Onsite Backup Generation and Interruption Insurance for Electricity Distribution*

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This paper extends recent work on interruption insurance for electric power by introducing onsite backup generation capacity as a supplementary form of interruption insurance. The basic model of interruption insurance as a mechanism for differential pricing is reviewed, the incentive for providing onsite backup generation capacity is demonstrated and the interaction between onsite backup generation and interruption insurance is analyzed. Two types of onsite backup, customer and utility owned, are discussed. It is shown that individuals' economic incentives to install onsite backup generation dominate the utility's incentive. Hence customer owned onsite backup decisions will pre-empt the utility's plan to mitigate compensation payments by providing onsite backup generation.

INTRODUCTION

Many factors, including poor forecasting of load demand in the 1970s, have left some utilities in the position of excess capacity while others -- many northeastern U.S. utilities in particular -- lack the new capacity necessary to maintain today's standard of reliability into the 1990s even with moderate demand increases. Different load management strategies, cogeneration, wheeling of power and uncertainty in the regulatory front characterize this new environment. This situation has encouraged a wide variety of responses from both utilities and consumers.

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Within this complex new environment, and in reality as a response to these pressures, it is now being recognized that electricity is in fact a *bundle* of different characteristics (time of delivery, voltage, reliability, etc.). Utilizing this notion of unbundling the characteristics of electricity, Oren and Doucet (1990) develop a conceptual model of interruption insurance for generation and distribution of electric power. The main contribution of that model, which extends earlier results of Chao and Wilson (1987), is to show that a priority service tariff consisting of a service charge and an insurance premium can induce self-selection by consumers and efficient supply rationing by the utility. The insurance premium is actually comprised of two portions: a priority charge and an actuarially fair premium. The priority charge, as in Chao and Wilson, determines the reliability of generation (i.e. probability of forced interruption) while the insurance premium insures against interruption, accounting for the reliability implicit in the consumer priority selection. It is because of this interdependence of the risk of interruption and the compensation selection that the total tariff is not itself actuarially fair. The tariff does, however, induce a rational expectations equilibrium in which consumers with a valuation for electricity above a certain threshold limit select compensatory insurance. This scheme is shown to be Pareto superior to the status quo of random rationing with a uniform service charge.

Though interesting, this interruption insurance scheme is rather limiting because consumers have only one option when responding to unreliable service, which is to purchase the utility's compensatory insurance. It is, in fact, more realistic to consider other options, such as the installation of onsite backup generation capacity by either the utility or the consumer.[1] In this paper we show that under the same rational expectations conditions as in Oren and Doucet there exists a threshold level valuation, dependent on the local distribution reliability, such that all consumers with valuations above the threshold install onsite backup. As in the first paper, we focus on social welfare maximization as the objective of the utility, allowing for the possibility of revenue constraints.

The next section briefly reviews the main points of the original model in order to establish the framework in which the notion of onsite backup is introduced. Following this the notion of onsite backup generation capacity, as a supplemental form of interruption insurance, is motivated. The modifications to the insurance tariff are presented, and consumer behaviour is studied.

1. Of course it is also possible to improve the capacity or reliability of central generation, or the distribution system. However, there do exist many situations where onsite capacity is the most viable option (computer systems are a good example) and hence it is relevant to focus on the production of onsite backup.

PRIORITY PRICING THROUGH INTERRUPTION INSURANCE

This section introduces, and briefly reviews, the conceptual model of Oren and Doucet (1990). We consider a model in which it is assumed that all consumers are risk averse and each consumer requires one unit of power for a specific duration (i.e. some unspecified, but fixed, period of time). In this sense the model is a static allocation mechanism. The assumption of a single unit of consumption is actually far less restrictive than it might appear since the latest electronic metering devices make it possible for users to stratify their demand in many ways (see, for example, Rosenfeld *et al.*, 1986, or Electrical World, 1990). It does, however, impose the assumption of constant returns to scale in production.

Consumers are assumed to differ in two very important characteristics: the benefit that they derive from uninterrupted service and the reliability of the distribution system through which power is delivered to them. Let v denote the type of consumer whose valuation, net of supply cost, for one unit of uninterrupted service is v, $v \in [O,V]$. The second attribute differentiates consumers according to the reliability of the electricity distribution system serving their location. Without loss of generality, a location is labelled by its particular distribution reliability P. The two attributes mentioned above uniquely determine the consumer type denoted (v, P).

As in the classical principle-agent problem (see, for example, Grossman and Hart, 1978), while the value of P for each consumer is assumed to be public information, each consumer's valuation of the uninterrupted service is private. As is usual, it is assumed that the distribution of consumer types is known, and is given by the function $H(v|P)$, where $H(v|P)$ = the number of consumers (i.e. potential load, since each consumer demands a single unit) with distribution reliability P having valuation v or higher $(H(V^+|P)=O)$.

Characterizing the reliability of the generation system, as seen by consumers, is somewhat more involved and actually depends on the compensation level chosen by the particular consumer. The compensation level, it will be shown, depends on the backup decision and hence on the consumer's potential loss u. Whereas in Oren and Doucet there was a one-to-one relationship between valuation and interruption loss ($u=v\text{-}s$, where s is a service charge), the addition of onsite backup will allow different consumer valuations to choose the same level of compensation. The effects of this realignment of compensation selection, and hence priority levels, is the main focus of the paper.

Let $Q(c)$ denote the probability that a consumer selecting compensation level c will not be interrupted due to a generation shortfall. The function $Q(c)$ is derived endogenously, assuming that the selected compensation by consumers fully reveals their potential interruption losses u and that this signal is utilized by the utility to ration the available power efficiently by interrupting consumers in increasing order of their interruption losses. Consumers are assumed to know $Q(c)$ either through rational expectations or from forecasts provided by the utility.

The overall supply capability of the generation system relative to the demand, *including* the mitigating effect of onsite backup generation, will be characterized in our model in terms of a function $r(u)$, where $r(u)$ = the probability that the utility's central generation system can supply all units with interruption losses of u or higher.[2]

Alternatively $r(u)$ may be interpreted in a spot market context as the probability (or fraction of time) that the market clearing spot price does not exceed value u. Naturally, since onsite backup generation mitigates interruption losses of consumers with such capability, the function $r(u)$ will be affected by the decision of consumers or the utility to install onsite backup generation. In turn, this decision and the interruption insurance premiums depend on $r(u)$. Hence, one of the main objectives of this paper is to characterize an equilibrium in which the amount of onsite backup generation, the interruption insurance premiums and the function $r(u)$ are consistent with each other.

Let $c(u)$ denote the mapping defining the compensation c selected for a unit with interruption losses u. This mapping is determined endogenously from consumer's self-selection in response to the posted tariff. Then the service reliability, provided by the generation system for a unit with interruption loss u, under efficient rationing must satisfy

$$Q(c(u)) = r(u). \tag{1}$$

In order to enable efficient rationing of electricity in the case of generation shortfall, it is required that the tariff structure induce truthful revelation of consumer's interruption losses through choices of c, the compensation level. In particular, the tariff should offer incentives such that each consumer makes a compensation choice which truthfully reveals his interruption losses, independently of the location parameter P. This will permit the utility to efficiently ration electricity by way of minimizing compensation payments, i.e. interrupting consumers in the order of selected compensation levels. Furthermore, since the utility is risk neutral whereas consumers are risk averse, a socially efficient tariff should induce transfer of risk to the utility through full insurance. This is the classical risk-sharing objective of principle-agent theory.

The proposed tariff consists of two parts. The first is a service charge s in excess of the supply cost, paid only when service is delivered. The second element of the tariff is an insurance premium $f(c,P)$ depending on both the selected compensation and the distribution reliability, paid whether service is

2. We refer here to social loss. Customer interruption losses will depend on service charges paid upon delivery of service.

delivered or not. In the event of a failure, in either generation or distribution, the consumer receives the preselected level of compensation c. The task of the utility is to select $f(c,P)$ so as to induce a self-selection mapping $c(u)$ which meets the criteria specified above. The existence of a rational expectations equilibrium meeting the above criteria was established by Oren and Doucet for a premium schedule of the form:

$$f(c,P) = c - P \int_{s}^{c+s} r(u)du. \tag{2}$$

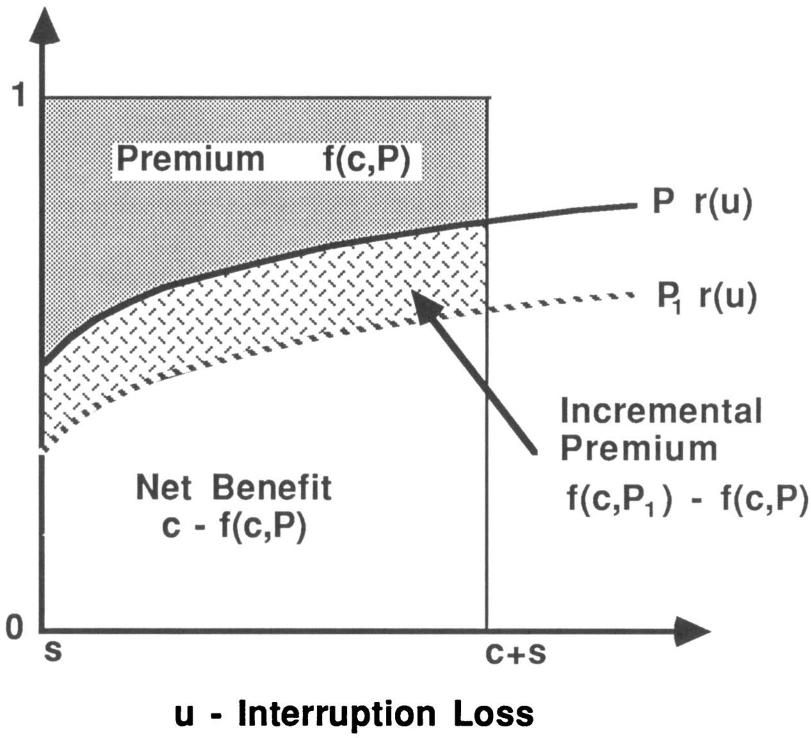
This premium will be referred to throughout the remainder of this paper as the "efficient premium." The efficient premium accomplishes two economic goals. First, it makes the consumer's chosen compensation level an accurate ordinal signal of his interruption losses, independent of the different spatial probabilities of the distribution system. It thus permits the utility to efficiently select the consumers to be interrupted in the event of a power shortage. Second, it induces risk averse consumers to purchase full insurance and hence arrives at an efficient risk sharing arrangement with the risk neutral utility. It is also of note that the given mechanism is informationally efficient in that the utility need not know the consumer's individual interruption losses or whether they own onsite backup generation but only their chosen compensation in order to make socially efficient interruption decisions. Figure 1 illustrates graphically the relationship between the function $r(u)$, the efficient premium and the net benefit received by consumers. For any level u, the efficient premium is given by the area above the curve $P \cdot r(u)$ and below unity, to the left of the value u. The consumer surplus received from the utility for that unit is given by the area under the curve $P \cdot r(u)$ to the left of u. Clearly, both the premium and the consumer surplus increase with u. Also, as P decreases the efficient premium for any level of compensation increases while the consumer surplus decreases accordingly.

ONSITE BACKUP GENERATION CAPACITY

The remainder of this paper explores the installation of onsite backup generation capacity as a supplementary form of interruption insurance in conjunction with the compensation scheme. Such backup generation may be, for instance, in the form of small diesel generation or developed cogeneration capacity. It is assumed that onsite backup generation has perfect reliability and is therefore always available when needed.

Onsite backup generation capacity is characterized in terms of a per unit fixed cost (amortized) of G (assumed to be strictly positive), and a variable incremental operating cost of s_1, in excess of the central capacity supply cost. It is assumed that $s_1 \geq s$, i.e. onsite backup has a higher marginal cost than central capacity. This is a reasonable assumption to make in the case of most electric utility situations. If, however, the technology were

Figure 1. Illustration of the Efficient Premium Function



such that $s_1 < s$, then the onsite backup generation capacity could be more rightly viewed as a *bypass* technology where the consumer uses his own capacity as a baseload. This, however, goes beyond the scope of the paper.[3]

Installation of onsite backup generation may be beneficial to both individual consumers and the utility, although their incentives are somewhat different. A consumer's motivation to install onsite backup in an environment which offers insurance at an efficient premium is to reduce his potential interruption losses and consequently insure his load for a lower compensation level at a lower premium cost. It is, in effect, a form of complementary insurance. The utility, on the other hand, will want to install onsite backup generation in order to reduce its compensation payments in the case of a failure of its central generation or distribution systems. We will examine both types of onsite backup generation (individual and utility owned) in conjunction with interruption insurance offered at the efficient premium. Although modern electricity systems generally have very small distribution outage

3. See Laffont and Tirole (1990) for a more general discussion of bypass in the context of a regulatory model.

probabilities, hence possibly mitigating the utility's motivation for onsite generation capacity, more competitive environments and consumer responses in fact make the study of utility owned onsite backup germane to the discussion of reliability differentiation. The current discussions and experimentation surrounding reliability differentiation actually make the issues dealt with here even more relevant. As pointed out by Hung-Po Chao, "We have witnessed a growing number of utilities experimenting with innovative pricing programs that involve reliability differentiation ... A large body of research ... indicates substantial benefits from reliability differentiated service" (Chao, 1991).

Customer Owned Onsite Backup

Customer owned onsite backup generation mitigates the interruption losses of each backed up unit of load, reducing it from $u=v-s$ (where v is the original net valuation of that unit in excess of its supply cost and s the service charge) to $u=s_1-s$, the incremental supply cost. Thus the function $r(u)$ is affected by individuals' decisions to install onsite backup. The backup decisions, on the other hand, depend on the insurance premium and the function $r(u)$. In evaluating an individual's decisions to install onsite backup we assume a two stage decision process. First he decides whether to install onsite backup for a unit of demand based on his expectations regarding the premium schedule and the probability of interruption associated with each level of compensation. Then, given his backup decision, he selects the compensation level for insuring his interruption losses. As indicated earlier, we are interested in a rational expectations equilibrium corresponding to the efficient premium in which every consumer fully insures his potential losses and hence receives a net surplus from the utility of $c-f(c,P)$ for a unit with interruption losses $u=c+s$ and distribution reliability P. Under such expectations, the decision of an individual of whether to backup a unit with valuation v and distribution reliability P amounts to choosing between a payoff $v-s-f(v-s,P)$ in the absence of backup and a payoff $(v-s_1)+s_1-s-f(s_1-s,P)-G$ with backup.[4] From the above, and by using (1), it follows that a consumer, attempting to maximize consumer surplus, will choose backup if and only if

$$G \leq f(v-s,P) - f(s_1-s,P) = v - s_1 - P\int_{s_1}^{v} r(u)du = G^*(v, P). \qquad (3)$$

It follows from the above condition that given a fixed reliability function $r(u)$, there exists for every net valuation $v \geq s_1$ and distribution

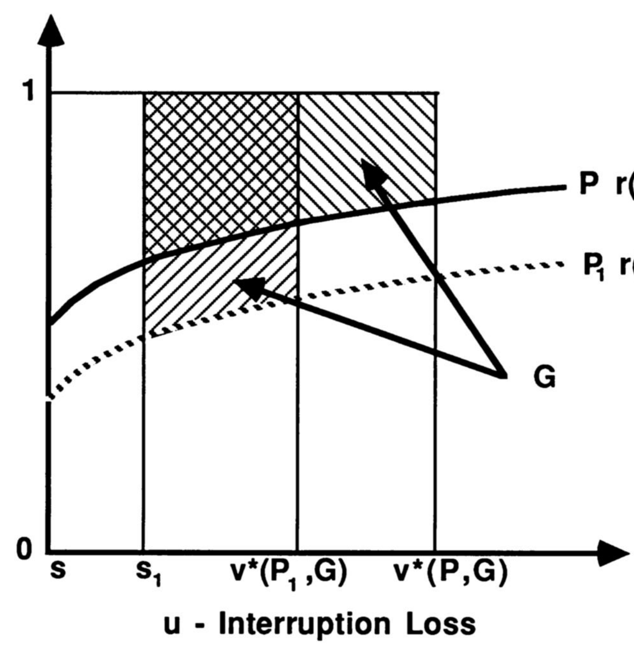
4. Note that with onsite backup the unit can always be served at an incremental cost s_1 and, therefore, the net valuation $v-s_1$ is added to the net benefit obtained from the utility.

reliability P a threshold value $G^*(v,P)$ such that onsite backup generation will be beneficial if $G \leq G^*(v,P)$. Figure 2 illustrates $G^*(v,P)$ as the shaded area. It is clear from Figure 2 and from (3) that $G^*(v,P)$ is linearly decreasing in P and monotonically increasing in v. In other words, higher valuations and lower distribution reliability justify onsite backup generation at higher amortized cost.

The monotonicity of $G^*(v,P)$ in v implies that for any fixed value P and amortized fixed backup cost G, there exists a threshold valuation $v^*(P,G)$, where $G^*(v^*(P,G),P)=G$ such that backup will be selected for all units with valuation $v \geq v^*(P,G)$. We can further show that $v^*(P,G)$ is monotonically increasing in P, i.e. as the distribution reliability deteriorates lower valuation units will be backed up by individual consumers. This follows from the fact that

$$\frac{\partial v^*(P,G)}{\partial P} = - \frac{\dfrac{\partial G^*(v,P)}{\partial P}}{\dfrac{\partial G^*(v,P)}{\partial v}} \tag{4}$$

Figure 2. Dependency of the Threshold Valuation on the Distribution Reliability P and Fixed Cost G



Since $G^*(v,P)$ is increasing in v and decreasing in P, the entire expression on the right-hand side of (4) is positive.

Once the backup decisions have been made, the amortized cost G should be treated as sunk cost and the efficient operation of onsite backup capacity in the system should be guided by marginal cost considerations. A welfare maximizing utility could potentially induce the use of onsite backup capacity in case of shortage by curtailing supply to backed up units of demand and diverting the supply to units of demand which would otherwise have been interrupted without onsite backup capability. Thus, a natural question which comes to mind is whether the utility could enhance economic efficiency by curtailing loads in an order different from that indicated by the selected compensation so as to exploit the available onsite backup capacity. Recall that under full insurance consumers who install onsite backup only sustain an interruption loss of s_1-s and insure their load for that amount. Consumers whose valuations net of service charge exceed that level of interruption loss (consumers who do not have onsite backup) are served in the efficient order when served in order of decreasing compensation. The only possibility of improving service reliability by taking advantage of the onsite backup generation is then to interrupt service to consumers with onsite backup and divert their power to consumers with net interruption losses below s_1-s (who otherwise would have been interrupted). This, however, would be inefficient because the cost of such diversion, which is s_1-s, exceeds the prevented interruption losses.

Figure 3 illustrates the order of curtailment of consumption units characterized in terms of (v,P) resulting from customers' optimal responses to the efficient premium schedule and their optimal backup decisions. Basically, customer self-selection of a premium will result in curtailment of consumption units according to the valuation ordering. However, the upper tier above the line $v^*(P,G)$ will select to back up their units; this reduces their interruption losses from v-s to s_1-s and puts them in front of the third tier in the curtailment order. This shift does not affect the reliability received by the first tier but it will increase the reliability of the second tier. Figure 4 shows the service reliability with the onsite backup generation under efficient rationing as a function of interruption losses when optimal backup decisions are being made by the customers. Note that curtailment among units with the same interruption losses is done on a random basis so all units being backed up having interruption losses s_1 get the average level between $r((s_1)^-)$ and $r((s_1)^+)$. Also note that in the range $((s_1)^+, v^*(P,G))$ the curve $r(u)$ applies to the unbacked units. (The backup units revert to interruption loss s_1 and this raises the reliability of the unbacked units.) The dashed line indicates the corresponding reliability function $r(u)$ when backup is not available.

It is important to note that although the provision of onsite backup does result in a reordering of priority levels and service from central generation, considering total electricity supply (central generation and onsite backup) shows that electricity continues to be supplied in decreasing order of consumer valuation.

Figure 3. Order of Interruption With Customer Owned Backup

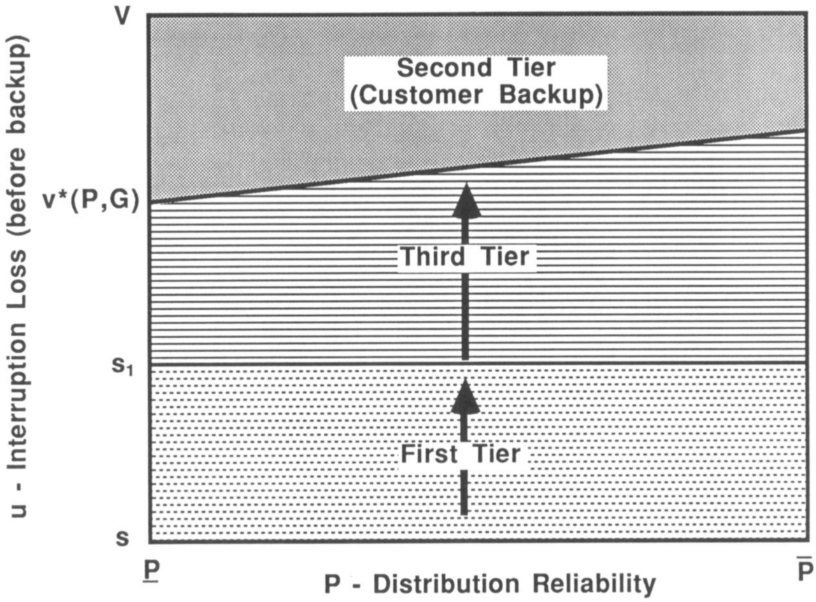
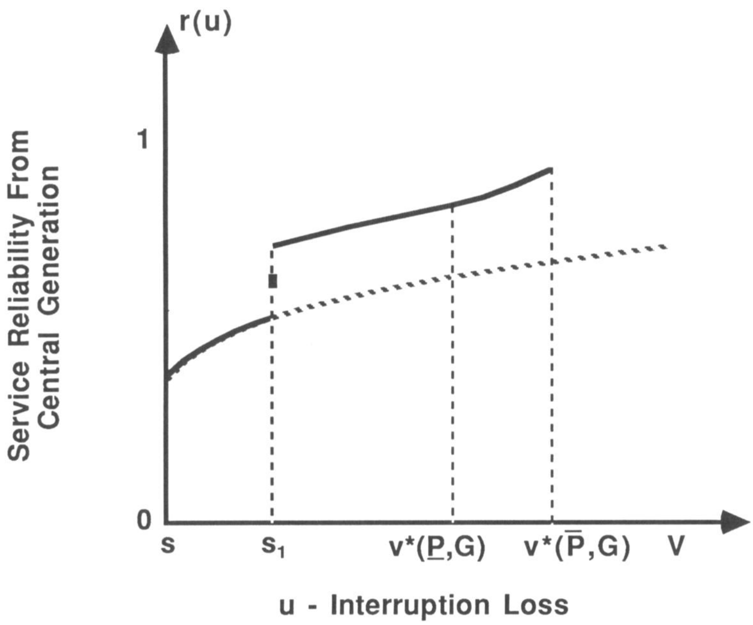


Figure 4. Effect of Customer Backup on the Central Generation Reliability Function



In order to compute the efficient premium function in the presence of onsite backup we need to simultaneously compute the threshold function $v^*(P,G)$ and the mitigated reliability function $r(u)$. These expressions get rather complicated for the general case with an arbitrary demand distribution $H(v|P)$ and they will be omitted here. However, to illustrate the effect of onsite backup on the equilibrium reliability and premium function we will consider the special case where all units of demand share the same distribution reliability P, so that $v^*(P,G) = v^*$ is constant for a given G. In that case, the reliability function with backup, which we will denote as $r(u)$, can be clearly expressed in terms of v* and the original reliability function $r(u)$.

As an illustrative example, consider the linear reliability function $r(u) = a+bu$ and further assume that $r(V^+)=1$ and $P=1$, i.e. distribution is perfect and the highest priority unit is always served. Under these assumptions, equation (3) simplifies to

$$G = \int_{s_1}^{v^*} [r(v^*) - r(u)]du = \frac{b}{2}(v^* - s_1)^2$$

and

$$v^* = \sqrt{\frac{2G}{b}} + s_1 \ .$$

The reliability function with backup becomes

$$r_b(u) = \begin{cases} a + bu & \textit{for} \quad u < s_1 \\ \tfrac{1}{2}(b(s_1) + 1+a - \sqrt{2Gb}) & \quad u = s_1 \\ 1 + bu - \sqrt{2Gb} - bs_1 & \quad u > s_1 \end{cases}$$

and the efficient premium,

$$f(c) = c - \int_{s}^{c+s} r_b(u)du$$

$$= c - ac - \tfrac{1}{2}bc^2 - bcs \qquad \textit{for } c \leq s_1\text{-}s$$

$$= (s_1\text{-}s)\ (1\text{-}a+b(c\text{-}s_1)) - \frac{bc^2}{2} + \sqrt{2bG}\ (c+s\text{-}s_1) \qquad \textit{for } c \geq s_1\text{-}s.$$

Clearly the highest compensation sought will be

$$\sqrt{\frac{2G}{b}} + s_1 - s.$$

Utility Owned Onsite Backup

In the previous section we analyzed the individual backup decision as a way of mitigating interruption losses and consequently reducing premium payments under a policy that induces full insurance. We will now examine the incentive that a utility might have for installing onsite backup generation.[5]

First, let us consider the utility backup decision under the assumption that each unit of consumption is insured for its full potential interruption loss and let $r(u)$ denote again the reliability function. The expected compensation payments by the utility to a unit insured for compensation c at a location with distribution reliability P is $(1-P \cdot r(c))c$. On the other hand, if such a unit is protected with utility owned onsite backup, the utility will incur the amortized fixed backup cost G and the expected incremental operating cost $(1-P \cdot r(c))(s_1)$. Once the unit of onsite backup generation capacity is available to the utility it will be economical to operate it whenever it is possible to avoid compensation payments that exceed the incremental operating cost s_1-s. This can be done by cutting off the backed up unit from the central generation and switching to the onsite backup generation while diverting the power from central generation to an unbacked unit that would have otherwise been interrupted. Note that such a strategy cuts off any backed up unit from central generation before any unit without backup whose social interruption losses exceed s_1, thus resulting in the same allocation priorities of central capacity as in the case of individually owned onsite backup. The expected incremental savings accrued by the utility from diverting a unit of backup protecting a consumption unit with compensation c to lower compensation units is given by

$$P \int_{s_1}^{c+s} (u-s_1)dr(u). \tag{5}$$

Adding up the various savings listed above and integrating by parts results in a total expected net compensation savings from backing up a unit insured for value c at a location with distribution reliability P of

5. The utility's decision to install onsite backup as a form of self-insurance is somewhat like the provider insurance scheme of Manove (1983). In this section, it is assumed that individual consumers do not have the option to install onsite backup generation capacity.

$$G^{**}(c,P) = c + s - s_1 - P\int_{s_1}^{c+s} r(u)du. \tag{6}$$

Thus, such a unit should be backed up by the utility if $G \leq G^{**}(c,P)$. The expression for $G^{**}(c,P)$ has the same form as $G^{*}(v,P)$, with c+s replacing v. Hence the illustration in Figure 2 also describes $G^{**}(c,P)$ with the appropriate substitution. Furthermore, $G^{**}(c,P)$ is monotone in c and P, which again implies a threshold value $c^{*}(P,G)$ such that units selecting compensation above these values will be protected by onsite backup. In the absence of customer owned backup, and under the assumption of full insurance, the selected compensation is $c=v-s$. In other words, the selected compensation equals the net valuation so that the criterion for utility backup is equivalent to that obtained for individual backup -- i.e. $c(v^{*}(P,G)) = c^{*}(P,G)$. Furthermore, since, as described above, utility backup will result in the same allocation strategy of central capacity, we conclude that both utility owned backup and individual backup result in the *same equilibrium*.

COMPARING INDIVIDUAL AND UTILITY BACKUP

Although the result of the last section is interesting, an important caveat applies. In analyzing the utility backup decision which led to the above conclusion we have assumed that no individual backup is possible and that each unit is insured for the full valuation. The latter assumption may not be realistic, however, for the following reason. Once consumers realize that selecting a compensation $c^{*}(P,G)$ results in backup (and consequently 100% reliability) there is no incentive for consumers to select a higher compensation level, even if their potential interruption losses are, in fact, higher. This is a straightforward result of consumer utility maximization. Suppose that there is a consumer of type (u,P) such that $c(u) > c^{*}(P,G)$. Since the premium $f(c,P)$ is increasing in c, it follows that $f(c(u),P) > f(c^{*}(P,G),P)$. However, note that because a compensation level of $c^{*}(P,G)$ results in backup (and 100% reliability), any higher level of compensation (i.e. $c(u) > c^{*}(P,G)$) is *superfluous*. Hence, all consumers with $c(u) > c^{*}(P,G)$ will choose $c^{*}(P,G)$ as their level of compensation.[6] In other words, utility backup will result in "bunching" at the threshold compensation level -- $c^{*}(P,G)$ -- of all consumption units with interruption losses exceeding that level. The immediate effect of this bunching is a reduction in utility revenues (reduced compensation level selections imply reduced premiums collected). However, the threshold level

6. With onsite backup reliability is 100% and consumers receive u-s-$f(c,P)$ *with certainty*. Since $f(c(u),P) > f(c^{*}(P,G),P)$ it follows immediately that consumers with $c(u) > c^{*}(P,G)$ will select $c^{*}(P,G)$ as an optimal compensation level.

$c^*(P,G)$ was calculated *without* consideration of this bunching. Taking this into account therefore implies a selection of a higher threshold compensation level for backup (the level of backup is determined by the economic savings of installing onsite capacity in order to avoid compensation payments). The exact details of the new threshold compensation level are not particularly relevant to this discussion. What is important is the net result: the threshold level of backup for the utility is higher than that for consumers -- $c(v^*(P,G)) < c^*(P,G)$. This leads to the conclusion that an equilibrium with only utility owned onsite backup will actually have less backup generation than the analogous equilibrium with only consumer owned backup.

The above discussion leads us to consider the case in which individually owned and utility owned onsite backup are possible, under the assumption that the same cost structure is faced by both types of agents.[7] Since under the full insurance hypothesis consumers face certain outcomes, their backup decision depends only on the premium schedule, regardless of whether the utility is protected by onsite backup generation. However, since the threshold compensation level for utility backup exceeds the net threshold valuation for individual backup -- i.e $c(v^*(P,G)) < c^*(P,G)$ -- it follows that there will be no units selecting compensation in the range that would justify utility backup. In other words, the individual backup decisions will pre-empt the utility backup.

CONCLUSION

The topic of reliability differentiation and the unbundling of the reliability characteristics of electricity in pricing are gaining importance in energy modelling. The main contribution of Oren and Doucet (1990) was to demonstrate that the proposed type of priority service tariff could induce consumer self-selection and supply rationing by the utility such that the result would be Pareto superior to random rationing. This paper offers an important extension to that initial model. In a free market context it is clear that consumers will seek other options, in addition to compensatory insurance, in order to protect against interruption losses. It has been demonstrated that under the condition of identical cost structures for the utility and individual consumers, individual backup decisions will pre-empt the utility backup. As such, implementation of a compensatory insurance scheme for interruptible power must take into account consumer provision of onsite backup. Sensitivity of the results to differences in the amortized cost of onsite backup between

7. The assumption of identical cost structures will obviously not always hold. Due to imperfections in the financial capital markets the utility will often face a lower cost of capital, and hence a lower amortized cost for onsite backup. This observation does not change the substance of our finding, but would impact on the sensitivity of the results for a particular case.

the utility and consumers is an important point to consider in the marketing of interruption insurance for priority service.

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