Status of NVE's work on network tariffs in the electricity distribution system

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Status of NVE's work on network tariffs in the electricity distribution system

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Sammendrag: NVE has undertaken a public consultation on possible changes to the regulation for setting network tariffs in the electricity distribution system for customers connected to the grid with a voltage of 22 kV or lower. How the network tariff is designed is important for how the network is utilised and developed, and for cost allocation amongst network users. The intention is to improve the utilisation of the network by shifting to a more cost-reflective tariff design.

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1 Introduction

The main objective of the Norwegian network regulation is to provide the basis for efficient electricity markets and efficient control of DSOs as natural monopolies. Network tariffs are set by DSOs according to principles set by NVE. In the current regulation, tariffs are designed, as far as possible, to give signals on efficient utilisation and development of the grid. Tariffs can be differentiated according to objective and verifiable criteria based on relevant grid conditions. Tariff design differs depending on what voltage level the customer is connected to.

By 1 January 2019, all electricity customers in Norway will have a smart meter. Smart meters will provide consumers with better information regarding installed and used capacity and prices, and facilitate opportunities for new tariff designs and new energy related services.

NVE has undertaken a public consultation[1] on possible changes to the regulation for setting network tariffs in the electricity distribution system for customers connected to the grid with a voltage of 22 kV or lower (the lower distribution system). The intention is to improve the utilisation of the network. Stakeholders generally support the need to make changes to the regulation. It is NVE's intention to provide clearer guidelines for how DSOs design tariffs, as well as to standardise how the methods for calculation of the settlement and settlement period are determined.

How the network tariff is designed is important for how the network is utilised and developed, but also for cost allocation amongst network users. A more effective, or smarter, network utilisation can reduce or postpone the need for future network investments, and provide lower electricity bills for users of the network overall. New technology leads to consumers having a more active approach to their energy usage and as such reduce their demand at specific periods while still maintaining the same comfort and user-friendliness. Whether or not consumers take advantage of these opportunities depends partly on how network tariffs are designed.

Current tariff design

The current regulation gives DSOs a large degree of freedom regarding how to design tariffs based on their allowed revenue, as set by NVE. Tariffs for households, vacation homes and small commercial customers mainly consist of a fixed charge (NOK/year) and an energy charge (NOK/kWh). On average, the fixed charge constitutes 30% of the network tariff.

[1] A description of alternative ways of designing tariffs in the electricity distribution network was presented in a consultation on 7 May 2015. The consultation submission deadline was 15 August 2015. The consultation and summary (only in Norwegian) is posted on NVE's website www.nve.no, and published in official NVE documents No. 3 2015 and 53 2016.

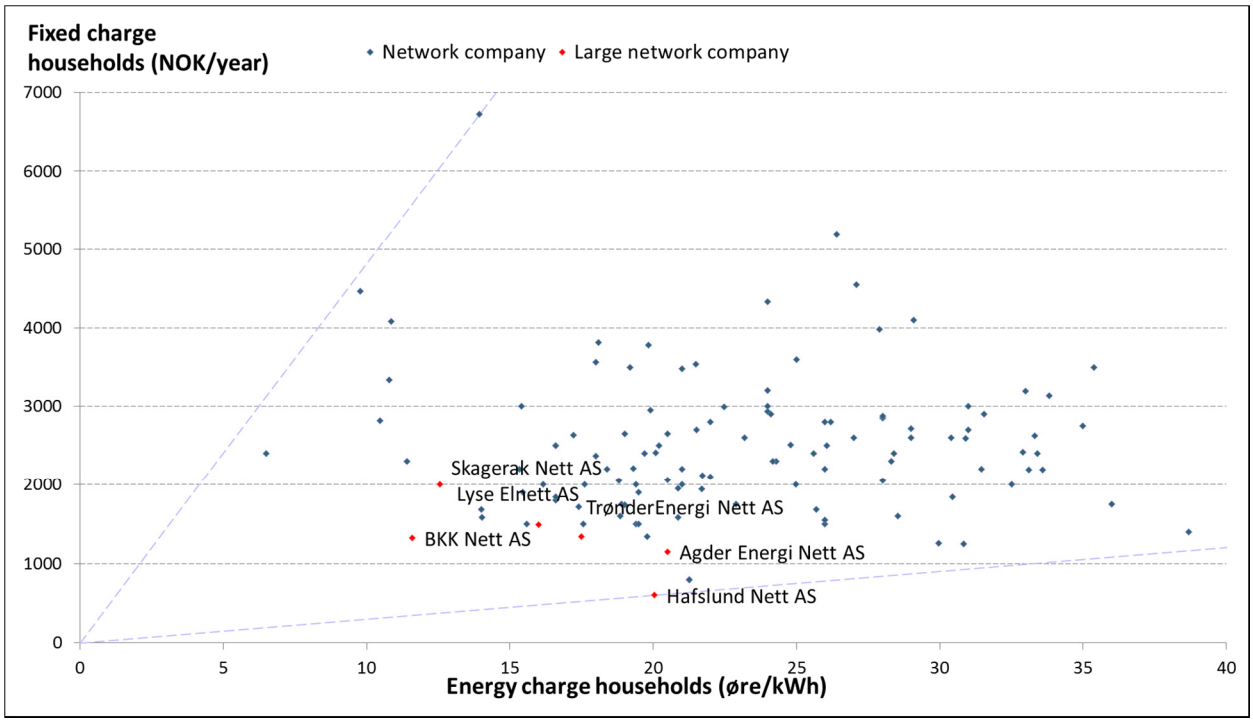

Figure 1 Level of fixed and energy charge (100 øre = 1 NOK) in the network tariff for household customers 2016

Customers with an installed capacity exceeding a set limit, for example over 80 or 125 amperes, or customers with an expected annual consumption exceeding 100 000 kWh, usually have a capacity charge (NOK/kW) in addition to the fixed and energy charge. The capacity charge is based on used capacity within defined periods of time.

When designing tariff regulations, it is important to be clear on the objectives. The Norwegian Energy Act Regulation gives guiding principles, which state that tariffs shall be designed so that they contribute to effective utilisation and development of the network. Furthermore, tariffs shall ensure customers non-discriminating access to the energy market, cover grid owners' costs within allowed revenue, as well as provide an acceptable allocation of costs between network users.

Future tariff design

Tariffs ought to be cost-reflective. Both the aim of effective utilisation and development of the electricity distribution network, and the objective of reasonable distribution of cost, suggest that tariffs ought to be designed according to network costs and what causes these expenses. The cost structure of the network has a large proportion of fixed costs that do not vary according to annual consumption. The main cost is related to being connected to the network and having the opportunity to use electricity from it. When investing in the network, demand for capacity during peak hours is a cost driver. In NVE's opinion this should be reflected in the tariff.

2 Capacity charge

Capacity (kW) is an important element when dimensioning the electricity network. It is, therefore, pertinent to give customers signals that their behaviour and decisions may affect how the network is developed and dimensioned. NVE foresees that tariffs should be designed so that it becomes more profitable to reduce demand in peak load, when network capacity is scarce.

What can be gained from capacity charges?
One purpose of pricing capacity is to stimulate demand response, which in turn can reduce network investments, i.e. when the cost of consumer flexibility is lower than that of network investment. Capacity charges can reduce customers' total demand for capacity, as well as contribute to increased flexibility. Adjustments customers make within 24-hours, such as choosing a different time to charge an electric vehicle (EV) at home, rather than during peak hours, may help reduce the maximum demand for capacity. Postponed investments or investments that are avoided, are profitable for all customers as network costs decrease or increases less.

The cost of building a network depends to a greater extent on customer demand for capacity, rather than energy usage. In future, capacity (kW) requirements are expected to be at least as important as energy (kWh) requirements, whilst correlation between customer's demand for capacity and energy consumption is expected to weaken. This challenges cost allocation in today's energy based tariff model. Capacity charges can be an effective and appropriate way of allocating network costs.

As a consequence of more demand for capacity (kW) rather than energy, the network will on average have more unused capacity. This leads to an inefficient use of capital invested in the network. Capacity charges may lead to consumers changing their behaviour to a more even use of the network which in turn leads to a more efficient use of the network.

What can't be solved by capacity charges?
Price signals regarding shortage in network capacity in the lower distribution system should be given in advance, so that the consumer can respond to them and prevent congestion. On higher voltage levels and in the transmission system, congestion management is solved mainly through bidding zones in the day-a-head spot market. In practice, real-time capacity tariffs in the distribution system are difficult to outline, as there are no such market mechanisms for lower distribution systems.

Capacity charges to solve real-time congestion in the distribution grid are inappropriate tools to solve the shortage problem which are more efficiently handled in other ways, such as through agreements for interruptible load and market based solutions for flexibility.

Consumer focus

It can be complex to design network tariffs, and they are not always very intuitive for the consumer. It is important to NVE that the tariff is easily understandable to customers, whilst also allowing them to make good choices regarding consumption and when selecting energy sources. When price signals are sent through tariffs, it is crucial that customers understand how their own behaviour affects costs. NVE finds it is reasonable that consumers that adapt favourably towards the network get lower tariffs.

Consumers and their willingness to adapt play an important role in achieving a low emissions and an environmentally friendly society. Tariffs can help encourage customers and generate commitment for beneficial adaptations. NVE wishes to make life easier for well-informed and partaking energy users. Through active consumer participation one can achieve favourable adjustments in the network distribution system, where measures made by consumers are weighed up against improvements in production and infrastructure. Such adjustments may be in charging patterns for EVs, water heaters or central heating and light settings at green houses. By giving customers incentives for favourable adjustments, capacity is made better use of. Increased flexibility, incorporated into investments customers would make over time anyway, should also be encouraged.

Consumers should not have to invest in expensive technical solutions in order to respond to price signals through such a tariff. Meanwhile, how the tariff is designed may facilitate and encourage consumers to adopt new smart technology. Such technology has become increasingly affordable and more user-friendly. This trend is expected to accelerate. By utilising new technological solutions in a good way, the need for new network investments can be postponed or avoided without customers experiencing that such adaptations mean loss of comfort.

The relationship to other energy sources

An important prerequisite for customers to make wise choices in terms of energy source, is that the design of the network tariff reflects costs incurred by the DSO through consumer use. Cost-reflective tariffs will ensure that electricity from the network is priced more accurately compared to other energy sources.

The restructuring of tariffs involves a transition from energy based to more capacity based tariffs. The price for the use of electricity per kWh goes down, whilst pricing for simultaneous consumption in kW is introduced as a supplement. Thus, it may be cheaper to charge an EV, but it can become more expensive during fast charging, particularly at times when the overall demand for capacity is otherwise high. Similarly, electric heating solutions or energy savings that also takes into account how consumer behaviour affects the electricity distribution network can become more favourable when capacity tariffs are introduced, compared to current energy charges.

The relationship to the Energy Efficiency Directive
According to the Energy Efficiency Directive[2], Article 15, users of the network shall, through network tariffs and regulations, be given incentives to implement energy efficiency measures, consumer flexibility ('demand response') and 'demand-side management'. NVE believes capacity based tariffs generally contribute towards energy efficiency measures taking into account how they affect the electricity distribution network. Capacity charges contribute more to increased customer flexibility than current energy charges, because they provide a price signal that levels out consumption.

Capacity charge and fire hazards
Attention from many actors has been drawn to the fact that economic incentives to use electrical appliances that require supervision at night will increase the risk of fatal fires. This aspect must be taken into account when outlining the details when designing a tariff model, as well as when assessing how strong the price signal should be. It is important that consumers are well informed about the risks of using different kinds of electrical appliances and to what extent supervision is required.

Capacity charge and charging of EVs
Tariffs should be general and basic principles should apply to all customers connected to the distribution system. The Norwegian EV Association's annual survey[3] shows that the majority of EV charging happens at home or at work with moderate or low demand for capacity. Switching to capacity charges will make such charging cheaper relatively to today's energy charges and fast charging and on-peak charging. Fast charging only stands for a small percentage of overall charging needs. The trend, however, is that EVs can be charged with increasingly greater capacity. In a few years, fast charging with a capacity of 150-350 kW can be commercially available. Capacity charge may be an incentive to incriminate the network less, for example by extracting power from a buffer battery. With smart communication and control systems and new market solutions, such buffer batteries may on occasion be able to supply power back to the network. Also EV batteries will be able to provide power to the network. EVs are normally on the move for short periods and their batteries unused the majority of the time. A capacity charge can make it attractive for EV owners to use car batteries to reduce the customer's total demand for capacity at peak times (vehicle to grid). Capacity charges, as such, provide incentives that contribute to EVs becoming an advantage in relation to network operation.

Discounts in tariffs for EV charging will increase costs for other network users, as well as distorting competition in relation to other climate-friendly technologies such as hydrogen. However, it is important to consider how the specific tariff design affects customers with low load factor, such as charging stations for EVs, ensuring that price signals that affect these customers unreasonably hard are not given.

[2] The Energy Efficiency Directive was adopted in the EU in 2012, but has not come into effect in the EEA.
[3] 'Elbilisten' 2015

3 Designing the network tariff

The network tariff in the distribution system must, according to current legislation, consist of a fixed as well as an energy charge. In addition, customers can be charged a capacity charge. The roll out of smart meters provides DSOs with several methods for determining network tariffs. This chapter covers how NVE foresees network tariffs to be designed in the future.

3.1 Energy charge based on marginal loss costs

The demand for network services should be priced as correctly as possible. Today, the energy charge is set too high. Data supplied by DSOs shows that the energy charge accounts for almost 70% of tariff income from household customers, while revenues from the fixed charge accounts for just over 30% of the tariff revenue.

Tariffs shall as far as possible provide price signals that reflect the actual cost users impose on the network system. Heat develops when power is transmitted through the network, and as a result some of the electricity is lost. Short-term variable costs in the network, if there are no capacity constraints, mainly consist of marginal loss costs, i.e. the marginal energy loss rate multiplied by the electricity price. The energy charge should in principle reflect the marginal loss cost of transferring electricity.

Pricing of marginal loss means that the energy charge will cover more than the actual loss costs. The energy charge constitutes a form of capacity pricing as the marginal loss can be significant when the load on the network approaches its peak. The size of the marginal loss depends on, amongst other things, the distance between production and consumption. Consumption far away from production entails a higher loss cost than consumption close to production. The size of the marginal loss will vary between different time slots, as the overall load in the network varies.

A more cost-reflective energy charge means that the maximum level, in future tariff formulation, will be reduced. This is to avoid adverse incentive impacts, and so that customers with a high annual energy demand do not cover a larger share of the network costs than those customers with a lower annual energy consumption but higher capacity use.

NVE intends to propose changes to the regulation, so that it will not be possible to regain costs beyond marginal loss costs through the energy charge. This will provide the right incentives and a more reasonable cost allocation between network users. It may be necessary to provide further guidance on how marginal loss can be determined. Such a change could come into effect one to two years after the roll out of smart meters.

How detailed should energy charges be?
To keep the tariff simple and understandable, with non-discriminating treatment of customers, NVE believes that, there should not be a requirement to differentiate energy charges within the DSOs' supply area.

Similarly, at this stage, NVE does not find it necessary to introduce an obligation for higher resolution rates for a marginal loss based energy charge than today's regulatory requirements. Today's requirements impose DSOs to offer tariffs with time differentiated

energy charges to all customers in the distribution system with expected annual consumption above 8000 kwh. However, DSOs should have freedom to differentiate, both geographically and in time, if carried out in a non-discriminatory manner and based on objective and verifiable criteria.

3.2 Models for capacity tariffs

NVE has outlined three alternative models to cover grid costs that are not covered by a marginal loss based energy charge.

- Capacity charges (NOK/kW) based on measured capacity usage
- Capacity charges (NOK/A or kW) based on installed capacity
- Capacity charges based on subscribed capacity, with penalties for consumption above subscribed capacity or using switches in the smart meter to curb this consumption

3.2.1 Capacity charge

NVE perceives that calculating network costs based on what capacity the customer has used is an appropriate way of providing price signals and allocating network costs. Several aspects need to be considered when stipulating the level of the capacity charge of the network tariff. The long-term price signal needs to be weighed up against short-term efficient use of the existing network capacity. A high price for capacity could give too strong an incentive for customers to reduce demand, i.e. avoid simultaneous consumption even when there is sufficient capacity. It might, therefore, be appropriate to provide more detailed guidance in the regulation for how such capacity pricing should be designed. Based on the DSOs' costs structure, one should be able to determine which costs relate to customers' demand for capacity.

In the long term it can be argued that most of the DSOs' costs, besides costs due to network losses and customer service, may be linked to the customer's demand for capacity or ability to consume power. As such, a capacity charge can, in principle, cover all network costs except those related to customer specific services and the customers' energy usage, given that the price signal is not too strong.

Cost reflective tariffs that provide signals for efficient network utilisation, must be weighed up against the tariffs being understandable and reasonable to customers. Certain aspects of customer's behaviour to reduce the demand for capacity as a result of price signals will have very low costs for the customer. Other adaptations may be more costly, for example, the discomfort or inconvenience caused by moving activities to other times of the day, investments in devices with low demand, or installation of control systems. Some types of electricity consumption will in a very low degree be affected by price signals through the network tariff.

It may be useful to distinguish between costs relating to capacity and those related to actual consumption:

- It is reasonable that the price for using capacity is based on network costs related to dimensioning of the network, and thus customers' demand for capacity. This includes the network's capital expenditures. The price of using

capacity can influence customer behaviour, so that customers that are not willing to pay for use at a given time may move their consumption to a time when it is more affordable, or even out consumption by using other heating sources such as firewood.

- Costs related to the option to use capacity are to a lesser degree dependent on when consumption takes place. Therefore, it can be argued that these costs should be covered by a tariff which better facilitates long-term price signals, and to a lesser extent affects customer behaviour in the short term. A differentiated fixed charge for installed capacity is a form of pricing electricity that provides a long-term price signal and to a lesser degree gives an incentive to change behaviour in the short term.

Methods for calculation of the settlement and settlement period
Customers connected to the distribution system are invoiced based on capacity usage in defined periods. The current regulation does not give clear instructions on how the capacity charge should be designed beyond that. The capacity charge may be designed to provide price signals that affect consumption, or with little influence on consumption. The design details are crucial for how the capacity charge works.

It is crucial that customers understand how their own behaviour affects costs, whilst it at the same time may be unfortunate to give signals on scarcity at times when there is available capacity. On the other hand, customers will not be able to change their consumption significantly, no matter how strong a price signal, if it is not sent before capacity is constrained. The need for awareness that the customer's demand for capacity is a cost driver must be weighed up against pricing consumption during periods with free capacity. A network tariff that does not take into account that the load in the network varies over time, will give the customer an incentive to reduce capacity demand, even when there is spare capacity in the network.

Pricing of capacity can be challenging to communicate. When the customer's peak load does not match the network's peak load, the price of capacity may be perceived as unreasonable.

The capacity charge ought to be designed so that it is profitable to reduce consumption at peak hours. Hence, during settlement, measured capacity should reflect typical peak hours.

Customers with a high demand for capacity relative to energy (low load factor) are likely to get increased costs during the transition from energy charges to capacity charges depending on how the model is designed. The transition to capacity charges is made smoother when multiple billable hours are used. More billable hours will reduce the impact of single peaks in consumption. Short settlement periods reduce the amount of time the customers are affected by single events, but mean that customers must consider their demand for capacity and any customisations more often.

3.2.2 Hourly network tariffs «time-of-use»

Energy (kWh) is defined by the power (kW) consumed over a one hour period. ‘Time-of-use’ tariffs set in advance value energy during typical peak hours at a higher rate than energy at other times. Customers are, thus, prompted that an additional kW during certain

hours is more expensive than an additional kW otherwise. Customers that use maximum capacity in typical off-peak hours will not get as high a tariff charge as customers that use maximum capacity at typical peak times. It is, therefore, attractive for customers to reduce their demand for capacity during expensive hours, and then achieve a more even demand profile.

This method of network tariffing may be easier to communicate to customers than one based on the customer's maximum capacity usage. Customers do not need to relate to the capacity usage, but that consumption at predetermined times (expected peak hours) are classified at a higher price than off-peak.

The model is relatively simple for the customer to relate to, whilst making it attractive to change consumer behaviour. Even commercial customers, will be able to move consumption to times that are more beneficial for the network. It will be relatively easy to calculate and verify profitability by establishing measures to reduce customer load during expensive periods. NVE believes this can be a good way to make the customers aware of costs they inflict on the network.

Easily understandable tariffs must be weighed up against the likelihood of customers making adjustments during off-peak hours. Generally, in Norway, the load is higher on cold winter days. This may indicate that a capacity charge (time-of-use) should be set on certain hours in the winter months. On the other hand, it may be easier for customers to relate to the fact that consumption at certain times may be more expensive than others, regardless of time of year. Hourly network tariffs throughout the year, may be more profitable for customers that want to use new smart technology. The tariff can be kept at a reasonable level while contributing to income coverage for DSOs. On the other hand, it increases the probability of unnecessary adaptation. The load profile in the network usually has two peaks. One in the morning and one in the afternoon. NVE believes it is appropriate to base time-of-use tariffs on these peaks.

3.2.3 Tariffs based on installed capacity

Customers are entitled to connection and use of the network from the DSO, normally against payment through a connection charge. The DSOs are obliged to provide power according to installed capacity. DSOs can make assumptions that not all customers will take out maximum demand simultaneously. However, the size of customers' installed capacity indicates how the network is dimensioned.

NVE believes that it is reasonable that all customers pay an annual fee for being connected to the network, with all the rights this entails. A fixed charge differentiated on the basis of the customer's installed capacity is a form of capacity pricing, which means that the possibility to take out high capacity is more expensive than for low capacity.

Tariffs based on the customers' physical installation are not very dynamic. However, it provides predictability in cost and revenue for both the customer and DSOs. On the other hand, it may be desirable that customers are given the opportunity to influence their tariff costs through continuous adjustment in consumer patterns, such as time-of-use or capacity charge.

3.2.4 Tariffs based on subscribed capacity

Subscribed capacity means that customers subscribe to a certain amount of network capacity at a given price per kW. If consumption beyond the subscribed capacity is permitted, a significantly higher price could be fixed for such consumption. Alternatively, consumption could be quenched/halted when the subscribed limit is reached.

If the customer exceeds the subscribed limit, the model provides strong incentives for behavioural change, even in periods with free capacity in the network. It is not obvious that the model to a larger extent contributes to effective use or more efficient development of the network in relation to other models, or a combination of these. On the basis of the feedback from public consultations, NVE understands that the subscribed capacity model is not preferred. NVE aims to limit the variety of tariff models. NVE does, therefore, not intend to change regulations in order to open for tariffs based on subscribed capacity at this stage.

The model for subscribed capacity may still be relevant in the future, when there is more experience regarding capacity tariffs, smart meters and new user interfaces, customer behaviour and preferences. It is possible to grant exemption from regulations for DSOs that want to try the model for subscribed capacity.

3.2.5 NVE's assessments on future capacity charges

Capacity charge should be priced both in order to postpone or save network investments, and also to ensure a more reasonable allocation of network costs amongst users. NVE intends to amend regulations regarding the tariff design in the distribution network.

The intention is, that the regulation specifies that capacity charges should be mandatory for DSOs. It may be reasonable that the level of the capacity charge should reflect the costs of network dimensioning. NVE stipulates that requirements for capacity charges are introduced one to two years after the introduction of smart meters, so DSOs can make use of the meter data.

Capacity charges can be calculated based on the customer's measured capacity usage at defined periods. NVE intends to provide clearer guidelines to standardise how the settlement basis and settlement periods for capacity charges are determined. The settlement basis should focus on typical peak hours.

NVE intends to open up for 'time-of-use' tariffs as an alternative to measured capacity charges. Consumption during expected typical peak hours are priced higher than off-peak consumption.

NVE encourages DSOs to map customers' installed capacity when rolling out smart meters, as costs related to customer's physical capacity are indicated by that.

NVE does not plan to amend regulations in order to facilitate for tariffing based on subscribed capacity. DSOs that want to try out such tariffs, may be given dispensation.

A successful restructuring of the tariff structure requires that DSOs have a good customer relationship. Parts of the outlined reform may be implemented before smart meters are rolled out. DSOs should consider a gradual tariff restructuring in the coming years. This may especially pertain to DSOs with high energy charges and low fixed charges.

3.3 Terminating the scheme of reduced tariffs for interruptible load and introduction of market based solutions for flexibility

NVE has outlined a solution where DSOs can, when required, buy flexibility from consumers through market solutions as an alternative to offering reduced tariffs to customers with an agreement on interruptible load.

There are many concerns that need to be assessed before NVE can impose a regulatory framework for market based solutions for flexibility. NVE does not plan to ban reduced tariffs for interruptible load, before a market solution for this kind of flexibility is developed. The flexibility that is currently awarded through tariffs for interruptible load can, in principle, give rise to reduced network investments because such agreements can also be useful during outages, operational challenges and maintenance, thus providing flexibility to the system. However, NVE finds it natural to consider the scheme alongside a market solution for buying and selling flexibility.

THEMA (2016), recently delivered the report 'A theoretical approach to a market solution for local flexibility', commissioned by NVE. Two important prerequisites for an effective market solution are pointed out: Demand must be specified, i.e. the DSOs must recognise the need for and cost of a possible network reinforcement, and the market solution must describe the actual offer. In order for supply and demand to find an equilibrium, THEMA states that flexibility products must be defined in a way that both meets DSO requirements as well as utilising the demand response. THEMA considers that neither DSOs nor potential providers of local flexibility are ready to introduce sophisticated market solutions for local flexibility at present, as neither technology nor the meter data are adequate, nor has the problem been adequately investigated.

THEMA, however, thinks that it is, in principle, possible to introduce a market solution that basically builds on today's scheme for tariffs for interruptible load, through long-term agreements on curtailment of consumer load. THEMA, however, points out that the following aspects need to be clarified before a market solution can be introduced:

How procurement is organised: Long-term auctions to ensure availability of adequate capacity and flexibility resources, if the network is not reinforced. Selection based on offered reserve price. Clarify the need for activation prices, and whether any strategic behaviour is implied as a result.

Product definitions: Specify demands in order to know what products the distribution company needs. Matching characteristics on the supply and demand side. The need for standardisation in order to ensure sufficient liquidity.

Ownership: The distribution company may operate the solution, provided that neutrality issues are assessed and managed.

Coordination with the TSO's system operation: It must be clarified whether the DSOs' use of local flexibility may come in conflict with the TSO's need for system services, and how any conflicts may be solved.

The interaction with existing regulations: The current income cap regulation may, in principle, distort the distribution companies' incentives in favour of choosing grid investments instead of paying for local flexibility. This needs further clarification.

NVE will investigate further possible regulatory frameworks on market solutions for retail flexibility, and is positive towards a pilot project. Further studies will be carried out separately from the work with the general tariff design in the distribution network.

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