BestRES

Best practices and implementation of innovative business models for renewable energy aggregators

Assessment of the Value of Aggregation

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The logos of the partners cooperating in this project are shown below and information about them is available in this report and at the website: www.bestres.eu

This report has been written by Daniel Schwabeneder, Carlo Corinaldesi and Andreas Fleischhacker (TUW-EEG). The authors thankfully acknowledge the valuable contributions from all project partners to complete this report.

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List of abbreviations and acronyms

ICT	Information and communication technologies
DER	Distributed energy source
BRP	Balancing Responsibility Provider
DSO	Distribution System Operator
TSO	Transmission System Operator
ESCO	Energy Service company
RES	Renewable energy sources
BM	Business model
LCA	Life Cycle Analysis
DSM	Demand side management
IoT	Internet of Things

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Executive summary

In the BestRES project, existing business models for aggregators have been identified in the report *"Existing business models for renewable energy aggregators"* [1]. Based on these, 13 improved business models have been developed in a qualitative way using the Business model canvas method [2]. The improved business models are presented in the report *"Improved Business Models of selected aggregators in target countries"* [3]. They have been analyzed quantitatively in detail in the report "*Quantitative analysis of improved BMs of selected aggregators in target countries*" [4]. The impact of these business model improvements on the competitiveness of RES technologies has been evaluated in the report "Analysis of RES competitiveness in the improved business models" [5].

In this report, based on quantitative results, we investigate in a qualitative way the value created by the improved business models for the energy system on different levels. For this purpose, we rely on the approach presented by Burger et al. [6] categorizing the value created by aggregation into three types: fundamental, transitory and expedient[1] value of aggregation.

[1] In the original work of Burger et al. [6], the term "opportunistic" is used instead of "expedient".

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1. Introduction

In the past, European electricity markets were designed around centralized fossil-fuel generation along national or regional borders. The electricity market landscape is however changing because a rising share of distributed generation increases intermittency and price volatility in the system. This requires a more flexible system with more flexible consumption. As highlighted in the state aid guidelines published in April 2014 by the European Commission, this implies that renewable sources are better integrated in electricity markets and rely less on subsidies as was the case in the past. Renewable energy aggregation can significantly accelerate the integration of intermittent electricity sources, enhance demand flexibility and decrease the reliance on renewable energy support schemes.

More aggregation and market integration can however not be achieved by single individual, commercial or domestic consumers since they would only have a limited impact. It is only through a coordinated steering of vast amounts and types of consumers and producers in a market that the use of distributed generation, demand response and battery storage can be effective. A lot of literature has been published with respect to demand response management and more and more market players are active in this field but management of distributed generation and storage including electric vehicles is less developed. An explanation for this might be that this requires the extensive use of new technological solutions and ICT to directly control consumption and generation at lower costs.

For this reason, there is an important role for Renewable Energy Aggregators who act on behalf of consumers and use technological solutions and ICT for optimization. They are defined as legal entities that aggregate the load or generation of various demand and/or generation/production units and aim at optimizing energy supply and consumption either technically or economically. In other words, they are facilitators between the two sides of electricity markets. On the one hand, they develop energy services downstream for industrial, commercial or domestic customers who own generation and storage units or can offer demand response. On the other hand, energy aggregators are offering value to the market players upstream such as BRPs, DSOs, TSOs and energy suppliers to optimize their portfolio and for balancing and congestion management. Furthermore, wholesale electricity markets might benefit from aggregation if appropriate incentives are present. A last option is that energy aggregators offer value to specific customers such as is the case for ESCO’s. In this situation, the player downstream and upstream could potentially be the same entity.

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1.1 The BestRES project

The main objective of the BestRES project is to investigate the current barriers and to improve the role of Energy Aggregators in future electricity market designs. In the first stage, the project is focusing on existing European aggregation business models taking into account technical, market, environmental and social benefits. In the second stage, we will develop improved business models that are replicable in other countries in the EU considering market designs and with a focus on competiveness and LCA. These improved business models will then be implemented or virtually implemented with real data and monitored in the following target countries: United Kingdom, Belgium, Germany, France, Austria, Italy, Cyprus, Spain and Portugal.

The BestRES entered into force on 1st March 2016 and will end until 28th February 2019.

The target group, the Renewable Energy Aggregators, has been directly involved in the BestRES project consortium as partners:

- Good Energy, renewable energies aggregator active in United Kingdom
- Next Kraftwerke Belgium, renewable energies aggregator active in Belgium
- Oekostrom, renewable energies aggregator active in Austria
- Next Kraftwerke Germany, renewable energies aggregator active in Germany,France and Italy
- Energias de Portugal, renewable energies aggregator active in Spain and Portugal

The BestRES activities to be implemented in Cyprus will be carried out by FOSS, the research centre for sustainable energy of the University of Cyprus. This is due to the fact that there are no aggregators in Cyprus at the time being (2016) and no market entrants are expected until 2020.

The innovative business models to be provided during the project will be based on on-going business models available in Europe and adapted to the future market design by research institutions and energy expert partners such as the Energy Economic Group of the Technical University of Vienna (TUW-EEG) and 3E. The consortium also includes a legal expert, SUER (Stiftung Umweltenergierecht /Foundation for Environmental Energy Law), who will provide a relevant contribution to the development of National and European recommendations on the business models implementation.

The BestRES project is coordinated by WIP – Renewable Energies. The project communication and dissemination will be carried out by WIP with the support of Youris.

A short description of the BestRES project partners is provided in the following paragraphs.

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WIP - Renewable Energies (WIP)

WIP - Renewable Energies has been founded in 1968 in Munich, Germany, and has been active in the renewable energy sector for over three decades, working with both industrial and public sector clients at the international level. The company's mission is to bridge the gap between research and implementation of sustainable energy systems. WIP's interdisciplinary team of professionals provides consultancy services to improve the grid and market integration of renewable energies. WIP offers project development, project management, technical supervision and realization of projects, which involve the co-ordination of international consortia. WIP counts more than 300 projects accomplished. WIP organizes international events in the field of renewable energies. Website: www.wip-munich.de

3E

3E is an independent consultancy and software service company, delivering solutions for performance optimisation of renewable energy and energy efficiency projects. We provide expert services to support project developers, asset managers, operators, investors and policy-makers and our key areas of expertise are solar, wind, sustainable buildings & sites and grids & markets. Bridging the gap between R&D and the market, 3E combines in-house innovation and partnerships with leading R&D centres. 3E's international team operates from Brussels (HQ), Toulouse, Milan, Istanbul, Beijing and Cape Town. The company has a project track-record of over 15 years in over 30 countries. Website: www.3e.eu

Technische Universitaet Wien (TUW-EEG)

The Energy Economics Group (EEG) is a department of the Institute of Energy Systems and Electric Drives at TU Wien, Austria. The core fields of research of EEG are: (i) system integration strategies of renewable and new energy technologies, (ii) energy modelling, scenario analysis and energy policy strategies, (iii) energy market analysis in general (competition and regulation), (iv) sustainable energy systems and technologies and (iv) environmental economics and climate change policies. EEG has coordinated and carried out many international as well as national research projects, international and national organizations and governments, public and private clients in several fields of research. Website: www.eeg.tuwien.ac.at

Stiftung Umweltenergierecht (SUER)

The Foundation for Environmental Energy Law (Stiftung Umweltenergierecht – SUER) was created on 1 March 2011 in Würzburg. The research staff of the foundation is concerned with national, European and international matters of environmental energy law. They analyze the legal structures, which aim to make possible the necessary process of social transformation leading towards a sustainable use of energy. Central field of research is the European and German Law of renewable energy and energy efficiency. The different legal instruments aiming towards the substitution of fossil fuels and the rise of energy efficiency are analyzed systematically with regard to their interdependencies. Interdisciplinary questions, e.g. technical and economical questions, are of particular importance. Website: http://stiftung-umweltenergierecht.de/

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Good Energy

Good Energy is a fast-growing, 100% renewable electricity supplier, offering value for money and award-winning customer service. Good Energy is proud to have been the first dedicated 100% renewable electricity supplier in the UK, with over 68,000 electricity customers – a mix of residential and commercial supplies – 38,000 gas customers and supports over 112,600 homes, business and communities generating their own renewable energy. We source our supply from a large and growing network of over 1,000 independent generators across the country, in addition to operating our own wind farms and solar farms. Website: www.goodenergy.co.uk

Next Kraftwerke Belgium (NKW BE)

Next Kraftwerke Belgium pools distributed renewable generation and flexible demand in a virtual power plant (VPP). We trade and deliver the aggregated power on the most relevant markets and, most importantly, we make the virtual power plant's flexibility available to the grid operator to support the management of the Belgian power system. Next Kraftwerke Belgium is a joint venture with Next Kraftwerke GmbH in Germany. Website: www.Next-Kraftwerke.be

Next Kraftwerke Germany (NKW DE)

Next Kraftwerke Germany is the operator of a large-scale Virtual Power Plant (VPP) and a certified power trader on various European energy exchanges (EPEX). The concept of a Virtual Power Plant is based on the idea to link and bundle medium- and small-scale power producing and power consuming units. The objective is to smartly distribute supply and demand and to profitably trade the generated and consumed power. Next Kraftwerke's VPP now bundles around 3,000 medium- and small-scale power-producing and power-consuming units. Among other energy sources, it includes biogas, wind, and solar power generators. Next Kraftwerke also operates in Belgium, France and Austria. Website: https://www.next-kraftwerke.com/

Oekostrom

Oekostrom AG is a holding company owned by about 1.900 stockholders. It was founded in 1999 aiming at building a sustainable energy industry, supplying customers with clean energy and supporting the development of renewable energy sources in Austria. All products and services of oekostrom AG represent an active contribution to climate and environmental protection and increase independence from fossil and nuclear energy sources. Oekostrom AG engages in the fields of power production, trading, sales and energy services and currently supplies 100 % renewable energy from Austria to more than 52.000 customers in all parts of the country. Website: http://oekostrom.at/

Research Center for Sustainable Energy of the University of Cyprus (FOSS)

The Research Centre for Sustainable Energy of the University of Cypruss (FOSS) was created in order to play a key role in research and technological development activities in the field of sustainable energy within Cyprus and at international level with the aim of contributing to the achievement of the relevant energy and environment objectives set out by Europe. FOSS is heavily involved in all spheres of sustainable energy spreading from sources of energy, smoothly

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merging RES in the integrated solutions of the grid, development of enabling technologies such as storage and ICT that will facilitate the seamless merging of sustainable technologies in the energy system of tomorrow, the complete transformation of energy use by the effective introduction of sustainable alternatives in meeting the needs for mobility, heating and cooling and exploring ways of achieving even higher levels of efficiency in all areas of the economy. Website: http://www.foss.ucy.ac.cy

Centre for New Energy Technology (EDP-CNET)

EDP Group is an integrated energy player, with strong presence in Europe, US and Brazil and the third player in the world in terms of wind installed capacity. EDP is an innovative European Utility with an important presence across all the energy value chain, in Generation, Distribution, Energy Trading and Retail of electricity and gas. EDP owns HC Energia, the 4th Energy Utility in Spain and Energias do Brasil. EDP Centre for New Energy Technologies (EDP CNET) is a subsidiary of the EDP Group with the mission to create value through collaborative R&D in the energy sector, with a strong focus in demonstration projects. Currently, EDP has no activity as an aggregator, but, as the electricity sector evolves, EDP may consider aggregation either on the generation or supplier side through different companies within EDP Group. In the scope of this project EDP has chosen to focus on the supplying activity, therefore the information provided in this report is focused on the retailer side.

Websites: https://rd-new.com and http://www.edp.pt/en/Pages/homepage.aspx

Youris.com (Youris)

youris.com GEIE is an independent non-profit media agency promoting the leading-edge European innovation via TV media and the web. youris.com designs and implements media communication strategies for large research organizations and EU-funded projects and is able to establish permanent links between the research communities and the media. youris.com media products cover a wide spectrum of research areas including ICT, Environment, Energy, Health, Transport, Nanotechnologies, Food, Society, Gender and many others and are designed for large-scale distribution world-wide. Youris.com is a European Economic Interest Group (EEIG) based in Brussels with branch offices in Italy, Germany and France. Website: http://www.youris.com

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1.2 Purpose of the document

The purpose of this report is to identify the factors that determine the role and the value of the aggregators in the improved business models developed in the BestRES project in the report: *"Improved Business Models of selected aggregators in target countries"* [3] and analyzed in the report: *"Quantitative analysis of improved BMs of selected aggregators in target countries"* [4].

The role of aggregators in the power system and the value created by aggregation differ significantly with respect to the considered business model. In this document, we rely on the approach presented by Burger et al. [6] to identify the categories of value that aggregators may create in the improved business model in the BestRES project.

In section 2, we describe the approach presented by Burger et al. [6] to identify the value of aggregation. In section 3, we categorize the value of aggregation of the improved business models in the BestRES project.

In section **Fehler! Verweisquelle konnte nicht gefunden werden.**, we present overall conclusions about the value of aggregation in the BestRES project.

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2. Methods

To assess the impact of aggregation on the energy system and on individual stakeholders, we build on the approach presented by Burger et al. [6] to assess the value of aggregation. Burger et al. [6] differentiate between two types of economic value: system value and private value. System value is an increase of the economic efficiency of the whole power system, while private value corresponds to economic benefits of a group of stakeholders or a single market participant only. Private value increases the economic benefit of single agents, and may not be in line with an economic benefit for the system. They identify three categories for the value that energy aggregators can create: **fundamental**, **transitory** and **expedient**[2].

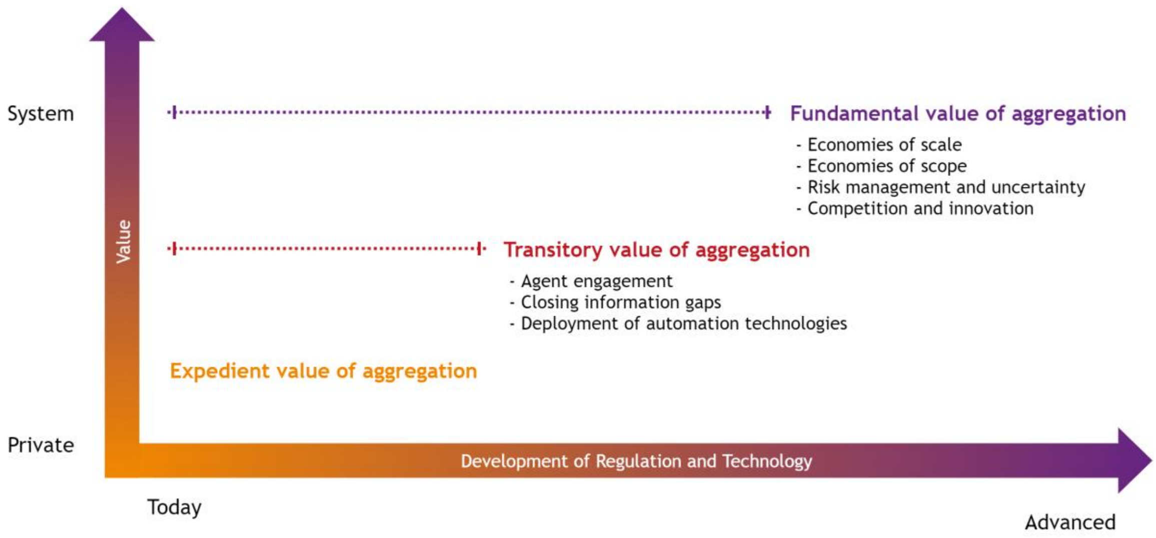

Figure 1: Different types of Value of aggregators. Own representation based on Burger et al. [6]

Fundamental value of aggregation means value that is intrinsic to aggregation itself and does not depend on regulatory frameworks, market designs or different agents[3]. Examples for fundamental value of aggregation are Economies-of-Scale and scope. Economies-of-Scale are present, if increasing the provision of a product or service reduces the average cost. This is often the case for products with a fixed – i.e. independent of the amount of production – cost component. A firm with fixed cost C_{fix} and variable cost C_{var}, producing n units, has total production cost of:

$$C_{tot} = C_{fix} + C_{var} \cdot n$$

Hence, the average cost

$$C_{avg} = \frac{C_{fix}}{n} + C_{var}$$

[2] In the original work of Burger et al. [6], the term “opportunistic” is used instead of “expedient”.

[3] With agents, we refer to consumers, producers and prosumers. They can operate DERs and therefore they can become active parties in the power system.

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decrease with increasing the number of produced units n. Economies of scope emerge when the provision of multiple different products or services uses common costs for business knowledge, technologies or engagement.

Furthermore, aggregators can create value via risk dispersion or hedging, which would not be possible for single market actors. An example for this are conventional electricity retailers that aggregate customers and stabilize price risks, e.g. by reducing the forecast error.

Considering the fundamental values of aggregation described above, in a static perspective on economic efficiency, it could be concluded that the optimal system design would result in one big monopoly aggregator, because this would provide the most benefits from Economies-of-Scale and scope. However, this ignores the value and potential benefits of competition, like innovation and customer engagement. Competition provides incentives for efficient prices and the development of new innovative products.

As the power system transitions to a more advanced future with respect to regulations and technologies, aggregators may unlock temporary value that is not intrinsic to aggregation. Burger et al. [6] call this **transitory value** and examples and provide as examples agent engagement, management of complexity, deployment of automation technologies, closing information gaps and coordinating agents for system operations. All these are services, often provided by different business models for aggregators, but the provided value is not intrinsic to aggregation. Aggregators just act as (temporary) intermediaries and enablers. An aggregator can for instance close information gaps by providing market signals to end users. However, it is possible that in a future energy system, customers will have this information available from alternative sources and do not require an aggregator for this.

The above categories of aggregation value increase the economic efficiency of the power system and, hence, provide system value. However, aggregators can also exploit regulatory flaws or weaknesses in market design to generate private value without providing benefits for the power system. We call this type of aggregation value **expedient value**. Burger et al. mention three categories of regulations that create opportunities for expedient aggregation:

- Rules related to the procurement of balancing services
- Rules related to the allocation of balancing costs to agents
- Inefficient locational price signals and inefficient network charges

In section 3 we systematically identify the value of aggregation created by the improved business models of the BestRES project [3] and allocate it to the three categories: **fundamental**, **transitory** and **expedient** value.

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3. Results

The value of aggregation created by the improved business models for aggregators in the BestRES projects can be classified into different categories, described in section 2. Here, we will discuss for each of the aggregation value types, fundamental, transitory and expedient, how different business models add to it. As a reminder, Table 1 lists the improved business models developed in the BestRES projects and provides a short explanation.

Table 1: Improved business models of all aggregators, including a short explanation

Aggregator	Improved business model	Label	Explanation	Group
Good Energy (UK)	Automation and control	BM1	Provision of hard- and software solutions allowing customers to automate their devices.	DSM
	"Peer-to-peer" (local) energy matching	BM2	Unite customers and generators on a local level and create value for both.	-
Next Kraftwerke Germany (Germany)	Dispatch flexible generation under changing market design on multiple markets	BM3	Increase value for generators by trading on multiple market places under changing market design, e.g. spot, balancing and reserves markets.	Market
	Suppling „mid-scale" customers with time variable tariffs including grid charges optimization	BM4	Time variable tariffs (especially grid charges) including monitoring will help consumers to benefit from market signals.	DSM
Next Kraftwerke Germany (France)	Providing decentralized units access to balancing markets	BM5	Distributed generators benefit from portfolio effects.	Market
Next Kraftwerke Germany (Italy)	Market renewables on multiple market places	BM6	Forecasting quality can be increased by using live data and portfolio effects. Valorizing pooled generation at dispatch and balancing markets.	Market
Next Kraftwerke (Belgium)	Trading PV and Wind power	BM7	Market the generation of renewable generators. As a result of portfolio effects, benefits could be achieved.	Market
	Using flexibility of customers as third party	BM8	This improved business model aims for customers whose supplier is not marketing flexibility. Flexibility can be valorized by an aggregator without changing the supplier.	DSM
Oekostrom AG (Austria)	Demand Side flexibilization of small customers	BM9	Activates demand side potential of customers. Allows a shift to a more integrated energy service provider.	DSM
	Invest and market distributed generation of customers in apartment houses	BM10	This improved business model aims in the market integration of solar generation of customers in apartment houses.	-

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EDP (Portugal)	Activation and marketing of end user's flexibility.	BM11	Flexibility of customers will be activated and valorized on energy markets.	DSM
EDP (Spain)	Activation and marketing of end user's flexibility.	BM12	Flexibility of customers will be activated and valorized on energy markets.	DSM
FOSS (Cyprus)	Pooling flexibility for local balancing market and energy service provision.	BM13	Because the Cypriot markets are not opened yet, this improved business model uses aggregation for providing DSO services.	-

Several business models share a similar approach and, hence, have similar characteristics with respect to the value of aggregation. In order not to enumerate all business models that show the same type of value creation, we define two groups of business models here. The business models **BM1**, **BM4**, **BM8**, **BM9**, **BM11** and **BM12** relate to demand side management (DSM) of electricity consumers. We cluster them into the group **DSM** business models. The other group of business models deals with aggregating distributed RES generation and marketing it on different energy or balancing markets. It includes **BM3**, **BM5**, **BM6**, **BM7** and we label it with **Market** business models. The remaining business models **BM2**, **BM10** and **BM13** cannot be clearly allocated to either of the above groups and will be mentioned individually.

3.1 Fundamental value of aggregation

The fundamental value of aggregation is independent of regulatory frameworks or market design. Burger et al. [6] identify four main categories for this fundamental value creation: Economies-of-Scale, economies of scope, risk management and competition and innovation. In the following subsections we will elaborate on the different types of fundamental value of aggregation in the context of the improved business models developed in the BestRES project.

3.1.1 Economies-of-Scale

We can detect Economies-of-Scale in all the improved business models in the BestRES project. Firstly, all business models require some kind of ICT infrastructure to enable communication between aggregator and customers. The investment in such ICT technologies is most likely characterized by Economies-of-Scale. So is the acquisition of expertise in this sector and the development of software for these purposes.

Furthermore, most of the **DSM** business models, like **BM1**, **BM4**, **BM11** and **BM12**, also include the deployment of automation technologies and the development of optimization algorithms for automated demand response. The production of automation boxes and software development is characterized by Economies-of-Scale.

Many improved business models in the BestRES project rely on access to wholesale or balancing markets. The **market** business models and to some extent

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BM8 and **BM10** all deal with marketing distributed renewable generation on different markets. Market registration and participation often comes with fixed registration fees and in many cases requires the applicant to be a Balance Responsible Party (BRP). This comes again with fixed costs, and, as discussed in section 2, they lead to Economies-of-Scale.

The business models dealing with intermittent RES production, like **BM2**, **BM6** and **BM7**, require forecasts for RES generation. Furthermore, both, the **market** and the **DSM** business models rely on market price predictions. The development or acquisition of methods and software for RES generation, demand or market price forecasts has fixed costs and, hence, is characterized by Economies-of-Scale.

3.1.2 Economies-of-Scope

Economies-of-Scope arise, when different products or services share common costs. The **market** business models considering multiple markets, like **BM3**, **BM6**, and **BM7** but also **BM8** use a common ICT infrastructure and common load or generation forecasting methods for the activities on several markets. So, value is created by the use of one tool for the access to multiple markets. As the aggregators are improving the capabilities of the tools and it is expected that the markets will mature, it is expected that the value provided by the Economies-of-Scope increases in the future.

Moreover, all business models of aggregators that are also energy suppliers, namely Good Energy, Oekostrom AG, EDP and Next Kraftwerke, i.e. **BM1**, **BM2**, **BM3**, **BM4**, **BM5**, **BM6**, **BM7**, **BM8**, **BM9**, **BM10**, **BM11** and **BM12**, can rely on available knowledge with respect to customer acquisition and services. Furthermore, software for load forecasting and services related to billing and similar that may be already available from conventional customer supply can be used in the BestRES business models as well.

Next Kraftwerke offers a broad range of products for energy producers, storages and consumers from active and reactive flexibility management to trading[4]. These different products share common costs for ICT infrastructure, market access, forecast and optimization software, customer acquisition and relationship and expertise in related fields. The improved business models for Next Kraftwerke in the BestRES project, i.e. **BM3**, **BM4**, **BM5**, **BM6**, **BM7** and **BM8**, can also benefit from and contribute to these available assets.

3.1.3 Risk management and uncertainty

Agents in the energy system face different kind of risks. Both, the **market** and the **DSM** models in the BestRES project, have to deal with uncertainty with respect to market prices. Burger et al. [6] note that aggregators and suppliers providing more customers act as intermediary between electricity consumers or

[4] https://www.next-kraftwerke.com/products last accessed on 16.01.2019

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distributed producers and energy markets can provide hedging solutions for price risks. This relationship is also shown in Figure 2.

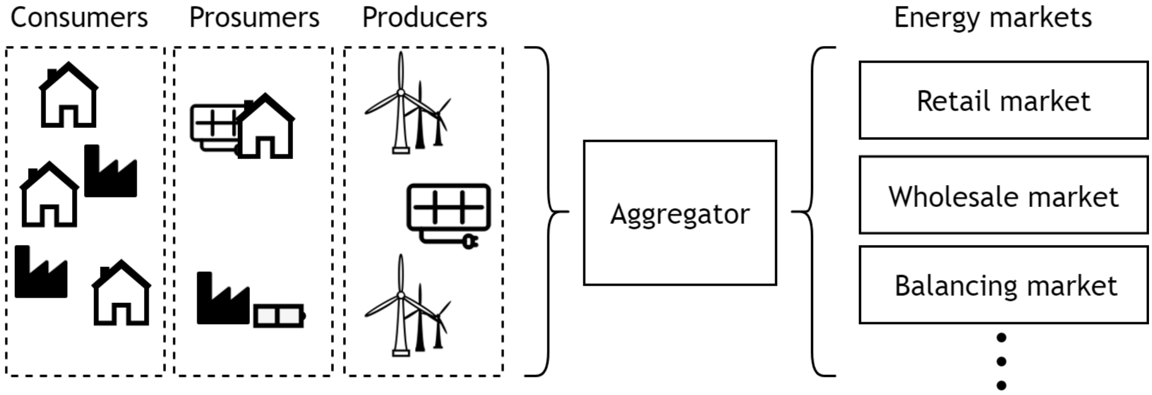

Figure 2: Aggregator as intermediary between consumers, prosumers, producers and energy markets.

BM10 investigates the investment in PV installations on apartment buildings. An aggregator or supplier has better options to hedge investment risks than individual end users do. This is in general true for all business models that require investments, e.g. for automation devices or market registration.

Another source of uncertainty for the improved business models in the BestRES project is the prediction of intermittent renewable production. When considering multiple stochastic RES producers the relative forecast error of the total portfolio is in general smaller than for a single power plant, because deviations from the prediction can be in different directions for individual power plants. This is relevant for **BM6** and **BM7**.

Finally, the business models that deal with balancing markets, like **BM3**, **BM5** and **BM8**, can mitigate risks of not being able to supply balancing energy due to outages of individual power plants. When trading a portfolio of technologies, an aggregator can compensate such failures with other power plants or flexibility options.

3.1.4 Competition and innovation

All improved business models in the BestRES project contribute to competition and innovation because they provide new products or improve existing services. **BM2**, for instance, is a very innovative business model providing the novel service of a peer-to-peer trading platform for residential customers, allowing them to decide, from which producers they want to procure energy and possibly, increasing end user engagement. In this context, consumer participation in the energy transition could be further improved, as this BM allows a deeper consumer involvement. **BM4**, **BM11** and **BM12** offer new innovative products for medium- to large-scale electricity consumers with flexibility options to reduce their energy bill. Similar innovative services are offered to residential customers in **BM1** and **BM9**. **BM3**, **BM5**, **BM6** and **BM7** deal with the entry into new markets

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and, hence increase competition there. **BM8** is very innovative, because it provides products to valorize flexibility as third party to customers, whose suppliers do not offer these services.

3.2 Transitory value of aggregation

The transitory value of aggregation is not intrinsic to aggregation. It may be significant in the near future as the power system is transitioning from imperfect regulations and technologies to a more advanced power system. The transitory value may be unlocked by engaging agents in electricity markets, closing information gaps and deploying automation technologies. Burger et al. [6] affirm that power systems today do not exhibit perfect information, regulations and rational agents. Technological or regulatory advances may diminish the transitory value of aggregation, but it will continue to exist as long as there are imperfect regulations. In the following subsections, we divide the transitory value of aggregation in three main categories: “Agent engagement”, “Closing information gaps” and “Deployment of automation technologies”. We will identify those types of transitory values of aggregation in the improved business models developed in the BestRES project.

3.2.1 Agent engagement

The agents at distribution system level provide opportunities to boost the efficiency of the power system as they may be capable of providing services to the system. However, they require incentives to provide these services, which may be offered by aggregators. Single agents may not be motivated to take actions for small benefits. Significant benefits are created only when many agents take coordinated actions.

All the **DSM** business models developed in [4] provide incentives for the agents to actively engage in the energy system and to offer their flexibilities. One of the roles of the aggregators in these business models is to price the actions that the agent may take, in a manner that incentivizes an efficient behavior. In the cases of **BM1** and **BM9** the aggregator does not communicate the real-time pricing information to the agents, but only a time of use tariff. The remaining **DSM** business models (**BM4, BM8, BM11** and **BM12**) allow the agents to access the wholesale and/or balancing markets indirectly via real-time tariffs and similar products. In this way, the agents are motivated to make their flexibilities available. In fact, in these business models the agents shift their loads/generations in order to achieve financial benefits.

The aggregator in **BM8** uses flexibilities of a third party supplier’s balancing group. In this case, the aggregator offers to the agent the possibility to achieve benefits providing a service that the supplier of the same balancing group of the agent does not offer.

In the **market** business models **BM3, BM5, BM6, BM7**, the aggregator is pooling flexible or non-flexible renewable energy generation to allow the agents to participate in wholesale markets and in balancing services. Reserve markets are

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usually open only for the agents that are able to offer and/or buy power in the region of 0.3-10 MW [7]. This limit does not allow small market agents to participate in these markets. Hence, aggregation offers agents various possibilities for trading flexibilities and this may affect their engagement positively.

3.2.2 Closing information gaps

Bridging the information gaps between agents, spot and balancing markets may enable market participants on the distribution system level to provide value for the energy system. Planning power operations requires the consideration of many factors. Agents may not know how the power system works and which technical reasons support the valorization of flexibilities. Furthermore, agents may lack the information about market prices and the factors that influences their electricity bill like grid charges, fees, etc. This information could unlock demand flexibilities of small agents. Aggregators may fill this lack of information and consequently give the agents the opportunity to hedge risks and optimize their operations through automated technologies. Burger et al. [6] allocate this value to the transitory values of aggregators, because in a more advanced or idealized future, agents may not need an aggregator to fill their information gaps to the wholesale markets.

The role of the aggregators in **BM3, BM4, BM5, BM6, BM7, BM8, BM9, BM10, BM11** and **BM12**) is to bridge the information gaps between the agents, the power system and the market prices. In the above listed business models, the aggregators use this information gaps to create transitory value. Moreover, in **BM3, BM5** and **BM8**, the aggregators also fill the information gaps between the agents and the reserve market prices. In these business models, aggregators optimal forecast the auction bids and the reserve activations. This possibility to achieve monetary benefits may motivate agents to offer an aggregator their flexibilities. In **BM10**, the consumption and the size of a PV plant for an apartment building with multiple flats is optimized in considering grid charges and market price signals.

3.2.3 Deployment of automation technologies

Automated devices and generators can provide optimal behavior to maximize the profits and/or minimize the costs. Hence, the deployment of information and communication technologies (ICTs) represents a technological advancement, which allows agents to coordinate distributed resource operations and to provide a set of services to the distribution system without particular efforts. Burger et al. [6] affirm that automation, supported – at least temporarily – by aggregators, and the technological innovations associated with the “Internet of Things” (IoT) are the future of an enhanced and more comprehensive vision of demand response.

In all the business models developed in the BestRES project [4], we identify transitory value of aggregators, due to automated energy management technologies. In particular, in **BM1**, the devices of small consumers are automated and a real-time-pricing tariff is applied. In the other **DSM** and **market**

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business models, different automation technologies for the optimal control of energy generation, consumption and/or energy trading are deployed. In **BM2, BM3, BM5 and BM6** the generation of flexible renewable power plants is controlled by optimization algorithms. In **BM2, BM4, BM8, BM9, BM11, BM12** and **BM13** the residential electricity usage is managed by software, while in **BM3, BM4, BM5, BM6, BM7, BM8, BM9, BM10, BM11** and **BM12** the energy trading strategies on the wholesale markets and the auctions bids on the reserve markets are automated. The automation of energy trading strategies allows aggregators to optimal trade the available products on multiple marketplaces. The German Aggregator “Next Kraftwerke” is already using remote automated control units (Next Boxes) to connect and control consumers and producers. These boxes are individually configured, can deal with various interfaces and establish connection between assets and the control system. Algorithms within the control system optimize the operations of the assets. Without optimization algorithms and automation technologies, it would be impossible to take into account all the variables of thousands of assets and their complex relationships with the energy markets.

3.3 Expedient value of aggregation

With expedient value of aggregation we mean private value unlocked by aggregators that does not provide value for the energy system or even decreases total system efficiency. The presence of expedient aggregation, however, is not the fault of aggregators, but it is caused by regulatory flaws that provide incentives for this behavior. For most of the business models in the BestRES project only aspects of fundamental and transitory value of aggregation could be found. However, we found one business model that is related to some aspects of regulation that Burger et al. [6] identified as creating opportunistic value.

Burger et al. [6] note that “provision of electricity services by aggregators (e.g. by changes on initial positions) without facing balance responsibility from energy deviations (i.e. when the aggregator is a not the Load-Serving Entity or balance responsible party) may lead to opportunistic aggregation strategies that should be avoided by regulation”. This is closely linked to the approach described in **BM8**, where the aggregator Next Kraftwerke Belgium uses the flexibility of a customer belonging to a different balancing group as third party. In the improved business model in the BestRES project, however, a bilateral contract between aggregator and supplier is signed, ensuring that the operation of the third party aggregator does not influence the suppliers revenue and imbalance cost. Hence, in the BestRES business model, no expedient value of aggregation is created.

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4. Summary and Conclusions

This report analyses in a qualitative way the value of aggregation created by the improved business models developed in the BestRES project. The value of aggregation in the improved business models can be categorized into **fundamental**, **transitory** and **expedient** value. Both, **fundamental** and **transitory** value, provide value for the whole energy system, while **expedient** value only creates private value for individual agents without increasing – or even decreasing – system efficiency.
The **fundamental** value of aggregation is intrinsic to aggregation itself and does not depend on market design, regulations or individual agents. The main drivers for **fundamental** value of aggregation are Economies-of-Scale, Economies-of-Scope, risk mitigation and the introduction of competition and innovation. All improved business models in the BestRES project exhibit aspects of fundamental aggregation. Economies-of-Scale and scope can be found in all BestRES business models and most of them contribute to risk mitigation. Furthermore, many of the improved business models for aggregators in the BestRES project show innovative improvements and increase competition in energy markets, which are typically controlled by conventional market players. This creates value as it matures the energy markets, although it may be counterintuitive considering the Economies-of-Scale.

The **transitory** value of aggregation might only be relevant temporarily while the energy system transitions into a more idealized future. Nevertheless, aggregators can play a key role here for the transition of the energy system by enabling agent engagement, closing information gaps and deploying advanced automation technologies. Many of the improved business models in the BestRES project deal with aggregators enabling decentralized agents to actively engage in the energy system. This is either achieved by closing information gaps through the provision of market signals to end users or by providing market access to distributed RES producers. Most of these business models require automation technologies in order to bring decentralized flexibilities into the markets. Hence, the improved business models in the BestRES project can contribute significantly to the advancement of the energy system.

The **expedient** value of aggregation can provide private value for individual agents without contributing to or even impairing total system efficiency. Hence, it is important to comprehensively investigate the effects of aggregator business models on other market participants and the total cost of the energy system. The **expedient** value of aggregation is linked to flaws in regulation that can be exploited by aggregators. However, in the BestRES project this type of aggregation value is not present in any of the improved business models.

Figure 3 shows the value of aggregation we identified in BestRES. It concludes that most of the business models provide fundamental and transitory value of aggregation. As introduced in the beginning of this report, the value of aggregators highly depends on the regulations and technologies. As stated in Burger at al. [6], in a future scenario with “perfect” regulations and markets

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that expose the full marginal costs of providing or consuming energy services coupled with autonomous end-user energy management systems (e.g. in the form of smart boxes), the only value of aggregators will stem from the fundamental value drivers identified herein. Although it may be assumed, that the "perfect" conditions may never be reached.

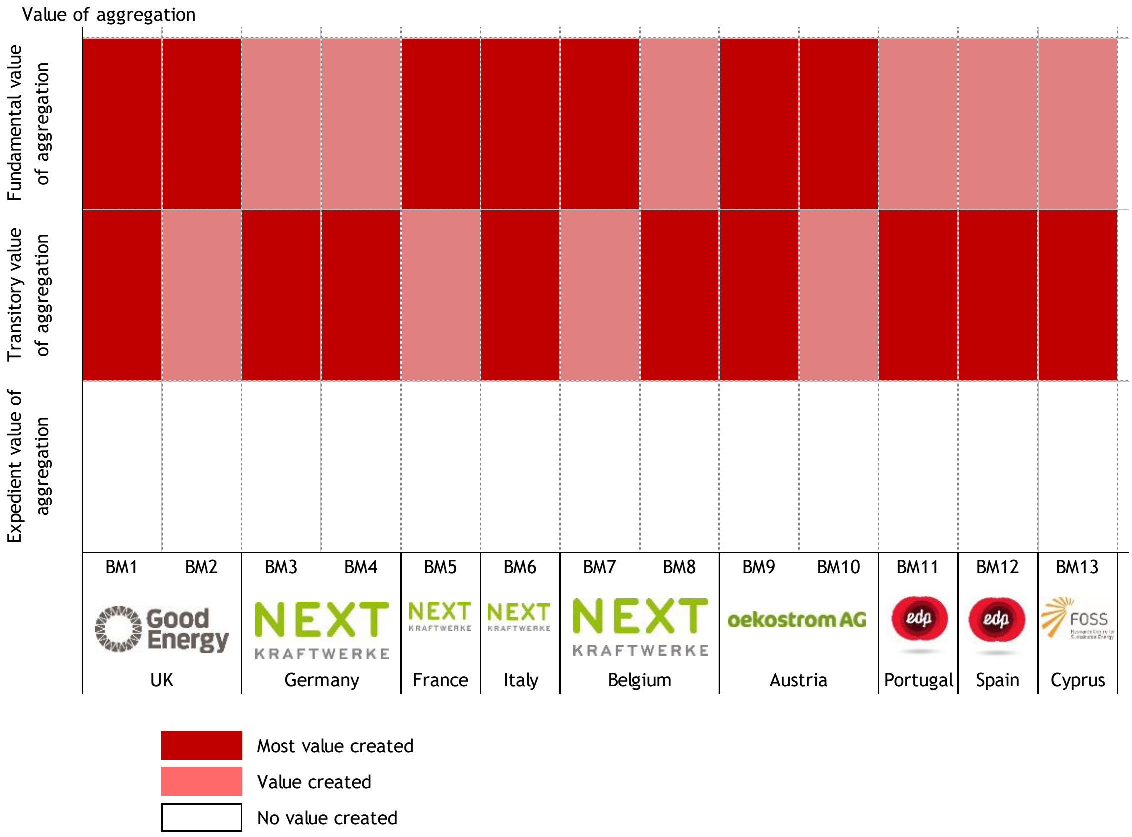

Figure 3: Categorization the value of aggregation on the business models identified within BestRES

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Technical references

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* PU = Public
PP = Restricted to other programme participants (including the Commission Services)
RE = Restricted to a group specified by the consortium (including the Commission Services)
CO = Confidential, only for members of the consortium (including the Commission Services)

v	Date	Beneficiary	Author
0.1	09/01/2019	TUW-EEG	Daniel Schwabeneder
0.2	18/01/2019	TUW-EEG	Carlo Corinaldesi
0.3	24/01/2019	TUW-EEG	Andreas Fleischhacker
0.4	25/01/2019	TUW-EEG	Daniel Schwabeneder
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