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OPTIMAL TARIFFS AND INVESTMENT IN NETWORK CAPACITY IN THE PRESENCE OF DISTRIBUTED GENERATION

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OVERVIEW

The increasing significance of distributed generation poses new challenges in shaping regulation of regional distribution networks. Tariff structure may play an important role in achieving the balance between investment incentives of the network and distributed generators. In this paper, we analyse the effects of tariff structure and regulation on the level of investments both in distributed generation by small consumers and in the corresponding network capacity by a network operator.

We consider a regional electricity market with a vertically separated *distribution network operator (DNO)*, which is a regional monopolist, and with households investing in *distributed generation (DG)*. The DNO sets tariffs. These tariffs may include fixed and variable distribution charges for all network users, as well as additional fixed and variable charges for the DG owners. These charges are subject to regulation and paid by the consumers. In practice, the tariff structure of a DNO is less flexible than we assume here. In the Netherlands, for instance, consumers pay only monthly fixed distribution charges and no variable charges; and DNOs may not impose additional charges on DG by small consumers.

Households are price takers. To satisfy their demand, they buy electricity at the retail price. They may also invest in DG and by doing so they can sell any surplus of electricity at the same retail price. We assume that investment in DG is price sensitive, and demand for electricity and production on the established DG are inelastic.

Demand and DG supply have peaks that may occur at a different time within a period. If the load on the network in that period becomes too heavy, the network may overheat and fail. To avoid the relating high costs and so to accommodate peaks in both production and consumption, the DNO needs to invest in capacity.

As shown in the economic literature, under price cap regulation, which is most commonly used in the electricity markets, a monopolist may lack sufficient incentives to invest. It may delay these investments or invest less than socially optimal.

Other regulatory problems may also contribute to the underinvestment. Firstly, network operators have an information advantage over the regulator with respect to its costs and demand. Secondly, a DNO is currently not allowed to differentiate prices across consumers, even though it faces uncertainty about the costs of installing DG technologies, DG supply and demand. These uniform prices can be due to a failure of efficient negotiation between parties or institutional restrictions.

These problems call upon the reconsideration of the current regulation. We seek answers to the following questions. 1) Should a DNO be allowed to charge prices to households for flowing electricity in and out through its network, and if so, what is the optimal level and structure of these prices? 2) Under incomplete information, what type of regulation would approximate the best the socially optimal level of investment in DG and network capacity?

METHOD

In the paper we set up a theoretical model to analyze a regional electricity market described above. We analyze a one-shot game with the following structure:

- Stage 0: Regulation. Given the type of regulation, the regulator that maximizes social welfare, i.e., the sum of consumer and producer surplus, imposes regulatory constraints on the DNO. For example, it sets tariff or revenue caps, or allows for price discrimination.
- Stage 1: Contracting. The profit maximizing DNO offers a take-it-or-leave-it contract to the households, which in turn accept or reject the contract. The contract specifies tariffs for multiple products delivered by the DNO, but not product quantities. Here we assume away the possibility of a commitment problem by imposing legal restrictions on the network operator.
- Stage 2: Investment in capacity. The DNO makes an expansion investment decision.
- Stage 3: Investments in DG and electricity consumption. The uncertain parameters related to the costs and types of DG technologies become known. Households invest in DG and decide on how much electricity to buy and sell.

The game is solved for subgame perfect Nash equilibria by backward induction. In finding analytical solutions we rely on the multi-product approach of Laffont and Tirole (2001, ch.2) and Vogelsang (2001) about determining optimal price structure.

RESULTS AND CONCLUSIONS

Firstly, it is never optimal to abolish network charges for DG, because it would ruin the investment incentive for the network operator. This conclusion contrasts with the current policies in many EU countries, such as the Netherlands.

Secondly, assume that the DNO’s costs related to network load, maintaining capacity and accommodating DG are independent, and it charges fixed fees for the usage of its network. Even under uncertainty about the future costs of DG, the regulator can induce optimal investments by imposing tariff caps. However, if the regulator imposes total revenue cap, it will not be able to achieve optimal investments: because of inelastic demand, the DNO will then charge a fee on consumption equal to the revenue cap, and foreclose DG by a very high fee on supply. Similar results apply if the regulator has an information disadvantage about the costs of the DNO.

We are currently working on an extension of our basic model where consumers can choose in which type of DG technology to invest. An optimal combination of different technologies may not necessitate investment in capacity expansion. However, the combination of technologies may be suboptimal: the peak-supply of different technologies may overlap with each other but not necessarily with peak-demand. This suboptimal combination can cause a high load on and also a failure of the network. Our intuition is that if instead of uniform prices the regulator allows a DNO to differentiate charges according to DG technologies, then given a network capacity (expansion), the optimal mix of investments in these technologies can be achieved.

REFERENCES

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