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Dynamic electricity pricing—Which programs do consumers prefer?

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HIGHLIGHTS

- Little is known about consumer preferences on dynamic pricing.
- Two studies are conducted to analyze this topic.
- A survey shows that consumers without experience prefer conventional programs.
- Test residents of a smart home were more open to dynamic pricing.
- They also prefer well-structured programs.

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ABSTRACT

Dynamic pricing is being discussed as one method of demand side management (DSM) which could be crucial for integrating more renewable energy sources into the electricity system. At the same time, there have been very few analyses of consumer preferences in this regard: Which type of pricing program are consumers most likely to choose and why? This paper sheds some light on these issues based on two empirical studies from Germany: (1) A questionnaire study including a conjoint analysis-design and (2) A field experiment with test-residents of a smart home laboratory. The results show that consumers are open to dynamic pricing, but prefer simple programs to complex and highly dynamic ones; smart home technologies including demand automation are seen as a prerequisite for DSM. The study provides some indications that consumers might be more willing to accept more dynamic pricing programs if they have the chance to experience in practice how these can be managed in everyday life. At the same time, the individual and societal advantages of such programs are not obvious to consumers. For this reason, any market roll-out will need to be accompanied by convincing communication and information campaigns to ensure that these advantages are perceived.

1. Introduction

Dynamic pricing has been discussed for some time as an important means of Demand Side Management (DSM). However, so far, few dynamic pricing programs are being offered to consumers (e.g. Energate, 2011) and the potential of dynamic pricing for successful DSM is not entirely clear. In Europe, steps in this direction have been taken by two EC directives in 1996 and 2003; subsequently, national governments as well as utilities throughout Europe have started working towards the introduction and market penetration of dynamic pricing programs. The German government has transposed these directives into national law and has obliged energy providers to offer tariffs that provide incentives for saving electricity as well as for controlling power demand; i.e. tariffs that are able to influence consumer behavior. The German law (EnWG §40) explicitly refers to dynamic pricing as one way to fulfill this requirement, as it is assumed that prices influence the demand for electricity. The basic concept behind dynamic pricing is that the consumer price per kW h varies either by the time of use and/or by the current load at household level.

The need for such actions on the electricity market has to be seen as closely related to changes on the supply side of electricity. Traditionally, the most common rate for pricing electricity in the residential sector in Germany like in many other countries is a fixed rate per kW h in combination with a base rate. The price per kW h remains stable over a longer period (in Germany usually one year). Some utilities also offer day and night rates, which include lower kW h prices at night, usually in combination with a certain minimum annual electricity demand. These rates were created to match the situation of large-scale power plants running on coal or nuclear which resulted in an over-supply of electricity at night. In combination with electrical night-storage heaters, such rates

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successfully contributed to a more balanced load curve (Klobasa, 2007; Quaschning and Hanitsch, 1999). However, due to an increasing share of fluctuating renewable energy sources like wind and solar, the situation has become more dynamic and supply is likely to become more variable. Dynamic pricing programs have been developed in order to influence demand in such a way that it correlates with the momentary supply. The price variation has two functions: First, low prices are supposed to incentivize demand during times of relatively high supply and, vice versa, high prices help to curb demand during periods of limited supply. Thus, dynamic pricing is supposed to directly influence behavior by providing an economic stimulus. Second, prices also have an informative function: They are a way of communicating with the consumer, e.g. indicating that demand threatens to override supply in a high-price period, i.e. a shortage in the resources for generating electricity (cf. Stadler et al., 2004; Faruqui and George, 2002). Thus, in an ideal scenario, varying prices lead to optimal capacity utilization in electricity generation and thereby reduce system costs, making electricity cheaper for the consumer as well (Cousins, 2009). On the supply side, dynamic pricing means that utilities are able to directly transfer part of the financial risk they bear by guaranteeing supply to the consumer. In addition to managing demand in line with supply, it is also hoped that dynamic pricing will help consumers to reduce overall demand, e.g. by becoming more aware of their electricity consumption in a first step and then acting to reduce it in a second.

Up to now, several field trials (see Faruqui and Sergici, 2010; Newsham and Bowker, 2010; Stromback et al., 2011 for reviews) have experimented with dynamic pricing and have been able to prove a certain degree of effectiveness, especially with regard to demand shifts and sometimes also demand reduction. However, so far, dynamic pricing is not common from the perspective of consumers and their market penetration is low (e.g. Bartusch et al., 2011 for Sweden, Moholkar et al., 2004 for US, Energate, 2011 for Germany). Thus, there has not been much experience made with regard to consumer preferences, i.e. we do not know which types of electricity tariffs consumers would prefer if a selection were available on the market. In field trials, consumers are usually not given the option to choose between different types of tariffs, so this type of research only offers a few insights into this issue. However, the question of consumer preferences is crucial, because even if (some) dynamic pricing programs could influence electricity demand in a desired way, this presumes that consumers are also willing to opt for them.

Therefore, this paper aims to investigate consumer preferences regarding dynamic pricing programs. This investigation is based on two empirical studies and combines quantitative and qualitative social science methods: (1) A conjoint analysis is performed based on data from an online questionnaire and (2) results are presented from a field experiment conducted in a smart home[1] laboratory. Both studies focus *first* on identifying the type of dynamic pricing program preferred by the respective respondents; *second* these analyses are complemented by exploring the broader expectations and evaluations of dynamic pricing programs. Here, especially the experiment in study 2 provides a basis for elaborating the motives behind these preferences.

This paper is structured the following way: We start by giving an overview of dynamic pricing programs and their possible specifications. Afterwards we outline the state of research with regard to consumer behavior and preferences. Based on the literature review two research questions are presented. The methods section then presents the research design, sample descriptions and approaches for analysis for both studies. Subsequently results for both studies are presented ordered according to the two research questions. In the concluding section findings from both studies are then jointly discussed, limitations outlined and conclusions drawn for research, practice and policymakers.

2. Dynamic pricing programs

Pricing programs vary in complexity, ranging from the standard rate to more dynamic programs with prices changing flexibly within short periods of time (cf. Gordon et al., 2006; Klobasa, 2007; Wolter and Reuter, 2005). Programs, where the price is fixed in advance for a long period and under a fixed timetable, are called time of use (TOU) programs. Due to its high stability, TOU pricing is sometimes not regarded as a dynamic program (Faruqui and George, 2002). The most dynamic program is real-time-pricing (RTP), where prices follow market prices more closely, e.g. on an hourly basis (Borenstein, 2002).

In principle, it is possible to imagine a vast range of possible programs: A pricing scheme incorporates several attributes, each of which may vary resulting in a large number of possible combinations (cf. Table 1). In the remainder of this section we will outline possible program specifications in more detail based on the attributes listed in Table 1.

Generally, an important categorization for dynamic pricing is the distinction between time-varying and load-based programs (attribute *program rationale* in our table). In case of a time-varying program, the billed rate per kW h depends on the point in time when the electricity is demanded; in case of a load-based program, the consumer rate depends on the current load level of the household. Of course, these two types can be combined within one program.

Another central attribute of a pricing scheme relates to its *dynamics* which comprises the definition of rates and the time-table (cf. Table 1). In case of time-varying pricing, the rate per kW h varies either regularly or irregularly according to the season, time of day, hour or even shorter periods. The number of rates can be pre-defined and limited—which is usually the case; however, it is also possible that no price zones are defined in advance. In addition to the number of rates, their time-table is part of the definition of the pricing scheme: The duration of a rate can be fixed (e.g. for day and night rates: the night rate could always start at 23 h and end at 6 h and thus last 7 h). However, the time-table could also be dynamic, e.g. include three or more rates of varying starting points and duration.

A further attribute are the *rates* of a pricing program, i.e. the prices per kW h. They also define the price spread, i.e. the cost difference between the time-zones. Many programs also include *fixed expenses* for the consumer, e.g. a base rate for connection to the grid.

On top of the attributes outlined so far, pricing programs can also include *extraordinary events*, such as extremely high penalty costs during critical periods (critical peak pricing—CPP; cf. Wolak, 2010)[2] or interruptible rates[3] .

So far, the attributes have been mainly discussed for a time variable pricing program. However, as outlined above, load limits

[1] The term “smart home” is generally used for linking different separate devices of a household to a network. The term can therefore include aspects of ambient assisted living, entertainment, and security. In our research, we focus on aspects of energy management.

[2] Most research on this model was conducted in the U.S., often in California, following an energy crisis which led to system overloads due to very high peak demand. In this context, this pricing model has shown some effectiveness in reducing demand peaks (cf. Faruqui and George, 2005), but is hardly known in the German market.

[3] Interruptible rates are so far only offered to business customers and include the condition that the customer has – upon prenotification – to radically reduce demand. If not, high fees apply. In Germany these tariffs are not common as the regulatory context for them (“Lastabschaltverordnung”) is still within the policy-making process.