bdew

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Discussion paper

Smart Grid Traffic Light Concept

Design of the amber phase

Berlin, 10 March 2015

1. Management Summary

The power grid is today already facing serious challenges due to the integration of renewable energies and increasing network bottlenecks. As the expansion of the distribution network is associated with high costs, the BDEW Smart Grid Traffic Light Concept represents a possible method of intelligently reducing the need for expansion of the distribution network. Measures such as intelligent feed-in management do not yet form part of the considerations. Principles for intelligent feed-in management are currently being developed within the regulatory framework. The conclusions reached in that process should be taken into account and further developed in the discussion surrounding the traffic light concept.

The traffic light concept raises a model for discussion as to how market participants and network operators can interact with one another in future. Using the logic of a traffic light, between the green market phase, in which the power grid functions for the marketplace without restrictions and the red phase in which the system stability is jeopardised, an amber intermediate stage is also defined.

The amber phase is entered if a potential network bottleneck exists in a defined network segment. In the amber phase, distribution system operators call upon the flexibility offered by market participants in that network segment in order to prevent a red phase situation. The Smart Grid Traffic Light Concept describes the process of determining flexibility and calling upon flexibility using case studies for all three traffic light phases.

2. Objective

The increasing degree of decentralisation in electricity generation but also the goals in the area of energy efficiency and energy saving require adjustments in the area of infrastructure as well as to market processes and to market communication. The business models of the energy industry are in a period of change.

In order to guarantee a secure, good value and environmentally friendly energy supply in future, distributed energy generation and controllable end consumption should be bundled and coordinated. To this end, dispatchable power plants and smart grids will be required as well as market participants who offer flexible capacity. This also requires that market participants and network operators interact more than they do at present.

In order to ensure that this interaction complies with unbundling regulations, the traffic light concept first laid out in the BDEW Roadmap, "Realisation of smart grids in Germany" (2013), can be used. The Roadmap defines which actors have to carry out which measures within the next ten years so that smart grids are able to provide their contribution to creating a system of energy supply based on renewable energies.

The Smart Grid Traffic Light Concept builds on the BDEW Roadmap. In today's power grid, there is only the green phase (market phase) which can, in extreme situations, suddenly become red (grid phase). As the transition from one phase to the other will become increasingly significant in future, the objective of this discussion paper is to provide greater detail on the amber phase - i.e. the interaction of market and grid. Whilst the Smart Grids Roadmap out-

lines the overall concept, the Smart Grid Traffic Light Concept now describes the precise rules for a long term, robust system. From that, procedures and then data formats can be defined.

3. Flexibility in the smart grid

Flexibility can be used in different ways. On the one side, it can be used by transmission system operators to maintain system stability. In this context, one refers to system flexibility. On the other side, it can serve market participants as energy balancing or serve trade in times of highly volatile market prices. This is referred to as market flexibility. In addition, flexibility can be demanded by distribution system operators to control critical local network situations. In this way, network expansion can be avoided, reduced or postponed. In this case, it is network flexibility.

The interaction between distribution networks and this network flexibility has a special significance for the amber phase in the smart grid. Unlike the other two forms of flexibility, the network flexibility is characterised by the local element with its effect in a specific segment of the network. **The traffic light concept relates to the use of network flexibility.** The use of network flexibility determines the phase of the traffic light. Flexibility can take the form either of a change in the energy feed-in or in the consumption. In addition to the established ancillary services, such as balancing energy and redispatch in the transmission network, the implementation of the concept represents an alternative to the expansion of the distribution network. Other options also exist, such as feed-in management and capping peak feed-in, independent of the traffic light concept.

As flexibility can be used for the benefit of the network, the system or the market, rules have to be created for the request and allocation for multiple marketing.

Network flexibility must be bindingly available in order to reduce the local need for network expansion. Non-binding and non-schedulable flexibility is unsuitable for network uses by the distribution system operator. Instead, it tends to lend itself more to market users.

In the network segments in which the distribution system operator is deciding or has decided, after a technical and economic analysis, to manage the network using flexibility, a non-discriminatory access to the flexibility market must be ensured. This means that the distribution system operator will examine, according to technical and economic criteria, the use of flexibility to avoid network expansion in his network. The employment of flexibility must technically serve to reduce the load on the network and must be less costly in the long run than network expansion. Should the respective analysis conclude that there will be a positive result, the distribution system operator sets out for the long term which are the relevant network segments which it considers suitable for the employment of flexibility and which fulfil the respective criteria. The distribution system operator publishes his need for necessary network flexibility in an appropriate manner. He ensures that the selection and contracting of flexibility occurs according to transparent and objective criteria thus guaranteeing non-discriminatory access to the flexibility market.

The distribution system operator calculates the need for adjustment at any given time (network segment, amount of relative adjustment required, duration) and informs the suppliers or aggregators accordingly. Suppliers and aggregators have different roles, however in the case of the utilisation of flexibility, they assume similar responsibilities. The distribution system operator informs only those suppliers/aggregators, who provide network flexibility in the respective network segment. For all other suppliers and customers in the network segment, there are no restrictions even during the amber phase. For them, there is in effect no difference to the green phase.

Depending on the actual demand and the available potential for network flexibility, the distribution system operator attributes the need for adjustment in a non-discriminatory manner to all participating flexibility providers (usually suppliers/aggregators) in the network segment concerned.

The supplier/aggregator implements the network flexibility requested by the distribution system operator in the respective network segment. The implementation of a holistic approach to flexibility can occur using a number of individual flexibilities from different flexibility providers. The suppliers/aggregators are free to choose whether they use fixed control quantities such as curtailment services or setpoint values and how they arrange the allocation to their network flexibility. The distribution system operator observes, with the help of the available sensor technology, the effect in the network segment concerned.

The use of flexibility requires communication between the network operators. The utilisation of flexibility must be properly processed between the network operators from an accounting and energy perspective.

4. A traffic light regulates the flow of electricity.

The idea behind the traffic light concept is that for a particular period of time and a particular network segment, the network status can be described using one of the colours, "green", "amber" and "red. Depending on the relevant traffic light colour, certain rules apply in the respective network segment for the interaction of all relevant market roles such as suppliers, balance responsible parties, generators, storage facility operators and the statutory regulated role of the network operator.

The concept proposed by BDEW describes the interaction between the different market roles. Therefore, it lays the foundation for the development of a flexibility market at the distribution network level and thus differs from other traffic light concepts such as that of ENTSO-E, which describes the network status and the capacity to act of transmission system operators (TSOs).

Figure 1 describes the basic idea behind the Smart Grid Traffic Light Concept as already presented in the BDEW Smart Grid Roadmap. The figure is designed to show clearly that the situation in the distribution network has a direct influence on the traffic light colour and thus the interaction of market and network.

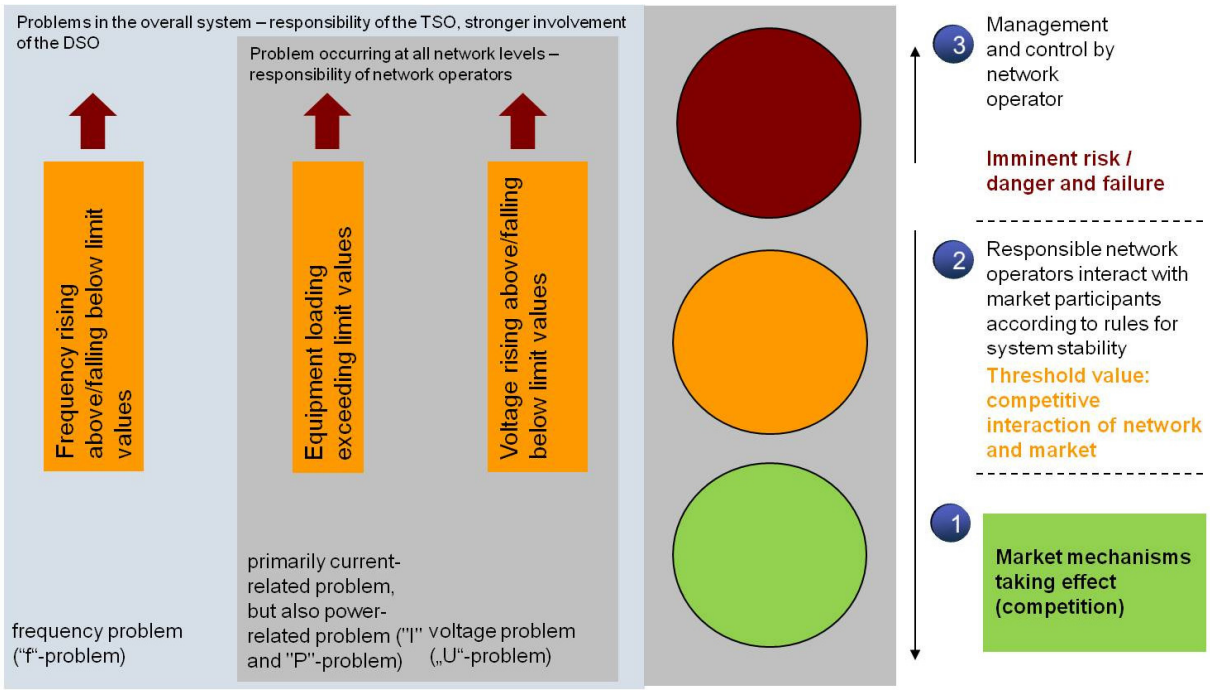

Figure 1: Traffic light concept from the Roadmap for Smart Grids (BDEW)

The distribution system operators calculate the current and forecast status of their network segment and allocate one of the three traffic light phases accordingly. With the implementation of this traffic light concept, network operators are able to signal a usually localised need for flexibility to the market participants and thus to create an incentive for altered customer behaviour. On the basis of the information provided by the network operator, the market participants can develop new products and offer them to the network operator. If the utilisation of flexibility by the distribution system operator (DSO) has an effect on the upstream network, the DSO will involve the upstream network operator in a timely manner.

4.1 The green phase

In the green traffic light phase, the market phase, no critical network situations exist. Demand and supply of flexibility takes place solely between non-regulated market participants. Network operators do not intervene in the market. The green phase thus exclusively serves the use of flexibility for the benefit of the market.

In this phase, all market products can be supplied and demanded without restriction. The market can achieve its potential within the supply of energy through financial incentives and thus contribute to the integration of fluctuating feed-in. The network operator observes the network status and does not intervene in the market.

4.2 The amber phase

In the amber traffic light, the interaction phase, there is a potential or actual network shortage in the defined network segment. The network operator remedies the situation by utilising the flexibility offered by market participants. There is an interaction between market participants and network operators. In addition, the market can use remaining flexibility for the benefit of the market.

In the amber phase, the distribution system operator calls upon contractually promised flexibility, taking into account the effect on the network shortage. This will generally be effected indirectly through measures agreed with suppliers/aggregators or in exceptional cases, should such measures be lacking, directly according to direct contractual arrangements. In this context, the involvement of the balance responsible party is absolutely necessary and a model for distributing the costs incurred must be found. The flexibility providers must ensure that due accounting procedures are followed. Interventions during the amber traffic light phase are always associated with payment for the flexibility by the network operator.

As a result, network users can adjust their behaviour and profit from the contribution to securing system stability. On the basis of historical values and the up-to-date system forecasts, the responsible network operators report the forecast need for flexibility to the market participants with which it has contractual agreements for the right to utilise flexibility.

4.3 The red phase

In the "red traffic light phase", the "network phase", there is a direct risk to the stability of the system and thus to the security of supply. In addition to the described measures in the amber traffic light phase, the network operator must intervene directly in a controlling or balancing manner in its own operational facilities, the operational facilities of downstream network operators and in the market. This occurs by way of direct instructions to the appropriate generation or consumption facilities.

Situations which jeopardise the system frequently extend to several network areas. For this reason, TSOs and DSOs interact in order to guarantee the stability of the system. In this process, measures to switch off generation and consumption facilities as per Sec. 13 (2) EnWG (German law on the energy industry) or in the distribution network as per Sec. 14 EnWG are employed. Certain EEG (German Renewable Energy Act) feed-in management measures as per Sec. 11 EEG also fall into this category.

As soon as the network operator has to employ non-market based regulation or control measures to ensure system stability, the amber or green phase changes to red. The red phase should largely be avoided in the interests of security of supply.

5. A practical example of the utilisation of flexibility

Figure 2 depicts the roles involved and their responsibilities in the calculation of the flexibility potential as a process diagram. The visualisation of the process has been presented in simplified form using the example of a flexible load on the end customer side. For clarity, not all steps in the process and not all contractual relationships are portrayed. The example can be adapted for flexible generation or storage facilities and for other customer groups.

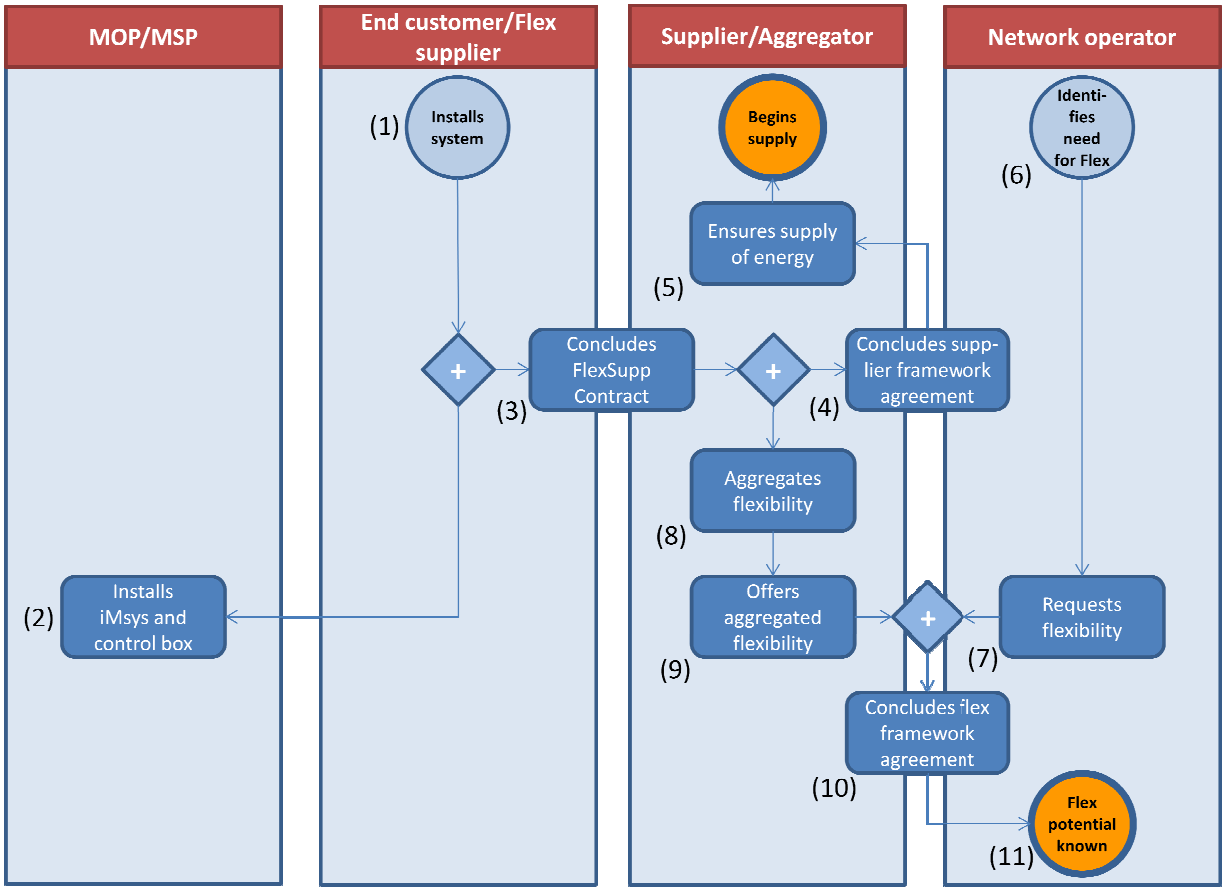

Figure 2: Calculation of the flexibility potential

(1) The end customer installs a device, the capacity of which can be made completely or partly available as network flexibility.

(2) In order that the device can be metered and controlled, the meter operator (MOP) installs a smart metering system with a control box.

(3) The end customer offers his flexibility to a supplier/aggregator. They both enter into a flexibility supply agreement. The end customer thus becomes both user of energy and provider of flexibility.

(4) The supplier/aggregator and the network operator conclude a supplier framework agreement.

(5) On the basis of the supplier framework agreement, the supplier/aggregator ensures the supply of energy to the customer system.

(6) The network operator identifies a need for flexibility in order to manage his network efficiently.

(7) The network operator requests the identified flexibility.

(8) The supplier/aggregator aggregates the contractually assured flexibility of the end customers.

(9) The supplier/aggregator offers this aggregated flexibility to the network operator.

(10) The network operator concludes a flexibility framework agreement with the supplier alongside the general supplier framework agreement.

(11) Through the flexibility offered by the supplier/aggregator the network operator is aware of the flexibility potential for the respective network segment.

All other steps in the green, amber and red traffic light phases are based on this process of calculating the flexibility potential.

5.1 Application 1: target model

The supplier/aggregator has a flexibility supply agreement with the end customer and a supplier framework agreement with the network operator (c.f. Figure 2). The network operator is aware of and contractually guarantees the flexibility potential. Figure 3 depicts the process of utilising flexibility in the target model.

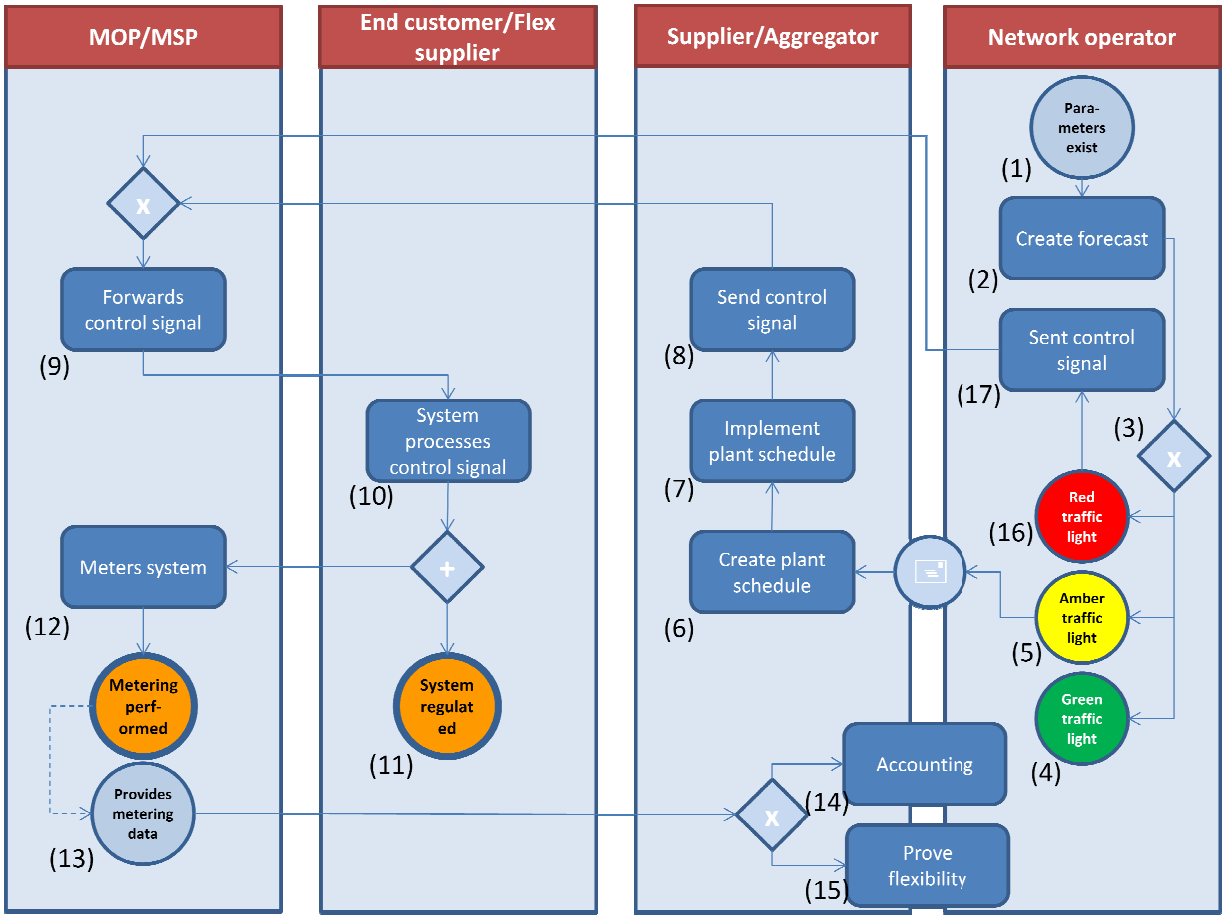

Figure 3: Utilisation of flexibility in the target model (usual situation in the amber phase)

(1) The network operator has all relevant information required for forecasting purposes.

(2) The network operator makes forecasts, on the basis of various different parameters such as load profiles and weather forecasts, as to the expected network status in the network segment in which the operator has identified a general need for flexibility.

(3) On the basis of these forecasts, the network operator determines the colour of the traffic light phase for each network segment.

5.1.1 Green phase in the target model

(4) The network operator's forecast shows that no adjustment of the expected load development in the network segment is necessary. The green traffic light phase.

The supplier/aggregator controls the systems in his portfolio according to the contractually agreed standard supply conditions. The generation plants can feed power into the system freely according to the supply of energy.

5.1.2 Amber phase in the target model

(5) The network operator's forecast shows that a potential network shortage exists and an adjustment of the expected load development in the network segment is necessary. He declares the amber traffic light phase for the respective network segment.

(6) The supplier/aggregator creates the plant schedule taking into account the balancing rules according to the adjusted demand request.

(7) The supplier/aggregator implements this plant schedule.

(8) Furthermore, the supplier/aggregator transmits the control signal to control the customer system.

(9) The control signal is forwarded by the meter operator in its function as gateway administrator to the customer system.

(10) The customer system processes the signal.

(11) The customer system is regulated according to the signal.

(12) The meter operator measures the energy usage and the feed-in of energy to the system.

(13) The meter operator provides the meter data.

(14) The meter data is used for accounting purposes. The accounting is completed according to the meter reading curve (in the case of standard load profile customers) or real load profile (in the case of real load profile customers), based on a time series of measured values.

(15) The measured values serve as a proof of rendering of flexibility between the supplier/aggregator and the network operator.

5.1.3 Red phase in the target model

(16) The forecast of the network operator shows that a direct danger to the network stability in the respective network area or even the upstream system stability exists and thus to the security of supply, even if the network flexibility is utilised. The network operator declares the red traffic light phase.

(17) The network operator directly transmits the control signal to control the customer system. After that, steps (9) to (14) as per the amber phase are followed.

5.2 Application 2: Transitional model for SLP and TLP applications

In the case of accounting on the basis of consumption metering, the target model is generally applicable and already in use today. In the case of accounting on the basis of standard load profiles (SLP) and temperature-dependent load profiles (TLP), such as heat flow applications, the target model cannot be applied. Therefore, this section will outline a transitional model for SLP and TLP applications to enable the network operator to gather experience with the management of a distribution network.

In order to mobilise flexibility, as a requirement for the successful integration of renewable energies into the market, in the near future, a transitional solution makes sense. This implementation of the solution should be simple and low-cost using existing processes and infrastructure, in particular existing metering systems and meters as well as control systems for feed-in management.

In the model, flexibility is only introduced through the cyclical adjustment of the temperature-dependent load profiles by the network operator who then makes these profiles available to all suppliers/aggregators in a non-discriminatory manner.

After the market-compatible introduction of a meter reading curve, the interim solution will transition to the target model. As such, the transitional model is a type of preliminary step and test bed in respect of the increasing complexity of future application cases.

5.2.1 Green phase in the transitional model

The transitional solution unlocks network flexibility for the distribution system operators.

5.2.2 Amber phase in the transitional model

The difference between the transitional model and the target model is that in the transitional model, the supplier cannot switch and uses the already existing switching and controlling possibilities of the respective network operator, for example, where compatible, the radio control and remote control technology. In the amber phase in the transitional model, therefore, the network operator performs steps (6) to (8) of Figure 3.

The other steps of the process correspond to the utilisation of flexibility of the target model, whereby a proof of flexibility (15) is not necessary.

5.2.3 Red phase in the transitional model

The red phases in the target model and the transitional model are identical.

6. Recommendations for action

The implementation of the BDEW Smart Grid Traffic Light Concept will enable the distribution network to be intelligently optimised and to provide an additional option to the existing planning principles for the design of the network. The idea behind the concept is that where a potential network shortage in a defined network segment exists, flexibility offered by market participants can be utilised upon request of the network operator in a manner as to prevent the red phase from occurring.

Models are already in operation today which are comparable to the basic principle of the traffic light concept, such as the use of storage heating systems. These existing mechanisms must not be weakened as a result of future regulations.

The implementation of the Smart Grid Traffic Light Concept requires the design of network flexibility to be compatible with the regulatory system so that the flexibility can be offered and utilised to the necessary extent. In addition, an accounting procedure must be created which is cost-effective for customers with low consumption.

In further development stages, a consistent package of regulations for smart grids will be required, on which the necessary market processes can be based.

7. Glossary

Definitions: Smart Grid Traffic Light

Smart grid: Energy network which integrates the consumption and feed-in behaviour of all → market participants connected to it. It represents an economically efficient, sustainable supply system with the objective of achieving minimal losses and high availability.

Smart Grid Traffic Light: Description of the interaction between → market participants and → network operators in the → smart grid.

Green traffic light phase: Market phase, in which no critical network situations exist. Supply and demand of → flexibility takes place solely between → market participants. → network operators do not intervene in the market.

Amber traffic light phase: Interaction phase, in which a potential or actual network shortage exists. The network operator remedies the situation by demanding the flexibility → offered by market participants. There is an interaction between → market participants and → network operators.

Red traffic light phase: Grid phase, in which a direct risk to the stability of the system and thus to the security of supply exists. In addition to the described measures in the amber traffic light phase, the → network operator must intervene directly in a controlling or balancing manner in its own operational facilities, the operational facilities of downstream network operators and in the → market.

Definitions: flexibility

Flexibility: Measures with the objective of balancing the difference between electricity demand and supply. Flexibility options can have an effect on the generation side, the demand side, through storage facilities or through networks.

Market flexibility: Utilisation of flexibility by the → market as balancing energy in the → green traffic light phase.

Network/local flexibility: Utilisation of flexibility by distribution system operators to manage local network situations in the → amber and → red traffic light phases.

System flexibility/system-wide flexibility: Utilisation of flexibility by the transmission system operator to maintain system stability in the control area in the → amber and → red traffic light phases.

Utilisation of flexibility: The colour change and thus the responsibility for switching always begins with the → network operator. This occurs by way of direct instructions to the appropriate → market participants.

Multiple marketing: → Flexibility can be offered for the benefit of the → market, → the network and → the system. Simultaneous utilisation in more than one area is not possible, however.

Definitions: roles

Network operator: Operator of transmission and distribution networks. Network operators are, unlike → market participants, regulated.

Market participants: Suppliers of generation, storage or consumption capacity as well as associated roles such as → aggregators and → suppliers. Market participants are, unlike → network operators, not regulated.

Aggregator: Specialised → market participant who bundles a number of different, short-term feed-in capacities or consumption loads for the purposes of sale or auction in organised energy markets.

Supplier: supplies electrical energy to end customers.

Definitions: metering

Consumption metering: quarter-hourly measurement in the case of customers with an annual consumption exceeding 100 MWh_{el} energy.

Meter reading curve: series of measurements of quarter-hourly meter readings.

Standard load profile (SLP): Load profile, which enables the load curve of an energy consumer to be forecast and accounted for without → consumption metering (e.g. household electricity customers).

Temperature-dependent load profile (TLP): Load profile, which enables the load curve of an interruptible, temperature-dependent energy consumer to be forecast and accounted for without → consumption metering (e.g. electric storage heaters, electric heat pumps).