Electricity Associations as Marked-based Steering Mechanism and Alternative to Fixed Feed-in Tariffs

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Abstract

This paper describes a business model for local electricity supply and demand steering using flexible electricity prices. Therefore it evaluates first the composition of the electricity price. Secondly it estimates the future renewable electricity generation cost. Therefore future renewable electricity generation prime cost are calculated with a combination of historically derived learning rates and global market growth estimations, both derived from literature. Thirdly it evaluates the tax burden on local traded electricity. As result a business model and legal construct which reduces the tax and levy burden on electricity is identified as crucial factor for flexible electricity prices. With electricity associations this paper identifies such a judicial construct. Finally centralised demand steering with smart flexible agents like electric vehicles, dishwasher and washer-dryer is described. This steering allows to synchronize renewable electricity generation from photovoltaic power plants, wind turbines and combined heat and power and the local electricity demand.

1. Introduction

Due to significant technology learning progress reached with subsidized feed-in tariffs on renewable energy generation the contribution of renewable electricity on overall electricity supply reached 23.9%, including 9.3% from wind turbines and 4.7% from photovoltaic. Especially daytime and seasonal peaks of photovoltaic, but also wind turbines have reached challenging levels. Therefore the volatile regenerative energy production makes an expansion of the energy grid necessary.

In the current situation a fixed feed-in tariff is as well criticised as the partial self-supply with electricity from photovoltaic. The president of the “Federal Grid Agency” J. Homan describes the renewable energy generation which is independent of the actual demand and only focused on feed-in tariffs as “produce and forget” philosophy. He claims that the current EEG is lacking a demand steering and leads to non-controllable costs. Furthermore a regulation where additional capacities are installed would be necessary. In general the debate should focus more on the economic viability. Furthermore a new electricity market design should take economic efficiency and the availability of enough assured power into account. [1]

This paper suggests as alternative to grid expansion and high fossil backup capacities regional electricity associations with smart load scheduling. They are expected to result in a better fit between volatile renewable electricity generation and demand. The association construct allows not only temporal but also local price signals. This model is not only environmental but also grid friendly. As indirect subsidies existing options for reduced fees and levies are used. As building blocks of the business model future renewable electricity prices are estimated.

1.1. Future Electricity Generation Cost

The crucial parts of a business models based on renewable electricity are taxes, levies and prime costs. In this part future electricity prices are calculated using experience curves. Therefore a

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literature review of statistical derived progress ratios were conducted for each technology. Those results were combined with long term world market scenarios.

As estimation method for future technology prices two main options exist. One option are expert estimations based on possible technology innovations and implementations and changes in input factor prices, the second option are learning or experience curves.

While expert estimations need concrete innovations in mind and include success or failure predictions, learning curves are statically derived. In this analysis only experience curves are used, because their use is robust for long time technology predictions and their usage is widely spread in policy scenarios. [2] The literature cited later in this section shows, that they are derived for nearly all renewable technologies, and its more often discussed how they are done best, and which parameters should be used, then if they have a predictive value at all.

Learning curves origin from Wrights observation the price of aircraft manufacturing dropped with a constant percentage for every doubling of production. Using a double logarithmic scale the learning curve is linear. A learning curve can be calculated as following : [3]

$$C_t = C_0 \left(\frac{Q_t}{Q_o}\right)^{\frac{Ln(PR)}{Ln(2)}} \tag{1}$$

C_t is the unit cost of a given cumulative production at time t.
C_0 is the unit cost at t = 0.
Q_t is the cumulative production at a time t
Q_0 is the cumulative production at t = 0

The Progress Ratio (PR) can be expressed as:

$$PR = 2^b \tag{2}$$

With b as the rate of innovation or learning parameter. It is statically derived from data.

The function describes, that the price of a unit depends directly on the number of units ever produced.

In general learning rates should be cleared by inflation. Therefore this paper is written in constant prices of 2013. Otherwise a rising inflation rate would underestimate learning rates, a decreasing inflation rate would overestimate future prices. With a constant inflation rate the learning is perceived lower but if the result is deflated it would lead to consistent results.

For photovoltaic the assumed market size is the baseline scenario from the IEA. [4] As progress ratio a value between 77% [5] and 82% [6] is suggested in literature. This paper uses the literature value of 80%. [7] In this paper the suggestion of C. Candelise et al. is used who estimate a PR of 80%. The price for PV-modules in 201 per kWp installed and ready to where in Germany 1900€ [8]. As estimation in Hanover, (lower Saxony) a yield of 930 kWh p. a. and kWp is used.[9]

In the calculation of future actual cost of electricity generated by wind turbines the predicted growth rates are adopted from Literature the GWEC. [10] As initial price of onshore wind energy projects the average price estimation of 0.073€ is used. [11] A review of PR from Å. Lindman and P. Söderholm offers a wide spectrum of global learning rates. This paper uses their recommended PR of 89%. [12]

For the battery sector the McKinsey estimation of 457€ in 2015 is adopted. The same study assumes that the current market growth rate of 26% continues until 2020. Due to a limited overall market, for later than 2020 a continued market size growth of 10% is assumed and a PR 86% is estimated.[13] Other studies estimate a learning rate of 83%. [14] Furthermore a battery lifetime of

5000 fullcycles is assumed. Due to a positive market dynamic mainly driven e.g. by the company Tesla a stronger battery market growth driven by the automotive sector is possible. Therefore a faster reaching of lower price levels on the experience curve is possible.

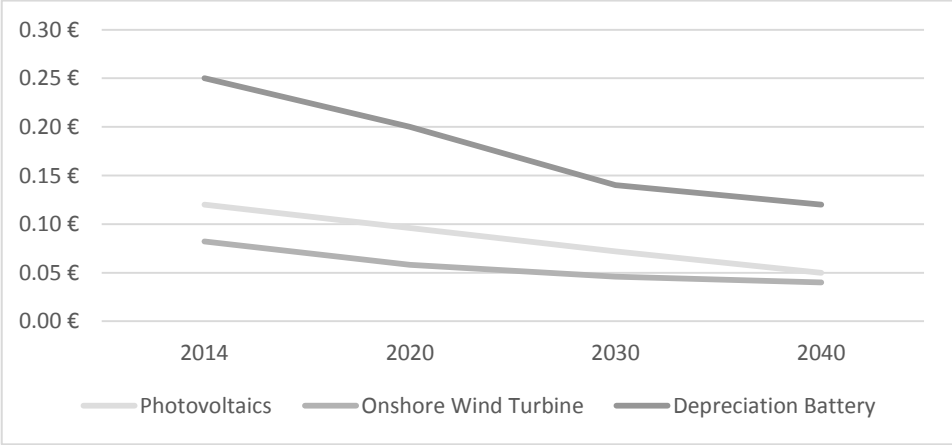


Figure 1: Actual cost of renewable electricity generation.

1.2. Tax and duty burden

Figure 1 illustrates, that from the actual costs perspective a business model based on local renewable electricity production is feasible and a spread compared with private consumer prices exists. A more significant influence factor is though the tax and levy burden included in electricity prices. They add up to 0.21€. Most important factors are the EEG-apportion (0.0624 €) and the grid fee (dependent on area with an average of about 0.07 €). Connected to the grid usage are also the concession levy, which differs dependent on the city size, increasing for larger cities (average 0.0179 €). The energy tax is dependent on extracting electricity from the public grid and the sales tax is an addition of 19% of the electricity price including and is also raised on the taxes included in the electricity prices. With such a high tax burden the consumer price of 0.21 € only for retrieving taxes is too high for flexible electricity tariffs. Therefore the business model needs an essential step to reduce the tax burden. Due to the nature of the different taxes the grid fee can be saved if no public grid is used. If a public grid is used, only the actual usage has to be paid. Therefore the usage of only one low voltage grid, saves the grid fees for high voltage usage.

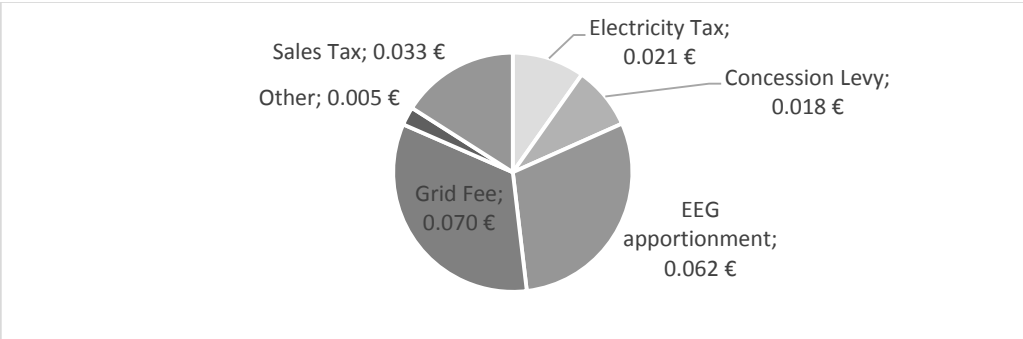


Figure 2: Tax and levy burden on private electrcity consumption per kwh.

The EEG apportionment can be saved if electricity from renewable sources is used by its propietary and the maximum power is below 10 kWp. If the maximum power is above 10 kWp 40% of the EEG apportionment has to be paid. [15] Furthermore the power generation units have to be in the same low voltage grid. The concession fee is dependent on the usage of a low voltage grid, therefore it has to be paid if electricity is transported from one household to another. The

assessment basis of the electricity tax is the usage of power from the public grid, which also cannot be avoided. The sales tax can only be reduced if other taxes and levies are reduced.

1.3. Association Model

As option for shifting electricity from one prosumer to another consumer Gleiss et al. [16] describes a juridical construct, which allows different natural persons to be one juridical person.

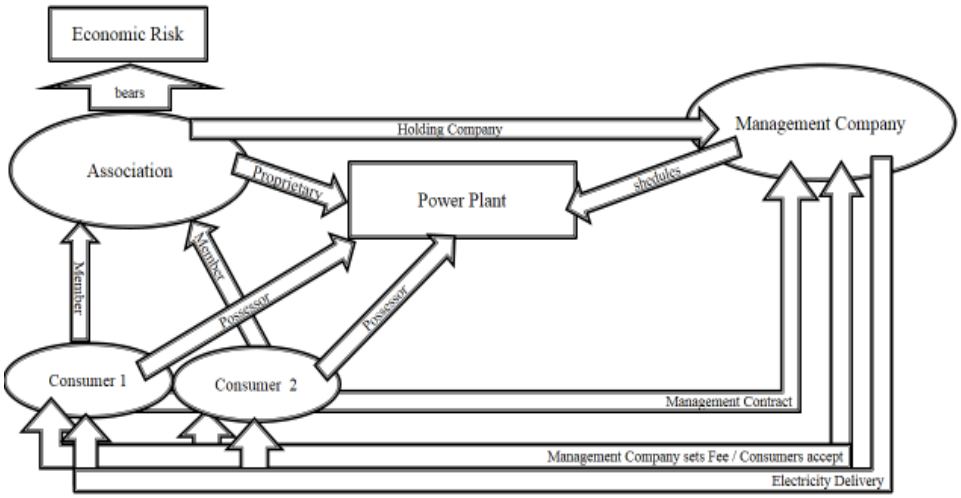
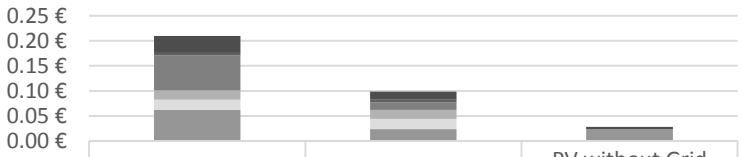


Figure 3: The energy association model. Own figure according to Gleiss et al. [16]

The power plants are run by a management company, which is a sub company of the electricity association. The consumers are possessors of the power plants and the association is proprietary of the power plant. All consumers are members of the energy association. Between consumer and management company exists a management contract, which allows the management company to influence the behavior of power plants and batteries.

The management company charges every consumer the same variable price for electricity. This offer accepts the consumer (automatically) for each 15 minute time period. This construct allows that no energy delivering contract exists.



	Privat Consumer	Association Modell	PV without Grid usage
Sales Tax	0.033 €	0.016 €	0.005 €
Other	0.005 €	0.005 €	0.000 €
Grid Fee	0.070 €	0.015 €	0.000 €
Concession Levy	0.018 €	0.018 €	0.000 €
Electricity Tax	0.021 €	0.021 €	0.000 €
EEG apportionment	0.062 €	0.024 €	0.024 €

Figure 4 Comparison of different tax and levy burdens.

As result from this model the fixed fees and levies decrease from 0.21 € in the initial situation to about 0.10 € in case the association model is used. As additional option the electricity which is not transferred through the public grid e.g. in case of a multi-family buildings is only charged the

reduced EEG apportionment and the sales tax. With this business model consumption within one building remains the most attractive option, but an overall supply and demand management is established. This allows to give not own consumer the chance to benefit from overproduction of photovoltaic power plants via flexible electricity prices.

This lower electricity prices make investments e.g. in comparable large flexible consumer as electric vehicles more viable.

2. Demand steering

Due to the reasons explained in chapter 2 regional markets are under the current law and levity conditions an option, to enable flexible electricity prices and therefore make price based demand steering possible. As positive side effect a better demand steering not only allows grid friendly consumer behaviour but also the higher the amount of local produced electricity is, the lesser electricity transport is necessary. Also the usage of the reduced levity and tax burden for the participating consumer increases, the more electricity from within the association is used. In the following the technical implementation is described.

Existing studies committed field tests, and evaluated the demand shift potential of different technologies. They identified the largest demand shifting potential in smart, automatic steerable white goods. Smart electricity consuming goods not only achieved the best results, but were also able to avoid the problem a fading consumer motivation and resulting reduced reaction on price incentives. Overall a price elasticity of 11% could be observed.[17]

Based on this results, this papers concept is based on automated demand shift, done by smart electricity consuming devices. The demand shifting potential could be enforced if consumer also change their usage behaviour of none smart devices e.g. by usage of price signals from their smart meter or a smartphone application.

In this papers concept the demand side of this regional market consists of perfectly price inelastic agents (e.g. TV, illumination) and price elastic, smart agents (e.g. electric vehicle, wash-dryer, heat generation and battery). As well the supply side consists out of perfectly inelastic agents (e.g. photovoltaic systems and wind turbines) and elastic agents (e.g. cogeneration units, batteries).

Aiming to minimize the communication and hardware demand the smart consumer only communicate if it is filled, and the by consumer demanded finishing time. A centralised agent aggregates those demands and schedules the demand fitting to the expected power generation from renewable power plants. Expected supply lacks are then filled by cogeneration power plants. As last option residual supply or demand is traded with other grid areas.

The electricity price can either follow strictly prime costs. In this case a high base fee is needed for financing the IT-infrastructure and the initial investments in renewable power plants and batteries. This is compensated with only taxation and levitation charged electricity in hours where photovoltaic or wind power is used. The alternative is charging a price which mainly is cost competitive with existing electricity charges aiming to finance fixed cost with an additional margin on the marginal cost.

3. Conclusion and further research

This paper shows that with the association model a constructs exist, which allow indirect electricity trading between its members without losing most of the tax and levy advantages. This allows flexible electricity prices, which at last allows price based demand steering. As research in progress some questions are left open. First this paper offers two options for financing the associations

overhead cost like IT infrastructure, but the question can only be answered if further simulations are conducted.

Other studies mention the even larger demand shifting potential in the industrial sector. [17] Due to tax exemptions and already flexible EEX based electricity prices for large electricity consumer, the business model cannot be expanded on large industrial electricity consumer. Due to only slightly reduced, inflexible electricity prices which small and middle sized electricity consumer need to pay, they can generally be included in the business model. In this papers concept they were excluded because a specific understanding of their workloads is necessary for selecting suiting shift able loads.

For increasing economic efficiency it is possible to use fossil based electricity in those hours with very small renewable electricity supply. This is charged normal tax and levy rates. This is an option to reach an overall efficient solution which uses for a transformation time also existing fossil power plant capacities.

The described areas with flexible regional tariffs have the potential to be innovation drivers. Time periods with low priced electricity increase the economic viability of green technologies as e-mobility or electricity based heat generation (heat pumps).

In further research the described simulation needs to proof, that regional markets including reserve capacities and supply and demand steering are economic efficient and able to deliver the expected results regarding grid services.

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