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Guide Book

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Abstract

This deliverable describes in short the Guide Book – a guide for third parties that contains the extract of the project results and it is published in the official e-balance web site.

Disclaimer

The information, documentation and figures available in this deliverable are written by the e-balance partners under EC co-financing (project number: 609132) and does not necessarily reflect the view of the European Commission.

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Abbreviations

ADR	Active Demand Side
ANN	Artificial Neural Network
API	Application Programming Interface
B2B	Business To Business
B2C	Business To Customer
BCA	Business Canvas Analysis
BRP	Balance Responsible Party
CMU	Consumer Management Unit
DAM	Daily-Ahead Market
DEF	Direct Energy Flexibility
DER	Distributed Energy Resource
DSM	Demand Side Management
DSO	Distribution System Operator
EV	Electric Vehicle
ICT	Information And Communication Technology
IDM	Intraday Market
IEF	Indirect Energy Flexibility
LV	Low Voltage
LVGMU	Low Voltage Grid Management Unit
MV	Medium Voltage
MVGMU	Medium Voltage Grid Management Unit
PC	Personal Computer
PV	Photovoltaic
QoS	Quality Of Service
RF	Radiofrequency
SWOT	Strength, Weaknesses, Opportunities And Threat Analysis
TLGMU	Top Level Grid Management Unit
WLAN	Wireless Local Area Network

1 The e-balance guide book' contents

The guide book edition aims at creating a friendly and attractive document that draws potential readers' attention regarding e-balance results (technical, business models and social research) and its experience in the demonstrators (Batalha and Bronsbergen).

The structure of the guide book aims at highlighting the two main applications of e-balance: the energy management platform and the energy efficiency and resilience for smart-grids. In addition, research on business models, social research and lessons learnt are included to guide readers who want to replicate the e-balance platform.

The structure of the guide book is as follows:

- Introduction to the guide book title **"How to read the guide book?"** with the following sections:
    - What is e-balance?
    - Who is the guide book for?
    - Apply our results
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- The energy management platform titled **"Smart energy balancing of neighbourhoods"** with the following sections and subsections:
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    - The e-balance energy management platform
        - The energy balancing algorithms
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        - Bronsbergen experience
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- The energy efficiency and resilience platform for LV and MV grids titled **"Energy efficiency and resilience for smart grids"** with the following sections and subsections:
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    - Smart-grid Low Voltage features
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        - How to deploy the solutions
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- Report on business model development and simulations titled **"Business models in a nutshell"** with the following sections:
    - Empowering new market players
    - Sustainability of the e-balance platform
- Report on social studies titled **"Social studies: end-user perspective"** with the following sections:
    - Challenges and goals
    - Activities and results
- Final chapter with **lessons learnt** of e-balance.

2 Executive summary of the guide book

How to read the guide book?

The e-balance project aims at developing hierarchical **management system architecture** for future smart-grids inspired by the fractal nature of electric and energy grids. As fractal systems, the electric grid is structured using the same organisation (connections) at different levels, which means that the same or at least very similar management approaches can be applied at different levels (e.g. household, neighbourhood, district, etc.).

The e-balance architecture is providing a kind of blueprint for implementing ICT solutions for smart-grids. In the course of the project we realized two complementary applications of our architecture in real life demonstrators. One highlights a certain aspect i.e. energy balancing and the other grid resilience. Even though in both cases the architecture is the same, specific implementations such as low level communication protocols and high level applications are different.

- The first application is the **energy balancing system** which is a ICT platform to enable energy balancing at different grid levels. It is composed of several management units (mini-PC or virtual machines) deployed at the homes of customers/prosumers as well as at the low-voltage grid that communicate with each other in a hierarchical manner. The goal is to satisfy both prosumers' and DSO's requirements with the intervention of energy retailers or aggregators as business enablers. At the home level, a Customer level Management Unit (CMU) is connected to existing smart-appliances (in our instantiation to Whirlpool and Mastervolt appliances) to schedule their energy profiles when it is more appropriate. In the following upper level, we can find the grid management units in the different power substations. In the secondary substations the low voltage grid management unit (LVGMU) is installed, which communicates with the CMU to balance the distribution grid, and with the upper level to check the grid status and combine the individual LVGMUs in a similar manner as the LVGMU does for the CMUs.
- The second application is a **management platform for low-voltage (LV) and medium-voltage (MV) grids** to increase the efficiency and resilience of a power system. The e-balance demonstrator for LV grids focuses on creating the means to enable the Distribution System Operator to: measure in near real-time consumption/production power flows (including distributed energy resources), detect and locate commercial losses (frauds), locate and detect faults, calculate energy losses and the quality of service (QoS) accurately. On the other hand, the MV solutions focus on optimising power flow, validation of optimised solutions, fault detection and location and self-healing.

Who is the guide book for? The target readers of the guide book are involved in the value chain of energy services offered by e-balance: **electricity market operators** (distribution system operators, energy retailers, energy aggregators, balance responsible parties...), **distributed energy producers**, **city authorities and smart-appliance manufacturers** that request innovative solutions to turn power systems into smart-grids.

Smart energy balancing of neighbourhoods

Due to a move to a sustainable society and with government incentives to support this, renewable energy sources become popular. End customers take part in this development by installing (rooftop) photovoltaic (PV) panels to supply their own energy. Furthermore, due to environmental and economic reasons, more and more customers procure electric vehicles (EVs) and heat pumps. However, the PV production peaks around noon, while EVs and heat pumps have the peak consumption at the beginning of the evening.

This development leads to a mismatch of production and consumption, an unbalance in the electricity grid. In the new situation, there will be two peaks: around noon (production peak) and in the evening (consumption peak). These peaks will be significantly higher than what was historically observed in the grid. They result in higher grid losses, congestion and a lower lifetime of grid assets. The DSO has to pay for grid losses, replace grid assets sooner than anticipated and needs to install more costly infrastructure.

Whereas in the old situation the (flexible) production is adapted to match the demand, the current trend is to move to a situation wherein the demand is adapted to the (inflexible) production; this is called demand-side management (DSM). Smart appliances are used that allow for such flexibility to balance the grid, e.g., EVs of which the amount and time of charging can be adopted by an ICT system to charge off-peak, or whitegoods that can be started such that their operation coincides with PV production.

To match supply and demand, a few challenges need to be overcome. Time-of-use pricing, dynamic pricing and similar tariffs are often proposed as possible solution to this problem. However, recent research shows that these approaches lead to higher peaks due to load synchronization and may at best only move the load peak [1]. As an alternative, capacity tariff is proposed [2], which means that customers are billed based on the maximum peak load. However, capacity tariffs may result in additional costs when there is no problem, e.g., when production and consumption match at a neighbourhood level.

To accomplish this we needed to tackle several challenges for the control methodology and many details on how to address the challenges can be found in our deliverables and scientific publications that are indicated:

- Hierarchical nature: the system architecture should be hierarchical in nature and the algorithms need to function at each level of the hierarchy [3].
- Cost effectiveness: there must be a relation between the costs and the optimization objective. Since the losses are quadratic with the current, this must be reflected in the objective that is collectively obtained [1].
- Predictions: to match supply and demand properly, flexibility needs to be reserved for when it is needed the most. For this, predictions of supply and demand are needed. Prediction models are modelled with artificial neural networks (ANN) and are further explained in [4].
- Efficient algorithms: the e-balance algorithms are executed on small devices that are installed in houses and have low computational power. Because of this the algorithms need to be designed to be very efficient [5] [6].

To facilitate the methodology and enable customer support services (e.g. data access) it is crucial to design an ICT system with this in mind. This ICT infrastructure offers secure and abstract services that support the hierarchical system and provide access to the required grid components. The main challenges of developing such a system are:

- Privacy: data from customers are used and exchanged. Due to the sensitive nature of this data, access must be restricted based on stakeholders.
- Security: all data exchanged are sensitive and need to be kept confidential, in addition data integrity and authentication of its origin need to be ensured. . Data is exchanged between different security zones and security measures such as firewalls and proxies need to be installed.
- Abstraction: the system supports services (balancing, data exchange, etc.) that require data exchange between different levels at the hierarchy. Abstract interfaces are needed to aid the implementation of such a system. More specifically, we need a middleware layer that offers locational transparency, data security, encryption, etc.

The energy management platform

The energy management platform is the first application of the e-balance hierarchical architecture. It aims at balancing the electric energy of neighbourhoods with flexible loads as smart-appliances (appliances whose cycles can be rescheduled), PV power inverters (with the capability of power curtailment) and smart-storage devices (e.g. electric vehicles or electric batteries with control and management features). As mentioned before, the energy management platform has to deal with the technical and market challenges that are still issues to integrate demand response and demand-side management services in current electric grids. For instance, the build-up of appliances manufacturers offering smart solutions that support these applications demonstrates an adequate level of maturity. However, the lack of standard and open platforms to connect and integrate technologies from different vendors and the lack of a business model to convince both electric market players and consumers lead to multiple initiatives that have to rethink their approach from scratch and manufacturers are developing independent management services, which force end-users to install and use disaggregated solutions.

The energy balancing algorithms that run in the energy management platform are based on the Triana approach and require the coordination between the low-voltage grid management unit (LVGMU) located within the secondary substation and every customer level management unit (CMU), which is connected to the smart-meter on the prosumers' premises. Therefore, the algorithm is split and executed into both management units.

The algorithm allows two different ways of balancing, selected by prosumers: **local balancing** to maximise energy generation (in Bronsbergen demo the PV panels) and **neighbourhood balancing** to flatten the energy profile, which has been one of the main goals in e-balance. Both options require accurate prediction provided in our case by neural networks algorithms, the former at the household level (poor accuracy due to the huge amount of uncertainties at home level) and the latter at the neighbourhood level (good quality predictions). Aggregation of energy demand prediction at the household level is not considered and recommended to apply the Triana approach unless new prediction methods or techniques improve the accuracy of predictions.

The algorithms have been implemented in Java and integrated in the e-balance middleware, which is described in the following sections. The designed algorithm for neighbourhood optimisation requires the interaction between the CMUs and LVGMU and is composed of the following steps:

1. **Get predictions** (at LVGMU): prediction algorithm, based on neural networks, which provides 24-hour predictions of neighbourhood energy demand in a 96-value array format.
2. **Calculation of priority factors** (at LVGMU): this step normalises the aggregated energy profile with the prediction values obtained in step 1.
3. **Calculation of available flexibility** (at CMU): in this step the best starting point for every smart-appliance available (scheduled) is calculated and sent back to the LVGMU.
4. **Ranking of CMUs** (at LVGMU): this step classifies CMUs according to flexibility.
5. **Optimisation** (at CMU): according to the order of the previous step, every CMU is requested sequentially to optimise the schedule of its smart-appliances and the output is the new energy profile, which will be used to update the aggregated energy profile.

ICT Architecture

Our concepts thrive when a lot of controllable connected devices communicate in a standardised way with the energy management system. The CMU should however be able to cope with this potentially large amount of devices. From the energy management point of view, only two "physical" connections were required in our demonstrator: **the connection with the smart meter and a wireless LAN router that provides internet access**. In the worst case, each amount of flexibility providing device needs to be connected to the CMU separately through the WLAN router or via a cabled solutions, for example, nearby sensors. In our case, the devices were connected to the participant's WLAN router, connecting to cloud services provided by **Whirlpool and Mastervolt**. In turn, our CMU connected to these clouds. The benefit this provides is that the number of connections to the CMU is limited and the number of APIs active can be minimised. This allows for a great many of devices being connected through cloud services, allowing for standard mini-PC hardware to run the CMU functionality.

Communication platform (middleware)

The communication platform is based on a middleware, which is simply a software layer that runs on a device which is used to provide high level communication services to applications and developers regardless of the underlying platform and communication stack. The high-level communication services provided by the middleware not only simplifies the development of applications, but also establishes a common communication API that all applications need to use in order to exchange information with each other. This means, that the underlying communication stack and platform are transparent to the applications.

In the e-balance project, the communication middleware is used to provide high-level communication services to the different management units in the system. It handles information exchange in the prosumer households (CMU) such as smart meter data and smart appliances configuration and schedule, in the different substations that control the grid and monitor/actuate in the households (LVGMU, MVGMU) and the control centres that have an overall picture of the status of the whole system (TLGMU). Deliverable [7] describes the general architecture of the middleware and the submodules it has. All applications running in each management unit use the same API, described in these deliverables, to exchange information regardless of the platform over which they run and the communication stack the use.

The energy management platform has been deployed in the Bronsbergen holiday park (the Netherlands), with 41 participant cottages participating in the energy balancing, rescheduling their smart-appliances (23 washing machines, 23 dryers and 49 Mastervolt inverters). The results and the experience are further explained in the guide book.

Energy efficiency and resilience for smart-grids

Presently, current ICT platforms available allow implementing better electric energy grids, meaning that they are better suited to face operational contingencies and fault occurrences, while providing a high service quality.

The answer to this challenge is the smart grid, as it copes with those grid limitations, providing the grid system operator with resilience features towards reducing the likelihood of outages occurring, besides mitigating their duration and impact on people, businesses and industry. Moreover, the smart grid aims also at being operated at minimal cost, thus implementing energy efficiency mechanisms through the implementation of advanced features.

Current smart grid technology goes as far as the MV grid goes, meaning that LV grids are normally excluded from participating in grid resilience features. Going beyond the state of the art, e-balance addresses both grid resilience and energy efficiency, through a set of new deployed features towards the LV and the MV grids.

Regarding the LV grid, those features comprise further automation and monitoring solutions downstream the secondary substation, the typical last mile frontier of the smart grid. Within e-balance, RF Mesh communication technology is embedded in LV sensors towards deploying monitoring features serving the distribution grid and public lighting circuits. Moreover, the concept of the LV Grid Management Unit is proposed, merging the role of smart metering data concentration with the role of controller, thus enabling features as fault detection and location, power flows and losses calculation, assessment of key performance indicators, among others.

Regarding the MV grid, those features comprise the calculation of optimal set-points towards controlling switching primary equipment, capacitor banks and transformer tap changers, towards improving grid performance through mitigating power losses. Moreover, the concept of autonomous self-healing was introduced, serving adjacent primary substations towards grid resilience improvement and outage time mitigation.

The LV and MV grid features have been tested in the EDP premises and distribution network in Batalha (Portugal). The results and the experience are further detailed in the guide book.

Business models in a nutshell

During the e-balance project we were working on a business model proposal for energy flexibility by balancing service, which is one of the services provided by e-balance platform. The most important assumption for introducing our system into the market is that the flexibility market should exist in a country where e-balance will be rolled out. It means that the market should create the needed environment for such service provided by prosumers from household level to the grid.

The e-balance platform is well defined and prepared for cooperation between prosumers, aggregators, suppliers and DSO. Full lean business canvas analysis (BCA) with business cases and simulation results are prepared and described in detail in [8].

New market actors: the aggregator is defined as a party who unlocks and maximises the value of demand side flexibility obtained from prosumers. Aggregators bundle numerous small flexibility resources into a useful flexibility volume. In cooperation with a Balance Responsible Party (BRP) and appropriate suppliers they provide flex products to the market and provide such services. They need to endorse a relevant contract with all main players.

Main features of our BM:

Depending on the aggregator's integration model (see BCA in [8]) the prosumers have an appropriate contract with the supplier/aggregator for flexibility products delivery.

This system proposes two flexibility products to the market provided by prosumers:

1. **Direct Energy Flexibility (DEF)** – a flex product dedicated to the balancing market and for auxiliary services. Requests for aggregation can be initiated due to the lack of balance and appropriate bids are resulting from the balancing and reserves market.
2. **Indirect Energy Flexibility (IEF)** – a flex product dedicated to optimise the portfolio of a retailer/supplier/BRP that provides their precise schedule of energy transactions on the day-ahead or intra-day market (DAM/IDM) or for DSOs to improve operational efficiency.

- Prosumers can have economic benefits (see [8] the appendix 1) when they agree with the system's requests to adjust the use of energy (e.g. shifting time of use or applying limitation/savings).
- Such adjustment can be provided every 15 minutes or faster. It depends on aggregator's reactivity for the market signals.
- Depending on this, aggregators enable the aggregation service and can access to different sources of benefits for themselves and for the supplier. The e-balance system owner/supplier sets up the business condition how to start as the user of the system.
- The system provider/aggregator has to propose pricing method /proposition to describe how prosumers will be incentivised. We have proposed:
  - A dynamic price/incentive for the dependent flex product provided by the aggregation service. It means the price is dependent on the flexibility volume provided during every day.
  - A flat price/incentive for independent flex product provided by the aggregation service. It means the price is clearing during the bids on the demand supply at the flexibility market.

Business partners and contracts:

- The contract between the prosumers and the aggregator (business to customer -B2C- subscription) has to give clear rules about how this system works and how much money users can earn depending on his/her behaviour in electricity use.
- The aggregator receives a commission for the energy exchange management and balancing service.
- The DSO has benefits (business to business -B2B- commission) mainly from the second service: grid monitoring and resilience. These are as follows: fault location, location of the service interruption, better quality of energy service providing.
- Suppliers/retailers can increase their current business by cooperation with the aggregators (B2B, commission). They are responsible for purchasing energy on the market and supplying it to the users according to the result generated by the balancing and optimisation mechanisms. They receive rewards for portfolio optimisation from spot and intraday markets.
- Other stakeholders like the manufacturers of intelligent energy devices or ICT, data providers have a possibility to develop their own businesses as the demand of the new dedicated e-balance tools/services increases.

What is our achievement in the matter of business model?

- Overall concept of the business model with SWOT analysis, added value analysis, stakeholder analysis and theoretical pricing method proposition (all at the beginning on the project). Results are published in [7].
- Lean business canvas analysis (BCA) with business cases for Poland and the Netherlands with market strategy, competitor analysis and risk analysis for the balancing service. Results are published in [8].
- Mathematical model for pricing method, and calculation for theoretical data. Results analysis and sensitivity analysis. Results are published in [8], in an appendix 1.

Social studies: end users perspective

While creating a new technology you cannot ignore the end-user perspective. If technology is to be introduced into market and truly adopted it must fit into people's everyday life, taking into account consumer habits and attitudes. The e-balance system redefines the usage of energy in households at many different levels. Nowadays, electricity is perceived by consumers as somewhat unspecified and intangible - for example, it is not known whether it is a product or a service. Consumers generally do not fully know how much power they are consuming (it is easier for them to say how much they are paying for it). It is an abstract, immaterial thing, something that users take for granted. This source is also subjectively inexhaustible (in the common sense you cannot exhaust the electricity from the grid – you can only be cut out from the source due to network failure).

In the new paradigm, introduced by Smart Grids, the electricity is:

- Something that we consume in our household and what by the very fact of production (and storage) is constantly in our attention (such as baked homemade cake, which we ourselves "create", and then we observe how it decreases in successive days).
- Something we can sell to the network. So there is a possibility for different strategies (because the prices on the market are dynamic and different from the seasons / day we can sell or store our energy in anticipation of a more attractive offer). It involves engaging and thinking about these strategies and in effect uses mental resources.
- Something we can optimise by giving the autonomy of our household to smart-home management programmes or third parties (for example, a power provider that will turn on our washing machine when we are at work, at a time that will be convenient to him).

This redefinition has fundamental importance and has been one of the greatest challenges in conducting social researches. We evaluated the concept of a technological solution that was very far from the everyday experience of ordinary consumers of energy. We had to map the potential barriers and obstacles to a future adaptation solution that was exotic and intangible to potential users.

However, during prototype testing at demo-site Bronsbergen, it turned out that even when designing a system for clearly defined potential users, it was impossible to predict everything. Here are some insights and tips to keep in mind when creating a system similar to e-balance.

- Privacy issues should be very clearly described. It is worth noting, however, that recipients do not perceive these issues spontaneously as threatening. They almost never perceive it as a real issue, assuming by default that the security level is proper and high. These issues become threatening only when users become aware of it. A large number of consumers are aware of the role of privacy in the use of new technologies, and the fact that data access is a kind of price for receiving various functionalities that enhance the quality of life. What people really care about is not the level of security, but the level and type of benefits.
- An important barrier to use smart devices may be the reluctance to leave them unattended at home, during its work. Some users are afraid of flooding the house due to a malfunction of the washing machine. Others concern the fire caused potentially by the dryer. This fear can be addressed with appropriate functionality (e.g. automatic SMS notification of hardware failure).
- The design of the interface is crucial. Even if 99% of the system is cables, electronic boards and software, and only 1% is a graphical display, then this one percent means all the experience of people. Satisfaction of our users is largely determined by the way they interact with the functionalities. In our case, the barrier has been the mediation of interacting with smart devices through the application. Not every user has a smartphone, not everyone likes and wants to use it. The prototype solution for starting a washing machine with a local balancing function using a series of steps (interaction with a washing machine display and a smartphone application) has proved to be too difficult. Therefore, launching functionality should be as simple as possible and not harder than before.

- Interface is everything (let's repeat it once again) - it should be as simple and user friendly as possible; understandable not only for technical geeks. Design it in such way, that even your grandmother would understand it (and can handle it when she forgets the glasses!). During design, as a system developer, we tended to visualize the end-user as Patrick (one of our personas). During the testing the prototype in real-life scenarios, it has often been Paul (or his mother).
- Electricity meets many functions at home. This means that for a system such as e-balance there is no single user of the system in the household, but there are many of them. Sometimes it can lead to strange, paradoxical situations. For example, in one of the tested households - the husband was responsible for all technical issues (including use of smartphone applications) and his wife was responsible for doing the laundry (and she was no smartphone user). The husband claimed that in terms of laundry functionality we should talk to his wife; she - when she heard about that washing machine through the application on the smartphone - directed us to her husband. The specificity of the designed interaction made none of them possible to use the functionality of local balancing.
- Remember that a system like e-balance alters and redefines the life of an entire household. It affects existing patterns of behaviour, habits, and attitudes. Therefore it can be said that the end-user in many cases is not a single person but the whole household.

Lessons learnt

Technical aspects

1. The architecture of e-balance needs to address also a way to integrate different legacy smart metering infrastructures, besides the one addressed in the project. For demonstration purposes, the researchers suggest that a complete pack of smart metering components should be included in the framework of a project willing to add further features as regards to legacy smart metering systems.
2. Even looking ahead towards achieving new architectural approaches and features, once your project copes with a demonstration involving existing legacy systems and platforms, be aware that their own characteristics may prevent the success of your endeavour. As a recommendation, your project must be history-proof, meaning that it has to cope with legacy systems if the project is meant to interface them or to be integrated with them. Spend some budget and time addressing this kind of integration issues.
3. The DSO owning a smart metering infrastructure must participate in the project – which was the case in e-balance –, namely involving staff related to and fully aware of such infrastructure, from the project start phase.
4. Do not trust that integration is easy, even using open systems. Often, status quo privacy and security rules prevent the deployment of what seems to be an easy and straightforward approach towards innovation.
5. Regarding the inclusion of DER actors and components in a project comprising a demonstration, do not rely on their availability, especially if they were used some years ago. Within e-balance, researchers relied on an existing MV storage installation, which proved to be out of order.
6. Still regarding the involvement of householders, if you rely on their WLAN home platform, be aware that your solution might affect the daily use of internet at domestic level. As a recommendation, you should comprise a router in your budget. Moreover, be aware that bandwidth use is limited; therefore, care on how to use it at domestic level must be a subject you should pay attention to, namely during the specification phase within an early architecture work package.
7. In order to reduce costs on computing devices, consider providing virtualization schemes to cope with computing needs, especially if one of the project consortium members is capable of providing a virtualised platform.
8. Consider very carefully in advance how solutions such as "smart plugs" and "remotely operable appliances" impact the proposed system and make sure that all partners are aligned about the concepts that need to be deployed or developed.

9. Transferring demonstrator equipment and responsibilities from one project to another is not a big problem within the stakeholder/company that owns the demonstrator "site". However, transferring dependencies and responsibilities of consortium partners from one project to another is. It is therefore very important to incorporate a true and proper demo-site plan that makes sure that (device) support goes beyond project lifetimes. It should at least make clear to other consortia what they can expect in terms of device availability so that they can perform a proper risk analysis or include additional partners into the consortium.
10. Any smart grid solution provided should be accompanied by on-site support by experienced and knowledgeable consortium personnel or sub-contracts to ensure proper operation. If partners are unable or unwilling to provide such support, measures should be taken into account that minimise this involvement. For example, supplying an additional router attached to a customer's router or modem via wired connection or connected it to a dedicated project 4G modem.
11. Deploying devices that are normally out of scope of consortium partners' normal operational expertise should be supported by experienced sub-contracted installation companies or suppliers and these companies should be involved from the start of the project.

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Business aspects

1. Our proposal of the business model emphasizes the importance of "good neighbourhoods". Only when the system provider will have 'bottom up' initiatives starting at the level of the neighbourhood (i.e. the community of energy cluster) that will be interested in being "environment-friendly and efficient", the effects of the active response can be huge. This will be possible when such neighbourhood cooperates with the aggregator, and the aggregator becomes an integral part of the cluster. The success depends on the people, and that is why a real demo site for business model testing with realistic market condition can indicate whether our proposal proves successful.
2. The key success factor is that the e-balance system must fulfil its objectives and bring the promised benefits to its individual participants. This is only possible when the flexibility market will be created, the demand for flexibility products from prosumers will be significant and revenue generated for all parties will be significant enough to cover investment and implementation costs.
3. The proposed price model and the chosen way of distributing the system among users are the key of importance. Results of a sensitivity analysis indicated that the higher the demand for flexibility products and the active demand side (ADR) are, the higher the income of the respective parties will be, the prosumers in particular.
4. The role of the aggregator and its place on the energy market is crucial. This function can be performed by suppliers or independent aggregators. Their model of inclusion in the current market (integration models of aggregators) and the preparation of legal regulations will define their effectiveness

Social aspects

1. If you are designing a system that affects so many aspects of the household, it is a good idea to carry out an ethnographic study first. In our case, the e-balance system has the ambition to coordinate production and consumption of energy and help to balance it locally. This affects basic housework in the household (like washing, drying clothes, washing dishes, using the oven, etc.). An ethnographic study would describe the practice of everyday life and show how the system can fit in. Otherwise you risk implementing a prototype that needs to re-orientate the habits of the family and introduce unnatural functioning.
2. It is worth to put the effort on planned design of system-user interaction. By saying "interaction" we mean not only the interaction with the screen, but the whole user experience (e.g. the procedure for turning on the washing machine with the local balancing function). The interaction designing process should be interwoven with the evaluation of the project (designing process-test-re-designing-test etc.). If the interaction with the system is not designed from the beginning, you have to use default and template solutions, designed for other purposes by other entities (for example, to turn on

the washing machine on two devices simultaneously: the washing machine display and the app on smartphone).

3. Even if 99% of the device is hardware and 1% is an electronic display, this display is responsible for the entire user's contact with the system. In fact, from user's perspective, display is the system. Therefore, separate resources should be reserved for tests of Graphic User Interface functionality.
4. Projects involving real households and people should focus on mild forms of social engineering. This can make (potential) participants ready to provide good-will. This good-will can compensate typical research project issues (they are sympathetic to flawed imperfect systems) and can also provide willingness to stay at home for the installation or (re)configuration of demonstrator devices.

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