INNOVATIVE TARIFF SYSTEM FOR PUBLIC LV DC DISTRIBUTION NETWORK

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ABSTRACT

The subject of this paper is the development of an innovative tariff system for a public Low Voltage Direct Current (LV DC) distribution network by Dutch distribution system operator Liander.

Today's distribution networks face numerous transformations. The increasing penetration of distributed renewables and storage systems, which generate DC power or require an intermediate DC stage, and the growth of appliances, based on power electronics and consuming DC power, bring to the possibility to use DC distribution networks. Liander is developing a public low voltage DC distribution network, which will connect DC supply with DC demand in the most efficient way. For this local DC network Liander is developing a new tariff system, which will contribute to reduction of integral social costs for both the customer and the distribution system operator. A new tariff system will offer incentives, which will stimulate customers of a local DC grid to collaborate and to balance with each other. This paper sketches contours of a new tariff system and describes the basic elements of this system.

INTRODUCTION

The last decades are marked by the enormous growth of renewables and storage systems, which generate DC (direct current) power or require an intermediate DC stage before power injection in an AC (alternating current) network. Furthermore the growth of appliances, based on power electronics and consuming DC power, is tremendous. This raises the question whether the present distribution networks can still satisfy nowadays demands. Looking from the perspective of the waste of energy, AC leads to a certain amount of losses due to its fluctuating nature and due to the converting needs. Such considerations open the possibilities for DC distribution networks, as a means to answering customer needs and to connecting DC generation and load in the most efficient way.

Convinced of its unique role in the energy transition and of the need of new sustainable energy solutions, Dutch distribution system operator Liander believes that a local DC network can provide certain benefits with respect to AC networks. A local DC network can help to reduce total social energy costs and support customers to make their sustainable energy choices. For these reasons Liander is developing a public low voltage DC distribution network, to be put in operation in 2018. This network will be implemented at the new Lelystad Airport Business park and will connect DC electric power consumers in commercial buildings, such as heat pumps, e-loading at public car parks and public LED lighting systems to local DC sources, such as photovoltaic systems.

It is expected that the linking of supply and demand in local DC networks will provide more possibilities for local balancing and will optimize the use of locally generated sustainable energy. For these reasons a tariff system is needed, which can support such developments in local DC networks. As the present tariff system for AC networks doesn't satisfy all requirements of local DC networks, Liander is developing a new tariff model, which can be implemented for public LV DC distribution networks.

NEW TARIFF SYSTEM

Challenges and objectives

The present AC tariff system doesn't offer the needed flexibility for local DC network. It also does not satisfy the range of expected future demands, from the customer side and from the distribution system operator side.

The main objective of Liander for the new tariff system for LV DC distribution network is that this tariff system will contribute to reduction of integral social costs for both the customer and the distribution system operator.

Pilot DC network topology

In the pilot local low voltage DC distribution network customers (both consumers and local sources) will be connected directly (radially) to a low voltage DC bus-bar.

Customers of this DC network will not need the individual AC/DC conversion anymore. The AC/DC conversion, which is needed for the connection of a local DC distribution network to the main AC grid, will be provided integrally by the distribution system operator and will make a part of the regulated domain.

Via a gateway, which will contain an integral AC/DC power converter, the local DC distribution network will be connected to the main AC grid (Figure 1).

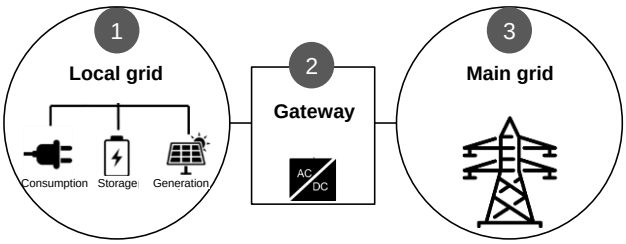

Figure 1. Network topology: a local DC network with connection to the main grid through a gateway.

Ways of reduction of integral social costs

A maximum achievable balancing between consumers and local sources in the above sketched local DC network will lead to the minimisation of power exchanges (via a gateway) between a local and the main networks. This will result in reduction of costs, concerned with energy losses in the gateway (losses in the AC/DC conversion step).

Furthermore if maximum achievable balancing will take place structurally, the next savings in integral social costs can be realized:

- Investments in the gateway can be reduced by means of decreasing of needed nominal power of the gateway (AC/DC conversion);
- By a higher degree of balancing in local networks, the main grid will be also less loaded. With a structural main grid load reduction, savings can be achieved on the dimensioning of the main grid;
- A reduced loading of the main grid will result reduction in return into lower energy losses.

Costs reduction, gained by local balancing, can be achieved by a tariff system, which will offer incentives to the customers who go down the road of the local balancing.

Requirements to a new tariff system

Liander is developing a new tariff system for low voltage DC distribution networks, which will be based on the next starting points:

- Cost causation principle. All costs concerning a DC network will be charged to DC customers. No socialization with an AC grid. The usage of the main grid will be passed to the customers;
- Stimuluses for the balancing between local production and demand. As a result, we strive for a minimum (peak) load from the main grid. The better the customers collaborate and balance, the lower rates they will have;
- Both suppliers and consumers should pay costs, caused by the transmission of the power to or from the customer. If not, the stimulating of balancing through collaborating between suppliers and consumers is not effective.

Tariff structure

A new tariff system will offer incentives for the customers in order to stimulate collaboration and balancing with each other. Basic elements of this tariff system are:

A. Flat rate tariff for the gateway

A flat rate tariff for the gateway in order to be connected to the main grid. The level of this rate depends on the dimensioning of the gateway (kW), that customers of a local distribution DC network will need. Efficient customers collaboration can lead to greater balance, and hence to a smaller gateway. That translates into a lower flat rate tariff for the gateway for the community and thus also for the individual customers.

- The capacity of the gateway is modular. Depending on the need of the community the capacity of the gateway can be changed. Periodically (possible annually), in agreement with the community, there will be determined if the capacity of the gateway needs to be adapted.

B. Variable rate tariff for the gateway

This rate tariff is based on load profiles of individual customers and on the integral load profile the community.

- The lower or flatter the integral load profile of the community (gateway) is, the lower the rate is;
- The share of the individual customer in the integral load profile of the community determines the variable rate tariff;
- In addition, a bonus or malus will be awarded if the integral load profile of the community deviates from the agreed profile. This bonus or malus will be then divided among the individual customers who have caused this deviation;
- Progressive rate for the use of the gateway capacity (at high load a rate will be progressively higher);
- If the community doesn't use the port, the variable rate tariff is zero.

C. Rate tariff for use of the main grid

- The common use of the main grid will be rated variably.
- There is still being investigated if also for this tariff component rate incentives have an added value. In theory, rate incentives for the use of the main grid can cause that multiple local grids will collaborate and balance with each other. Thereby they can potentially achieve similar benefits as customers by balancing in the local networks (as mentioned in this paper).

An example of the impact of incentives of a new tariff system on the dimensioning of a gateway is shown in Figure 2.

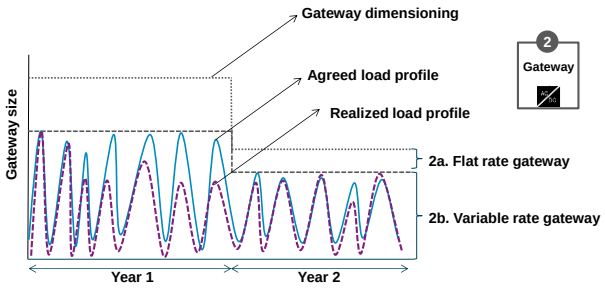

Figure 2. An example of the impact of incentives of a new tariff system on the dimensioning of a gateway.

CONCLUSIONS AND FURTHER WORK

Contours of the new tariff system for LV DC distribution networks is outlined.
The new tariff system is primary aimed at the minimizing of the gateway of the local LV DC distribution network.
Secondary, this system will help to reduce the load of the main grid. Savings can be achieved on the dimensioning of the gateway of the local LV DC distribution network and on the dimensioning of the main grid. At the end the new tariff system will lead to reduction in conversion losses and transportation losses. This tariff system will contribute to reduction of integral social costs: the costs for customers and the costs for the distribution system operator.
A new tariff system will offer incentives, which will stimulate customers of a local DC grid to collaborate and to balance with each other. Collaboration and interaction between the suppliers and the consumers is especially needed for the most effective local balancing.

The further development of the new tariff system will address the following challenges:

- Data processing and analysing. The proposed system requires ability of the customers to have more insight in the own load data and forecasting;
- Data sharing and communication. The participants should be able to have insight in the load and forecasting data of the entire community;
- Privacy and security aspects;
- Legal framework. A new regulation should be developed, which will enable innovative energy services;
- Acceptance by customers.

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