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BestRES

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

Technical, market, environmental and social benefits of aggregation BMs within the consortium

August 2016

www.bestres.eu

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Acknowledgement

This report has been produced within the BestRES project "Best practices and implementation of innovative business models for Renewable Energy aggregatorS".

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 Ruben Verhaegen (3E), Carlos Dierckxsens (3E) and Pieter Joseph (3E). The authors thankfully acknowledge the valuable contributions from all project partners, especially from Andreas Fleischhacker (TUW-EEG) and Georg Lettner (TUW-EEG) to complete this report.

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Abbreviations

BM	Business Model
BRP	Balancing Responsibility Provider
CAPEX	Capital Expenditures
CfD	Contracts For Difference
CHP	Combined Heat and Power
DR	Demand Response
DSM	Demand Side Management
DSO	Distribution System Operator
EPC	Engineering, Procurement, Construction
ESCO	Energy Service company
EV	Electric Vehicles
FiP	Feed-in-Premium
FiT	Feed-in-Tariff
ICT	Information and Communication Technology
IoT	Internet of Things
NRV	Net Regulation Volume
PPA	Power Purchase Agreement
ToU	Time-of-Use
RES	Renewable Energy Sources
TSO	Transmission System Operator
VPP	Virtual Power Plant
VRE	Variable Renewable Energy

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Executive Summary

In a changing electricity market landscape, where the share of intermittent renewable energy in the energy mix is increasing, system flexibility becomes crucial. As part of the solution, the aggregation of renewable energy can significantly accelerate the integration of intermittent electricity sources, complement demand flexibility and decrease the reliance on renewable energy support schemes. Aggregators of demand and/or generation are therefore expected to have an increasingly important role to play in the future. The BestRES project investigates the current barriers for aggregators and suggests ways of improving the role of aggregators in future electricity market designs.

In this context, this second deliverable analyses the potential technical, market, environmental and social benefits of energy aggregation. The focus has been set on the countries in which the consortium is active; the United Kingdom, Germany, France, Belgium, Austria, Portugal, Spain, Italy and Cyprus. In depth interviews were carried out by 3E and TUW with aggregators whereas literature was also reviewed.

General Benefits

The general benefits of aggregation can be found in an improved security of supply and market integration, prosumer and consumer empowerment, CO2 emissions reduction and boosted competition and innovation. Figure 1 illustrates these potential benefits according to the aggregators.

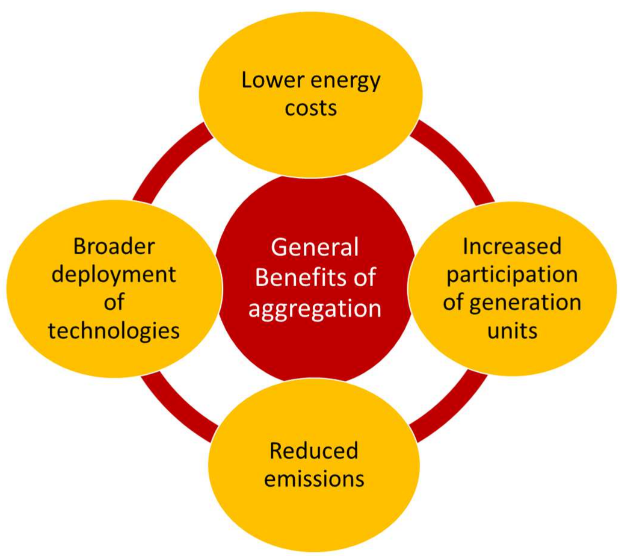

Figure 1: Principal potential benefits of aggregation

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The increased participation of generation units to markets of aggregation services and the broader deployment of both generation and other technologies such as Virtual Power Plants (VPPs) and Internet of Things (IoT) is already visible in several countries, mainly in Germany and the United Kingdom. The lower energy costs and reduced emissions are, however, more difficult to measure at this moment because other factors such as the share of VRE play a major role.

Another important point is that benefits are significantly more present in markets that are opening up such as Germany, the United Kingdom, Austria and Belgium whereas the market for aggregation is (relatively) closed in Spain, Portugal, Italy and Cyprus. In France the situation is somewhere in between.

Market Benefits

Figure 2 furthermore indicates that potential market benefits can be viewed from 3 different perspectives.

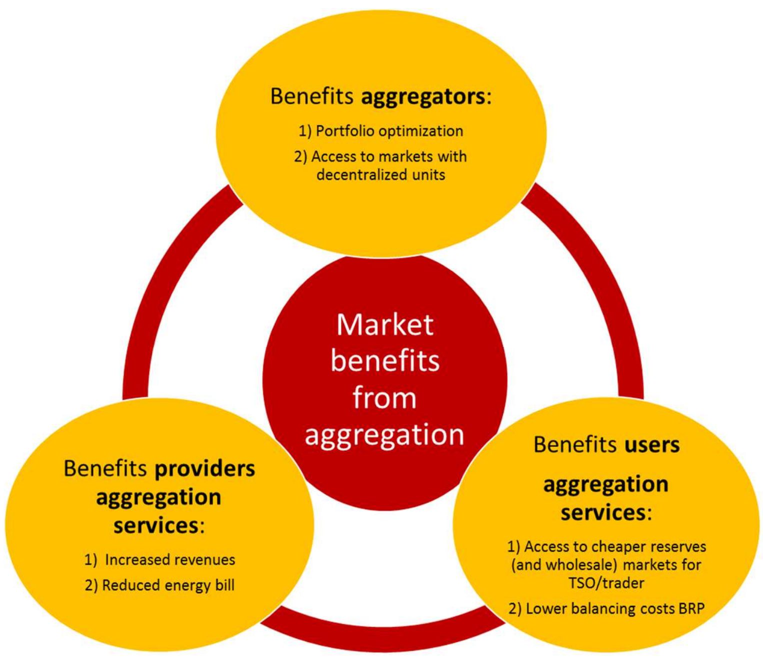

Figure 2: Market benefits of aggregation

According to our research, the main benefits from aggregation for aggregators are portfolio optimization and the increased market access with decentralized units. It can also improve the relationship between prosumers and aggregators.

For providers of aggregation services, the potential benefits include increased revenues and a reduced energy bill. The optimal remuneration scheme depends

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on the customer segment but fixed fees play an important role to provide financial stability to providers. It can be expected that aggregation services will become increasingly attractive for providers in the coming years.

With respect to users of aggregation services, aggregators commonly perceive lower prices on control reserves and wholesale markets as a key advantage since more units are participating. Furthermore, aggregation has the potential to lower balancing costs and decrease the energy costs for prosumers. Some of these advantages are however very difficult to measure.

Technical and social benefits

Other important benefits identified by the consortium through the interviews and literature are displayed in Figure 3.

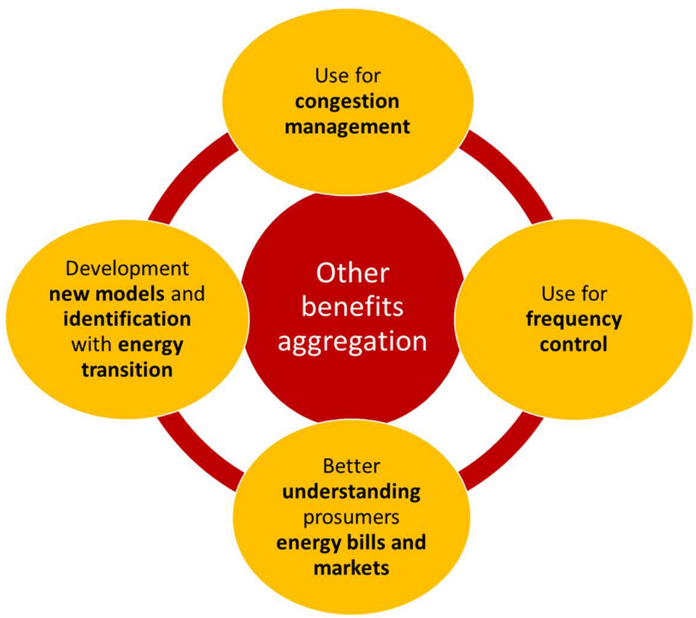

Figure 3: Other benefits of aggregation

Since aggregators deliver primary, secondary and tertiary reserves in the United Kingdom, Germany, France, Belgium and Austria, provision of frequency control is already relatively common. Congestion management is less common but the consortium identified potential business cases both in Germany and the United Kingdom.

Finally, aggregators, in collaboration with other partners, can develop new “life-style” models that make customers more aware of climate issues. This, and other new ways of collaborating, can increase the identification with the energy transition and allow prosumers to better understand energy bills and markets.

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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 individuals, 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 it 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

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this situation, the player downstream and upstream could potentially be the same entity.[1]

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 (life-cycle analysis). 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.

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[1] Guidelines on State aid for environmental protection and energy 2014-2020

Sauba G., Van der Burgt J., Varvarigos E., Makris P., Schoofs A., VIMSEN – Smart Tool for Energy Aggregators, Conference Paper, 37th IEEE International Telecommunications & Energy Conference (INTELEC), October 2015

NordREG Nordic Energy Regulators, Discussion on different arrangements for aggregation of demand response in the Nordic market – February 2016, February 2016, Available at: http://www.nordicenergyregulators.org/wp-content/uploads/2016/02/NordREG-Discussion-of-different-arrangements-for-aggregation-of-demand-response-in-the-Nordic-market.pdf

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Eurelectric, Flexibility and aggregation, Requirements for their interaction in the market, January 2014, Available at: http://www.eurelectric.org/media/115877/tf_bal-agr_report_final_je_as-2014-030-0026-01-e.pdf

European Commission-Seventh Framework Programme, DREAM electricity market design, WHITE PAPER, October 2014, Available at: https://webhotel2.tut.fi/units/set/ide4l/DREAM2%20DREAM-market-design.pdf

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The BestRES project will last three years. It 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
- RE-Pro, renewable energies aggregator active as ESCo provider in Italy and Cyprus
- Next Kraftwerke Germany, renewable energies aggregator active in Germany and France
- Energias de Portugal, renewable energies aggregator active in Spain and Portugal

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.

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

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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.
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/

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

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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/

RE-Pro Management (RE-Pro)

RE-Pro is a renewable energy provider dedicated to clean and renewable energy sources. Specialized in the fast-growing areas of solar power generation and energy efficiency management, RE-Pro has successfully launched its services through a range of photovoltaic power parks in southern Europe. Guaranteed power purchasing contracts with national grids generate a stable revenue stream, which forms the basis for the development of RE-Pro's innovative energy efficiency management services.
Website: http://www.re-pro.eu/

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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

1.2 Structure of the document

The objective of this report is to determine technical, market, environmental and social benefits that aggregators bring to power markets and systems.

The remainder of the document is structured as follows:

- Section 2 briefly outlines the project methodology
- In Section 3, we elaborate on the potential benefits of aggregation
- In Section 4, we look into benefits that aggregators bring to power systems and markets in the countries that are covered by the consortium
- Section 5 concludes the current discussion of this report

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2. Methodology

In the proposal phase of the project, project partners in different regions of Europe were selected. A total of 6 aggregators in 9 different countries were included:

1. Western Europe: Germany (Next Kraftwerke DE), France (Next Kraftwerke DE), Belgium (Next Kraftwerke BE) and Austria (Oekostrom)
2. Southern Europe: Spain (EDP) and Portugal (EDP), Italy (RE-Pro) and Cyprus (RE-Pro)
3. British Isles: the United Kingdom (Good Energy)

In order to better understand the benefits aggregators bring to power markets and systems, 3E carried out an extensive desk research to develop a comprehensive questionnaire (annex 1). The questionnaire was revised by all consortium partners and afterwards surveys were carried out with the aggregator consortium partners. The results of the surveys and complementary desk research are extensively discussed in the following sections.

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3. Benefits of energy aggregation

The objective of this part of the report is to identify potential benefits of energy aggregation such as market integration, prosumer and consumer empowerment, CO2 emissions reduction and boosting competition and innovation. Some benefits are already visible since a significant amount of providers of aggregation services, such as distributed generators and demand response providers, are already connected to the grid. Aggregated volumes are expected to significantly multiply in the coming years so benefits in the mid-to-long run (2020) will be a lot higher. Also, the amount of electric vehicles and public charging stations is expected to increase in the future. Increased total volumes in combination with technological innovations can allow aggregators to valorize aggregation and encourage customers to interact with the market.[2]

The consortium looked into the potential of each provider of aggregation services. Figure 4 shows the summarized potential for Demand Response (DR) in the industry (iron & steel, metals, chemical & petrochemical, mineral, paper, pulp & print and wood), the tertiary sector (commercial refrigeration, air-conditioning, space & water heating) and the residential sector.

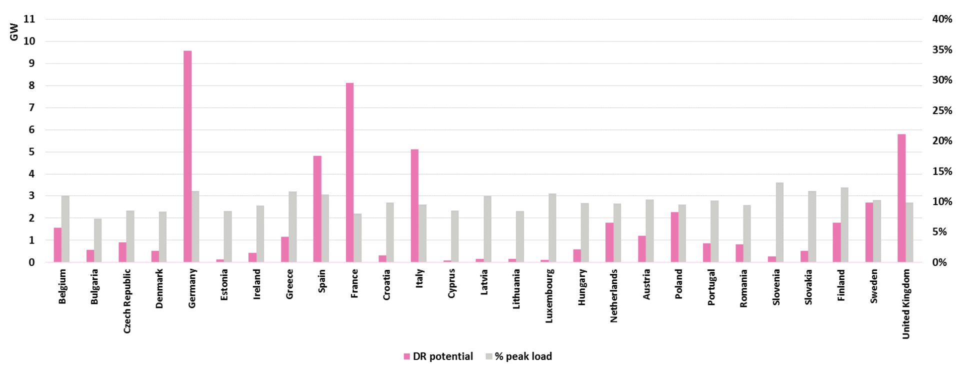

Figure 4: DR potential per country in the European Union[3]

[2] Delta Energy & Environment, The Battleground for Flexibility (Part 1), How technical innovations and business models are shaping the commercial demand response market, June 2016
CEER, Council of European Energy Regulators, CEER Advice on Ensuring Market and Regulatory Arrangements help deliver Demand-Side Flexibility, June 2014, Available at: http://www.ceer.eu/portal/page/portal/EER_HOME/EER_PUBLICATIONS/CEER_PAPERS/Electricity/Tab3/C14-SDE-40-03_CEER%20Advice%20on%20Demand-Side%20Flexibility_26-June-2014.pdf

[3] Sia Partners, Demand Response: A study of its potential in Europe, February 2015, Available at: http://energy.sia-partners.com/20150205/demand-response-a-study-of-its-potential-in-europe

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Slovenia (13%), Finland (11%), Germany (11%) and France (11%) have the highest potential in terms of % peak load, whereas Germany (9.5 GW), France (8 GW), the UK (6 GW) and Italy (5 GW) have the highest estimated potential in terms of GW. These countries are therefore interesting countries for developing aggregation services.

With respect to distributed generation, around 129 GW of wind power and 87 GW of PV solar power were installed at the end of 2014. Germany has the highest installed capacities for both technologies. Table 1 reviews the installed capacities of onshore wind and PV for the countries covered by the consortium at the end of 2014 and forecasted for 2020.[4]

Table 1: Potential (forecasted installed capacities) of onshore wind and PV solar in countries covered by the consortium

	Installed onshore wind capacity end 2014 (MW)	Forecasted capacity onshore wind 2020 (MW)	Installed PV solar capacity end 2014 (MW)	Forecasted capacity PV solar 2020 (MW)
United Kingdom	7953	12440	5203	16834
Germany	38369	45000	38301	51285
Belgium	1247	3000	3105	3989
France	9285	18500	5600	12820
Austria	2095	3400	770	6400
Portugal	4913	5700	419	670
Spain	22982	26000	4787	7456
Italy	8665	12000	18450	25613
Cyprus	147	300	65	No data available

With respect to the potential of storage, research from Navigant assumes that utility-scale storage capacity will grow by 63% per year worldwide up to 2023. This is mainly driven by considerable cost decreases of storage technologies. Few data is available for home storage but Germany is the only European market where this is really developing.[5]

4 EWEA, The European Wind Energy Association, Wind energy scenarios for 2030, August 2015
E&Y, a study commissioned by SolarPower Europe, Solar Photovoltaics Jobs & Value Added in Europe, November 2015, Available at: http://www.solarpowereurope.org/fileadmin/user_upload/documents/Media/Jobs___Growth.pdf
5 Insight-E-7th Framework programme for Research and Technological Development, How can batteries support the EU electricity network?, November 2014, Available at: http://www.insightenergy.org/ckeditor_assets/attachments/48/pr1.pdf

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We will subsequently elaborate on the general (section 3.1), market (section 3.2), technical (section 3.3) and environmental and social (section 3.4) benefits that aggregators can bring to markets and systems in the following sections.

3.1 General benefits of aggregation

As defined by CEER (Council of European Energy Regulators), the main potential benefits of aggregation are an improved security of supply and market integration, prosumer and consumer empowerment, CO2 emissions reduction and competition and innovation can be boosted.

Aggregation provides users of aggregation services such as the system operator with a diverse portfolio, which ensures that the committed capacity will be delivered by the aggregator even when some individual loads are not able to deliver so they increase system reliability. Also, aggregation services and flexibility will improve the integration of distributed energy resources and help to deal with the growing peak demand for electricity. For providers of aggregation services, aggregators are valuable because they help to participate in the market and reduce risks. Furthermore, consumers regularly don't know about their own flexibility potential and aggregators can provide expert support. All of this can significantly improve revenues for providers of aggregation services and enforce consumer empowerment in the energy system.[6]

It is also crucial to emphasize the distinction between fundamental and more temporary benefits. In the first case, value will be permanent and does not depend on regulation and market awareness of technologies in place. In the latter case, aggregation can contribute to better functioning of the power system but may disappear when technical, managerial and regulatory conditions improve. Apart from these 2 categories, aggregation can also be

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http://www.pv-magazine.com/news/details/beitrag/portugal-adds-33-mw-of-pv-for-330-mw-cumulative-solar-capacity_100016340/#axzz4GSg0MFmQ

[6] CEER, Council of European Energy Regulators, CEER Advice on Ensuring Market and Regulatory Arrangements help deliver Demand-Side Flexibility, June 2014, Available at: http://www.ceer.eu/portal/page/portal/EER_HOME/EER_PUBLICATIONS/CEER_PAPERS/Electricity/Tab3/C14-SDE-40-03_CEER%20Advice%20on%20Demand-Side%20Flexibility_26-June-2014.pdf
SEDC (Smart Energy Demand Coalition), Demand Response: Clarification of the standard processes required between BRPs and independent aggregators, July 2015
EnergyPool, Smart Energy Management, Demand response Market Opening The Role of Aggregators, July 2014
EG3 report, Smart Grid Task Force, Regulatory Recommendations for the Deployment of Flexibility, January 2015
Interviews with aggregators

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purely opportunistic when aggregators benefit from imperfect or asymmetric information, technology constraints, political interferences and conflictive regulatory principles. The situation is summarized in Figure 5.[7]

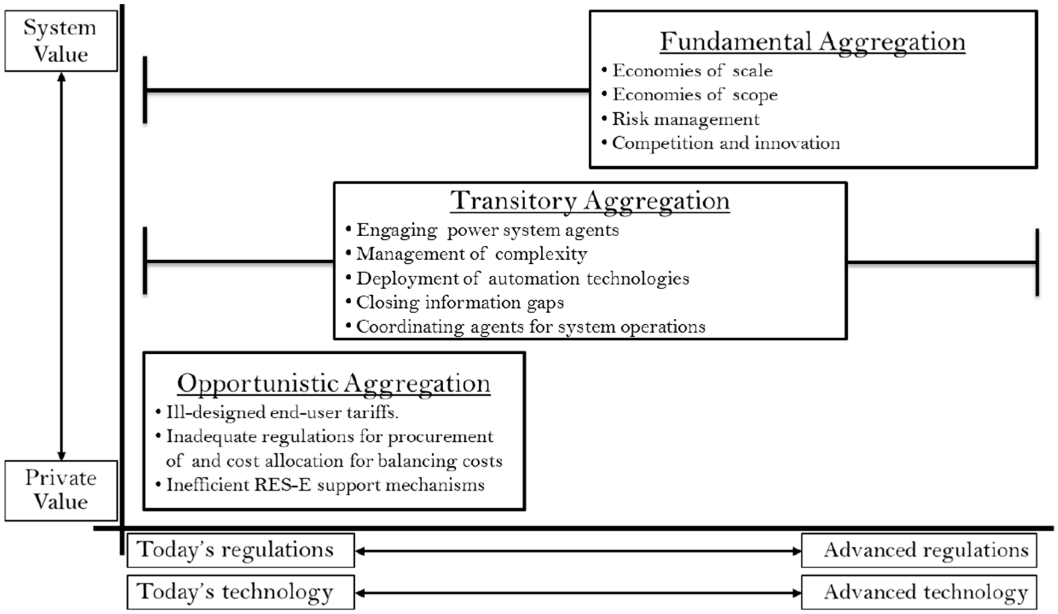

Figure 5: MIT Center for Energy and Environmental Policy Research - The benefits from aggregation based on technology and regulatory contexts

The figure illustrates the different types of aggregation in function of regulatory and technology progress and the value both for the aggregator and the system as a whole. If aggregation only creates private opportunistic value, regulation should be modified in a lot of cases. In some cases, however, such regulation can be desired as a form of temporary subsidy. Finally, the value of aggregation will be largely related to the level of competition in the market.[8]

3.2 Markets benefits of aggregation

Aggregation can bring market benefits to the different stakeholders on the markets: aggregators, providers of aggregation services and users of aggregation services. These benefits will also go hand in hand with market benefits for the system as a whole such as increased competition, faster

[7] MIT Center for Energy and Environmental Policy Research, The Value of Aggregators in Electricity Systems, January 2016
[8] MIT Center for Energy and Environmental Policy Research, The Value of Aggregators in Electricity Systems, January 2016

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deployment of new technologies and innovation on the side of the system operator.[9]

3.2.1 Market benefits for aggregators and the power system

Acting as an aggregator involves incurring costs such as customer acquisition, the remuneration of providers of aggregation services, information and communication technologies (ICT) and costs to comply with power regulations and market rules. These cost components include fixed and variable costs and therefore **economies of scope and scale** can be achieved. If fixed costs are a significant part of total costs, there is value in aggregation through economies of scale because average costs are going down when more providers of aggregation services are connected. Furthermore, if there are common technologies, transaction and acquisition costs, aggregation has the potential to create value through economies of scope.

Other crucial benefits of aggregation are increased competition and innovation. Aggregation can facilitate the market opening to a large number of participants and bring in new models, products and services. For the grid operator, it is likely that it is easier and more cost-efficient to coordinate a limited amount of aggregators compared to the situation where a huge amount of providers of aggregation services needs to be coordinated. Aggregators will also be better placed to deal with rapidly changing technologies. A last potential advantage of aggregation is that aggregators, by acting as mediator between DR providers/generators and volatile markets, provide risk hedging solutions to providers of aggregation services.[10]

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[9] MIT Center for Energy and Environmental Policy Research, The Value of Aggregators in Electricity Systems, January 2016
CEER, Council of European Energy Regulators, CEER Advice on Ensuring Market and Regulatory Arrangements help deliver Demand-Side Flexibility, June 2014, Available at: http://www.ceer.eu/portal/page/portal/EER_HOME/EER_PUBLICATIONS/CEER_PAPERS/Electricity/Tab3/C14-SDE-40-03_CEER%20Advice%20on%20Demand-Side%20Flexibility_26-June-2014.pdf
http://www.energynetworks.org/electricity/futures/network-innovation/network-innovation.html

[10] MIT Center for Energy and Environmental Policy Research, The Value of Aggregators in Electricity Systems, January 2016
EnergyPool, Smart Energy Management, Demand response Market Opening The Role of Aggregators, July 2014
CEER, Council of European Energy Regulators, CEER Advice on Ensuring Market and Regulatory Arrangements help deliver Demand-Side Flexibility, June 2014, Available at:
http://www.ceer.eu/portal/page/portal/EER_HOME/EER_PUBLICATIONS/CEER_PAPERS/Electricity/Tab3/C14-SDE-40-03_CEER%20Advice%20on%20Demand-Side%20Flexibility_26-June-2014.pdf

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Figure 6 summarizes different potential benefits related to the appearance of aggregators.

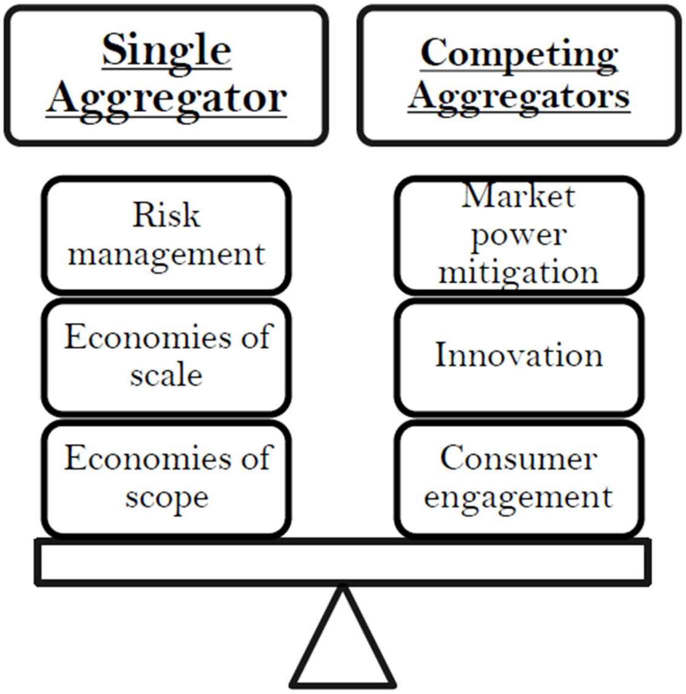

Figure 6: Benefits from aggregation with and without competition[11]

The figure shows the extreme difference between the situation where there is only one aggregator and the situation where there is a lot of competition between aggregators. In most of the countries that are covered by the consortium of the BestRES project, the ongoing developments are somewhere in between these two situations. Also, if a lot more providers of aggregation services are coming on the market and users of aggregation services are requesting more services, the market is growing. In this situation, an aggregator might be able to generate economies of scale and scope while there is also space for innovation and consumer engagement. This case is probably more feasible in a large market with a lot of providers and users of flexibility such as Germany and the United Kingdom compared to smaller markets such as Portugal and Cyprus.

[11] MIT Center for Energy and Environmental Policy Research, The Value of Aggregators in Electricity Systems, January 2016

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3.2.2 Market benefits for providers of aggregation services and the power system

Since aggregation is not possible without providers of aggregation services, these providers will of course also need a trigger to participate. DENA, the German Energy Agency, concluded in a recent analysis that providing flexibility will become increasingly attractive until the year 2025 and that both the application frequency and income incentives may double. DENA developed different indicators that characterize flexible demand as well as potential income possibilities for flexibility options.[12]A recent report in the framework of the IndustRE project also highlight the valorisation of flexible industrial electricity demand (DSM). The project specifically looks into offering reserve capacity to the TSO, imbalance optimization and on-site VRE optimization and clearly shows that quite interesting business cases can already be calculated with publicly available information.[13] Another report from 2015 highlights that the value of demand-side flexibility in the USA amounted to over €2.2 billion in 2014.[14]

Finally, Delta EE recently showed that stakeholders that are involved in aggregation activities expect that small commercial/distributed loads will touch the most important part of the benefits of demand response in 5 years' time as shown in Figure 7.

[12] DENA, The German Energy Agency, Development of revenue options for flexibility on the electricity market, April 2015, Available at: http://www.dena.de/publikationen/energiesysteme/dena-analyse-entwicklung-der-erloesmoeglichkeiten-fuer-flexibilitaet-auf-dem-strommarkt.html
[13] IndustRE, Adapted methodology for optimal valorization of Flexible Industrial Electricity Demand, Deliverable 3.2, June 2016, Available at: http://www.industre.eu/downloads/
[14] SEDC, Smart Energy Demand Coalition,

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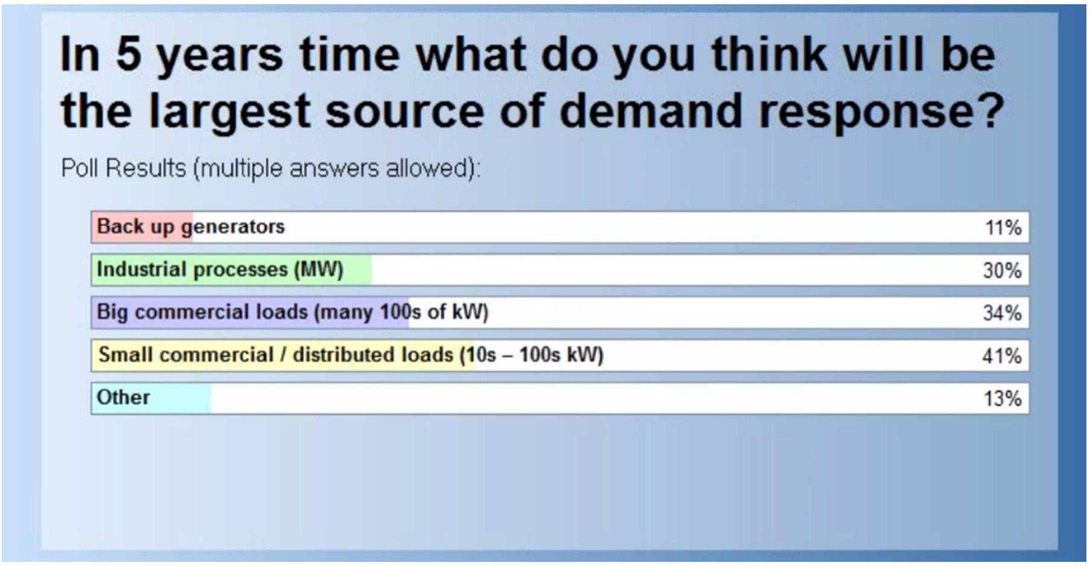

Figure 7: stakeholders' expectations with respect to source of demand response[15]

[15] Delta EE, The Battleground for Flexibility (Part 1), How technical innovations and business models are shaping the commercial demand response market, June 2016,

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3.2.3 Market benefits for users of aggregation services and the power system

Demand response and other flexibility can bring benefits to system operators and BRPs (Balancing Responsibility Parties) as recently mentioned in different studies. Furthermore, traders and energy suppliers can benefit from aggregation. Finally, they will bring important costs benefits to electricity consumers in the case of an aggregator providing ESCO services.

In the case of system operators, aggregation service providers can increase the system's adequacy and reduce the need for peak generation capacity as underlined in recent documents published by SEDC (Smart Energy Demand Coalition). Aggregation can add stability to the power system, create a situation where there is less need for centralized generation that uses fossil fuels and avoid network investments. Furthermore, the relationship between aggregators and users of aggregation services can increase competition on markets that were historically often dominated by a few large players and allow the participation of independent aggregators (a detailed description in D2.1 of the BestRES project).[16]

In the case of the BRP, aggregation services could be used either for balancing the portfolio or for generating revenues from imbalances. In the second case, we can for example assume that, through aggregation, downward and upward forecasting errors for a 100 MW portfolio in Belgium are significantly decreasing and symmetric. In this scenario, the yearly balancing cost paid by the responsible BRP is equal to 0. The aggregated portfolio can now help the Belgian TSO Elia to maintain system balance and the BRP could benefit from this when there are very high negative tariffs for negative imbalance (a negative price means that the project receives money from Elia). At certain moments in time, the portfolio is producing significant volumes of electricity and negative imbalance tariffs are negative:

- The BRP sells 100 MWh on the market at a price of 27.60 euro/Mwh on 13/03/2016 at 3 pm[17]
- The BRP nominated (nomination= schedule of a planned power injection or offtake) of 100 MWh at the connection point to Elia
- The production is 100 MWh at the moment (so no forecasting error)
- The negative imbalance tariff at this moment was -283 euro/MWh. The BRP curtails the full production for increasing profits.[18]

[16] SEDC, Smart Energy Demand Coalition, Mapping Demand Response in Europe Today, 2015
[17] www.belpex.be

[18] http://www.elia.be/en/grid-data/data-download

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- The BRP (and his providers of aggregation services) earn approximately 311 euro/MWh at this moment

In this context of this example, 3E looked in detail into the relationship between production data of 100 MW renewable generation assets and the balancing tariffs (hourly values as average of the 15-minute published price data) for 2015. It will be interesting to curtail the portfolio when remuneration is higher than the lost value of green certificates (we assume a value of 90 euro/green certificate - guaranteed value for Flanders region- and 1 green certificate for 1 MWh of production). Figure 8 highlights all moments of the year when the portfolio produced electricity and when negative imbalance tariffs were lower than -90 euro/MWh.

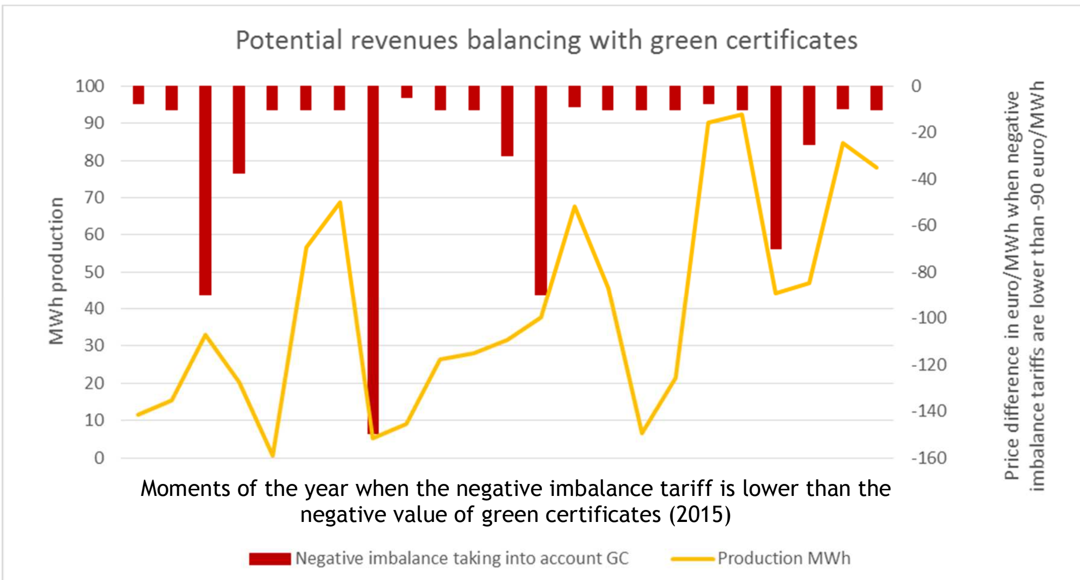

Figure 8: Potential revenues balancing with green certificates[19]

The potential benefit in this case is approximately EUR 20,000

If no subsidies for renewables are in place (scenario in the future), the portfolio will be curtailed at any moment of negative tariffs for negative imbalance. This situation is summarized in Figure 9.

[19] http://www.elia.be/en/grid-data/data-download

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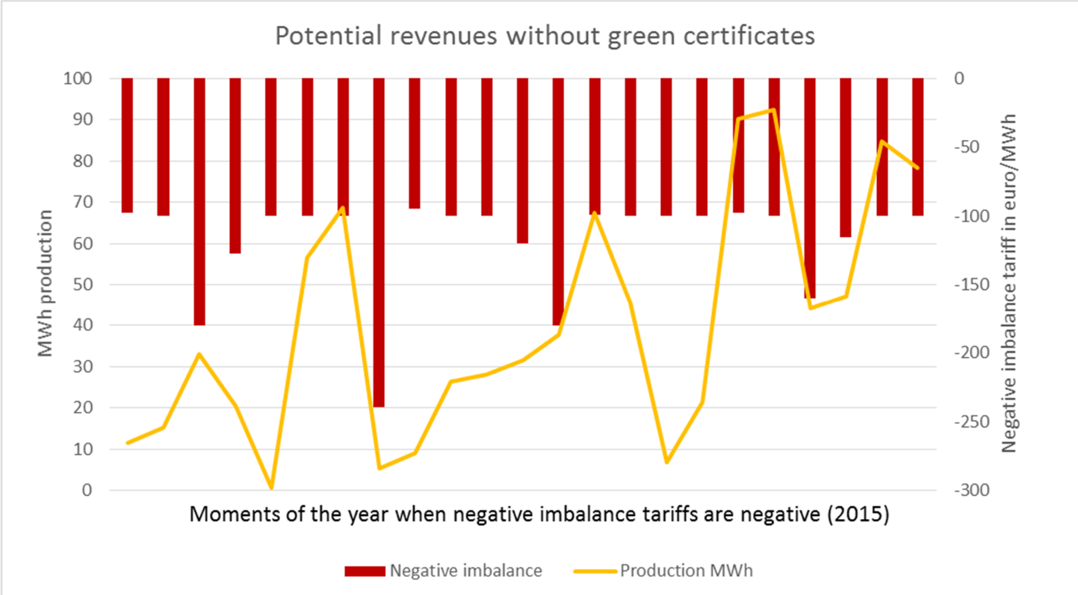

Figure 9: Potential revenues balancing without green certificates[20]

The potential revenue in this case is approximately EUR 165,000.

Finally, since aggregation services become more important, it can only be expected that reserves and imbalance markets are becoming more important in terms of volumes. In this context, for example Elia recently published a study on the evolution of reserves markets up to 2018. The study emphasized that an important increase is expected for the downward (volumes are activated downwards) R2 market.[21]

In the case of aggregators providing ESCO services, the situation of the prosumer (the user of aggregation services in this case) is optimized with renewable on-site generation facilities, technical innovations and/or substitution of inefficient equipment. This combination allows to significantly reduce the CO2 footprint and to substantially support the local grid.

[20] http://www.elia.be/en/grid-data/data-download
[21] Elia, Evolution of ancillary services needs to balance the Belgian control area towards 2018, May 2013, Available at: http://www.elia.be/~/media/files/Elia/Grid-data/Balancing/Reserves-Study-2018.pdf

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3.2.4 Other market benefits: faster deployment of new technologies and innovation on the side of the system operator

Recent documents published by Delta EE confirm that the market of aggregation services including Demand Side Response (DSR) is a big growth opportunity for a large amount of companies across the value chain: aggregators, utilities, product manufacturers, technology providers and transmission and distribution operators.[22] Many different technology companies look into this market and therefore we can say that aggregation can significantly contribute to the deployment of technologies and innovation in general.

3.3 Technical benefits of aggregation

Industrial, commercial and domestic customers can provide technical services to different actors in the value chain as was explained in deliverable D2.1 of the BestRES project. BRPs will optimize their portfolios and reduce imbalances by decreasing/increasing outputs of wind and PV installations in combination with other generation/supply (together with trading). TSOs/DSOs subsequently have to balance the system and will therefore use aggregation services to manage congestion in the system and carry out voltage control. [23]

Due to the need of ICT infrastructure for (RES) aggregation, aggregation seems to be a driver for the digitalization in power systems. Additionally it is an opportunity for non-utilities to enter electricity markets. Electricity is used for providing multiple energy services. Therefore, increased flexibility and aggregation strengthens the interconnection of multiple energy carriers.

Finally, prosumers in the large and SME sector are mainly focused on corporate stability and reduction of energy costs. In this context, they mainly look into generation such as PV for auto-consumption and less into energy efficiency increases. Aggregators can offer technical solutions to impose technical efficiency increases and add additional auto consumption production units (CHP, tri-generation & quarto-generation) to substitute high energy costs but still meet the customer’s energy mix needs.[24]

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[22] Delta EE, DSR: a big growth opportunity. How can you get a piece of the pie?, 2016, Available at: http://www.delta-ee.com/research/demand-response.html
[23] EG3 report, Smart Grid Task Force, Regulatory Recommendations for the Deployment of Flexibility, January 2015
European Commission – Seventh Framework Programme (FP7), DREAM electricity market design, White Paper, October 2014
[24] Interviews with aggregators

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3.4 Environmental and social benefits of aggregation

3.4.1 Environmental benefits

As recently highlighted by CEER (The Council of European Energy regulators), there are important potential environmental benefits from aggregation. With good market integration, the entire system might cover its energy needs with less installed generation capacity. This results in more resource efficiency and in a reduction of CO2 emissions, as current peak units do not have to ramp up and curtailment is less needed. In total, this can notably contribute to reaching the 2020 targets.[25] Figure 10 shows the reduction of CO2 compared to 1990 with different shares of RES by 2030.

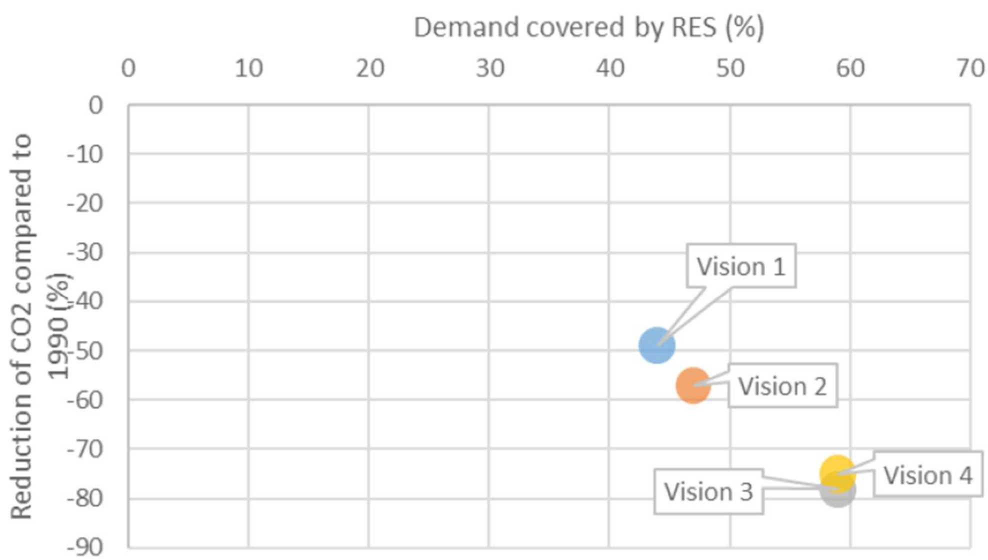

Figure 10: Reduction of CO2 wit high shares of RES[26]

The range of the different visions in Figure 10 is large and meets the expectations of different stakeholders. The 4 Visions mainly take into account the trajectory towards the Energy roadmap 2050, fuel and CO2 prices and the consistency of the generation mix development strategy. Furthermore, from Vision 1 to Vision 4, the share of electric vehicles and heat pumps ranges from

[25] CEER, Council of European Energy Regulators, CEER Advice on Ensuring Market and Regulatory Arrangements help deliver Demand-Side Flexibility, June 2014, Available at: http://www.ceer.eu/portal/page/portal/EER_HOME/EER_PUBLICATIONS/CEER_PAPERS/Electricity/Tab3/C14-SDE-40-03_CEER%20Advice%20on%20Demand-Side%20Flexibility_26-June-2014.pdf

[26] ENTSOE, Ten-Year Network Development Plan 2016, Available at: http://tyndp.entsoe.eu/projects/Executive-report.pdf

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negligible to 10% of peak load and related potential for demand response from 5% in the case of Vision 1 up to 20% in the case of Vision 4.
With respect to ESCO services, the environmental impact depends on the pre-ESCO energy mix vs. post-ESCO energy mix.

3.4.2 Social benefits of aggregation

Creating flexibility and aggregation in the electricity system will require active participation and empowerment of customers. This can potentially result in social benefits as Figure 11 illustrates.

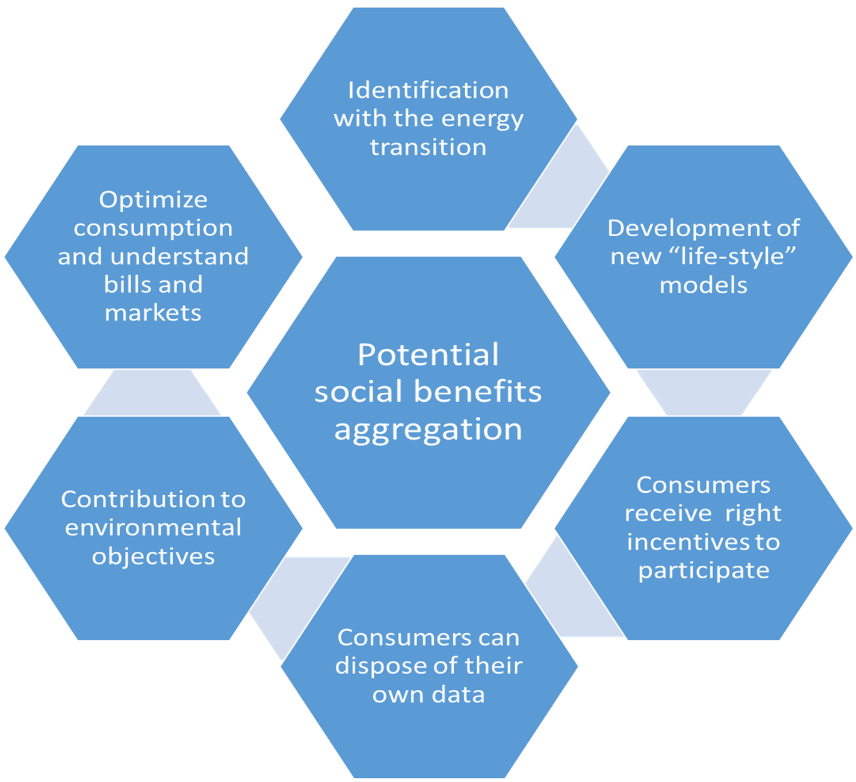

Figure 11: Social benefits aggregation

Figure 11 underlines that, through aggregation, consumers have the possibility to optimize their consumption and their energy bill and meanwhile contribute to environmental objectives. Furthermore, aggregation seems to be a possibility to enhance the customer's identification with the energy transition due to local generation, flexibility and consequentially economic benefits. Another effect is the development of new business and "life-style" models, e.g. "energy communities". Aggregation can equally help providers of aggregation services to understand different options on a new market and help them to be aware of potential benefits. Governments, regulators and other market players should be proactive to assist these providers. If aggregation is

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facilitated in an appropriate way, consumers will receive incentives so that both themselves and the system benefit from it. A last identified potential benefit is that consumers can own their own data and related privacy. Looking at all those benefits, a balance needs to be found between giving a choice to consumers and protecting them. Other more important social and environmental benefits that are worth mentioning are the reduction of fossil fuel import dependency and the creation of new jobs.[27]

[27] EG3 report, Smart Grid Task Force, Regulatory Recommendations for the Deployment of Flexibility, January 2015
CEER, Council of European Energy Regulators, CEER Advice on Ensuring Market and Regulatory Arrangements help deliver Demand-Side Flexibility, June 2014, Available at: http://www.ceer.eu/portal/page/portal/EER_HOME/EER_PUBLICATIONS/CEER_PAPERS/Electricity/Tab3/C14-SDE-40-03_CEER%20Advice%20on%20Demand-Side%20Flexibility_26-June-2014.pdf

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4. Benefits from aggregation in the countries that are covered by the consortium

The 6 aggregators who are part of the consortium are active in 9 countries: the United Kingdom, Germany, France, Belgium, Austria, Portugal, Spain, Italy and Cyprus (Figure 12).

Figure 12: Countries covered by the consortium

In the following sections, we will elaborate on the various benefits that aggregators can bring to power system and markets in these countries. It is however important to highlight that some benefits are difficult to assess since aggregation is a relatively new subject and benefits might just be appearing on the market. Also, some evolutions are not only the consequence of more aggregation but also of trends such as the higher share of variable renewable energy (VRE) and decommissioning of power plants. A lot of the insights will therefore be qualitative but the consortium tried to measure trends where it is possible.

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4.1 General benefits from aggregation

Table 2 illustrates the most important benefits for the system as a whole according to the aggregators (system value in Figure 5).

Table 2: Benefits from aggregation for the system as a whole

	Benefits for the system as a whole
Good Energy (United Kingdom)	* Market participation and deployment of broader mix of technologies * Reduced emissions * Reduced network costs and reduced requirements for ancillary services
Next Kraftwerke Germany (Germany)	* Access to markets (wholesale, reserves) that singe units cannot access * System stability * Higher liquidity *More flexibility in the market * A system less dependent from conventional power plants
Next Kraftwerke Germany (France)	
Next Kraftwerke (Belgium)	* Access to markets (wholesale, reserves) that single units cannot access * Lower energy costs and higher liquidity * System stability
Oekostrom (Austria)	* Grid balancing and the avoidance of expensive reserves * More efficient markets
EDP (Portugal)	* More flexibility * More efficient markets * Lower energy costs
EDP (Spain)	* More flexibility * More efficient markets * Lower energy costs
RE-Pro (Italy)	* Lower prices and grid losses * System stability
RE-Pro (Cyprus)	* Lower prices and grid losses * System stability * Quality of the electricity provided

Table 2 shows that commonly mentioned benefits are lower energy costs, a broader deployment of technologies and increased efficiency. This might be translated into decreasing reserves market prices, decreasing volumes of imbalance energy and decreasing variability on the spot market (intraday and day-ahead). Therefore, the consortium looked into these trends in each of the countries covered by the consortium (sections 4.1.1-4.1.3).

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With respect to other general benefits, Good Energy underlines the importance of reducing emissions, encouraging market participation and reducing network costs and requirements for ancillary services. It is however important to highlight that there is no specific prove up to date that investments into generation/transmission capacity are already avoided/deferred because of aggregation/flexibility because grid investments are often to cope with absolute worst-case scenarios peak.

As another advantage, Next Kraftwerke (Germany and Belgium) and Good Energy highlights the opportunity to access markets that single units cannot access and to make the whole system less dependent from conventional power plants. For example when a nuclear plants is used on the reserves market and there is an outage, the TSO directly loses a high percentage of the total reserves capacity. With a very high number of aggregated units, an outage of one single unit will be less an issue. Also, Next Kraftwerke Belgium indicated that more and more large units are going out of the market so the benefits of aggregation will increase. Oekostrom accentuates the benefit of avoiding expensive volumes of control reserves. Finally, our research demonstrates that in Italy and Cyprus, which are energy markets that are not well-integrated, aggregation can mainly help to decrease the overall instability of the grid and high fluctuations in voltage.

Next Kraftwerke Germany, however, underlines that, in Germany, shifting consumption towards moments of low prices does not always bring much lower prices to the customer compared to the net consumer price. Also, grid charges and other charges are always the same and are not related to price spreads in the wholesale markets. If these charges would be linked to spot prices, the incentives to offer flexibility could be a lot higher.

4.1.1 Benefits through increased participation and lower prices on reserves markets

With respect to reserves markets, it was decided to look into relevant (not all markets are open for aggregation in the countries covered by the consortium) reserves markets for the years 2013, 2014 and 2015 since this is the most relevant data and data that is mostly available. Furthermore, it was decided to look into the remuneration for capacity and not for energy since prices for capacity are mostly publicly available whereas prices for energy are case-specific and not publicly available in several of the countries. Also, in some of the countries, there is no remuneration for energy on reserves markets. We will underline it if the situation is different in some of the covered countries. Nevertheless, all aggregators also underline that other factors than aggregation play a role on control reserves markets such as the drop of gas prices across Europe and the decommissioning of existing plants.

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Reserves markets evolution in the United Kingdom

In the United Kingdom, demand response and aggregation is possible on all ancillary services markets but procedural and operational requirements are still inappropriate which makes participation of aggregators difficult.[28] Table 3 shows the evolution of control reserves capacity prices in the United Kingdom.

Table 3: Evolution capacity prices reserves on markets in the United Kingdom

	2013	2014	2015
R1*	29.22 GBP/MW per hour	34.71 GBP/MW per hour	33.38 GBP/MW per hour
R2	No requirements for R2		
R3	**7.38 GBP/ MW per hour (2012/13)**	**5.83 GBP/ MW per hour (2013/14)**	**3.87 GBP/MW per hour (2014/15)**

* National Grid does not release detailed data and prices are therefore a mixture of symmetrical/negative prices.

Table 3 illustrates that prices on the primary reserves markets (R1) are more or less stable whereas there are significant prices decreases on the tertiary reserves market (R3). Although more market participants and the presence of VPPs affects these reserves market prices according to Good Energy, many other factors such as the percentage of VRE and plant decommissioning (coal plants) also play a major role.

Reserves markets evolution in Germany

In Germany, demand response and aggregation are possible on the different reserves markets but actual participation is in some cases very difficult.[29] Table 4 displays the evolution of control reserves capacity prices in Germany.

[28] JRC Science for Policy report, Demand Response Status in EU Member States, 2016, Available at: http://iet.jrc.ec.europa.eu/energyefficiency/sites/energyefficiency/files/publications/demand_response_status_in_eu28_member_states-online.pdf
[29] Idem

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Table 4: Evolution capacity prices reserves on markets in Germany

	2013	2014	2015
R1	**17.6 euro/MW per hour**	**20.91 euro/MW per hour**	**21.86 euro/MW per hour**
R2 (negative)	11.54 euro/MW per hour	4.95 euro/MW per hour	2.46 euro/MW per hour
R3 (negative)	**6.58 euro/MW per hour**	**3.85 euro/MW per hour**	**1.78 euro/MW per hour**

Similar to the United Kingdom, prices stay more or less steady on the primary reserves market (R1) whereas there are significant prices decreases on the secondary (R2) and tertiary (R3) reserves markets. According to our interviews, these capacity price decreases have been largely driven by more market participants and the presence of VPPs but other factors also play a major role as highlighted before.

Reserves markets evolution in Belgium

In Belgium, the TSO Elia has done significant efforts to allow for aggregation on reserves markets and opened different programs. The primary and tertiary reserves markets are open whereas the secondary reserves market is not open yet. A new market opening just took place recently since Next Kraftwerke Belgium started to provide R1 down as the first supplier for this service with decentralized units connected to the DSO grid. However, in Belgium, an important barrier is that a demand side participant needs the permission of the electricity supplier for accessing reserves markets. Table 5 shows the evolution of control reserves capacity prices in Belgium.[30]

Table 5: Evolution capacity prices reserves on markets in Belgium

	2013	2014	2015
R1 (negative)	**No data available**	**2.5 euro/MW per hour**	**10.93 euro/MW per hour**
R2	The market is not open for aggregation		
R3 (R3DP)	**No data available**	**3.38 euro/MW per hour**	**3.07 euro/MW per hour**

[30] JRC Science for Policy report, Demand Response Status in EU Member States, 2016, Available at: http://iet.jrc.ec.europa.eu/energyefficiency/sites/energyefficiency/files/publications/demand_response_status_in_eu28_member_states-online.pdf
https://www.next-kraftwerke.be/en/first-belgian-virtual-power-plant-replacing-services-of-large-nuclear-and-gas-units-through-a-network-of-renewable-energy-installations/?preview=true

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Next Kraftwerke Belgium underlines that other factors than aggregators are crucial. Examples of this are that R1 negative was annual in 2014 (monthly in 2015 and now weekly) or that some nuclear units were shut down. Furthermore, the R1 (symmetric) market is coupled with Germany since August 2016 and R1 prices are therefore expected to go down.

Reserves markets evolution in France

In France, reserves markets are open to demand response and aggregators via a secondary market. A standardised framework for the relationship between aggregators and BRPs/suppliers is in place. Within the primary (R1) and secondary reserves markets (R2), aggregators can sign bilateral agreements with large generators who have the obligation to provide control reserve. Since EDF also owns a large share of the generation capacity, this gives a lot of market power to EDF. Furthermore, prices are not measurable because of the decentralized secondary market so it creates a situation that is not transparent. For the tertiary reserves market, only data for 2016 is available.[31]

Reserves markets evolution in Austria

The Austrian TSO, APG, opened different reserves markets for aggregation and demand response in 2013. Several improvements with respect to preconditions and prequalification were furthermore implemented in 2014. However, aggregators can only work together with providers of large volumes of flexibility (prequalification at the level of individual consumers) and the relationship between aggregators and suppliers/BRPs is still unclear which hinders market development. Table 6 shows the evolution of control reserves capacity prices in Austria.[32]

[31] JRC Science for Policy report, Demand Response Status in EU Member States, 2016, Available at:
http://iet.jrc.ec.europa.eu/energyefficiency/sites/energyefficiency/files/publications/demand_response_status_in_eu28_member_states-online.pdf
https://clients.rte-france.com/lang/fr/clients_producteurs/services_clients/reserves_rapides_complementaires.jsp

[32] JRC Science for Policy report, Demand Response Status in EU Member States, 2016, Available at:
http://iet.jrc.ec.europa.eu/energyefficiency/sites/energyefficiency/files/publications/demand_response_status_in_eu28_member_states-online.pdf

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Table 6: Evolution capacity prices reserves on markets in Austria

	2013	2014	2015
R1**	**23.36 euro/MW per hour**	**21.20 euro/MW per hour**	**21.70 euro/MW per hour**
R2 (negative during peaks)**	8.95 euro/MW per hour	7.63 euro/MW per hour	3.68 euro/MW per hour
R3	**2.33 euro/MW per hour**	**2.29 euro/MW per hour**	**1.55 euro/MW per hour**

** Capacity remunerations are per week in Austria

Table 6 underlines that Austria is the only country of the countries covered by the consortium where prices are going down for capacity on the primary reserves markets (R1). On the secondary and tertiary reserves market, price decreases are also remarkable. According to our interviews, this decrease is driven by the increased number of players on the reserve market.

Reserves markets evolution in Spain and Portugal

Both Spain and Portugal are closed markets for aggregation at this moment. In Spain, large consumers can participate on reserves markets in theory but this option has not been used by the TSO, Red Eléctrica de España, for many years. Table 4 displays the evolution of control reserves capacity prices in Spain and Portugal.[33]

Table 7: Evolution capacity prices reserves on markets in Portugal and Spain

	2013	2014	2015
R1 (negative)	Primary reserve is a compulsory market service that all generators must provide, but it is not paid for, hence there is no primary reserve market.		
R2 Portugal	37.5 euro/MW	24.6 euro/MW	20.2 euro/MW
R2 Spain	29.6 euro/MW	23.3 euro/MW	19.6 euro/MW
R3 (negative) Portugal*	**19.7 euro/MWh**	**18.4 euro/MWh**	**29,0 euro/MWh**
R3 (negative) Spain**	16.8 euro/MW per hour	11,9 euro/MW per hour	24,8 euro/MW per hour

* This the weighted average of secondary and tertiary reserves for traded energy (only information available). In Portugal, there is no remuneration for capacity. These reserves markets are specifically designed for hydro and thermal plants
** Weighted average price for tertiary regulation

In both countries, the primary reserves market (R1) is not yet benefiting from aggregation because participation is compulsory and generators are not paid for it. On the secondary reserves market, the amount of energy traded in secondary reserves has been decreasing which may explain the price decreases. Also, in Portugal, reserves markets are specifically designed for hydro and thermal plants whereas in Spain, all generators can participate but only if they fulfil specific test procedures. We can conclude that there are very few opportunities for aggregators on these markets at this moment and that aggregation can thus not have a significant impact on the price level.

Reserves markets evolution in Italy and Cyprus

In Cyprus, there are no aggregators participating to control reserves markets at this moment and the Electricity Authority of Cyprus (EAC) is the only company generating and supplying electricity. The small volumes in the market will further furthermore limit developments in the future. In Italy, we observe a similar situation as reserves markets are closed for aggregation. For all non-intermittent generators bigger than 10 MW, participation in the primary reserves market is an obligation without but they don’t receive a compensation for this. Nevertheless, the Italian TSO Terna is more and more confronted with issues related to frequency and system security and is therefore looking for solutions in the year to come. This could enable the participation of aggregators.[34]

4.1.2 Benefits through a decreasing need for balancing energy

As briefly mentioned earlier in this document, there might be less need for balancing energy when there is more aggregation but factors such as the increasing share of variable renewable energy and improved forecasting techniques will also be crucial. Table illustrates the evolution of the average Net Regulation Volume (NRV) for imbalance energy. Data was also commonly available for the years 2014 and 2015.[35]

[34] JRC Science for Policy report, Demand Response Status in EU Member States, 2016, Available at: http://iet.jrc.ec.europa.eu/energyefficiency/sites/energyefficiency/files/publications/demand_response_status_in_eu28_member_states-online.pdf

[35] The ***Net Regulation Volume*** (NRV) is, for a considered quarter, the difference between:
– on one hand, ***gross volume of upward regulation*** as ordered by Elia, for

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Table 8: Positive and negative NRV for imbalance energy

	Net Regulation Volume (NRV)	Volumes imbalance market 2013	Volumes imbalance market 2014	Volumes imbalance market 2015
United Kingdom	Average positive NRV [MW]	187.3	163.55	212.05
	Average negative NRV [MW]	-413.68	-361.4	-370.57
Germany	Average positive NRV [MW]	230,43	192,63	234,78
	Average negative NRV [MW]	-312,63	-201,64	-119,95
France	Average positive NRV [MW]	159,58	124,17	134,67
	Average negative NRV [MW]	-153,07	-160,5	-146,166
Belgium	Average positive NRV [MW]	97.04	94.36	89.27
	Average negative NRV [MW]	-120.67	-96.48	-93.49
Austria	Average positive NRV [MW]	413	439	496
	Average negative NRV [MW]	-407	-446	-495
Portugal	Average positive NRV [MV]	~200	~170	~160
	Average negative NRV [MV]	~80	~70	~70
Spain	Average positive NRV [MV]	619	677	685
	Average negative NRV [MV]	512	502	511
Italy & Cyprus	No data available for Italy & Cyprus			

the considered quarter, for maintaining the balance
expressed in MW, and
– on the other hand, ***gross volume of downward regulation*** as ordered by
Elia, for the considered quarter, for maintaining the balance
expressed in MW (Elia)

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Table 8 underlines that volumes for imbalance energy are not going down or are rather stable in the different countries at this moment. Also, the consortium observes that volumes for downward regulation are going down more than volumes for upward regulation. Imbalance volumes in Austria are stable to slightly growing due to aggregation activities, in spite of ongoing increases in installed capacity of intermittent renewables. In Germany, the negative NRV is going down whereas the positive NRV is rather stable. The introduction of a market premium model could be seen as a driver for less balancing energy because it incentivizes renewables to sell their energy at power exchanges which increases the need for forecasting quality to avoid increasing balancing costs. In Portugal, wind and hydro volumes decreased whereas coal and gas contributed more to electricity supply in 2015 compared to 2014 (Figure 13).

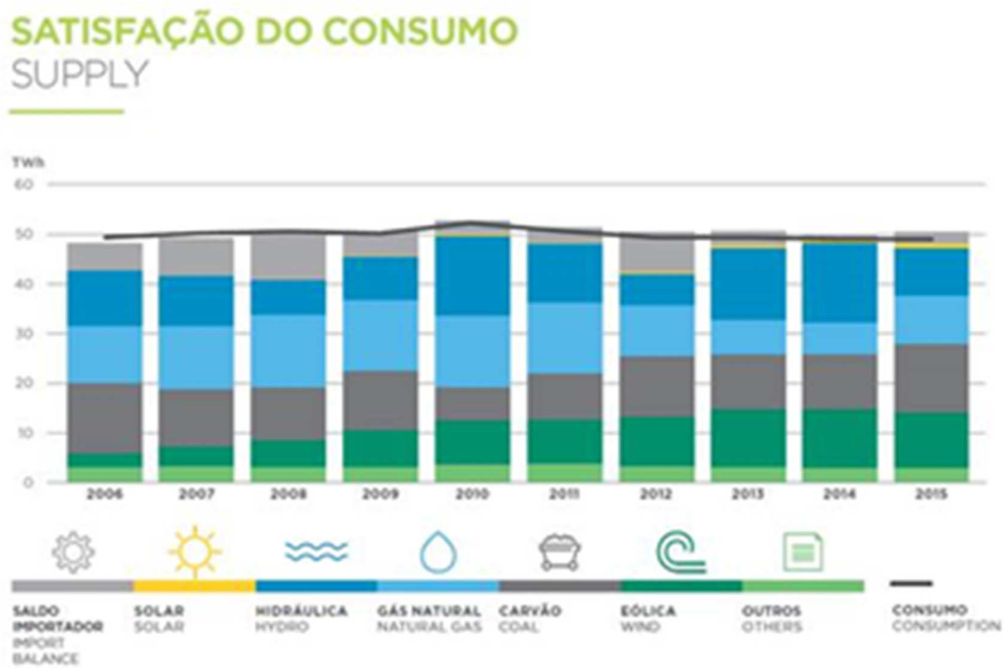

Figure 13: Electricity supply in Portugal

The share of renewable energy was thus lower and this might be an explanation for the decreasing volumes of balancing energy.

4.1.3 Benefits through decreasing price variability on wholesale electricity prices

Aggregation can also be expected to have an impact on wholesale electricity prices. Price levels are however largely driven by the increasing share of renewable electricity and large capacities such as nuclear plants in countries such as Belgium and Germany. The impact (although also small due to the impact of other factors) of aggregation will therefore rather be observed on a

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decreasing price variability measured by the standard deviation. Table 9 summarized the situation on the intra-day market between 2013 and 2015.

Table 9: Price variability on the intra-day market measured by standard deviation in the countries covered by the consortium

	Intensity aggregation activities	2013	2014	2015
United Kingdom	Medium	15.53	13.78	12.82
Germany: open	High	23.54	18.81	17.47
France: open	Medium		14,80	14,67
Belgium: open	Medium	18.09	14.04	13.81
Austria: open	Medium	10.69	8.54	7.98
Portugal	No activity	20.55	18.75	12.07
Spain	Low	20.56	18.7	12.1
Italy	Low	Aggregation is not allowed on the spot markets		
Cyprus	zero	Energy prices follow diesel prices and the Electricity Authority of Cyprus (EAC) remains the dominant producer of electricity		

Table 9 underlines that price variability is going down in all covered countries. Aggregation can certainly be an explanation for decreasing variability in the United Kingdom, Germany, France, Belgium and Austria. These countries have an average or high share of increasing renewable energy which can be expected to increase variability and aggregation can reverse this effect through improved forecasting.

However, if VRE production significantly increases, the variability can be expected to increase again in the future. Also, as was the case for reserves markets, other factors play an important role. In the United Kingdom for example, overcapacity built in 2010-2012 and carbon prices that push up off-peak prices are drivers for a decreasing price variability. In Belgium, the share of electricity traded on intraday and day-ahead markets is still very low compared to the total market volumes because there are a lot of direct agreements between suppliers and generators. Finally, in Austria, an explanation is that large hydro storage systems are getting more and more competition.[36]

The importance of these other factors is also observed in Spain and Portugal. Although they have a limited share of aggregation and the share of renewables is decreasing over the period 2014-2015, Table 9 shows that price variability is strongly decreasing. In fact, in Portugal and Spain, around 85% of electricity is traded at day ahead market and only 15% is traded in intraday. As a consequence, one can argue that intraday markets are not yet mature and competitive enough. Also, only generators with a production unit of at least 50 MW can participate as seller in wholesale markets. Finally, regulation and market structure doesn't allow for aggregation in Italy and Cyprus.

[36] JRC Science for Policy report, Demand Response Status in EU Member States, 2016, Available at: http://iet.jrc.ec.europa.eu/energyefficiency/sites/energyefficiency/files/publications/demand_response_status_in_eu28_member_states-online.pdf

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4.2 Market benefits from aggregation for key stakeholders

The results from the survey highlight that stakeholders have various reasons to develop aggregation services. In the section below, we will subsequently describe the market benefits for aggregators, providers of flexibility and users of flexibility.

4.2.1 Market benefits for aggregators

Table 10 provides the reader with an overview of the key benefits from aggregation for aggregators.

Table 10: Market benefits from aggregation for the aggregator

	Benefits for the aggregator
Good Energy (United Kingdom)	* Possibility to link decentralised assets with power markets_ * Potential to introduce new products into the market * Potential to optimise portfolio
Next Kraftwerke (Germany)	* Possibility to link decentralized assets with power markets * Economies of scale and scope
Next Kraftwerke (France)	* Possibility to link decentralized assets with power markets * Economies of scale and scope
Next Kraftwerke (Belgium)	* Economies of scale and scope * Fulfil product requirements that cannot be fulfilled with one single unit
Oekostrom (Austria)	* Use aggregation services for balancing activities * Provide access to markets for providers of flexibility
EDP (Portugal)	* Portfolio optimization * A closer relationship between retailer and customer promoting customer loyalty
EDP (Spain)	* Portfolio optimization * A closer relationship between retailer and customer promoting customer loyalty
RE-Pro (Italy)	* Achieve an economic margin on ESCO activities
RE-Pro (Cyprus)	* Achieve an economic margin on ESCO activities

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Table 10 shows that the most important benefits for aggregators are portfolio optimization and the fact that they can access markets with decentralized assets. On some of these markets, there are various product requirements such as a minimum bid size and a minimum activation period. Aggregation can facilitate market participation in this case. Another principal advantage is, as accentuated by Good Energy, the introduction of new products on markets. Besides, EDP emphasises that increased customer loyalty is important given that aggregation creates an additional relationship between the prosumer and the supplier who is aggregator apart from the supplier contract for electricity. For RE-Pro, the main benefit is that aggregation of prosumer volumes allows to achieve an economic margin on ESCO activities based on the installation of auto-consumption units and significant increases in energy efficiency and technical innovations.

Finally, in Germany, generators are encouraged by the government to provide more aggregation services. Biogas plants receive an additional “flexibility premium” if they are investing in additional capacity without increasing the energy output. This will facilitate the activities of aggregators.

4.2.2 Market benefits for providers of aggregation services

Different types of providers of aggregation services

Since providers of aggregation services are offering aggregation services, it is crucial to look into the benefits for these stakeholders. In D2.1 of the BestRES project, it was illustrated that some aggregators from the project consortium are focusing on DSM whereas others on distributed generation. This split up is also being observed across Europe. The consortium subsequently asked all aggregators to indicate which providers have the highest interest in providing aggregation services. Table 11 summarizes the results.

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Table 11: Benefits for providers of aggregation services

	Industrial consumers	Commercial consumers	Domestic consumers	Distributed generators
Good Energy (United Kingdom)	2 (high peak usage charges)	2 (high peak usage charges)	3	3 (but strongly emerging)
Next Kraftwerke (Germany)	2	3	4 (not their focus at this moment)	1
Next Kraftwerke (France)	2	3	4 (not their focus at this moment)	1
Next Kraftwerke (Belgium)	2	3	4 (not their focus at this moment)	1
Oekostrom (Austria)	4	4	2 (importance of smart meters)	1 (wind, hydro, power, biogas)
EDP (Portugal)	1 (electricity costs in Portugal higher than in rest of Europe)	2	3 (only in the very long run)	4
EDP (Spain)	1	2	3 (only in the very long run)	4
RE-Pro (Italy)	1	3	4	2
RE-Pro (Cyprus)	1	3	4	2

EDP and RE-Pro indicate that industrial consumers have the highest interest (providers for DSM) in providing aggregation services. In this context, EDP highlights that one industrial client can provide more flexibility than several small clients. They have industrial processes that can be shifted in time and sometimes energy storage devices. Next Kraftwerke Germany, Next Kraftwerke Belgium and Oekostrom mention that distributed generators have the highest interest. Good Energy, although they are more focused on distributed generation, emphasise that industrial demand side providers have the highest interest in providing aggregation services because their participation is more optimized in the current UK market design. Good Energy is however encouraging open participation for all in the energy market and they expect the market for distributed generators to grow in the long run. This is in line with our findings from D2.1.

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Next Kraftwerke Belgium also underlines that flexibility from generation has more potential than DSM and storage because the potential volumes are significantly higher and distributed generation is rapidly becoming cheaper. With respect to demand side management in Germany, industrial consumers can get a reduction on grid charges when they have a more steady consumption profile. Customers pay for the grid-capacity per kW and energy consumption is therefore optimized on the maximum load. Also, energy intensive companies can reduce grid costs up to 20% by having a constant consumption profile and can significantly reduce grid costs if they reduce load during daily peak-load-slots that the grid operator defines. As a consequence, industrial consumers already receive a part of the benefits through grid charges and less potential benefits are left on markets for aggregation services. Nevertheless, in the United Kingdom, Good energy highlights that aggregation services from generation have to compete with subsidy regimes (Contracts for Difference) which represents big challenges for alternative operating regimes. We can expect to observe the same barrier in many European countries.

Additionally, Next Kraftwerke Belgium specified that the costs for connection of demand processes on household level, the measuring of the processes and the control are still very high per MW flexibility. The question is whether the system will really need such a high volume of system services that also the aggregation of household demand will be cost competitive. In this context, both Next Kraftwerke Germany and Next Kraftwerke Belgium are focusing on larger consumers (rough estimate: > 100 MWh on a yearly basis). Oekostrom considers profiles with consumptions of more than 1 GWh as an interesting future target group. However, Oekostrom equally underlined that companies in Austria such as Awattar, which offers block tariffs to small end customers with synthetic load profiles, are coming up.[37] Oekostrom does not see advantage in offering block tariffs for those customers yet as long as DSOs use synthetic load profiles for those customers. Finally, Good Energy indicates that, in the future energy system in the United Kingdom, domestic demand will account for half of peak demand. Therefore, they see domestic consumers as a key area to address. As a vertically integrated energy supplier, it is also easier for them to address domestic customers.

Remuneration of providers of aggregation services

With respect to the remuneration for the different providers of aggregation services, Good Energy and Next Kraftwerke (Germany and Belgium) highlight that fixed remuneration is important as it delivers the financial certainty required for investment / behaviour change. Oekostrom agrees with this as for demand side activities. For generation, a remuneration depending on the amount of flexibility provided but on a fixed rate can promise a considerable

[37] https://www.awattar.com/

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profit. Good Energy also mentioned that the remuneration highly depends on customer segment, engagement and risk profile. In other words, smaller customers will likely lean towards a fixed remuneration whereas larger customers are often willing to engage in markets and take risks. Furthermore, Next Kraftwerke (in Germany and Belgium) charges a fixed fee to generators for direct marketing on wholesale markets whereas revenues from other flexibility products such as reserves are split up between the providers of aggregation services and Next Kraftwerke. Since EDP is not yet an aggregator at the moment of writing this report, they have not implemented remuneration. They however mentioned that they will probably start with a fixed remuneration since this is the easiest way for providers of flexibility to understand how they are paid.

In case of RE-Pro in Italy and Cyprus, the remuneration for the aggregation services depends on the measures and contractual principles agreed on. In the case of auto-consumption measures, the contractual relationship is based on a PPA contract. In the case of energy efficiency measures, a sharing of the savings based on an Energy Performance Contract (EPC) is the basis whereby the parameters are determined by the expenses, the savings achieved and the timeframe of the contract.

4.2.3 Market benefits for users of aggregation services

Table 12 puts together the market benefits from aggregation for users of aggregation services. Some aggregators contributed with a ranking of benefits whereas others brought in an overview of benefits without raking them.

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Table 12: Market benefits for users of aggregation services

	Benefits for users of aggregation services
United Kingdom	1) Lower costs for control reserves 2) Lower balancing costs for BRP
Germany	1) Lower costs for control reserves and more competitive wholesale elec prices 2) Lower balancing costs for BRP 3) Reduced investment costs for TSO/DSO and other market players
France	
Belgium	
Austria	Lower costs for control reserves, lower wholesale elec prices and lower balancing costs for BRP
Portugal	They are only planning to use it for balancing of the portfolio and they don't know about any other usage in Portugal
Spain	They are only planning to use it for balancing of the portfolio and they don't know about any other usage in Portugal
Italy	White certificates
Cyprus	No aggregation business at this moment

Although it is challenging to measure the effects at this moment as shown earlier, it is clear that the access to cheaper reserve markets is a very important benefit for system operators, mainly for Transmission System Operators (TSO). Aggregation results in more competition on different reserves markets and the system operator will therefore be able to source for a lower price. Another potential benefit for these system operators, as highlighted by Next Kraftwerke (Germany and France) and earlier by Good Energy, are the reduced investment costs in grid capacity. There are however no already existing cases where this has been proven, but recent documents of ENTSOE (European Network of Transmission System Operators for Electricity) highlight the importance of flexibility for ancillary services.[38]

For Balancing Responsibility Parties (BRPs), aggregation can also results in lower balancing costs or it can allow them to generate revenues by going out of balance. All aggregators in the consortium apart from RE-Pro are also BRPs and, as Table 13 in D2.1 of the BestRES projects shows, balancing of the own

[38] ENTSOE, European Network of Transmission System Operators for Electricity, Ten-Year Network Development Plan 2016, Available at: http://tyndp.entsoe.eu/projects/Executive-report.pdf

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portfolio is a very important revenue stream for Good Energy, Oekostrom and EDP. EDP even highlights that they expect balancing to be the only benefit from aggregation in the short-to medium term.

In case of ESCO services (RE-Pro), which is a local activity, the market benefits are exclusively shared between the prosumer and the ESCO provider. In this context, the white certificates scheme plays an important role. White certificates are tradable instruments giving proof of the achievement of end-use energy savings through energy efficiency improvements initiatives and projects. Under the scheme, electricity and natural-gas distributors are required to achieve yearly quantitative primary-energy saving targets.[39]

[39] http://www.gse.it/en/White%20Certificates/Pages/default.aspx

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4.3 Market benefits from aggregation for the market as a whole

4.3.1 Benefits from technology innovations

With respect to investments in technology for increasing the amount of aggregation services, the situation largely differs in the different countries covered by the consortium. In Spain and Portugal, EDP indicated that markets are currently not investing in any technologies and that EDP would have to invest in these technologies itself. According to Good Energy, some investments are done but not at all to the full potential because the market is driven towards low CAPEX and quick deployment technologies. This mainly refers to the deployment of large volumes of diesel generation instead of low-carbon alternatives such as batteries for TSO ancillary services over the past years. In contrast, for Next Kraftwerke Germany, Next Kraftwerke Belgium and Oekostrom, investments in technology are already in a rather advanced phase and there is a trend towards smaller units and platforms. As an example, through Next Kraftwerke's VPP, already 3000 units were connected.

Figure 14: Next Kraftwerke's Nextpool

Findings are also confirmed by the fact that there are many technology companies active on the market of aggregation services. In Germany, examples are not only Next Kraftwerke with its VPP (Figure 14) but also companies such as Siemens and Sonnen, a battery provider.[40] In the United Kingdom, a good example of such technology development is VCharge, a company that

[40] https://sonnen-batterie.com/en-us/sonnenbatterie?_ga=1.206541137.379286732.1468246321

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developed a platform to use flexibility from EV to be valorised on different markets.[41] In France a good example is Voltalis, who develops software to specifically control for flexibility.[42] Finally, in Belgium, a good case is Fifthplay, who develops Internet of Things (IoT) technology.[43] Recent documents published by Delta EE also describe some of these companies and underline that partnerships between product manufacturers, control companies, aggregators and energy suppliers will gain importance in the years to come. RE-Pro emphasized that investments in technologies happen already a lot more in Italy than in Cyprus but are limited in both countries due to financing constraints. They highlight that a dynamic ESCO market would automatically open markets for additional aggregation business such as VPP's, demand-supply management and remote-control of auto-consumption production facilities.

4.3.2 Job creation by aggregation

There are very big differences with respect to the number of aggregators active in the countries of the consortium. In Germany, Belgium, the UK, Austria, the number of aggregators is moderate to high. In Spain, Portugal, Italy and Cyprus, there are no or very few aggregators. France can be considered as a country somewhere in between at this moment, and market evolution will mainly depend on the design of the market premium model. Table 13 summarizes the situation.

Table 13: Competition in the field of aggregation in 2016 and 2020

	Competition for aggregation in 2016	Competition for aggregation 2020
United Kingdom	Some new market entrants in recent years	New market entrants expected but still significant capacity/barriers to entry
Germany	A lot of new market entrants in recent years.	Not many new entrants and consolidation of existing aggregators expected
France	A few new market entrants in recent history	New entrants expected because of market premium model
Belgium	Some new market entrants in recent years	Different market are expected to further open in the coming years
Austria	Some new market entrants in recent years	New entrants expected but markets still tend to favour conventional generation units

[41] http://www.smartbricks.com/about
[42] http://www.voltalis.com/
[43] http://www.fifthplay.com/en

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Portugal	No aggregators	New market entrants expected but significant barriers
Spain	Almost no aggregators	New market entrants expected but significant barriers
Italy	Almost no aggregators	New market entrants expected but significant barriers
Cyprus	No aggregators	No market entrants expected

Table 13 demonstrates that markets are already relatively open and mature in Germany whereas competition can significantly be improved in Portugal, Spain, and Cyprus. In the other countries, the market for aggregation is significantly changing. The consortium asked the aggregators as well to estimate the number of aggregators in the country. The results are summarized in Table 14. Some aggregators were able to come up with specific numbers whereas others could only deliver qualitative information.

Table 14: Number of companies involved in aggregation

	Estimated number of companies involved in aggregation
United Kingdom	20. The UK market for aggregation is also growing
Germany	A very large amount of players that is not expected to increase
France	Not that many players but can change in the near future because of market premium model
Belgium	Not that many players but new players are entering the market. Market is however dominated by large players
Austria	20. The market is dominated by large players
Portugal	No aggregation
Spain	Very few existing and new players
Italy	100 - 200
Cyprus	No aggregation

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Table 14 underlines that, according to the interviews, there is most aggregation activity in Germany whereas there is least activity in Cyprus. In Germany, the most mature market, there are a lot of players but, because economies of scale and scope (section 4.3.3) are important, not many new players are expected to appear in the coming years. The United Kingdom and Italy are also large markets. In the case of Italy, the aggregators are mostly ESCO providers that are representing a significant development potential and are expected to grow in number and business activities in the coming years. In France, there are not that many aggregators active but this can rapidly change because the market is waiting for the deployment of the market premium model. In Belgium and Austria, the market is dominated by a few large players, with a lot of capacity, so there is not a lot of room for new players since they have to face tough competition. Finally, in Spain, Portugal and Cyprus, the number of players involved in aggregation is negligible.

4.3.3 Benefits by economies of scale and economies of scope

Many aggregators underline that there is not much room for new players on the market of aggregation services. An important driver for this is that an aggregator, for developing a feasible business model, needs a portfolio of a considerable size to benefit from economies of scale and scope.

In the consortium, we observe that some aggregators already achieved a lot more economies of scale and scope than others. Next Kraftwerke is most advanced through Next Kraftwerke’s VPP, which connects 3000 units in Germany and is rapidly developing in Belgium and France (and recently also in the Netherlands). Good Energy aggregates power from around 1000 independent units while Oekostrom works together with about 20 wind parks and hydro power plants and is seeking to expand numbers in the future. In Spain and Portugal, EDP is only starting to simulate the impact of aggregation in 2016 and they will target 3 industrial clients in a first phase. If simulations and the results from the BestRES project illustrate that aggregation is interesting, they hope to target up to 100 clients in the coming years. In the case of RE-Pro, economies of scale are a lot more difficult to achieve because each project is unique.

4.3.4 Benefits from innovation on the grid operator side

Looking at innovations on the grid operator side, aggregation can also be important. In the United Kingdom, there are several initiatives, such as the Low Carbon Networks (LCN) to encourage Distribution System Operators (DSOs) to provide security of supply and value for money. DSOs explore how they can facilitate the take up of low carbon and energy saving initiatives such as electric vehicles, heat pumps, micro and local generation and demand side

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management. A good example of where a DSO, Northern Powergrid, implements such a project, is the “customer-led network revolution”.[44]

In Germany, a good example of an initiative is the funding programme “Smart Energy showcases – Digital Agenda for the Energy Transition” or SINTEG. The program aims to develop and demonstrate in large model regions exemplary solutions for a climate-friendly, secure and efficient energy supply with high proportions of intermittent power generation on the basis of wind and solar energy. Some examples of showcases within this programme that focus on aggregation are the projects “Enera” and “Designnetz”. The first project looks into how, by upgrading the technology used by generators, consumers and storage units, by using new technology, and by using new equipment to build a better grid, the energy system is to be made more flexible. The second project showcases the optimised use of flexibility options that benefit the market, the grid and the overall energy system. The goal is to develop solutions for using decentralised solar and wind energy for the supply of large centres of demand.[45]

[44] Northern Powergrid, Successful reward delivery application, customer-led network revolution, May 2015, Available at: https://www.ofgem.gov.uk/sites/default/files/docs/2015/05/clnr_sdrc_application.pdf
[45] Funding programme "Smart Energy Showcases - Digital Agenda for the Energy Transition" (SINTEG), Available at: http://www.bmwi.de/EN/Topics/Energy/Grids-and-grid-expansion/sinteg,did=718778.html

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4.4 Technical benefits from aggregation

We elaborated on the potential technical benefits from aggregation in section 3 of this report. The results from the surveys reveal that aggregation is increasingly important for congestion management, frequency and portfolio optimization across Europe.

4.4.1 Congestion management

Congestion management is gaining importance in the countries covered by the consortium, Cyprus being an exception. The location of new renewable energy generators is often different from existing conventional power plants and at the extremities of the electricity network. As a consequence, there will be new transmission needs and aggregation can be the answer to these needs, both for domestic congestion as for cross-border congestion.[46] The TSO can for example enter into contracts with providers of aggregation services to an agreed output with a service provider ahead of time to aid the management of a transmission constraint. A common style of contract is to agree on a cap or collar on the output of a power station. Since constraints are locational, a unit's ability to be able to resolve a constraint will depend on the position relative to the constraint and the stations size relative to the constraint volume.[47]

Our interviews however illustrate that the benefits of aggregation for congestion management are rather limited. In Germany, aggregation can for example play a role in Northern Germany where congestion management costs tend to increase significantly due to higher wind generation and proposed power plant investments.[48] In the United Kingdom, new distribution connected generation faces problems because the grid is "full". Aggregation could offer solutions for this in the future. In Austria, according to Oekostrom, the problem of congestion management costs is not perceived as being very important. Networks are currently strong enough where the epicentre of renewable intermittent generation is located and enough reserve is available. In order to reinforce the grid, investments particularly in the eastern part of the country, are planned.

[46] DIW Berlin and Electricity Policy research Group, University of Cambridge, Smart Power Market project, Congestion Management in European Power Networks: Criteria to Assess the Available Options, January 2011
[47] http://www2.nationalgrid.com/uk/services/balancing-services/system-security/transmission-constraint-management/
National Grid, Constraint Management, Service description, February 2013
[48] Friedrich Kunz, Congestion Management in Germany – The Impact of renewable generation on Congestion Management Costs, 2011, Available at: http://idei.fr/sites/default/files/medias/doc/conf/eem/papers_2011/kunz.pdf

4.4.2 Portfolio optimization

Virtual Power Plants (VPPs) such as the one developed by Next Kraftwerke Germany, can be crucial for balancing because, if one asset such as a wind power source generates a bit more electricity than forecasted and another generates a bit less, they will compensate each other and we will thus observe a more accurate forecast. The aggregators that are part of the consortium generally use controllable assets such as biomass plants to smooth out forecasts errors. VPPs and improved wind forecasting are also mentioned to be the main mitigation measures for system balancing in recent documents published by the government of the United Kingdom, before reducing gate closures, electricity storage, interconnection between systems and centrally operated curtailment.[49] Limejump is another example of a UK VPP that uses biogas to optimise output.[50] In Austria, better portfolio optimization of the balancing groups with renewable sources, especially the balancing group with the generation units under the subsidy scheme (OeMAG), would have a positive effect for the profit of all balancing groups. Spatial distribution of the generation sites for an aggregator is crucial in order to avoid correlation of forecasting errors.

4.4.3 Frequency control

Aggregation is also used to deal with frequency issues in the electricity grid. We explained before that Next Kraftwerke offers aggregation services in France and Belgium on reserves markets. In the United Kingdom, a number of new mechanisms are being tailored to address the adoption of new technologies such as a recent enhanced frequency response mechanism to support responders such as lithium batteries. Furthermore, a number of aggregators such as Kiwi, Limejump and Open Energy are performing frequency control services. In Austria, aggregation of small plants allows to reach the minimum size for bids of 5 MW at the reserve markets. This allows to access the reserve markets since about 2012.

[49] http://www.renewableenergyworld.com/articles/print/volume-16/issue-5/solar-energy/virtual-power-plants-a-new-model-for-renewables-integration.html
Government of the United Kingdom, Wind imbalance in UK, Technical solutions for mitigation, Available at:
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/253178/Technical_mitigation_of_imbalance_risk__analysis_by_Mott_MacDonald___Presentation_at_April_workshop_.pdf

[50] http://www.limejump.com/home/

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4.5 Environmental benefits from aggregation

4.5.1 Contribution to reducing CO2 emissions

Our interviews illustrate that aggregation can contribute to the 2020 targets in various ways. It allows to make better use of available renewable/low carbon capacity and thus creates further potential to react on fluctuating generation for a given set of assets. Another potential environmental benefit is the avoided investments into high-carbon peaking capacity. Aggregation furthermore allows conventional generation to operate at higher load rates which improves operational efficiency. Finally, aggregation can ensure a longer period of operating/life time and therefore RES production of a set of assets. In other words, assets get a longer life time if additional revenues can be generated through offering flexibility compared to decommissioning.

4.5.2 Impact of CO2-prices on aggregation activities

The interviews illustrate that the impact of CO2-prices on aggregation activities is unclear. All aggregators are convinced that there is a positive impact since higher CO2-prices can drive the market towards low-carbon technologies which might increase the importance of aggregation in the future, certainly in the post-subsidy era. Nevertheless, Good Energy highlights that increased competition in a bigger market may result in higher procurement costs to do client acquisitions. Another interesting insight from Next Kraftwerke Germany is that, for aggregators, price spreads in the market are significantly more important than price levels. Finally, it could be dangerous for reasons of security of supply if too high CO2-prices push too much capacity out of the market.

4.6 Social benefits from aggregation

The consortium also looked into how social benefits of aggregation are perceived by the different aggregators who are a part of the consortium. The results are discussed in the sections below.

4.6.1 Development of new “life-style” models

Aggregation allows for the development of new types of models. A good example of such a model is Sainsbury’s in collaboration with Open Energi in the United Kingdom. Sainsbury’s tries to unlock the potential of demand response across its network, and, by introducing new technologies, they reduce energy costs, cut the UK’s dependence on fossil fuels and reduce CO2 emissions. For achieving this, they work together with the aggregator Open Energi since 2011 and they make customers more aware of climate issues by aiming to be the

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UK's greenest grocer.[51] Through ESCO activities, aggregators are following the same approach since energy-efficiency, auto-consumption of RES production and CO2 reductions are marketed together and make customers more aware of climate issues.

In Austria, A1, a telecommunications company, has adapted its emergency backup generators in order to put them together in a virtual pool. This is the basis for the activity as a service provider, to link flexibility capacities to markets. The flexibility to be integrated can be from water and wind generation, biogas, pumps, heating and cooling and artificial snow machines.

4.6.2 Identification with the energy transition

Since aggregation is impacting both providers and users of aggregation services, it can also significantly contribute to the feeling of identification with the energy transition, thanks to local generation, flexibility and consequentially economic benefits.

Oekostrom is certainly promoting this because they are the only supplier of renewable power that is also aggregator with an own independent balancing group. The company shows a steady growth and develops new activities, engages against nuclear power and supports social initiatives. Another relevant example is the Nice Grid project in France. In this case, two aggregators, Edelia (residential flexibility) and Netseenergy (industrial and commercial buildings flexibility),validate technical solutions for flexibility aggregation and carry out behavioural tests where clients were informed the day before by means of text messages of the need for behavioural change (load shifting, curtailment and consumption increase in solar hours).[52]

4.6.3 Better understanding of energy bills and markets

Another social benefit of aggregation is a better understanding of energy bills and markets by providers of aggregation services. While Next Kraftwerke Germany indicates that this is certainly the case, the other aggregators underline that the potential benefit depends on certain parameters. In this context, Oekostrom accentuates that there might be a benefit but only if aggregation offers are relatively easy to understand and if there is an economic gain so that customers are interested. For Re-Pro and EDP, aggregators will have to invest a lot of time and money in educating the providers of aggregation services before they will understand these benefits. Good Energy also highlight that gains are strongly related to the level of engagement of consumers whereas RE-Pro accentuates that consumers might better

[51] http://www.openenergi.com/our-customers/sainsburys/
[52] http://www.nicegrid.fr/

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understand separate parts of a bill but, due to increased complexity, be more frustrated than in the current situation. Finally, the importance of a clear visualization of data, for example through a billing app, is mentioned by oekostrom.

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4.6.4 Consumers receive fair incentives to participate

If there is enough competition between aggregators, consumers can, through aggregation, receive more fair incentives to participate in the market. In this case, there is a need for smart meters, controllable appliances and block tariffs to make it economically interesting for the wide public to participate. Oekostrom also highlighted that, in a future with more aggregators, appliances with storage possibility, such as heating and cooling systems, could offer flexibility and thus generate additional revenues for consumers.

4.6.5 Consumers can dispose of their own data

At this moment, large consumers such as most industrial and commercial consumers already dispose of their own data. Therefore, potential benefits in the future would only be significant in the case of small commercial and domestic consumers. A customer-friendly visualization is important in order to make energy flows well-understood.

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5. Conclusions

Our research demonstrates that aggregation has many potential benefits on different levels. The objective of this report has been to analyse these benefits with a focus on the different countries covered by the consortium. In-depth interviews were carried out by 3E and TUW with 6 project partner aggregators (Good Energy, Next Kraftwerke Belgium, Next Kraftwerke Germany, Oekostrom, RE-Pro and EDP) in 9 countries. Also, an extensive literature study was carried out to complement the analysis.

5.1 General benefits from aggregation

Our research illustrates that a principal potential benefit from aggregation is the lower energy cost. Aggregators highlighted that aggregation can help to reduce prices on control reserves markets. In countries with a high (Germany) or average (UK, Austria and Belgium) share of aggregation, secondary and tertiary reserves market prices have been significantly decreasing over the period 2013-2015 and are a lot lower than in countries with a lower level of aggregation (Spain and Portugal). However, the exact impact of aggregation is difficult to measure because other factors such as the increasing share of VRE and the decommissioning of existing power plants (nuclear and gas plants) are playing a major role. Aggregation can moreover reverse price variability on wholesale markets with an increasing share of VRE.

A second important benefit from aggregation is the broader deployment of technologies. Countries with an average to high level of aggregation tend to have a wider variety of generation technologies on the different markets (wholesale, reserves, balancing) and have more upcoming new technologies such as Virtual Power Plants (VPPs) and Internet of Things (IoT) technologies. In this context, partnerships between product manufacturers, control companies, aggregators and energy suppliers will be key in the coming years.

Other key potential benefits from aggregation comprise increased efficiency and reduced emissions through an increased participation of generation units to markets of aggregation services. Aggregation can finally create jobs and boost innovations on the grid operator side. This is already happening in countries such as the United Kingdom and Germany.

It is also crucial to highlight that benefits are more visible in markets that are opening, Germany, the United Kingdom, Austria and Belgium than in the other countries that are covered by the consortium.

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5.2 Market benefits from aggregation for different stakeholders

There are potential benefits from aggregation for different stakeholders: aggregators, providers of aggregation services and users of aggregation services.

According to our interviews and desk research, the main benefits from aggregation for aggregators are portfolio optimization and the increased market access with decentralized units. For providers of aggregation services, the potential benefits include increased revenues and a reduced energy bill. If DSM or distributed generation providers have the highest incentive to provider services highly depends on the country, and the optimal remuneration scheme depends on the customer segment but fixed fees play an important role to provide financial stability to providers. Finally, with respect to users of aggregation services, aggregators commonly perceive lower prices on control reserves and wholesale markets as a key advantage since more units are participating. Furthermore, aggregation has the potential to lower balancing costs and decrease the energy costs for prosumers.

5.3 Technical, environmental and social benefits from aggregation

Figure 15 outlines the most important environmental, technical and social benefits that were identified.

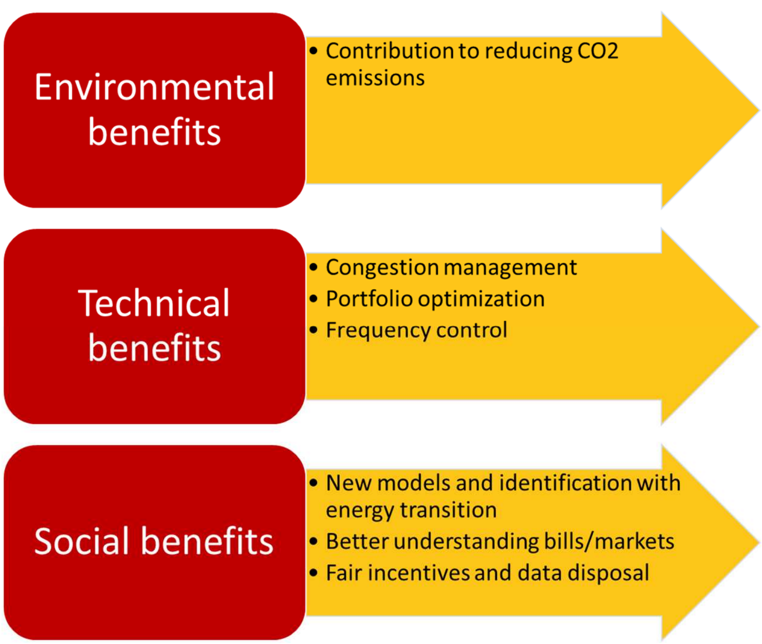

Figure 15: Technical, environmental and social benefits from aggregation

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Our research shows that aggregation contributes to the 2020 targets since generation capacity is supposed to be better used, new investments are avoided, conventional generation can run at higher rates because other assets are more flexible and the lifetime of generation assets can be longer. These benefits are, however, difficult to measure.

Aggregators equally highlight that technical benefits of aggregation are critical but are only just starting to be visible in some of the covered countries. Aggregation can be used for congestion management in countries or regions where the grid is “full” and, in combination with increased forecasting, can be useful for optimizing portfolios and frequency control.

Lastly, social benefits of aggregation are indispensable to be mentioned. New models of environmental friendly lifestyle were identified, as well as contribution to ones identification with the energy transition, helping prosumers to understand energy bills and markets and last but not least, improved data disposal and availability of price information.

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6. Annexes

Annex 1: Questionnaire with respect to benefits that aggregators bring to power markets and systems

General benefits from aggregation	
1) What are the most important benefits from developing aggregation for the aggregator?	
2) What are the most important benefit from developing aggregation for the system as a whole?	
3) Which providers of flexibility have the highest interest in providing flexibility? [please also rank 1-3 with 1: most important]	3.1) Industrial consumers
	3.2) Commercial consumers
	3.3) Domestic consumers
	3.4) Distributed generators
4) What is the market share of aggregated resources in the total reserve market of your country (% of contracted volumes MW)? Can you provide us with a split up for RES, CHP, storage and DSM?	

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Market benefits from aggregation	
5 a) What are the most important market benefits that aggregators can offer to providers of aggregation services [please also rank 1-3 with 1: most important]	5a.1) Revenues through fixed remuneration or time of use tariffs
	5a.2) More cost efficient integration of renewables (lower prices)
	5a.3) Better service quality
	5a.4) Others?
5 b) How much revenue has aggregation added for renewable energy producers, DSM and other technologies (% of their turnover)	
6) What are the most important market benefits from aggregation for users of aggregation services (BRP, TSO, DSO, supplier, producers) [please also rank 1-4 with 1: most important]	6.1) Avoided of reduced market costs (BRP: imbalance, TSO: reserve market)
	6.2) Avoided or reduced investment costs (TSO and DSO: grid reinforcements & backup capacity, BRP: other & more expensive flexibility, producers and suppliers)
	6.3) Others?
7) Are the following market benefits already being realized by the market (benefits for all market participants)?	7.1) Investments in technology for increasing the amount of potential flexibility

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	7.2) Market opening to a large number of participants (competition) & elaboration of flexibility standards
	7.3) Triggered innovation on the grid operations side
	7.4) Economies of scale (what is the share of fixed costs?) and economies of scope (cloud computing, computer power, etc…)?
8) How many aggregators can operate on the national market until the markets are saturated?	

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Technical benefits from aggregation	
9) What are the most important technical benefits from aggregation for users of aggregation service?s	9.1) (Long-term and short-term) congestion management (TSO/DSO)
	9.2) Portfolio optimization (BRP)
	9.3) Frequency control (TSO) through frequency containment reserves (FCR), frequency restoration reserves (FRR) and replacement reserves (RR))
	9.4) Grid losses reduction (TSO)
	9.5) Voltage control (TSO/DSO) through active or reactive power
	9.6) Increase revenues of customers with flexible tariffs
	9.7) Others?

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Environmental and social benefits from aggregation	
10) Does aggregation contribute towards meeting European overal RES 2020 targets?	10.1) (Long-term and short-term) congestion management (TSO/DSO)
11) Do you foresee a significant change in your business once CO2-prices would rise again (impact of ETS mechanism)?	11.1) Portfolio optimization (BRP)

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Technical references

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Contributing beneficiaries	All partners
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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
1.0	12/07/2016	3E	Ruben Verhaegen
2.0	08/08/2016	3E	Ruben Verhaegen
3.0	25/08/2016	3E	Pieter Joseph
4.0	29/08/2016	WIP	Silvia Caneva

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