Implementation of Variable Retail Electricity Rates in the German System of Taxes, Fees and Levies

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***Abstract*—Flexibility of residential customers can be a substantial contribution to meet the challenges in an energy system with high amounts of renewable generation. Utilizing this potential by variable electricity rates requires mapping flexibility demands to sufficiently large price differences in order to cause changes in behavior. It is analyzed whether this is possible in Germany's current regulatory setting and which approaches for improvement are to be recommended.**

***Index Terms*— electricity pricing, variable retail rates**

I. INTRODUCTION

Retail electricity rates in Germany consist of several components like costs of power generation, grid fees, EEG levy, electricity tax, VAT, concession fees [1] etc. In today's market setting, all these components are usually charged per unit of energy; therefore, a constant energy price applies to energy consumption of retail customers, which poses no incentive for adjustments of the consumption behavior to external requirements.

Since increasing generation from volatile renewable sources causes higher demand for flexibility in the energy system, flexibilization of household customers' consumption patterns can be an important contribution. Utilization of this potential can be enabled by variable electricity rates with elements like time-dependent pricing, peak pricing, real-time pricing or demand charges [2], [3], [4]. Recommendations for useful rate design can be deduced by simulation based on measured consumption data [5], [6], [7], [8]. This raises the question: Which price components should be charged in a variable way in order to reproduce the optimal rates with necessary spreads and to assign price risks to the appropriate market players?

II. ELECTRICITY RATE STRUCTURES

In order to incentivize behavioral adaption of consumers to flexibility demand by the system, several rate elements can be applied and combined. In general, electricity rates consist of one or more of three fundamental elements, which can also be designed in various variable ways.

A. Fundamental rate elements

Retail customers can be charged per grid connection point, per capacity and/or per consumed energy. This is implemented by three different fundamental rate elements, which can be combined:

The basic fee is a constant amount which accrues per unit of time, usually per month or per year, and is charged per grid connection point. It is therefore independent of the actual consumption behavior und poses no incentive for load shifting or energy saving.

The necessary capacity for energy supply of the respective consumer can be represented by a demand charge. It is determined by the maximum demand in a given time frame. This can therefore motivate behavioral changes (load shifting and/or energy saving) in order to smooth the load curve.

The third fundamental element is the energy price, which is charged per consumed unit of energy. This represents the cost for the generation of electrical energy and is the element which is commonly viewed as "electricity price". It can be interpreted as an incentive to avoid energy consumption, but is not relevant for load shifting measures.

In the German retail market, usually a combination of a basic fee and an energy price is applied. Both elements are constant in this system. As already pointed out, this is a suitable approach to cover the costs, but is not useful for utilizing the flexibility potential of residential consumers. Therefore, additional variability is to be included.

B. Influences and dependencies

The overall aim is to incentivize load shifting measures in households by varying rate elements dependent on external parameters. Therefore, the basic fee is unsuitable for this purpose, which leaves demand charge and energy price as relevant elements.

1) Time

Both demand charges and energy prices can be time-dependent. Daily and weekly energy price patterns with two price levels are fairly common, since they can be implemented with conventional double-rate meters. Further options are seasonal differences or a higher number of different price levels. Time-dependent rates (also called time-of-use rates) usually define the time frames at least one month ahead, which can be considered quite convenient for customers to adapt to.

2) Load

Load-dependency is another form of variable rates. This means that the applicable price level depends on the current total load of the customer's household. Again, several price levels or alternatively a continuous increase can be implemented.

3) Energy consumption

Similarly to load-dependency, the current price level can also depend on the cumulative energy consumption within a defined time frame, e. g. within a day or within a month. Rates with increasing prices at higher cumulative consumption are also called "progressive".

4) Grid state

Prices can be adjusted based on the current or expected grid state in order to avoid grid problems. Since the prediction horizon is rather small, these kinds of rates are usually implemented in form of critical peak pricing (CPP). This means that customers get the information about higher or lower prices for critical situations on short notice.

5) Renewable generation

Another influence which can be represented as CPP is renewable generation. This is aimed at consuming as much as renewable energy as possible, and thus at avoiding curtailment by reducing prices (energy or demand) at times with high renewable generation.

6) Spot market

Prices at the EPEX SPOT wholesale market change hourly and can also be directly passed on to the retail customer as a part of the energy price. This structure is called real-time pricing and assigns the price risk entirely to the consumer, not to the energy supplier as it is the case with the other variable rate possibilities.

C. Price spreads

The combination of one or more fundamental elements with one or more dependencies forms a variable rate. The described variants show that there is an infinite number of possible variable rates for different goals. In order to achieve these goals, sufficient monetary incentives are necessary. A wide variety of studies and surveys tried to quantify the minimum price spreads which lead to actual changes on the behavior.

The results differ vastly: Some studies show that price spreads of 4 cents already cause reliable reactions; others request spreads of up to 80 cents. This paper does not try to confirm these numbers, but to answer the questions: Is it possible to achieve price spreads like this in retail electricity rates in today's regulatory environment? If not: which changes are necessary regarding the price components?

III. Electricity Price Components

German retail electricity prices consist of several components beyond the costs of procurement and sales. Most of them have a fixed price per consumed unit of energy and are defined by some kind of regulatory entity, which means the involved stakeholders have no possibility to adapt these components to current necessities.

A. Current retail price components in Germany

According to recent statistics, the average electricity price for German households consists of 10 components, displayed in fig. 1. These are explained in detail in the following subsections.

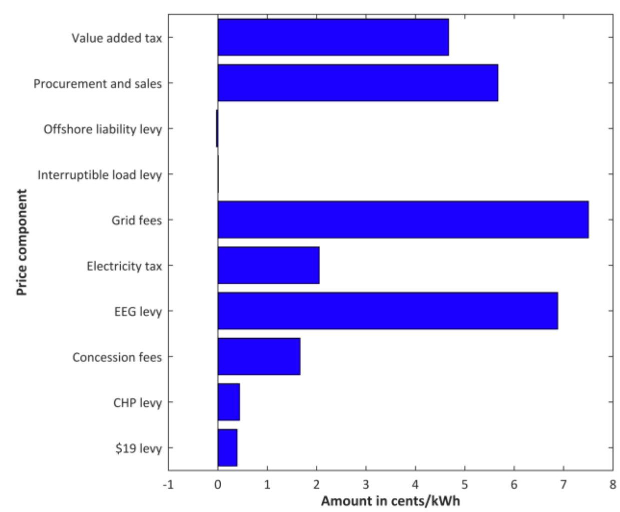

Figure 1. Price components

1) Procurement and sales

The first component covers the costs for the actual generation and/or purchase of the electrical energy, as well as the expenses for sales and marketing. It accounts for 5.67 cents/kWh on average [1] and also includes the potential profits for utilities. The amount of this component is solely set by the energy supplier; therefore, variable design is possible here.

2) Grid fees

Grid fees are charged by the respective grid operators for construction and maintenance of the electric grid on both distribution and transmission level. The calculation of the amount is defined by the regulator, so individual grid operators have no possibility to vary this component. There have been recent changes to the calculation of grid fees, since the TSOs' grid fees are to be unified [9]. This process is not finished yet and does not change the fixed nature of this component, so it will not be considered here.

For larger customers, grid fees usually include a demand charge, which is not possible at the moment for residential customers [10]. This leads to a mean value of 7.50 cents/kWh and therefore to the largest component of today's prices [1].

However, there are already possibilities to reduce grid fees for customers with grid-friendly consumption patterns [11]. Although these measures called “atypical grid usage” or “intensive grid usage” are not relevant for residential customers, this shows that the general concept of variable or at least individual grid fees is a valid option for future improvement.

3) Value added tax

This tax is applied as a general consumption tax, so it is not specific for electricity distribution. It is defined by a fixed percentage (19 %) of the retail price (without VAT) [12], which yields 4.67 cents/kWh at the moment for Germany [1]. Adjustment of this component would require major modifications to the whole system of taxation, which makes it quite complex to vary.

4) Concession fees

Concession fees are payed by the grid operator to the respective municipality for the concession to operate the electricity grid; therefore, they are also charged to the customer. The amount is defined in the particular concession contract, but is subject to upper limits, which are defined by law [13]. This yields a current mean value of 1.66 cents/kWh [1].

Concession fees are only allowed to be charged per kWh according to applicable law [13]. Therefore, flexible design of this component would require adjusted legislation. Additionally, the exact formulation would still depend on the individual contracts between the parties involved.

With the so-called “low load fee” it already includes an incentive for variable rates and load shifting, which applies to rates with at least two price levels. But the achievable spread is quite low due to the small total amount of this component. Moreover, free adjustment depending on current requirements is not possible, so it will not be considered sufficiently flexible for these investigations.

5) EEG levy

The expenses caused by the differences between EEG remuneration and actual market prices of the generated energy are reallocated via the EEG levy by the transmission system operators [14]. It is annually recalculated and the current value is 6.88 cents/kWh [1].

According to the relevant law, it is charged per kWh, so a flexible EEG levy is not possible within this regulatory framework. Changes to this system have been proposed several times [15], [16], and are expected to have significant impact on customer behavior.

6) CHP levy

Similarly to the EEG levy, extra costs for the promotion of CHP systems are reallocated by the CHP levy [17]. The amount is much lower with 0.438 cents/kWh [1], but the system of calculating and allocating the costs is identical to the EEG [18]. As before, regulation demands billing per unit of energy and needs to be adjusted in order to design variable implementations.

7) §19 levy

As mentioned before, atypical or intensive grid usage allow for reduced grid fees under certain conditions [11]. The resulting missing revenues for grid operators are reallocated by this levy, which is named by the section of the respective law. Its current value is 0.388 cents/kWh [1], and analogously to the previous levies, flexibilization would require regulatory changes.

8) Offshore liability levy and interruptible load levy

Two more levies which cover the costs for missing connection of offshore wind power plants [19] and for demand response measures [20] amount to –0.028 cents/KWh and 0.006 cents/kWh, respectively [1]. Again, the calculation and billing is designed similarly to the ones before.

9) Electricity tax

As a last component, the electricity tax is charged by the government and accounts for 2.05 cents/kWh [21], [1]. The amount is defined by law and not assigned to a specific purpose.

B. Possible additional price components

Analogously to already implemented support schemes for renewable generation (EEG) or CHP systems, similar measures for financial support and promotion of new technologies might be introduced in the future. This would allow the integration of flexible elements in the new “levy” in line with the currently discussed flexibilization of the EEG levy [15], [16]. Thus, the regulatory design of this price component could be used to pose an additional incentive for behavioral changes and therefore increase the possible price spread.

IV. Discussion

A. Current situation

As described in the previous section, currently all components of German retail electricity prices are charged per energy and are usually constant over time. They can be clustered in three different groups, based on the current price formation mechanism:

- Price is defined by the energy supplier
- Fixed price defined by law or regulation
- Price is dependent on other components

These groups are described and analyzed in the following subsections.

1) Supplier component

The first group consist of the component “Procurement and Sales”. As pointed out, its function is to cover the costs of electricity generation or purchase and for all other processes of the energy supplier that are necessary to supply energy to its retail customers. Therefore, the exact pricing structure, as well as the price level, is up to the energy supplier, making it a perfect candidate for the implementation of variable rates. Fig. 2 shows the relation of this potentially flexible component to the other components.

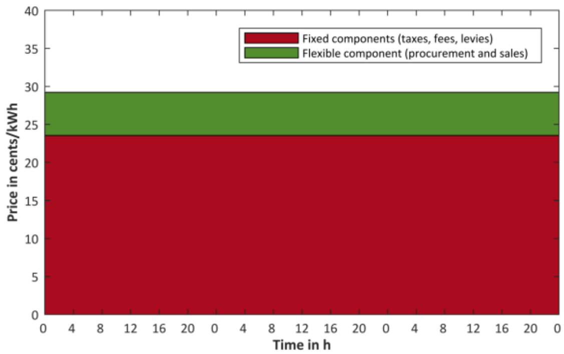

Figure 2. Comparison of flexible and fixed components

Since this component accounts for about 5.5 to 6 cents/kWh, spreads of about 11 to 12 cents/kWh are possible in a conservative implementation of time-of-use rates. Conservative here means an approximately uniform distribution of time slots with high price level and time slots with low price level, a nonnegative low price level and (at least approximately) revenue neutrality for both energy supplier and customer (provided that the customers' behavior remains unchanged). This schematically depicted in fig. 3.

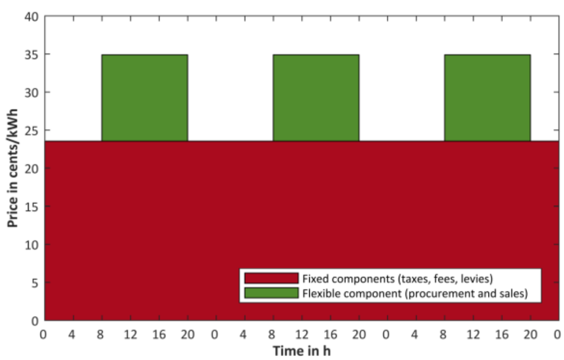

Figure 3. Flexibilization of procurement and sales

But none of these assumptions are legally necessary, so in theory, arbitrarily high peak prices can be implemented as an incentive for load reduction or load shifting in critical situations. Analogously, negative values of this component can provide an incentive to increase the current consumption. Therefore, potential price spreads are not limited by the current average value. Demand charges are currently not explicitly allowed, but also seem to be in accordance with the law, since they are mentioned for a special group of retail customers [22].

However, completely free rate design is not advisable from an economic point of view. Cost savings on the customer side have to be somehow compensated for the energy supplier by cost reduction on the wholesale market or other financial benefits. Moreover, rate structures which are too complicated or include very high price spreads might receive little acceptance in today's highly competitive retail electricity market.

As described, the component is defined and charged by the energy supplier. Therefore, grid requirements cannot be represented due to unbundling laws [23]. This means that theoretically, most flexibility requirements in retail electricity pricing could be mapped to the component, but in practice the necessary information is not available.

2) *Regulatory components*

The second group consists of all components which are defined by some kind of law or regulation, and typically fixed for at least one year. This includes all kinds of fees and levies, as well as the German electricity tax. These components are charged per energy, so demand charges are not possible in the current setting. Due to the static definition, they are unusable for dynamic pricing approaches. Thus, using these components as additional incentives for load shifting and other changes in behavior requires regulatory changes.

3) *Leverage component*

The third "group" also consists of only one component, which is the value added tax. This component is defined by federal law and amounts to 19 % of the sum of all other components. Since this ratio is fixed, no flexible design of the component itself is possible, but price spreads in other components are increased by 19 % due to the VAT. Therefore, this introduces additional leverage to incentivize changes in consumption behavior. With this effect taken into account, the rate structure displayed in fig. 3 actually results in a higher spread, depicted in fig. 4.

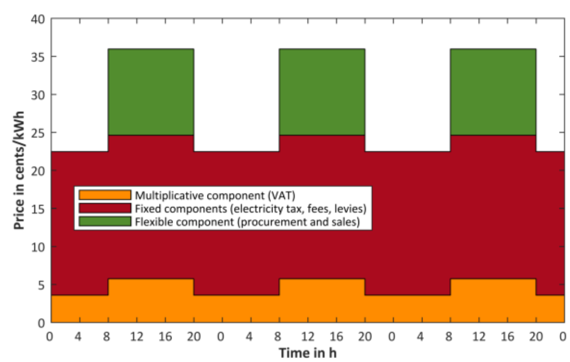

Figure 4. Leverage effect of VAT

4) *Summary*

The analysis of the current situation shows that only the energy supplier has the possibility to dynamically adjust prices. All other relevant stakeholders like grid operators and regulator have no means to vary their respective components under current legislation. To include all relevant influences and dependencies (cf. section II.B) in the final retail price, this requires appropriate adjustments. These will be discussed in the following section.

B. *Possible future improvements*

In general, there are three possible approaches to redesign the system to overcome the described drawbacks:

- Price signals by other stakeholders to the energy supplier

- Legislative redesign of components
- Introduction of new components

All of these approaches require substantial adjustments to existing laws or regulations and therefore, market players in energy economics cannot implement them without support of the legislator.

1) Price signals

As already pointed out, influence of grid operators or possibly other stakeholders on the actual price for energy supply, so on the component defined by the energy supplier, would allow including all relevant factors in the price formation process. Therefore, adjustments of further price components can be avoided, which could potentially reduce legislative implementation effort.

On the downside, new processes for aggregation of all signals have to be defined, in order to establish measures to deal with conflicting interests, e.g. between grid operator and energy supplier or between grid operators on different voltage levels. Similar challenges are currently being addressed in the field of CLS-management [24].

2) Legislative redesign

Changing the respective regulations which define grid fees, concession fees or several levies could enable dynamic design and adjustments of these components. Thus, grid operators and/or the regulator have direct influence on the final retail price and are able to include their requirements in this price. Depending on the current situation of the energy system, this could raise the total price spread seen by the customer, which increases the incentive effect of the variable rate.

However, in other situations with contradicting flexibility requirements of the respective market players, the adjustments might cancel out. Moreover, the price spread which can be realized with one component directly depends on the current value; therefore, the spreads might be too low to sufficiently incentivize load shifting. EEG levy and grid fees enable spreads in the same range as discussed for procurement and sales before (cf. section IV.A.1), whereas all other components are in the range of few cents.

Grid fees could potentially include demand charges which allocate the costs of grid construction and maintenance to the respective cause, potentially leading to awareness regarding load peaks. Since a large share of the grid fees is assigned to the DSO, this would enable the local grid operator to flexibly react to local congestion situations. Depending on the actual grid state, thresholds and prices can be dynamically adjusted. On the downside, this would be quite complex to implement for uncertain results, since the mere existence of a price difference does not automatically cause the desired reactions.

Quite similar advantages and disadvantages hold for a flexible EEG levy. Here, the general idea is the utilization of a price component caused by the funding of renewables for improved integration of renewables by incentivizing load shifting to high renewable generation [15], [16]. Implementation by coupling to wholesale electricity prices or to forecast renewable generation would be possible, but again causes potential conflicts with requirements by other stakeholders, e.g. local grid situation.

3) New components

For increased spreads and therefore additional leverage, it can be helpful to include additional components which incentivize behavioral changes. Several variants have been proposed and will be described in this section.

Usually, this new price component is denoted as flexibility component [25], [26], which is adjusted based on current flexibility demand. To pose an incentive for increased consumption it can be 0 or negative; to cause a reduction of consumption, it is positive and therefore increases the price per unit of energy.

Therefore, with this instrument being regulatory possible, virtually arbitrary energy prices could be defined by the energy supplier and/or the grid operator. Given the assumption that there is the same flexibility demand in both directions, this could in fact be designed revenue neutral for the grid operator [26].

With the usual approach to a flexibility component system, it is not possible to include demand charges for utilizing flexibility potential. This might be another new component with the goal of a smoother consumption behavior. To avoid additional financial burden for customers, other components might be reduced. This could be applied as an instrument to avoid load peaks in critical situations.

C. Conclusion

The analyses show that in the current regulatory setting, only the amount for procurement and sales of the energy supplier can be potentially designed in a variable and flexible way in order to pose an incentive for residential customers for behavioral changes. This evinces two main disadvantages: the potential spread is restricted by external factors and other stakeholders in the energy system have no means of influencing the final retail prices.

Possible improvements of the system include three different approaches. The first one is the regulatory introduction of price signals from other stakeholders to the energy supplier, providing an opportunity for e.g. grid operators to react to their specific requirements. This could be also achieved by flexible design of further price components like grid fees or EEG levy. As a last option, the implementation of new price components, e.g. a flexibility bonus, yields highest flexibility for customized rate structures. Therefore, further development of the regulatory environment in one or more of these directions is recommend in order to tap the full potential of residential flexibility in the electricity sector.

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