An introduction to the Universal Smart Energy Framework

USEF

The Universal Smart Energy Framework

The Universal Smart Energy Framework (USEF) developed by the USEF Foundation provides non-discriminatory access to smart energy systems at acceptable cost-to-connect and cost-to-serve levels. By providing an open and consistent framework of specifications, designs, and implementation guidelines, USEF enables participants to seamlessly co-create a fully functional smart energy system. The USEF Foundation acts as the framework's steward and aspires to establish it as the de facto framework for smart energy products, services, and solutions. By 2020, the foundation hopes to have ten million Prosumers[1] using USEF-compliant products, services, and solutions throughout Europe - and, hopefully, beyond.

To accelerate the development of commercially viable offerings based on the framework, the USEF Foundation is developing a reference implementation. The reference implementation will enable stakeholders to develop smart energy products, services, and solutions in an unambiguous, well-defined way. These offerings will in turn enable the large-scale international deployment of smart energy systems.

In the coming years, USEF will be validated in a number of large-scale international demonstration projects, which will support the commoditization of smart energy products, services, and solutions. Two launching customers have already committed to deploying USEF in their demonstration projects in the Netherlands, and many more are expected to follow soon.

This document summarizes USEF and introduces you to its content and components: the interaction model, market-based control mechanism, grid operations, smart energy services, privacy and security guideline, and IT architecture. Flip the booklet over and you will find an allegoric tale highlighting the ideas behind USEF and its benefits for society.

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[1] See chapter 6 for a definition of Prosumer and other USEF roles.

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1

The need for a universal smart energy framework

There is a global drive to drastically reduce CO_2 emissions and to lessen our dependence on fossil fuels. This growing environmental awareness is leading us to cut down on the energy we use and to turn to renewable sources for what we do need. A significant share of our future energy will be derived from intermittent, local sources such as the wind and sun. Couple that with an increasing demand for electricity, primarily driven by the large-scale introduction of electric transport, the use of heat pumps for space heating, and a growing number of local energy communities, and a need emerges for a new order in the supply of energy that optimally matches the changing social context of the twenty-first century.

Currently, Europe's electricity markets form a fully integrated chain that enables the free exchange of energy within the capacity limits of the interconnecting transmission lines, as depicted in figure 1. Large industries form an integral part of the system and have free access to the energy market. Trading services have already been introduced to provide power exchange access to medium-sized customers; by banding together in groups, these customers are able to negotiate free access to the energy system to cool homes, heat greenhouses, and more.

Today many people recognize that our current national distribution grids need to transform into a unified, fully bidirectional system. To this end, many new technologies such as solar panels, energy storage systems, and smart meters will soon connect to the grid. Low-volume energy consumers will become prosumers - both producers and consumers - and actively participate in our future energy system. Their behavior will have a major impact on the entire energy ecosystem. A unified smart energy framework will enable consumers to transform into individual energy “up- and downloaders” while keeping the overall, differentiated energy system safe, reliable, and affordable and ensuring the system develops toward increasing sustainability.

Such a framework impacts the entire downstream energy distribution system. Current approaches to integrating individual new services and technologies do not address the fact that the current energy value chain was designed using a top-down approach. It was not designed with two-way traffic in mind, and it is unprepared for the introduction of new market roles such as prosumers, energy service companies, and aggregators. Unless a universal framework supplies a common denominator, projects attempting to individually introduce new services and technologies onto the market will be confronted with the limitations of the

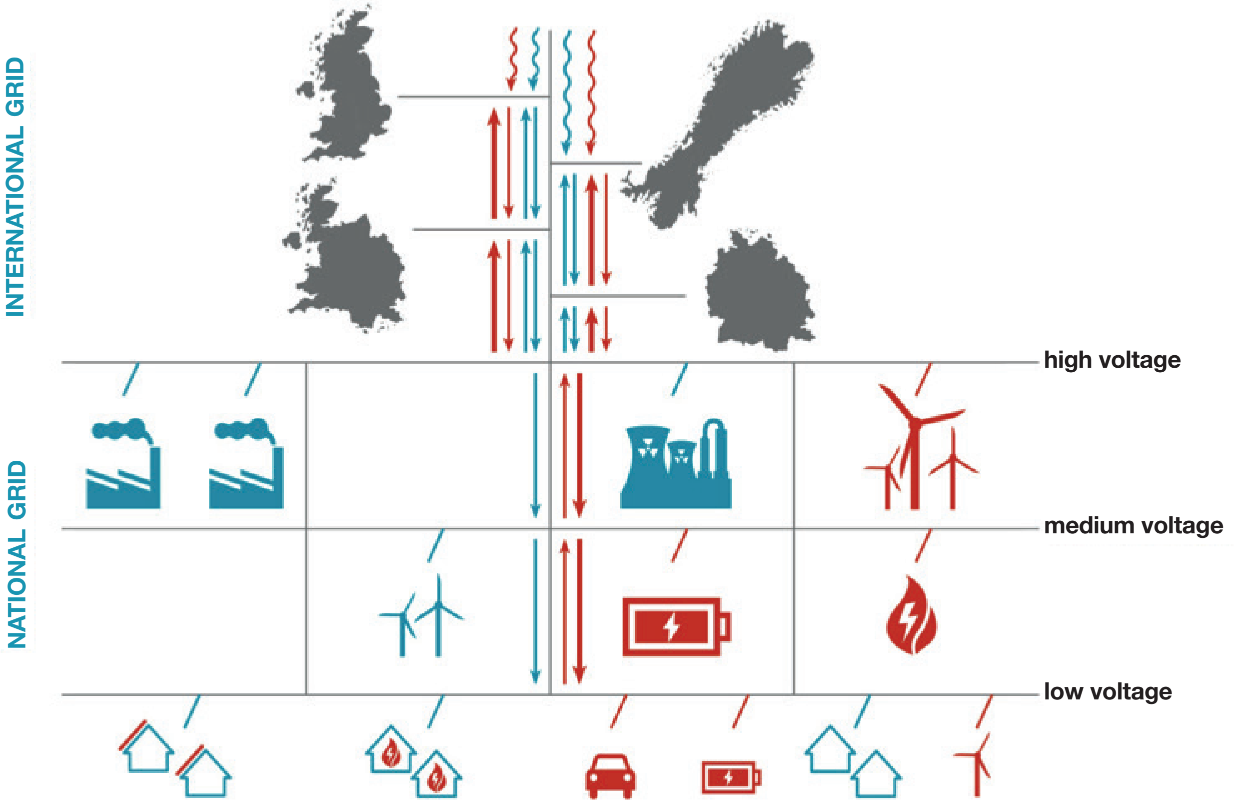

Figure 1: An overview of existing (blue) and emerging (red) assets and energy flows in the energy system.[2]

current system's design without being able to effectively alter it to meet their needs. Most likely the result will be a set of suboptimal, incoherent solutions. And as the number of new products, services, and technologies grows, it will become more and more complicated to integrate each new solution into the current energy system.

Close cooperation between all the parties active in the energy distribution system - including the industries that provide innovative energy products, services, and solutions - is essential to transform it into a modern, integrated system that meets the needs of all the stakeholders in the energy value chain. A prerequisite for the large-scale market introduction of smart energy systems for SMEs and residential end users is the commoditization of these products, services, and solutions so that they become commercially viable; that is, it is essential to reduce the cost-to-serve and the cost-to-connect for those end users and their appliances.

The introduction of new energy services will be accompanied by the introduction of new market players such as aggregators, energy service companies, and energy communities, who will need access to the energy markets in order to valorize their energy (or services). These market players will be significantly smaller than traditional players, and the number of parties active in the energy system will increase considerably. It is therefore essential to standardize market access for these new players; otherwise it will become impossible to serve them in a cost-effective way, and market conditions will become unmanageable.

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[2] This color coding is used throughout the document.

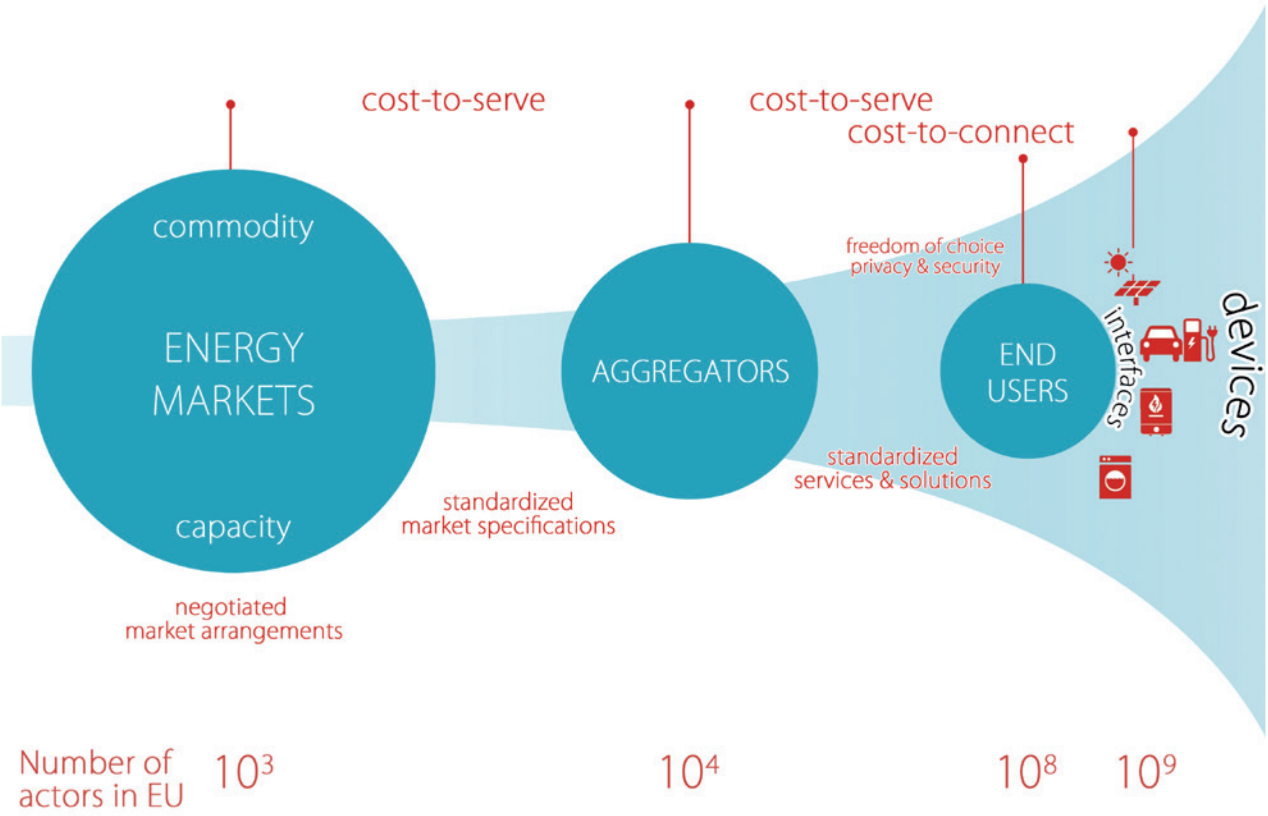


Figure 2: The challenges facing smart energy systems.

At the same time, billions of devices need to connect to the energy system, requiring both standardized communication protocols and energy service features and the accompanying exchange of information. Without these, not only will the cost-to-connect fail to reach an acceptable level; end users' freedom to choose who supplies their energy will also be in peril. After all, the economic and technical life of the connected assets is on the order of a decade, whereas service contracts typically run for a year. End users will own appliances from different vendors, which need to be interoperable to enable in-home optimization and integration. If each service provider or technology vendor develops its own infrastructure, both the cost-to-connect and the cost-to-serve will increase.

The USEF Foundation has developed the Universal Smart Energy Framework (USEF) to meet all these needs. USEF provides a technology - and implementation - agnostic framework that acts to catalyze the development of a common market for smart energy products. USEF is well aligned with the smart-grid standardization developments at CEN-CENELEC and NIST and with the SGAM model. It builds on these and other relevant initiatives to develop a coherent, comprehensive solution that will meet tomorrow's energy market and infrastructure needs.

The USEF Foundation takes a pragmatic, practical approach to USEF's development to enable vendors to devise commercially viable solutions. This creates an essential competitive advantage for all involved and enables them to set up sustainable businesses delivering smart energy products, services, and solutions that can be gradually rolled out worldwide in the coming decades.

2

Value creation

Demand response through load shifting and the storage and management of locally generated energy provide new means to unleash flexibility in the distribution grid and adjust end users' load profiles. Within USEF this flexibility can be accessed for grid capacity management and active balancing at time scales ranging from long-term agreements to near-realtime active control.

USEF partners aim to develop products, services, and solutions that together form a commercially viable smart energy system. To this end, a common understanding of value creation in smart energy systems is needed to:

- unlock all potential sources of value using USEF,
- validate the model in USEF-compliant demonstration projects, and develop the business case for both the USEF partners and the projects where USEF is being deployed.

To avoid the pitfall of trying to achieve a positive business case at the scale of a demonstration project (under current market conditions), it is crucial to gain insight into the business case for large-scale deployment.

2.1 Different levels for costs and benefits

When creating smart energy systems, costs are often incurred locally while benefits are partly generated on a national level. To optimize the system, we must understand the link between the flexibility made available by USEF locally and the benefits on both the local (grid) and national (grid, generation, imbalance) levels. USEF helps to identify the value of smart energy systems that is realized along the energy value chain and to identify the stakeholders involved.

2.2 Localized peak load reduction on the grid

The grid is designed for the maximum required peak load capacity. The fuel shift toward electricity will significantly increase the peak load on the system, requiring capital-intensive grid reinforcements in the business-as-usual scenario. Under USEF, distribution system operators can mitigate this effect by using the flexibility provided by end users to locally reduce the peak load in the distribution grid. As a result, grid reinforcements can be deferred or even completely avoided. The reduction of grid losses by establishing a better local balance between supply and demand creates additional value.

2.3 Active balancing

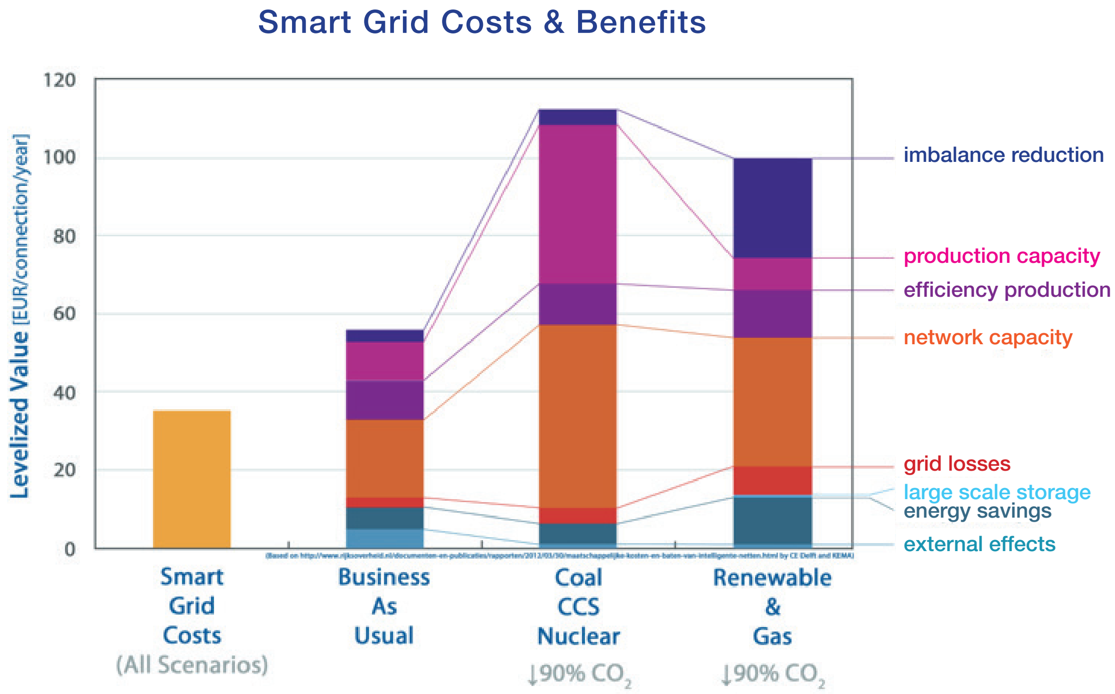
The USEF market-based control mechanism (see chapter 8) enables the continuous optimization of the energy supply and demand from all assets in the system and seeks the most economical dispatch pattern and the lowest costs for the overall system. The resulting cost savings stem from two quarters:

(a) The reduction of generation costs, which can be achieved in three ways:

- **Shaping the load profile**
  An ideally shaped load profile means less use of peak generation capacity. This enables operators to avoid dispatching assets with relatively high operational costs and hence lowers energy production costs.
- **Reduction peak generation capacity**
  By reducing the peak load on the system, operators can reduce their investments into generation capacity.
- **Prevent load curtailment**
  Insufficient flexibility in the system can potentially lead to oversupply (of renewable energy). This in turn can result in system imbalances that are too large, forcing operators to take extreme measures such as load curtailment to stabilize the system. This not only results in reduced service but also - and importantly - estroys economic value. By shifting loads to periods with abundant (traditional or renewable) energy production, load curtailment and hence decapitalization can be prevented.

(b) The reduction of imbalance costs

Balance responsible parties (BRP) are required to maintain a continuous balance between their clients' energy demand and the energy produced. They can realize this balance by directly controlling their own assets, by using their clients' assets, or by trading with other parties. The transmission system operator compensates for imbalances between the total load and production, and the resulting costs are allocated to the parties responsible for the imbalance. Using the flexibility that USEF unlocks, a BRP can continuously compensate for its imbalances and hence reduce imbalance risks.



Smart Grid Costs & Benefits

(Based on http://www.rijksoverheid.nl/documenten-en-publicaties/rapporten/2012/03/30/maatschappelijke-kosten-en-baten-van-intelligente-netten.html by CE Delft and KEMA)

Figure 3: An example of the results using the value creation tool for three different energy mixes.[3]

2.4 The value creation model

USEF contains a model to provide insight into USEF-compliant systems' potential for value creation and to analyze the value that flexibility creates across different markets using standard or self-defined scenarios.
The model can be used to evaluate the influence of several parameters, to compare different services, to understand the impact national developments have on the business case for a local smart energy system, and to quantify and monetize the benefits on a national level. These are crucial elements for the business cases for each USEF partner and for the individual demonstration projects. Figure 3 shows a typical example of the model's output.

The data show a typical result from applying the value creation model to three different scenarios using different energy mixes:

- a business-as-usual scenario
- a low-CO_2 scenario predominantly based on coal-fired power plants with carbon capture and storage (CCS)
- a low-CO_2 scenario based on gas-fired power plants and renewables

In all three scenarios, the costs of smart energy systems are comparable. The use of smart energy systems ultimately leads to beneficial changes in the load patterns of individual user groups. Value is created through reduced energy cost, reduced network cost, reduced required central generation (peak) capacity, and more efficient use of central generation units, among other things. External effects (mainly the value of the reduction in CO_2 emissions) and the potential value of selling the available capacity to imbalance markets are also included in the value creation model.

This example shows that while smart energy systems add value even in a conservative business-as-usual scenario, their value increases considerably in more ambitious low-emission scenarios. The potential value for the imbalance market is greatest in the renewable scenario, as renewables are expected to increase the need for imbalance power and electricity prices are highest in this scenario.

USEF partners can create their own scenarios, on both the national and local levels. Figure 4 shows the steps required to calculate the value created. The selected national scenario describes the factors in play on a countrywide

[3] See "The social costs and benefits of smart grids," CE Delft and DNV KEMA, 2012 (http://www.cedelft.eu/publicatie/the_social_costs_and_benefits_of_smart_grids/1249).

Figure 4: Basic workflow of the value creation tool.

scale, such as the total amount of renewable energy and the total energy demand. The user then creates a local scenario that specifies the characteristics of the community where the services will be used and the expected penetration of various technologies in that community.

The current model has three main limitations:

- It does not yet quantify the non-energy value generated by insight or auxiliary services.
- It does not yet quantify the costs of USEF-compliant products and services.
- It does not yet attribute the value created to the various roles.

The value creation model is continuously being updated with results and insights from USEF-compliant projects.

2.5 Providing insight

USEF supports additional value creation by information services based on the exchange of captured data. A broad range of insight services can be introduced, such as these:

- energy consumption data visualization
- tailored advice for investments in new assets
- condition-based remote maintenance
- prediction of renewable energy generation

USEF-compliant smart energy systems also generate indirect value, for example by stimulating investments into more energy-efficient applications and sustainable energy production. This added value is an essential part of the business case for local organizations when implementing USEF-compliant smart energy systems, resulting in lower CO_2 emissions as well as reduced primary energy consumption.

2.6 Auxiliary smart energy services

Various auxiliary services can be delivered by the Energy Service Company role[4] in a smart energy system.
These services can unlock latent residual value present in the smart energy system and increase the system's appeal. By broadening the ecosystem and attracting more parties not directly active in the energy value chain, the overall business case improves and the viability of smart energy systems increases. Examples of such services include providing insight into energy usage, peer-to-peer energy supply, and off-site lease constructions. These services need USEF's data exchange system functions, but do not rely on its market-based control mechanism.

[4] See chapter 6 for definitions of the USEF roles.

3

The scope of USEF

The European energy markets and networks are already integrated on the national and international levels. USEF will further transform the distribution grids into a fully bidirectional energy system. The framework's scalable market solution unleashes the added value generated by smart energy systems and enables the system's continuous economic optimization.

USEF provides non-discriminatory access to smart energy systems for all active stakeholders at acceptable cost-to-connect and cost-to-serve levels.[5] USEF-compliant products, services, and solutions become interoperable, catalyzing competition in the market while preventing vendor lock-in and ensuring controlled data access that promotes privacy and security by design. The threshold for new market entrants is reduced by providing seven essential service features, enabling them to easily develop propositions using their own cost structures. USEF's implementation guidelines will assist market players in setting up their USEF-compliant energy service businesses.

USEF achieves all this by providing a consistent and coherent framework detailing the minimal requirements for all relevant components in the system. Framework elements range from the scalable market model with its market-based control mechanism (see chapter 8) through the corresponding roles, tasks, and responsibilities in the market (based on ENTSO-E role definitions; see chapter 6) to the processes and communication between these market players. This provides standardized market access and enables the development of standardized service features (see chapter 11) and communication between all actors in the system.

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[5] USEF is described in the context of the current liberalized electricity market model, but is in essence applicable to multi-utility energy infrastructures.

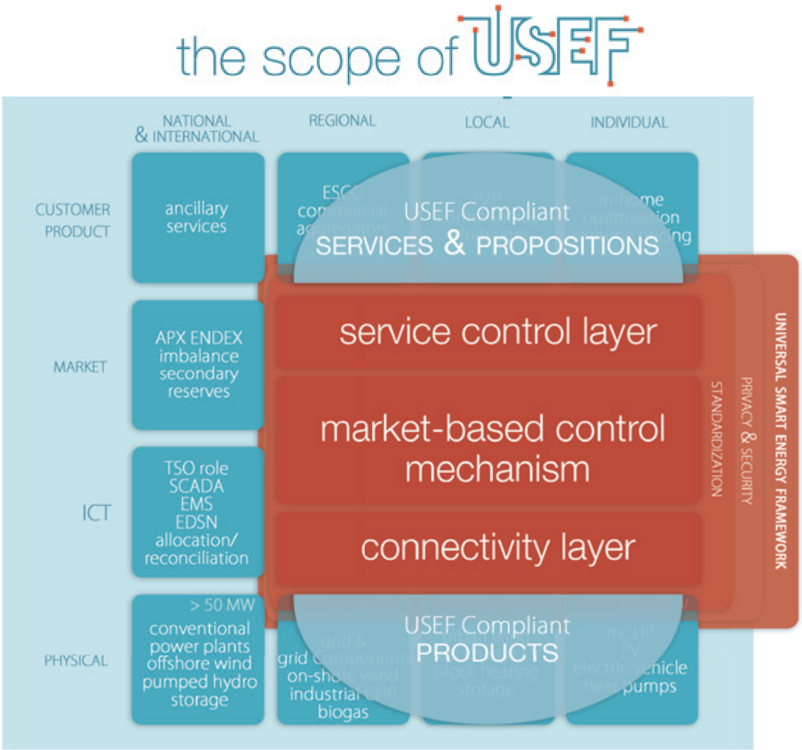

Figure 5: The scope of USEF.

The service control layer (see section 11.1) offers generic functionality for the different flexibility service features as well as integrated views of all integrated assets.

The connectivity layer provides universal and interoperable access to all assets. Data access is subject to the USEF privacy and security guideline (see chapter 12). This is essential to reliably operate the system; it also engenders consumer trust in all the actors in a smart energy system, significantly enhancing the acceptance level for USEF-compliant services.

USEF introduces new grid operating regimes (see chapter 10) that enable the effective transport of more energy using the same classic grid design. Sensors and actuators are needed to continuously monitor and control the grid, deployed in such a way that these technologies improve network stability and availability. USEF does not provide specifications for automatic power rerouting and self-healing grid functions at this time, since these can be implemented by the distribution system operator independent of the functionality provided by USEF.

4

Yellow is the new Green

The amount of energy that can be transported and distributed is limited by the grid's physical capacity. Load shifting enables the transport of additional energy using the same physical network capacity and increases grid utilization. As a result, investments into grid reinforcements can be delayed or even avoided, resulting in significant value creation for society through cost savings. USEF distinguishes four network operating regimes to increase the effective use of grid capacity.

In normal operations, termed the Green regime in USEF, the grid has enough capacity to distribute all the required energy; hence prices are freely determined on the market without the need to take local capacity into account. In the current market, this Green regime is the modus operandi.

Currently, no functionality is available to temporarily reduce the load when grid capacity is insufficient. As a result, grid protection systems are activated as soon as the system overloads, and all or part of the distribution grid is switched off to prevent damage to the infrastructure. The result is a direct transition from the Green regime to the Red regime: a power outage.

In USEF-compliant energy markets the Distribution System Operator[6] (DSO) uses supply-and-demand flexibility to keep peak loads in congested areas within grid capacity limits. This is called grid capacity management, or the Yellow regime. Load reduction is achieved by procuring flexibility on both the demand and supply sides in such a way that power flows stay within acceptable limits. In the Yellow regime, the DSO is active on the energy market and despite the grid's capacity limitations, energy can be freely traded between market parties. This regime significantly enhances the distribution capacity of the local grid without the need for grid reinforcements. The Green and Yellow regimes will become regular practice in day-to-day grid operation once USEF is implemented.

In exceptional situations where the market is no longer able to maintain the grid load within acceptable limits, USEF-compliant energy systems switch to the Orange

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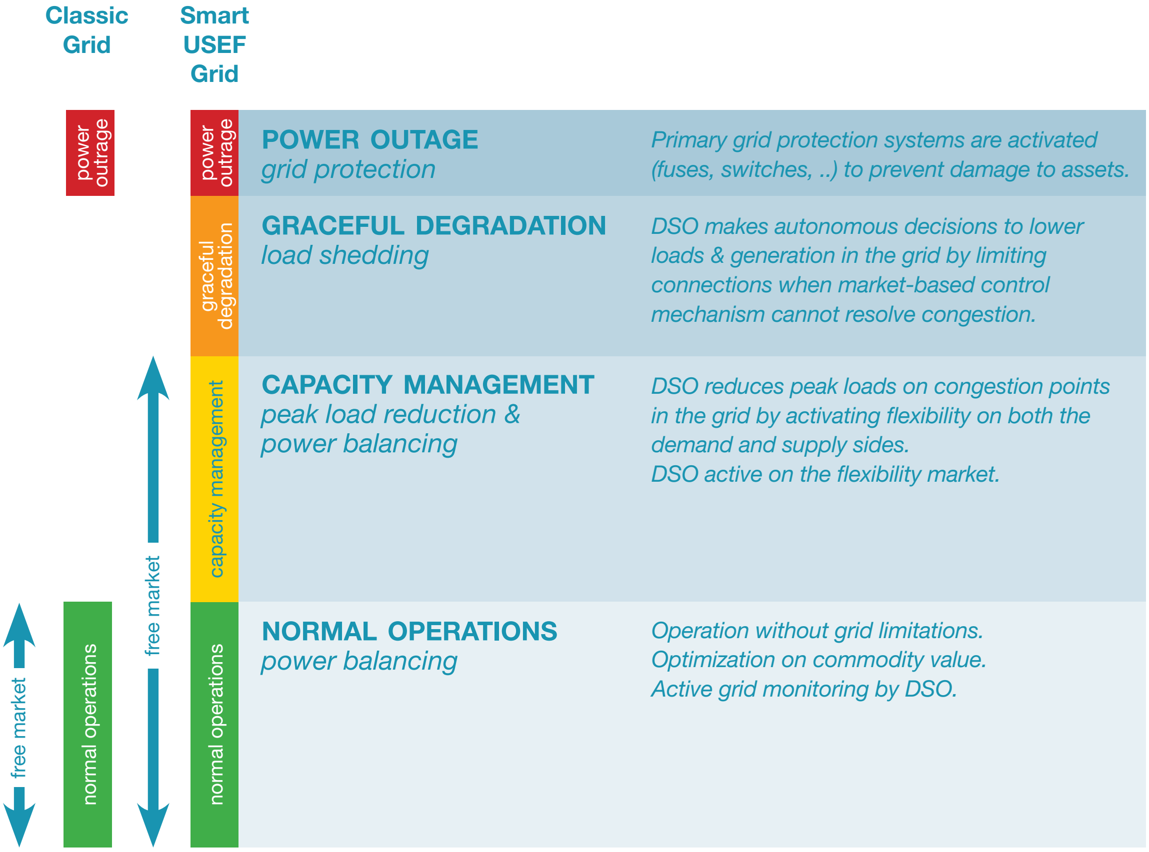
6 See chapter 6 for definitions of the USEF roles.



power outrage	**POWER OUTAGE** *grid protection*	*Primary grid protection systems are activated (fuses, switches, ..) to prevent damage to assets.*
graceful degradation	**GRACEFUL DEGRADATION** *load shedding*	*DSO makes autonomous decisions to lower loads & generation in the grid by limiting connections when market-based control mechanism cannot resolve congestion.*
capacity management	**CAPACITY MANAGEMENT** *peak load reduction & power balancing*	*DSO reduces peak loads on congestion points in the grid by activating flexibility on both the demand and supply sides.* *DSO active on the flexibility market.*
normal operations	**NORMAL OPERATIONS** *power balancing*	*Operation without grid limitations.* *Optimization on commodity value.* *Active grid monitoring by DSO.*

Figure 6: The USEF operating regimes.

regime by starting the process of graceful degradation. Grid connection capacity is limited (stepwise) until the network load is once again within acceptable limits. In this Orange regime, the DSO temporarily overrules the market to prevent a complete power outage. The DSO can differentiate its connection conditions, thereby providing different levels of reliability to different types of connections. These conditions establish connection priorities, enabling the DSO to differentiate between clients who critically depend on energy (such as nursing homes) and connections where a service interruption has a lesser impact (such as public charging stations for electric vehicles). As soon as the system restores itself, the market can take over again.

USEF's market-based control mechanism and network operations are described in chapters 8 and 10, respectively.

5

Democratizing the energy market

The transformation of consumers into active up- and downloaders was not foreseen in the design of the current energy system. USEF's market-based control mechanism (MCM; see chapter 8) addresses this omission: it is set up to support basic freedoms for all participants in the energy system and to transparently allocate costs and benefits. As a result, all assets will be dispatched in the most economical possible way within the limits of USEF's free-market operating regimes: Green (normal operations) and Yellow (grid capacity management).

European guidelines and national legislation are based on three basic market freedoms, which are an essential condition for energy market liberalization. These are as follows:

- **Connection:** every party has the right to connect to the grid.
- **Transaction:** parties have the right to engage in energy transactions with each other.
- **Dispatch:** parties have the right to take energy from or feed energy into the grid at all times.

The transformation into a smart energy system is potentially at odds with these three basic freedoms. USEF provides an MCM that extends the free market to the regional, local, and individual levels, as indicated in the USEF scope diagram (figure 5 in chapter 3). It offers access to the energy market for all participants, who can freely dispatch their assets.

As a result, all assets in the system effectively become a part of this energy market. The MCM provides a transparent cost allocation method distinguishing different prices for commodity, capacity, and flexibility. The market facilitates the dispatch of all assets at the lowest cost; hence the MCM enables the system to operate in the most economical way possible. Since market prices are formed on timescales down to the near-realtime domain, rapid variations in supply and demand can be resolved on the market by continuously balancing energy supply and demand. This ability becomes increasingly important as intermittent renewable energy sources grow in market share; their sensitivity to weather conditions means they generate power with large fluctuations that are hard to accurately predict.

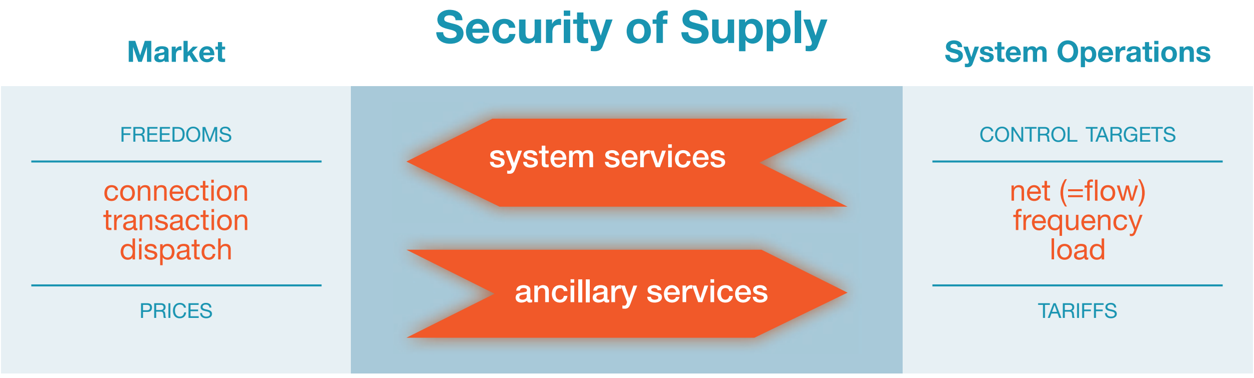


Figure 7: The relationships between the energy market and system control operations.

6

Roles and responsibilities

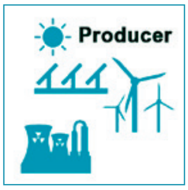
Smart energy markets require new services, new markets, and new roles that operate alongside existing ones. Opportunities emerge to develop new business through various manifestations and combinations of these roles. This chapter describes the roles and responsibilities in a USEF-compliant smart energy system.

The USEF MCM is designed to align smoothly with existing market roles, but its introduction on the energy market will impact several of them. New roles are envisioned and current roles will be altered. Each of the existing and new roles is described in detail in this chapter.

Opportunities for new business arise from the new roles themselves, and USEF also permits businesses to combine these roles to create a competitive advantage, as long as these combinations satisfy local regulations.

USEF-compliant systems must implement every role in the USEF roles model, and each role must be filled. Though one entity may fill multiple roles, it is important that the roles themselves remain distinct to preserve the system's flexibility and applicability across countries, markets, and regulatory regimes.

In liberalized energy markets, there is a clear division between the **physical supply chain** and the **energy value chain**, as depicted in figure 8. The actors in the physical supply chain are responsible for the physical transport and distribution of energy. The energy value chain covers the commercial processes for the energy produced. In both chains, energy demand and supply must be kept in balance at all times. The administrative processes to coordinate both chains are organized in well-documented and structured market processes that involve data exchange between stakeholders. Figure 9 shows the new and existing roles in the USEF model, which we describe below starting with the physical supply chain. In this document, USEF role names are capitalized to distinguish them from traditional roles having the same or a similar name.



The role of the **Producer** is to feed the output of its primary process - the transformation of energy into usable form - into the energy grid. In doing so, the Producer plays an important role in the security of the energy supply. The Producer's primary objective is to operate its assets at maximum efficiency. Though its responsibility remains unchanged, the introduction of demand response and changes to the merit order can alter its operating conditions quite drastically, since renewable energy sources such as wind and solar power have a relatively low operating expense and compete with existing power generation units.

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7 Roles are embedded within the ENTSO-E model.

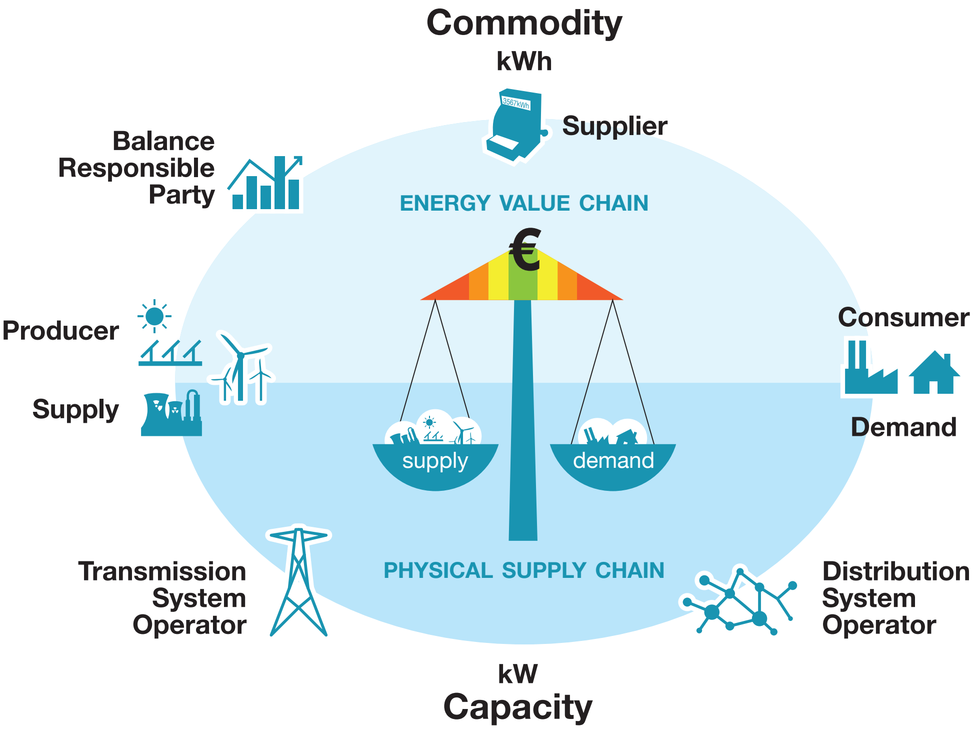

Figure 8: Market roles in liberalized energy markets.

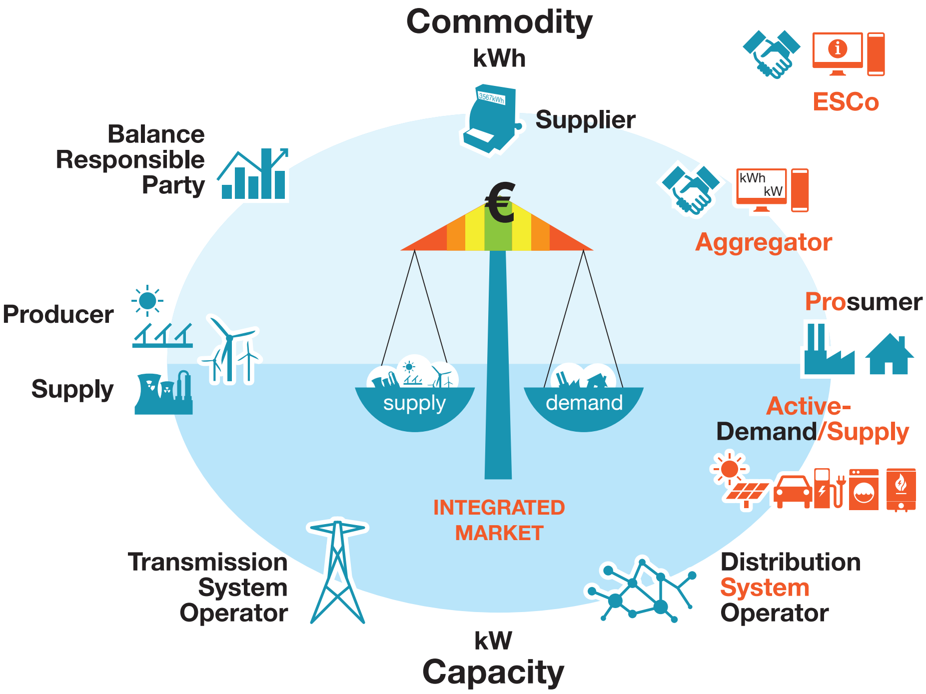

Figure 9: The roles in a smart energy market. New roles are depicted in red, existing ones in blue.

The role of the **Transmission System Operator (TSO)** is to transport energy in a given region from centralized Producers to dispersed industrial Prosumers and Distribution System Operators over its high-voltage grid. The TSO also operates interconnectors that link to other high-voltage grids in neighboring regions and countries. The TSO safeguards the system's long-term ability to meet electricity transmission demands. The TSO is responsible for keeping the system in balance by deploying regulating capacity, reserve capacity, and incidental emergency capacity. The role of the TSO is not affected by USEF.

The role of the distribution network operator (DNO) is superseded by the role of the **Distribution System Operator (DSO)** in the USEF model. The difference between the DSO and the DNO is that the DSO is able to perform grid capacity management.[8] Note that in the USEF model, the DSO will not perform frequency control in the distribution grid. The DSO is responsible for the cost-effective transfer of energy in a given region over the distribution grid to and from end users and for the connections to and from the transmission grid. The DSO ensures the distribution system's long-term ability to meet electricity distribution demands. The introduction of the USEF grid capacity management regime enables the DSO to minimize grid capacity costs while safeguarding security of supply.

The role of the consumer transforms into that of the **Prosumer**. Residential end users and small and medium-sized enterprises become active up- and downloaders of energy. Prosumers offer their flexibility, resulting from the Active Demand & Supply they own, to the market. Empowered by insight services provided by an Energy Service Company, they may economically optimize the use of their assets and improve their energy efficiency. Not all consumers are expected to transform into Prosumers, but for the sake of simplicity, we include only the Prosumer in the roles model. In this model, traditional consumers are Prosumers who consume but do not produce energy.

A **Balance Responsible Party (BRP)** is responsible for actively balancing supply and demand for its portfolio of Producers, Aggregators, and Prosumers. The BRP forecasts its portfolio's energy demand and supply and seeks the most economical solution for the energy to be supplied. The BRP can source the requested energy on behalf of the Supplier in two ways: directly, by dispatching power plants with which it has a contractual agreement, or indirectly, by trading on the energy markets. Additional value can be created by assisting the TSO in maintaining system balance, such as by trading on the imbalance market. USEF provides an additional option to help the BRP optimize its portfolio: tapping the flexibility in Active Demand & Supply that Prosumers offer through Aggregators.

The role of the **Supplier** is to source, supply, and invoice energy to its customers. The Supplier and its customers agree on commercial terms for the supply and procurement of energy. USEF enables the mass customization of customer propositions, providing opportunities for product differentiation and brand recognition. Since the Supplier is the only role that has a contractual agreement with Prosumers,[9] USEF assigns the Supplier an additional responsibility: to invoice or reimburse the flexibility that Prosumers have provided.

The role of the **Aggregator** is to accumulate flexibility from Prosumers and their Active Demand & Supply and sell it to the BRP, the DSO, or both. The Aggregator's goal is to maximize the value of that flexibility, taking into account customer needs, economic optimization, and grid capacity. USEF allows Prosumers to directly access the flexibility market, in which case they implicitly act as the Aggregator for their own portfolios. USEF allows the accumulation of multiple Aggregators into one larger Aggregator.

USEF distinguishes between an Aggregator and an **Energy Service Company (ESCo)**.[10] The ESCo offers auxiliary energy-related services to Prosumers but is not directly active in the energy value chain or the physical infrastructure itself. The ESCo may provide insight services as well as energy management services.

8 USEF uses the term grid capacity management to denote congestion management (a term more commonly used in some countries). Please note that congestion management is a temporary measure, while grid capacity management as described by USEF may be applied permanently by the DSO.

9 Understanding the roles and responsibilities in the USEF roles model starts with understanding the rationale behind the contracts in the energy supply chain. The strict regulations for granting a supply permit on public networks are closely related to collection risk and the required financial stability to guarantee the supply of energy. Since, from a social standpoint, the supply of energy must not be interrupted, end users remain connected to the grid when a Supplier goes bankrupt. When this happens, the financial risk is carried by the remaining Suppliers in the system.

10 The role of the ESCo is already recognized by the market, but note that various definitions are in use. This is the definition used by USEF.

Active Demand & Supply (ADS) represents all the energy-consuming or -producing appliances that have the ability to shift, increase, or decrease their energy consumption or production. Through this functionality, ADS provides flexibility to the energy system. The ownership of and responsibility for ADS lies with Prosumers. USEF therefore does not regard ADS as a separate role, but as an actor in the energy system. In this regard, ADS interacts with both Aggregators and Prosumers: Aggregators control the flexibility offered by ADS, while Prosumers control the user settings[11] and remain in control of their own preferences. Please note that these user settings might influence the flexibility these appliances and assets can offer to the Aggregator.

Relationship to roles in the market model for electric mobility

Electric mobility is a special case, since its success relies on the availability of a public charging infrastructure, which has its own market organization with specific roles. EURELECTRIC has recognized that a new market model is needed for electric mobility.[12] This market model introduces two more roles specific to public charging, summarized below:

- **Charging Station Operator (CSO):** a party that operates the charging infrastructure from an operational-technical point of view, that is, who handles access control, management, data collections, repair, and so on. There may be further differentiation between the technical operator and the commercial operator, who uses the charging infrastructure to offer services to the electric vehicle driver. Charging Station Operators engaged in commercial activities may buy electricity on the supply market and include it in the services they sell, or they may sell charging services that do not include the supply of electricity.

- **E-mobility Service Provider (EmSP):** a party that sells e-mobility services to e-mobility customers. For example, an EmSP might provide flexible and complimentary access to charging stations run by different Charging Station Operators. EmSP services may be bundled with other services (EV location, parking, and so forth) and may include the supply of electricity.

For EV charging using the public infrastructure, a temporary relationship between a Prosumer and a Charging Station Operator is established for the duration of the charging process. This is fundamentally different from fixed connections to buildings and homes governed by a regular contract. EURELECTRIC identifies two alternative market models:

- **Independent e-mobility model (charging service roaming)**
  In this model the electricity contract is between the CSO and the Supplier; in other words, the CSO sells an all-inclusive service (electricity plus charging services).

- **Integrated infrastructure model (electricity and service roaming)**
  In this model the electricity contract is between the EmSP and the Supplier. The EmSP sells electricity to its customers, and the CSO sells only a charging service.

Both market models support smart charging and EURELECTRIC defines a secondary role, Flexibility Operator, for this purpose. This role is similar to the Aggregator role defined in USEF. As a result, both market models can be made USEF-compliant by mapping the Aggregator role to either the CSO (first model) or the EmSP (second model).

Based on current European market developments, the first model will dominate for the next few years. Therefore, USEF2014:I.II lists the requirements for the CSO in the Aggregator role, including settlement relationships. Future updates to USEF might specify the roles and responsibilities for the second market model.

The technical operation component of the CSO role is outside USEF's scope. It can be considered an ESCo service specifically targeted to e-mobility customers. The same holds true for the bundled services offered by the EmSP.

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[11] For example, by setting the time at which an electric vehicle needs to be charged, or by controlling the room temperature in a dwelling.

[12] See "Deploying publicly accessible charging infrastructure for electric vehicles: how to organise the market? A EURELECTRIC concept paper," 2013 (http://www.eurelectric.org/media/84461/0702_emobility_market_model_final-2013-030-0501-01-e.pdf).

7

The USEF interaction model

Smart energy systems give rise to new business opportunities and relationships between stakeholders. The USEF roles model is accompanied by a generic interaction model that describes the interactions between the various roles active in the smart energy system.

The USEF interaction model depicts the essential interactions between the various market roles. Each of these interactions is further broken down into specific interactions in each phase of the MCM: Plan, Validate, Operate, and Settle (see chapter 8). Two contractual relationships (shown in orange) are made explicit because they seem essential to understanding the interaction model, but additional contractual relationships exist. To keep the diagram clear, all relationships are depicted as 1-to-1 connections, but most of them are 1-to-N or N-to-M relationships as described in the next section.

Supplier and Prosumer (1-to-N)

The contract for the supply and uptake of energy to and from Prosumers must be negotiated between the Supplier and Prosumer.[13] That contract also defines the operating conditions for the demand response service executed by the Aggregator acting under the Supplier's flag. Note that this implies the contractual agreements with Prosumers concerning demand response are formalized by Suppliers, not by Aggregators. As a result, the responsibility for billing or reimbursing flexibility also lies with the Supplier.[14] Note that participation in demand response programs is not mandatory: Prosumers can choose a profile-based contract instead.

Supplier and Aggregator (N-to-M)

The Supplier and Aggregator sign a framework contract for all Prosumers serviced by the Aggregator. This framework contract defines the operating conditions for the demand response service executed by the Aggregator acting under the Supplier's flag and corresponds with the terms agreed upon between the Supplier and Prosumer.

Aggregator and Active Demand & Supply (1-to-N)

The Aggregator controls the Active Demand & Supply assets and appliances owned by its Prosumers. USEF defines the Aggregator's control to start with forecasting its Prosumers' demand and supply profiles. Based on this forecast and the expected flexibility, the Aggregator optimizes its complete portfolio.

Prosumer and Active Demand & Supply (1-to-N)

The Prosumer controls the user settings of the smart energy appliances and assets that are controlled for demand response purposes by the Aggregator. Note that

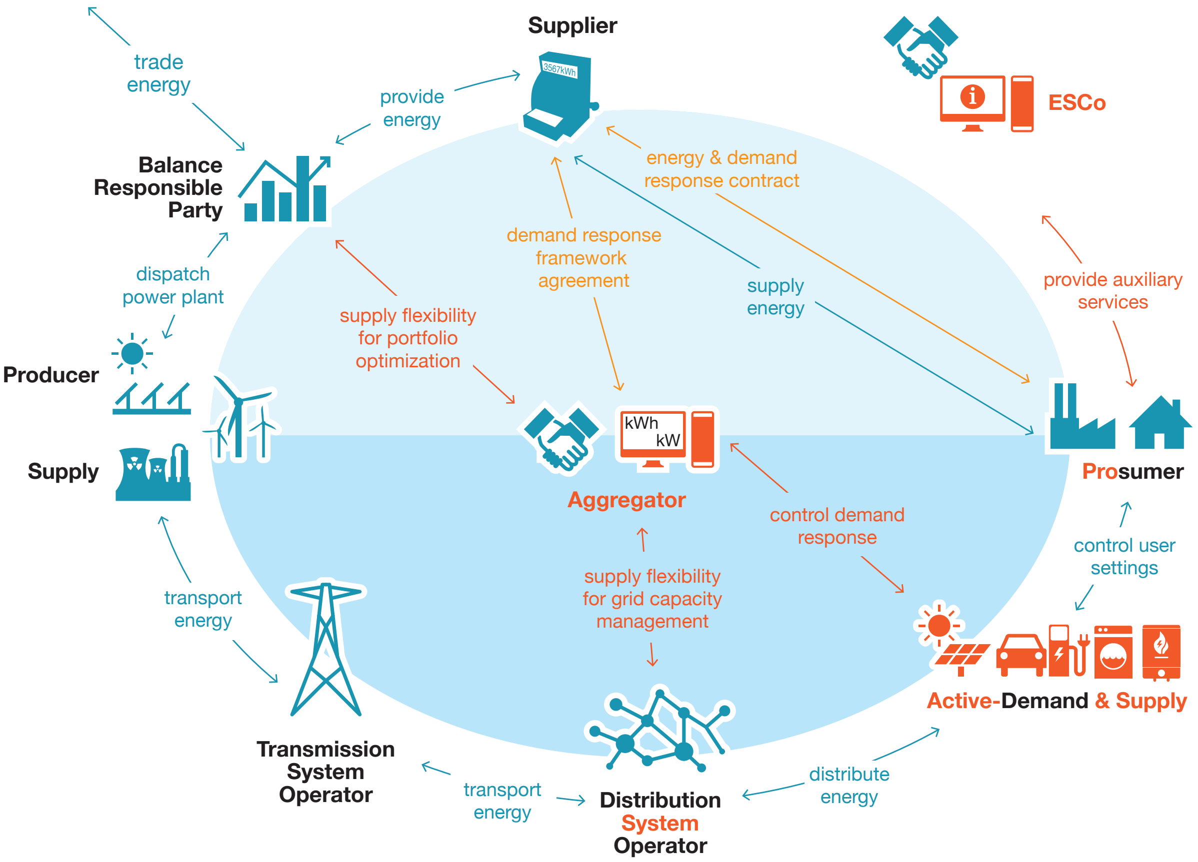

Figure 10: The USEF interaction model, including the most important contractual relationships.

these settings may influence the flexibility these appliances and assets can provide to the Aggregator.

BRP and Supplier (N-to-M)

The Supplier has a contract with the BRP that defines the commercial terms under which the BRP sources the energy demand and supply of the Prosumers under contract with the Supplier. This contract, which is already in place in the current liberalized energy market, is not affected by USEF.

BRP and Aggregator (N-to-M)

The Aggregator and BRP negotiate how to mutually optimize their portfolios and identify the lowest operational costs. Flexibility is traded according to the MCM. Although in general an Aggregator can interact with multiple BRPs, an Aggregator can only interact with a single BRP for any given connection. This BRP must be the same BRP that provides energy to the Supplier with whom the Aggregator has a framework agreement for that connection.

BRP and Producer (N-to-M)

Based on its portfolio optimization, the BRP determines the most economical way to balance its portfolio. This process determines how much energy each power plant should produce in the upcoming period. The BRP orders the Producer to dispatch that amount of energy in the upcoming period or purchases it on the market. In the Operate phase (see chapter 8), the BRP can ask the Producer to alter its production plan. This process, which is already in place in the current liberalized energy market, is not affected by USEF.

TSO and BRP (1-to-N)[15]

The TSO validates whether the energy transport planned by all the BRPs (in their E-programs) can be executed reliably and safely. The TSO continuously monitors network conditions and, when imbalances arise, buys regulating power from the BRPs to balance the system.

13 Although third parties can serve as energy resellers under the auspices of the Supplier's supply permit, the responsibilities remain with the Supplier.
14 The reasoning behind this is that commodity and flexibility are inherently linked to one another, and hence also the settlement of commodity and flexibility. This becomes even more apparent when time-of-use tariffs are applied.
15 Assuming there is only one TSO active in the country. If multiple TSOs are present, the relationship would be N-to-M. This also holds true for the TSO-DSO interaction.

TSO and DSO (1-to-N)

The TSO validates whether the expected import and export of energy through the DSO grid connections (the T-program) can be executed safely and reliably. If so, the TSO will transport this energy to and from these grid connection points.

DSO and Supplier (N-to-M)

In alignment with the current market design, multiple Suppliers can be active on the DSO's grid. The DSO performs both the physical distribution of the energy supplied by these Suppliers and the administrative processes related to it.

DSO and Active Demand & Supply (1-to-N)

The DSO distributes energy to and from the Active Demand & Supply owned by Prosumers and other energy-using devices. The DSO controls the Prosumer's connection(s). The conditions for this kind of control are reflected in the Prosumer's connection code.

DSO and Prosumer (1-N)

The conditions for the distribution of energy to the Prosumer's connections are reflected in the connection code. After the system has been in the Orange regime, the DSO settles with the Prosumers affected by load shedding.

DSO and Aggregator (N-to-M)

If the DSO expects congestion issues in its distribution grid, it will procure flexibility from one or more Aggregators who are actively offering flexibility to the DSO at that moment. The operating conditions are covered by the MCM.

ESCo and Prosumers (optional) (N-to-M)

The ESCo might offer auxiliary energy-related services such as providing insight information to Prosumers or remote maintenance on the Prosumer's Active Demand & Supply. To enable these services, the ESCo can retrieve data from the Prosumers' Active Demand & Supply.

In the interaction model above, existing trading processes between BRPs and others are not described by USEF, but remain operational in the market.

Combining roles in business models

There are three combinations of the Supplier and Aggregator that are likely to appear regularly in new business models, and we describe them in this section.[16] Although this is an implementation issue and not part of the roles and interaction models themselves, for most people these combinations provide greater clarity on these roles, their responsibilities, and the interactions between them:

1. Supplier and Aggregator are separate businesses
The roles of Aggregator and Supplier are filled by independent companies. In this case, the Aggregator optimizes the ADS belonging to a specific set of the Supplier's Prosumers, or a specific set of assets. A typical example would be an Aggregator for electric vehicle charging stations who optimizes the charging process on behalf of the Supplier.

2. Supplier is also Aggregator
The Supplier includes the role of Aggregator in its own business and executes all Aggregator-related tasks itself. Existing Suppliers will likely be tempted to follow this path.

3. Supplier outsources its role to Aggregator
The Supplier outsources its tasks of contracting, invoicing, and servicing customers to one or more Aggregators. The Supplier might also provide a complete platform for performing these tasks to all Aggregators operating under its flag. The contract between the Aggregator and Prosumer is based on a framework agreement between the Aggregator and Supplier and contains a reference to that agreement. This reference dictates that the energy supplied to or procured from the Prosumer is formally provided on behalf of the Supplier. The regulatory authority might require the Aggregator to clearly communicate that its business is "powered by the supplier" for reasons of transparency. A typical example of such a business would be a local energy company or community.

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[16] Note that business models can also include one or more instances of the ESCo role to encompass auxiliary services.

8

The USEF market-based control mechanism

To optimize the value of flexibility across all roles in the system, USEF introduces a new market-based control mechanism (MCM) along with new processes. The MCM provides all stakeholders with equal access to a single integrated market. To this end, it facilitates the delivery of value propositions (i.e., marketable services) to various market parties without imposing limitations on the diversity and customization of those propositions. This unique approach is intended to create a future-proof energy market. The USEF MCM is designed to work for all energy commodities[17] and enables the market to optimize for time, capacity, and power. This chapter describes the MCM's high-level processes.

The USEF MCM is meant as an addition to the current liberalized market model, aligning smoothly with existing processes in the energy market. As a result, most existing processes remain unchanged and will not be described by USEF. This chapter defines the new market processes and describes where existing processes need to be altered. Note that this chapter only describes the processes in the Green and Yellow operating regimes, since undisturbed market operation is only possible in the normal operations and grid capacity management states. Chapter 10 covers the relevant processes in the Orange regime.

The USEF MCM operations scheme (see figure 11) distinguishes four phases:

- **Plan:** In the planning phase, energy demand and supply are forecasted for the upcoming period, usually a calendar day. Both the BRP and the Aggregator carry out an initial portfolio optimization. During this phase, the BRP can procure flexibility from its Aggregators. The Plan phase results in an Aggregator plan (A-plan) agreed upon by the Aggregator and the BRP. The BRP then creates its energy program (E-program) as usual.

- **Validate:** In the validation phase, the DSO uses a **D-prognosis[18]** to determine whether the forecasted energy demand and supply can be safely distributed without limitations. If the prognosis predicts congestion, the DSO can procure flexibility from Aggregators to resolve it. It is important to note that there can be multiple iterations between the Plan and Validate phases; that is, after validation, it is possible to go back to the Plan phase.These iterations continue until all the forecasted energy can be safely distributed without limitations.

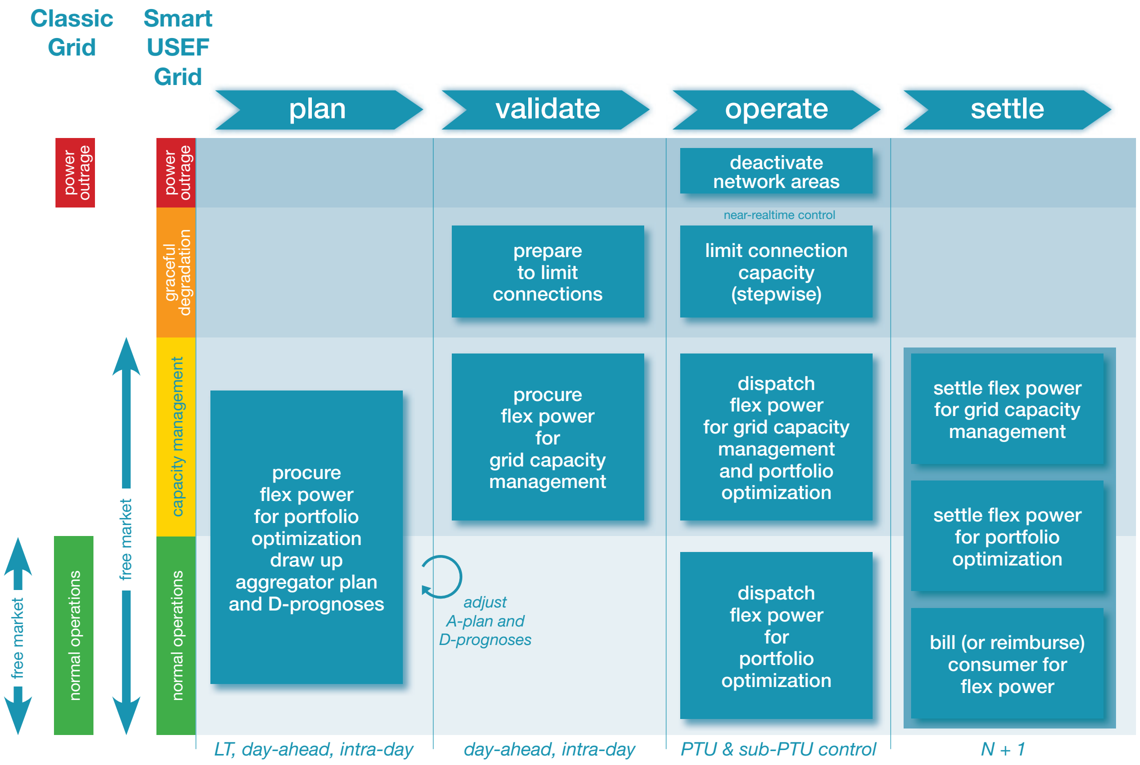

Figure 11: USEF operations scheme.

- **Operate:** In the operation phase, the actual assets and appliances are dispatched and the Aggregator adheres to its D-prognoses and A-plan. When needed, DSOs and BRPs can procure additional flexibility from Aggregators to resolve unexpected congestion or to solve imbalance issues.

- **Settle:** In the settlement phase, any flexibility the Aggregator has sold to the BRPs and DSOs is settled.

The aim of the Plan and Validate phases is to make optimal use of grid capacity and to maximize all stakeholders' freedom of dispatch and transaction before the actual delivery of energy takes place. The time scales in these phases range all the way from years and months down to just hours before the Operate phase starts. This broad window facilitates trading on different energy markets (such as the forward market, day-ahead spot market, and intraday spot market) and the ability to accommodate changes in the required grid capacity. USEF proposes that the national regulatory authority determine the details of the gate closure times. A current common practice in energy markets is to close one hour before delivery in the intraday process.

The Validate phase comprises two steps executed in parallel: **Validate-E** and **Validate-D**. The D-prognosis and its validation (Validate-D) are the MCM's added value; they enable flexibility and demand response to be deployed within the distribution grid. Validate-E is already in place on a national level and is not affected by USEF; we mention it here for the sake of completeness.

8.1 Plan

The aim of this phase is to find an economically optimal program to meet the energy demands of all the Aggregator and BRP portfolios for a certain period. The Aggregator's result is reflected in the A-plan, which is similar to the current E-programs used by BRPs. Please note that unlike E-programs, the A-plan need not be in balance.

The Plan phase starts when the Aggregator collects forecasts for the Prosumers it serves. The DSO determines where congestion may take place (Congestion Points; see section 10.1). The DSO declares these Congestion Points to the Aggregators. Having received the forecasts and Congestion Points, the Aggregator optimizes its own portfolio and plans how to maximize the value of the flexibility options in its portfolio, resulting in an A-plan. The Aggregator optimizes its portfolio based on its clients' needs.

[17] USEF2014:I.II only addresses electricity. However, conceptually, the MCM can be applied to any energy commodity.

[18] A D-prognosis is a subset of the A-plan for a specific Congestion Point (see section 10.1).

For example, the Aggregator may apply in-home optimization or optimization to maximize the sharing of sustainable energy among clients. After this optimization, the Aggregator sends its initial A-plan to the BPR. If the forecasts change (e.g., because a new weather forecast is available), the Aggregator may reoptimize its portfolio, resulting in an updated A-plan.

Likewise, the BRP optimizes its portfolio of Aggregators, Producers, and Suppliers to attain an economically optimal program. During this process it will negotiate with its Aggregators to exploit the available flexibility in the market and optimize its value. For example, based on a spread in energy prices on the day-ahead market, a BRP may ask Aggregators to provide flexibility and make changes to their A-plans. If the BRP identifies market changes that may affect its portfolio, it may reoptimize its portfolio. After the A-plan has been aligned with the BRP portfolio, the BRP creates its E-program, which forms the basis for the imbalance settlement process between the BRP and the TSO.

8.2 Validate

The Validate phase consists of two intricately linked processes, executed in parallel by different market roles: Validate-D and Validate-E. In these processes the (draft or final) D-prognosis created at the start of the Validate phase and the draft E-program resulting from the Plan phase are validated against grid constraints by the DSO and TSO, respectively. Please note that the Validate-E process, performed by the TSO, is an existing process already in use in many countries. USEF does not alter the Validate-E process.

At the start of the Validate-D process, each Aggregator creates D-prognoses for all Congestion Points where it is active, using its A-plan as a basis. The DSO accumulates the D-prognoses from all its Aggregators. These D-prognoses are combined with the profiles of those connections not served by an Aggregator (for which forecasting is performed by the DSO), which enables the DSO to perform a grid safety analysis. This analysis determines whether the planned energy can be distributed or the limits of the distribution grid have been reached. In the latter case, USEF moves to the Yellow regime and the DSO procures flexibility on the market to resolve these congestion issues. If the available flexibility is not sufficient to resolve the expected congestion or no flexibility is available, USEF moves to the Orange regime.[19]

Naturally, the DSO's procurement of flexibility may impact Aggregators' A-plans.[20] For this reason, the Validate phase is iterative with the Plan phase; that is, an Aggregator may repeatedly adjust its A-plan to the extent allowed by time and its bilateral agreement with the BRP. By the time the gate closes, all issues must be resolved and the A-plans and D-prognoses must be aligned within the constraints of the three basic freedoms mentioned at the start of chapter 5. This is the Aggregator's responsibility.
Finally, the DSO combines the aligned D-prognoses with forecasts for those connections that are not at a Congestion Point to create a T-prognosis, which is sent to the TSO for verification.

8.3 Operate

As long as no deviations from the validated A-plans, D-prognoses, and E-programs occur, the energy system remains in balance with no congestion issues. However, it is quite unlikely that all A-plans, D-prognoses, and E-programs will be executed exactly according to plan. Deviations can arise from all sorts of sources, ranging from changing weather conditions to a football match running overtime. Deviations can lead to imbalances in energy supply and demand at the total system level (affecting the BRP), to changes in the agreed-upon A-plan (affecting the Aggregator), and to local congestion in the distribution system (affecting the DSO). During the Operate phase, which takes place at the PTU level, additional flexibility can be used to compensate for these deviations.

In the Operate phase, the Aggregator's main goal is to adhere to its agreed-upon A-plan and its D-prognoses. To achieve this, the Aggregator must first plan to operate the Active Demand & Supply that it controls in such a way that the flexibility sold during the Plan and Validate phases is also reflected in real life. These settings should already be known before the Operate phase starts. Second, the Aggregator measures the net demand of its cluster (using smart meter data, for example) to detect deviations from its A-plan or D-prognoses. In the likely event that deviations occur, the Aggregator will have to reoptimize its portfolio. Perhaps deviations can be solved within the portfolio itself; if not, the Aggregator will have to deploy flexibility in order to adhere to its A-plan.

In the Operate phase, it is in the BRP's interest to minimize its imbalance costs. If market circumstances change as a result of the TSO maintaining the system balance, or if the BRP detects that it is causing imbalance by deviating from its E-program, the BRP can procure additional flexibility from Aggregators.

Although the DSO will reduce congestion risks in the Validate phase, the DSO can still ask Aggregators for additional flexibility to resolve congestion issues in the Operate phase. However, in such cases the corresponding BRP's portfolio will no longer be in balance. As a result, the Aggregator will most likely charge the DSO an additional fee to cover the imbalance risk.

8.4 Settle

In the final phase of the MCM, the flexibility the Aggregator has sold to the BRPs and DSOs is settled. Only two settlement procedures are covered by the MCM, as described below. The billing or reimbursing of flexibility to Prosumers is covered in chapter 11.

- **Settlement of flexibility for grid capacity management (DSO-Aggregator)**
  The flexibility transactions (and associated deviations) between the DSO and Aggregators are settled in this phase. The basis for this settlement process is the latest set of validated D-prognoses.

- **Settlement of flexibility for portfolio optimization (BRP–Aggregator)**
  The flexibility the BRP has procured for the purpose of portfolio optimization in the Plan and Operate phases is settled between the BRP and its Aggregators. This also covers the settlement of any differences between the Aggregator's forecast and realization, since Aggregator-initiated changes to a Prosumer's forecasted demand or supply affect the BRP's E-program.

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19 Please refer to chapter 9 for more detail on the procurement process.

20 This is not the case when the Aggregator can manage the deviation itself, such as when one Prosumer uses more energy, another Prosumer uses less energy, and the two cancel each other out.

9

Wholesale processes

A key element of USEF is to disclose demand-side flexibility to create value in energy markets and grid operations. The current design of the wholesale markets in European countries is based on synthetic demand profiles for SMEs and residential end users. As a result, demand response provided by these users is not reflected in the volumes allocated to their suppliers or BRPs. Flexibility valorization therefore requires adjustments to these wholesale processes, and that adjustment forms a prerequisite for USEF's implementation.

These wholesale processes are already part of the existing market design and differ from country to country. This section is therefore not a part of the USEF specification itself; rather, it serves as a prerequisite and guideline for USEF's implementation. The necessary modifications to these wholesale processes are described, as well as their impact on key stakeholders' financial and energetic balance sheets.

The allocation and reconciliation of wholesale processes should be based on the load profiles actually measured for SMEs and residential end users. This requires 15-minute interval meter reads provided by a smart meter; hence a smart meter infrastructure for end users providing demand response flexibility is a prerequisite for USEF. The allocation of retail customers based on smart meter interval data is denoted by the term smart meter allocation. The associated settlement process is referred to as wholesale settlement, which renders the reconciliation process redundant for this segment.

The design's basic premise is to keep modifications to current wholesale market processes at a minimum. As wholesale market processes differ between European countries, our main focus is on the process flow, where small deviations may occur due to regulatory conditions with respect to roles and responsibilities.

The current process for retail customers, where allocation is based on static, synthetic profiles, will not become obsolete. It will coexist with smart meter allocation to give customers a choice between the current single or double tariff structures and dynamic tariffs based on smart meter allocation. This also enables gradual implementation. The following processes are affected:

- **Nomination**
  Nomination occurs at an aggregated level (the BRP's portfolio) and is not directly affected by the inclusion of smart meter data. However, the forecasting and planning

processes that provide input to the nomination phase can be improved significantly.

- **Allocation**
  Allocation in USEF will be based on actual measured consumption and production (per PTU), as is already common practice for the allocation of large commercial and industrial (C&I) customers. For every PTU and for all connections involved, smart meter data is aggregated per BRP, per Supplier, per Aggregator, and per grid area. The result is called a dynamically allocated cluster (DAC). The data aggregation is handled by the DSO, similar to the existing practice for C&I customers, where a DAC is considered as one virtual C&I connection. The aggregated data also serves as input for the USEF Settle phase.

- **Wholesale settlement between BRPs**
  Though wholesale settlement replaces the reconciliation process for profiled customers, monthly settlement between BRPs is still necessary to account for incomplete or invalid smart meter data. For a proper settlement process, the monthly volumes must be complete. As the completeness of the smart meter data is not guaranteed, the meter data company needs to determine the monthly volume even when no or only limited smart meter data is available.

- **Standard annual usage determination**
  In contrast to normalized synthetic load profiles, standard annual usage (SAU) volumes are still relevant for those Prosumers participating in smart meter allocation. A Prosumer's SAU is used to estimate its daily load profile in the event of incomplete interval data, for billing when Prosumers prefer a fixed monthly invoice, and, last but not least, by the BRP or Aggregator for forecasting purposes.

10

Grid Operations

The introduction of smart energy systems has a profound impact on the energy infrastructure's mandate to ensure an affordable, reliable, and sustainable energy supply. Instead of relying exclusively on grid reinforcements to guarantee sufficient capacity even during peak loads (Green regime), USEF describes how to affordably and reliably implement grid capacity management (Yellow regime) and how to gracefully degrade the grid (Orange regime) to avoid a total power outage in the event of capacity market failure.

10.1 Congestion Points

The growing demand for electricity will significantly increase the load on the distribution grid. For certain parts of the grid, demand will, at peak times, exceed the available capacity. Under USEF, the DSO will identify and publish the locations in the grid where overload might occur: the Congestion Points.

A DSO identifies Congestion Points well in advance of actual congestion occurring, based on its analysis of the trends in energy flows in its grids. It then informs Aggregators of the Congestion Points that involve connections under their purview. Using this information, Aggregators can approach their customers to collect sufficient flexibility to offer the DSO.

When a Congestion Point is declared, the option to switch to the Yellow regime becomes available. Aggregators serving Prosumers in a congestion area are required to provide D prognoses for their Congestion Points to the DSO on a daily basis, in which the planned amount of energy to be distributed per PTU is recorded. This enables the DSO to reliably forecast the energy to be distributed and to take the necessary steps - that is, procure flexibility - to optimize grid usage.

10.2 Normal operations (Green regime)

The DSO receives the Aggregators' D-prognoses for Congestion Points (see section 8.1) at the start of the Validate phase. The DSO then performs a grid safety analysis. If this analysis shows that load flows are expected to remain within grid safety margins, there is no need for the DSO to procure flexibility; the grid will operate under the Green regime.

During the Operate phase in the Green regime, sensors measure the actual load flows to monitor current conditions. The measurements at Congestion Points are used to check that the load is indeed staying within the limits of the grid's capacity. In other parts of the grid, the measurements are used to predict future Congestion Points.

10.3 Grid capacity management (Yellow regime)

In areas where the Validate phase shows possible grid overload for certain PTUs, the DSO will procure flexibility to keep power flows within acceptable limits. The DSO has two basic options:

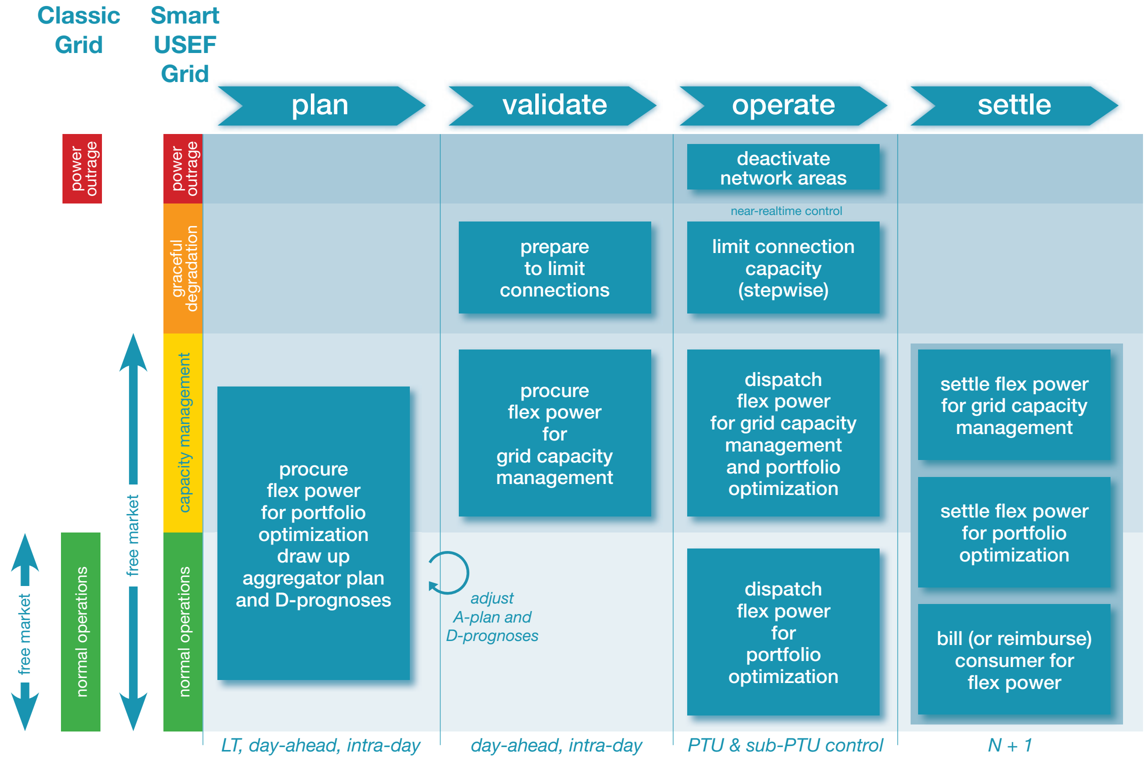

Figure 12: The USEF grid operations highlighted.

- **Activate long-term flexibility:** use flexibility procured through prearranged bilateral contracts. DSOs may arrange flexibility contracts with one or more Aggregators in advance. The value represented by the presumably high reliability of this option can be offset by fixed fees that are due regardless of whether flexibility is requested. The DSO will select the most optimal contract(s) from a cost and quality[21] perspective that provide the required flexibility. Such contracts most likely will not reflect all the flexibility in the market, nor will the price level reflect the actual marginal costs for the flexibility provided.

- **Acquire short-term flexibility:** buy flexibility that Aggregators have offered for a specific day. In this case, the Aggregator has no contractual obligation to supply flexibility and decides what to offer the market on a day-to-day basis. This option inherently involves flexibility that is only valid for a specific day. The price will much more closely reflect actual marginal costs; however, short-term flexibility is not guaranteed to be available.

The DSO's procurement of flexibility may affect the Aggregator's initial A-plan, thereby kicking off a new iteration of the Plan phase (see chapter 8).

Because the majority of congestion can be forecasted, USEF is designed so that most of the flexibility trading to resolve congestion occurs before the Operate phase, as described above. However, if the grid sensors do indicate developing congestion during the Operate phase, the DSO can still procure flexibility to resolve the situation. Because of the limited time available in the Operate phase, the DSO cannot initiate new flexibility requests; however, standing flexibility offers can be called upon.

10.4 Graceful degradation (Orange regime)

In exceptional situations where the market is no longer able to maintain the grid load within acceptable limits because of insufficient available flexibility, USEF-compliant energy systems begin the process of graceful degradation: the Orange regime. In this regime, the DSO temporarily overrules the market by limiting connections in the overloaded sections of the grid. This operating regime acts as a fallback for the Yellow regime and leads to higher overall grid availability, but the service level will be limited for certain Prosumers. It is therefore essential to establish clear, public criteria that legitimize this operational state and engender its public acceptance.

The DSO can invoke the Orange regime in two situations:

- when the DSO concludes in the Validate phase that, even after all flexibility offers on the market are exhausted, the grid will be overloaded
- when unanticipated situations arise during the Operate phase, such as unexpected loads or grid component failure

The DSO can offer different service levels and connections to different types of end users. Based on these contracts, the restoration of full connection capacity can be prioritized for clients who critically depend on energy (such as nursing homes) over connections where a service interruption has a lesser impact (such as public fast-charging stations for electric vehicles).

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[21] For example, shifting energy to PTUs with a minimal load is considered a higher-quality choice than shifting energy to PTUs where the load is near the maximum grid capacity.

11

Kick-start your smart energy service business

To accelerate the development of smart energy products, services, and solutions, USEF offers a set of standardized smart energy service features. Suppliers and Aggregators can easily create value propositions for their Prosumers - alone or combined with offerings from other market parties - based on USEF's standardized service capabilities. These provide connectivity and data exchange using Active Demand & Supply (ADS), as well as a standardized method for valorizing ADS flexibility using USEF's market-based control mechanism (MCM). This significantly reduces both the cost-to-connect and cost-to-serve and facilitates the optimization of the Aggregator's load profile.

The availability of a complete IT infrastructure to connect ADS and the functionality required to optimize a portfolio of clients are prerequisites for kick-starting a smart energy business. Technology commoditization is also essential, to reduce the cost-to-serve and cost-to-connect and ensure profitable operations. This goes hand in hand with the need to avoid vendor lock-in to ensure Prosumers' freedom of choice, so they can easily switch service providers. Investments in energy-consuming assets are too high to replace them during their technical lifespans. If ADS product-service combinations from one vendor created vendor lock-in, competition in the energy services market would be hampered and fail to reach its full stature.

USEF's standardized smart energy service capabilities provide the necessary building blocks to develop new services and value propositions for Prosumers. USEF offers specific functionality for specific types of assets combined with generic functionality for maintenance, support, and ADS flexibility valorization.

The Supplier and Aggregator can focus on developing attractive Prosumer value propositions using their own pricing models by providing their customers with valuable smart energy services combined with ADS assets. USEF's MCM guarantees that the best value for the flexibility this unleashes can be achieved in the energy market.

11.1 The USEF service framework

USEF introduces a service framework comprising a standard set of service capabilities, connectivity, data exchange, and a set of service control features (see figure 13). Suppliers, Aggregators, and ESCos can build services on top of this framework. USEF differentiates between flexibility services, which use ADS flexibility to create value, and auxiliary services, which are not directly related to flexibility.

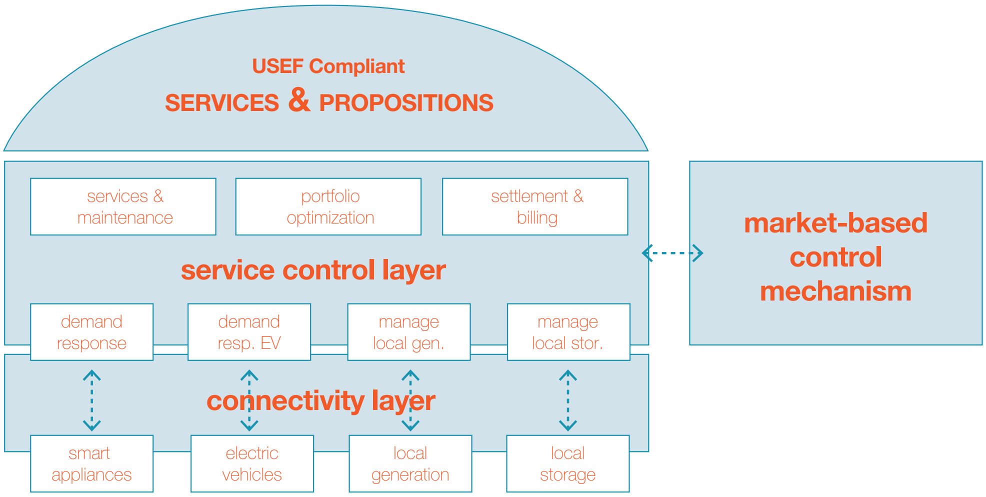


Figure 13: The USEF service framework.

Service capabilities

The different ADS types are the basis for demand response. All types provide flexibility via a specific load profile. This load profile can be shaped by shifting the load in time, buffering the energy, or reducing the volume of energy required. USEF provides a uniform way to access, quantify, and control this flexibility through device abstraction. The service capabilities represent this abstract view. There are four different service capabilities, each corresponding to one underlying ADS type.

Flexibility services

Flexibility services are built upon USEF's service capabilities. The Aggregator plays the central role in mapping the service capabilities to flexibility services. It is the Aggregator who offers Prosumers a value proposition, controls the ADS on the Prosumer's premises, and sells the resulting flexibility via the MCM to the BRP or the DSO; hence the Aggregator acts as the provider of flexibility services.

Auxiliary services

Various auxiliary smart energy services can be delivered by the ESCo role. These services can unlock latent residual value present in the smart energy system and increase the system's appeal. By broadening the ecosystem and attracting more parties not directly active in the energy value chain, these services improve the overall business case and increase the viability of smart energy systems. Examples of such services are the provision of insight into energy usage, peer-to-peer energy supply, and off-site lease constructions. These services require data exchange (see below) but do not rely on the MCM.

Service capability	Demand Response	Remark
smart appliance demand response	↓	Load profile has a fixed part and an optional flexible part. Profile can be shifted in time or flexible load can be altered.
local generation management	↑	Flexibility is provided through energy generated by local generation units.
local storage management	↑↓	Stored energy can be used freely for optimization purposes.
electric vehicle demand response	↑(↓)	Flexibility is provided by changing location or shifting charge time. Supports a specific setup for public charging. Note vehicle-to-grid is outside the scope of USEF2014:I.II.

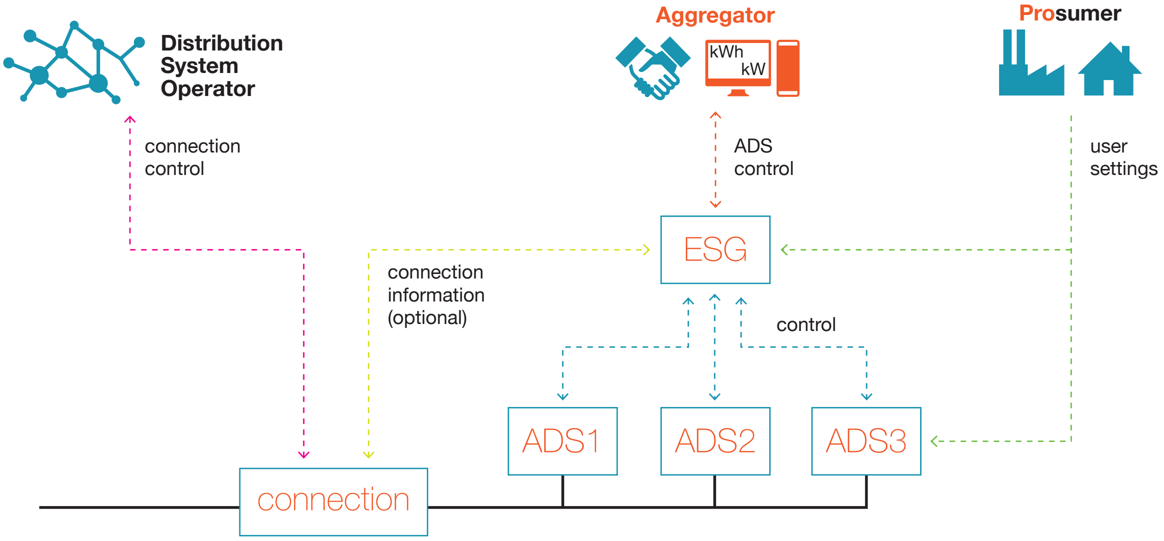


Figure 14: The USEF in-home control setup. The DSO controls the connection, the Aggregator controls the ADS via a building energy management system (BEMS), and the Prosumer controls the ADS user settings.

Data exchange

Data exchange is essential to unleash the flexibility offered by ADS and to enable insight services. USEF provides a standardized method for connecting these devices and a set of data exchange functions. The exchange of information via this and other services is governed by the USEF privacy and security guideline (chapter 12), ensuring that it is implemented in a secure and socially acceptable manner.

The sharing of information provides an attractive, efficient way to mutually generate value and optimally operate the connected assets. A multitude of appealing propositions can be built on top of this functionality, inviting stakeholders to become active participants in the smart energy system and develop their own smart energy applications and services on its foundation.

Service control

Service control capabilities are available to Aggregators to help optimize their portfolios and to facilitate the maintenance and support of their connected Prosumers and ADS. These control functions offer generic functionality for the different flexibility service capabilities, as well as an integrated view of all connected assets. The latter enables Aggregators to optimize their offers to the BRP and the DSO and thus create maximum value for the flexibility offered by the ADS. USEF's MCM support for market processes and billing is accessed using the generic service control capabilities. Interaction with the connection register is provided to ensure that Prosumers are correctly registered and to provide support for switching Suppliers, changes of address, and so forth.

11.2 Enabling demand response

Accessing the flexibility provided by ADS assets requires a dedicated information structure and control protocols. USEF provides a standardized information structure linking the Aggregator, Prosumer, and ADS. This guarantees independence between the ADS products and the Aggregator's services and is a vital component of ensuring a low cost-to-connect and a low cost-to-serve.

Figure 14 shows the in-home control setup with three important control interfaces:

- **connection control:** used by the DSO to control capacity and measure energy consumption
- **ADS control:** used by the Aggregator to control ADS devices through a building energy management system (BEMS)
- **user setting control:** used by the Prosumer to control its ADS devices, either by directly controlling the individual device or by using the BEMS

Future updates to USEF might specify communication protocols for the first two control interfaces.

ADS control

In the Green and Yellow operating regimes, the Aggregator uses ADS flexibility to maximize its customers' value. To this end, the Aggregator controls the ADS appliances and offers the resulting flexibility to the BRP and the DSO.

The Aggregator controls the ADS through a BEMS.

This BEMS is a logical entity, not necessarily a physical device. The BEMS aggregates all the ADS behind a connection and most likely performs in-home optimization.

The physical implementation of the BEMS is subject to the vendor's choice. The BEMS can be implemented as an energy service gateway (ESG) or as a cloud, or be integrated with other devices such as Internet routers or appliances with sufficient computing and connection capabilities.

Connection control

In the Orange regime, the DSO directly controls the connection and its capacity. The DSO owns the connection, and the control system provides a guaranteed response for USEF connection control that enables the DSO to limit power to or even completely switch off the connection.

Communication with the BEMS is required to automatically adjust the in-home power balance to meet the capacity limit set by the DSO. (This might require switching off devices based on priorities set by the Prosumer.) If this functionality is not implemented, manual intervention by the Prosumer is required to handle the resulting inconvenience. The current version of USEF does not specify this functionality in detail.

One-to-one relationship

Prosumers might want to purchase smart energy services from different Aggregators for different devices, such as a smart EV charging service from one Aggregator and a heat pump optimization service from another. This means there can be more than one Aggregator active in the same house or building. For settlement purposes, this requires an individually metered connection for each Aggregator, so the DSO can establish a one-to-one relationship between the Aggregator and the energy produced and consumed.

11.3 Control strategies

USEF distinguishes four control strategies that the Aggregator may apply. All four enable the Aggregator to optimize its portfolio. However, the strategies differ in five areas:

- the amount of resulting flexibility
- the response time
- the Prosumer's involvement
- the amount of device information used
- the way the Prosumer's comfort settings are handled

The USEF control strategies are as follows:

- **Manual**
  Prosumers manually change their loads based on notifications sent by the Aggregator, such as information on device displays, e-mails, or text messages. Although individual appliance response is not directly controlled by the Aggregator, the total response can be statistically determined. The Aggregator can valorize the resulting flexibility by offering it to the BRP and the DSO using USEF's MCM. Since the appliances are not controlled remotely, there is no need for a data connection.

This provides an easy-to-roll-out form of demand response at very low implementation costs. However, the amount of flexibility provided is limited and the response time is relatively slow.

- **Incentive-based**
  The Aggregator sends a control incentive to the appliance, such as a price signal via the ESG. The appliance's control logic determines its response based on its actual state and possibly its predicted utilization in the near to mid-term future. As above, the response to this incentive can be statistically determined, and the resulting flexibility can be traded using the MCM.

- **Predictive-based**
  The ESG communicates a forecast for the aggregated load profile (production and consumption) to the Aggregator, or the Aggregator communicates its forecast to the ESG, or both. (Hence the exchange can be either one-way or two-way communication.) This exchange may also include forecasts for additional parameters such as the control incentive, temperature, and so forth. Forecast communication enables greater economic optimization on appliance dispatch.

- **Override**
  Power consumption and production is directly adjusted by the Aggregator's control signal and does not take the Prosumer's preferences or the actual state of the appliance into account.

The main characteristics of the four control strategies are summarized in table 1.

type	Prosumer Interaction	forecast	guaranteed response
manual	yes	no	no
incentive-based	no	no	no
predictive-based	no	yes	no
override	no	no	yes

Table 1: The main characteristics of the four USEF control strategies.

11.4 The USEF device interface (UDI)

To facilitate interoperability between different ADS devices and the Aggregator's control mechanisms, we need a standardized device interface. This section introduces the USEF device interface (UDI) for standardized communication and control of ADS-generated flexibility. The BEMS communicates with ADS devices through the UDI.

The UDI includes provisions for all four control strategies. These provisions include but are not limited to the following:

- **Device control schedules**
  This includes a forecast for when the device should produce or consume its energy.
- **Device control incentives**
  The UDI communicates a control incentive from the BEMS to the ADS device. This control incentive could be a price signal, for example.
- **Simple device control**
  The UDI must be able to turn an ADS device on or off.
- **Guaranteed response**
  If the override strategy is used, the UDI needs to communicate to the ADS device that the energy request from the BEMS is mandatory.

USEF supports standardized and generalized information interfaces between ADS devices and the BEMS via the UDI. However, this implies that a generalized information profile must be specified. The Flexible Power Alliance Network (FAN) is an industry initiative that defines such specifications, for both the interface and the information format.

12

Privacy & Security

The introduction of smart energy systems will create an explosion in the amount of energy usage data captured, from which a wealth of personal information can be distilled. Smart energy systems - like most complex information systems - deal with sensitive data and therefore require effective measures to preserve security and privacy. Privacy and security are systemwide issues; the protection of individual subsystems and components is not enough. The system is only as strong as the weakest link, and there is no way to realize a sufficiently large market for smart energy products and services if privacy and security issues undermine Prosumer trust. USEF is therefore designed with privacy and security in mind.

Privacy and security are distinct but related entities. Security is an essential foundation for managing privacy; you must implement security to ensure privacy.

The security objectives of energy networks differ from those in most other industries. For energy grids, it is vital that security measures do not adversely affect the grid's availability. Availability is the primary security goal, followed by integrity. The final security goal is confidentiality.

In smart energy systems, confidentiality becomes more important, because grid functionality is interwoven with personal data and market information.

USEF contains a privacy and security guideline structured around nine "windows" that together present a complete view of the privacy and security aspects associated with smart energy systems. The guideline forms the basis for the logical security architecture that is part of the USEF IT framework.

Essential insights from the guideline are shared below.

12.1 Legal framework

A multitude of national and international regulations are being developed that address the privacy and security aspects of smart energy systems, capturing society's views on the benefits and risks of these systems collecting and analyzing vast quantities of data. These regulations form the backdrop against which smart energy systems are taking shape. They strive to strike a balance between guaranteeing security of supply, protecting customer privacy, and enabling value creation through high-quality, innovative energy services.

USEF is designed to comply with the new European General Data Protection Regulation, which is scheduled to replace the current Data Protection Directive no later than 2015, and to embody the principles of legal protection by design.[22] All data on energy consumption is treated as personal data and subject to a Data Protection Impact Assessment.

Data streams based on necessity, such as those serving the public interest or a legal obligation, are separated from those based on consent, such as for value-added services.

12.2 Value creation through data sharing

Through analytics and predictive profiling, a wealth of information can be distilled from the usage data generated by smart energy systems. Individuals and businesses can both benefit from sharing certain privacy-sensitive data. Such sharing makes it possible to tailor propositions to the Prosumer and to manage the grid more efficiently.

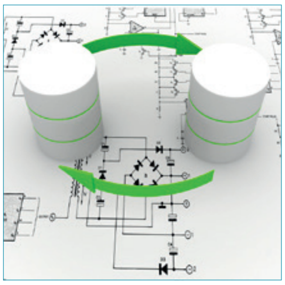
The value benefits for grid operators and energy service providers include proactive network maintenance, reduction of adverse events, improved operational efficiency, and better asset management. Customers are empowered to become Prosumers, realizing greater efficiency and monetary savings and, depending on the sophistication with which smart energy systems are integrated, other benefits such as integrated home management and automated and remote energy control. Corporations can expand their markets by providing smart energy services where the service provider and the energy provider are separate entities, or by using the information shared through smart energy technologies for other purposes, such as marketing.

The success of smart energy systems thus critically depends on the sharing of data and on large-scale Prosumer participation. Data sharing to accommodate all legitimate interests and objectives requires trust among all stakeholders, which in turn requires a coherent and transparent approach to privacy and security.

Vendors, Suppliers and other stakeholders signal trust by providing transparency and clarity to customers and demonstrating corporate responsibility. Prosumer acceptance also requires that the value created in smart energy systems is allocated to stakeholders in a fair, transparent, and unambiguous way. Users of smart energy systems are encouraged to actively participate in their own privacy protection. To achieve this, USEF enables the creation of services aimed at assisting Prosumers in making privacy choices that increase both individual and societal welfare.

Smart energy is a relatively new field, both technologically and in a regulatory sense. USEF is built on a sustainable IT framework that incorporates privacy-by-design and legal-protection-by-design principles. It provides flexibility in addressing privacy and security issues that may surface with the advent of new smart energy technologies and regulations. USEF provides a common approach to data management for all its participants that is based on risk assessments and built around the need-to-know security principle, focusing on maximizing value creation by establishing trust.

[22] See “Legal Protection by Design in the Smart Grid,” Mireille Hildebrandt, 2013.



12.3 Identification, authentication, authorization, and trust

In a smart energy system, transaction supply and demand come together to reach a desired optimum.
That optimum may be the lowest possible financial cost, lowest environmental impact, maximum profit, optimal resource utilization, or another desired and defined goal.

As for any real-world transaction, there must be trust between participating actors to ensure the envisioned outcome. Trust is built in a transaction when each actor does what it has promised, that is, produces or consumes the agreed-upon amount of energy at the agreed-upon time and, where applicable, fulfills its financial and other obligations associated with the transaction. Trust increases the likelihood that actors will participate in future transactions that benefit the system, and that the system will engage enough actors to function as a successful whole.

Trust increases when actors' identities, authenticity, and authorization are known and verified. Trust is further enhanced when the actual transactions are carried out satisfactorily: when all actors behave as agreed. Trust is reduced when actors cannot rely on actors' authenticity, that is, when identities can be abused (stolen, faked), when transactions cannot be properly authorized, or when transactions do not stay within preset limits. Transparency in actors' identities and behavior may therefore benefit the system. One way to create this transparency might be to rate actors (such as Suppliers, Prosumers, or device types) within the context of a transaction or even publicly: rankings are a form of explicit trust.

The USEF privacy and security guideline provides principles to address these issues. Advanced identity management supports the privacy and trust needs of a smart energy system. The use of unique identifiers, provided by smart energy identity providers, is recommended to reach economies of scale. The guideline also provides principles to guide the design and implementation of authorization and rating systems.

12.4 Data management and communication

USEF provides a common approach to data management for all its participants that is based on risk assessments and built around the need-to-know security principle, focusing on maximizing value creation by establishing trust.

In smart energy systems, several complex relationships between confidentiality, integrity, and availability exist. As an example, the likelihood of power outages is related to the integrity of the exchanged data. Incorrect data or no data at all (when data exchange itself is unavailable) may thus lead to grid unavailability. Smart energy systems introduce a dependency between the availability of the power grid itself and the supporting IT systems. USEF describes confidentiality, integrity, and availability in the context of smart energy systems and establishes principles that address their dependencies.

The focus on a risk-assessment-based approach ensures that the measures to protect data are always proportional to the potential damage incurred by a privacy or security breach. It also implies that there can be no one-size-fits-all recommendations on encryption levels, data retention times, and redundancy levels, as they depend on the outcome of risk assessments that may include subjective and context-sensitive risk quantifications. USEF contains a sample risk assessment as well as a recommended risk assessment methodology.

All data managed by USEF is subject to a data policy that specifies, at a minimum, who is the data subject, why it is in the system, how it can be accessed, and what its lifetime is. The use of well-defined roles for data management and explicit data policies provides transparency to all stakeholders and engenders trust.

The communication requirements for smart energy systems do not differ from those for other data communication networks such as the Internet. USEF ensures the end-to-end protection of data streams against network attacks by encrypting the data and avoiding transport nodes where data must be disclosed, rather than protecting access to the medium only.

12.5 Recovery

When things go wrong, we are faced with the need to recover. We must consider disaster recovery from outages or other negative events involving IT systems when designing the future power grid. Well-designed disaster recovery protocols accomplish two things: they maximize the grid's proper, uninterrupted operation and, in the event of temporary failure, they mitigate the consequences for all stakeholders involved and ensure the continuous supply of energy to all connected parties. USEF provides principles that enable disaster recovery to be designed and implemented in a robust and, where possible, quantified fashion.

13

IT architecture

To achieve the desired interoperability and enable system components to evolve independently, all participants in a USEF market system must share a common logical architecture and standardized interfaces. USEF defines the logical interface standard, but does not define how to implement it. This stimulates innovation and competition among both technology providers and other stakeholders active in the energy value chain. In order to kick-start this process, the USEF Foundation provides a reference implementation that can serve as the basis for full-fledged commercial USEF implementations.

The goal of USEF is to develop a framework for creating commercially viable smart energy systems for products, services, and solutions from multiple vendors. The investments required from the various stakeholders needed to populate such a smart energy system will be characterized by different technical and economic lifetimes and depreciation timescales. Consequently, the components of the system must be independent and easily interchangeable. We achieve this by designing a technology- and implementation-agnostic IT architecture with a strong focus on interoperability. Interoperability creates a future-proof energy system that enables a wide range of products and services to be deployed at competitive prices in an open, accessible market, without vendor lock-in.

USEF's IT architecture standardizes the logical interfaces and defines minimum component functionality in the form of use cases, an information model, and a message model. This promotes innovation and unlocks opportunities to develop implementations focused on different features, such as the size of the market, specific local circumstances, or the commercial exploitation of USEF platforms. Actors in a USEF ecosystem can and must develop business roles and capabilities independently, focusing on their own core business and competitive advantage.

The core of the USEF specification comprises the market-based control mechanism (MCM) and the processes governing this mechanism, which define how the different stakeholders interact. A USEF implementation will typically consist of multiple information systems interacting in accordance with the USEF interaction model in order to run the market processes. The USEF Foundation does not want to narrow the open nature of the USEF specifications by defining exactly how the information system architecture must be implemented.

13.1 Use cases

The information system architecture translates the business process models into use cases and defines additional use cases for the governance and moderation of the business processes. Use cases covering the basic MCM processes during the Plan, Validate, Operate, and Settle phases have been defined. Additional use cases for initial market setup and configuration and for the timing and control of market processes are being created. These use cases describe the functionality that needs to be available in the systems running a USEF-compliant market, and also form the basis for the functionality available in the reference implementation.

13.2 The message model

USEF provides a message model that covers the information exchange required by USEF its Market-based Control Mechanism. To ensure reliable operation of the distributed USEF system, each participant must operate a message queue, both for outgoing and for incoming messages, in order to achieve fully asynchronous and decoupled operations. Communications between these queues must support the HTTP version 1.1 protocol over TLS. Participants may implement different standardized secure protocols, such as AQMP-over-TLS or HTTP 2.0, but due to uncertainties about interoperability, any alternative protocols are optional and fallback to the common protocol must be supported.

USEF requires all participants to be able to securely transmit and authenticate messages. For these purposes, a transport-independent cryptographic scheme is specified.

13.3 Reference implementation

The USEF Foundation will provide a reference implementation for the USEF specification. This provides stakeholders looking to deploy USEF with an example of how the specification can be implemented.

The reference implementation will be a fully functional and tested implementation of the design specification and will be made publicly available in the form of downloadable source code. It will contain the minimal interfaces, algorithms, and business logic required to demonstrate USEF's full functionality.

Parties looking to adapt USEF can modify and add to the reference implementation to suit their local contexts. Such modifications may include the following:

- implementing advanced forecasting algorithms that replace rudimentary forecasters in the reference implementation
- removing functionality related to the implementation of roles not present in a field trial
- extending and implementing interfaces to connect with external functions
- creating components to connect existing processes and systems to an instance of the USEF reference implementation

The reference implementation is an excellent starting point for the development of a commercially viable USEF ecosystem. The USEF Foundation will provide the reference implementation and the accompanying documentation under an open source license, and will facilitate the creation of a community to further develop the USEF reference implementation.

13.4 Standardization

Standardization is a prerequisite to achieve interoperability. Standardization initiatives currently abound in the smart energy system arena, ranging from the standardization of specific components to initiatives focusing on market roles. USEF is well aligned with the smart grid standardization developments at CEN-CENELEC and NIST and with the SGAM model. It builds on these and other relevant initiatives to develop a coherent, integral solution that covers tomorrow's energy market and infrastructure needs. The USEF foundation takes a pragmatic, practical approach to USEF's development to enable vendors to devise commercially viable solutions.

14

Improve, rinse, and repeat

The practical validation of USEF is an essential step toward the large-scale market introduction of smart energy systems. USEF-compliant demonstration projects not only support the promotion of the framework but also help to illuminate USEF's many aspects. Though USEF is designed to be implementation-agnostic, in practice, implementation choices do have to be made. Demonstration projects provide insight into what best fits the goals of the USEF Foundation.

Full-fledged demonstrations of USEF-compliant smart energy systems are essential to convince stakeholders and to show how the envisioned smart energy systems function in practice. By actively involving Prosumers, we learn what drives them to become active up- and downloaders of energy, and we gain insight into their needs and requirements for smart products and services. Demonstration projects therefore provide a rich source of information and insights for improving and perfecting USEF.

Although USEF's design is implementation-agnostic, demonstration projects are vital to bridge the gap between the conceptual, functional, and logical design levels and practical implementations. Companies developing USEF-compliant products must make technology choices. Demonstration projects provide testing and demonstration environments for these USEF-compliant products and services and enable the validation of their functionality and interoperability.

Large-scale demonstration is essential not only to commoditize USEF-compliant smart energy services, products, and solutions, but also to validate the business case parameters and various hypotheses underlying USEF's design. The validation of the business case is crucial for the commercial success of both USEF itself and the demonstration project.

USEF is therefore proud to announce that two Smart Energy Collective demonstration projects in the Netherlands, “Heerhugowaard” and “Hoog Dalem,” will be implementing USEF. This will generate 250–500 Prosumers served by USEF-compliant products, services, and solutions in the first quarter of 2015.

The USEF Foundation is actively marketing USEF in Europe, with an initial focus on countries surrounding the North Sea, to reach its ambition of 10 million connected users in 2020.

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