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Definition of new Business Models

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Abstract

This document aims at a market assessment and overall preparation of the business aspects for the e-balance system. For this purpose, the added values for each market stakeholders have been recognised. Also, the electricity market has been considered in context of the e-balance system market compatibility. Furthermore, the socio-economic recommendations on how to release the added value to the prosumers and how to leverage the value to the stakeholders have been prepared.

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Executive Summary

Currently, European energy users have become accustomed to the high availability of electricity. Historically, energy production facilities have been centralised due to economies of scale. These large scale centralised power plants benefit from continuous production levels in terms of energy conversion efficiencies. For this reason, it is advantageous for these production facilities to have energy consumption levelled out over the day. A diversification of tariffs throughout the day has historically been used to increase loads during periods which otherwise would have had low amounts of loads.

The rise of a great number of unbuffered decentralised renewable production facilities results in a much more complex combination of supply and demand. This will inevitably lead to challenges in maintaining the balance between supply and demand due to the varying nature of solar irradiation and wind.

This project investigates and implements a secure and interoperable platform called *e-balance* that allows realizing energy balancing and grid resilience services. These services add flexibility in energy exchange to the energy mix as a complementary means to maintain balance between supply and demand of electric energy.

This deliverable of the e-balance project describes the analysis performed on how flexibility in energy exchange can be unlocked from a market and from a social perspective (*Business Aspects of the e-balance system*).

To this end, we looked at every technical component and algorithm developed in the e-balance and determined the added value these components could have for each market role. This is complemented by possible business opportunities and possible services that can be delivered by that particular market role or stakeholder. We have found that the added value can be a lot more than lowering the User's energy bill. Amongst others, energy exchange forecasts can be provided to the market with better knowledge of the User's behaviour than it is currently the case.

As it is important to not only have the technical relations clear between the different market roles, we also provide reward mechanisms for the Distribution System Operator (DSO), Energy Retailer, Aggregator and the End User. We have chosen a system where the Aggregator acts as a Service Provider to the market. Energy exchange flexibility is unlocked via Aggregators. Market parties can hire flexibility through Aggregators. Furthermore, we propose a mixed tariff structure for both the DSO and Energy Retailer. Both the Energy Retailer and the DSO will use a fixed and a flexible tariff. The DSO will indirectly lower the capacity tariff if an Aggregator achieves specific goals, which reduce the operational costs for the DSO. The Energy Retailer can provide lower energy tariffs for those that are contracted by this Energy Retailer and aid an appointed Aggregator achieving the Energy Retailer's goals.

The e-balance consortium has recognised the importance of the stakeholders (SWOT analysis), and especially the User's involvement. Without cooperation, commitment and involvement of the User, there will be no flexibility made available to the market. Therefore, a study has been performed looking into the barriers that can be faced when deploying a system like e-balance. Subsequently, possible mitigation means have been formulated. Furthermore, an overview has been given of possible means and incentives to encourage consumers to become prosumers and get involved in DSM mechanism.

To evaluate the effectiveness of the e-balance system we point out a few countable and precisely defined quantitative indicators as KPIs. They concern to customer comfort and profits, ecological impact, grid stability and cost-efficiency as well as increased grid flexibility in energy exchange. These indicators are very supportive for technical and business aspects preparation and validation in real life.

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Table of Contents

Executive Summary....3
List of authors....4
Table of Contents....5
List of Tables....6
List of Figures....7
Abbreviations....8
1 Introduction....10
1.1 Aim of this study....10
1.2 The European market context....10
1.2.1 Internal energy market mechanisms....11
1.2.2 General rules on the electricity market....11
1.2.3 Data processing and information on the market....13
2 The future energy market: unlocking flexibility in energy exchange....15
2.1 The historical and current situation....15
2.2 The future situation....16
2.2.1 Energy balancing within e-balance using the Triana methodology....17
2.2.2 Bottom-up balancing within e-balance: the household level....17
2.2.3 Influencing the customer's energy exchange....18
2.2.4 e-balance system compatibility with the current market....19
2.2.5 Possible other solutions....20
3 The proposed socio-economic solution....21
3.1 Added value and Business opportunity analysis....21
3.1.1 End users of the energy system – the customers....23
3.1.2 TSO/DSO Subsidiaries....26
3.1.3 Supplemental electricity producers....29
3.1.4 Aggregators....31
3.1.5 The energy retailers....33
3.1.6 Independent Service Providers....35
3.1.7 Regulator....37
3.1.8 IED Manufacturer....38
3.1.9 Government/ local government....39
3.2 Price mechanism analysis....40
3.2.1 The DSO....43
3.2.2 The Energy Retailer....43
3.2.3 The Aggregator....44
3.2.4 The end User of the energy system....44
3.3 The e-balance system ownership....44
3.4 How to engage end users into the e-balance system....45
3.4.1 Barriers for stakeholders and how to mitigate them....46
3.4.2 Users are key for the e-balance success....49
3.4.3 The incentives....50
3.4.4 Business scenario recommendation and the preliminary implementation strategy....53
4 KPIs for measuring effectiveness of the e-balance system....55
4.1 Customer comfort and profits....56
4.2 Ecological KPIs....58
4.3 Grid stability and cost-efficiency....60
4.4 Increased grid flexibility and capacity in energy exchange....62
5 Conclusions....64
REFERENCES....65
APPENDIX A....66

List of Tables

Table 1: Different types of tariffs 16
Table 2: Overview of stakeholder priorities, added value and the business model propositions for the User of the electricity system 24
Table 3: Overview of priorities, added value and business model propositions for the TSO/DSO....27
Table 4: Overview of priorities, added value and business model propositions for the Supplemental Energy Producer 30
Table 5: Overview of priorities, added value and business model propositions for the Aggregator 32
Table 6: Overview of priorities, added value and business model propositions for the Energy Retailer .34
Table 7: Overview of priorities, added value and business model propositions for the Independent Service Provider 36
Table 8: Overview of priorities, added value and business model propositions for the Regulator 37
Table 9: Overview of priorities, added value and business model propositions for IED Manufacturers .38
Table 10: Overview of priorities and added value for the Local and National Government 39
Table 11: Theoverall proposition for the price mechanisms 41
Table 12: Possible barriers for stakeholders and the ways how mitigate them 47
Table 13: How to encourage the users to use the e-balance system 49
Table 14: System of possible incentives 51
Table 15: Methods to support the user on equipping his house – examples 52
Table 16: KPIs – Customer comfort and profits area 57
Table 17: KPIs – Ecological area 59
Table 18: KPIs – Grid stability and cost-efficiency area 61
Table 19: KPIs – Increased grid flexibility and capacity in energy exchange 63
Table 20: For whom and how the e-balance platform will be implemented 66
Table 21: Customers (consumers/prosumers) SWOT analysis 69
Table 22: Energy retailers or aggregators SWOT analysis 70
Table 23: Distribution System Operator (DSO) SWOT analysis 71
Table 24: Microgrid Operator: SWOT 72
Table 25: ICT providers / Appliances vendors / Property owners / BMS provider SWOT 72
Table 26: Municipalities / Regulatory Bodies SWOT 72
Table 27: For whom and how the service: “Grid Control and Monitoring” will be operating 73
Table 28: Customers (consumers/prosumers) SWOT 74
Table 29: Energy retailers or aggregators SWOT 74
Table 30: Distribution System Operator (DSO) SWOT 74
Table 31: Microgrid Operator: SWOT 75
Table 32: ICT providers SWOT 75
Table 33: Municipalities SWOT 75

List of Figures

Figure 1: The electricity system and actors 11
Figure 2: Time scale schedule for current electricity market 12
Figure 3: The retail price (tariff) structure for the end user 13
Figure 4: The aggregator's role – visualization 19
Figure 5: Relationships between stakeholders and the identified locations of added value. Red edges indicate new added value, whereas green indicates existing value 22
Figure 6: Added value enabled by the e-balance system for the User of the energy system (in red) 23
Figure 7: Added value enabled by the e-balance system for the TSO/DSO (in red) 26
Figure 8: Added value enabled by the e-balance system for the Supplemental Energy Producer 29
Figure 9: Added value enabled by the e-balance system for the Aggregator 31
Figure 10: Added value enabled by the e-balance system for the energy Retailer 33
Figure 11: Added value enabled by the e-balance system for the Independent Service Providers 35
Figure 12: Added value enabled by the e-balance system for the Regulator 37
Figure 13: Added value enabled by the e-balance system for IED Manufacturers 38
Figure 14: Added value enabled by the e-balance system for the Local and National Government 39
Figure 15: Flow diagram between main participants – the win-win strategy 43
Figure 16: The e-balance system on the energy market 45
Figure 17: The e-balance Key Performance Indicators 55
Figure 18: Functions for the customer/prosumer in the e-balance system 68
Figure 19: Functions for the DSO\Aggregator in the e-balance system 69

Abbreviations

ACER	the Agency for Cooperation of Energy Regulators
AMI	Advanced Metering Infrastructure
BM	Business Model
BRP	Balancing Responsible Party
TSO/DSO	Transmission System Operator/ Distributed System Operator
CEN	the European Committee for Standardization
CENELEC	the European Committee for Electrotechnical Standardization
CMU	Customer Management Unit
CPP	Critical Peak Pricing
CPR	Critical Peak Rebate
DAM	Day Ahead Market
DAPM	Data Access Party Manager
DER	Distributed Energy Resource
DERMU	Distributed Energy Resource Management Unit
DMU	Device Management Unit
DoW	Description of Work
DSM/ADR	Demand Side Management/ Advanced Demand Response
DSO	Distribution System Operator
Elspot	the energy exchange Nord Pool Spot
EPEX	The European Power Exchange
ESCO	Energy Service Company
ETSI	the European Telecommunications Standards Institute
ETSOE	the European Network Transmission System Operators of Electricity
EV	Electric Vehicle
FIT	Feed in Tariff
FDIR	Fault Detection Isolation and Recovery
ETM	Electricity Target Model
F2F	Face to Face Survey
G2V	Grid to Vehicle
GUI	Graphical user's Interface
H2V	Home to Vehicle
HEMS	Home Energy Management Systems
IED	Intelligent Energy Device
IDM	Intra-Day Market
ICT	Information and Communication Technology
IHD	In Home Display
IoT	Internet of Things

KPI	Key Performance Indicator
LVGMU	Low Voltage Grid Management Unit
MAIFI	The Momentary Average Interruption Frequency Index
MS1	Milestone 1 in the e-balance project
MVGMU	Medium Voltage Grid Management Unit
MVP	Minimum Viable Product for user
NPS	Net Promoter Score
OPEX	Operational Expenditures
QoS	Quality of Supply
PX	Power Exchange
RM	Retail Market
RTP	Real Time Pricing
SAIDI	System Average Interruption Duration Index
SAIFI	The System Average Interruption Frequency Index
SG	Smart Grid
SM	Smart Meter
STM	Short Term Market
SWOT	Strengths, Weakness, Opportunities and Threats analysis
TLGMU	Top Level Grid Management Unit
TSO	Transition System Operator
ToU	Time of Use tariffs
USEF	The Universal Smart Energy Framework (The Netherlands)
V2G	Vehicle to Grid
V2H	Vehicle to Home

1 Introduction

1.1 Aim of this study

This deliverable presents the findings of the e-balance project with respect to the development of possible business models (BM) and business aspects for new services supporting the balancing of energy consumption and production in energy efficient smart neighbourhoods (WP2: Task 2.2).

The aim of the e-balance project is to develop a smart grid platform that supports current and new services in the field of energy balancing, customer data acquisition, customer interaction, energy exchange flexibility and grid resilience.

The proposed ICT platform will be a fractal-like system which can increase the flexibility of energy exchange in the grid and optimise operational costs on the electricity market.

In this context, the business aspects analysis presented in this report ***identifies how all stakeholders: existing energy supply companies, energy distribution companies, aggregators, prosumers, consumers and other market participants could capture added value from the innovations in the (local) balancing of energy consumption and production on the current electricity market.***

This preliminary analysis is continued and will be evaluated in Task 2.4: Validation of the proposed Use Cases and Business Models.

1.2 The European market context

Nowadays, the European energy exchange markets are transforming into a fully integrated chain that will allow exchange of energy within the interconnection capacity limits in a bidirectional way in the entire European system. The electricity sector in the European Union should respect the principle of sustainable development. This is acknowledged by the widespread integration and support of renewable energy sources in order to increase energy efficiency and to decrease energy generation and distribution costs. Many new technologies such as roof top solar and PV panels, energy storage systems, e-vehicles, smart sensors etc. have been connected to the grid. Small energy users are becoming prosumers and are expected to actively participate in the future energy market. Thus, distribution of energy in European countries needs to be modernized and transformed by facilitating bidirectional power flows and maximising the flexibility in energy exchange that customers can provide.

The expected large number of Distributed Energy Resources (DER) connected to the Low Voltage (LV) and to the Medium Voltage (MV) grids, will cause an increasingly higher amount of mismatch between the time and location of production and consumption of energy. The majority of today's grids were designed with centralized production in mind and the possibility of a huge integration of DER was not considered. Without any changes in design policies, significant grid reinforcements will be required, resulting in capital intensive investments.

The e-balance system provides the possibility of time shifting loads and generation on a local level and thus decreasing the future costs of imbalance directly in the LV and MV grids. By utilizing the unlocked flexibility in local demand and supply, both technical grid related phenomena can be mitigated, e.g., peak shaving, as well as market related requirements can be facilitated, e.g., compensation of reduced production. The energy balancing service and unlocked flexibility, grid capacity optimization, customer data and its analysis can all be given as services.

The system will also monitor Quality of Supply (QoS), perform fault detection, location, isolation and restoration (FDIR) and flow recognition and monitoring (grid monitoring and control service) in the local grid controlled by DSO. Since the e-balance system will be fractal-like, it can be applied on every level in the hierarchical electricity system and scale accordingly.

Many European organizations and committees highlight these aspects of grid transformation and goals in their documents [1]-[4].

1.2.1 Internal energy market mechanisms

The creation of an Internal Energy Market (IEM) is one of the main challenges in the European energy sector nowadays. European agencies like The Agency for Cooperation of Energy Regulators (ACER) and The European Network of Transmission System Operators for Electricity (ETSOE) are responsible for preparing harmonization processes and working out guidelines with lists of recommendations for market coupling and the EU wide cross zonal approach for capacity allocation. It may help in creating a common Electricity Target Model (ETM) and network code documents. The goal of the ETM is to prepare market integration for a single Day Ahead Market (DAM) coupling, a single Intra Day Market (IDM) coupling[1] and methods to eliminate the cross border barriers to market integration.[2] In fact, efforts towards the IEM were started many years ago and were expected to be finished soon, however, this process is still not completed.

1.2.2 General rules on the electricity market

The main structure of the current electricity market in most countries is presented in Figure 1. Electricity generated at power plants (energy producers) is frequently bought and sold in the wholesale market before reaching the final users through the retail market. The final users can be: residential and industrial customers and also prosumers who not only consume but also produce energy for their own needs and can deliver energy to the grid also. The wholesale market consists of The Derivatives Market, Bilateral Market, the Day Ahead (DAM), Intra Day (IDM) and Balancing (BM) Markets. The derivatives market and bilateral market are long term transactions markets where the participants (on the wholesale market) can protect their energy purchase in long term.

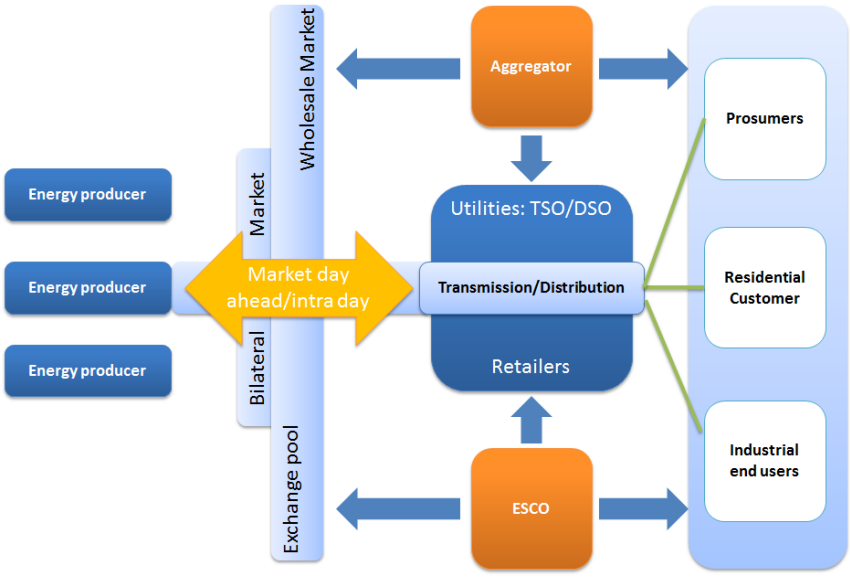

Figure 1: The electricity system and actors

Currently, the Day Ahead Market (DAM) is a market where bids have a form of spot contracts submitted to the Power Exchange (PX) for the following day. DAM market participants consist of scheduling coordinators and wholesale trade entrepreneurs. The goal is to ensure a transparent market price formation by clearing demand and supply curves in order to optimize the social welfare and generation costs. The spot transactions are made for each hour or half an hour of the next day (H1-H24) by submitting bids in energy capacity and price.

[1] Market coupling - The target model for the Day-Ahead and Intra-Day timeframe is a European Price Coupling (EPC) which simultaneously determines volumes and prices in all relevant zones, based on the marginal pricing principle.

[2] Infrastructure for cross-border electricity exchanges is increasingly a bottleneck. The administrative, political and physical barriers to cross-border electricity exchanges still exist.

The DAM has a fixed time flow each day:

1. Offers are delivered between 7 to 11 a.m. the day before the day of implementation.
2. In most cases, e.g., Elspot and EPEX spot market, trading is closed at noon. Between 12 a.m. and 1 p.m. The prices are calculated and after 1 p.m. The trades are invoiced between sellers and buyers.
3. Execution plans are ultimately prepared by 4 p.m. the day before the day of implementation.
4. Technical validation of the plans and re-planning if required.

Currently, the continuous market or Intra Day Market (IDM) is an energy market for energy sale/purchase during the day of delivery. It is used to adjust the schedule obtained from the DAM settlement before real time operation. It is the market where currently the Balance Responsible Party is responsible for this trade segment. It is carried out continuously, both day before (after gate closure) and on the day of the contract execution according to the specific short term schedule. In the "day n-1 market" (the previous day) market participants can submit bids for every hour of the next day, and during the current "day n", participants can submit bids for every 15 minutes (e.g., in Germany and Austria) or every hour, on smaller time intervals (e.g., 45 min. or 1 h) ahead the execution. The price signal of 15-minute contracts contributes to the added value of flexibility and provides at the same time incentives for system stabilization. Figure 2 illustrates the time schedule of the current electricity market.

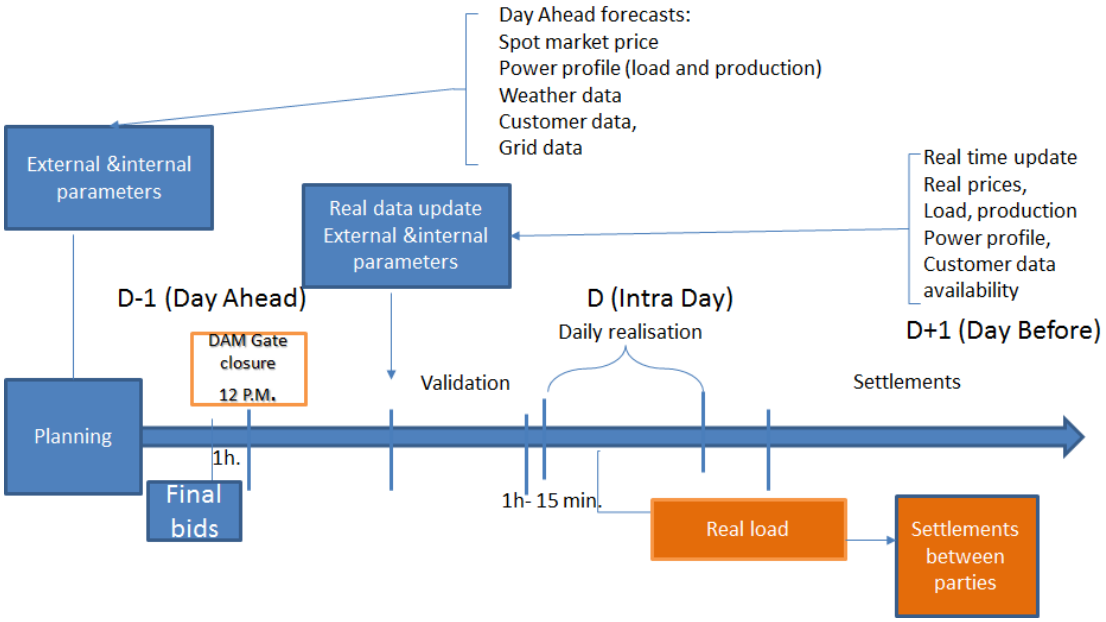

Figure 2: Time scale schedule for current electricity market

The Balancing Market (BM) includes all decisions and operations from intraday "gate closure" to real time operation. The Technical System Operator takes final responsibility for BM as well as for the technical balance in near to real time operation. He has the ability to use available offers for technical reserves and ancillary services, as well as Demand Side Management/ Demand Response (DSM/DR) programs to compensate eventual technical constraints of the electric grid through the use of these offers. The prices for the electricity which compensates the imbalance on BM are the highest.

The Retail Market (RM) is a market where the energy retailers sell and buy electricity to and from end users (residential, commercial and industrial users). Currently, in several countries in Europe, retailers are obliged to buy energy from small prosumers that is fed back to the grid. This means that administratively, the retailer adds this energy to its energy mix portfolio. Each residential end user has a contract for an energy delivery service and energy supply. In case of small consumers, the method of determining the usage profile differs from country to country. For example, in the Netherlands, a generic market profile is used by the entire sector, based on the tariff choice (single or double) and the connection capacity. In Poland, the profile is adapted twice a year according to an individually prepared profile of usage, prepared by retailers. The tariffs for the energy are prepared by retailers as well. These

can be shaped as two or three zonal prices, depending on seasons or night/day time. The customers can freely choose their electricity retailer and they make separate contracts with their DSO and retailer.

Through the tariff, the residential users also pay for grid services. In most countries these components are regulated by national regulators. It means that the DSO can utilise a fixed capacity tariff at the account of the capacity reserved for each connection on the electricity grid. In the Netherlands, small consumers no longer see a direct fee for transport losses on their energy bill. Herein, energy losses of the entire grid are divided equally to all customers in the operator's area operation (distribution grid service charge)[3]. Figure 3 gives an overview of the retail tariff structure for the end User. (Other tariff's components like subsidies, incentives are not included on this picture).

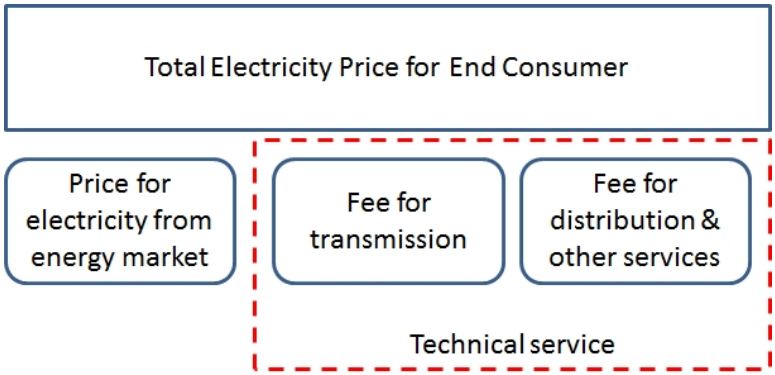

Figure 3: The retail price (tariff) structure for the end user

The prosumers – the end users who also produce the energy from their own sources can sell the produced energy to the retailers. Retailers have a duty to buy each portion of energy provided to the grid which is regulated by law in many countries. This causes a high volatility of the energy exchanged via the grid, since production is firmly dependent on the weather condition: wind (wind mills) or sun (PVs). In case of sunny or windy days a huge surplus of energy may be provided to the grid; meanwhile in other days the renewable energy is insufficient. Nonetheless, this intermittent generation is promoted in European countries by feed in tariffs (FIT) policies, net metering, auctions and green certification systems.

In some countries it is more profitable to sell the produced energy to the energy retailers than use it for its own needs[4]. The current situation in Germany, which has the highest penetration of PVs in EU, shows that an excess of the energy injected in the grid sometimes causes spot prices on the PX to fall drastically[5].

1.2.3 Data processing and information on the market

European Smart Grids Task Force - Expert Group 3 (TF EG3) has developed a market reference model exploiting the synergies with the data processing and all electricity market actors. They worked out three possible cases of SG data handling models [5].

The mentioned models are depending on the smart meter (SM) development and are as follows:

- The DSO operates as a market facilitator and is the sole owner of consumption data.
- One third party market facilitator operates as an Independent Central Data Operator (Hub). It manages all data on the market.
- Multiple third party market facilitators operate as Data Access Point Managers (DAPM) for full decentralized and dynamic market system.

[3] https://www.acm.nl/nl/publicaties/publicatie/14379/Tarievencode-Elektriciteit/ available: [07.2015]

[4] 1). *European Energy Review*, 5 July 2012, See more at: http://www.brunoleoni.it/nextpage.aspx?codice=11679 [available: 07.2015]

2). Dąbrowski J., Hutnik E., Profitability Analysis of Energy Production from a Micro Installation of Renewable Energy in a Residential Buildings, Rynek Energii Journal 3/2015 ISSN 1425-5960 p. 102-108

[5] https://www.eex.com; historical data published in 2013 about energy price in Dec., 2012; http://www.forbes.pl/ujemne-ceny-energii-w-niemczech,artykuly,136560,1,1.html available 07. 2015

DSO as a market facilitator - In this model, the DSO is the unique agent responsible for all his sub-processes. The DSO can be responsible for metering, although this can also be assigned to dedicated metering companies. The DSO is the owner of meters and the corresponding data. The DSO acts as a data provider for the retailers during the switching processes allowing both new and old suppliers to exchange information efficiently. The DSO acts neutrally towards all market parties. The data provided should be completely secure and certified. The DSO has the technical infrastructure as well as the data hubs and is an enabler of new value-added services. This model is implemented in the Netherlands and partly in Portugal for example.

Independent Central Data Operator (Hub) – It consists of an independent central communication platform, which is a new actor on the market. This platform is based on one or several hubs which will interact with different SG stakeholders. The key functions of this platform are access control, receiving data from different parties and delivering it to the authorized parties. This model is implemented, for instance, in: GB, Italy, Denmark and Poland (in the first stage). In some countries, meters are outside the responsibility of the DSO. The Independent Data Operator is responsible for meters and meter readings.

Data Access Point Manager (DAPM) - It can be a commercial role played by certified companies which act as data gate keepers providing data access to any certified market players and consumers/prosumers. As a consequence, a suitable mechanism for handling the information and functionalities from a wide range of new and existing devices connected to the grid is required. The mechanism should allow connections, disconnections, update and localization of any devices in the network. It enables the activation of different actors to retrieve data directly from the meter without asking a regulated third party to deliver the data. Only the consumer and DAPM are aware of the full set of the data that actors retrieve. DAPM is responsible for clearings between suppliers and DSO. In this model there will be an opportunity to develop business cases and demand side programs based mainly on the integration of resources such as EVs, appliances, solar power and smart devices. Elements of the DAPM are already in use in Great Britain and Germany.

These different types of data handling models in Europe should have a common goal: to keep, send, share, process and interpret all energy market data and users' data in secure and non-discriminatory way to these market players who are authorized to use it.

2 The future energy market: unlocking flexibility in energy exchange

Currently, European energy users have become accustomed to the high availability of electricity. Energy grids are highly reliable and the availability of electricity is regarded almost as natural as the air we breathe. Historically, energy production facilities have been centralised due to economies of scale. These large scale centralised power plants benefit from continuous production levels in terms of energy conversion efficiencies and energy losses. Furthermore, the transport and distribution of electricity via electric grids also benefits from a more levelled out utilisation.

2.1 The historical and current situation

Due to technical limitations and the clear top down structure of the energy supply, a limited amount of time dependent tariffs have been introduced. The exact granularity of these tariffs usually differs per supplier / region / country. Depending on the nature of the energy demand and the production facilities, the tariff structure has been adapted, often not exceeding two or three different tariffs for example, a peak, regular and valley energy tariff. This differentiation is a simple and effective way of influencing behaviour and even industrial or corporate systems. Now also the real time pricing is tested in different pilots and countries. The end users should learn how to behave in each situation (e.g. energy use or load shifting) when they are informed in near real time about differences between energy prices during the day. The most common time dependent tariffs are given and briefly analysed in Table 1.

Table 1: Different types of tariffs

	ToU – time of use pricing	RTP- real time pricing	CPP – critical peak pricing	CPR – critical peak rebate
Goal	Change routine behaviour	Adapt consumption to external data (spot prices, prognoses, excess power from RES)	Reduce critical peak demand (in case of grid overload)	Increase demand when electricity is abundant (from RES)
Cost components	Energy and grid service (distribution and transmission)	Energy and grid service (distribution and transmission)	Energy and grid service (distribution and transmission)	Energy and grid service (distribution and transmission)
Number of time blocks per day	Limited 3-6	24 (hourly) or 96 (quarterly)	Prepared only for using when critical situation will happen	Prepared only for using when critical situation will happen
Price update frequency	Weekly or monthly reflecting average cost of energy	Daily, reflecting daily system costs from wholesale market	Can be changed irregular. It depends on the agreement's condition and law	Can be changed irregular. It depends on the agreement's condition and law
Type/duration	Weekly/monthly	Daily	When peak time/shortly	When peak time/shortly
Occurrence	Varying time resolutions: from 30 minutes to multi hours, day/night and seasons changing. It can be combined with CPP or CPR tariffs.	Real time changing	Is used a few times a year. It can be combined with ToU tariff.	Is used a few times a year. It can be combined with ToU tariff
Price spread	Prices in peak hours are 2-4 times higher than in off peak hours(*)	Depend on external situation of market.	Prices in peak hours are 6-8 times higher than in off peak hours	Prices in peak hours are 6-8 times higher than in off peak hours
Applicable to cost components	Generation T&D	Generation T&D	Generation T&D	Generation T&D

* *Source*: on the base of consumers test results in Poland 2013- 2014 (http://www.energa-operator.pl/25243.xml) [available: 07.2015].

2.2 The future situation

The large scale development of renewable resources like windmills and PVs introduces a higher volatility in the production levels of electricity as well as a much less smooth power distribution in time. Furthermore, the very nature of these resources allows a much more decentralised approach to production. This enables all energy end users to become also electricity producers. If production levels of these renewable sources increase further and further, the balance of supply and demand will be increasingly challenging. This is mainly caused by the limited technical flexibility of large centralised power plants and the large investment needed for energy grid expansions that would allow the accommodation of increasing levels of renewables. Additional means to maintain balance on the electricity grid are thus welcome.

A smart grid system, like the one the e-balance project proposes (the *e-balance system*), fully enables to utilize those part of the energy market which can be resulted by energy exchange behaviour of end-users. There are many different approaches to unlocking flexibility in energy exchange. For example, the next step from two or three tariffs, is providing a price (incentive) vector comprising many time steps. Instead of two or three distinct tariffs, users will now receive a much more grained signal indicating subtle changes on timescales of 15 minutes or less. This is also referred to as RTP (Table 1). Furthermore, influencing the user behaviour can be done pro-actively. There are several ways to interact

with customers and convey this information for their acknowledgement and behavioural change. The user can have an energy in-home display, requiring people to consider a tariff or incentive vector before they turn on energy intensive devices. Another approach is to use a much higher level of automation, attempting to reduce the mental burden or interaction with control systems of the end-user. The e-balance approach is one of the latter. With an automated system, power consumption and generation profiles need to be generated with decisions made based on these profiles. This information can be used for all kinds of scheduling methods and smart grid solutions. This area of consumption and production forecasting will be crucial for planning and balancing optimisations.

2.2.1 Energy balancing within e-balance using the Triana methodology

The University of Twente has developed a set of algorithms which together are named "Triana". Triana is a means to balance consumption and production in a fractal manner, using a fast iterative approach. The Triana method is chosen by the e-balance consortium as the approach to balance the electricity system. It is centred around the "desirable power profiles". Each hierarchical level tries to achieve the "desired power profile" by asking the level below to change its own desired power profiles to match the one of the higher level. In case the desired power profile cannot be obtained, an imbalance between the desired behaviour and the expected behaviour will arise. This imbalance will be displaced to the next hierarchy level, which will try to resolve this imbalance with its other subordinates. We can here thus distinguish between the actual overall imbalance between production and consumption and the location where we want to achieve balance. A more detailed description is provided in deliverable D5.2 of this project.

For example, to avoid grid failure in a weaker part of the grid, the desired power profile of that section of the grid can be adjusted, so that all technical limits are respected. Another option is to set all desired power profiles to "zero" by default and enforcing it, effectively forcing self-supporting local or regional areas if consumption, production and possibly storage options are sufficient. This could also increase self-consumption.

If we want to replace the current balancing system within the Dutch market for example, we can envision scaling up the e-balance system from the end-user level all the way up to the national (single TSO) level. The TSO will enforce the "flat" power profile at the highest level. In case no flexibility at the end users exists, every end user's profile will be aggregated on each level and the technical power imbalance will become apparent at the top level. It is there where the centralised power plants will aid in correcting the imbalance, via the hierarchy of the e-balance system.

Of course, the assumption is that there *will* be flexibility at the end users and new decentralised production facilities or any other asset that provides flexibility. Assuming a nationally operating system, this aggregated imbalance will be communicated back and forth through the hierarchy, unlocking the necessary flexibility in all the existing levels. It is important to realise that, in this scenario, the incumbent centralised electricity production facilities are also considered to be a user of the grid, participating in the balancing scheme. In order to assure renewable priority, a merit order system should be designed or incorporated one way or another into the balancing system. This is out of scope of the project as the project focusses on the part of the grid that falls under the control of the DSO.

2.2.2 Bottom-up balancing within e-balance: the household level

In order to decide how much flexibility is available at a household, or in other words, how much power consumption can be reduced, increased or displaced in time, a (local) schedule of some kind has to be constructed, indicating which devices or aggregated loads will be active at which time. Furthermore, it needs to be taken into account which constraints are present for which load. For example, an electric vehicle needs to be charged enough to be able to make a certain trip, and a washing machine needs to be finished before a certain point in time to be able to use or dry the clothes. These constraints are usually comfort related.

In order to be able to provide flexibility in energy exchange, the user's behaviour has to be steered and/ or the user's devices should be capable of being controlled. Within e-balance we make use of Intelligent Energy Devices (IEDs) that can communicate their expected energy usage in the form of power profiles. In other words, they transmit their time dependent behaviour with respect to electricity consumption. Of course, not all devices will be IEDs. Hence, the e-balance system uses a prediction module that attempts

to predict the energy consumption of non-IEDs. Combined, the IEDs expected profiles and the predicted aggregated non-IED profile combine into the expected power profile of the user. Finally, weather forecasts will enable the prediction of renewable energy production and temperature related energy consumption, depending on the quality of the weather forecast.

Technically, a GUI allows the interaction between the user and the methods that together form the aggregated power profile. The user can thus use the GUI to provide the boundary conditions for these methods.

2.2.3 Influencing the customer's energy exchange

Basically, the unlocking of flexibility at the point of energy exchange with the grid is about influencing the customer's or associated devices' energy behaviour. A DSM system will have several means at its disposal to achieve the desired behaviour to unlock the customer-agreed flexibility. Incentives and tariffs can be made time dependent, providing a varying economic control mechanism. Furthermore, contracts can be used to agree on a certain behaviour as specified. For example, heat pumps that are controlled directly by a DSO in case of congestion. Finally, a more direct approach requesting very specifically the amount of power reduction or increase can be implemented.

Within the e-balance project, we use a combination of real-time pricing and direct power requests. The balancing method is technically about iteratively reaching an agreement about power distribution throughout the grid, resulting in a matching of supply and demand of electrical power. The "desired profile" is iteratively adjusted until the system converges, whereby each management unit at each hierarchy level respects the boundary conditions, set by its operators/users.

There are many ways in which the e-balance balancing methods (see deliverable D5.2) can be incorporated into a market system. It is important to realise that the fractal-like hierarchy can be used to execute balancing on both the highest level as intermediate or lower levels. Providing the possibility of balancing top-down including the entire hierarchy, as well as local balancing, including only a small portion of the hierarchy. Translating this to a market system means that an Aggregator can be active with a single goal on every hierarchy level, trying to use the power of large number of end users to accomplish its goal i.e. local balancing. It also means that geographically bound Aggregators can be active to facilitate local balancing amongst a specific group of customers. Multiple Aggregators can operate in parallel throughout the hierarchy.

The DSO provides the ability to balance the system e.g. by using the e-balance platform and validates the balancing activities based on the communicated expected power exchanges as well as forecasts based on local measurements and measurement history. The Aggregator will use the infrastructure to reach its customers and to achieve its goals[6]. For example, it requests its customers to aid in achieving a certain goal (e.g. desired power profile). The customers respond via their customer management unit (CMU) to what extent they can aid the Aggregator with this request. Note that in our line of thinking, market parties like the Aggregator *ask* the customer to *aid* in achieving a goal. The customer is not obliged to help. It is however, by contract, not allowed to aid another market party / Aggregator. This keeps the customer in control over the amount of flexibility offered. This large amount of control over the flexibility made available by the customer, may limit the flexibility that is available on the individual level. In order to reach the Aggregator's desired profile (e.g. 2MW flat profile), a larger number of customers will need to be aggregated compared to the situation where end users do not have control over their devices. A geographically bound / locally operating Aggregator will hence have to ensure a high level of customer involvement, much more than a nationally operating Aggregator has to. A schematic overview of the aggregator's role in the system is given in Figure 4.

[6] The Aggregator wants to earn money giving its services. This means that it wants to get maximum rewards (incentives) from DSO for achieving the desired power flexibility.

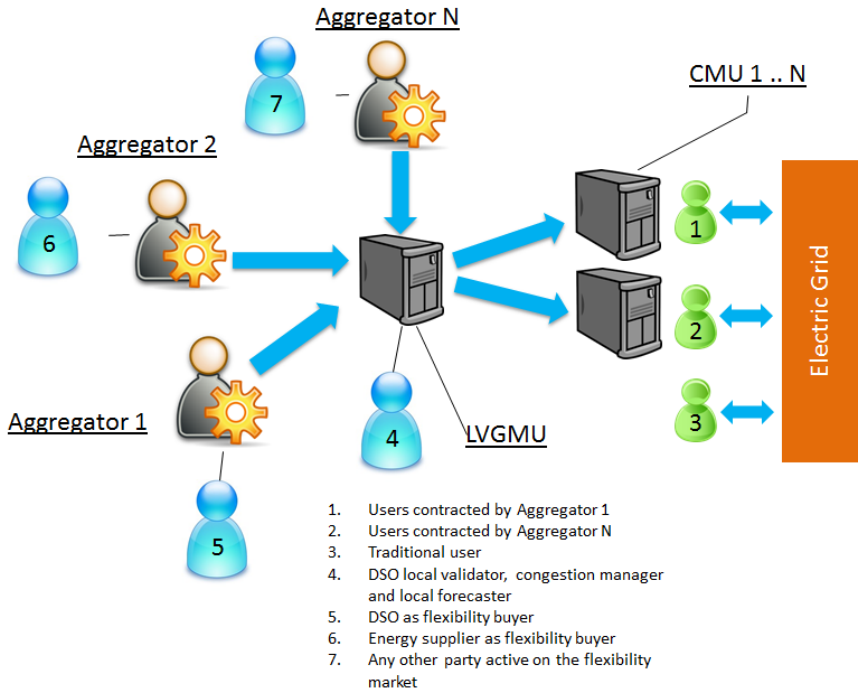

Figure 4: The aggregator's role – visualization

This line of thinking enables the e-balance system to support a broad variety of business models regarding energy exchange flexibility, allowing a complex market system with many variations operating in parallel.

2.2.4 e-balance system compatibility with the current market

A system of incentives and energy prices on the current market is strictly dependent on the availability of data regarding user consumption and production. The higher the time resolution of the data, the more customizable and flexible pricing can become. Smart meters and Advanced Measure Infrastructure (AMI) infrastructure allow the exchange of information in two directions:

- to the consumer: pricing or tariff slots,
- to the supplier/retailer: amount of energy consumption and production near real time. In many countries Time of Use (ToU) or dynamic tariffs (RTP) are being tested and deployed. The intensity of testing depends on the level of smart meter deployment.

In most countries, suppliers are preparing adaptive profiles according to their needs of capacity. The tariffs proposed to users are flat (two or three zonal) and consumption based. Their update is possible one or two times a year.

On the other hand, systems like the e-balance system can provide far better adaptive profiles on 15 minute or less time scales.

The proposed system will be fully compatible with the current market model. The bottom-up approach with the balancing algorithm will cooperate with Day Ahead and Intra Day Markets preparing a sliding 24 hour aggregated load portfolio, corrected every 15 minutes or less. Longer or shorter planning periods are provided by default, covering the Intra-Day market. The Intra-Day market, depending on the electricity market type, presents typically a time-step of one or half an hour.

The balancing mechanism can work with every time interval, as long as the hardware running the algorithms and the telecommunication can keep up. The technical details will be described in the e-balance project deliverable D5.2 (Chapter 4) and D6.1.

A system of incentives and tariffs should be prepared and aligned to the specific segment of clients to reach satisfied amount of the grid flexibility and the user's satisfaction and savings.

To summarize, we propose to use both, intra-day and near to real time mechanisms on the local level using the balancing algorithm every 15 min (or smaller) time intervals.

This will unlock detailed information about the planned energy consumption and production. It will also unlock the flexibility in consumption and production of small and large consumers and producers to the market where needed. Every piece of local imbalance that cannot be resolved due to the lack of flexibility, will be shifted up to the next hierarchy level in the system and the grid. This can be scaled to regional, national or even European scale, depending on the regulatory framework and geo-political interests. The use of the e-balance system can lead to only one, Short Term Market (STM) with strong local and bottom-up balancing mechanism even on integral EU energy market.

2.2.5 Possible other solutions

We propose an e-balance business model as described shortly in Chapter 2.2.3. In this proposal, the aggregators are responsible for (local) balancing effects and cooperation between the DSO, the retailer and the end users.

We also recognized other possible models where:

- The role of the aggregator will be taken by the DSO: this model is without the aggregator role for local balancing. In this case the DSO would be the main provider of all the e-balance services and infrastructure. All operational risk and all responsibility will be on the DSO side.
- The role of retailers will be shared with aggregators: model where the retailer role is provided by the aggregators for those users who are contracted with them in order to obtain a balance. In this case we met difficulties with finding the win-win strategy for the aggregator – retailer relation on the market.

In both mentioned cases the current market model and market regulations would have to change drastically. Our goal is to fit the e-balance system to current market models, without fundamental changes when it comes to the role of other market participants (existing aggregators or existing retailers).

Through the cooperation with other projects in Sustainable Places (http://sustainable-places.eu/), such as: CityOpt, INDICATE, AMBASSADOR, IURBAN, URBGRADE, READY4SMARTCITIES, BESOS, OPTIMUS, District of Future, we are working on finding the best suitable business model for the e-balance system on the energy market.

By cooperation in this project we would like to describe all difficulties found during the BM formalisation process concerning stakeholders' engagement, regulatory constraints and market environment in current state of energy market development in Europe.

3 The proposed socio-economic solution

In this chapter we propose some socio-economic solutions to transform the current energy market into a fully dynamic and smart electricity market with Demand Response (DR) local energy balancing efficiency. We have prepared an added value analysis as well as business models aspects propositions, which are enabled by the e-balance system. In Appendix A we also present the SWOT analysis for the proposed services to show their strengths, weaknesses, opportunities and threats.

3.1 Added value and Business opportunity analysis

We have considered a broad list of market roles, which exist in the future energy market supported by e-balance. While making this list, the future is envisioned to have the vast majority of electricity production from renewable sources with a great number of decentralised production facilities. The list of the most important roles is as follows:

- End users of the energy system – the customers.
- TSOs/DSOs (or subsidiaries thereof).
- Aggregators.
- Supplemental electricity producers (lower priority production units).
- Energy retailers.
- Independent Service Providers (it can be ESCOs, weather forecast agencies or data providers etc.).
- Regulators.
- IED and automation solutions providers (IED Manufacturers).
- Governments (national level).
- Governments (local level – like municipalities).

We have prepared a description of the current services and propose new value for each mentioned market role. This analysis shows all added values which can be released on the future market and how the e-balance system can be incorporated into the value chain. It can engage all stakeholders to participate in the system development and deployment.

In the following sections, each of the stakeholders mentioned above is discussed in more detail, indicating its role, the services it will be able to provide and the new value created. Figure 5 presents the relationship between all stakeholders based mostly on contracts. It indicates the places in which added value related to the e-balance system has been recognised. The red colour informs where the added value is placed. The blue arrows illustrate the connections and cooperation (or a possibility of) among all stakeholders.

The end user has a strong relation and/or contracts with: DSO, Retailer, Aggregator, and data/ICT service provider/weather forecast provider. Additional relations exist between the user and manufacturers of tools and smart devices and the local government.

The following sections will describe for each market role what services it can offer and what the principle priorities for this market role are. In other words, what their core business is. In the following, the technical system is stripped down and analysed for possible added value it can bring, if the functions of the technical modules were present as commercial solutions.

The following work was also inspired by the Universal Smart Energy Framework (USEF) document [3].

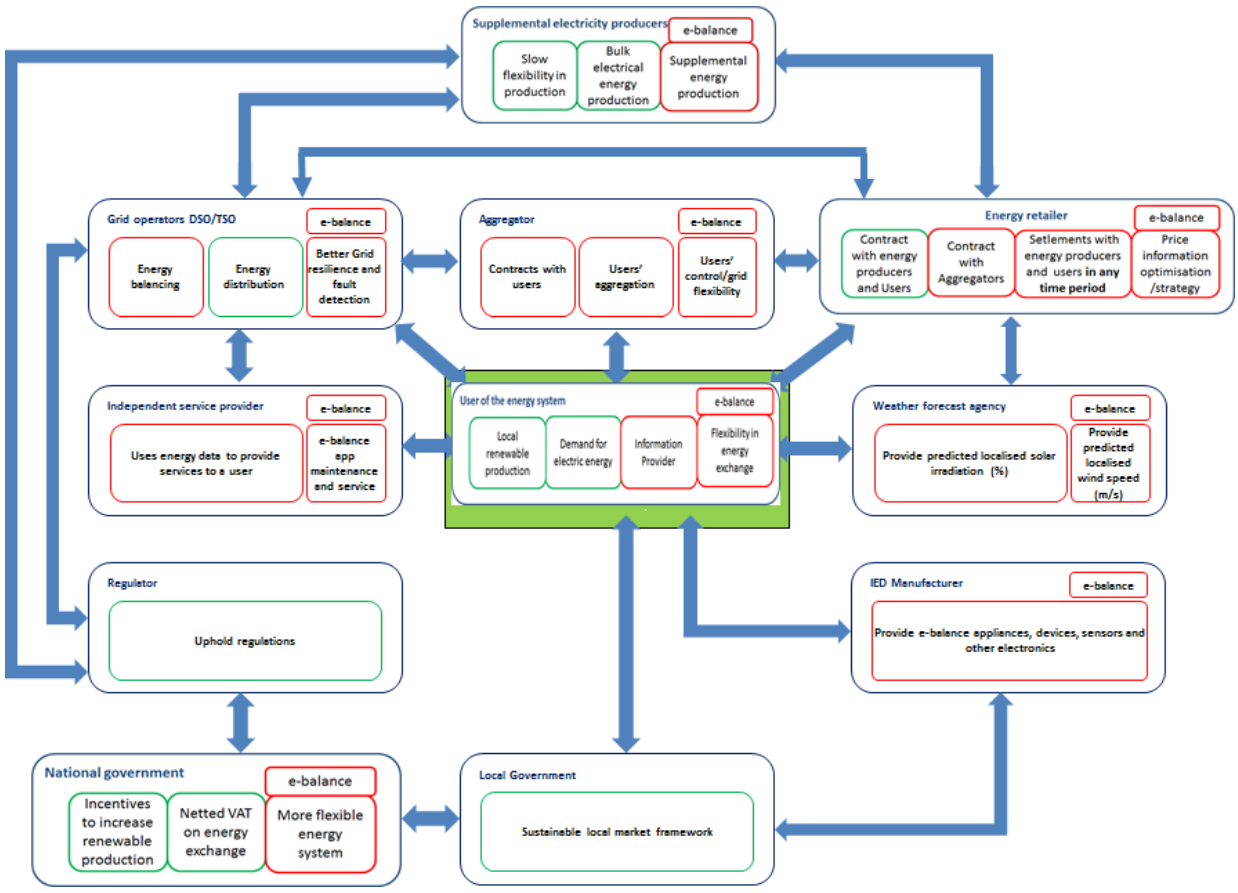

Figure 5: Relationships between stakeholders and the identified locations of added value. Red edges indicate new added value, whereas green indicates existing value

3.1.1 End users of the energy system – the customers

3.1.1.1 Description of the role in the energy system

An End User of the energy system is defined as any legal entity that exchanges energy via the power grid, but does not have production of electricity as primary activity. Most of them currently only consume energy from the grid. In the energy system the user is not limited to a group of small consumers and prosumers. It also includes businesses and industry. For example, a householder with PV or a horticulture owner will have the primary goals of "comfortable living" and "growing plants", respectively. Energy surplus or shortages caused by their production units are side effects that can be provided to the market as a service.

3.1.1.2 Services

Currently, the end users are rather passive (being consumers) and becoming active (being prosumers). The vast majority of services in the Smart Grid system will be focussed on the end users of the energy system. However, these services will require information from the Users. As such, the services provided by the Users of the energy system consist primarily of information and behavioural effects. The services identified for the end users include:

- Data supplier of historical energy consumption and production, and/or as the aggregate "energy exchange with the grid".
- Predicted production data.
- Predicted consumption data.
- Predicted energy exchange with the grid data.
- Provider of flexibility in the energy exchange with the grid:
    - On request the amount of power drawn from the grid can be reduced or increased both in amplitude and direction (i.e. withdrawal or feed-in). User strategies determine the amount and shape of flexibility provided.

3.1.1.3 New value from e-balance system

New value for the end User can be separated into two types: value provided by the end User and value consumed by the end User. This section focusses on the new value provided by the end User.

The end User will be enabled to create new value with the e-balance system by providing more accurate information regarding historical and expected energy exchange, consumption and production. This information can be acquired and used by other stakeholders to improve operational activities or to aggregate information provided by multiple end users into new insights[7]. Also, by being flexible in energy exchange, the User can support other market participants, who require additional power production or consumption and can be compensated accordingly. The added value is graphically represented in Figure 6.

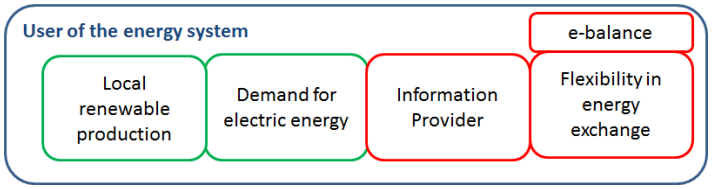

Figure 6: Added value enabled by the e-balance system for the User of the energy system (in red)

[7] Currently end User can get insight into his energy behaviour by allowing his retailer to access 15 minute data, under this premise. It is logical that end User gives his information for free, as user wants to receive insight at the lowest price possible. On the other hand, if market parties gain additional Value from end User's information, they should give some reward to the data owner (user), as he made it possible. Information and data suppliers can couple a price value to their information and data. Long term operation will show whether this price will be paid by interested parties. This price can of course also be zero.

Table 2: Overview of stakeholder priorities, added value and the business model propositions for the User of the electricity system

Priority	Technical aspect	Additional value enabled by e-balance	Business propositions enabled by e-balance
1[8]	Consumption of energy	Energy consumption based on comfort and necessity. The real data from SM and GUI app. regarding the energy price, quantity and quality parameters. Real time strategy planning and load profile information. Lower cost of energy consumption.	The end User can sell or exchange information regarding consumption and or energy exchange. In return, an ESCO can provide improved predictions of future energy consumption, to aid the User in making better decisions within the balancing system. It is envisioned that internal modules of technical components of the e-balance system can be made exchangeable. For example, a prediction module can be replaced or overruled by a better module or service provided by an ESCO. Predictions of the envisioned energy consumption of the end User can be supplied or even sold to the retailer. For example, an Energy Retailer needs the data to improve the knowledge of its portfolio and can use the User's data as a reference, possibly resulting in better pricing in the long term. Scheduling of consumption provides the means to lower the energy bill, by being more price-sensitive.
1	Production of local (renewable) energy based on the availability	User makes the maximum use of the available resources, such as solar irradiation and wind. Integration of weather forecast information gives the possibility to forecast the quantity of production and use (optimal usage of production) in the local area.	The end User can sell or exchange information regarding production and or energy exchange. In return an ESCO can provide improved predictions of future energy production, to aid the User in making better decisions within the balancing system. Weather forecasts will enable better production forecasting. In return, short-term historical production data will enable weather forecast agencies to improve short term forecasts.
2	Feed-in surplus energy to the grid	User can feed the surplus energy into the grid.	Short balancing periods (15 minutes or less) enable more accurate accounting and availability of financial exchanges. If so desired, payment[9] can be done on shorter time scales than the current monthly/yearly bills. Dynamic prices determine the costs of energy feed-in to the grid.

[8] The priority- means the level of importance (1 – highest priority). Sometimes two indicated elements have the same importance, the only difference is in the flow direction.
[9] The term: payment refers to the all type of rewards like user's tariffs (prepared on the base of spot prices), additional monetary, non-monetary incentives.

2	Energy withdrawal from the grid	Insufficient local production is compensated by production elsewhere. The user withdraws this energy from the grid.	Short balancing periods (15 minutes or less) enable more accurate accounting and availability of financial exchanges. If so desired, payment can be done on shorter time scales depending on the user's need. Dynamic prices determine the costs of energy withdrawal from the grid.
3	Flexibility	Adjustment of the energy exchange based on external incentives. Additional monetary reward.	Iterative Balancing automatically incorporates the process of unlocking flexibility. Thus, simplifying the balancing system. End users are rewarded proportional to their contribution to the balancing process. Depending on the scale, users may be represented by an Aggregator or Energy Retailer to reduce the number of directly trading parties. End users can be contracted by an Aggregator to supply additional flexibility.
4	Information	User gains access to information regarding energy exchange and consumption of devices.	End User's data can be exchanged or sold to whoever is approved by the end User. These parties can then use the User's information to provide improved or new Services. For example: ESCOs can offer end users information of similar or equal devices as those of the User for comparison and energy saving potential. The DSO can provide energy exchange statistics to the User allowing for comparisons. ESCOs can supply gross energy consumption data to allow for comparisons between Users.

3.1.2 TSO/DSO Subsidiaries

3.1.2.1 Description of the role in the energy system

A TSO/DSO can consist of several subsidiaries, with the primary one being the Grid Operator. A Grid Operator enables the electricity system as a whole by providing the infrastructure and management needed to technically exchange energy. With the e-balance concept, new management equipment (ICT) will be introduced to facilitate the balancing of power consumption and production in a bottom-up way and to improve the resilience of the grid. The addition of these devices to the assets of the Grid Operator will require a close cooperation of these two activities (energy balancing and grid resilience) from the operational and the safety point of view. As such, a close relation between the owners of these assets (infrastructure and the new ICT equipment) is required. Therefore, we propose that the new grid related management equipment to be owned by either the Grid Operator or a dedicated subsidiary of the TSO/DSO.

3.1.2.2 Services

As a core infrastructure operator, the TSO/DSO provides the following Services:

- (Access to the) Reliable electricity grid infrastructure.
- Enabler of the exchange of energy exchange data (historical and predictive) with the authorised stakeholders via the Advanced Metering Infrastructure.
- Provider of localised Quality of Supply information (Open Data).
- (Access to the) Energy Balancing System.

3.1.2.3 New value from the e-balance system

The DSO has new options to provide an even more stable power flow with minimal maintenance costs, as well as improved control with less losses and faults. New investments in the network can be delayed or avoided entirely, generating considerable cost savings.

Optimization of the network decreases losses and increases operational efficiency and, as a result, causes operational expenditures (OPEX) reduction for the DSO. Furthermore, at the system level, these savings should be seen as avoided production. The DSO will be able to better manage the assets and free up additional grid capacity. The peak-shaving effect is directly related to the deferred investment which is valued at around 400-500€/kW per year for a DSOs operating MV networks [6].

The e-balance system can increase reliability (considering the energy resilience functionalities) and service quality levels as perceived by the customer. Improved the System Average Interruption Duration Index (SAIDI), the System Average Interruption Frequency Index (SAIFI) and the Momentary Average Interruption Frequency Index (MAIFI). These rates are usually compensated to the DSO by regulators. Penalties for the not supplied energy or service disruptions can be minimised.

In case of energy balancing in neighbourhoods, the TSO/DSO will have the core system of the e-balance platform. The e-balance balancing algorithms can work with every time interval, as long as the hardware running the algorithms and the telecommunication can keep up. For example, we will start with a 15 minutes time base to prepare the profile load. Every step, a complete prediction and balancing for the next long-term time block will be made. During the project development, we are focusing on a long-term block of 24 hours. This block can be extended if the market desires so, for example by removing the need of a fixed day ahead. The added value for TSO/DSO is graphically represented in Figure 7.

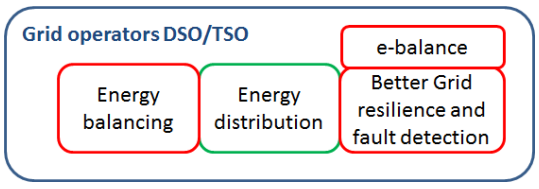

Figure 7: Added value enabled by the e-balance system for the TSO/DSO (in red)

Table 3: Overview of priorities, added value and business model propositions for the TSO/DSO

Priority	Technical aspect	An additional value from the e-balance system	Business propositions enabled by e-balance
1	Continuity of the energy supply	Greatly reduced amount of power failures due to resilient grids; increase of reliability. New tools and algorithms are provided as the e-balance system. (see D3.1, D5.1 D6.1 and [8])	The DSO can achieve cost reductions caused by deferral of investments.
2	Distribution and transport of energy	Facilitate the distribution of energy in an efficient manner for the lowest achievable costs. Less energy losses and extended grid monitoring.	Cost reductions by having to buy less energy and CO_2 credits in relation to losses. The DSO can share this benefit with the Users that helped to realise it via the fee for the Aggregator. In the long term, every customer will profit from the more efficient operation.
3	Energy balancing	Facilitating information and control signal flows to balance production and consumption.	The e-balance enabled infrastructure allows for different balancing schemes, aimed at for example local balancing. This can result in an increase of production near places of consumption and efficiency gains due to lower losses.
3	Unlock flexibility	The ability to unlock flexibility in energy exchange is added to the electricity distribution system.	By accessing flexibility in energy exchange, the system operators can realise: Peak shaving. Loss reduction. Release power line capacity. Lower the amount of thermal cycles of electric grid components.
4	Load and production forecast	Each grid management unit will be supplied with User-supplied forecasts for energy exchange. Furthermore, it will produce energy exchange forecasts for the aggregated remaining non e-balance end users.	Regional and local grid level forecasts enable regional and local balancing and markets. Aggregated local forecasts may improve total Market forecast accuracy.

5	Information	More detailed information becomes available at each management unit.	Detailed local and regional information can be aggregated, anonymised and presented as Open data. This will leverage the potential of several other functionalities and new services within the e-balance framework.

3.1.3 Supplemental electricity producers

3.1.3.1 Description of the role in the energy system

An energy system running entirely on renewable energy sources and without storage would require a vast amount of installed renewable production over-capacity with curtailment in place, to ensure a sufficient production at all times. This is very cost-inefficient and currently unaffordable. Hence, a mixture of interconnectors, storage, as well as fossil fuel based production is needed, in order to supplement renewable energy sources. Currently, the bulk of the energy production is realised with conventional gas, coal or nuclear based technologies. The technologies of the e-balance system become especially important when the number of renewables increases significantly. In such a situation, the conventional power plants truly become supplemental to renewables and should be treated as such in the market and in wording. A supplemental electricity producer does not have to be a fossil based power plant. Stand-alone energy storage units can also act as supplemental electricity producers, offering their capabilities to the market as either load or production unit. These supplemental electricity producers will be active in both, the balancing and the flexibility market.

3.1.3.2 Services

Supplemental electricity producers produce the electricity in the base for the market and in accordance to Day Ahead and Intra Day markets. They provide the "missing" production that is not covered by renewables directly. Also, they deliver system services, in case of any real-time imbalance. It is worth noting that renewable production units have no technical reason to be excluded from supplying system services.

3.1.3.3 New value from e-balance system

The e-balance system will enable balancing of both electricity demand and production on a more fine grained level than previously possible. Assuming that the e-balance system architecture is expanded to the TSO level, the management unit that is active at the highest level will use a "flat power profile" as the "desired power profile". As such, any deviations from this flat profile at the highest architecture and grid levels will constitute an imbalance in production and demand on the TSO level. And this is the imbalance that needs to be covered by the supplemental electricity producers.

Primary frequency control – the future renewable production units will be able to aid in real-time balancing by assisting the primary frequency control of the grid. However, fast responding storage, virtual power plants or fossil based units will be required to maintain real-time electricity balance for quite some time. Primary frequency control is part of what is referred to as "system services". This topic is out of scope of the e-balance project. The added value for supplemental energy producers is graphically presented in Figure 8.

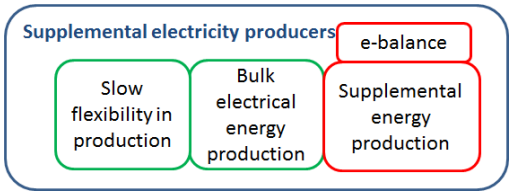

Figure 8: Added value enabled by the e-balance system for the Supplemental Energy Producer

Table 4: Overview of priorities, added value and business model propositions for the Supplemental Energy Producer

Priority	Technical aspect	An additional value from the e-balance system	Business propositions enabled by e-balance
1	Supplement energy production	If the energy production of a very marginal or zero cost is insufficient to meet the demand, the more expensive production is needed to supplement energy which meets the demand. Higher merit order production facilities will complement renewables.	Supplementing the energy production can be realised by means of flexibility in energy exchange of Users which are contracted (indirectly) by the energy producer. These Users did not participate in the initial balancing phase.
2[10]	Increased efficiency	In case initial peaks in loads or energy surpluses are levelled out by default via DSM mechanisms, remaining imbalance will be a lot smoother.	Higher operational efficiency due to lower requirements for control power.

[10] Optional and configuration dependent.

3.1.4 Aggregators

3.1.4.1 Description of the role in the energy system

The Aggregator combines multiple end users to form a new single market participant. The aggregator trades energy from the prosumer's resources with market players who need them. The aggregator enables end users to offer flexibility for specific purposes. Each Aggregator may only realise one type of functionality. For example, an Aggregator assigned to peak shaving for a specific DSO, cannot support a Supplemental Energy Producer in balancing the system. This approach provides more transparency in the activities by each aggregator and simplifies the user data management – from the privacy point of view.

3.1.4.2 Services

- Administrative relieve[11].
- Smart Production Optimisation.
- Sub-Market enabler.
- Electricity balancing amongst participants.
- Combine customer flexibility with the energy exchange and provide this to the Energy Retailer, DSO or Supplemental Energy Producer.

3.1.4.3 New value from the e-balance system

The main service, which the aggregator provides on the market using the e-balance system, is to reach a desired profile of users' consumption and production in his aggregated neighbourhood. Every owner of a CMU chooses between participating in the primary balancing market and offering his services to a bound aggregator. The Aggregator can offer on the market the additional demand-response flexibility as a service. At the same time, an aggregator can enable market relations which currently do not exist such as energy trading between local neighbours[12].

This service should be profitable for the aggregator, so the aggregator has a contract with users, DSO (for receiving distribution and balancing service) and retailers (for providing the energy and receiving settlements). The added value for the aggregator is graphically represented in Figure 9.

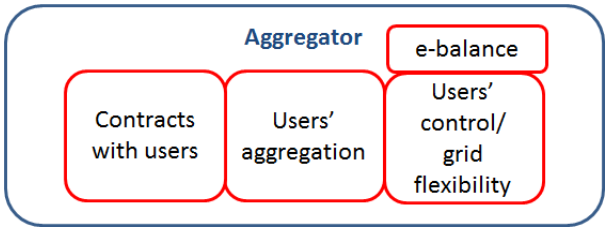

Figure 9: Added value enabled by the e-balance system for the Aggregator

[11] The administration regarding aggregation of users is done by the aggregator and thus relieves the energy supplier or others of that burden.

[12] *Microgrids Architectures and Control*, Hatziargariou N. (ed), Wiley IEEE Press 2014 ISBN: 978-1-118-72068-4, p. 23, e-book: www.wiley.com/hatziagariou_microgrids.

Table 5: Overview of priorities, added value and business model propositions for the Aggregator

Priority	Market aspect	An additional value from e-balance system	Business propositions enabled by e-balance
1	End user Contract	The aggregator has a contract with the retailer, DSO and end user to reach a desired power profile. The end user can only be contracted by one Aggregator.	The Aggregator unlocks flexibility in energy exchange at end users for market parties that contract the Aggregator. A difference in price between their contractor and payment to end users will be the basis for the Business Proposition.
1	End user Aggregation & Control	Multiple contracted end users will be combined to act as one market party. The Aggregator is dedicated to a single purpose, trying to realise a certain aggregated power profile for its commissioning partner, distributed throughout the geographical market.	

3.1.5 The energy retailers

3.1.5.1 Description of the role in the energy system

The energy retailers sell the electricity to the end users and provide accounting services for the energy exchanges. They act as intermediaries of electrical energy consumers and producers, both on the large and small scale. The role of the energy retailers as such is to prevent market monopolies created by producers.

3.1.5.2 Services

The services provided by an energy retailer consist of:

- Accounting the energy exchange.
- (Currently) Collecting grid connection, capacity and system services fees for the TSO and DSO.
- Using flexibility in the energy exchange provided by customers/aggregators to compete with asset-based power production facilities (small and large) on the market.

3.1.5.3 New value from the e-balance system

The energy retailer has an online connection with the end users by means of datalink (with Customer Management Unit - CMU) or the e-balance web site and informs the end users about all changes in prices. The e-balance system can provide means to create new possible services: the energy purchase and bills' optimisation. The incentives will be offered according to the end users' activity in the system. The added value for energy retailers is graphically represented in Figure 10.

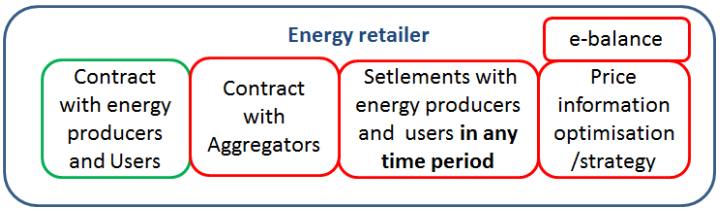

Figure 10: Added value enabled by the e-balance system for the energy Retailer

Table 6: Overview of priorities, added value and business model propositions for the Energy Retailer

Priority	Technical aspect	An additional value from e-balance system	Business propositions enabled by e-balance
1	Contract with energy producers aggregators and end users	To settle all payments between parties engaged in the e-balance system, the retailer has all the needed contracts referring to the energy flexibility and DSM in place. This means it can act and calculate tariffs with rewards for energy flexibility provided by end users.	Contracts with Aggregators allow the Energy Retailer to complement contracts with energy producers in terms of supply and demand.
2	Settlements with energy producers, aggregators and end users	The retailer should settle with the end users according to their activity on the market. The bill has to be prepared with all additional rewards and rebates. The retailer receives margin from the services provided to end users and aggregators.	The retailer offers tariffs for its clients. This tariff will be more attractive for end users. They reflect the user's participation in the e-balance system. The retailer also performs its business as usual, invoicing and performing services to its clients.
3	Prices information and strategy, Creation of new services	The information about ToU or dynamic tariffs and distribution service charge has to be current and adequate. The user is informed about it in near real time. This gives a possibility to create other, new financial services for the end users.	The near to real time information from the end users gives new possibility to calculate prices more precise and in a dedicated way.

3.1.6 Independent Service Providers

3.1.6.1 Description of the role in the energy system

The Service Provider is an entity that deals with the information/data. It focuses on bookkeeping, analysis, and advising regarding earning more money by changing behaviour, by being more efficient and eco-friendly or by improving performance on the market. The service provider can also be a supplier of information that can aid a user in achieving one of the previously mentioned goals. For example, the weather forecast agency is a service provider, which provides weather data; the ICT provider provides ICT service for all the parties; the Data Provider provides customers' data maintaining authentication and data security; the ESCO provides services related to the energy consumption, production and exchange with the grid.

3.1.6.2 Potential new service providers that can benefit in the e-balance system

We can suspect that other service providers can benefit from the e-balance system and for that reason they might be eager to take responsibilities for the mechanism development.

- ICT providers can turn home appliances into controllable devices, e.g., turning them on/off (which extends the scope of the CMU).
- The energy independent service companies (ESCOs) will create additional tools to evaluate the building, neighbourhood or group performance (including energy systems). That will allow to propose more efficient solutions (energy savings) or even to adjust the CMU to improve the current user's strategies.
- Micro-generation vendors will develop a better market framework to sell their solutions.
- Smart appliance manufacturers will find a more available market framework to exploit the potential of the "smart" functionalities, and also the related sensor manufacturers.
- A detailed knowledge about the consumption habits of the population will help to better address the energy policy and grid infrastructures' plans.
- Dedicated EV Aggregators – they can participate in energy aggregation on the LV level.
- Charging Station Operators (CSO) – they can develop their business using the e-balance system.
- E-mobility service providers – they provide additional services (businesses) such as EV location, parking place, and price comparisons through mobile applications.
- Estate developers will have additional value offering home management services and other smart equipment and systems in homes.

This is merely short list of possible services based on the e-balance infrastructure. The future might show new possibilities and advantages for the new BMs in different areas of market and life.

3.1.6.3 New value from the e-balance system

The independent service provider, e. g. the weather forecast agency, facilitates the weather data which is the most important one for the DER generation forecast. This kind of service is very useful in the e-balance system. End users will have to pay for it additionally. ESCOs can provide new services for the final clients regarding energy management service and tools maintenance. Peak-shifting and ToU or dynamic tariffs are good examples of achieving the increase in the end users' energy efficiency with these services from ESCOs. The added value for the independent service providers is graphically represented in Figure 11.

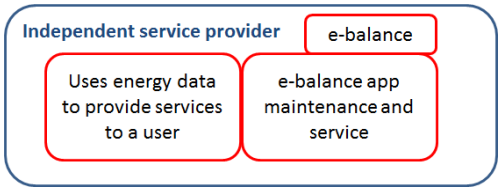

Figure 11: Added value enabled by the e-balance system for the Independent Service Providers

Table 7: Overview of priorities, added value and business model propositions for the Independent Service Provider

Priority	Technical aspect	An additional value from the e-balance system	Business propositions enabled by e-balance
1	Uses energy data to provide services to a user.	• Energy efficiency advice. • Balancing / flexibility advice. • Data aggregation /re-packaging. • Statistical information.	Weather forecast agencies can improve the accuracy of forecasts by using renewable production information. ESCOs can provide energy consulting services, giving custom advice on how to save energy. ESCOs can provide improved load and production forecasts based on the user's data.
2	The e-balance apps maintenance and service.	Maintenance and service for all e-balance applications, modules and tools.	This functionality can be provided by ICT provider in cooperation with the DSO, aggregators and suppliers using the e-balance hierarchical platform.

3.1.7 Regulator

3.1.7.1 Description of the role in the energy system

The Regulator observes the correct implementation of the corresponding regulations and supervises the monopolies of the Grid Operators.

3.1.7.2 Services

- Protection of all end users' interests.
- Making sure that energy consumers and producers act fairly towards each other, within the boundaries set by the governments.

3.1.7.3 New value from the e-balance system

The e-balance system gives new value to this stakeholder indirectly. Nonetheless, the regulator has to regulate huge changes on the market. Using our system, the regulator can have access to the information on more transparent way. The most important challenge is to regulate the energy trade in the local area (neighbour to neighbour, for example).

In a liberalised future market, the energy regulator needs objective measurements to determine how well a DSO performs. By having access to more detailed Quality of Supply (QoS) information and the amount of energy losses, some of the most important technical criteria for judging the performance of a DSO are provided. The regulator uses the total amount of outage minutes in a year as one of the criteria to evaluate the performance of the grid operator.

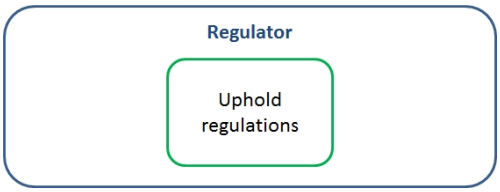

Figure 12: Added value enabled by the e-balance system for the Regulator

Table 8: Overview of priorities, added value and business model propositions for the Regulator

Priority	Technical aspect	An additional value from the e-balance system
1	Uphold regulations	The regulator ensures that regulations are upheld by all the involved parties.
2	Information	More detailed Quality of Supply (QoS) information and the amount of energy losses. Transparent market information and more accurate stakeholder's audit.

3.1.8 IED Manufacturer

3.1.8.1 Description of the role in the energy system

Manufacturers of electronics and household appliances can incorporate into their products features that enable the unlocking of flexibility in the consumption, production or exchange of energy.

3.1.8.2 Services

- Providing Intelligent Energy Devices and electronic solutions.

3.1.8.3 New value from the e-balance system

IED Manufacturers will have additional profit from the products' sale. New lines of business can be created and started based on the e-balance system. The IED manufacturer can collaborate with the owners of the e-balance system. Such collaboration would perform a combined roll-out of e-balance equipment (CMU) and capable devices (white goods, storage, etc.). The added value for the IED manufacturers is graphically represented in Figure 13.

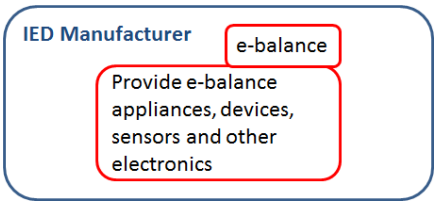

Figure 13: Added value enabled by the e-balance system for IED Manufacturers

Table 9: Overview of priorities, added value and business model propositions for IED Manufacturers

Priority	Technical aspect	An additional value from e-balance system	Business propositions enabled by e-balance
1	Provide e-balance appliances, devices, sensors and other electronics	Profits from sales of the specific smart appliances and other electronics.	It can increase the current business (new area of product selling) and profit for maintenance service.

3.1.9 Government/ local government

3.1.9.1 Description of the role in the energy system

The government provides political choices that enable or disable certain aspects of the energy system. These choices are expressed in the form of law and regulations. As such, the government provides the boundary conditions and freedom in the system as a whole.

3.1.9.2 Services

- Providing regulations that ensure the operation of the energy system acts according to the current national political views.
- Optionally, measures can be taken to temporarily favour or discourage activities related to the energy market by means of incentives or subsidies.

3.1.9.3 New value from the e-balance system

The e-balance system enables establishing a fully functional smart and flexible energy system. This is an added value that does not evolve into separate and specific business on national level, but is desired as an important value of the smart electricity grid in the future. The added value government is graphically represented in Figure 14.

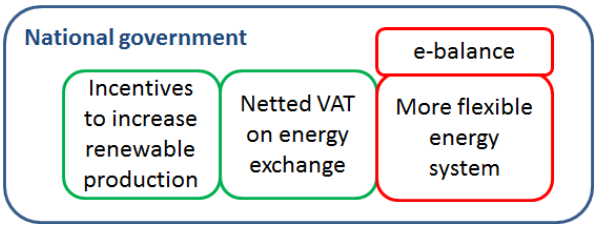

Figure 14: Added value enabled by the e-balance system for the Local and National Government

Table 10: Overview of priorities and added value for the Local and National Government

Priority	Technical aspect	An additional value from the e-balance system
1	Continuity of the energy supply	No power failures due to back-up power and resilient grids (lower cost of grid maintenance).
2	Sustainability of the energy supply	Low environmental and social impact.
3	Income generation	VAT calculated over energy sold (benefits).
4	National or European energy independence	Being able to maintain the current and future societies with nationally available resources; a more self-sufficient system.
5	Policy instruments, Non-discrimination in energy supply Privacy protection	More flexibility in the energy grid assures a sustainable system in which the energy efficiency increases and the non-discriminatory energy supply is provided in secure way.
5	Sustainable Local Market	Has a sustainable development in a region and CO_2 effects. Provides incentives to support specific types of market participation, based on local and regional policies and principles.

3.2 Price mechanism analysis

Similar to the previous section, we have prepared possible new price mechanisms for the important market roles in our system, like the DSO, the Retailer, the Aggregator and the end user. These price mechanisms follow the chosen business model and the best win-win strategy for all of the stakeholders. The prepared propositions are summarised briefly in Table 11 and presented graphically in Figure 15. A more detailed analysis is given in the following subsections that also highlight the changes proposed by the e-balance system to the current market. Note that this analysis only reflects the pricing for the energy exchange and flexibility in the energy exchange. It does not include pricing for the additional values as described in Chapter 3.1.

Table 11: The overall proposition for the price mechanisms

No.	Current price mechanism without e-balance system	The stakeholder	Price mechanism in the e-balance system
1	The DSO has a contract with the Retailer and currently existing Aggregators who provide the auxiliary services and DSM on the market. The DSO allocates grid capacity costs to users according to the corresponding contracted rated capacity. The DSO has no possibility to offer any incentives.	DSO	The DSO uses a fixed capacity based tariff in its contract with the end users. Furthermore, it may contract one or multiple Aggregators to achieve operational goals, such as, for example, peak shaving and extension of component lifetime. The resulting deferral of investments and correspondingly avoided costs are partially made available to the Aggregator and subsequently to its contracted end users. **Reward for DSO** = ∑ Avoided operational costs and losses – payment for the aggregator's service (incentives)
2	The Retailer only uses fixed tariffs prepared as ToU, which can change seasonally or weekly. User data and information is available in a limited way. There is a risk of mismatch between forecasts of energy consumption and production and thus, a risk of higher prices for energy purchases on the balancing market in case of imbalance in the Retailer's portfolio. The energy delivered to the grid by small prosumers has to be bought by the Retailer.	Energy Retailer	The Retailer uses a tariff structure that combines a tariff based on energy exchange (kWh exchanged, per 15 minute time interval) and a tariff based on flexibility (change in kW for a specific time interval). The flexible part is made available through an Aggregator. End users that are able to aid the Aggregator to achieve its goals the most, will achieve the largest cost reduction. **Reward for Retailer** = Income for energy flexibility supply on the market + avoided penalty in case of imbalance – reward assigned to the Aggregator.

No.	Current price mechanism without e-balance system	The stakeholder	Price mechanism in the e-balance system
3	Currently, this type of Aggregator does not exist. Existing aggregators provide specific services and do not offer local balancing services like the e-balance system will do.	Aggregator	The Aggregator supplies a service to the other market parties[13]. It realises a certain goal, as agreed with the party that contracted the Aggregator. Flexibility in energy exchange of contracted end users enable the Aggregator to achieve the goals it was contracted for. A margin is obtained between the prices received and those given to the Users. **Reward for Aggregator** = Reward from DSO for flexibility released - ∑ Incentives for end users + Income from an additional flexibility served on market
4	The end user has a contract with the DSO and the Retailer. He has to pay for energy and distribution services according to the ToU tariffs. The end User has no possibility to decide about his energy bills and money savings (no possible actions from the market perspective).	End User	The end user has a contract with the DSO (optionally via the Energy Retailer), with the Energy Retailer and, *optionally, with the Aggregator*. The DSO is paid for providing capacity within the grid. The Energy Retailer is paid or pays for the exchanged energy. Finally, the Aggregator pays the User for the flexibility in Energy Exchange. **Reward for End User** = ∑ (incentives + savings on energy buying/selling on the market (attractive energy prices/market signals in tariffs))

[13] Inspired by USEF document.

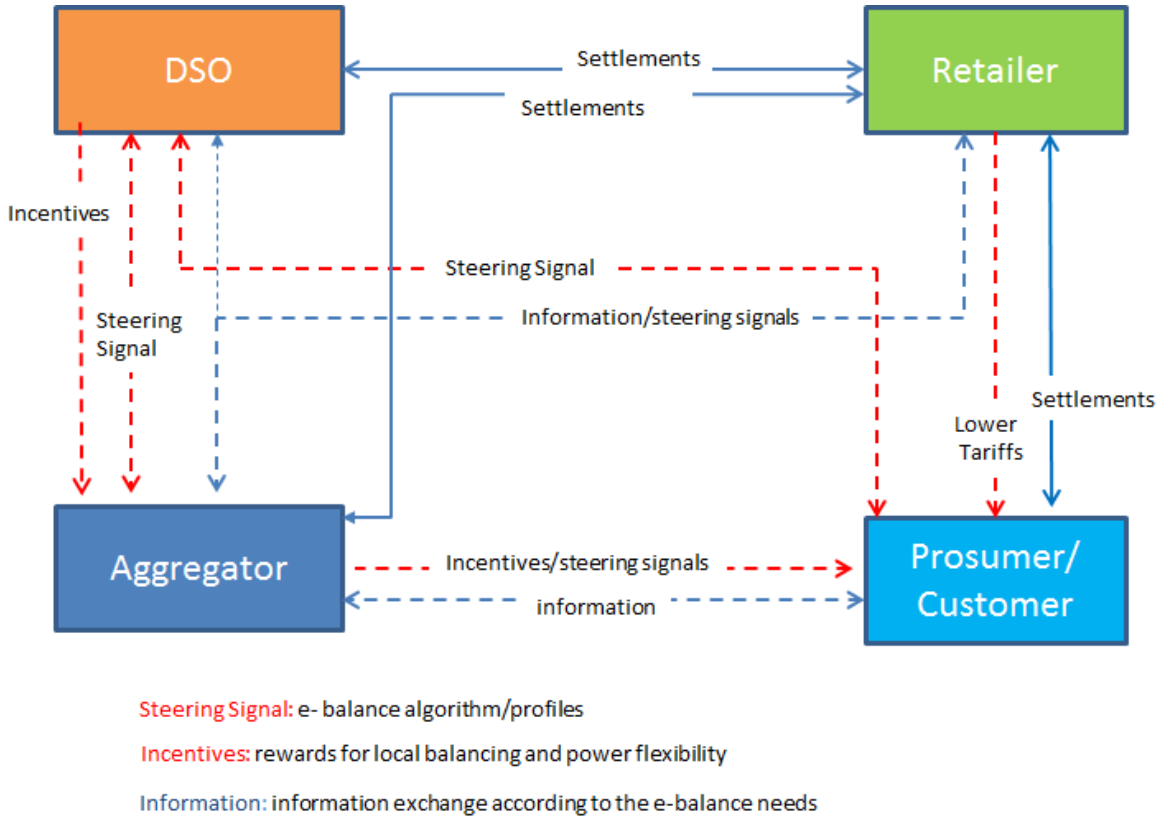

Figure 15: Flow diagram between main participants – the win-win strategy

3.2.1 The DSO

The DSO uses a fixed capacity based tariff in its contract with the end Users. This contract may be provided indirectly through the Energy Retailer. A great portion of the capacity tariff is based on the past and future investments. Therefore, a part of this tariff is made flexible. To make use of this flexibility, the end User is required to sign a contract with one of the Aggregators contracted by the DSO to achieve lower operating costs (prices), translated into the capacity tariff.

The DSO as a market facilitator can only offer a reward to the Aggregator if the operational costs are decreased. The e-balance balancing mechanism can be used to avoid grid congestion, decrease distribution losses and reduce the number of thermal cycles on grid components (ageing) by flattening the distribution of component loading in time. Furthermore, in the interaction with the TSO, peak reductions also have value for the DSO. Peak reductions also reduce the requirements for available grid capacity. A reward is given to the Aggregator(s) that aid the DSO in achieving these goals. The Aggregator in turn gives the reward (minus a margin) to the Users that actually realised the goals of the DSO via the Aggregator.

Please note that up till now the assumption has been made that there will be a distinction between Users that participate in the highly automated e-balance system and those that do not. It is interesting to note that the DSO's objectives as formulated here can also be determined by simply analysing the Smart Meter historical records. As such, by contract, Users can be rewarded for a flattened power profile throughout time. This will reduce grid losses, peaks and reduce thermal cycles. This can already be achieved now (using storages or EVs), without additional hardware other than a Smart Meter.

3.2.2 The Energy Retailer

The Retailer is responsible for buying/supplying the energy for its contracted Users. This involves both consumers and prosumers. Via the e-balance system, the retailer will gain detailed knowledge about the forecasted behaviour of the prosumers participating in it. This information can be used by the Retailer to more accurately manage its portfolio. The Retailer can choose from a large variety of pricing schemes. It is not unlikely that future markets will see a large diversity and combination of these pricing schemes.

It is not the intention of this project to fully explore all different pricing schemes possible at the Retailer. We give an example of how such a pricing scheme could look like:

- A fixed tariff is used for both directions of the energy exchange (please note that there can be two separate tariffs). Also, part of this tariff is made flexible, allowing the User to lower the cost of energy exchange. In order to make use of this flexible part of the tariff, the User must cooperate with the Aggregator(s) contracted by the Energy Retailer. The flexible part of the tariff will be based on the actual power value of the energy exchanged. Users that are able to provide the Aggregator with a better matching response will achieve lower rates.

3.2.3 The Aggregator

The Aggregator acts as a Service Provider towards the market. This entity is able to realise an increase or decrease in energy exchange or even change the energy flow direction on an aggregated scale or on a more localised scale, depending on the nature of the Aggregator. It is contracted by other market parties to achieve specific goals, which are important for such a market party. The Aggregator will be rewarded for the achievement of the goals for which it is contracted. This reward is shared with the Users that are contracted by the Aggregator and are thus technically responsible for the success or failure of the Aggregator's task. A margin between the two contracts is the profit of the Aggregator and can be used to finance its operation.

3.2.4 The end User of the energy system

The end User is at the centre of the new market system and will determine the amount of flexibility available to the market and the levels of consumption asked from the market. In a highly decentralised system it is also the User that is predominantly providing energy to the market. Yet, a single end User is in general too small to have an effect on the market. Hence, the current system of Energy Retailers is maintained. The end User has a contract with an Energy Retailer. The end User pays for energy withdrawn from the grid and receives money for energy delivered to the grid. The end User can also offer flexibility in energy exchange to the market via an Aggregator. Cooperation with an Aggregator can for example lead to a change in energy exchange tariffs or in DSO capacity tariffs.

3.3 The e-balance system ownership

The e-balance system and the planned services require a complex infrastructure, measurements and communication solutions which will be managed by the DSO.

Distributed generation modules and prosumer's installations can be provided by manufacturers and PV suppliers. The exact ownership depends on the financial constructs chosen to finance these installations.

As such, the e-balance system should be seen as a platform that can be managed and owned by several stakeholders that can be responsible for some of the devices and/or functionalities. The grid operators will be prominent in their roles as utilities and will be the owners of the e-balance infrastructure components, like the Low Voltage Grid Management Units (LVGMU) and Medium Voltage Grid Management Units (MVGMU) and others software solutions for the infrastructure. Communication infrastructure ownership will depend on the chosen telecommunication technology. It is likely that PLC based systems will be owned by the distribution grid operator, but other solutions are also possible. The ownership of the telecommunication is thus dependent on the specific operations in practise by the different grid operators and also implementation specific.

The Customer Management Units (CMU) may be offered by a Retailer or ESCO to the Users as part of the service or may be bought directly by the users (customers) in an electronics store. It is also feasible that it can be included in the Advanced Metering Infrastructure (AMI) built into Smart Meters and owned by the DSO. The Device Management Units (DMU) are part of the respective intelligent devices and as such are owned by the end users owning the devices (smart appliances).

The DERMU (management units built for the DER devices) will most probably be owned by the promoter of the DER or the DER operator. Depending on the regulation framework, the Smart Meter can be owned by the DSO or by the end user. According to the regulations, it is also possible that the Measurement Operator/Data Provider – as a specific service provider will be an independent owner of the measurement information on the market. It can support all stakeholders in approving the operation.

A service provider, e.g., an ESCO, can also own a set of Smart Meters, depending on the regulation framework, as well as the scope of services offered.

Currently, we have only two services running in the energy management platform, i.e., the energy balancing service and the grid resilience service. They provide grid flexibility as a result of the local balancing and additional parts of flexibility when the Aggregator will request a change in energy exchange on behalf of market parties. Parts of these services can be run on behalf of different stakeholders (energy retailers, aggregators or service providers). Other services are possible to be provided in the future by the service providers. ICT providers provide the new software and hardware for the current and new services.

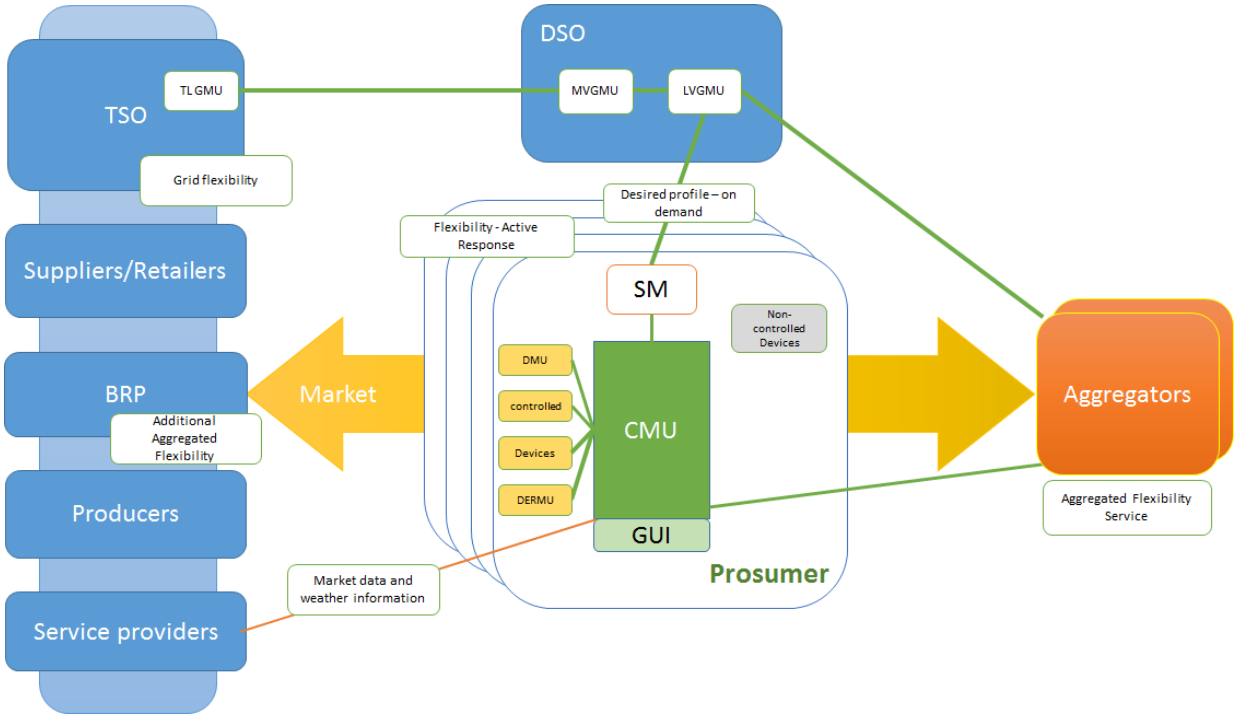

Figure 16: The e-balance system on the energy market

The e-balance system and his main tools and offered products on the electricity market are presented on Figure 16.

3.4 How to engage end users into the e-balance system

Any system that relies on the full participation of a large of variety of stakeholders will require the acceptance and cooperation of these stakeholders. This is especially valid if a large scale system to be deployed requires, besides the participation, cooperation and acceptance also the placement of hardware or software at the stakeholder's premises or property.

We have prepared a short analysis of real barriers concerning the involvement of stakeholders within the e-balance system. We also provide the possible methods to mitigate these barriers or indications on how to cope with them. Furthermore, different types of incentives to stimulate participation are shortly presented. Finally, we discuss a viable business scenario from the user's perspective to better visualize our proposed future system.

3.4.1 Barriers for stakeholders and how to mitigate them

We have identified real barriers for transforming the existing market model in the European countries to the level of the future market that incorporates a system like the e-balance system. Some of the most important barriers are listed in Table 12.

Most of these barriers depend on policy makers and regulators on the European level and individually in every country. The investment in DER, in dispersed generation and in high technology devices are supported by law, by national programs and by the EU funds, but in most of the countries (like Poland) the level of the investments is still rather low – except the situation in Germany. Therefore the National Regulators should work with all involved energy market business parties to prepare supportive national conditions for a new business framework. Proper signals to entrepreneurs and to the end users defining incentives, long term national and European strategies for energy market development, together with viable road maps with real goals to achieve and clear vision of benefits for all the parties are the basis for energy sector activation toward smart solutions on the future electricity market.

In the matter of the standardisation and data security, the existing regulations are not enough in context of the e-balance platform needs. Security is a crucial topic, which extends from the grid infrastructure right into the customers' homes. The introduction of new technologies into the smart grid introduces many new potential attacks that require innovative protection means. Furthermore, a large amount of private information can be unlocked and need to be dealt with in a secure and trustworthy manner. The e-balance is researching innovative means to protect user privacy[14].

Standardisation bodies like CEN, CENELEC or ETSI in cooperation with the International Electro-technical Commission (IEC) are responsible for interoperability of all new and existing devices in the whole business ecosystem of the future electricity market.

[14] The currently investigated approach is based on combining individually encrypted data to a single encrypted item. This can be done for values of a single user over time or for several users in a predefined area (neighbourhood). The combined item does not allow to connect user-IDs s to a certain measurement value.

Table 12: Possible barriers for stakeholders and the ways how mitigate them

No	Stakeholder	Barriers on the market	How to mitigate the barriers
1	Prosumers/End Users	• High costs of the needed investments in DER. • Long term contracts with the system owner. • Barriers related to the relationship with the DSO/aggregator/retailer and with new system utilization. • Fear about the personal data security. • Low amounts of additional income compared to investments. • Loss of comfort.	• National programs, start-up businesses, ESCOs activity, bank credits, leasing systems. • Adequate incentives and real tangible and intangible benefits are needed to get users involved. • Consumer must be in the centre of the DSO/ aggregator /retailer's interests. • Standardization and the data privacy and security prepared by standardisation bodies. • The e-balance system solution for data privacy and security. • Clear legal regulations concerning data ownership and data management. • Effective incentives and attractive market prices. • Attractive access conditions to the e-balance system.

2	DSO/TSO	• A new business model, with high investment risk and cost.
		• Investments in new infrastructure are costly.
		• Lower saturation in RES and Micro generation in users' houses than currently expected.
		• Not enough flexibility available for the DSO:
		  ○ Other stakeholders may have more attractive offers for Aggregators.
		  ○ Users cannot offer enough flexibility.
		  ○ Flexibility turns out to be unreliable.
			• Supportive national conditions for new and intensive business development.
			• Market and law support for the acquisition of new technology by users.
			• National programs and long term plans and roadmaps for European/national energy market development.
			• National programs and EU funds can help decreasing cost of investment.
			• Stable law for investors/investments.
			• Regulation mandates cooperation in case of congestion management.
			• Pilots experiences (demonstration projects) with a representative number of clients.

3	Aggregator	• This new function on the market in the area of e-balancing needs new applications, tools, devices which are very costly. • The requested amount of flexibility cannot be realised by the Aggregator.	• National programs and EU funds, start-up businesses, business cooperation with other stakeholders can help with R&D projects. • Increase the number of involved Users.
4	Retailer	• The requested amount of flexibility cannot be realised by the Aggregator.	• Increase the involvement of more Users.
5	Energy producers	• Unwilling to be supplementary producers.	• New business models for producers. • Market regulations to prevent negative prices.
6	IED Manufacturer	• New market with high input risk.	• Stable law for investors/investments. • Standardisation of Communication interfaces (Open Smart Grid Protocol for example)
7	Regulators/ Law Makers	• Lack of appropriate standardizations. • New regulations for unlocking market flexibility on the market. • New market regulations about price signals, tariffs preparation, users' data security, users' data access.	• Development of a common European legal solution. • European recommendations. • Stable National regulations. • The policy makers and regulators should prepare rules for unlocking market flexibility some propositions are pointed out in document D2.2

3.4.2 Users are key for the e-balance success

Considering the key conditions for the success of the e-balance system, one should put a spotlight on the stakeholders who are located in the centre of the electrical energy and business ecosystem. The activities of the end users will have the most important impact for the success of the e-balance system. That is why an effective strategy to convince, recruit and retain a sufficient number of engaged end users seems crucial (Table 13).

Table 13: How to encourage the users to use the e-balance system

Users behaviour[15]	How to encourage the users to use the e-balance system (strategy for the system owners)
• Customers can be unwilling to provide control over their devices and over their personal data. • Customers can be unwilling to provide too detailed measurements that make them scared about their privacy. • Customers only want to have lower electricity bills and savings from the new systems will be too low. • Customers do not see the benefits and profits for them. They do not want to cooperate and to take a risk in the development phase. • Customers want self-service advice, smooth experiences with new applications or tools, personalised information, predictive analytics and a good intuitive and automatic billing advisor. • Customers' satisfaction is driven by the service experience during the key moments that matter (the specific situation when they need help or advice). Poor performance on these key elements drives them nervous. These key moments are: alert about higher bill, need to contact with call centre, bill increase or a failure in the system. • The customer wants the right information at the right time.	• The utilities and new market players should change their strategy towards their customers. They need to take into account that the end users interests and their needs must come first. • Clear information about usage of the system and how to get the most out of its functionalities can cause the positive user attitude to the new system. • *A wide range of incentives, well prepared and personalized offers.* • Professional education about e-balance system and support in the system maintenance. • Easy-of-use GUI of the e-balance system application, • Useful system functionalities. Clarity and a user friendly framework with clear feedback from the system during e-balance execution. • Clear and easy prepared information on the bills. • Easy communication with the e-balance application. • Wide range of additional services offered to the users. • Effective marketing. • Effective service when errors and alarms occur. • Set of additional information/hints prepared for users: e.g. how to equip the home or flat with the smart appliances/sensors etc. • Additional supportive partner programs and social media support. • Development of other businesses correlated with the e-balance system, like: electric biking, car sharing access or discounts or other services based on the personal and real time data.

Taking this into account customers need support and education on all features of the e-balance system while it is introduced into the market.

[15] Based on [13][14] and users studies prepared in this project.

A distinction can be made between incentives during the operation (monetary, performance related) and incentives during the customer acquisition phase. The latter can also be of a non-monetary nature.

According to the social studies within WP2 of the e-balance project, one of the key elements of the e-balance system from the users' perspective will be the system application and its graphical user interface. An intuitive GUI will communicate with the system and the system will communicate with the user (see D5.2 for details [8]). The clarity and user friendly framework will be an issue of key importance.

Privacy and security of data in the system is of paramount importance. The client should be aware of his energy data value – such data can be sold to the balancing service providers returning lower energy bills.

The users of the system should get a positive and trustworthy image of the balancing activity. Such image should be a part of a strategy-based approach of introducing the e-balance to the market as a competitive product starting to fight for recognition and interest of potential customers, comparable to the strategies used to market a new tablet, a hybrid car or a home theatre system.

3.4.3 The incentives

The end users should be able to shift their load sufficiently to gain a financial or psychological advantage in order to create a desire to participate in the e–balance system. Besides the attractive price, additional incentives can be used to convince a user to be involved in this system. An incentive stands for a stimulus aimed to motivate final users to change their behaviours by offering an additional reward as a compensation for a certain action that they would otherwise not have undertaken. Such incentives can have different goals:

- to get potential participants to join the e-balance system in its introductory phase,
- to steer the users towards desirable long-term activities (shifting or change the energy consumption pattern), or
- to help the user with the home equipment with the smart appliances/sensors in the future.

Table 14: System of possible incentives

Monetary incentives	Non-monetary incentives
In order to be involved in the e-balance system	
• Tangible promotions: gifts, additional applications and smart appliances, maintenance service. • Additional monetary rewards partnership systems.	• Users' associations and Users' clubs, access to the exclusive smart and eco community. • Easy access to the smart appliances/sensors. • Gamification for Users' feedback. • Recommendations and free access to the Internet. • Expert's consultations and meetings.
In order to be an active consumer/prosumer	
• Rebates, monetary vouchers. • Tangible gifts. • Additional applications and smart appliances in promotion system, maintenance service - as additional benefit. • Subscription and license system.	• Virtual points/coins in Customer Loyalty systems. • Social gratifications. • Free additional supporting applications. • Attractive conditions for an access to charging points, EV renting/parking cars discounts. • General discounts with municipalities' collaboration (restaurants, cinemas, theatres, taxes etc.).
In order to equip a home with the smart appliances/sensors/e-balance system in the future (also see Table 12&13)	
• Financial programs. • Additional applications and smart appliances broad propositions to buy or easer possess from system providers. • Maintenance service offered as additional service. • Purchase taxes exemptions. • Rebates and favourable bank credits to support the acquisition of devices.	• DSM promotions, educational programs. • Legal regulations supporting users/prosumers[16] in their activation in the e-balance system. • Coalitions with smart appliances' deliverers and producers, home developers and ICT providers to support new technology development in buildings.
• Consumer's leasing, favourable credits. • Dedicated and recommended smart appliances with discounts. • More new appliances towards "smart" appliances at industrial level (manufacturers). • ESCOs support in RES /and the e-balance system development.	• Target advertisements and goods recommendations (technology and innovations for Smart Grid technology development). • Social media/mass media marketing activities to promote DSM/DR. • Maintaining service and investment advice of experts.
• Partners' systems and advertisements of smart installations. • Cooperation with vendors and real estate agencies.	• Advanced tutorials and guidance on regional and even national level.

The incentives (Table 14) provided to a customer can be individualized. More detailed decisions which type of incentives is worth to choose should be pointed out before commercialization process.

In many countries, systems of incentives for various types of appliances or investments already exist. Such initiatives increase the energy efficiency in users' homes or simply support users to save money and to participate in DSM programs.

Table 15 presents examples of the useful incentives when it comes to the replacement of the user's appliances by the smart ones.

[16] Some legal regulation proposals are given in D2.2. (T2.3) [8]

Table 15: Methods to support the user on equipping his house – examples

Incentives	Examples outside Europe	Recommendation in e-balance project
Rebates for new appliances or for recycling the old appliances (like refrigerator, TV set, dryer, dish washer or freezer, heat pump or air condition). The new devices should have an energy efficiency certificate A/A+ or A++	In the USA, CPS Energy offers $65 to recycle old refrigerators or freezers. The user can get $35 additionally, for buying a new unit (dedicated model, getting certification and being produced by dedicated business partners). The old unit must be produced before year 2004 and the new unit must be produced after 2012. The old unit must be picked up by the selected (recommended) business partner. http://www.cpsenergysavers.com	ESCOs can analyse the device or household data and draw conclusions regarding the efficiency of the devices. It is then possible for them to give specific offers regarding replacement of the devices or advice on how to use the devices differently, thus providing a highly personalised advice.
Sensors, dedicated plug on meters together with GUI interface.		We recommend adding this for free together with an in home display for e-balance apps. It can be a reward for getting contract accession with an aggregator or system contractor[17].
Smart appliances or very modern appliances/systems with time control and the possibility of usage shifting (home automation system or BMS).	In some countries it is recommended to give huge rebate for product purchasing or usage during first year.	Taxes exemptions for purchases. Recommendation for business partners to give rebates for product purchasing[18].
Batteries for energy savings and electrical cars.	In many countries it is recommended to give non-monetary privileges or rebates for product purchasing or usage during first year.	Recommendation and product certification will be the basis for credits or discounts. The usage of EVs on the preferable incentives (parking in the city centre or charging on the preferable principles with additional gifts, etc.).
PV installations, basic and with advanced system or modular system (on grid installations)	In some countries it is recommended to give a huge rebate for product purchasing or usage during first year[17] In the USA, each state has its own tax regulation and rebates tax for DER installations. Rules on: www.dsireusa.org	All methods can be recommended. The choice can depend on a detailed contract, country and user's preference. The PV installation should be prepared and made by a dedicated business partners
Smart energy program for new buildings or after renovation	Sample from USA: Smart Energy is a residential builder program offering rebates to local home builders for new construction.	Dedicated program prepared with incentives for developers and estate owners can be worked out. Tight cooperation with municipal authorities in recommended.
For easy design of the user's e-balance system – an additional service for configuration, reconfiguration and system maintenance is offered.	In the USA there is a very common supportive service in many other DSM programs. E.g. at http://www.wholesalesolar.com/ we can find: four steps how to design in an easy way your own system. It depends on the user's preferences.	This will be an additional incentive – because the users are rather non-balance system experts. List of recommended services: Lower your energy use – service for getting an advice how to decrease the electricity bill. Pick your components service (web site) – will give the user an approximate system wattage for getting an idea of cost and components needed for his system. How to set up your e-balance system, etc.

[17] As a promotion in the first year of the system deployment.
[18] According to partnership and cooperation in business between suppliers of IEDs and the owners of the e-balance system.

3.4.4 Business scenario recommendation and the preliminary implementation strategy

In order to better understand how the e-balance system *can be* introduced and operated, the user's business scenario has been prepared and presented in this section, as a probable one.

3.4.4.1 The equipment and beginning conditions

The e-balance system users will receive the necessary tools and system elements as home equipment devices. Additionally, they will have a GUI which is accessible from any internet device. After a testing period, they can receive those devices free of charge. In return they can have longer time contracts for the e-balance system subscription. In the in-depth process of learning how the system works and the possible benefits it can deliver, users will be able to learn how to use it, under the experts' guidance.

However, it is most important for the end users to be prosumers and that they have smart devices in their households. For that reason, users will receive professional support concerning best financial solutions such as the possibility of investing and owning installations. As such, the cooperation with ESCOs is expected. Some of the smart devices, such as refrigerators or washing machines can be given to the users for the time of program implementation. Users can also be able to purchase those devices at preferential terms from the companies if they will cooperate in the e-balance development program.

Both the ICT and weather forecast provider, as well as other essential service suppliers will collaborate with the e-balance users and will guarantee the proper access to customized information regarding the weather conditions and to the data and application module (ICT communication solutions).

Users can be informed upfront about the best manner of power supply and consumption by the executed energy audit. They will also receive the estimations on power savings, as well as the analysis of the predicted time of pro-ecological return on investment (including the pro-environmental effect). Such information can be the basic stimulus in the decision regarding participating in the e-balance system.

In the future, users will acquire the access to the system based on subscription and the purchased license for the dedicated tools. Without such subscription, users can have access only to the basic information web panel regarding the energy consumption and production; correlated with the supplier's application (client's service application). The DSO and aggregators have to cooperate closely with each other. In the beginning, the system will be tested in the background, i.e., users will be accounted according to the current rules, with which they are familiar. Simultaneously, users will be accounted according to the new rules related to the e-balance implementation. If users gain savings, they will receive additional gratifications. However, if they fail to save and have to pay more – they will be accounted according to the previous rules and prices.

3.4.4.2 How the system may operate

The users have a contract with a Retailer and an Aggregator. In order for this entire system to operate, the local energy and power measurements should be available with a time resolution of 15 minutes or better. A Smart Meter can be used to supply this information. Furthermore, integration of contract specifications in the Smart Meter will allow automatic configuration and registration services for the e-balance system, by means of EAN code and price information. It allows all users to be properly identified and their personal data to be correctly shared with the service providers. The users also have to agree that their contracted balancing partner will aggregate their data with that of other users for the purpose of balancing.

The user's e-balance enabled smart devices and appliances will communicate with the e-balance Customer Management Unit (CMU). The CMU is a device installed at the user's premises. It can either be supplied by the retailer, aggregator or bought at an electronics store by the user. In case the user does not have a Smart Meter, the user is responsible for acquiring measurement devices that are compatible with the e-balance system. The retailer or aggregator can specify by contract that a Smart Meter is required and will request priority instalment of a Smart Meter with the Metering Company. The user will interact with the CMU via an App, a PC program or a dedicated visualisation device. The CMU will supply the user an aggregation of both the energy consumption and production and can supply the user with insights into the energy dynamics on his premises.

The users have the possibility to provide their own consumption and/or production strategy and the ability to provide priorities regarding e.g. when they want to buy, sell or store the electricity. They are also notified of the current status of the grid, power quality parameters and the energy production limits. The CMU also provides forecasting of local energy production and consumption.

During the system's operation, the User's CMU receives requests from their contracted balancing partner (Retailer or Aggregator) to aid in realising a certain amount of power exchange at the given point in the grid. Based on the user chosen strategy for his devices, the CMU will calculate the amount of power/energy that can be exchanged in the specified time slots. The retailer or aggregator will negotiate with all its contracted users automatically to come as close as possible to the desired aggregated power exchange profile. Users are rewarded for the amount and quality with which they complied with the requested power exchange. The users interacting with the electricity grid in such a way will pay less for their energy than users that do not participate actively in the balancing system. It is also possible that other benefits as money are provided. For example, forms of customer loyalty programs. The retailer is responsible for providing the energy price calculation to the users.

The information and education module in the e-balance application are extremely important and have to be provided to help the users to choose a better strategy or contract. In the future, a retailer and aggregator comparison Apps or websites can be used to provide the users with the advice on which retailer or aggregator can provide the best service for the specific user, given the energy exchange details of the user, which are stored locally at the user's premises.

Regarding the communication with the users in the initial testing and the learning phase, there will be a way of direct communication with the system experts. Later, it will be available in a form of application module or a call centre. A contract binds the user with an aggregator, retailer and indirectly with his DSO, as well as with the additional service providers. User can still change his energy retailer regardless of other conditions. However, if the aggregator and the retailer supported the purchase of devices and e-balance system elements, the contract might bind the end users for a longer period of time.

The more detailed information about the contract conditions will be prepared in T2.5 after the e-balance first tests and users' feedback.

4 KPIs for measuring effectiveness of the e-balance system

This part of the document contains a proposal of the Key Performance Indicators (KPIs) enabling multi-faceted and multi-lateral evaluation of the system effectiveness. Aim of this list is to find measurable, accurate and precise quantitative indicators to be used in order to determine the level of achievement of the set goals and the expectations of both the creators and the users of the system. Performance will be assessed from the perspective of key players and processes.

The assumption in the selection of KPIs was based on establishing such indicators, which will be applied to all relevant areas and stakeholders of the system: economical / business, technological, social, ecological as well as compliance with the EU strategy of sustainable and secure energy ("20-20-20" targets). The benefits of the key stakeholders already mentioned in section 3.1 were the basis for the selection of KPIs. Common benefits of different players were sought. A mapping exercise was conducted to understand relations between e-balance benefits of the stakeholders and choosing the best KPIs. The e-balance project KPIs are presented in Figure 17.

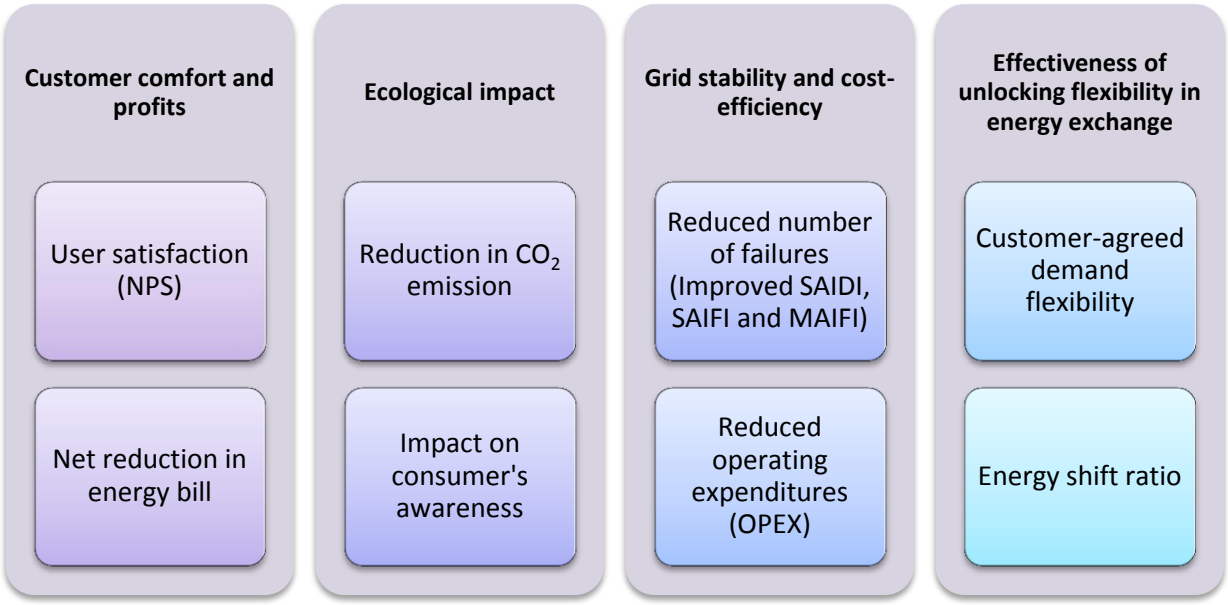

Figure 17: The e-balance Key Performance Indicators

While focusing on the expected benefits of the various stakeholders, keeping in mind users' expectations toward the system and objectives of the e-balance project, four main areas of effectiveness should be addressed. This selection of indicators is by no means exhaustive, but sets a list of variables to be used for closer and possibly multi-faceted evaluation of the system. It should also enable us to compare the e-balance to other similar systems.

The first group of KPIs is related strictly to the customers' profits and comfort. Potential users are, besides technology and algorithms, one of the pillars of e-balance system and their involvement (combined with satisfaction) sets our light in the project. Within this group of KPIs we open our ears on the voice of the customers by using the Net Promoter Score[19] (NPS) and observe real-life benefits identified as a key advantage in social studies.

The second area of KPIs corresponds to the environmental aspects of the system, or reducing negative impact on the environment. One of such positive impacts is increasing consumer awareness of electricity striving to make their behaviour more environment-friendly. The evaluation criteria proposed take their starting point from the perspective of awareness of consumers and in consequence, the reduction of carbon dioxide.

The third group of KPIs refers to the technical aspects of the network and DSO benefits, either represented by reducing the number of breakdowns and maintenance costs. At this point, we offer

[19] Reichheld F., 2003, Harvard Business Review, "One Number You Need to Grow"; http://hbr.org/2003/12/the-one-number-you-need-to-grow/ar/1 [09.2015]

proven, widely known and recognized indicators i.e. SAIDI, SAIFI and MAIFI[20] followed by the reduced grid operating expenditures (OPEX).

The last group of KPIs refers to the effectiveness of unlocking the flexibility in the energy exchange. As mentioned in the previous sections of this document, e-balance was created partly to enhance the energy market flexibility by increasing the free flow of energy and the associated monetary value. The aim of e-balance algorithms is to increase the quality of the daily power profiles that are well planned and tailored to the behaviour and habits of users. Seamless power management should convert into greater customer-agreed energy exchange flexibility, which in turn will allow more flexible management of energy flows in the network.

Briefly speaking, these four groups of KPIs refer to core aims of the system, which are:

- Effective balancing of costs and benefits related to energy production and consumption by prosumers and consumers.
- Increasing the comfort and security of grid users.
- Increasing the network reliability.
- Increasing the local consumption and deployment of DER.
- Reducing the CO_2 footprint.
- Increased flexibility in energy exchange.

4.1 Customer comfort and profits

The e-balance system is designed with respect to the end user's needs and preferences. We have learned from social studies that comfort, savings or earnings and conversion towards an integrated local community of prosumers turned out to be crucial factors of system acceptance. Thus, a group of KPIs for this area is suggested.

One of the project's aims is to increase comfort and benefits of the end users. A measurable, reliable and accurate KPI should address at least three areas.

The first is *customer's satisfaction.* Typically, *customer satisfaction* should be high and result in the willingness to recommend the system to others. This is particularly important at the beginning of the roll out when the system will need ambassadors, innovators and pioneers who will advocate this solution to their acquaintances, friends and family. We choose NPS measurement standard to determine this KPI. It is a widely known, easily understandable, accurate and reliable method in the field of social sciences for measuring satisfaction based on coherent model recommendations. The Net Promoter Score is a customer loyalty indicator calculated by answering a simple question: *How likely is it that you would recommend our company/product/service to a friend or colleague?* The range of answers is based on a 0 to 10 scale (very unlikely vs very likely). The NPS is calculated by difference of percent of Promoters (score from 9 to 10) and percent of Detractors (score from 0 to 6). Such difference creates the NPS index, which can range from −100 (everybody detracts), to +100 (everybody wants to recommend). Positive NPS (better than zero) is considered as good, and an NPS of 50 or more is excellent. Net Promoter Score (NPS) measures the loyalty between a system provider and a consumer / user. NPS offers numerous benchmarks, an intuitive methodology and the possibility of constant pattern analysis, making it easy to interpret.

The second KPI concerns the actual savings on the electricity bill. Net reduction of the monthly paid electricity bill compared to the payments from last year in the same period of year (respective month) is a simple and tangible indicator referring to the key motivations of users and sets a universal benefit. Such a comparison would reveal long-term effects of the system as well as eliminate seasonal effects (such as winter heating), but it should take into account the external conditions (e.g. weather conditions between two consecutive years) in order to obtain a correct interpretation of deviations.

Table 16 shows the definition of KPIs in the first (customer benefits-oriented) area, indicating the reasons for the inclusion of the indicator, relevant stakeholders and the measurement unit.

[20] explained in section 4.3

Table 16: KPIs – Customer comfort and profits area

Factor	Description	Measurement unit	Stakeholders involved	Reason to include
User satisfaction (NPS)	Asking one question provides a clear measure of system performance through customers' eyes. This question is "How likely is it that you would recommend the e-balance to a friend or colleague?" Customers respond on a 0-to-10 point rating scale and are categorized as follows: Promoters (score 9-10) are loyal enthusiasts. Passives (score 7-8) are satisfied but unenthusiastic customers. Detractors (score 0-6) are unhappy customers who can damage the system image through negative word-of-mouth.	This indicator calculated by answering a simple question: How likely is it that you would recommend our company/product/service to a friend or colleague? The range of answers for is based on a 0 to 10 scale (very unlikely vs very likely). The NPS index is calculated by difference of percent of Promoters (score from 9 to 10) and percent of Detractors (score 0-6). Only positive results will be accepted.	User (SME/regular household), retailer, DSO	Widely known, understood, accurate and reliable method for measuring satisfaction based on coherent model recommendations. Easy to interpret offering numerous benchmarks, intuitive herein, constant pattern analysis.
Net reduction in energy bill	Net reduction of monthly paid electricity bill compared to the payments from last year in the same period of year (respective month). Such comparison would reveal long-term effect of the project as well as eliminate seasonal effects.	The difference in the bill in EUR (next year compared to the previous one – same month). Difference between measured and reference data multiplied by price. Negative value indicates satisfactory effect of the system. If result of the calculation is positive the system may not have a positive impact. Decrease of at least 5% will be considered as an indicator of success.	User (SME/regular household), retailer, DSO, Aggregator	Additional value enabled by e-balance for the user is a lower electricity bill. We suggest it as a simple, tangible indicator referring to the key motivations of users and the universal benefit.

4.2 Ecological KPIs

The second area of system performance indicators includes factors related to improvement of environment protection and users' awareness improvement. Environmental effects are based primarily on increasing the share of energy from renewable sources and energy saving by increasing awareness.

The first category relates to the reduction of CO_2 emission. Amount of kWh of energy from renewable sources injected to the electric grid as a consequence of the e-balance system. By comparing this amount over a period of time with similar period without the system, we obtain an improvement ratio.

The second KPI is related to user's awareness and engagement. The e-balance system will interact with its users via a GUI by using a browser, mobile phone or in-house display application. These interactions will include tips for energy saving, pro-ecological persuasion and stimuli to change behaviour into more sustainable. We are not able to control the user's behaviour and do not assume that it depends entirely on interaction with the system. However, we can assume that time spent with the system applications will effect in assimilating (by active interaction with the system [16]). I.e. more pro-environmental tips and desired behaviours can be presented to the user and thus help persuading the user to modify his routines. Table 17 shows the definition of KPIs in the ecological area, indicating the reasons for the inclusion of the indicator, relevant stakeholders and the measurement unit.

Table 17: KPIs – Ecological area

Factor	Description	Measurement unit	Stakeholders	Reason to include
Increase of renewable energy fed into the grid	Amount of kWh of energy from renewable sources injected to the network through the e-balance system will be an alternative for the same amount of dirty energy from fossil sources.	Amount of KWh of "dirty" energy replaced by clean energy by the e-balance system. It will be calculated by increase of "clean" energy produced by RES (KWh) compared to amount injected without e-balance within the same timeframe and similar period within year span. Increase of 3% will be considered as achievement by this KPI.	Regulator, User, Aggregator, Energy Supplier (producer)	The pollution reduction is one of the objectives of the project. It does not refer to the key functions of the system, but shows its ecological potential.
Impact on consumer's awareness	Site centric IHD / feedback system statistic + sensors	Amount of time (hours) spent weekly interacting with the system. At least 15 minutes weekly spent on interaction with the system will be considered as satisfactory.	User, Aggregator, Regulator, DSO, Retailer	Increasing awareness is a prerequisite for user involvement. Such user is probable to become a smart consumer / prosumer and promoter of the e-balance system within his social group and/or in social media.

4.3 Grid stability and cost-efficiency

Increasing the stability and safety of the power grid is one of the main purposes of the implementation of the e-balance system. The benefits of achieving these objectives serve all stakeholders. The e-balance system can increase reliability (considering the energy resilience functionalities) and service quality levels as perceived by the customer and grid operators. The main actor involved in ensuring the stability and reliability of the grid is the DSO. The e-balance system provides the DSO with new options to provide a more stable power flow, with less losses and faults. New investments into the network can be delayed or avoided entirely, generating considerable cost savings. Optimization of the electric grid decreases losses and increases operational efficiency and, as a result, causes an OPEX reduction for the DSO. We base the KPI for this section on this actor's savings.

Continuity of supply and avoidance of failure is a crucial intangible advantage. It creates a feeling of satisfaction and reliability for the user and avoids costs for the DSO. Any grid failure is felt considerably, which translates into a decrease in user comfort and costs of repair. Thus, we refer to the measures of SAIFI, SAIDI and MAIFI to monitor this area of KPI:

- Improved SAIFI - System Average Interruption Frequency Index – measurement for the particular year with e-balance compared to the previous one.
- Improved SAIDI - System Average Interruption Duration Index – measurement for the particular year with e-balance compared to the previous one.
- Improved MAIFI - Momentary Average Interruption Frequency Index – measurement for the particular year with e-balance compared to the previous one.

We also want to monitor system performance on the business level. It is hard to extract pure net effect of the system functioning within a complex and dynamic energy system, even if we limit our scope of interest to DSO's statistics. On the other hand we want to choose a well – known and widely used indicator with solid theoretical and technical background. It should be related to business and financial parameters which are monitored, analysed and archived in almost every organisation. OPEX is a business - level financial indicator related to the grid operating expenses (covered mainly by DSO and TSO). A sum of grid (or its part) operating expenses for a period of time, in our case a year would settle a measurable factor to be compared as KPI. We suggest to use the total amount of expenditures (EUR) yearly spend on grid operation (with the e-balance) compared to previous years (without the system).

Table 18 shows the definition of KPIs in the grid stability and cost-efficiency area, indicating the reasons for the inclusion of the indicator, relevant stakeholders and the measurement unit.

Table 18: KPIs – Grid stability and cost-efficiency area

Factor	Description	Measurement unit	Stakeholders	Reason to include
Reduced number of failures (Improved SAIDI, SAIFI and MAIFI)	Continuity of supply and avoidance of failure is a crucial intangible advantage creating the feeling of satisfaction and security. Any grid failure is felt considerably, which translates into a decrease in user comfort. Three measures will monitor this area of KPI: Improved SAIFI - System Average Interruption Frequency Index – measurement for the particular year with the e-balance compared to the previous one. Improved SAIDI - System Average Interruption Duration Index – measurement for the particular year with the e-balance compared to the previous one. Improved MAIFI - Momentary Average Interruption Frequency Index – measurement for the particular year with e-balance compared to the previous one.	SAIFI is the average number of interruptions that a customer would experience, measured by number of them counted per year. SAIDI is the average outage duration for each customer served, measured by number of outages and their duration in minutes. Decrease of 10% compared to previous year (without e-balance) will be considered as system satisfactory performance.	DSO, User, TSO	Commonly used as reliability indicators by electric power utilities.
Reduced operating expenditures (OPEX)	Business - level financial indicator related to the grid operating expenses. A sum of grid (or its part) operating expenses for a period of time, in our case a year.	Total amount of expenditures (EUR) yearly spend on grid operation (with e-balance) compared to previous years (without the system). Reduction of 3% costs versus past year (operating without e-balance) would be considered as system success.	DSO, TSO	A well-known widely used indicator with solid theoretical and technical background. Related to business and financial parameters which are monitored, analysed and archived.

4.4 Increased grid flexibility and capacity in energy exchange

The last, fourth area of system performance indicators includes factors related to the increased flexibility in energy exchange and grid capacity. One of the major objectives of the e-balance system is to increase flexibility by using balancing algorithms in order to match the consumption of electricity to electric grid conditions, DER generation and market conditions.

This effect can be stimulated by monetary rewards, informational support or psychological rewards for the end users. Users get rewarded in ratio for their contribution to the balancing process.

We plan to measure how good the e-balance optimises the energy usage and how good our algorithms are in unlocking flexibility. These algorithms, generally speaking, do their best to adjust (at the Aggregator level) the current power profile to the desired one.

Aggregation of produced energy and balancing it on the level of local neighbourhoods contributes to increasing the importance of small producers in the power grid and increases both the total volume of electricity, as well as the possibility of using it locally.

Table 19 shows the definition of KPIs in the area of increased grid flexibility indicating the reasons for the inclusion of the indicator, relevant stakeholders and the measurement unit.

Table 19: KPIs – Increased grid flexibility and capacity in energy exchange

Factor	Description	Measurement unit	Stakeholders	Reason to include
Customer-agreed demand flexibility measured by quality of achieved power profiles	The e-balance system algorithms, work to adjust (at the Aggregator level) current energy balance profile to the desired one. Using various measures of fit and compatibility of the desired profile and the resulting one can determine how effective the various methods are correcting energy use and production at Aggregators level.	Determine the Euclidean distance between the desired power profile and the realised power profile and use this as a measure for how well flexibility has been utilised. Any reduction of the distance compared to system operating without the e-balance will be considered as satisfactory.	DSO, User, Aggregator	Refers to the core functionalities of the system and its main objectives.
Energy shift ratio	The amount of flexible energy (shifted during consumption) will reveal the efficacy of shifting demand algorithms. KPI is counted in flexible energy KWh compared to the average daily consumption (ratio).	Shifted energy (KWh) divided by total average daily consumption. We expect min. 3%-5% of energy usage will be shifted daily.	DSO, User, Aggregator	Refers to the core functionalities of the system and its main objectives.

5 Conclusions

The e-balance project proposes the balancing and grid resilience services realized within the *e-balance system*. It adds flexibility in energy exchange to the energy mix as a complementary means to maintain balance between the supply and the demand of electrical energy.

This deliverable of the e-balance project describes the analysis performed on how the flexibility in the energy exchange can be unlocked from the market, as well as from the social perspective (*Business Aspects of the e-balance system*).

The proposed system will be fully compatible with the current market model. The bottom-up approach with the Triana algorithm will cooperate with the Day Ahead and the Intra Day Markets preparing a sliding 24 hour aggregated load portfolio, corrected every 15 minutes (or less). Longer or shorter planning periods are provided by default, covering the Intra-Day market. The Intra-Day market, depending on the electricity market type, presents typically a time-step of a full or half an hour.

From the business and socio-economic view, a smart grid system, like the one the e-balance project proposes, fully unlocks and enables the under-utilised part of the energy market addressing the influencing of the energy exchange behaviour of end-users.

An in-depth analysis of the value added to the value chain of the electricity market was shown pointing out the benefits for each recognised stakeholder.

The overall price mechanism between the most important stakeholders/and system owners shows that a win-win strategy will allow to achieve monetary and non-monetary benefits. We decided to recommend using ToU dynamic tariff on the market as well as a set of monetary and non-monetary incentives to encourage prosumers into being active in our system (changing the usage based on signals coming from the system). A non-monetary incentive can be the local energy mix to indicate how much of the withdrawn energy is or will be from renewable sources. It is clear though, that an in-depth sensitivity analysis should be prepared to check the possibility of real monetary results (savings) for prosumers and for other stakeholders when the system will be introduced to the market.

In the ownership analysis we pointed out that our system is fractal-like and also that it needs many sub-owners. As such, the e-balance system should be seen as a platform that can be managed and owned by several stakeholders that can be responsible for some of the devices or functionalities. The grid operators will be prominent in their role as the utility and will be the owners of the e-balance infrastructure components. The customer management unit ownership will be determined by local social choices and most dominantly by the contracts that Energy Retailers and Aggregators will come up with. We envision scenarios where the customer management unit will be bought by the customer at an electronics store, but also where the Energy Retailer or Aggregator will be supplying the unit as part of a contract.

Furthermore, KPIs were proposed for measuring the effectiveness of the e-balance system. These indicators allow assessing the effectiveness of the system in a quantitative and concise way. We have defined four areas of the evaluation respecting to the customer comfort and profits, the ecological impact of the system, the grid stability and cost-efficiency, as well as effectiveness of the flexibility unlocking in the energy exchange. Within these four areas, we plan to monitor the KPIs relating directly to the objectives of e-balance.

The e-balance system brings opportunities to contribute to the current electricity market on local and regional level and to solve some of the current challenges of electricity grids, and providing some meaningful benefits to different stakeholders of the energy system.

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APPENDIX A

Main stakeholders and SWOT analysis for proposed services

Main stakeholders (for whom the e-balance system is dedicated) and a description of the high level general functionalities (how the system will work) are provided in Table 20Table 20. Within the e-balance general requirements, active consumer response and a consumer centric approach are considered.

Table 20: For whom and how the e-balance platform will be implemented

Stakeholders	Requirements and general functionalities
Consumer /prosumer (customer)	• Has a contract with his supplier/aggregator. Agrees upon a protected and secured access to his aggregated measurement data for other local customers, when the local energy balancing flow is considered. • Also gives access to his (consumer's) strategy for his aggregator/DSO/ supplier. • Has installed smart meter related equipment (Graphical User Interface (GUI), display monitor interface) enabling aggregation of both the consumption and production of energy. Furthermore, in his local area information about the state of the grid and the need of production and consumption is presented. • Has the possibility to provide his own consumption and/or production strategy and the ability to provide priorities regarding e.g. when he wants to buy, sell or store the electricity. • Is notified of the current status of the grid, power quality parameters and the energy production limits. These are especially important in case of an outage and limiting conditions during islanding. • Has tools for forecasting his own production and consumption. This will be combined with information about future consumption in his local area, provided by an aggregator or the DSO. (It will be given as the amount of power/energy and as price indications.) • Has to be able to define his data storage preferences, He has the possibility to remove data and can define the frequency of its collection. • Receives impulses from energy supplier/aggregator/DSO which can influence the implementation of his strategy of stored energy (charging/discharging, EV usage) mainly by prices, and amount of energy to buy/sell. The DSO/aggregator should have the ability to directly access customers' appliances for controlling and steering purposes, if agreed upon in the contract. They can control the customers' devices to follow the customers' strategy. • Has intelligent appliances for which he can specify constraints with respect to its operation (maximum energy consumption, production, time regime etc.) The appliances should have a possibility to set their parameters automatically or manually. The main parameters and functionalities that the customer can read, prepare, send and modify by his GUI are: • Limitation of the power/energy amount provided to the grid production (according to his own production possibility) , • Limitation of consumption (priorities signals of limitation are received). • Demand and response program, tariffs. • Information and advice on energy efficiency savings. • Information about production and consumption in the local area. • Sending responses to the control signals to the

	DSO/supplier/aggregator. • Information about the financial benefits (estimated profits at the time and in the particular currency) from being in the e-balance system.
DSO/aggregator	• The DSO has his own strategy for the production and consumption of energy by all consumers in the local area. It has a production and consumption short-term forecast for the considered area. • The DSO/aggregator checks forecast information about the amount of energy to be produced and to be consumed and decides to buy, to sell or to steer directly some customers' devices and influence the strategy by sending signals to the consumers. • The DSO /aggregator has to react to all grid signals and adjust its own strategy in time. • Has contract with prosumer/consumer for the e-balancing service • The DSO delivers data to the GUI as well as open and easy access to the information about consumer's usage, parameters, all *important information and steering signals* (it will be specified in WP3, in T3.1 and T3.2) current status of the prices, data about contract etc. • The DSO/aggregator can monitor and control the amount of the energy produced by consumer to prevent failures. Therefore the DSO establishes together with the customers the energy production limits and energy production parameters in case of an unbalanced situation in the local area. • Could have an extended contract (demand response agreement) and can intervene or apply steering signals to consumer's strategy and appliances when there are grid limitations or in case of an outage. • In the mutual obligations in the agreement (between the DSO and consumer/prosumer), the fixed amounts of the energy to be produced and consumed are described. Surplus and shortages will be treated at extra rules of settlements. **Notice**: the DSO/aggregator should have some tools to optimize the power flow management. The DSO should give the access to the e-balance system for every customer who is willing to be involved in the system through the selected installations of sensors. If other appliances are required they will also be delivered.
Suppliers/Retailers	• They have a contract with the customer. • According to the customer's activities in the energy consumption and production and according to consumer's strategy they have to account and settle a bill for either buying or selling the energy, using consumer-specific dynamic tariffs. • They will provide real-time wholesale price information and energy efficiency price signals from the market. • They have to analyse the ability of increasing the income (of customers/prosumers) by preparing suitable price offers. • Retailers or ICT providers can deliver to customers the weather forecasting tools for production and demanded prediction.
Microgrid Operator	Microgrid can be seen by the DSO like a single customer and inside the selected area, the customers can be seen in the same manner as different appliances at home. Of course, the prices and the needs will be different.
ICT Providers	Provide means and all back office systems and mobile mechanisms, as well as sensors connected to the Internet. This is to provide an easy access via the internet or a web portal in order to make smart decisions. Furthermore, information and signals can be spread via the Internet to all actors involved.

	Maintain and provide the web portal and ICT systems for getting access to customers' portals. They should install the connection to fast internet (high bandwidth and low latency).
Building Management System Providers	They should ensure the compatibility and interoperability for both systems especially when we think about the consumer's strategy driven decisions and consumption and production forecasting.
Property owners	They can allow installing the connection to Internet and to the Home Area Network (HAN) infrastructure on their properties.
Home appliances vendors	They can develop their own business models for the smart appliances market. The use of standards to guarantee interoperability is utmost importance.
Municipalities	They should support the actions of consumers, prosumers or the DSO and aggregators in increasing the energy efficiency.
Regulatory Bodies	Have to adapt regulations. Especially in the area of data protection and security. Detailed information how to adjust the electricity law and regulations is available in deliverable D2.2.

All main functions and processes mentioned in Table 20 for the most important stakeholders are presented in diagrams using UML - The *Unified Modelling Language* below; Figure 18 and Figure 19.

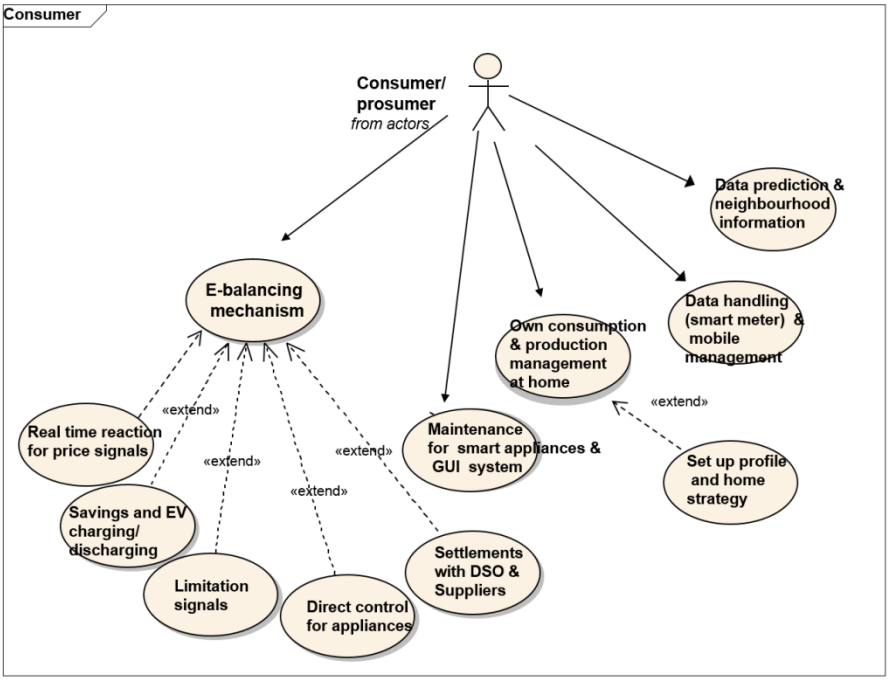

Figure 18: Functions for the customer/prosumer in the e-balance system

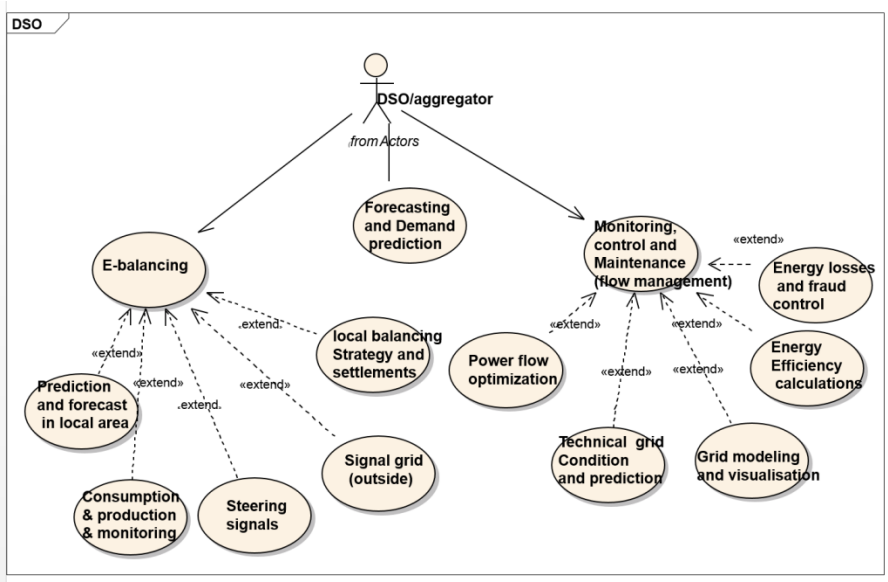

Figure 19: Functions for the DSO\Aggregator in the e-balance system

The next set of tables (Table 21, Table 22, Table 23, Table 24, Table 25 and Table 26) present the main benefits (strengths), weaknesses, opportunities and threats (SWOT analysis) for all segments of actors involved in the e-balance system.

Table 21: Customers (consumers/prosumers) SWOT analysis

Strengths (benefits)	Weaknesses
• **The technology deployment of smart meters assures that the customers may easily accept the installation (cornerstone of the e-balance system) because of the product's maturity (solid tested product) and the offered service. This service allows to know the energy consumption patterns more accurately than only through the energy bills.** • **The customer can have real benefits if the pricing strategies and optimisation mechanisms reflect balancing benefits. (According to surveys a minimum of 30% energy savings (electricity usage) has been assumed).** • **Customers receive real time information about the possibilities of local balancing (and in an easy way i.e. via GUI). This means attractive possibilities for changing their own strategies to increase their income.** • **The proposed system allows customers to increase their awareness regarding energy savings. They will be able to manage their own energy through changing production- or storage-strategies and consumption priorities, which leads to realising that different energy saving levels, can be achieved.**	• Consumers might worry about their independency. They are worried about their measurement data and privacy. • Relations between energy strategies (mix of production, storage, and consumption) and the energy/money savings have not been demonstrated yet due to the limitation of micro-generation and energy storage technologies. Customers usually distrust new things especially if actual incomes are not clear enough. • The balancing system will be poorly suited to the consumers' practical needs. The system can require a behavioural change of the consumer to obtain full scale of its advantages. • The complexity of the e-balance system for customers is one of the first barriers to be defeated. This complexity should be reduced with intelligent systems that guarantee the customers' profits with an unattended control. Customers should be free to decide whether they want to interact with the energy market, without any disservice. • Inexperienced customers can be worried about making wrong decisions in their energy strategies or priorities. The system should guarantee a minimum level of profits

• They have additional service applications and tools such as: short time forecasting tool, the information about neighbourhoods' activities, advanced GUI, or Internet portal. • Can have additional incomes from direct control management (operational direct control signals form the DSO or aggregators to consumers' appliances) contracts. • Through the information exchanged and distributed by all users, customers can know with a benchmarking analysis (ranking) if there are chances to improve their energy behaviour or upgrade their energy appliances to get a better performance and more savings.	
Opportunities	**Threats**
• Customers can use new technologies (micro-generation and storage) to improve their position in the energy market, reducing the consumption and increasing savings. • The information about the current energy price allows customers to assess if the energy market rules meet their needs and protect their current standard of living. • Services from ESCOs by aggregation of renewable energy production, storage or electric vehicle charging stations etc. • The forecast of energy/weather parameters allows customers to anticipate the best conditions for the next days (referred to their comfort and behaviour). • More balanced network with smaller need of new investments consequently gives less cost for customers.	• The technology evolution may upgrade appliances and facilities of new customers (more power, efficiency or flexibility). • In competitive models, a balance situation which does not allow other players to increase their profits might occur. In such case, the customers can feel cheated by the new system. The presentation of possible scenarios without the new system is recommended to motivate e-balance users. • Low saturation of the DG does not allow developing all benefits and the potential of the e-balance system, which can present this solution as inefficient. • Price mechanisms could be perceived as little effective. • The risk of incompatible smart appliances being produced by different manufacturers (e.g. different communication standards, ports) can result in customers wasting their money and time.

Table 22: Energy retailers or aggregators SWOT analysis

Strengths (benefits)	**Weaknesses**
• The e-balance system provides retailers an in-depth control tool to manage all their customers. • Can detect easier any fraud in the LV grid through the monitoring system and balance calculation. • Can update/calculate energy profits at the same level of granularity as the energy consumption/production of the customers. • Can remotely connect, disconnect and change	• Inaccurate predictions can cause the energy retailers to lose money due to the transactions of daily and intraday energy market. • The level of complexity of settlements with all balancing parties increases and will be much more exposed to errors. • Errors in measurements cause energy retailers to take wrong decisions that can punish customers unfairly. The support of state estimators can fix or

the energy tariff of their customers. • **Can apply demand response and demand-side management strategies if customers allow them to control some appliances (priorities) or facilities (generation) to reduce the energy in peak hours.**	reduce the impact of this issue. • Installation of this system for distant or isolated customers can be expensive (individual nodes, routers and other ICT facilities). • Demand response and demand-side management depend on the customers' premises and contractual obligations. Only users owning smart appliances and dedicated means have a possibility to be the e-balance system users.
Opportunities	**Threats**
• **Can offer their services online (e.g. via Internet) without personal interaction.** • **Can prepare more attractive tariffs/contracts/discounts to increase the number of customers.** • **Advanced tools give more suitable answers for consumers' expectations by providing customers' service in settlements.** • **The Management of micro-grids or high number of customers' aggregated (power and energy demand) make it easier to obtain better prices at auctions. This benefit is propagated to customers.** • **Can find synergies with other types of services (telecommunications, TV, etc.) to offer special tariffs.**	• The saturation of the local energy grid can further limit the energy efficiency decisions and can make the energy management harder or not satisfying in comparison to promised commitments. • Economic balance of costs and profits does not guarantee the repayment in the agreed period adopted by participants. • Loss of a considerable amount of customers in short-term can increase energy prices. Therefore it may affect the rest of customers (propagation).

Table 23: Distribution System Operator (DSO) SWOT analysis

Strengths (benefits)	Weaknesses
• **The main benefits for the DSO are increasing the energy efficiency and reliability, which increases the profits.** • **Less losses due to the balancing between consumption and generation and prediction.**	• The level of complexity of settlements with all balancing parties increases and will be much more exposed to errors. • The energy loss estimations from different grid locations could show different accuracy level depending on the kind of facilities and weather conditions. Correction factors are needed.
Opportunities	**Threats**
• **Can evaluate the profitability of the grid expansion through simulations, e.g. the penetration of new production/storage technology (optimal investments).** • **More automation in the grids gives opportunities on grid management and in reducing of outages.** • **Innovation project gives possibility of receiving rewards from the local regulators and the EUC.**	• More information in the grids needs more knowledge and experience with ICT which may make the system difficult to manage at the beginning.

Table 24: Microgrid Operator: SWOT

Microgrid Operator: SWOT for Microgrid operator consists of the combined features of the SWOT for DSO and energy retailers.

Table 25: ICT providers / Appliances vendors / Property owners / BMS provider SWOT

Strengths (benefits)	Weaknesses
• **The interoperability of the system simplifies the installation of devices (e.g. wireless technology).** • **The compatibility with previous smart-home appliances allows reusing conventional devices.**	• They have to ensure the reliability of web site operation and services. • BMS and the e-balance systems must be fully interoperable. • They must learn to install, use and program the necessary devices of the e-balance systems (resistance to change). • Owners cannot afford the installation of advanced sensors and systems in their buildings.
Opportunities	**Threats**
• **New business opportunities - ICT can expand the smart-metering market in order to deliver it to every kind of energy customer.** • **Appliance vendors and home developers can expand the intelligence appliance catalogue. They also can offer new services related to the implementation of strategies and energy consumption priorities manually, automatically, or remotely controlled by, for instance, the DSO.** • **Short/medium-term support for the provided systems.** • **Increasing the property values (for property owners).** • **Development of new solutions and services gives more income for ICT providers.** • **New solution can be later sold to others beneficiaries with some adoptions and can give new business model opportunities for them.**	• Home appliance vendors can suffer sudden changes of standards

Table 26: Municipalities / Regulatory Bodies SWOT

Strengths (benefits)	Weaknesses
• **They can use the monitoring and control features of e-balance to optimize municipal systems for instance public lighting.** • **Regulatory bodies can roll out in short-term European Directives encouraging e-balance approaches.**	• Depending on the level of technology implemented in the city, the building supply can be difficult to be modernized without national grants or the help of energy companies (ESCOs). • Public entities cannot take the advantage of off-peak hours due to their inactivity. In this case they should install storage/production

systems.

Opportunities	Threats
• **Municipalities can add new rules to the local business model and take the advantage of aggregating several public buildings, using renewable energy or CHP, storage systems, etc.** • **They can pave the way to modernize the city and move it towards the smart-city model. They are able to do that by installing electric charging stations and generation/storage systems, which constitutes energy/money savings and better environmental protection.**	• Development and deployment of new technologies depend mostly on grants and people's acceptance. Advertisement campaign usually solves the lack of people's awareness. • The energy poverty can force to an additional effort to avoid the discrimination due to flexible tariffs and old-fashioned metering systems in some sectors of the population. • Little interest in cooperation with other market actors in the new business model.

Table 27 has gathered main stakeholders and a description of high level general functionalities considering the second service: Grid Control and Monitoring.

Table 27: For whom and how the service: "Grid Control and Monitoring" will be operating

Stakeholders	**Needs and general functionalities for EMS (system for power flow recognition, quality grid monitoring, resilience and self-healing)**
DSO	• The proposed system allows recognizing the energy flow in MV and LV (identifying DER and centralized power plants by their capacity and location in real time). Moreover, it allows using grid modelling and visualization for the current or time specific power flows. Data retrieval from other ICT devices and grid devices will be possible. • It allows predicting the technical conditions for energy flows and electrical infrastructure assets (the grid configuration when faults are detected or the grid is restored by self-healing). • It allows calculating the optimal power flow based on the capacity of demanded and generated energy at a specific time. It should provide the possibility to identify a list of switching operations that need to be performed within the distribution grid. • The energy efficiency indicators for every MV-customer and every neighbourhood can be calculated. • The system enables economic calculation of the minimum costs and the maximum demand generation with the minimum energy loss, broken down by transportation energy losses and fraud events and losses and unexpected energy consumption in a neighbourhood (for example due to energy fraud). • It enables the calculation of the amount of energy losses and energy waste due to the lack of demand or higher generation.
City municipality	• The system enables control of QoS indicator for the city management. • Gives information for economic calculation of the energy efficiency indicators. • Facilitates the monitoring of public lighting circuits (fault detection).
Customers	• The system enables the monitoring of the QoS for customers, prevents frequent breakdowns and gives protections from failures. Moreover, it calculates the optimum energy production of prosumers.
Suppliers/Retailers	• The system increases the reliability of the energy delivery and the customer satisfaction.
Notice:	For better understanding of the processes that occur inside the system we should simulate the electricity – storage mechanisms and EV penetration in LV and MV grid. It is because in current systems the penetration of EV and electricity storages reaches quite a low level.

The next set of tables (Table 28, Table 29, Table 30, Table 31, Table 32 and Table 33) present the main benefits (strengths), weaknesses, opportunities and threats (SWOT) for all segments of actors involved in e-balance solutions for Grid Monitoring and Control.

Table 28: Customers (consumers/prosumers) SWOT

Strengths (benefits)	Weaknesses
• **Prevention of breakdowns.** • **Additional protection against failures.** • **Optimization of the energy production**	• Consumers need training to understand the role of the local energy generators.
Opportunities	**Threats**
• **Through a benchmarking of the energy efficiency of generation systems in the neighbourhood, customers can recognize if their production systems should be replaced or updated with new technology.** • **Can take the advantage of ESCO solutions regarding maintenance contracts and facility leasing.**	• Prosumers' facilities can be disconnected remotely if they do not meet the QoS indicators or the energy costs are higher than other generation systems. • Security and privacy issues related to cyber-crimes.

Table 29: Energy retailers or aggregators SWOT

Strengths (benefits)	Weaknesses
• **The e-balance system provides an in-depth control tool to manage all customers with a finer granularity of energy parameters.** • **Can detect any fault in the LV grid easier through the monitoring system.** • **Can redefine rated power and other energy parameters of their customers remotely.** • **Can apply demand response and demand-side management strategies if customers allow them to control some appliances (priorities) or facilities (generation) to reduce saturation level of lines.**	• Inaccurate predictions can imbalance the LV grid. The support of state estimators can fix or reduce the impact of this scenario. • The level of complexity of settlements with all balancing parties may increase and the procedure will become more error prone.
Opportunities	**Threats**
• **Can offer their services on-line (e.g. Internet).** • **Can detect the necessity of grid expansion or oversized lines thanks to the more accuracy of the historic data.**	• The low saturation of the DG in local energy grid can further limit the energy efficiency decisions and can make the energy management difficult. • It can be hard to fulfil the contractual obligations ICT system failures due to external or environmental factors.

Table 30: Distribution System Operator (DSO) SWOT

Strengths (benefits)	Weaknesses
• **The main benefits for the DSO come from increasing the energy efficiency and reliability, which increases the profits and**	• The level of settlements' complexity with all balancing parties increases and will be more error prone.

supply reliability of downstream users, respectively. • **Additional tools to calculate and forecast optimal energy flows.** • **Generation of different scenarios according to the prediction based on all grid/users parameters.**	• The energy losses' estimations from different grid locations could show different accuracy level depending on the kind of facilities and weather conditions. Correction factors could be needed.

Opportunities	Threats
• **Can evaluate the profitability of grid expansion through simulations, e.g. the penetration of new production/storage technology (optimal investments).** • **Fraud detection can become easier to achieve**	

Table 31: Microgrid Operator: SWOT

Microgrid Operator: SWOT for Microgrid operator consists of all combined features of SWOT for DSO and energy retailers.

Table 32: ICT providers SWOT

Strengths (benefits)	Weaknesses
• **Not foreseen/identified**	• Not foreseen/identified

Opportunities	Threats
• **New business opportunities, ICT can expand the smart-metering market to DSOs.** • **Short/medium-term support for the provided systems.**	• Not foreseen/identified

Table 33: Municipalities SWOT

Strengths (benefits)	Weaknesses
• **They can use the monitoring and control features of e-balance to optimize municipal systems for instance public lighting. This allows reducing the energy consumption.**	• Depending on the level of technology implemented in the city, the building supply can be difficult to be modernized without national grants or the help of energy companies (ESCOs).

Opportunities	Threats
• **They can pave the way to modernize the city and move it towards the smart-city model by installing electric charging stations and generation/storage systems, which constitutes an improvement of the electric system's reliability.**	• Development and deployment of the new technologies depend mostly on grants and people's acceptance. Advertisement campaign usually solves the lack of people's awareness.