CEN-CENELEC-ETSI Smart Grid Coordination Group

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SG-CG/M490/L_ Flexibility Management

Overview of the main concepts of flexibility management

Version 3.0

Foreword

Based on the content of the M/490 EU Mandate in its phase 1 (2011-2012), the general scope of work on standardization of the Smart Grid might be considered as follows:

> CEN, CENELEC, and ETSI are requested to develop a framework to enable European Standardization Organizations to perform continuous standard enhancement and development in the field of Smart Grids, while maintaining transverse consistency and promote continuous innovation.

In the light of the discussions held between the EC Reference (EG1) Group and the Smart Grid Coordination Group (SG-CG), the need to iterate the EC Mandate M/490 was considered and agreed by both sides.

As a main objective of the mandate phase 2, the SG-CG wishes to implement the developed methodology, which set up the foundations for managing the continuous engineering and deployment of standards to ensure a real end-to-end interoperability for all generic use cases explicitly including security.

A further refinement of the methodology will be used for the set of consistent standards [SG-CG/G] (under item 3.1 and 3.2 of M/490).

The work is based on [SG-CG/C] and [SG-CG/E].

A set of documents is addressing this objective:

- The main report as a summary of different tools, elements and methodologies developed by the different working groups of the Smart Grid Coordination Group [SG-CG/F],

and additional separate reports detailing specific issues addressed by the working group “Methodology and New Applications”:

- The conceptual model and its relation to market models for Smart Grids [SG-CG/J]
- SGAM User Manual - Applying, testing & refining the Concepts, Elements and Tools for the Smart Grid Architecture Model (SGAM) [SG-CG/K]
- Overview of the main concepts of flexibility management [SG-CG/L] (this document)

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History of document

V1.0	18/12/2013	For publication and review by the BTs and TCs.
V2.0	29.08.2014	Final for distribution to the SG-CG, commenting phase
V3.0	31/10/2014	Final version after commenting period in SG-CG and integrating of the received comments

1 References

Smart Grid Coordination Group Phase 1 Documents

[SG-CG/A] SG-CG/M490/A_Framework for Smart Grid Standardization

[SG-CG/B] SG-CG/M490/B_ Smart Grid First set of standards

[SG-CG/C] SG-CG/M490/C_ Smart Grid Reference Architecture (this document)

[SG-CG/D] SG-CG/M490/D_Smart Grid Information Security

[SG-CG/E] SG-CG/M490/E_Smart Grid Use Case Management Process

Smart Grid Coordination Group Phase 2 Documents

[SG-CG/F] SG-CG/M490/F_Overview of SG-CG Methodologies

[SG-CG/G] SG-CG/M490/G_Smart Grid Set of standards

[SG-CG/H] SG-CG/M490/H_ Smart Grid Information Security

[SG-CG/I] SG-CG/M490/I_Smart Grid Interoperability

[SG-CG/J] SG-CG/M490/J_General Market Model Development

[SG-CG/K] SG-CG/M490/K_SGAM usage and examples

[SG-CG/L] SG-CG/M490/L_ Flexibility Management (this document)

Other references made in this Annex

[ADDRESS-1] ADDRESS Project, Active Distribution network with full integration of Demand and distributed energy RESourceS, http://www.addressfp7.org/

[ADDRESS-2] ADDRESS, “The ADDRESS Project: Developing Active Demand in Smart Power Systems integrating Renewables”, Régine Belhomme, Ramon Cerero, Giovanni Valtorta and Philippe Eyrolles, IEEE General Meeting, Detroit, USA, July 2011

[CEER 13] CEER, public consultation document, Regulatory and Market Aspects of Demand-Side Flexibility, November 2013

[CEN-CLC-ETSI TR 50572:2011] Functional reference architecture for communications in smart metering systems http://www.cenelec.eu/aboutcenelec/whatwedo/technologysectors/smartmetering.html

[DCC 2012] Demand Connection Code, ENTSO-E, 12/2012, https://www.entsoe.eu/fileadmin /user_upload/library/resources/DCC/ENTSO-E_finalises_DCC/ 121221_final_Network_Code_on_Demand_Connection.pdf

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[EG3 2014] EU Commission Task Force for Smart Grids, Expert Group 3: Regulatory Recommendations for Smart Grids Deployment, report to be delivered at the end of 2014, available at: http://ec.europa.eu/energy/gas_electricity/smartgrids/ taskforce_en.htm

ENNET-0001 - ENNET-0018 Use cases, refer to [SG-CG/E]

[ENTSO-E 2012] ‘Modular Development Plan of the Pan-European Transmission System 2050’ of the e-HIGHWAY2050 Project Consortium

[EURELECTRIC] EURELECTRIC Views on Demand-Side Participation, Brussels, 2011

[HEM-RM 2011]	The Harmonized Electricity Market Role Model (December 2011), ENTSO-E, online: https://www.entsoe.eu/fileadmin/user_upload/edi/library/role/role-model-v2011-01.pdf.
[IEV 617-04-15]	International Electrotechnical Vocabulary www.electropedia.org/
[IEC IEV Electropedia]	International Electrotechnical Vocabulary, Electropedia: reference 603-04-32 www.electropedia.org/
[MIRABEL]	MIRABEL, Micro-Request-Based Aggregation, Forecasting and Scheduling of Energy Demand, Supply and Distribution
[SEC 13]	Smart Energy Collective, An introduction to the Universal Smart Energy Framework, version 1.0, 2013
[THINK]	FP7 project Think, Topic 11 Final Report, 'Shift, Not Drift: Towards Active Demand Response and Beyond', June 2013
[WGSP-xxxx]	Use cases, refer to [SG-CG/E]

2 Terms and Definitions

NOTE some of the terms below are also defined in the main body of the report. In case some differences exist, the definition of the main body of the report should prevail.

Customer Energy Manager (CEM)

The internal automation function of the *customer* role for optimizations according to the preferences of the customer, based on signals from outside and internal flexibilities.

EXAMPLE A demand response approach uses variable tariffs to motivate the customer to shift consumption in a different time horizon (i.e. load shifting). On customer side the signals are automatically evaluated according to the preset customer preferences like cost optimization or CO_2 savings and appropriate actions of one or more connected devices are initiated.

Demand Response (DR)

A concept describing an incentivizing of customers by costs, ecological information or others in order to initiate a change in their consumption or feed-in pattern ("bottom-up approach" = Customer decides).

Alternative Defined in [IEV 617-04-15] as: action resulting from management of the electricity demand in response to supply conditions.

Demand Side Management (DSM)

Measures taken by market roles (e.g. utilities, aggregator/flexibility operator) controlling electricity demand as measure for operating the grid ("Top-down approach").

Alternative. Defined in [IEV 617-04-15] as: process that is intended to influence the quantity or patterns of use of electric energy consumed by end-use customers.

Flexibility

On an individual level, flexibility is the modification of generation injection and/or consumption patterns in reaction to an external signal (price signal or activation) in order to provide a service within the energy system. The parameters used to characterize flexibility in electricity include: the amount of power modulation, the duration, the rate of change, the response time, the location etc. [SOURCE: Eurelectric, Jan 2014].

Flexibility offer (short: Flex-offer)

Offer issued by roles connected to the grid and providing flexibility profiles in a fine-grained manner dynamically scheduled in near real-time, e.g. in case when the energy production from renewable energy sources deviates from the forecasted production of the energy system [SG-CG/E]

NOTE Flexibility offer starts a negotiation process.

Flexibility operator

A bundle of roles from [HEM-RM 2011] which links the role *party connected to the grid* and its possibility to provide flexibilities to the conceptual domains energy services and operations; generic role that could be taken by many stakeholders, such as an Energy Service Company (ESCO) or an energy supplier. [Adapted from [SGCG/Sustainable Processes] to match the terminology in the Conceptual Model].

Smart Grid Connection Point (SGCP)

Borderline between the area of grid and markets towards the role *customer* (e.g. households, building, industry). [SG-CG/E]

Traffic Light Concept

A concept in which different grid states are defined, in order to define market models and processes which are state dependent. On one hand a concept which describes the relation between the use of flexibilities on the grid side (red phase) and the market side (green phase) and the interrelation between both (yellow phase), on the other hand a use case which evaluate the grid status (red, yellow, green) and provides the information towards the relevant market roles.

Intelligent Load Shedding

A modified Load Shedding process where the selection of loads, which have to be disconnected, can be selected in a finer granularity using advanced control possibilities of the connected loads based on communication infrastructures.

Load Shedding

The process of deliberately disconnecting preselected loads from a power system in response to an abnormal condition in order to maintain the integrity of the remainder of the system

[SOURCE: IEC IEV Electropedia: reference 603-04-32].

Market

An open platform operated by a market operator trading energy and power on requests of market participants placing orders and offers, where accepted offers are decided in a clearing process, usually by the market operator.

EXAMPLES Energy, balancing power / energy, capacities or in general ancillary services.

Microgrid

A low-voltage and/or medium-voltage grid equipped with additional installations aggregating and managing largely autonomously its own supply- and demand-side resources, optionally also in case of islanding.

3 Symbols and abbreviations

AD	Active Demand
BDEW	German Association of Energy and Water Industries
BRP	Balancing Responsible Party
BT	Technical Board (CENELEC)
CCMC	CEN-CENELEC Management Centre
CEM	Customer Energy Management
CEN	Comité Européen de Normalisation
CENELEC	Comité Européen de Normalisation Electrotechnique
CHP	Combined Heat and Power
CNE	Comisión Nacional de Energia (Spanish regulator, new)
CNMC	Comisión Nacional de los Mercados y la Competencia (Spanish regulator, new)
DCC	Demand Connection Code
DER	Distributed Energy Resources
DR	Demand Response
DSF	Demand Side Flexibility
DSL	Digital Subscriber Line
DSM	Demand Side Management
DSO	Distribution System Operator
EC	European Commission
EEX	European Energy Exchange
EG	Expert Group
EG3	EU Smart Grid Task Force Expert Group 3
EPEX	European Power Exchange
ESCO	Energy Service Company
ETSI	European Telecommunications Standard Institute
EU	European Union
EV	Electric Vehicle
FLIR	Isolation and Restoration
FO	Flexibility Operator
HBES	Home and Building Electronic Systems
HEM-RM	Harmonized Electricity Market Role Model
HES	Head End System
ICT	Information and Communication Technologies
IEEE	Institute of Electrical and Electronics Engineers
LFCR	Network code on Load Frequency Control and Reserves
LNAP	Local Network Access Point
MDM	Meter Data Management

MG	Microgrid
NNAP	Neighborhood Network Access Point
SGAM	Smart Grid Architecture Model
SG-CG	Smart Grid Coordination Group
SG-CG/SP	SG-CG Sustainable Processes
SGCP	Smart Grid Connection Point
SM	Smart Meter
SM-CG	Smart Meters Coordination Group
SME	Small and Medium Sized Enterprise
SO	System Operator
TC	Technical Committee
TLC	Traffic Light Concept
TSO	Transmission System Operator
USEF	Universal Smart Energy Framework
VAr	Unit of Reactive Power
VPP	Virtual Power Plant
VVO	Volt/Var Optimization
WACC	Weighted Average Cost of Capital
WG	Working Group
WGSP	Working Group Sustainable Processes (Phase 1 of the M/490)

4 Introduction

4.1 Background / Challenges

Climate change, growing populations and electrification of energy use, cost efficiency and many other factors are requiring policy makers, engineers and researchers to rethink the power system. Tomorrow’s energy system will need to accommodate and support generators with stochastic output, distributed energy resources and new loads such as electric vehicle chargers, electric heat pumps, etc.

In this new era, keeping the balance between demand and supply, as well as using transmission and distribution capacity as economically as possible without overloading and blackouts are major challenges. This transition calls for a paradigm shift. Not only may a two way flow of power be introduced because of decentralized generation, but also a two way flow of flexibility is required as is shown in Figure 1.

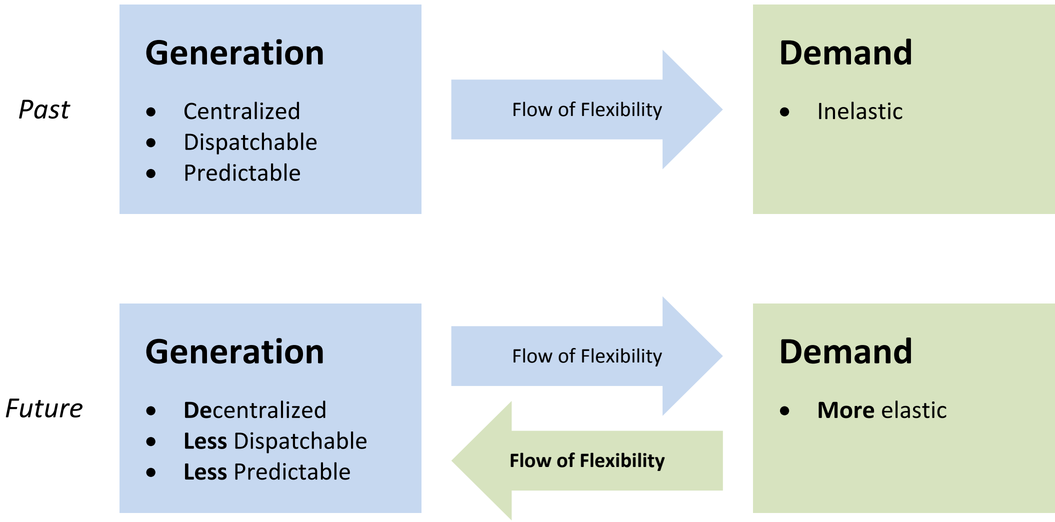

Figure 1: Two way flow of flexibility (SOURCE: [THINK])

One piece in this puzzle is the intelligent management of flexible (distributed) supply and demand or **flexibility management** – or in other words: the integration of these new users of the power system into power markets, scheme's for balancing and protection, etc.

4.2 EU-wide uniform implementation of flexibility management

An EU-wide uniform implementation of flexibility management (one EU wide flexibility market) urgently requires well defined mechanisms. The realization of the EU 20/20/20 objectives drive towards large scale integration of DER in the grid and energy system, and subsequently large scale DER integration in the grid drives towards the need of managing flexibility. In addition to the existing, further regulation, standards and interoperability profiles are urgently required to support the mechanisms for demand side flexibility management.

4.3 Scope and purpose of this document

Flexibility management covers the 'Flexibility Concept' and 'Traffic Light Concept' which are analyzed in [SG-CG/E]. This annex builds on this work and complements it with the work from [SG-CG/C] on Smart Grid architectures and recent developments on this subject from leading European institutions and research efforts. Moreover it is the aim to – in the remaining timeframe of the 'Methodology and New Applications' Work Group – further develop standardization recommendation as well as recommendations to organizational / regulatory issues identified from this work.

Based on the analysis of the use cases received during the collection period – in the previous iteration of M/490 – and the subsequent development of the generic use cases (see [SG-CG/E]) it was decided to introduce clusters of use cases by means of conceptual descriptions. This annex provides an overview and background to the main concepts related to flexibility management. It also provides first suggestions for functional architectures that are required to detail the generic use cases.

4.4 Structure of this document

Flexibility management in this annex is considered to cover a range of methods and practices to leverage the flexibility of demand, DER, storage, etc. in order to optimize the efficiency of the power system, integrate renewables, etc. Section 5 further elaborates on where flexibility originates from and how it is provided. Section 6 further details the areas of application of the flexibility provided, i.e. what usages it has.

In relation to conceptual model introduced in [SG-CG/F][SG-CG/J], the 'flows of flexibility' considered are illustrated in Figure 2. This figure shows how grid users provide flexibility with their flexible production, storage and consumption units. Section 7 provides analysis of how the use of flexibility can be organized / implemented in market structures.

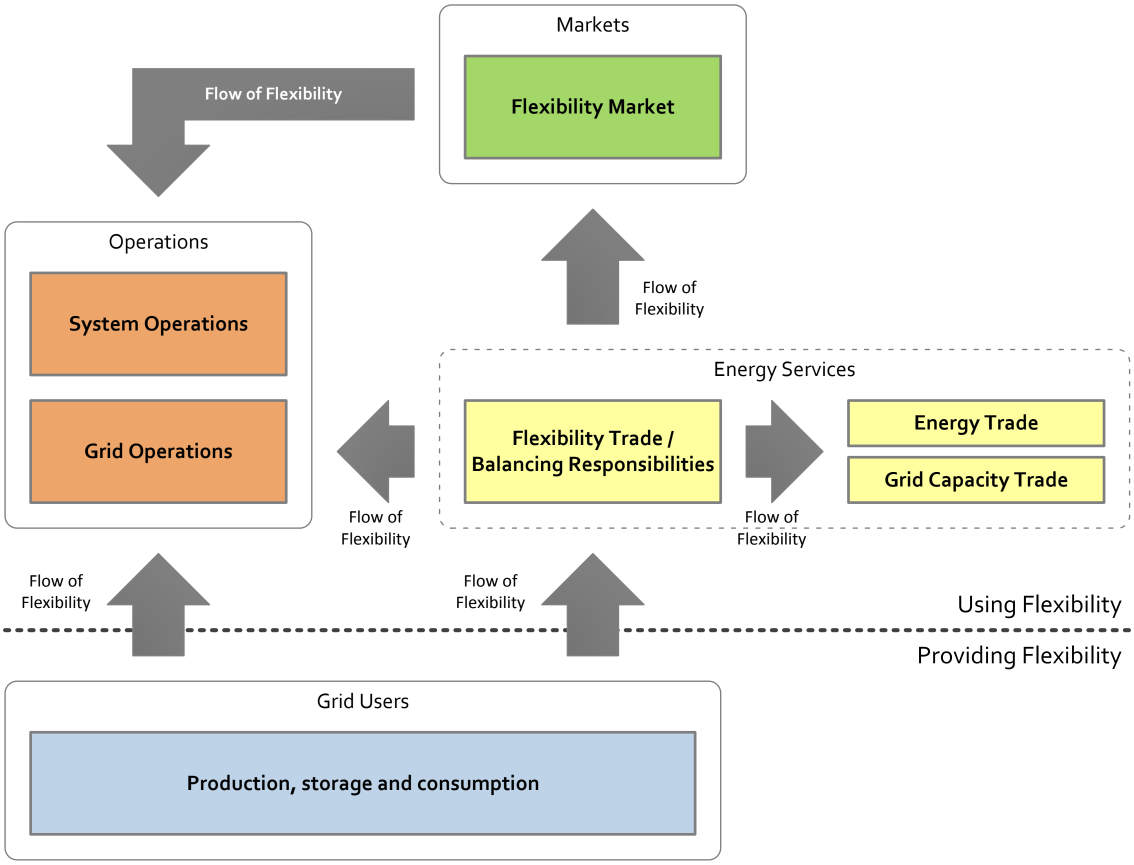

Figure 2: Flow of Flexibility plotted on Conceptual Model from Providing to Using Flexibility

Finally section 8 provides recommendations on an architecture level and section 9 gives recommendations pertaining to the standardization of flexibility management as well as related regulation.

5 Flexibility in demand and supply in Smart Grids

5.1 What is flexibility?

The flexibility in demand and supply in the context of Smart Grids considered in this annex covers

the changes in consumption/injection of electrical power from/to the power system from their current/normal patterns in response to certain signals, either voluntarily or mandatory.

This follows the definition of active demand response from [THINK], but is extended to 1) also cover flexibility from e.g. distributed generators and 2) to include cases where providing a response is mandatory.

5.2 Providers of Flexibility

As introduced in section 5, traditionally, the providers of flexibility in the power system are the centralized power plants and its customers on transmission level. This is known as supply-side flexibility. They ramp up or down their generation, following demand. With the decentralization of generation, introduction of renewable power sources, and new loads being integrated into the power system (e.g. heat pumps, electric vehicles), there is a need to source flexibility from elsewhere.

Flexibility can be sourced from a range of generators, storage and demand. Both on supply as on demand side, flexibility can be provided. On the demand side, flexibility is provided by industrial, business and residential customers, directly or via a flexibility operator/ aggregation service provider (for residential customers).

This flexibility can be characterized according to Figure 3. This figure shows a progression in the extent to which an energy resource can be controlled. It is an adaption of a figure in [THINK] to extend it to cover also generation and with freely controllable equipment (e.g. distributed generators with the main purpose of generating electricity which aren't bounded by other processes).

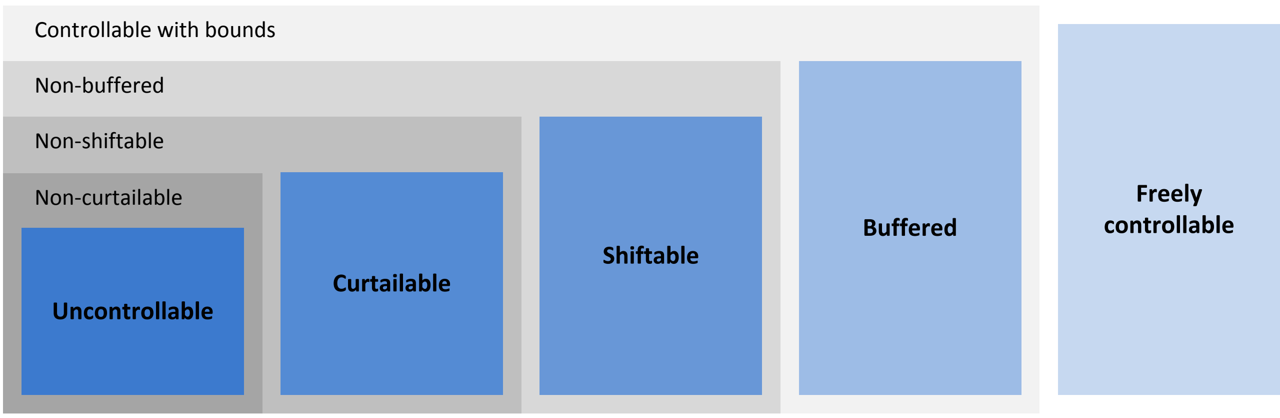

Figure 3: Categorization of Flexibility Sources
(adopted from [THINK])

5.3 How is it provided?

Flexibility management covers a variety of mechanisms as is shown in Figure 4. It ranges from direct control of resources to price reactions. Flexibility management encompasses at least: Demand Response (DR), Demand Side Management (DSM) and explicit provisioning of flexibility to the market. In the following section, some definitions around providing and using flexibility management are formulated. For more details, please refer to the literature listed in the section 1.

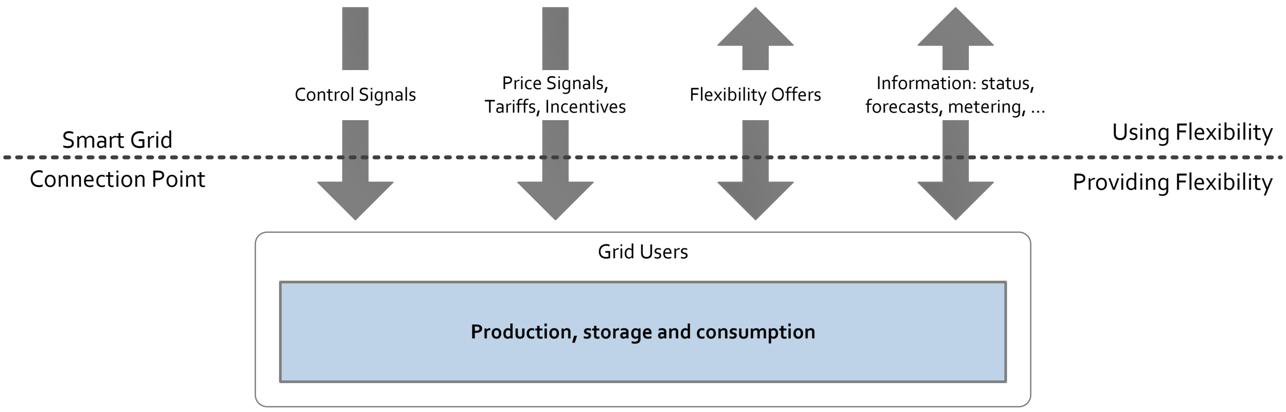

Figure 4: Interactions to provide / address flexibility of grid users

The concepts described in these definitions are elements of flexibility management where both the grid/market and the customer can take the initiative to use or offer flexible demand, generation or storage.

See also section 6 which indicates how these signals relate to the parties interacted with and section 8.2 for further details on the concept of the 'Smart Grid Connection Point'.

5.3.1 Demand Side Management

As defined by [EURELECTRIC]:

*<u>Demand Side Management (DSM)</u> or Load Management has been used by the [mainly still vertically integrated as opposed to unbundled] power industry over the last thirty years with the aim to reduce energy consumption and improve overall electricity usage efficiency through the implementation of policies and methods that control electricity demand. Demand Side Management (DSM) is usually a task for power companies / utilities to reduce or remove peak load, hence defer the installations of new capacities and distribution facilities. The commonly used methods by utilities for demand side management are: combination of high efficiency generation units, peak-load shaving, load shifting, and operating practices facilitating efficient usage of electricity, etc. DSM is therefore characterized by a **'top-down' approach**: the utility decides to implement measures on the demand side to increase its efficiency.*

5.3.2 Demand Response

As defined in [THINK]:

Changes in electric usage implemented directly or indirectly by end-use customers/prosumers from their current/normal consumption/injection patterns in response to certain signals.

As defined in [EURELECTRIC]

*<u>Demand Response (DR)</u>, on the contrary, implies a **'bottom-up' approach**: customers become active in managing their consumption – in order to achieve efficiency gains and thus reap monetary/economic benefits. Demand Response (DR) can be defined as the changes in electric usage by end-use customers from their normal consumption patterns in response to changes in the price of electricity over time. Further, DR can be also defined as the incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized. DR includes all intentional modifications to consumption patterns of electricity of end use customers that are intended to alter the timing, level of instantaneous demand, or the total electricity consumption. DR aims to reduce electricity consumption in times of high energy cost or network constraints by allowing customers to respond to price or quantity signals.*

5.3.3 Explicit provisioning of flexibility to the market

As defined in [MIRABEL]:

<u>The flexibility [offering] concept</u> assumes that parties connected to the grid produce offerings of flexibility in load and (distributed) generation. Thereby, so-called flex-offers are issued indicating these power profile flexibilities, e.g. shifting in time or changing the energy amount. In the flex-offer approach, consumers and producers directly specify their demand and supply power profile flexibility in a fine-grained manner (household and SME[1] level). Flex-offers are dynamically scheduled in near real-time, e.g. in case when the energy production from renewable energy sources, such as wind turbines, deviates from the forecasted production of the energy system.

[1] Small and Medium-sized Enterprise

6 Flexibility Management Applications Areas

6.1 Introduction

The areas in which flexibility management can be applied – or in other words the use of flexible resources – can occur over different time horizons (from milliseconds to years). This is shown in Figure 5.

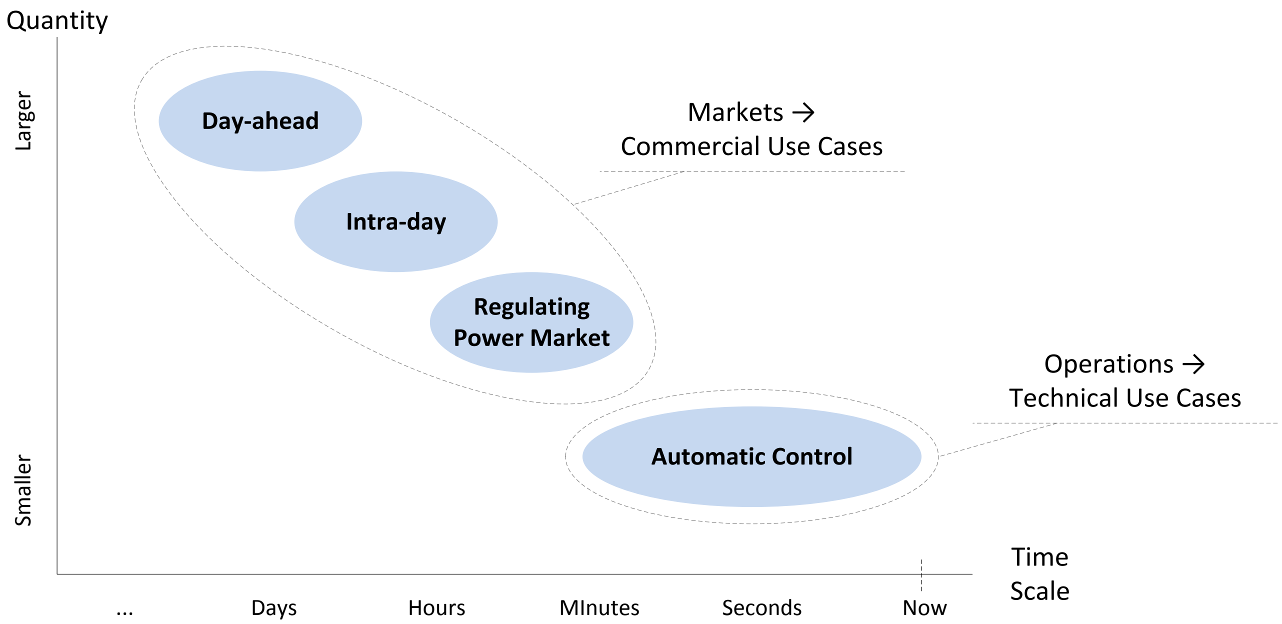

Figure 5: Use of flexibility on different time scales

(Source: based on use cases from Energinet.dk and [SG-CG/E])

The sections below provide an overview of these areas.

6.2 How flexibility is used

The application areas where flexibility in supply and demand provide value can roughly be divided into two main clusters of use cases: use of flexible demand, storage and generation in commercial and technical use cases; see also Figure 6. The technical use cases can be further subdivided into use cases related to system and grid operations.

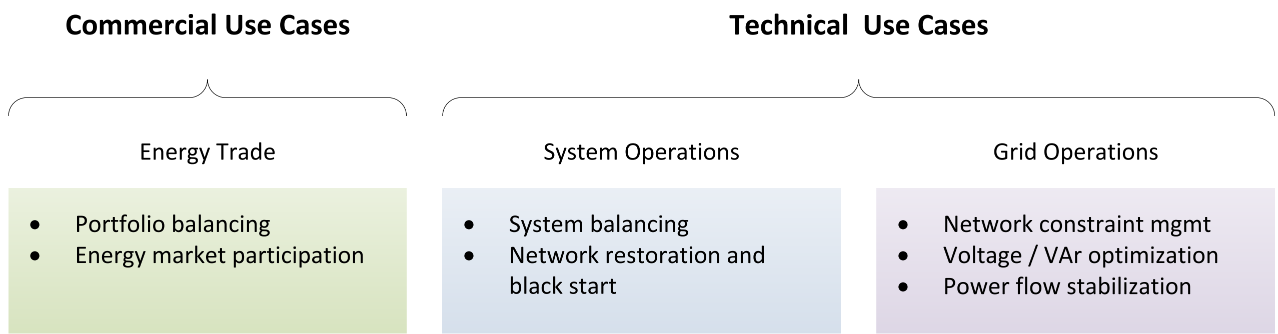

Figure 6: Application areas of flexible demand, storage and generation

These application areas are further detailed below.

6.2.1 System operations

The application area of system operations (TSO) concerns the use of flexibility in order to ensure stable operation of the power system as a whole; i.e. on the level of entire grids or market balance / control areas. The applications identified are:

- **System balancing** – ensuring frequency stability, preventing deviation between measured and scheduled inter-control-area power exchange, etc.
- **System restoration and black start** – using flexibility in energy resources for ‘orderly’ restoration of the power system after e.g. a black out.

6.2.2 Grid Operations

Grid operations is an area where flexibility allows for local optimizations in power grids. The applications identified are:

- **Local network constraint management** – ensuring grid capacity isn’t exceeded (on different voltage levels) and that voltages remain within the statutory limits.
- **Voltage / VAr optimization** – optimization of voltage profiles and power flows; see also use case WGSP-0200 from [SG-CG/E].
- **Network restoration** – using flexibility in energy resources for ‘orderly’ restoration
- **Power flow stabilization** – reducing the variation in power flow across (network) assets to increase asset lifetime.

6.2.3 Energy Trade

In the area of trade in energy as a commodity, flexibility can be used to optimize trading portfolios and reduce balancing cost resulting from deviations between scheduled and actual inflow/off-take.

- **Market / portfolio balancing** – reducing the difference between scheduled and measured/actual inflow/off-take of market participants.
- **Energy market participation** – participation of any (aggregated) flexible resources in energy markets (on time scales varying from e.g. minute-ahead to day-ahead).

6.3 Use cases

In this section, a number of the use cases offered by stakeholders market and/or grid’s use of flexibility will be explored in more detail.

It must be noted that further developments and harmonization is required in this area in relation to new, emerging market models. Nevertheless, the following use cases have been provided as a base to start from and encase consideration of the standardization effort required in order to support emerging future market models.

The intension of this section is not to artificially limit the range of such models and the possible solutions within them.

In general it may be differentiated between two major blocks on the “grid and market” side:

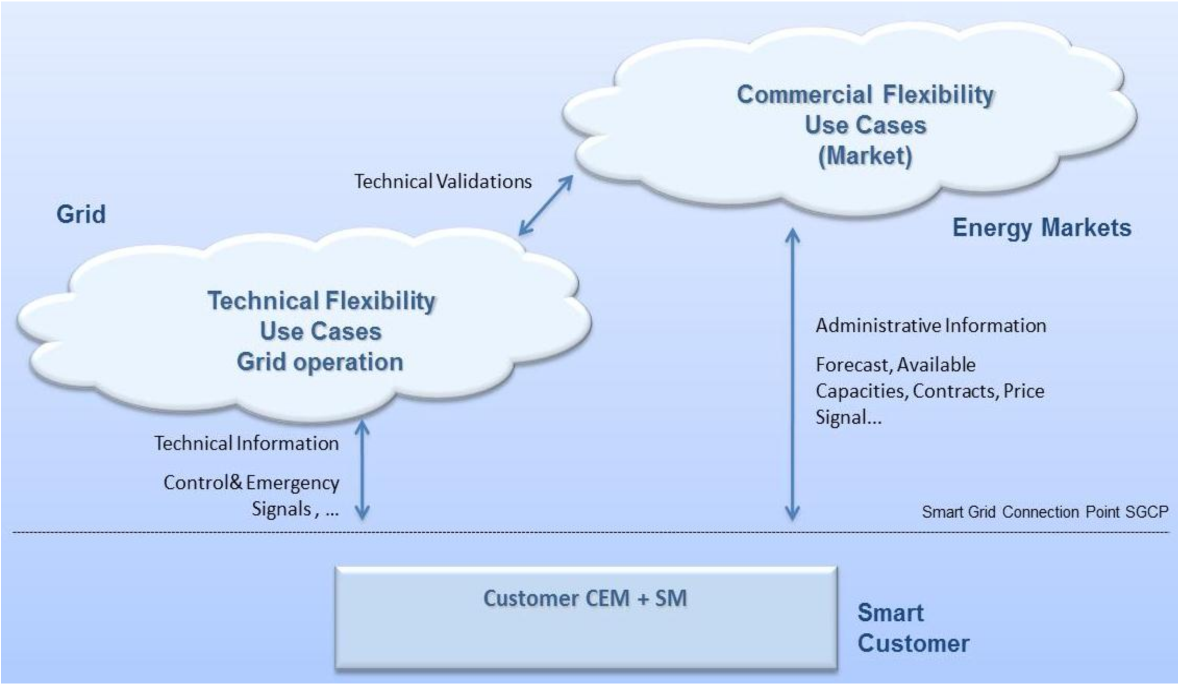

Figure 7:Commercial and technical flexibility use cases in the grid and market area[2]

6.3.1 Technical use cases

The primary task of these use cases is to stabilize the grid in the given limits for power quality. The following key actions are suggested under these use cases, reflecting different sections within the discussed 'Traffic Light Concept' (refer to chapter 8.6).

Example use cases regarding the role of the DSO from [SGCG/E] are:

1. The Distribution System Operator (DSO) sends a request for procuring flexibility services for stability reasons (e.g. emergency signals, load shedding, need for reactive power, requesting more or less generation).
2. DSO receives information from e.g. the Smart Meter with[3] information regarding power quality, outage, etc.
3. DSO providing e.g. a correction (price, control) for market price signals in case of local grid overload (congestion management).
4. Or in case of emergency the DSO sends direct command signal according to legislation or contractual situation.
5. The DSO is the actor / market role for the technical use cases within the operation block.
6. Those technical demand response control functions might be used by other high level use cases like Microgrids (MG) or Volt/VAr Optimization (VVO), please refer to the respective generic use cases.

Other roles, such as the Aggregator/Flexibility Operator (see Chapter 7) or other new emerging service providers can implement similar use cases as provided here for services to the DSO.

[2] Generic use cases (e.g. DR/DSM) are providing flexibility and offer the basic functionality for both, technical and commercial flexibility. There will be "higher level" use cases dedicated to either technical or commercial.

[3]Discussions, if the information must be anonymous due to privacy considerations or if e.g. local geographical information are required.

An additional use case regarding the role of the TSO is exploiting demand flexibility in balancing. In that case the TSO sends a request for procuring flexibility services for balancing.

6.3.2 Commercial use cases

It is worth emphasizing that the general premise employed here is that the application of commercial flexibility use cases can be differentiated. The general instances in which commercial flexibility use cases are likely to be relevant to include:

Energy and balancing power

- Selling, buying, trading energy (whole sale markets) based on prices in a liberalized market environment
- Balancing (after market closure)

Existing or new markets

- Existing energy markets: several use cases suggest the use of additional flexibility which has to be gathered in order to participate in existing markets (primary, secondary, tertiary markets, intra-day, day-ahead …)
- New markets are suggested for real time corrections, e.g. within a balancing area.

Both the TSO and market participants (such as a Aggregator/Flexibility Operator (see Chapter 7), employing roles such as a Balance Responsible Party and Balance Supplier) can access these flexibilities.

7 Market Implementation Considerations

7.1 Introduction

Sections 5 and 6 above provide conceptualizations of flexibility management – how flexibility in demand, generation and storage can be provided and used. This section provides an overview of considerations pertaining to implementing these concepts into market structures. This has to be taken into account in standardization of flexibility management techniques.

A general consideration is that the current transition towards a smart grid should rely on the existing regulatory framework. The current establishment of the electricity market is based on existing rules that have led to an increased integration within Europe in the past 20 years. According to the principles of the regulatory framework both DSOs and TSO's should comply with the existing rules of the internal market. This is important during and after the present phase of the integration of the European Market, avoiding to jeopardize the big step forward obtained in the past years.

7.2 Roles, rights, expectations and responsibilities: Parties connected to the grid (e.g. consumers)

In order to enable an affordable future energy system, demand side participation is essential for success. Customer/ parties connected to the grid need to be empowered and rewarded for delivering flexibility. They will have the right to sell their flexibility in all markets. However this should lead to product definition of flexibility with a guaranteed firmness, which will be required by the system operation for balancing purposes and by the DSO for grid constraints management purposes[4].

[4] Based on EG3 report on flexibility, chapter 1 [EG3 2014]..

In order to become a recognized market participant, the parties connected to the grid will also require additional information and information exchange from TSOs, market parties and DSO's. This information exchange should be implemented via standards.

It is widely accepted that the energy transition will not be successful without customer empowerment and engagement. Therefore it is important to consider that:

1. Any action to limit individual usage or to directly control demand needs to be performed with the informed consent of the consumer.
2. The consumer must be able to withdraw previously given consent at any time.
3. A safety net is in place to ensure that vulnerable consumers are protected from risks to health resulting from restriction of usage.

7.3 Roles and responsibilities: Flexibility Operator[5]

In this section, the flexibility operator will be explored with relevant potential use cases noted which might interact with a range of possible market models. It should be emphasized that potential market models and regulation continue to be developed in this area, and it is not the role of standardization to define these.

In particular the output from the European Commission's Smart Grid Task Force Expert Group 3 (EG3) is likely to have an important impact on the emerging regulation, use cases or standards relating to the role of the flexibility operator. Therefore, use cases should be revisited, iterated and updated as the output from this group with respect a market model for Smart Grids is finalized [EG3 2014].

The role of the flexibility operator is a bundled role that pools the small flexibilities of customers / network users (e.g. from CEMs) in order to make use of them in the grid or on energy markets.

[5] In this document the term Flexibility Operator is used according to [SGCG/E], this corresponds with the term Aggregator in EG3 and in the recently published IEC 62913-1 (CD) with the term Flexibility Aggregator.

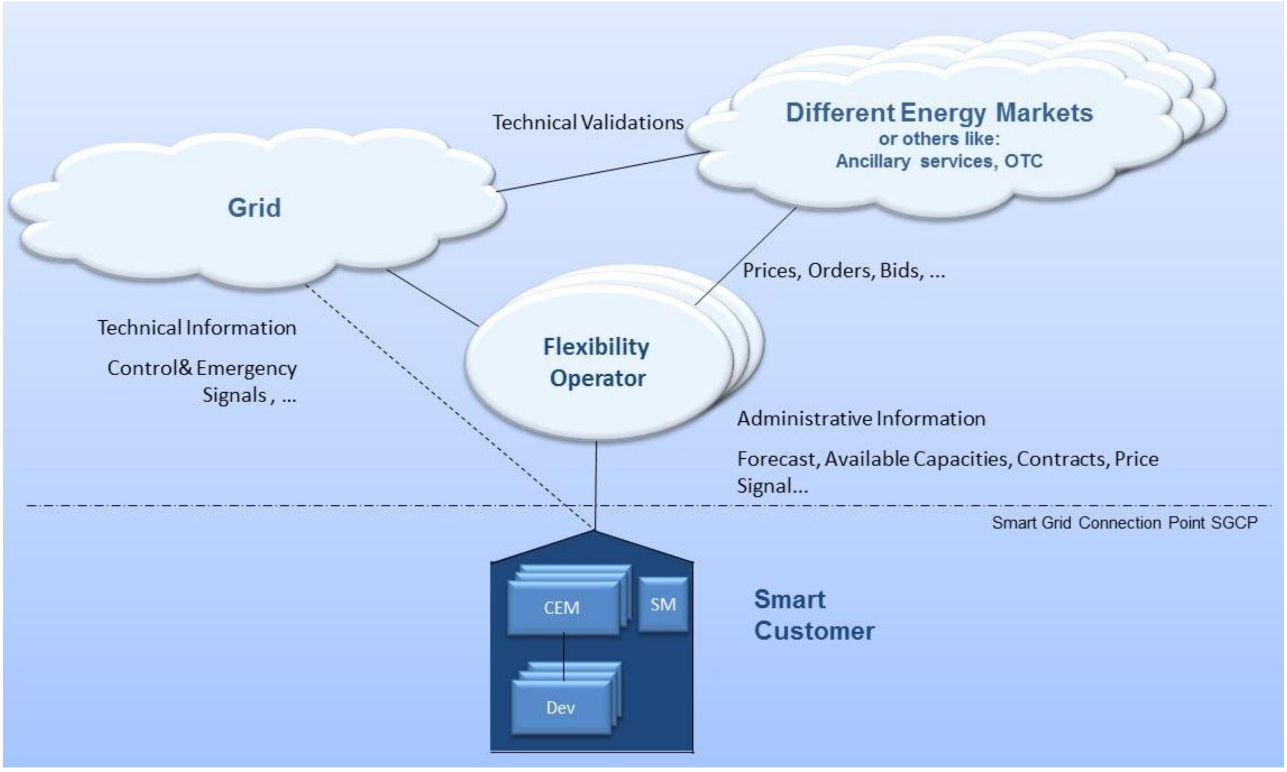

Figure 8:Flexibility operator gathering flexibilities from different customers and 'sells' them to the 'end-users of flexibility' (grid / system operators, commercial entities, etc.)

The concept of the flexibility operator, often referred to as aggregator, seems to be widely accepted, although the name and its detailed tasks are varying. Its basic responsibility is to act as an intermediary between a supplier of flexibility (e.g. Producer or Consumer) and a user of flexibility (e.g. Grid Operator). This responsibility might be carried out by existing bundled roles in the energy market, like energy suppliers with variable prices, aggregators, Virtual Power Plant (VPP), energy servicing company, agent, etc.

2 types of flexibility operators can be defined:

- A flexibility operator with (own) BRP responsibility
- A flexibility operator without own BRP responsibility

The importance of the balance responsibility role of the energy system is well understood, as it plays a crucial role in maintaining system stability and security of supply. The introduction of customers as market participants, possibly represented by aggregators operating the customers flexibility, should not jeopardize this.

Therefore it will be essential that customer related metering data, which is delivered to existing and new market parties, uniquely corresponds with data required by the balance responsibility roles in the market (no gaps or overlaps). This may lead to further differentiation in measuring metering data.

It is worth emphasizing that the flexibility operator defines their own optimization strategy making use of the flexibilities offered to them on the one hand and on the other hand participating in new or existing balancing power markets and energy services on the other hand. As such different levels / strategies of the flexibility concept can be considered.

8 Architecture Recommendations

8.1 Introduction

The previous sections conceptualize the flexibility management scope. This section reiterates a number of concepts and recommendations on this conceptualization as expressed in [SG-CG/E]. This section is intended as an indication of the status quo and a stepping-stone for further work in this area.

8.2 Smart Grid Connection Point (SGCP)

In this conceptual model, the Smart Grid Connection Point (SGCP) defines the physical and logical borderline / interface from the customer to the network/market or from the network/market to the customer considering small scale generation, storage or demand. The SGCP can be implemented by one or more separate interfaces (e.g. Smart Metering Gateway to an external actor).

The SGCP can be used as an abstraction that will help to reduce the complexity in the description of the interactions between different "domains" such as grid/market and "resources" in a general meaning (DER or customer premise) or between “providing flexibility” and “using flexibility”.

The different physical or informational "flows" that pass through the SGCP depend on the services defined between market/grid and the customer. In that respect the SGCP can be regarded also as service access points of the services delivered on the SGCP. The definition of these are dependent on different functionalities, which should be standardized taking into account as far as possible that there might be different regulations as well as market models as defined by the respective authorities for these functionalities. In the following the flexibility concept concentrates on the generic functionalities for this interface based on use cases that were received in the use case selection period and consequent discussions in the SG-CG.

For a flexibility operator or a balancing responsible party (BRP), the demand or generation flexibility of the SGCP just represents positive or negative control power. In order to define these flexibilities, the supported use cases at a specific SGCP can be used within an auto registration process (refer to chapter 8.4).

8.3 Flexibility functional architecture

Most use cases are describing the DR/DSM together with automation functions on the customer side, here called the Customer Energy Manager or CEM. Through the work undertaken here it appears that a fairly harmonized view on a functional architecture in the evaluated use cases is evident. The picture below represents a possible generic functional architecture example for the flexibility use cases.

Here, the CEM provides the flexibility of connected smart devices, through the energy management gateway, while the smart meter and the simple external consumer display provide a number of functionalities that are described in more details in work of the Smart Meters Coordination Group (SM-CG). The energy management gateway communicates with the metering channel and the smart metering through the Smart Metering Gateway. The gateways in this architecture split different networks (Wide Area Network, Neighborhood Area Network and Local Area Network) and may be, as further described below, integrated with other functional entities.

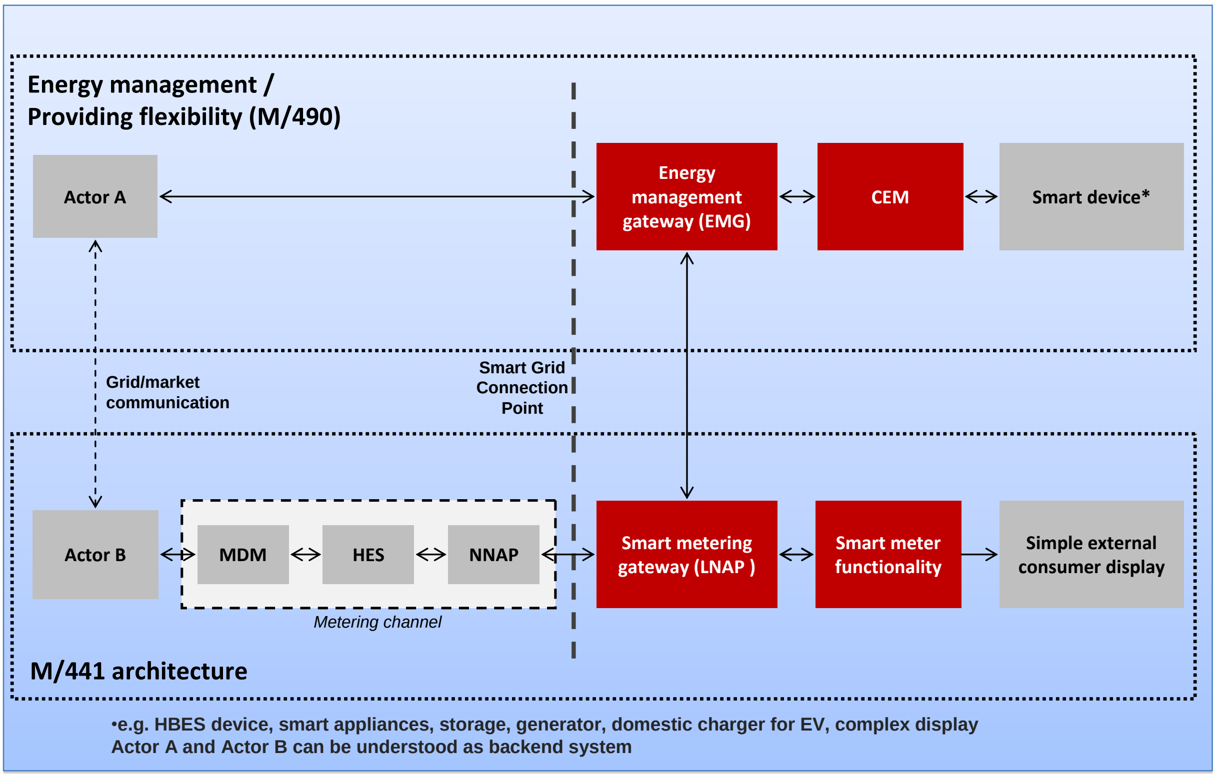

Figure 9: Flexibility functional architecture

Note that the actors in the above architecture are functional / logical entities, which means that some of them may be part of the same physical device (e.g. CEM functionality may be part of a smart device, the smart meter might also encompass the smart metering gateway and CEM, etc.).

Note that the communication path between the smart metering gateway and energy management gateway is optional (as are all communication path is in this architecture). In the aforementioned case, the information exchange between the metering channel and energy management channel will take place between Actor A and Actor B.

The external actors A and B, identified in this functional architecture represent (bundle of) roles that communicate through the Smart Grid Connection Point. Examples of these roles are a meter data collector, meter operator, aggregator/flexibility operator, supplier etc. The actual role of actor A or B depends on the local market organization in a member state and competition. In the scope of this report, actor A is defined as the external actor communicating with the energy management gateway while actor B is defined as the external actor communicating with the smart metering gateway.

Functionalities of Head End System (HES), Neighborhood Network Access Point (NNAP), Local Network Access Point (LNAP), smart metering and the simple external consumer display are described in more details in the functional metering reference architecture according to SM-CG [CEN-CLC-ETSI TR 50572:2011]. The communication in the metering channel (going via Meter Data Management (MDM), HES and NNAP) is not described in detail in the use cases of the flexibility cluster since, in these use cases, their function is to pass through the information sent between smart metering gateway and actor B. Although the NNAP and LNAP can include intelligence to locally and independently implemented Smart Grid services and applications, their service in the current flexibility use cases is to pass through the information.

This functional architecture can be mapped in the following way on the Smart Grid Architecture Model (SGAM) as defined in [SG-CG/C] Phase 1, [SG-CG/K] [SG-CG/F] Phase 2.

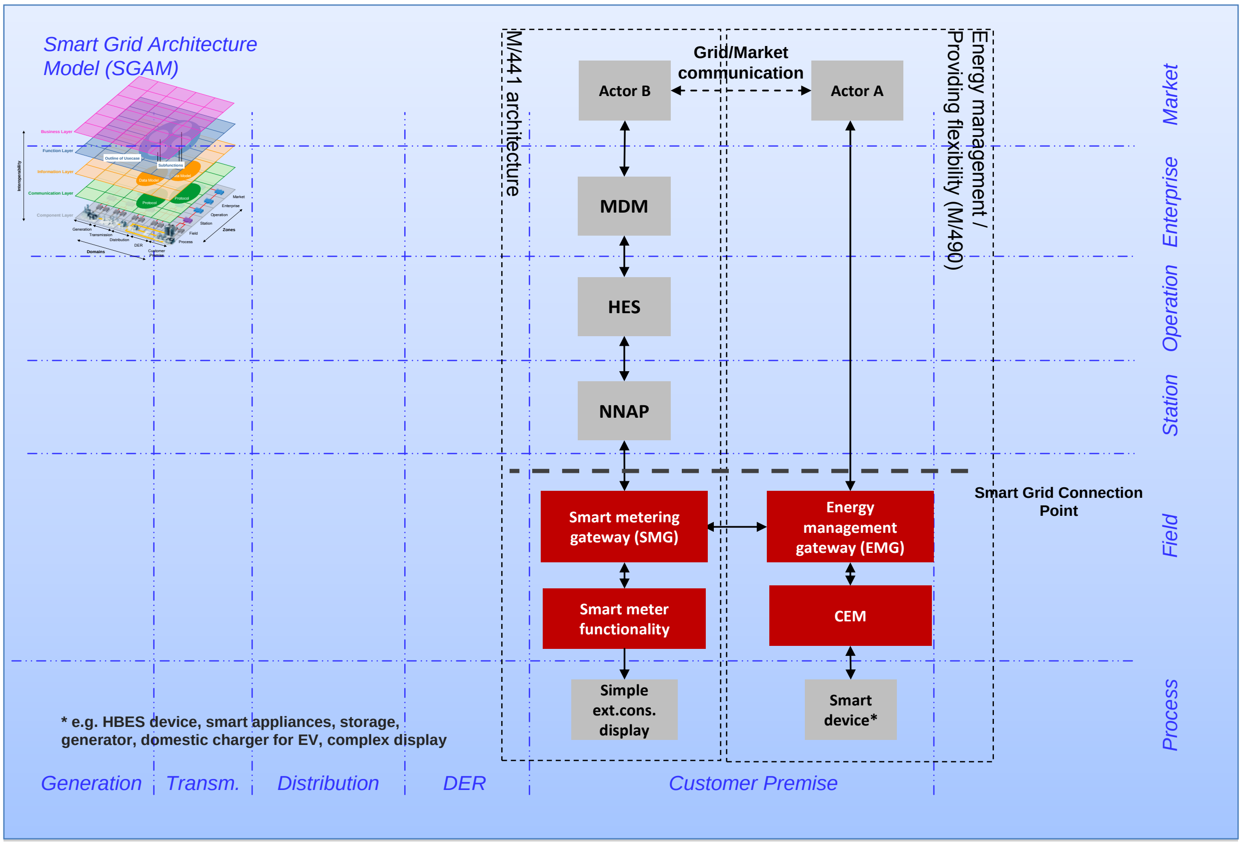

Figure 10: Mapping of flexibility functional architecture on SGAM

8.4 Auto registration of participating devices and customers

8.4.1 Auto registration CEM to flexibility operator

Subsequently the suggestion of the Smart Grid connection point which is defined by criteria and as it is expected that there are millions of these SGCPs, several use cases suggest that there should be an automatic registration procedure and partly a kind of plug & play functionality for the technical registration and connection of all smart customers to their flexibility operators or other relevant market roles like DSO, energy supplier or energy services companies.

New Smart Grid market roles like an aggregator/flexibility operator, which collects small energy flexibilities, need low transaction costs in order to achieve a valid business case. Use cases and standardization with automatic functionalities like auto-registration are a possibility for lowering these transaction costs (e.g. by reducing the engineering connection effort).

Similar to other ICT systems (e.g. registration of DSL connection) with auto registration, the CEM will provide and receive information to/from “Grid / Market”. This information may include supported functionalities given the related contracts or technological possibilities (e.g. load shifting, reduction of generation or provision of reactive power). Further information exchange during auto registration may include: contract details (legal/billing relevance), power ratings, available status information, geographical information, security information like credentials and authentication, time synchronization and others.

Relevant contract details are to be dealt with in advance of auto registration.

8.4.2 Auto registration smart devices to CEM or to SGCP

Also within the Customers Energy Manager, auto-registration and “plug & play” functionalities should be applied in order to ease the use of smart devices and to convince the customers to participate in the Smart Grid. In case the CEM is part of the smart device, this registration might be limited to linking in-home devices to the home gateway (Energy Management Gateway or Smart Metering Gateway). Also the CEM might exchange the required information of the smart devices and aggregate them towards the flexibility operator or other relevant market roles.

In case of multiple smart devices one CEM may perform the registration towards the grid / flexibility operator. Alternatively the internal CEM’s of the smart devices may individually register to the grid / flexibility operator directly.

This auto registration is not part of the Mandate M/490, but it is logically interrelated with the interface to the flexibility operator or grid.

8.5 Relation between the flexibility operator and the European harmonized electricity market role model

The use cases identified by the SG-CG/SP Sustainable Processes Work Group on ‘providing flexibility’ concerns control/management of flexible demand & supply. In these use cases, flexibility in demand and supply is provided by ‘smart customers’, for usage in use cases related to e.g. system balancing, network constraint management, Volt/VAr optimization, network restoration and black start, power flow stabilization, market balancing.

I.e. the flexibility is used by parties related to grid / power system management and/or electricity markets. A 'Flexibility Operator' performs pooling of this flexibility as described in 7.3. The flexibility use cases cover several means of interacting with ‘smart customers’, including:

- Communication of price signals, tariffs and other economic incentives
- Explicit trade in flexibility in demand and/or supply
- Direct control of demand and/or supply

Although analyzed in combination in the flexibility use case, distinguishing between these approaches allows for better analysis in relation to the European electricity market. Below, each of these approaches is analyzed further with respect to their relationship with the organizational structure of the European electricity market.

The figures used throughout the analysis below show roles and their associations from the European harmonized electricity market role model and how they relate to actors [SG-CG/J] and their associations from the use case. This is graphically represented according to the legend as shown in Figure 3.

Note that in use cases the bundled roles of the flexibility operator are depicted as actors, showing their interactions and the different roles they perform their task in.

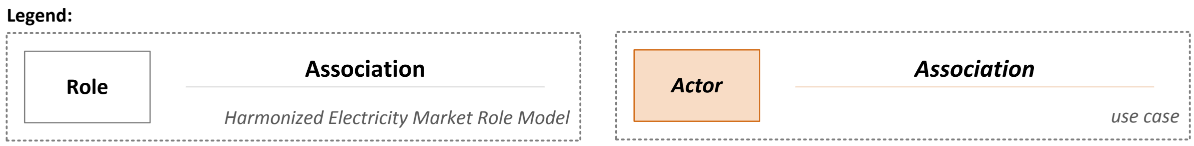

Figure 11: Notation used in analysis of relation between flexibility operator and [HEM-RM]

8.5.1 Communication of price signals, tariffs and other economic incentives

Economic incentives can be given to parties connected to the grid, primarily based on state of the grid or market. Within [HEM-RM 2011], parties connected to the grid are ‘associated’ to the market through the

Balance Supplier role and connect to grid operations through the Grid Access Provider role. Figure 12 provides a visualization of this mapping.

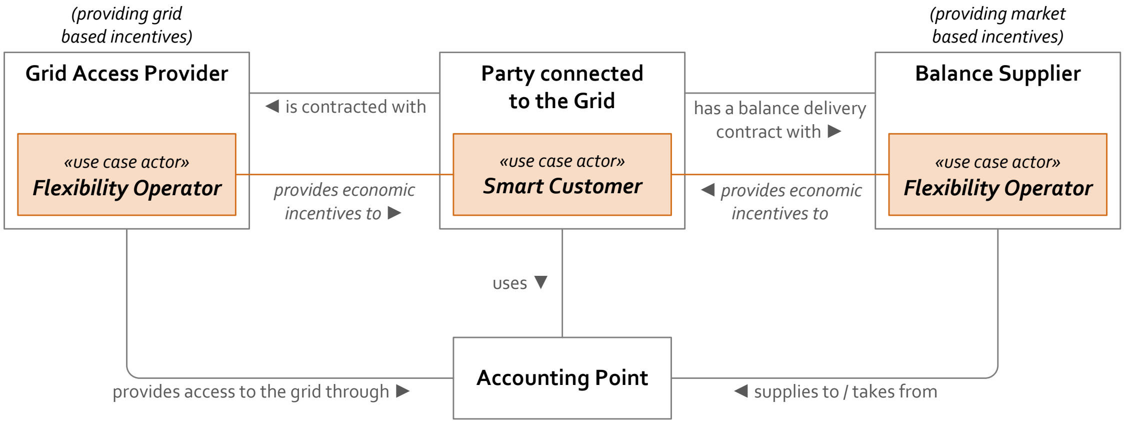

Figure 12: Economic incentives in the flexibility use cases in relation to [HEM-RM]

8.5.2 Explicit trade in flexibility in demand and/or supply

The explicit trade in flexibility is closely related to the mapping of the use case wherein the Flexibility Operator performs direct control; with the major differences that the 'smart customer' moves in the value chain in the sense that it now takes the Resource Provider role itself instead of the Flexibility Operator. This mapping is visualized in Figure 13.

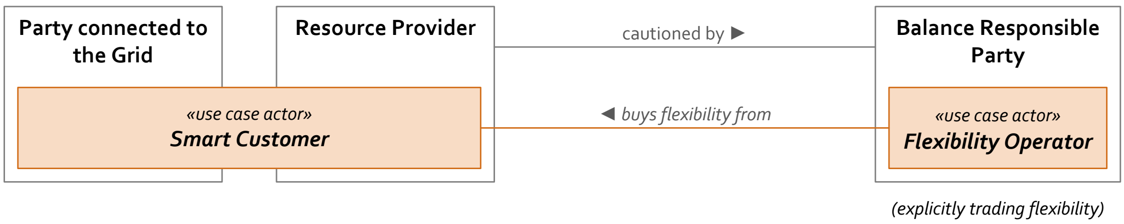

Figure 13: Explicit trade in flexibility in relation to [HEM-RM]

8.5.3 Direct control of demand and/or supply

Within [HEM-RM 2011] the role of Resource Provider is identified, actors with this role take part in system operations by providing reserve (balancing) services, by up/down regulation of 'resource (or reserve) objects' under its control. In case of direct control, the Flexibility Operator can be considered performing the Resource Provider role. The mapping of this use case to the roles of [HEM-RM 2011] is visualized in Figure 14.

NOTE the relationship between "Party connected to the Grid" and "Resource Provider" is not defined in [HEM-RM 2011]. The relationship between "Resource Object" (a domain from [ENTSO 2012], not to be mistaken with the domains of the European conceptual model) and the "Party connected to the Grid" is assumed.

NOTE the Flexibility Operator in its role of Resource Provider connects to power system management and the market via another party (or by itself) performing the Balance Responsible Party role.

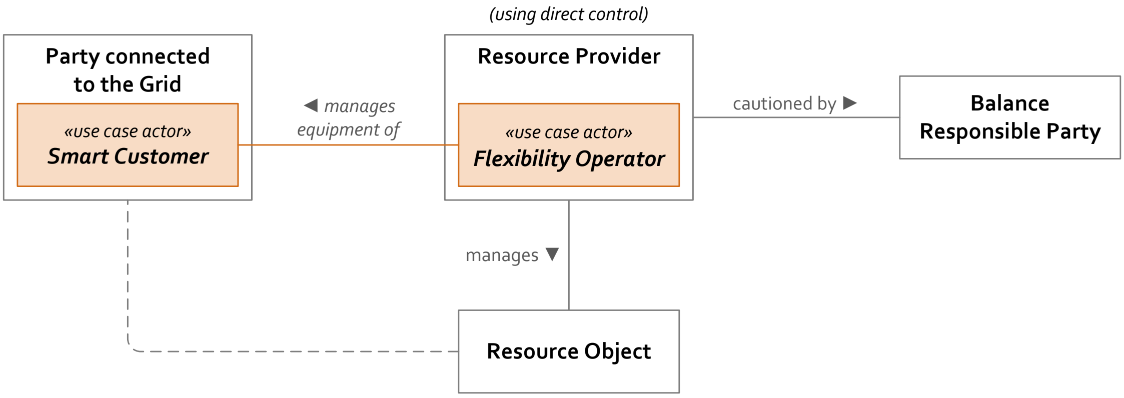

Figure 14: Direct control of demand and/or supply use case in relation to [HEM-RM]

8.6 Traffic light concept

The interaction between market roles (e.g. supply, trade, produce, store, consume, etc.) and roles regulated by law (system operations, grid operations, etc.) is in the context of the flexibility concept very complex. In order to maintain balance and prevent blackouts, a grid / system operator requires control mechanisms that interfere with market operations to ensure quality of supply.

A helpful framework to aid in the identification of key interactions between the grid operations on the one hand and market operations on the other hand is the Traffic Light Concept (TLC). The TLC is developed within the German Association of Energy and Water Industries (BDEW) and defines three different states of grid and market operations.

These states provide the system/grid operators and the market participants with information on the current and forecasted condition of the network:

The **green state** is the region where the “smart market” competitively operates freely; the system/grid operator may or may not interact with the market at this point. This should be seen as the “normal operating state”.

The **yellow state** indicates the state where the system/grid operator actively engages with the market in order to keep the system from becoming unstable; it is therefore a temporary state preventing the grid from entering the red state. This could be by executing pre-agreed contracts or by stepping in to procure in real time at market prices. This does not mean that the customer has to accept any situation where a third party (system/grid operator) decides when they can use what is in their home or business premise. Instead intelligent solutions and economic incentives should be provided to allow the customer to decide and accept some limits in order to provide the needed flexibility.

During the **red state** the system/grid operator needs to take control of market interactions in a certain area where the constraint has occurred. However, actions in this state must be specific and well defined and be temporary in nature. In this situation the grid operator can override contracts existing in the market, execute dedicated emergency actions through flexibility operators, or execute direct controls over generation or demand in order to re-stabilise the system as far as a contract or regulation / legislation allows to do so.

These concepts closely relate to the concepts introduced in [SEC 13] in the universal energy services framework of capacity management and graceful degradation.

In simple terms the TLC assumes that the highest priority is system availability, with the system/grid operators as the responsible actors. The traffic lights themselves inform the market participants of grid constraints, whereby price and control signals steer market actions. Here the TLC is also a use case itself and not only a general framework.

Note that the TLC will require coordination between system operators at the different levels, e.g. transmission and distribution (TSO and DSO) in order to ensure that these do not perform conflicting actions.

As a framework for thinking it helpfully illuminates a key boundary area, the “yellow” state, whereby the system/grid operators offer market participants the opportunity to deliver system support services (e.g. flexibility). Within the “yellow” state assured available flexibilities are essential for the interaction between market and grid. System/grid operations planning should allow the operator to use flexibility via market solutions or to verify traded flexibilities, where this is more efficient and effective than investing new assets.

However, the red state is not a long-term substitute for necessary grid investment. Finally from a customer perspective it is important to recognize and be sensitive to the fact that customers will not accept, unless incentivized or required by law under grid codes, a wholesale imposition of the situation where a third party (system/grid operator) decides when they can use what is in their home or business.

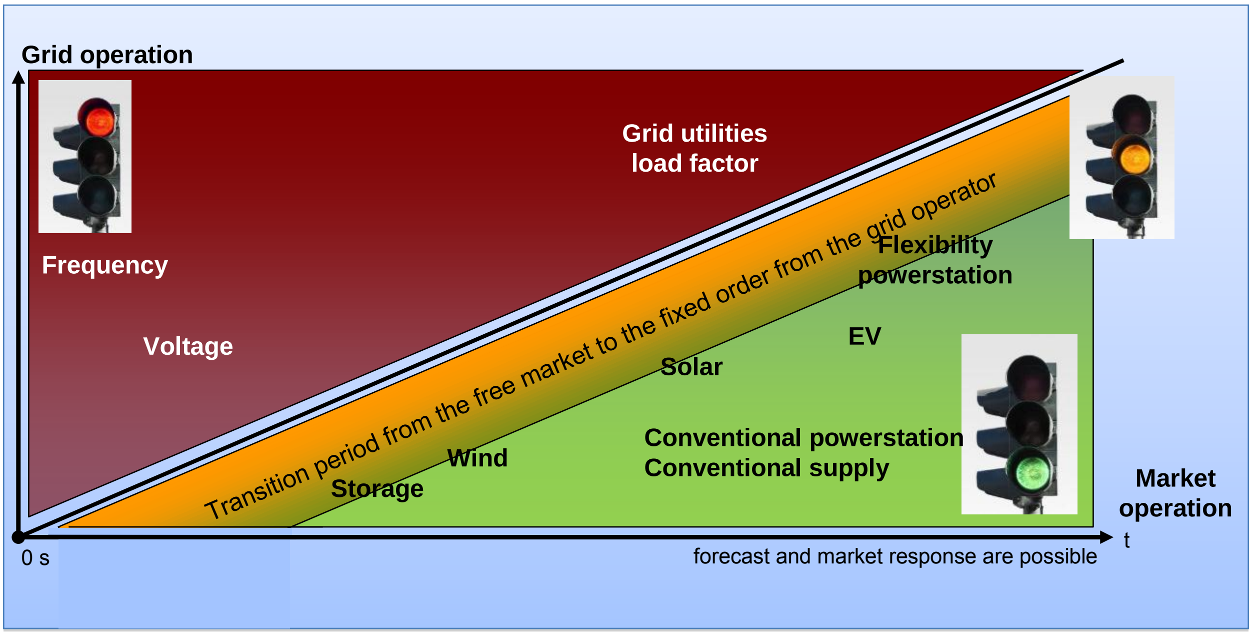

Figure 15: Traffic Light Concept

(Source: German Association of Energy and Water Industries (BDEW))

The original use cases that served as a basis for the Traffic Light Concept are: ENNET-0001 through ENNET-0018, and the use cases described in the ADDRESS project. The German Association of Energy and Water Industries (BDEW) has identified the following use cases:

Table 1: Use cases for the Traffic Light Concept in relation with the tasks of a grid operator

State	Task	Use case(s)
Red (grid)	Grid construction, operation and maintenance	System operations, e.g. maintain grid balance, reduction of grid losses, grid expansion, grid improvement, billing
	Provide system services (WGSP-0100+0200)	Volt/VAr Optimization (VVO), Frequency management, Fault Location, Isolation and Restoration (FLIR), Black start

State	Task	Use case(s)
	Grid monitoring (WGSP-0600, 0301)	Communication infrastructure management, data exchange, determination of network status, energy information network
	Capacity management of supply and demand (WGSP-2300)	Emergency Signals, Load Shedding Plan Selection
Yellow (both)	Third party system services	Voltage optimization, Reactive power, frequency optimization, black start, network losses
	Third party grid monitoring (WGSP-0600)	Communication infrastructure, data exchange, energy information network
	Grid capacity controlled demand management (WGSP-2110+2120)	Grid stability, Customer Energy Management, price incentives.
Green (market)	Energy supply to customers based on predicted usage	'Classical' use case
	Energy supply to customers based on profiles	'Classical' use case
	Energy supply to customers based on meter readings	Flexible tariffs
	Energy (efficiency) services	Service specific use case, e.g. energy usage insight for customers
	Price or control signal-based energy management (WGSP-2110+2120)	Demand-side Management, Demand-Response Management, Load management ((u)CHP, storage), Virtual Power Plants
	Intelligent gateway measurement systems for value-added services	Smart Home solutions
	Management of Smart market communication infrastructure	Operation of cost-effective Smart Grid Infrastructure
	Metering operations	Responsibilities with respect to Metering operations and billing
	Control area balancing	Responsibilities with respect to a Balance responsible party

9 Recommendations on standardization and regulation

9.1 Introduction

This section provides a number of recommendations to standardization and development of regulation, ranging from the implementation of the flexibility operator role to further cases to study. Keep in mind that the topic of flexibility and aggregation is currently (October 2014) under discussion in EG3, which will produce a report on this, including recommendations, at the end of 2014 [EG3 2014]. Therefore this chapter offers an intermediate overview of the recommendations on flexibility management.

9.2 Implementation of flexibility operator market role

The following list of actor interactions with a flexibility operator is not intended to be exhaustive, but instead the descriptions offered here are intended to provide a general overview of the 'flexibility concept' and therefore it is not a legal definition. The suggested market roles and actions include the following and may represent commercial use cases:

- **Energy supplier** - supplying energy to customers and could send different price signals to their customers in order to influence their consumption behavior (e.g. demand response or demand side management).. The customer might use the information and react manually or automatically.
- **Aggregator/Flexibility Operator –** aggregating demand side flexibility and offering this as a service to BRP's, TSO's (balancing) or DSO's (congestion management). In case the flexibility operator holds own balance responsibility, it can also act itself on wholesale markets. It is general accepted that this is a market role (see also the EG3 documents [EG3 2014]), however DSO's could facilitate this market role with supporting services.
- **DSO -** is interested in services which help to mitigate grid constraints and maintain power quality. In the case where they either have direct contract to control a customer's load or have contracted with an aggregator/flexibility operator, the DSO will send command signals based on legal or contractual preconditions. The reaction of the customer might be fiscal (i.e. paid for) according to these pre-conditions, but there might also be mandatory legal requirements (especially for a Feed-In Management of distributed generation) with or without revenue.
- **Agent, Energy Servicing Companies** is likely to provide energy management tasks in the name of the customer(s): e.g. negotiating congestion management, reaction on tariffs.

Currently the barriers for end customers and /or aggregators participating in existing markets are high. Therefore, in order to incentivize greater demand side participation, classical DSM concepts provided by the energy supplier should be complemented by additional concepts in a new market design which close the gap between the small ratings of the individual flexibilities and the market places (refer to [SG-CG/E] for detailed use cases). This may require new or modified standards and specifications to support this in a level playing field. The recommendation is to investigate this.

9.3 Relationship between standards and codes for the Traffic Light Concept

A clear open issue is the agreement on the information that needs to be exchanged between market parties and the grid operator in case of congestion in order to apply flexibility management on the scale of the entire European Union. As per the traffic light concept described in 8.6, these interactions may differ depending on the 'state the system is in'. A coordinated effort between standardization and European / national code development is required.

Moreover, the 'green, yellow and red' states need a clear definition from a regulatory perspective. In that process special attention has to be placed on the prevention of state transitions that might trigger cascading bulk reactions in changes of supply or demand (e.g. like the "50,2 Hz Problem" in Germany). Also regulatory directives (in a mediator role) should be developed on how often and how long the yellow & red state may occur (since there will be a conflict of interests between DSO/TSO's and commercial market parties here).

Overall these actions are geared to form a basis for regulation and legislation that define the allowed interaction between grid operators and markets. Possibly this may differ per member state, but a uniform regulatory framework across the union should be strived for.

Therefore the recommendation is to implement the (BDEW) Traffic Light Concept in a uniform regulatory framework, i.e. define the red, yellow and green states, the information exchange between actors in the different states, how often the red and yellow states may occur, and the duties and rights of each actor in the different states.

9.4 Moving towards a 'smarter energy' future

The drivers behind the shift towards a smarter energy future are well known, however, in light of the expected shift to electric mobility, the electrification of domestic heating and the integration of intermittent renewables and DERs, the important role of flexibility operators in supporting system availability becomes even more pronounced.

Within the TLC the role of the flexibility operator has been suggested as acting towards both new and existing markets. These complex market interactions are not in the focus of this report, but again the TLC can provide a useful framework for exploring use cases:

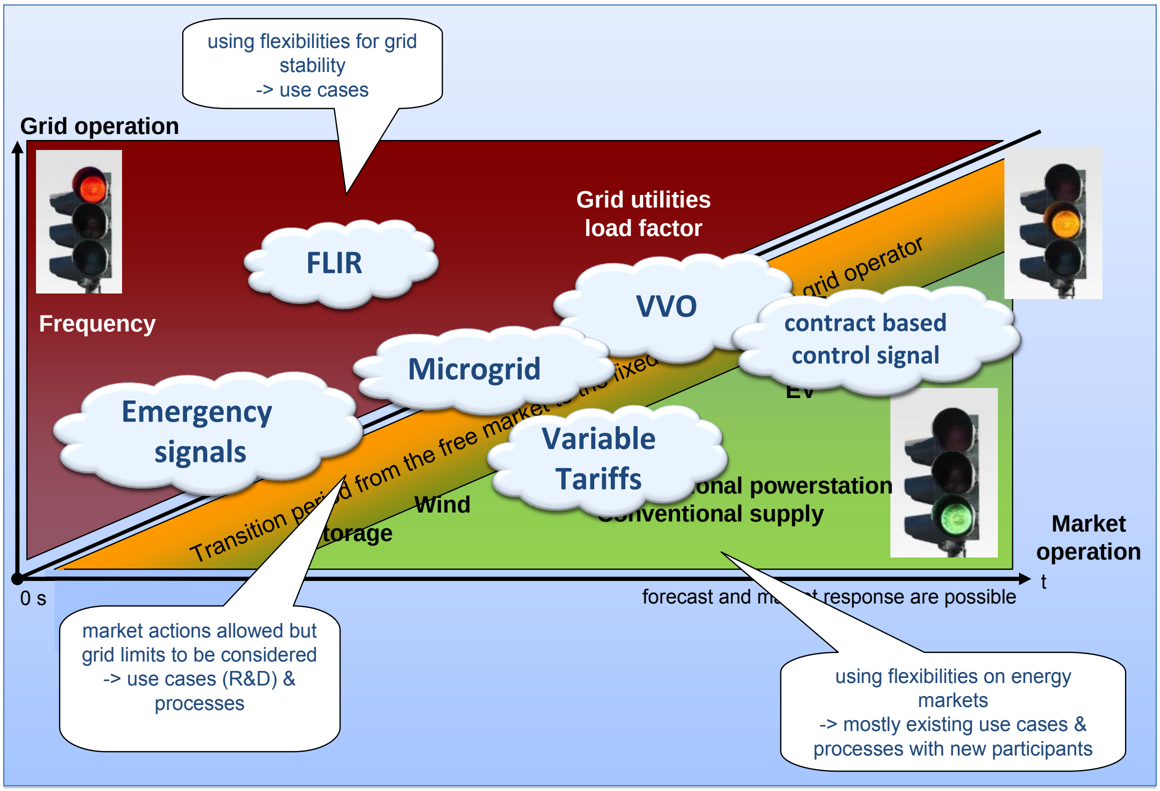

Figure 16 – Traffic light concept and use cases

Current, complex markets are not described in details within this sub-chapter as they are mature and use cases in this area are not part of the Smart Grid Mandate M/490 (refer to [SG-CG/E]). Nevertheless, it is worth emphasizing that a number of possibilities exist with respect to future market designs and energy related products influencing flexibility use cases and related ICT interfaces.

Today markets are realized mainly on a transmission level (control areas with balancing authorities, wholesale markets such as EPEX and EEX[6]). Participation is only possible for market participants who provide a large volume of energy (several MW, but decreasing currently) and which have passed a prequalification. These wholesale markets will continue as set out in the third package and the relevant grid codes. In this future world the Smart Grid Connection Point will represent the critical interface/boundary between the **use** of flexibility by the grid and/or market and the **provision** of flexibility. The Smart Grid Connection Point (SGCP) is discussed in more detail in chapter 8.2 and [SG-CG/E]. It is recommended to take this for further study.

9.5 Recommendations from commercial / grid area

The transformation of the energy system towards a lower carbon, smarter system brings about a number of practical and technical challenges and thus requires more sophisticated and responsive approaches to communication. This brings with it the need for interoperable standards to promote a consistent approach to interfacing and integrating with current and future actors within the smart market. However, in acknowledging the need to follow such a direction, regional variation in legislation, such as national grid connection rules and network codes will need to be carefully considered within standardization processes. In particular relevant is the Demand Connection Code, which includes a set of Demand Response related System Reserve Categories [DCC 2012].

Therefore, a clear need exists for clear co-ordination and alignment between work being undertaken by regulation and in the area of network codes. Important linkages exist between the elements of market model design, network codes and standardization which could be identified, collated and acted upon via a common expert group focusing on the development of market use cases which can help to direct standardization activities within this field. The recommendation is to better connect the world in which the standards are developed with the world in which the market models are designed.

Although there are very different market models in the EU, discussions should take place to see if there is the possibility for a limited generic set of use case. In addition it is recommended that it should be discussed and analyzed, if certain technical architectures and innovations (e.g. like Trusted Computing) which are outlined in the Smart Grid Information Security report in the context of privacy could help to support the continuous evolution and innovation in energy markets.

The problem for different price systems is that the same semantics should apply in order to maintain interoperability. On one hand it is expected that the energy suppliers are as innovative and competitive as possible in the liberalized market, inventing new “products” (tariffs, energy supply schemes, CO_2 emission reduction optimization, special energy service contracts, etc.) for energy supply which might include flexibility concepts. On the other hand standardized interfaces are required so that all participating market partners (particularly the CEM and smart devices) automatically understand any new tariff schemes or prices. These tariff arrangements should be as flexible as possible within practical limits.

However, it is important to note the need from appliance manufacturers for standardized arrangements so as to ensure participation and interoperability within a smart market context, thus avoiding an appliance being stranded or ‘losing its smartness’ upon a ‘change of supplier’ scenario, or system/smart meter upgrade, or change of geographic location. Use cases can play an important role in engaging diverse groups of stakeholders around the need to encourage interoperability and in helping to define suitable standardized arrangements.

Following the considerations in section 7.2 on the customer, confidentiality of data needs to be a top priority and is the basis for confidence of the consumer on the market. This should be reflected in all market designs, network codes and standards. It is recommended to take the above described topics for further investigations.

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[6] EPEX European Power Exchange http://www.epexspot.com/en/; EEX European Energy Exchange AG http://www.eex.com/en/

9.6 Open issues still under discussion

The following key issues have been captured and remain under discussion at the time of writing this report. However, their implications are worthy of consideration and are explored briefly within this sub-section.

9.6.1 Considerations of technical limitations in the grid

A number of the use cases provided encouraged the careful consideration of the spectrum of possible violations of technical limitations or power quality at both local / regional level (e.g. overload of lines during "happy hour" prices). Although it was also suggested that market design should be based on the principle that large liquid wholesale energy markets are efficient and that balancing and grid constraints etc. are strictly imposed from the beginning which then create other markets for services such as the case in the Smart Grid and smart market. In order to promote efficient investment in the systems enabling flexibility it is important for flexibility operators to be allowed to access multiple markets. It was also suggested that the rules governing these interactions need to be clear. Therefore a variety of different use cases for congestion or capacity management / markets have been suggested:

9.6.1.1 Distinction of market / price processes and technical limitations

Flexibility use cases can be split into both commercial and technical. However, the question of whether flexibilities can be offered to different markets simultaneously and how use cases can help bring clarity to the range of possible interactions with different markets is one which need to be clarified further and perhaps discussed via an expert group (e.g. by different time scales, level of priority). As of this writing, this is subject of study in EG3 [EG3 2014].

9.6.1.2 Combined consideration of commercial activities and technical limitations

A number of the use cases provided suggested that this issue needs to be differentiated based on the products which will be merchandized: e.g. wholesale market – no location considered, special ancillary services – geographical information of the products offered needs to be considered.

The following description (provided by [ADDRESS-1], [ADRESS-2]) represents one such example of a use case that had been described in similar ways in several use cases:

After the market gate closure, the aggregators [or flexibility operators] send their Active Demand (AD) [flexibility] program to the DSO. The DSO verifies the technical feasibility of the AD program on the distribution grid. If the amount of power involved is significant, the DSO aggregates the distribution network situation at the connection point with the TSO and sends this situation to the TSO for verification. TSO verifies the technical feasibility of the AD program on the transmission grid. The assessment is basically made by means of a load-flow calculation, carried out taking into account both the AD actions and the scheduled/ forecasted operation of the grid.

If the assessment results in the violation of some constraints in the network, the system operator (SO), i.e. either the DSO or the TSO depending on the case, will first look for a possible solution that it has at its hand. If the SO cannot find such solution, then it will determine "curtailment" factors for the AD actions that cause the violations. The curtailment factors are determined so as to minimize the curtailment of the traded AD products.

At the end of the technical verification process the DSO sends to the aggregation function [SG-CG/SP: flexibility operator]: either an acceptance signal, if the foreseen AD actions can be fully carried out, or a curtailment factor, so that the aggregator can take the appropriate measures regarding its AD program.

Additionally, the establishment of transparent rules allowing a fair market is also of high importance. For example, competition rules shall be established and adhered to, e.g. to make sure that the grid operator cannot take advantage of the information it has.

Furthermore, the use of flexibilities on the grid needs to be implemented by taking the global maximization of welfare into account [EG3 2014]. For example this could mean that, if the DSO can use some flexibilities to manage their own grid, the DSO shall bear the cost of the flexibilities they are activating. Therefore, ad hoc information needs to be exchanged between DSOs and TSOs to ensure the safety of operation before activation, e.g. as specified in the draft of the LFCR code (the network code on Load Frequency Control and Reserves). In Europe, according to the draft of balancing network codes, the activation of the flexibility bids shall be done by the TSO.

9.6.2 Many concepts for commercial use cases still remain under R&D

An additional issue requiring consideration is the fact that a number of commercial use cases still remain at the R&D stage.

9.6.2.1 Concept of micro grids

One such example is the concept of ‘micro-grids’ (refer to WGSP-0400). A CEM or the flexibility operator system might act also as a microgrid which may operate in islanding mode. In this case the flexibility operator also has to provide some of the functionalities of a local grid operator in cases of islanding mode and to balance load and generation. In this sense the flexibility operator role is only a part of a microgrid operator.

9.6.2.2 Cellular structure (R&D project “moma” / E-Energy as example)

Another future example is the case of where the flexibility operator may be a local cell which interacts also with the neighbor cells (other flexibility operators) in order to balance regional/local supply and demand. However, it is worth noting that this is not currently the case within certain market’s regulatory regimes. Various neighbor cells may implement some kind of swarm intelligence acting as a group by means of decentralized automation, just supervised by central control. One possible case of direct control of a large number of DERs and smart customers could be new decentralized automation concepts.

9.6.3 Further key considerations relating to system stability and political framework

A great deal of R&D is on-going in this field. First results from R&D projects are presented in the use cases collection which are also presented as a basis for discussion. Nevertheless, several open questions still need to be verified or even evaluated and tested, for example:

9.6.3.1 Stability

Several measures to stabilize the grid are working together. In the past, the task of maintaining system balance was controlled due to the system inherent stability of large generation units and a well-defined set of control and recovery actions. Power control like primary, secondary and tertiary controls is clearly differentiated by the respective time constants.

As discussed, in the future control of the grid will require to rely more heavily on statistical and probabilistic measures due in part to the expected proliferation of small embedded generation units which may cause system instability within specific parts of the network. To manage such challenges certain actions may be required to be taken in parallel and increasingly involving lower voltage levels which more closely involve the demand side. As the system can be considered as a control loop, stability functions will need to be defined. However, whilst the proliferation of DERs present system challenges, in certain instances it may be more economic in the future for DSOs to procure services from a competitive market based on management of DERs from operators in the market, respecting the physical boundaries of the energy system.

9.6.3.2 Political framework

It is also important to note that a number of legislative initiatives are in progress such as those which focus on the definition of legal frameworks for initiating first steps towards a Smart Grid: national and European grid codes, national laws, and regulations. These will directly influence business cases and related use cases - also for a flexibility use / demand response.

EXAMPLES: feed-in tariffs, legal obligation to provide services or to change supply patterns.

9.7 Recommended flexibility management case studies for further study

There are currently a wide range of activities on Flexibility Management pilots in the EU member states, mostly related to smart grids as listed in [CEER 13] and the table below.

Table 2: Flexibility management case studies

Member State	Nature of pilot(s)	Links/fuller description
Austria	Smart Grids, Smart Meter	Smart grids play an important role in making a successful transition to sustainable energy. The Smart Grids Model Region Salzburg (SGMS) shows how intelligent electricity networks can look like in practice through comprehensive research activities and demonstrations. In applying the philosophy that "the whole is more than the sum of its parts", SGMS has endeavoured to combine the findings of the numerous individual projects into a systematic whole: Smart Infrastructure Salzburg. www.smartgridsalzburg.at (available in English)
Belgium	Smart Grids	www.linear-smartgrid.be/?q=en The pilot by the DSOs: http://www.eandis.be/eandis/pdf/21120E3.DOC_DataId_8789831_Version_1.pdf
Cyprus	Smart Grids	Net metering with the use of Photovoltaic systems with smart meters.
Denmark	DSF	Time differentiated tariffs and/or agreements on regulation of large companies. http://www.dongenergy-distribution.dk/SiteCollectionDocuments/eFlex/The%20eFlex%20Project-low.pdf http://www.dongenergy.com/en/innovation/developing/pages/eflex.aspx
Great Britain	Energy Demand Research (consumer behaviour) and the Low Carbon Network Fund	www.ofgem.gov.uk/Sustainability/EDRP/Pages/EDRP.aspx Energy Networks Association Portal (containing details of the LCNF and IFI projects): http://www.ena-eng.org/smarter-networks/index.aspx
Greece	Smart metering	A new pilot project for the installation and monitoring of 160.000 smart meters will be initiated shortly (the Bidding Documents are currently under public consultation) by the Greek DSO, aiming at investigating the benefits of large scale introduction of smart metering. http://www.deddie.gr/Default.aspx?id=60970&nt=18&lang=2
Hungary	Smart metering	Pilot including multi-utility smart metering, please see [CEER 13] for more details.

Member State	Nature of pilot(s)	Links/fuller description
Ireland	Demand-side Units Smart meters	Smart Grid concepts are the key area of interest for the System Operators in terms of demonstration projects. This could include Demand side management concepts, System Operation including advanced voltage control at transmission level, System Services e.g. reserve provision, Transmission technology types e.g. dynamic line rating http://www.eirgrid.com/operations/demonstrationprojects/
Italy	Smart grids, Electric Vehicles (EV) charging infrastructure, Storage, Multiservice smart meters	Selected smart grids pilots benefit from a 2% extra WACC in addition to the standard rate of return on capital, for 12 years. Pilots on EV recharging infrastructure are open to both DSOs and third parties (charging service providers). Storage pilots include both energy and power storage (see the Status Review of the Implementation of the Guidelines of Good Practice for Storage System Operators as described in the CEER 2013 work programme). More recently the framework to select multiservice smart meters demonstration projects has been defined. [CEER 13]
Norway	Smart Grids the energy system of the future	Three Norwegian pilot projects in smart grid technology aim to connect traditional electricity supply systems with modern ICT systems, thereby taking the first steps towards a smarter energy distribution grid. www.sintef.no/home/SINTEF-Energy-Research/Xergi/Xergi-2012/Artikkel11/ [CEER 13]
Portugal	DSF	The revision of the Tariff Code establishes that the network operators (TSO and DSOs) shall present a study to ERSE on the viability of introducing dynamic tariffs. For example the DSO EDP Distribuição has a pilot test on smart grids called Inovgrid (http://www.edpdistribuicao.pt/pt/rede/InovGrid/Pages/InovGrid.aspx) [CEER 13]
Spain	CNE Smart Grids WG Gad project	This WG was convened by CNE (now CNMC) and gathered representatives from the industry in order to prepare proposals for DSF such as tariff review, price signals, information management and exchange, etc. Government-led project on active and efficient electric consumption management for households http://gad.ite.es/index_en.html [CEER 13]
The Netherlands	Smart grids	PowerMatching City is a living lab demonstration of a future energy system. In PowerMatching City the connected households have smart appliances that match their energy use

Member State	Nature of pilot(s)	Links/fuller description
		in real time, depending on the available (renewable) generation. http://www.agentschapnl.nl/content/factsheets-12-proeftuinen-intelligente-netten-juli-2013 and http://www.powermatchingcity.nl/site/pagina.php
The Netherlands	USGEF (Universal Smart Grid Energy Framework)	The Universal Smart Energy Framework (USEF) provides non-discriminatory access to smart energy systems for all active stakeholders at acceptable cost-to-connect and cost-to-serve levels. The energy framework enables you to seamlessly co-create a fully functional smart energy system and provides an open and consistent framework of specifications, designs and implementation guidelines. http://www.usef.info
Germany	E-Energy	http://www.e-energy.de/en/ Objective is to create an "Internet of Energy". The phrase "E-Energy" was created for this new field of innovations tanding for the comprehensive digital networking and optimization of the energy supply system, encompassing everything from generation and distribution right up to consumption. The project developed methods for more effective utilization of the existing supply infrastructure, expand the use of renewable energy resources and reduce CO_2 emissions in six model regions.

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