THE IMPACT OF DISTRIBUTION GRID TARIFFS ON THE LEVEL PLAYING FIELD IN THE INTERNAL EUROPEAN ELECTRICITY MARKET

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Overview

In most countries in the EU, regulators are currently revisiting their distribution grid tariffs because the assumption that customers are passive and price inelastic may not hold anymore. Due to the decreasing costs of photovoltaics (PV) and energy storage systems (ESS), a growing share of residential consumers may own small scale PV and/or ESS in the future. Distribution tariffs designed in the past, when all consumers were passive, are often not suited to allocate network costs between heterogeneous consumers. A volumetric distribution tariff structure with net-metering, currently in place in, e.g., Belgium, causes significant welfare transfers between consumers and potentially reduces the revenue of the distribution system operator (DSO) (Schittekatte et al., 2017). To adress these challenges, researchers and regulators have proposed other distribution tariff designs with different combinations and implementations of fixed charges, volumetric charges and peak demand-based charges (Borenstein, 2016; Hledik & Greenstein, 2016). At the same time, the European Commission proposes to harmonize distribution grid tariffs (European Commission, 2016). Production of electricity is decentralizing and unharmonized distribution tariffs can distort the level playing field of the internal electricity market in Europe. Many stakeholders have however argued that distribution grid tariff (design) should remain a national prerogative (CEDEC, 2017; CEER, 2017).

In the academic literature on distribution grid tariff design, wholesale markets are typically modeled exogenously (e.g. Schittekatte et al., 2017). The aim of this work is to study the impact of distribution grid tariffs on the level playing field in the EU electricity market. We study the effects in a simplified electricity system, consisting of two interconnected countries, with a common wholesale market. In one of these countries, there are active consumers (who can invest in PV and ESS), while in the other country all consumers are passive. This is an extreme version of the reality in Europe today with some countries that are more advanced in the energy transition than others. In each country, a regulator sets the national distribution grid tariff. The proposed model, formulated as a non-cooperative game, considers the investments at the generation side, and also the investment by the active consumers to arrive at a competitive equilibrium obtained as output of a mixed complementarity problem (MCP). This work entails the first steps in building the model and analyzing welfare effects and investment decisions for different scenarios with harmonized or unharmonized distribution grid tariffs.

Methods

The non-cooperative game output characterizes the competitive equilibrium between the supply side (thermal and renewable generators) and the demand side (industrial, commercial and residential consumers) on a wholesale market that is cleared by a price-setting agent (Gabriel et al., 2012) (Figure 1). The wholesale market is perfectly competitive (i.e., generators always bid their capacity at marginal cost) and there is no transmission congestion between country A and B. As a consequence, the system at hand can be studied as a single wholesale market with different consumer groups representing consumers in different countries. The residential consumers are divided into three groups: active and passive consumers in country A, and passive consumers in country B. Other consumers (e.g., industrial and commerical) are not modeled explicitly: their inelastic demand is incorporated in the market clearing constraint. The generators maximize their revenue by optimizing their investment in generation capacity. The residential consumers minimize their electricity bill, which consists of an energy and distribution tariff component, with the retail energy price equal to the wholesale market price. The active consumers can optimize their investment in and operation of PV and ESS. The passive consumers are forced to satisfy their inelastic demand by buying electricity on the market. The price-setting agent guarantees that the market is cleared by matching supply and demand. The electricity price is the dual

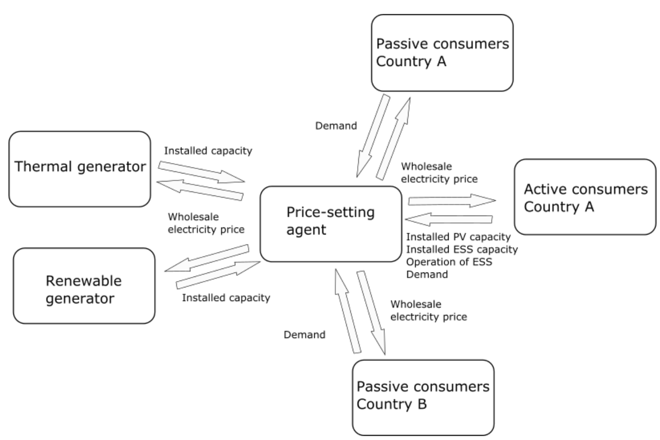

Figure 1: The agents and exchanged variables in the proposed non-cooperative game.

variable of the associated market clearing equation. The national distribution tariffs are exogenously imposed.

Results

A methodological one-day case study on different harmonized tariff structures (but unharmonized tariffs) illustrates some insights that can be gained from the model. In country A half of the residential consumers are active and the other half is passive, while country B only has passive consumers. One renewable, one base load thermal and one peak load thermal generator are considered. The DSOs in both countries need to recover 500 €/year from a consumer on average. Figure 2 presents the distribution costs of the consumers, equal to the recovered costs per consumer by the DSOs, for different values of a volumetric tariff with net-metering (consumers are charged per kWh of net consumption over one year). From this figure the required distribution tariffs, that ensure cost recovery, can be derived for both countries: 0.15 €/kWh in country A (the intersection of the purple and black curves) and 0.075 €/kWh in country B (the intersection of the blue and black curves). The figure also shows that active consumers in country A evade all network costs as of a distribution tariff of 0.025 €/kWh. They do this by installing 3.7 kW of PV and 2.3 kW/4.6 kWh of ESS. As a consequence, each passive consumer in country A pays 1000 €/year to the DSO. In country B each (passive) consumer pays only 500 €/year under any tariff structure as all consumers are assumed identical. On the supply side, 15.8 GW of base load, 2.1 GW of peak load and 1.9 GW of wind generation is installed. Similarly, assuming a peak demand-based tariff structure (consumers are charged per kW of peak consumption during one year), the active consumers in country A avoid all network costs by installing 3.7 kW of PV and 5.5 kW/11 kWh of ESS. This means that their peak consumption is zero, indicating that the active consumers are self-sufficient on the studied day. However, analyzing a single day heavily skews the result towards self-sufficiency. As a result, passive consumers in country A pay 1000 €/year to the DSO (the tariff is 610 €/kW). The installed generation capacities are 17.5 GW of base load and 4.3 GW of peak load (wind generation capacity is not installed). Under a volumetric tariff with bi-directional metering (consumers are charged per kWh of net withdrawal and injection during each hour of a year) of 0.11 €/kWh in country A, active consumers do not evade all network costs: an active consumer pays 253 €/year while a passive one pays 747 €/year. An active consumer installs 2.8 kW of PV and 2.35 kW/4.7 kWh of ESS in this case. The installed generation capacities are 17.5 GW of base load and 2.9 GW of peak load.

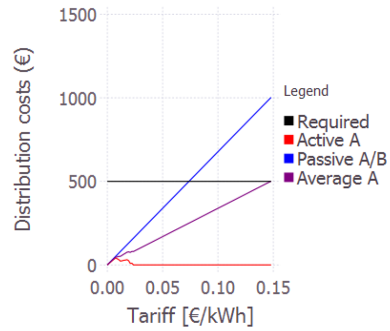

Figure 2: Yearly distribution costs for consumers under different values of a volumetric tariff with net-metering.

Conclusions

A non-cooperative game has been proposed that represents a common wholesale market of two interconnected countries with their own national regulator and DSO. The model allows analyzing the effects of having different harmonized or unharmonized distribution tariffs on, e.g., investment decisions and welfare. The first results indicate that distribution tariffs, when the tariff structure is harmonized, can differ greatly between two countries with different amounts of active consumers. Compared to a country with only passive consumers, the distribution tariff in a country with many active consumers is higher because active consumers can evade network costs. As a consequence, passive consumers are worse off in countries with high shares of active consumers. The results also show that different distribution tariff structures lead to different investment decisions by generators and active consumers. A peak demand-based tariff structure, for instance, promotes more investment in ESS and PV than a volumetric tariff structure with bi-directional metering. This indicates that a level playing field for distributed generation and storage may not be guaranteed in the case of unharmonized distribution tariff structures. In future research the current findings will be further quantified.

References

S. Borenstein, *The economics of fixed cost recovery by utilities*, The Electricity Journal, vol. 29, no. 7, pp. 5-12, 2016.

CEDEC, *Recommendations for the Clean Energy Package*, Tech. Report, Brussels, Belgium, 2017.

CEER, *Distribution and transmission network tariffs and incentives*, CEER White Paper series on the European Commission's Clean Energy Proposals, Brussels, Belgium, 2017.

European Commission, *Proposal for a Directive of the European Parliament and of the Council on common rules for the internal market in electricity*, Brussels, Belgium, 2016.

R. Hledik & G. Greenstein, *The distributional impacts of residential demand charges*, The Electricity Journal, vol. 29, no. 6, pp. 33-41, 2016.

T. Schittekatte, I. Momber & L. Meeus, *Future-Proof Tariff Design: Recovering Sunk Grid Costs in a World Where Consumers are Pushing Back*, RSCAS Working Paper, 2017.