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PRICING POLICY IN THE PRESENCE OF PRO-ENVIRONMENTAL CONSUMERS

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Pricing Policy in the Presence of Pro-environmental Consumers

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Abstract: In response to the climate change issue, many electric utilities introduce price schemes for inducing their customers to reduce electricity consumption. When a significant fraction of consumers find costly to save electricity, one would expect utilities to 'pay' them to use less electricity. This paper suggests a model that helps to understand why a typical electric utility may rather prefer to price discriminate against its pro-environmental customers, by increasing the price of electricity for these latter. This result holds even when the utility is charged for its greenhouse gas emissions. But in this case the price increase is sufficiently small so as to induce energy saving also from customers who have a positive cost of doing so.

Keywords: pricing structure, environment, electricity, consumer switching costs

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1. Introduction

In accordance with the general concern about climate change, consumers are urged to save energy resources. Many studies confirm that appropriate incentives must take into account not only households' financial constraints but also demand inertia (Department of Energy & Climate Change, 2009). Some structural strategies have therefore been implemented to make energy conservation more attractive to households (Steg, 2008). A strand of the literature focuses on the opportunities afforded by digital communication technologies and time-variable tariffs (Wall and Crosbie, 2009; Kiesling, 2008). Another strategy is to increase the cost of energy through taxes on the consumption of fossil fuels by households, yet their levels still remain controversial as evidenced in the current debate in France (Kanter and Saltmarch, 2009). Finally, many governments have policies to promote more efficient product choices such as, labeling and free-rebate combination on purchase of energy-efficient appliances (David Suzuki Foundation, 2007).

In this paper we focus on price-oriented mechanisms whereby electricity utilities design new tariffs aimed at inducing lower electricity use. In this respect, one concrete example attracted our attention. When the French residential electricity market opened up to competition, a new entrant retailer, Poweo introduced one innovative time-of-use tariff with discounted running charges for its new customers provided they do not consume more than a contracted amount. Two years or so later, Poweo removed this rewarding scheme! This example suggests either that Poweo's tariff was merely a means to attract customers. It could also suggest that Poweo's new customers spent more on electricity than they budgeted for, notably if we consider that they had to make effort to reduce their electricity use.

Reversing this practice leads to an increase in the price of electricity at higher consumption levels. To mention a few examples, in 2008 one Canadian utility (BC Hydro, 2008) introduced a block-inclining tariff, and that was revenue-neutral to it, similar to that faced by most Californian electricity consumers (Reiss and White, 2005). Such tariffs also exist in Japan, for Tokyo Electric Power Company's customers who subscribe to the monthly Meter-Rate Lighting tariff. With this tariff households are charged the first 120 kWh at yen 17.87/kWh (nearly 20 cents with January 2010's exchange rates), increasing 23% up to 300 kWh and 5% above that level. One reason to believe that penalizing pricing structures could be efficient tools for inducing energy conservation is suggested e.g. in Thaler and Sustein (2009) who assert that energy conservation methods framed in terms of losses are effective nudges because most people are loss averse.

Overall, these pricing strategies suggest that the structure of electricity tariffs has unavoidably to adapt to the need for inducing consumers to reduce their electricity use. The present paper suggests a theoretical model for analyzing the pricing policy of an independent electric utility when it has as objective to induce its customers to conserve energy. Our analysis relies on the assumption that there is a continuum of consumers differentiated by their attitude towards the environment akin to the cost of switching between two brands

(Chen, 1997; Klemperer, 1987). A central finding here is that a first-best optimum exists where only consumers who attach a 'non-negative' value to environment protection are charged for energy conservation. This result holds even when the firm has to pay a price for its greenhouse gas emissions. In this case, the firm charges a lower penalty so as to induce energy saving from of a fraction of its customers who have a positive cost of doing so.

The rest of the paper is organized a follows. Section 2 supports the assumption that reducing energy consumption involves behavioral costs. Section 3 provides our model. Section 4 discusses the policy implication of the results and possible directions for future research.

2. Barriers to Households Energy Saving

The environmental economics literature is replete with empirical studies on barriers to investment in demand-reducing equipments, such as Banfi et al. (2008) for residential building and Wall and Crosbie (2009) for electricity demand reduction in lighting. Attempts to explain demand inertia in the field of electricity consumption is not new to the literature. Though not directly related to energy saving, Taylor (1975) provides an earlier reference where the role played by habit formation is given as an explanation of the small value for own-price elasticity estimates in the short run. More recently, Maréchal (2009) surveys the energy economics literature on habits as an important factor to understand the limited effectiveness of energy saving incentives provided by policy makers. This is supported by empirical evidence found in Japan that most customers do not care a great deal about their electricity expenses because they routinely use electricity every day (Yamamoto et al., 2008). Even in the longer run, purchases in energy-efficient appliances may not lead to a reduction in energy demand. One mechanism underlying this effect is called the "direct rebound effect". It is such that "[i]mproved energy efficiency for a particular energy service will decrease the effective price of that service [,which] leads to an increase in consumption of that service." (Sorrell and Dimitropoulos, 2008, p. 637).

Few of the studies however provide theoretical underpinning for the empirical evidence. Brennan (2009) considers energy efficiency investments by consumers who do not bother to take advantage of energy efficiency investment because of incomplete information or inability to translate that information into beneficial action (evidence of such barriers are supported in Banfi et al., 2008). In his model, a fraction of consumers are not choosing to invest despite they would be better off doing so. A rationale for this is the little awareness of consumers of the energy efficiency of electricity-using appliances (Yamamoto et al, 2008; Steg, 2008 and see the references therein). Another reason could be that electricity is not visible, so consumers do not know when they are using a lot of it (Thaler and Sustein, 2009). Although we adhere to these factors, here we take a different route than Brennan (2009) who considers transport rather than switching costs. In the model that follows, 'under-saving' in energy may simply reflect a transaction cost akin to the cost of switching between two identical products. One reason for this kind of inertia could be people's desire to reduce cognitive dissonance or the psychic 'cost' of exposure to information dissonant with maintaining one's current consumption behavior (Akerlof and Dickens, 1982). For example, it is likely that consumers who discard a potentially energy-saving tariff and have a tendency to go along with their default tariff simply want to avoid the discomfort of learning the amount they could have saved on their bill. Another possible barrier to energy saving is the existence of efforts of optimizing under different tariffs (Train, 1994). As asserted by this author, these efforts are essentially the cost and time of learning about a tariff.

3. Pricing Policy when Consumers have Different Attitudes towards the Environment

Rather than attempt to consider the potential for energy saving through investment in energy-efficient technologies or technology substitution, we try to focus on waste reduction. We assume identical customers who use an amount of electricity equal to $(1+\delta)q^*$, where $\frac{\delta}{1+\delta}$ is the fraction of electricity used that is wasted. As electricity is used at the very instant it is transmitted to consumers, they cannot engage in resale. Wastefulness in this model is captured in the following assumption that consumers only derive a satisfaction from the services they actually use. To capture the observation that electricity demand is not very elastic in the short run, q^* is considered fixed. Formally, utility is $U(q^*)$ which we denote by U^*. It is also the consumers' reservation value and q^* is common knowledge. There is a continuum of consumers of measure 1, each of whom and is characterized by its cost to reduce her consumption from $(1+\delta)q^*$ to q^*. Choe and Fraser (1999) use a similar assumption in a model of waste management with a representative household whose waste depends on a positive waste reduction effort.

Here, the cost to reduce electricity consumption is a fixed cost per unit of electricity saved akin to the cost of switching between brands of products that are ex-ante undifferentiated. As suggested in Klemperer (1987, footnote 6, p. 378), in our single-period model, the role of consumer switching cost is quite similar to horizontal product differentiation. We prefer to consider those costs as 'transportation costs' à la Klemperer as wasted and non wasted electricity are exactly the same products. However, Unlike Choe and Fraser (1999) and actually almost all papers on consumer switching cost, this cost can be negative. We denote it by s . The rationale for our weaker assumption is that s is a gross cost to spend time or efforts in saving energy less the value attached to environment protection. This 'net cost' could be for example the psychological cost to turning off the lights in unoccupied rooms less the value attached to such action. For consumers who have a negative attitude towards the environment, the difference is positive whereas it is negative for pro-environmental consumers. This assumption borrows from Green (2000) who models competition between electricity retailers when consumers have switching costs. He distinguishes between the consumer's cost of switching the incumbent and the added value of buying from a new entrant. But the difference between them is assumed to be always positive in Green's model. s is thus an independent realization of a random variable S that is uniformly distributed on $[-\theta,\theta]$ for convenience, where $\theta > 0$.

The firm introduces an optional tariff $pq^* + f - m$, where p and f are the unit and standing charges of the old tariff, and m is a discount payment offered to customers who switch to this optional tariff provided they reduce their consumption to the level q^*. By introducing this new tariff, the firm can price discriminate between its customers who will sort themselves depending on their cost to save electricity. U^*, p , f and *s* are in monetary terms and we assume that $\theta \geq p$ and that $U^* > \theta\delta q^*$. A consumer is indifferent between switching to the new energy-saving tariff and continuing to waste electricity if s is such that $U^* - pq^* - f + m - s\delta q^* = U^* - p(1+\delta)q^* - f$, which leads to $s = p + \frac{m}{\delta q^*} \equiv \tilde{s}(m)$. Therefore, all consumers whose switching cost is higher than $\tilde{s}$ stay on the old tariff. We can see immediately that the number of switchers increases with the discount payment. In the remaining of this section we shall calculate the discount payment and the corresponding fraction of energy savers under various situations.

Case1 (all consumers switch). A first interesting solution is to determine the discount payment m^* such that all customers reduce their consumption to q^*. It suffices to set $\tilde{s}(m^*) = \theta$, which leads to $m^* = (\theta - p)\delta q^*$. The firm's profit takes the simple form $pq^* + f - m$ that is equal to $p(1+\delta)q^* + f - \theta\delta q^*$, the profit before it introduce its new tariff, less the amount $\theta\delta q^*$. As we can see, unless it is subsidized, the firm won't offer m^*. Following Fudenberg and Tirole (2000)'s argument, this suggests that Poweo's attempt at paying customers to switch can be a "mitake" equilibrium. Besides, this situation is inefficient for consumers whose $s > 0$, which implies a deadweight loss that is equal to $\int_0^{\theta}\left(\frac{s}{2\theta}\right)ds = \frac{\theta}{4}$. Given the presence of pro-environmental consumers who count for half the market, overall there is no deadweight loss overall. This can be seen from the calculation of total surplus that remains unchanged. It is equal to U^* since the amount $\theta\delta q^*$ also represents the change in consumers' surplus relative to the situation before the introduction of the new tariff.

Case 2 (monopoly). Let us consider the case now where the firm behaves as a monopoly that has some power over its customers. We denote by α the share of customers who stay on the old tariff and $1-\alpha$ the fraction of consumers who opt for the energy-saving tariff. These shares will depend on the value of m set by the firm. The share α of consumers who stay on the old tariff is given by:

$$\int_{\tilde{s}}^{\theta}\frac{1}{2\theta}ds = \frac{1}{2} - \frac{1}{2\theta}\left(p + \frac{m}{\delta q^*}\right), \tag{2}$$

provided $\theta \geq p + \frac{m}{\delta q^*}$. Since the firm serves all its customers, then $1-\alpha$ is equal to 1 minus the above expression. The utility maximizes its profit with respect to m where its profit is given by:

$$[p(1+\delta)q^* + f]\alpha + [pq^* + f - m](1-\alpha) \qquad (3)$$

The first order condition for profit maximization leads to:

$$m^* = -\left(p + \frac{\theta}{2}\right)\delta q^*. \qquad (4)$$

The discount payment is negative, which means that consumers who switch to the new tariff are charged more. As $S(m^*) = -\frac{\theta}{2}$, it follows that these consumers are only those who attach a high value to energy-saving switch to the energy saving tariff. As the population of consumers is distributed on the interval $[-\theta, \theta]$ we can deduce easily that these consumers represent only one fourth of the total. One can also verify that the change in firm's profit is $\frac{\theta \delta q^*}{8}$. Thus, the firm can make profit by inducing only a small fraction of its consumers to save energy. This would suggest that penalizing pricing structures may be more robust than rewarding ones in decentralized markets. Note that when switching costs approach zero, $m^* \uparrow -p\delta q^*$, and $S(m^*) \uparrow 0$. The extra charge applied to switchers approaches the revenue lost on them that is the monetary value of the electricity no longer wasted, $p\delta q^*$.

We shall examine two further cases. The former (*Case 3*) is inspired by the decision in 2008 of the Canadian's utility BC Hydro to introduce an energy-saving tariff that, as we mentioned in the introduction of this paper, was revenue-neutral to it. Then we consider revenue-neutrality assuming the firm is emitting greenhouse gases, which it is charged for (*Case 4*).

Case 3 (revenue-neutrality). Setting (3) equal to $p(1+\delta)q^* + f$ leads to $m^* = -p\delta q^*$. In this situation, half the consumers adopt the new tariff ($S(m^*) = 0$). It turns out that this situation is also Pareto Optimal in the sense that the discount payment maximizes the sum of consumers' surplus and firm profit. This qualitative result is similar to that found in Choe and Fraser (1999). But in that paper all households make a positive waste reduction effort, implying that a first-best can only be achieved using environmental tax on the firm and a waste collection charge. Note that the result we obtain under revenue-neutrality is not only optimal but also distribution free in that it does not depend on the distribution that specifies the cost to consumers to save electricity.

Case 4 (revenue-neutrality with a charge for greenhouse gas emissions). The optimality of revenue-neutrality invites us to see what would be the value of the optimal discount payment in the more realistic situation where the firm has to pay a cost for emitting greenhouse gases. Let us therefore assume that δq^*, the amount of waste before the introduction of the new tariff, produces a quantity $\beta\delta q^*$ ($\beta < 1$) of greenhouse gas emissions. And, denote c the corresponding per unit price ($c < p < \theta$) which is exogenous. A rationale for considering δq^*

as the only source of externalities is that this quantity is produced from fossil-fuel plants whereas q^* is produced from say, nuclear plants. The firm's profit is now:

$$[p(1+\delta)q^* + f - c\beta\delta q^*]\alpha + [pq^* + f - m](1-\alpha).$$

Under the constraint that the firm keeps its revenue equal to $p(1+\delta)q^* + f - c\beta\delta q^*$, we obtain $m^* = (c\beta - p)\delta q^*$. The discount payment is still negative but it leads to more energy conservation ($\hat{s} = c\beta > 0$). This shows that when the utility has to pay a price for its greenhouse gas emissions, its discount payment is still negative, but it is sufficiently low for inducing a fraction of consumers who attach a negative value to the environment to save energy. We can compare this result with the effect of a charge for emissions when the firm behaves as a monopoly case. The discount payment would increase and the marginal consumer would be $\hat{s} = c\beta - \frac{\theta}{2}$, the value of which depends on the magnitude of c .

4. Discussion and Conclusion

The first policy implication relates to the rewarding-penalizing debate we introduced at the beginning of this paper. When mandatory to all customers (*Case 1*), rewarding tariffs will not necessarily imply a deadweight loss on the demand side provided the fraction of environmental-friendly consumers is as high as the fraction of consumers whose have to pay a switching cost to use less electricity. Unless the firm attaches a high positive value to the environment or it is subsidized, which we have not considered here, this strategy is not sustainable however. In fact, in a decentralized environment and when the firm has some market power over its customers (*Case 2*), it is optimal to it to penalize its pro-environmental customers, which comes at the expense of environmental protection since only one-fourth of the consumers reduce their consumption from $(1+\delta)q^*$ to q^*. As we have shown in *Case 4*, charging the firm for its greenhouse gas emissions can improve the situation, for the introduction of a charge on the firm's greenhouse gas emissions forces it to induce a fraction of consumers who make a positive effort to conserve energy. But now there would be a trade-off between consumption efficiency and the deadweight loss due to switching from consumers who have to pay a cost to use less electricity.

These results also lead us to discuss the usual assertion that measures taken to protect the environment imply sacrifices of one's comfort (Hansla et al., 2008). Except in *Case 4* there is no consumer sacrifice in the model, for consumers who reduce their electricity consumption are always those who attach a positive value (negative switching costs) of doing so. Thus in terms of policy implication this result claims for increasing the share of these latter by converting the others to switch to environmental-friendly ways of using electricity. This undoubtedly requires changes in preferences as asserted by Stern (2008). This kind of psychological strategy is precisely what governments in many countries have been trying to achieve through conservation campaigns ". . . aimed at changing people's knowledge, perceptions, motivations, cognitions and norms related to energy use and conservation." (Steg, 2008, p. 4450; see also Banfi et al., 2008, p. 515).

The results of our model have relied on a one-period framework and a simple pricing structure. To assess their generality one could assume that U is a continuous function. If consumption is made up to the point where marginal willingness to pay equals price, then the optimal consumption level, q^{**}, would be such that $U(q) - pq - f + s(q - q^{*})$ reaches a maximum, with q^{*} the level of electricity consumption when $s \leq 0$. Ignoring further constraints, the first order condition is $U'(q^{**}) = p - s$. It is noteworthy this point corresponds to a lower slope than the point q^{*}. Thus assuming a disutility to save energy straight in the utility function can straightforwardly explain why consumers resist to save electricity. Second, one could design a more sophisticated model with several competing firms that set the optimal level of both the access fee and one or more running rates. But, a further inertia that would have to be considered then is brand switching. Finally, one could consider a full contractual framework of the effort made by households to reduce electricity consumption. The problem could be one of hidden-information where households have private information about their attitude towards the environment. Moral hazard (hidden action) could also be important an issue here, although with today's enabling technologies the firm can have at its disposal all the information regarding the volume of electricity used by its consumers. There is one piece of information not likely to be available to policy makers, and that should be hard to contract for, namely electricity waste which should remain a genuine impediment to energy conservation.

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References and Notes

Akerlof, G.A., Dickens, W.T. The economic consequence of cognitive dissonance. *The American Economic Review* **1982**, *72*, 307-319.

Banfi, S., Farsi, M., Filippini, M., Jakob, M. Willingness to pay for energy-saving measures in residential buildings. *Energy Economics* **2008**, *30*, 503-516.

BC Hydro. 2008 residential inclining block application, 2008, http://www.bchydro.com/etc/medialib/internet/documents/info/pdf/info_2008_residential_inclining_block_application.Par.0001.File.info_2008_residential_inclining_block_application.pdf, **2008**, last access: January 2010.

Brennan, T. Optimal energy efficiency policies and regulatory demand-side management – How well do they match? Resources for the Future discussion Paper **2009**, No. 08-46, www.rff.org/RFF/Documents/RFF-DP-08-46.pdf, last access: January 2010.

Chen, Y. Paying customers to switch. *Journal of Economics & Management Strategy* **1997**, *6*, 877-897.

Choe, C., Fraser, I. An economic analysis of household waste management, *Journal of Environmental Economics and Management* **1999**, 38, 234-246.

David Suzuki Foundation. Switch Green – Energy Star Appliance feebate, An analysis prepared for the David Suzuki Foundation by Mark. K. Jaccard Associates Inc., **2007**.

Department of Energy & Climate Change. Smart demand. In *Delivering Secure Low Carbon Electricity: a Call for Evidence*, **2009**, Ch. 4, URN 09D/736.

Fudenberg, D., Tirole, J. Customer poaching and brand switching. *Rand Journal of Economics* **2000**, 31, 634-657.

Green, R. Can competition replace regulation for small utility customers? Center for Economic Policy Research's discussion paper, No. 2046, 2000.

Hansla, A., Gamble, A., Juliusson, A., Gärling, T. Psychological determinants of attitude towards and willingness to pay for green electricity. *Energy Policy* **2008**, *36*, 768-774.

Kanter, J., Saltmarch, M. More in Europe look to carbon tax to curb emissions, *The New York Times*, 10th September **2009**, http://www.nytimes.com/2009/09/10/business/energy-environment/10carbon.html, last access: January 2010.

Kiesling, L. Retail electricity deregulation: prospects and challenges for dynamic pricing and enabling technologies, Draft prepared for the Searle Center Annual Review of Regulation, 2007, last access: November 2008.

Klemperer, P. Markets with consumer switching costs. *Quarterly Journal of Economics* **1987**, *102*, 375-394.

Maréchal, K. An evolutionary perspective on the economics of energy consumption: the crucial role of habits. *Journal of Economic Issues* **2009**, *43*, 69-88.

Reiss, P.C., White, M.W. Household electricity demand, revisited. *Review of Economic Studies* **2005**, *72*, 853-883.

Sorrell, S., Dimitropoulos, J. The rebound effect: microeconomic definitions, limitations and extensions. *Ecological Economics* **2008**, *65*, 636-649.

Steg, L. Promoting household energy conservation. *Energy Policy* **2008**, *36*, 4449-4453.

Stern, N. The economics of climate change, *The American Economic Review* **2008**, 98, 1-37.

Taylor, L.D. The demand for electricity: a survey. *Bell Journal of Economics* **1975**, *6*, 74-110.

Thaler, R.H., Sustein, C.R. *Nudge: Improving decisions about health, wealth and happiness*, 1st Ed., Penguin Books: London, England, 2009, pp. 40, 206.

Train, K.E. Self-selecting tariffs under pure preferences among tariffs. *Journal of Regulatory Economics* **1994**, 6, 247-264.

Wall, R., Crosbie, T. Potential for reducing electricity demand for lighting in households: an exploratory socio-technical study. *Energy Policy* **2009**, *37*, 1021-1031.

Yamamoto, Y., Suzuki, A., Fuwa, Y., Sato, T. Decision-making in electrical appliance use in the home. *Energy Policy* **2008**, *36*, 1679-1686.