'" (Baltimore Gas and Electric 2007, slide 4, emphasis in original).

[11] MEA (2008) offers a full spectrum of such proposals.

[12] Some utilities may incur obligations to procure reserve capacity in case of an outage from its primary wholesale suppliers. These could lead to higher costs for energy as well.

[13] This is known as the "rebound effect." (Gottron [2001] attributes the idea to Stanley Jevons in 1865.) Suppose an appliance of efficiency level k delivers k units of service for each unit of energy it uses. If the price of energy is p, the cost per unit of service delivered is p/k. The total amount of energy consumed, e, then will be $Q(p/k)/k$.

$$de/dk = -Q/k^2 - pQ'/k^3.$$

This expression will be positive if

$$-[p/k][Q'/Q] > 1,$$

Holding the number of subscribers constant—with electricity price fixed by the cap14—and neglecting other variables that affect costs to focus solely on informational issues, we assume that the regulated utility chooses I to maximize profits under the cap p_r:

$$p_r Q(p_r, I) - h(I).$$

The profit maximizing level of information meets the condition

$$p_r Q_I = h'.$$

Since $h' > 0$, in equilibrium $Q_I > 0$. Under price caps, a utility will provide only information that boosts demand.[15]

Before concluding that price caps are contrary to the conservationist cause, three caveats merit recognition. First, the analysis requires an assumption that utilities are a unique source of information relevant to electricity demand. This seems specious in light of the vast amount of consumer information provided by media outlets, governments, and environmental advocacy organizations. Second, on welfare grounds, one perhaps should judge the consumer welfare of consuming electricity on the basis of the information that the consumers would get from the utility. One cannot conclude, using post-“informed” consumer preferences as a basis, that consumption is excessive. Such a consideration may not deter judgments based on other norms or if there are negative externalities not captured by p_r. However, one can conclude that utilities will provide demand-boosting information, but not demand-reducing information.[16]

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i.e., the demand for the energy services is elastic. If there are other marginal usage costs apart from energy, such as wear-and-tear, the elasticity required for increased efficiency to increase energy use is greater.

[14] We assume the price cap is binding, in that the firm would not want to set price below the cap, thus eliminating it as a variable in the maximization.

[15] Mark Jamison suggested looking at revenue-cap regulation as well. If revenues ($pq(p, I)$) are kept constant, then the firm will clearly want to minimize $h(I)$. It will provide as little information as possible, regardless of whether such information stimulates or reduces demand.

[16] The analysis is similar to quality under price caps (Weisman 2005). Although price caps have been understood to reduce quality because of the reduction in costs, reducing quality also reduces demand, which sacrifices profits. Weisman (2005, 168) shows that reducing the cap reduces quality; this would also hold for information that boosts demand here. For quality, that could be efficient if a monopolist would set an excessive level of quality, because the marginal boost in demand exceeds the inframarginal valuation of quality (Spence 1975; Sheshinski 1976). In this case, a tighter price cap would mitigate any bias toward offering only one-sided, demand-increasing information.

A third and perhaps most important point begins with the observation just made that many distribution utilities are also in the business of selling energy. This adds a wrinkle that, sometimes, the allowed price may be less than the cost of obtaining energy from wholesale suppliers and, thus, its cost of production. To see this, we expand the above model to include a cost $c(Q)$. The maximized profits are now

$$p_r Q(p_r, I) - c(Q(p_r, I)) - h(I).$$

The profit maximizing level of information satisfies

$$[p_r - c']Q_I = h',$$

where c' is the marginal cost of supplying output given the level of information provided I and the price cap p_r. In general, if prices exceed marginal cost, the above result applies—the utility will supply only information that boosts demand. If the price is above marginal cost, demand in general is too low. Demand-increasing information would presumably be efficient unless externalities were present, such as environmental effects beyond those reflected in prices through taxes or marketable permit programs.

If the electricity price is set under conventional practice where prices are an average of low off-peak marginal costs and very high on-peak costs, then it will be sold at prices below marginal cost during peak periods.[17] As part of political bargains to open markets, utilities also may be selling electricity at prices set some years ago that are below the cost of acquiring electricity in present wholesale electricity markets. In these settings, absent other means by which wholesale costs can be automatically passed on to customers, the utility will on its own want to supply information that reduces demand.[18]

[17] Electricity is extremely expensive to supply on peak because it cannot be stored, and demand is highly variable. I have seen data for Maryland indicating that 15% of electricity supply capacity is engaged less than 0.5% of the time. Recovering the costs of electricity generated requires very high prices, perhaps on the order of 50–100 times off-peak levels.

[18] This observation is also the basis for suggesting that utilities have incentives to adopt real-time pricing measures to reduce demand, absent policy intervention (Brennan 2004). I thank Wayne Shirley for pointing out that automatic pass-through of costs on an averaged basis will also stifle an incentive to conserve. Such automatic pass-through will not be available when utilities offer standard service to customers, particularly residential customers, under rates only periodically reviewed by state regulators, unless the utilities are allowed to raise rates to cover not just current costs but to cover retroactive losses.

In such cases, which remain the norm, utilities will have at least some incentive to supply information to reduce peak demand, e.g., encouraging consumers to use less electricity during peak times or to install more energy efficient appliances that are used at peak times—air conditioners, for example (subject to the rebound effect). This, of course, does not imply incentive to reduce demand for reasons unrelated to peak period costs. It does suggest that the method by which distribution costs are recovered—price caps or decoupled—has less of an effect than the relationship between wholesale and retail prices.[19]

Subsidizing Electricity Substitutes and Complements

Proponents of decoupling also suggest that it is necessary to induce utilities to supply not just information that affects demand but also technologies that reduce demand for electricity—in other words, substitutes for the electricity they provide. We examine here the effects of price caps on the incentive of a utility to subsidize a complement or substitute. Let r refer to the regulated service and x to a secondary good that may be a complement or substitute. Demands for r and x from the regulated firm as a function of their prices are, respectively, $Q^r(p_r, p_x)$ and $Q^x(p_r, p_x)$. Let c_r and c_x be the marginal cost, assumed constant for convenience, of the utility's producing r and x. The price of the regulated service, p_r, is assumed to be effective and binding. The utility can set p_x to maximize profits, subject to the constraint that $p_x \leq c_x$. The constraint represents an assumption that x is available in competitive markets at marginal cost, hence that the utility cannot charge a price above c_x.

The regulated firm thus maximizes profits given by setting p_x to maximize profits Π,

$$\Pi(p_r, p_x) = [p_r - c_r]Q^r(p_r, p_x) + [p_x - c_x]Q^x(p_r, p_x),$$

subject to the constraint that $p_x \leq c_x$, the competitive price. The derivative of profit with respect to p_x is

$$d\Pi^x/dp_x = [p_r - c_r](\partial Q^r/\partial p_x) + [p_x - c_x](\partial Q^x/\partial p_x) + Q^x(p_r, p_x).$$

[19] In the extreme, utilities may face bankruptcy when retail prices are fixed and wholesale prices skyrocket (Brennan 2001)

For the price-capped firm to want to subsidize x, i.e., charge a price below marginal cost, this derivative should be negative at $p_x = c_x$, indicating the profits would rise by reducing p_x below c_x.[20] For this to be the case,

$$-[p_r - c_r](\partial Q^r/\partial p_x) > Q^x(p_r, c_x) > 0.$$

A necessary condition that a firm would subsidize x is that $[p_r - c_r]$ and $\partial Q^r/\partial p_x$ have the opposite sign. This is not sufficient. For the utility to subsidize x, these two terms would together have to be of sufficient size so that their product exceeds the absolute value of Q^x, the demand for x the regulated firm faces at c_x and p_r.

These results indicate that a utility will subsidize only complements ($\partial Q^r/\partial p_x < 0$) if the price is above marginal cost, and may subsidize substitutes ($\partial Q^r/\partial p_x > 0$) only if the price is below marginal cost. If a utility is not in the energy-selling business but sells only distribution, the marginal cost of additional energy use is essentially zero, implying that under price caps it will only subsidize complements, not substitutes (e.g., conservation). As with demand-reducing information, the firm will subsidize goods and services that reduce electricity use only if the price is below marginal cost. This is qualitatively consistent with the "theory of the second best," which indicates that one should subsidize complements of a good when its price is above marginal cost and subsidize substitutes for it when its price is below marginal cost.[21] However, because the magnitude of the divergence times the effect on demand has to be, in absolute value terms, not just positive but greater than Q^x, the utility may not subsidize complements or substitutes as much as would be efficient, even if the only distortion is that imposed by the price cap.[22] For example, it may under-promote the use of electricity off-peak and under-conserve the use of power on peak.

[20] As before, assumptions necessary to assume a unique maximizing value of p_x are invoked.

[21] One consequence of this result is that a regulated entity subsidizing its own complements or substitutes may not be motivated by anticompetitive concerns—such as exploiting market power over distribution by vertically integrating into a complement market and using cross-subsidies to suppress competition in that market (Brennan 1990). It could reflect a response to reduce the inefficiency of distortions in regulatory pricing.

[22] Unless the utility bears environmental costs through a tax or permit program that raises energy prices, it will not take those external costs into account in deciding if it would be better off subsidizing substitutes.

Optimal Efficiency Subsidies

The analysis of the propensity of price-capped utilities to subsidize substitutes leads to the larger question of when and whether energy efficiency should be subsidized at all. This is a natural extension, not just to establish a benchmark for such subsidies generally. Decoupling is part and parcel of a general interest in reducing electricity demand. In modeling these arguments, we introduce a general feature, not included in the above models, that drives much of the argument: that subsidies are needed to induce people to make energy-efficiency purchases (e.g., compact fluorescent light bulbs, high efficiency air conditioners). Following the perspective of energy efficiency advocates, we posit that such purchases would make people better off, but for some reason, despite these benefits, people fail to make them. Such an assumption (or perhaps a utility bias in information provision, as modeled above) turns out to be necessary to explain how a demand-reduction advocate can simultaneously argue that consumers use too much electricity and that the price of electricity is too high.[23]

For notational convenience, we assume a continuum of consumers indexed along the line from 0 to 1. For modeling convenience, we also assume that the consumers have identical demand functions for electricity, given levels of efficiency investments. The only difference among consumers is that only a fraction $t(p_x)$ takes advantage of efficiency investments, where p_x is the price consumers pay for efficiency investments. Having covered utility incentives to distribute information above, and focusing on subsidies here, we assume $t' \leq 0$, i.e., that subsidies induce more consumers to take advantage of efficiency investments the lower the price. Portraying consumers as otherwise identical reflects the view that such investments are equally beneficial to all. The only difference is that for exogenous reasons, such as cognitive limitations or insufficient information, a fraction of $1 - t(p_x)$ does not bother to take advantage of those investments.

As above, we let p_r be the price per kWh of electricity, capped by regulators. We let $x(p_x)$ be the amount of efficiency equipment or investment purchased by the $t(p_x)$ fraction of consumers

[23] Such a claim is quite common, particularly in states where residential rates have dramatically risen as regulations expire that fixed prices for a time period following initial opening of retail markets to competition. Martin O'Malley, the current governor of Maryland who has proposed an "EmPower Maryland" to program reduce per capita electricity use 15% by 2015 (MEA, 2008 at 21), campaigned on a platform emphasizing that consumers were paying too much for electricity. See his campaign's online article, "Defending Maryland Against Rising Energy Prices," http://www.martinomalley.com/content/591, accessed July 29, 2008.

aware of efficiency benefits at p_x. The consumer surplus of those who make these purchases will be

$$t(p_x)\int_{p_r}^{\infty} Q(z, x(p_x))dz, \tag{CS1}$$

where $Q(p_r, x)$ is the demand for electricity at price p_r, and with energy efficiency purchases of x.[24] The similar expression for the surplus for those who do not purchase any energy efficiency is:

$$[1 - t(p_x)]\int_{p_r}^{\infty} Q(z,0)dz. \tag{CS2}$$

The total amount of electricity demanded when efficiency investments are priced at p_x will be

$$t(p_x)Q(p_r, x(p_x)) + [1 - t(p_x)]Q(p_r, 0).$$

To calculate total welfare, we add in the profits of selling this electricity at price p_r, which will be

$$p_r[t(p_x)Q(p_r, x(p_x)) + [1 - t(p_x)]Q(p_r, 0)] - c(t(p_x)Q(p_r, x(p_x)) + [1 - t(p_x)]Q(p_r, 0)), \tag{Π}$$

where $c(.)$ is the cost of generating total power demanded.[25] We can also incorporate an externality cost $e(.)$,

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[24] The demand for electricity investments $x(p_x)$ can be derived for these consumers by choosing x to maximize (substituting z for p_r)

$$\int_p^{\infty} Q(z, x)dz - p_x x.$$

The first-order condition defining $x(p_x)$ is

$$\int_p^{\infty} Q_x(z, x)dz = p_x.$$

The marginal increase in surplus from using electricity more efficiently at price p_r just covers the cost of the investment. The demand curve for energy efficiency is negative, i.e., $x' < 0$, if

$$\int_p^{\infty} Q_{xx}(z, x)dz < 0.$$

The more one spends on efficiency investments, the incremental effect on consumer surplus falls.

[25] Since surplus for efficiency is based on quantity, not price, we need only subtract the cost of providing the level of energy efficiency investment, set out below as EC.

$$e(t(p_x)Q(p_r, x(p_x)) + [1 - t(p_x)]Q(p_r, 0)). \qquad \text{(EXT)}$$

Last, we include the cost $h(.)$ of providing the efficiency investments consumers purchase, $t(p_x)x(p_x)$, which is:

$$h(t(p_x)x(p_x)). \qquad \text{(EC)}$$

The monetary value of the subsidy is:

$$[h' - p_x]\, t(p_x)x(p_x). \qquad \text{(SUB)}$$

Because the monetary value of the subsidy is a transfer, we neglect any cost associated with it.[26] We thus choose p_x to maximize welfare $W(p_x)$:

$$W(p_x) = \text{(CS1)} + \text{(CS2)} + (\Pi) - \text{(EXT)} - \text{(EC)}.$$

From these equations, and suppressing some arguments, the derivative of W with respect to p_x is:

$$tx'\int_{p_r}^{\infty} Q_x(z,x)dz + t'\left[\int_{p_r}^{\infty} Q(z,x)dz - \int_{p_r}^{\infty} Q(z,0)dz\right]$$
$$+[p_r - c' - e'][tx'Q_x(p_r,x) + t'[Q(p_r,x) - Q(p_r,0)]] - h'[tx' + xt'].$$

It is useful to separate and collect terms by whether the effect is driven by the change in energy efficiency from those who are already purchasing it (tx'), and whether the effect is driven by the change in those who consume energy efficiency at all (t'). The first set of terms is:

$$tx'\left[[p_r - c' - e']Q_x(p_r,x) + \int_{p_r}^{\infty} Q_x(z,x)dz - h'\right], \qquad \text{(E1)}$$

and the second set is:

[26] A full model including SUB could reflect one of the following:. If the subsidy is paid for out of general revenues, then one would want to include as a cost the burden of the taxes associated with raising the funds to cover these subsidies. If, as is more likely, the subsidies are covered out of ratepayer payments to utilities for electricity (State of California 2002), one would want to add a constraint to the model to the effect that p_r would increase to cover these costs. For ease of exposition, we neglect that exercise here.

$$t'\left[[p_r - c' - e'][Q(p_r, x) - Q(p_r, 0)] + \left[\int_{p_r}^{\infty} Q(z,x)dz - \int_{p_r}^{\infty} Q(z,0)dz\right] - h'x\right]. \qquad \text{(E2)}$$

Consider first the effect on those who are consuming, described by (E1). This effect is similar to the effect described above for the incentives of the price-capped utility to subsidize substitutes for energy use. If the electricity price p_r is correct, equal to the sum of marginal production cost *c*' and marginal externality cost *e*', the first term is zero.[27] If efficiency investments are priced at their marginal cost, *h*', the sum of the last two terms in (E1) is zero because the integral is the marginal benefit of making an additional investment in energy efficiency. If one neglects the effect on inducing more consumers to overcome their cognitive hurdles in order to purchase additional energy efficiency (E2), then there would be no incentive to subsidize efficiency, were prices correct.

Neglecting the increased efficiency adoption effect, for a subsidy of energy efficiency to be optimal—when marginal cost *h*' exceeds marginal benefit, indicated by the integral in (E1)—the first term, $[p_r - c' - e']Q_x(p_r, x)$, would have to be positive for the first-order condition to be zero. If, as is expected, $Q_x(p_r, x)$ is negative, i.e., the energy efficiency reduces energy use at the capped price *p*,[28] the efficiency of subsidizing energy investments requires $[p_r - c' - e']$ to be negative. Demand-reduction subsidies are efficient if and only if prices are too low—less than marginal production and externality cost. This is consistent with the above analysis; as price being too low is usually required to show that consumption is excessive and thus that demand-reducing substitutes merit subsidies.

This result need not hold if the effect of subsidies on inducing additional consumers to adopt energy efficiency, when the benefits to those consumers exceed the costs but for some reason have not yet made such investments, should be factored in. Keep in mind that these added efficiency benefits do not follow from a change in net benefits themselves, which depend on the

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[27] The cost faced by the distribution utility is the wholesale price. We do not distinguish here between short-run and long-run marginal generation costs in setting that price. Overall, wholesale prices of electricity should be high enough not just to cover short run fuel and operating costs but the costs of the generation capacity used to produce that electricity (Brennan 2006).

[28] Energy subsidies can reduce demand for energy at price p_r, yet increase surplus by increasing the value of inframarginal consumption. This is to be expected, given that energy efficiency increases the services rendered by the first units of energy consumed. At sufficiently high prices, $Q_x(p_r, x)$ will be positive, displaying the rebound effect set out in footnote 13.

aforementioned possibility that price is too low because it does not reflect costs at a particular time or negative externalities. Rather, they follow from the posited behavioral effect that too few consumers make efficiency investments that would make them better off.[29] To help understand what is going on, we make a few notational abbreviations. Let the reduction in electricity demanded when people switch from no energy efficiency to making investments at p_x be given by ΔQ:

$$\Delta Q = Q(p_r, x(p_x)) - Q(p_r, 0) .$$

We take $\Delta Q < 0$; those who make energy investments use less electricity. The change in surplus, ΔCS, is given by

$$\Delta CS = \int_{p_r}^{\infty} Q(z, x)dz - \int_{p_r}^{\infty} Q(z,0)dz.$$

We can then rewrite (E2) as

$$t'[[p_r - c' - e']\Delta Q + \Delta CS - h'x].$$

If we calculate (E2) where there is no subsidy, i.e., price equals marginal cost ($p_x = h'$), then the second term is positive. From the assumption that energy investments would be efficient if priced at marginal cost, the incremental consumer surplus from consuming $x(h')$ at that point exceeds the cost of purchasing x. Since $t' \leq 0$, i.e., reducing price leads to more consumers adopting energy investments, we have from (E2) alone that $W' < 0$ from this effect. The subsidy increases welfare by inducing more consumers to act in their own interest.

Increasing the price of electricity p_r mitigates the net surplus effect in (E2). If the electricity price exceeds the sum of marginal production and externality cost, the first term in the brackets is negative (since ΔQ is negative), countering the net surplus effect. With price above marginal social cost, there is too little consumption, mitigating the benefits of efficiency investments.[30]

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[29] One consumer's reduction in demand may benefit others as well, by reducing the quantity of electricity needed to meet demand and thus price.This may increase the net economic welfare of consumers, but not necessarily overall welfare, if the price is depressed below the competitive level as an exercise in monopsony power.

[30] It may help the intuition to note that the same result obtains if marginal production or externality costs are smaller. Either reduces the justification for reducing electricity use through efficiency investment subsidies.

However, the magnitude of the net surplus effect can outweigh this effect in (E2) and (E1) as well. Hence, one can justify subsidies even when the price is too high.

Before accepting that as a policy conclusion, however, four important and perhaps fatal caveats should be kept in mind.

- The analysis neglected the cost to the economy of raising funds to pay for the subsidy, defined in (SUB) above. If the price of electricity p_r is too low and the cost of the subsidy is passed on to ratepayers by increasing p_r, then the subsidy may be beneficial, but that is because of the price effect.[31] It could be just as beneficial if the money raised by the higher prices were spent on building pyramids.

- For the effect to hold, $t' < 0$. If so, for reducing efficiency prices to increase adoption, $t < 1$. In other words, there must be people who do not make utility-maximizing investments. The argument for subsidizing energy efficiency when prices are high requires cognitive shortcomings on the part of electricity users.

- Even assuming that we have such shortcomings, the value of the subsidy depends on the number of consumers it adds, not including those who would have adopted the technology but for the subsidy. In electricity conservation discussions, misinterpreting t' as t is known as the “free rider” effect. In one regulatory docket in Maryland, the case for allowing utilities to cover the cost of efficiency programs is based on the assumption that no net investments in efficiency would have taken place but for the subsidies, i.e., that $t(h') = 0$ (MDPSC 2008, 24–25).[32]

- A positive net benefit of efficiency subsidies depends on their being beneficial even if efficiency investments were not subsidized, i.e., that $\Delta CS > h'x$. It is not enough to argue that consumers are better off by making efficiency investments at subsidized prices.

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[31] A similar benefit would be realized if prices were too low, when reduced usage induced by efficiency measures raises the price necessary to cover distribution costs.

[32] The justification is that the “free riders” who would have made the investments anyway are balanced out by “spillovers,” which can be defined as “changes in participant behavior not directly related to the project, as well as to changes in the behavior of other individuals not participating in the project,” i.e., nonparticipants (Vine and Sathaye 1999, 6).

Conclusion

Decoupling revenues or profits from output, so that revenues or profits are fixed, is an increasingly consequential policy tool in discussions of electricity use and conservation. It challenges the conventional wisdom in regulatory economics that fixing prices instead of profits improves efficiency by eliminating distortions in input choices, when allowed profits rates are specified erroneously and incentives are restored to cut costs that profit controls eliminate. We identify the following considerations that should be incorporated in any assessment of decoupling:

- Even when all costs are independent of use, usage fees (rather than fixed revenues per customer that are decoupled from use) may be efficient if the fixed fees equal to the marginal cost of an additional user are insufficient to cover total costs.
- Decoupling advocates are correct that, under price caps, utilities have incentives to supply only demand-increasing information when prices are above their marginal costs. This may increase efficiency by increasing demand when prices are too high. When prices are below cost, particularly at peak periods, utilities will have an incentive to supply demand-reducing information.
- Under price caps, utilities may subsidize energy efficiency investments. Doing so would be in the direction suggested by the theory of the second best: They will subsidize investments, as substitutes for electricity at the margin, only when price is below cost. If prices exceed marginal costs, utilities will subsidize complements to boost demand.
- The case for subsidizing energy efficiency investments when prices are high requires that consumers fail to make investments that, without the subsidy, would benefit them—and that increasing the level of subsidies induces additional consumers to do so.[33]

[33] A task for future research is to link the assortment of proposed cost-effectiveness tests for ratepayer-funded utility energy efficiency programs (State of California 2002) to the criterion for efficient efficiency subsidies provided here.

As noted above in the discussion of information provision, utility associations, policy observers, and conservation advocates have claimed that decoupling—replacing price caps with profit caps—is not sufficient to induce additional efficiency investments by utilities themselves (Carter 2001; CEEP 2005, 3; EEI 2007, 11; Sotkiewicz 2007). If conservation investments are desirable, and utilities are the ones that should make them, then utilities will require an affirmative reward, and not just the elimination of an incentive, to provide only information on the benefits of electricity use.

Perhaps more important is the implicit, and sometimes explicit, reallocation of responsibility for consumption decisions. This is illustrated by the contrast between benefits of true decoupling of profits or revenues from use—eliminating usage charges altogether—and incentives regarding information. It is even more salient in the finding that efficiency investments merit subsidy only to the extent that such subsidies induce people to make investments that would have benefited them without the subsidies.[34] With all the information on energy efficiency that is available, the conventional presumption is that consumers have the information to make choices, and the job of policy makers is to get prices right. It is hard not to get the sense that the political attractiveness of blaming anyone but consumers for their choices—to avoid having consumers face the true cost of their energy use and to shift the responsibility for using less from users to suppliers—drives the demand for decoupling.

However, political considerations suggest an important aspect of the decoupling discussion that our economics focus may miss. The main reason for decoupling profits from use may not be to change the behavior of utilities in the marketplace. Rather, the importance of decoupling may be political. If utilities are not "held harmless" were efficiency policies to be enacted, they would be expected to oppose them. To the degree they have political clout, neutralizing that opposition through profit guarantees may be warranted if the utilities would otherwise block desirable efficiency policies.

Such considerations form a general rationale for compensating politically powerful parties who lose under changes in regulatory policy (Brennan and Boyd 2006). This is not the first time such considerations have played a role in the development of electricity policy. Commitments to

[34] A topic for future research is the extent to which conservation policies are driven not by efficiency but by monopsony (see footnote 28), where reduced demand maximizes consumer benefit (but not overall economic benefit) by forcing prices below competitive levels.

compensate utilities for stranded costs—losses incurred as a result of moving from regulation to competition—were important in fostering deregulation, regardless of the economic merits of whether such compensation should be part of an implicit contract between utilities and their regulators (Brennan and Boyd 1997).

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