LOAD MANAGEMENT AT DISTRIBUTION GRID LEVEL: A PRICING MODEL FOLLOWING THE 'POLLUTER PAYS PRINCIPLE'

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Overview

The 'Polluter Pays Principle' is a term in the environmental policy debate concerning the internalization of external costs. [1] Within the regulated German energy sector external costs occur for example when individual consumers use the electricity grid at unfavourable times. During these times electricity demand and supply cannot be balanced easily. As a result measures have to be taken to meet challenges like network congestions or at worst network expansions. Network users must bear the costs incurred. The current pricing model used by the typical German distribution system operator allocates the network costs to the generality of consumers distinguishing between the annual peak loads but not between the points of consumption or the utilization rate. Major changes in the feed-in and load behavior accompany the rapidly increasing share of renewable energies in the power production in Germany. In this context times increase of imbalance of electricity demand and supply.

In this study a pricing model will be developed for distribution system operators, which establishes a load management system. Thereby the integration of renewable energies into the power grid will be ensured on the one hand. On the other hand, potential savings for both the distribution grid operator and the consumer can be achieved. The basic aims of the developed pricing model are the increase of the utilization rates of the grid infrastructure and the allocation of the network costs among the users according to the costs-by-cause or following the environmental economics term the "polluter pays principle".

Methods

The research is based on the results of the preliminary study [2], in which the monetary potential savings of consumers and distribution grid operators due to an automatic electrical load management system, have been evaluated by a statistical modeling within the limits of the laws in force. As a first step, the existing implementations of the 'Polluter Pays Priciple' in the field of energy economics have been analysed to derive implications for the new pricing model. The next step was the development of the new pricing model (MinLoad pricing model) with the target to increase the utilization rates of the grid infrastructure and to allocate the grid costs to the causing customers. For this purpose the demand rate was set as the only tariff component. As a function of the respective minimum necessary load level (at the highest possible utilization rate of 100 %) a base demand rate for each network level has been calculated. The following figure illustrates the difference between the peak load of network level 7 and the appropriate minimum load (MinLoad).

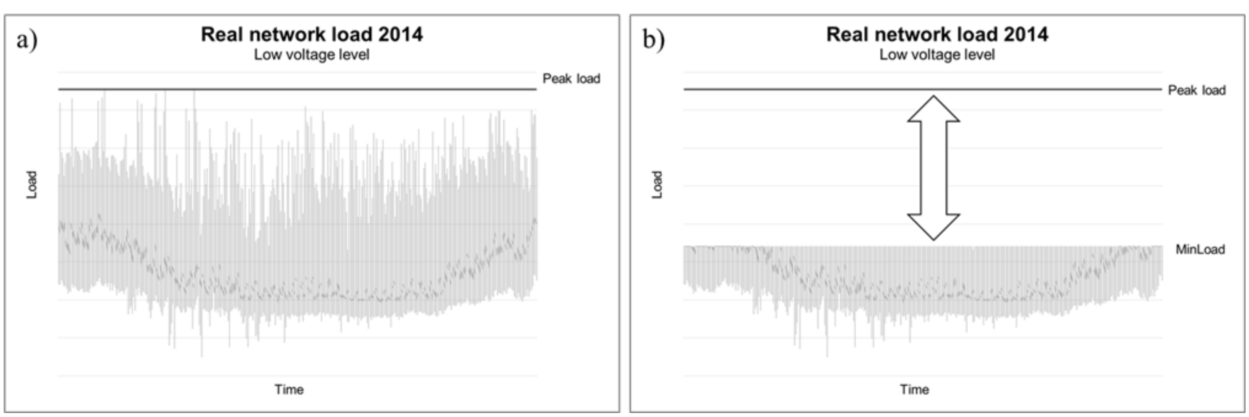

Figure 1: Schematic diagram of the real network load 2014 of the practice partner within network level 7: a) Peak Load. b) Difference between peak and minimum load. [Own figure]

The introduction of a relatively low base demand rate (BDR) and a significantly high penalty demand rate (PDR) incentivize customers to reduce peak loads and to straighten their load profile. The customers, who contribute to the total peak load have to pay the caused additional grid costs. As third step, the underlying load management system that allows the reduction of the peak loads has been evaluated. Household customers, as a specific group of users, are the research subject. Smart meters installed in each household is the prerequisite for implementing the load management system and the appropriate pricing model. It is assumed that there will only be changes in consumer behaviour concerning energy efficiency by technological instruments without waiving convenience aspects. [3] Consequently, the premise for electrical household appliances which are capable of load controlling (washing machine, tumble dryer, dishwasher, etc.) is that they are equipped with automatic control units. It is assumed that in each household the distribution grid operator installs a storage battery and its state of charge is used as the behaviour-guiding information. By calculating the total required capacity of the storages to reduce the residual peak load of network level 7 and the potential monetary savings due to the load reduction the maximum possible investment costs can be determined. A typical municipal distribution grid operator in Germany acts as practice partner providing real data concerning feed-in and purchase structure and grid costs.

Results

The first result is that it is extremely expensive to cover the total residual peak load by a storage system due to the high required storage capacity and the high market prices for storage systems. However, the developed MinLoad pricing model incentivizes the customers to reduce their peak loads and straighten their load profiles. To reach the peak load reduction alternative load management measures can be more efficient than electricity storages at present. By implementing the MinLoad pricing model with the significant incentives to reduce peak loads the most efficient technologies (or a combination of a number of technologies) will turn out over a period of time. The third result is that a two-step approach of the pricing model is necessary to be applied. Due to the German regulatory framework the potential savings approach zero over time. In the first step, the network costs can be the regulator of the load management system. In the second step, the costs of generating electricity have to be focused to reach the shown goals. The development of the two-step pricing model facilitates the integration of renewable energies into the power grid on the one hand. On the other hand, potential savings for both the distribution grid operator and the consumer can be achieved.

Conclusions

In summary, the advantages of the MinLoad pricing model are as follows: Due to the increase of the utilization rate of the existing grid infrastructure a reduction of grid costs per unit can be achieved. Moreover, future price increases can be kept at a lower level because of the reduction of the necessary grid expansion. Since grid expansions at higher network levels are planned [4] the increase of grid charges at higher network levels must be expected. As a part of the end-user electricity price the higher transmission grid costs will affect the generality of network users. Using the MinLoad pricing model enables distribution grid operators to create a locational advantage for the region they operate in due to at least lower distribution grid costs. Furthermore, the objective to allocate grid costs in accordance with their polluter can be achieved. Customers will pay for the network costs they cause. However, the result is also that an exclusive storage based load management system cannot be financed only by the saved grid costs at present. Therefore, the development of the second step of the pricing model will be conducted within the next part of the study.

References

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