BestRES

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

Documentation of pilot business model implementation and results

Authors: Ruben Verhaegen (3E) and Raphael Beaumont (3E)

Co-Authors: Georg Lettner (TUW-EEG), Daniel Schwabeneder (TUW-EEG) and Andreas Fleischhacker (TUW-EEG)

Reviewers: Antoon Soete (3E) and Carlos Guerrero (3E), Fabian Pause (Stiftung Umweltenergierecht) and Stefanie Wizinger (Stiftung Umweltenergierecht), Silvia Caneva (WIP)

September 2017
www.bestres.eu

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 691689.

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) and Raphael Beaumond (3E). The authors thankfully acknowledge the valuable contributions from all project partners, especially from: Fabian Pause (Stiftung Umweltenergierecht), Stefanie Wizinger (Stiftung Umweltenergierecht), Georg Lettner (TUW-EEG), Daniel Schwabeneder (TUW-EEG) and Andreas Fleischhacker (TUW-EEG) to complete this report.

Disclaimer

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 691689. The sole responsibility for the content of this report lies with the authors. It does not necessarily reflect the opinion of the European Union. Neither INEA nor the European Commission are responsible for any use that may be made of the information contained therein. While this publication has been prepared with care, the authors and their employers provide no warranty with regards to the content and shall not be liable for any direct, incidental or consequential damages that may result from the use of the information or the data contained therein. Reproduction is authorized providing the material is unabridged and the source is acknowledged.

Contacts

Project coordinator

Silvia Caneva, Ingrid Weiss & Pablo Alonso
WIP – Renewable Energies
Sylvensteinstrasse 2, Munich, Germany

Email: silvia.caneva@wip-munich.de
Email: Ingrid.weiss@wip-munich.de
Email: pablo.alonso@wip-munich.de

Author(s)

Ruben Verhaegen (3E) and Raphael Beaumont (3E)

Address:

Kalkkaai 6 Quai à la Chaux
1000 Brussels, Belgium

Email: info@3E.eu

Co-Author(s):

Georg Lettner (TUW-EEG), Daniel Schwabeneder (TUW-EEG) and Andreas Fleischhacker (TUW-EEG)

Reviewer(s)

Antoon Soete (3E) and Carlos Guerrero (3E), Fabian Pause (Stiftung Umweltenergierecht) and Stefanie Wizinger (Stiftung Umweltenergierecht), Silvia Caneva (WIP)

BestRES This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

Table of Contents

BestRES This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

BestRES This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

List of Figures

BestRES This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

List of Tables

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

Abbreviations

BKZ	Baukostenzuschüssen (Building Cost Control)
BM	Business Model
BRUGEL	Brussels Energy Regulatory Body
CHP	Combined Heat and Power
CREG	Commission for Electricity and Gas Regulation in Belgium
CWaPE	Wallonia Energy Commission
DR	Demand Response
DSM	Demand Side Management
DSO	Distribution System Operator
Elia	Transmission System Operator in Belgium
ENDEX	Spot market for electricity in Belgium
FiP	Feed-in-Premium
FiT	Feed-in-Tariff
GoO	Guarantees of Origin
M&A	Mergers & Acquisitions
MAE	Mean Absolute Error
PPA	Power Purchase Agreement
SME	Small and medium-sized enterprise
SVR	Support Vector Machines Regression
TRV	Thermostatic radiator valves
TSO	Transmission System Operator
UK	United Kingdom
VEA	Flemish Energy Agency
VREG	Flemish Electricity and Gas Regulatory Body

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

Executive Summary

In a changing electricity market landscape, where the share of variable 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 their integration, 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 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 D3.2 “Improved BMs of selected aggregators in target countries” of the BestRES project, improved aggregator BMs are identified in each of the countries covered by the consortium. In D4.1 “An assessment of the economics of and barriers for implementation of the improved BMs”, we identified which of these models are ready for implementation (defined as group 1 BMs). 7 such BMs in 6 countries are identified. In this document, we provide support for implementation to each of them as summarized in Figure 1.

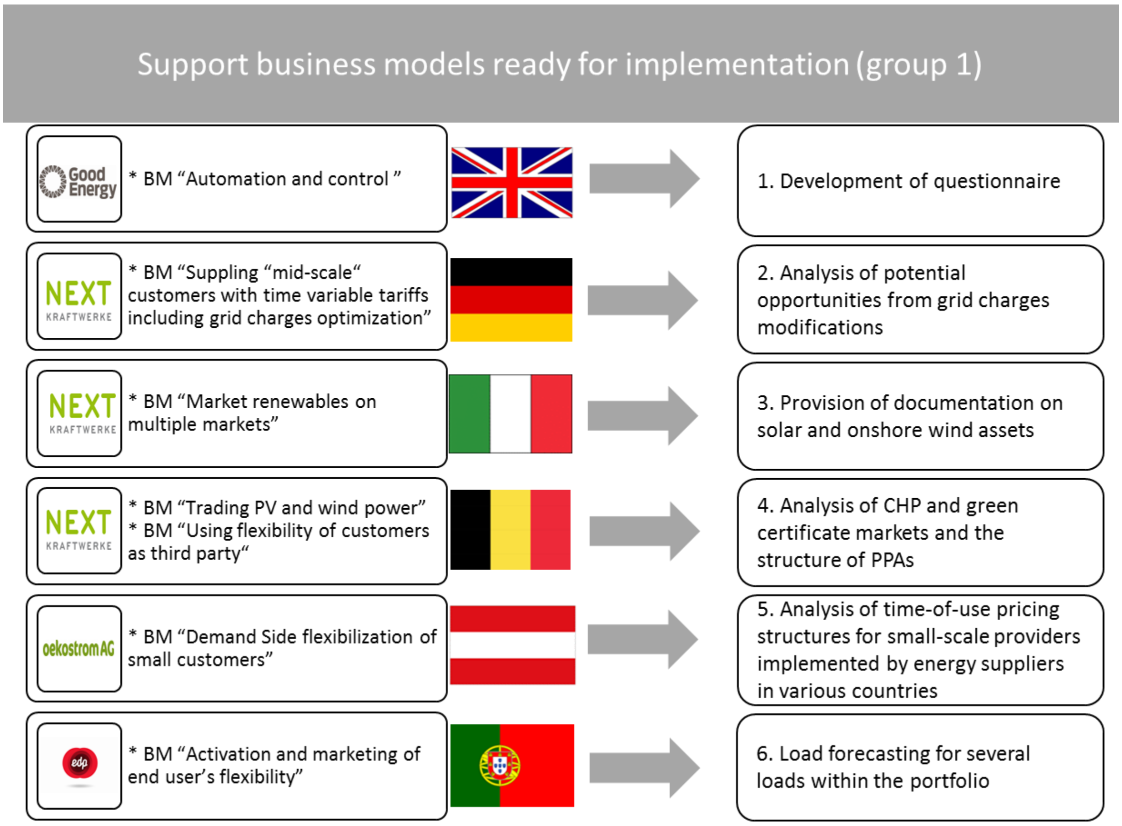


Figure 1: Support for BMs ready for implementation

Below we discuss some of the most interesting conclusions and recommendations drawn from these different support actions.

BestRES
This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement N°691689.

It is crucial for Good Energy to identify the detailed flexibility potential for different groups of small-scale consumers

The consortium developed a questionnaire for targeting small-scale consumers in the United Kingdom. The questionnaire allows to target a broad group of potential customers and to determine, for each type of customers (where the main distinction is made between people with PV-storage systems and people with flexible electric loads such as refrigerators, freezers, water boilers, heat pumps and electric radiators), the detailed flexibility potential. Good Energy also has to find, for each customer group, the most appropriate channel for sending the questionnaire.

Orienting demand in function of grid congestion would offer the best opportunities for Next Kraftwerke Germany

In Germany, the consortium analysed the current grid charges regulation to identify the most relevant ongoing potential grid modifications when supplying "mid-scale" customers with time variable tariffs. Four important grid charges modifications under discussion are distinguished: 1) Coordinating solutions of production- and grid expansion, 2) Aligning current grid charge references with the additional incurred grid costs, 3) Orienting demand in function of the grid congestion and 4) Geographically redistributing regional costs. Orienting demand in function of the grid congestion, and especially with time-variable tariffs, offers the most relevant opportunities for Next Kraftwerke Germany.

The Italian renewable energy market is rapidly changing and is characterized by an active secondary market and consolidations

Our market research clearly demonstrates that, in Italy, subsidy schemes for wind and solar energy have been changing in recent years with important cuts in feed-in tariffs for existing solar projects. For solar energy, there is an active secondary market for utility-scale projects, a consolidation trend and the 3 most important investors are EF Solare Italia, RTR Energy and Tages Helios. For onshore wind energy, the 3 major investors are ERG, Enel Green Power and E2i.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

NEXT KRAFTWERKE

Next Kraftwerke should take into account price increases (and decreases) in green and CHP certificates in Belgium

The consortium has shown that, in Belgium, green and CHP certificates are mostly sold to grid operators at minimum support because market prices are low due to a surplus of certificates on the market. However, our study underlines that surpluses could go down and prices go up in the short to medium term. For this reason, Next Kraftwerke should take into account these price increases (and decreases) when contracting PPAs and for fulfilling its obligation, as an energy supplier, of sending certificates to regulators.

oekostrom AG

Some suppliers in countries with smart meter infrastructure have time-of-use tariffs for small-scale consumers but potential savings are difficult to estimate

The consortium identified time-of-use tariffs for small-scale customers implemented by suppliers in Austria, the United States, Sweden, Spain and the United Kingdom. Information about such tariffs will help oekostrom to set up an appropriate tariff structure for their clients during the implementation period in the BestRES project. It is clear that smart meters are key for such operations but the exact potential benefits for oekostrom are difficult to estimate. The potential savings of clients of the other provider in Austria, aWattar, are estimated at 30%. For most other suppliers, the exact savings are not known. If oekostrom wished to better understand this, the company could use questionnaires to better estimate the potential of different types of customers.

edp

Advanced forecasting techniques such as Support Vector Machines for Regression (SVR) can outperform traditional load forecasting models

In Portugal, the consortium forecasted the loads of entities in the metallurgy and food industry and for an SME. We demonstrated that, for each of those loads, advanced forecasting techniques such as Support Vector Machines for Regression (SVR) can outperform traditional load forecasting models. For further improving the results, it could be relevant to investigate the potential of including larger datasets and external variables such as ambient temperature and irradiation data.

BestRES This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

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 changing because a rising share of distributed generation increases variability and price volatility in the system. This requires a more flexible system with more flexible consumption and generation. 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 weather dependent electricity sources, enhance demand flexibility and decrease the reliance on renewable energy support schemes.

More aggregation and market integration can however not be achieved by single individual, commercial or domestic consumers since they would only have a limited impact. It is only through a coordinated steering of larger amounts, numbers and types of consumers and producers in a market that the use of flexible distributed generation and demand response in combination with storage technologies 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. Apart from the inadequate market design in several countries, an explanation for this is the requirement 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 technically and/or economically. In other words, they are facilitators between the two sides of electricity markets – demand and supply. 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 benefit from aggregation if appropriate incentives are present.[1]

---

[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, Available at: http://www.nordicenergyregulators.org/wp-

BestRES This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

1.1 The BestRES project

The main objective of the BestRES project is to investigate the current barriers for aggregators and to improve the role of energy aggregators in future electricity market designs. In the first stage from March till September 2016, the consortium identified business models of aggregators across Europe. In the second stage, we will develop improved business models that are replicable within the EU investigating different market designs with a focus on competitiveness and life-cycle assessment (LCA). These improved business models will be implemented or virtually implemented with real data and monitored in the following target countries: United Kingdom, Belgium, Germany, France, Austria, Italy, Cyprus, Spain and Portugal.

The BestRES project will last three years. It started on 1 March 2016 and will end on 28 February 2019.

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

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

The BestRES activities to be implemented in Cyprus will be carried out by FOSS, the research centre for sustainable energy of the University of Cyprus. This is

---

content/uploads/2016/02/NordREG-Discussion-of-different-arrangements-for-aggregation-of-demand-response-in-the-Nordic-market.pdf

IndustRE project, Main variations of business models for Flexible Industrial Demand combined with Variable Renewable Energy, Working Document, Deliverable 2.1, April 2015, Available at: http://www.industre.eu/downloads/category/project-results

Quentin Lambert, Business Models for an Aggregator, Application to the situation on Gotland, KTH Royal Institute of Technology, Available at: https://www.kth.se/social/upload/5093c048f276545fbd1c6378/KTH%20Energy%20Award-QL.pdf

The birth of a European Distributed EnErgy Partnership, The Main players of the DER aggregation field, EU-deep, Available at: http://www.eudeep.com/index.php?id=653

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

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 due to the fact that there are no aggregators in Cyprus at the time being (2016) and no market entrants are expected until 2019-2020.

The innovative business models to be worked out during the project will be based on currently applied business models in Europe and adapted to the expected future market design. They will be developed 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

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, Paris, London, Istanbul, Delhi and Cape Town. The company has a project track-record of over 15 years in over 30 countries. Website: www.3e.eu

BestRES This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

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

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

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement N°691689.

Next Kraftwerke Germany (NKW DE)

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

Oekostrom

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

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

The Research Centre for Sustainable Energy of the University of Cyprus (FOSS) was created in order to play a key role in research and technological development activities in the field of sustainable energy within Cyprus and at international level with the aim of contributing to the achievement of the relevant energy and environment objectives set out by Europe. FOSS is heavily involved in all spheres of sustainable energy spreading from sources of energy, smoothly merging RES in the integrated solutions of the grid, development of enabling technologies such as storage and ICT that will facilitate the seamless merging of sustainable technologies in the energy system of tomorrow, the complete transformation of energy use by the effective introduction of sustainable alternatives in meeting the needs for mobility, heating and cooling and exploring ways of achieving even higher levels of efficiency in all areas of the economy.
Website: http://www.foss.ucy.ac.cy

Centre for New Energy Technology (EDP-CNET)

EDP Group is an integrated energy player, with strong presence in Europe, US and Brazil and the third player in the world in terms of wind installed capacity. EDP is an innovative European Utility with an important presence across all the energy value chain, in Generation, Distribution, Energy Trading and Retail of electricity and gas. EDP owns HC Energia, the 4th Energy Utility in Spain and

BestRES This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

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

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

1.2 Structure of the document

In D4.1 "An assessment of the economics of and barriers for implementation of the improved business models" of the BestRES project, we decided, for each improved BM, if it is ready to be implemented (group 1 BMs) based on an assessment of the economic feasibility and a barriers analysis. In a next step, our aim is to support aggregators with the implementation. Business models ready for implementation are identified in 6 countries: United Kingdom, Germany, Italy, Belgium, Austria and Portugal. We will assist the aggregators with formulating a pilot implementation plan and/or supporting efforts to identify and attract project participants.

The remainder of the document is structured as follows:

- Section 2 briefly outlines the project methodology
- In Sections 3-8, we elaborate on the support provided to each of the aggregators with improved BMs ready for implementation in the 6 countries
- Section 9 concludes with an overview of the support and some important conclusions drawn from the different support actions. We will also provide the reader with some recommendations for further implementation

BestRES This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

2. Methodology

4 aggregators and 1 research centre (section 1.1 of this document) in 9 countries in different regions in Europe are included in the BestRES project:

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

In D4.1 “An assessment of the economics of and barriers for implementation of the improved business models” of the BestRES project, the consortium identified the aggregators who have BMs that are ready for implementation in each of the target countries as Figure 2 illustrates (left side of the figure).

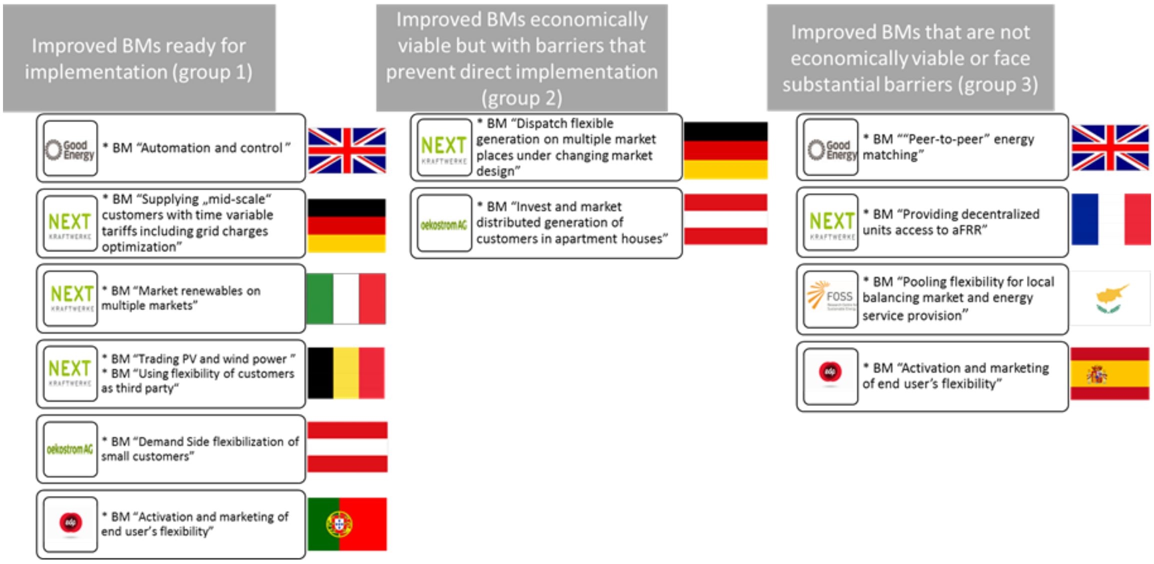


Figure 2: Aggregator business models ready for implementation

Figure 2 highlights that aggregators with BMs ready for implementation are active in 6 out of the 9 target countries. In a next step, the consortium discussed the details of each of those BMs with the aggregators in order to understand their needs in terms of support for implementation. In this context, aggregators have very different profiles and very different relationships with clients. Based on the discussions, it was decided to provide the following support to each of the aggregators:

- Good Energy in the United Kingdom: development of a questionnaire for targeting small-scale providers of flexibility in the “automation and control” BM
- Next Kraftwerke in Germany: an analysis of the issues with current grid charges and potential grid charges modifications for implementation of the

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement N°691689.

“Supplying “mid-scale” customers with time variable tariffs including grid charges optimization” BM

- Next Kraftwerke in Italy: a detailed analysis of the evolution of the Italian solar and onshore wind energy sector and documentation on solar and onshore wind assets and investors. This will allow Next Kraftwerke to target interesting providers of flexibility for implementing the “Market renewables on multiple markets” BM
- Next Kraftwerke in Belgium: the provision of documentation on the operation of the green and CHP certificate systems, related markets and market players and PPAs. This will allow Next Kraftwerke to better understand the impact of green certificates in valorising flexibility
- oekostrom in Austria: an analysis of time-of-use pricing for small-scale customers of different suppliers in various countries. This will allow oekostrom to set up an adequate price structure for their “Demand side flexibilization of small customers” BM
- EDP in Portugal: support with understanding the potential of adequate load forecasting of loads within the portfolio of EDP. This will help EDP to implement the “Activation and marketing of end user’s flexibility” BM

BestRES This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement N°691689.

3. Implementation support Good Energy (United Kingdom)

As described in D4.1 “An assessment of the economics of and barriers for implementation of the improved business models” of the BestRES project, Good Energy is implementing the improved business model “Automation and control” in the United Kingdom. The focus will be on houses and small-scale commercial customers with different devices (refrigerators, freezers, water boilers, heat pumps, electric radiators) that can potentially provide flexibility for balancing and on wholesale and reserve power markets. For better understanding which household and small-scale commercial customers should be targeted, Good Energy requested the consortium to prepare a detailed questionnaire to be sent to potential clients. Good Energy will be able to integrate the questions from this questionnaire in marketing material and it will allow to better understand the potential with each of the different existing Good Energy customers. Moreover, in a next step, the questionnaire could also be sent to potential customers that are not yet off-takers of gas and electricity with Good Energy.

The end purpose of the questionnaire is to categorise consumer preferences into three major groups. The first group, Group-1, will reflect consumers who will respond well to financial incentives such as time-of-use tariffs as they attempt to reduce bill costs. The second group, Group-2, represents individuals which will balance product characteristics against financial incentives to assess whether their preferences can be superiorly met by the new product in comparison to the existing ones. Lastly, the third consumer group, Group-3, reflects early adopters who make decisions driven by lifestyle choices with technology grid parity being less of a concern. As such, it is expected that each group will expect flexibility product and services to address a varying unmet need and the questionnaire will be used as a guiding tool in addressing those needs.

3.1 Content questionnaire

The content of the questionnaire is presented in the different sections below

3.1.1 About you

What services do you receive from Good Energy? Please tick all that apply.

- Electricity
- Gas
- Feed-in-Tariff
- I don’t know

BestRES This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement N°691689.

Approximately how long you have been a Good Energy customer?

- Less than 1 year
- 1-2 years
- 2-5 years
- 5 years or more
- I don't know

How concerned are you about the expected future price rises in electricity?

- A lot
- A fair amount
- Not very much
- Not at all

3.1.2 Household profile

Which best describes your household tenure?

- Owner-occupied
- Private rented
- Rented from a housing association
- Rented from a local authority
- Other
  - Please specify

Which best describes your home?

- Detached
- Semi-detached
- Bungalow
- End terrace
- Mid terrace
- Purpose built flat
- Converted flat
- Other
  - Please specify

How many bedrooms does your home have?

-

How many people live in your home?

-

BestRES This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

Roughly when was your home built?

- pre 1919
- 1945–1964
- 1965–1980
- 1981–1990
- 1991-2000
- post 2000
- I don't know

Which of the following best describes where your home is located?

- City – centre
- City – suburb
- Town – centre
- Town – suburb
- Village, hamlet or isolated dwelling
- Other
    - Please specify

Which best describes the occupancy of your home on a typical weekday during working hours (from roughly 9am to 5pm)?

- The house is generally unoccupied
- The house is generally fully occupied (all occupants are in the house during working hours)
- The house is generally partly occupied during the day

Do you know about the yearly electricity consumption of your house?

- Yes
- No

If yes, please communicate the last available figure:

-

3.1.3 Smart meters

Here are some pictures of smart meters for your understanding:

BestRES This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

Smart meters are able to communicate with energy suppliers by sending and receiving information about the amount of energy being used. Smart meters are installed by a professional engineer from your gas or electricity company, unlike an energy monitor which can be installed by householders themselves.

Before today, had you heard of smart meters?

- Yes, I have one
- Yes, but I do not have one
- No – I have never heard of them
- I don't know

3.1.4 Heating systems

Do you have a gas or oil boiler?

- Yes
- No
- I don't know

Do you have electric heating?

- Yes, night storage heaters
- Yes, not night storage heaters
- Yes, underfloor heating
- No
- I don't know

Do you have an air source heat pump?

- Yes
- No
- I don't know

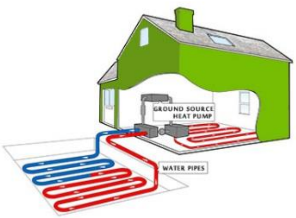
Here is a picture as an example:

BestRES This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

Do you have a ground source heat pump?

- Yes
- No
- I don't know

Here is a picture as an example:



Do you have a biomass boiler?

- Yes
- No
- I don't know

Here is a picture as an example:

Do you have a solar thermal system?

- Yes
- No
- I don't know

Here is a picture as an example:

BestRES This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

4.3.7 Roughly when was your heating system installed?

- Less than 12 months ago
- 1-3 years ago
- 3-5 years ago
- 5-10 years ago
- Over 10 years ago
- I don’t know

-

When you come to replace your existing heating system, what do you think you will replace it with?

- Gas boiler
- Oil boiler
- Electric heating (night storage heaters)
- Electric heating (not night storage heaters)
- Electric underfloor heating
- Biomass boiler
- Air source heat pump
- Ground source heat pump
- Solar thermal
- Wood burning stove / open fire
- Other
- Please specify
- I don’t know

Does your home have a hot water tank?

- Yes
- No
- I don’t know

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement N°691689.

Do you have any of the following heating controls installed in your home? Please tick all that apply.

- A room thermostat
- A programmer (a timer)
- Thermostatic radiator valves (TRVs)
- A smart thermostat (for example, a Hive or Nest)
- None of these

Which of the following best describes the heating practice of your household over the winter season? This question assumes that you will 'boost' your heating when necessary.

- We only turn the heating on when we feel cold
- We use a thermostat to switch the heating on when the temperature drops below a certain level
- We programme the heating to come on at regular times throughout the week
- We programme the heating to come on at regular times throughout the week, but only when the temperature drops below a certain level
- Other
    - Please specify

How much attention do you pay to the amount of heat you use in your home?

- A lot
- A fair amount
- Not very much
- None at all
- I don’t know

3.1.5 Refrigerators, freezers and water boilers

What kind of boiler do you have?[2]

- Standard boiler (your house may also have a separate hot water tank)
- Condensing boiler (with hot water tank)
- Combi boiler (providing heating and instant hot water, usually without a hot water tank)
- Condensing combi
- Back boiler (usually behind a fireplace)

[2] https://www.cse.org.uk/downloads/file/home_and_energy_use_questionnaire.pdf

BestRES This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement N°691689.

- No boiler
- I don't know

Do you have refrigerator(s) in your house?

- No
- Yes

If yes, how many?

Do you have freezer(s) in your house?

- No
- Yes

If yes, how many?

3.1.6 Rooftop solar systems

Do you have solar panels on the rooftop of your home?

- Yes
- No

[If answered yes to 4.5.1 …]

What is the size of your solar system?

-

[If answered no to 4.5.1 …]

Do you consider installing solar panels?

- Yes
- No

3.1.7 Home battery energy storage system

Do you have a home battery energy storage system?

- Yes
- No

[If answered no to 4.6.1 …]

Do you consider installing a home battery energy storage system?

- Yes
- No

BestRES This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

4. Implementation support Next Kraftwerke Germany (Germany)

As analysed in D4.1 "An assessment of the economics of and barriers for implementation of the improved business models" of the BestRES project, the economic assessment of grid charges optimization (BM "Supplying „mid-scale" customers with time variable tariffs including grid charges optimization") is generally positive for Next Kraftwerke and implementation should therefore be feasible.

Current grid charges challenge an efficient integration of an increasing share of renewable energy and therefore the grid charges framework is expected to change in the near future. Since Next Kraftwerke's business model will rely on grid charge optimization, providing an overview of the possible evolution of the grid charge components will be important. It will allow to propose relevant policy and adapt to the new frameworks in due time. Therefore, an overview of both the issues with current grid charges and a proposal of potential modifications is the subject of the analysis below.

4.1 Issues with current grid charges

4.1.1 Grid charges regulation hampers flexibility measures

As previously explained in the BestRES project, flexibility is becoming increasingly important for integrating renewable energy into the electricity system. In contrast to the conventional flexibility options such as gas turbines, a number of alternatives are being developed e.g. flexible power plants, electricity storage, distributed generation or power-to-gas. Companies can also contribute to greater flexibility by adapting their power consumption (demand Side management (DSM)).

In Germany, grid charges are an important part of the electricity cost for companies. Currently, there are different network control regulations that make it difficult or even prevent companies from participating in flexibility measures. For instance, the so called "7000-hours principle" allows an exemption on grid charges for companies who consume more than 10 GWh per year and have a full power of at least 7000 hours per year.[3] Such regulatory framework hamper market incentives to stabilize the grid using the spread between scarcity and oversupply prices. This is especially true for large-scale consumers and power-intensive companies.

[3] Strom-Großverbraucher sparen zulasten von Verbrauchern, Available at: http://www.handelsblatt.com/unternehmen/industrie/befreiung-von-netzgebuehren-strom-grossverbraucher-sparen-zulasten-von-verbrauchern/6506762.html

BestRES This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

In order to further develop policy regarding grid charges, the German Energy Agency DENA has launched a direct exchange of important stakeholders in the industry including a specific taskforce on grid charges. The objective is to find a practice-oriented solution that incorporates the different perspectives of the different taskforce members consisting of more than 20 network operators, industrial enterprises and associations.[4]

The taskforce will develop a strategy paper that contains solutions and recommendations for the revision of grid charges. This will provide an impulse for energy policy discussion. Due to the broad range of partners, the results have a high practical relevance and complement theoretical analyses which already exist or are currently being developed. The publication is scheduled for autumn 2017.

4.1.2 Grid charges lead to an unfair distribution of costs

Grid charges are growing significantly in 2017 but are evolving very differently depending on their location as shown in a recent study commissioned for Agora Energiewende. The study shows that rural regions with a high share of renewable energy supply, especially wind energy, have rising grid charges while cities in the regions of the TSOs Amprion and Transnet BW have maintained their already very low grid charges. This is due to the costs corresponding to grid expansion and the increasing redispatch (german “Einspeisemanagement”).[5] Also, in Germany, renewables will get curtailed when it is not possible to ramp down conventional production capacity anymore where the compensation (including missed subsidies) paid to the operator by the TSO will eventually be charged to consumers through grid charges. As a result, there is an increasing difference between regional grid charges for electricity consumers in expensive regions paying more than twice for grid charges compared to consumers in regions with favourable tariffs.[6]

Furthermore, the same study shows that many network operators tend to increase their basic rates more than their operational expenses. As a rule, this is justified by the fact that the grid-related fixed costs are higher for intermittent power generation, especially for solar power. This trend is however putting much weight on some customers. In addition, the surveyed network operators do not collect additional basic charges for special electricity consumers with for example EVs and heat pumps. From the point of view of Agora Energiewende this

[4] Taskforce Netzentgelte, Available at: https://www.dena.de/themen-projekte/projekte/energiesysteme/taskforce-netzentgelte/
[5] Was ist Einspeisemanagement?, Available at: https://www.next-kraftwerke.de/wissen/direktvermarktung/einspeisemanagement
[6] Netzentgelte: Unterschiede nehmen zu, November 2016, Available at: https://www.agora-energiewende.de/de/presse/agoranews/news-detail/news/netzentgelte-unterschiede-nehmen-zu/News/detail/

BestRES This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement N°691689.

is not consistent, since the electricity consumption of these specific consumers will result in higher fixed grid costs compared to the standard use case.

4.1.3 Grid operators will not be able to cover for the costs with increasing self-consumption

The original structure of the grid charges is now generating unwanted incentives due to the dynamic development of decentralized renewable energies. In the current context, no network charges should be paid for self-consumption. The reasoning behind this is that, since actors with own electricity generation are not consuming electricity from the grid, they should not pay for grid charges. The same generally applies for power stations which can use net-metering for consumption and production happening at different times.[7]

Rising purchasing costs and declining production costs make it increasingly interesting for industry, commerce and households to look into self-consumption. The economic profitability of this self-consumption results from the comparison with the reference costs from the public network. Since grid charges are paid depending on the electricity purchased (only including power component costs for <100 MWh/year while grid charges include both capacity as well as power costs for >100 MWh/year), the incentive to generate own electricity in areas with high grid charges is certainly present.[8]

Therefore, expensive networks have a potential for self-reinforcing redistribution dynamics: the higher the charges to be paid for electricity coming from the grid, the greater the incentive for self-consumption, for which these costs are not incurred. This leads to rising network charges for the remaining consumers, since the grid infrastructure must continue to be maintained and operated for all, i.e. largely independent of consumption. This increases again the incentive to self-production and self-consumption, etc.

If the framework conditions remain unchanged, it can be assumed that self-consumption will increase and lead to significant redistribution of local and regional grid charges.

4.2 Potential grid charges modifications under discussion

To deal with the different issues with existing grid charges as described in section D4.1 of the BestRES project, many options for updates can be investigated. In

[7] Agora Energiewende, Netzentgelte in Deutschland, 2014, Available at: https://www.agora-energiewende.de/fileadmin/downloads/publikationen/Analysen/Netzentgelte_in_Deutschland/Agora_Netzentgelte_web.pdf

[8] Bundesministerium der justiz und für verbraucherschutz, Verordnung über die Entgelte für den Zugang zu Elektrizitätsversorgungsnetzen (Stromnetzentgeltverordnung - StromNEV) 17 Ermittlung der Netzentgelte, Available at: http://www.gesetze-im-internet.de/stromnev/__17.html

BestRES This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

this section, we elaborate on some relevant potential grid charges modifications that are being discussed at the moment of writing this document.

4.2.1 Coordinating solutions of production- and grid expansion

In order to achieve an optimal allocation of renewable energy as well as conventional production from an economic perspective, the costs of additional grid expansion or savings by avoiding grid investments should be reflected directly in grid charges for producers. Two options for managing production and grid expansion are the introduction of feed-in tariffs (Generation-components) and the use of building cost-control (BKZ).

A G-component for power generation plants can provide allocation signals for an optimized geographical distribution. It is a feed-in tariff which must be paid for each energy unit or power input. The feed-in tariffs are usually levied both on existing and new plants. In order to implement signals for a geographical allocation, the grid charges can be differentiated regionally. One option would be that the charge depends on the grid connection point (location and voltage level as well as the associated costs) and the feed-in characteristics. For example, a gas power plant connected to the high-voltage network would be regarded as a load-following, controllable and secured power producer and pay a low fee. A wind farm in northern Germany on a weak high-voltage grid, which injects fluctuating power, by contrast, would pay a higher fee and thus making a larger contribution to additional operating and expansion costs of the network.

Alternatively, a Building Cost Control (BKZ) scheme could be introduced. Important network expansions are necessary to integrate renewable energy systems in some of the German distribution grids. Investments are also necessary on the transmission network, which are mainly caused by the transition of the energy industry. A building cost control, for example in the form of a one-time payment related to a specific network connection, could help to give a local signal. The amount of the BKZ would be based on the network expansion costs necessary for the connection. If a grid expansion is not necessary, the BKZ will be set to zero meaning that locations with a low BKZ would be selected first. As a result, the required network configuration can be reduced because the existing network is used more efficiently. In addition, an increase in grid charges in the affected regions can be effectively managed with a BKZ and the distribution rights can be addressed. The external effects on the final consumer caused by the integration of renewable energy in the affected regions are internalized. If the BKZ is restricted to the distribution network, the geographic allocation signal would also be limited on the DSO level. BKZ systems are already used on the load side to allocate costs for grid connection to the consumers.

The comparison of the two instruments reveals that the BKZ has advantages over the G-component in terms of market efficiency. Firstly, the wholesale market is not influenced by the introduction of the BKZ. Secondly, the additional costs for

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

renewable energy will be distributed fairly to all final consumers via the EEG apportionment and will not remain as higher grid charges for local end-users.[9]

However, looking at the relevance of both options for aggregators, it is important to accentuate that implementing a coordination mechanism for integrating renewables through a G-component or BKZ will not allow further optimization opportunities for aggregators as both these incentives are static and focused on the geographic aspects rather than time patterns in consumption or production.

4.2.2 Aligning current grid charge references with the additional incurred grid costs

Another option is looking at the cost structure of the grid charges and including additional incurred costs from integrating renewables. The electricity network is characterised by high fixed costs creating natural monopolies. By reflecting the cost drivers in the different grid charge components, grid charges would be shifted from power consumption to fixed connection costs (option 1). In other words, fixed costs should be a higher share of the electricity bill. In this context, the main cost drivers are 1) the connection to the grid (producers and consumers, 2) the network expansion cost for connection to the public grid and 3) administrative costs and costs due to grid losses (vary with the grid usage)

Three existing grid charge components can be defined in relation to these three cost drivers:

1. A basic charge reflecting connection costs and the fixed administrative costs
2. A power price, based on the individual consumption;
3. A working rate related to operational expenses, for example losses or (partial) operation.

A second option (option 2) could be to introduce an update of the simultaneity function (variable expenses based on peak consumption), which is the calculation method currently used. Today, in Germany, all costs are allocated to the tariff components using the simultaneity function. In order to minimize the risks, the simultaneity function should better reflect the characteristics of the grid users in the respective network area. Different options are being discussed[10]

Both options are suitable to meet the current challenges of the lack of solidarity between urban and rural areas, the excessive avoided network charges and the cost reflectiveness but a significant difference between the two approaches is that the cost orientation limits the power component (option 1) while the application of the simultaneity function (option 2) makes the energy purchase more expensive which will contribute to energy efficiency incentives.[11]

---

[9] Agora Energiewende- Neue Preismodelle für Energie: Grundlagen einer Reform der Entgelte, Steuern, Abgaben und Umlagen auf Strom und fossile Energietrager, April 2017

[10] Efzn, Stichwort: Gleichzeitigkeitsfunktion, March 2014, Available at: https://www.efzn.de/uploads/media/08_Kevin_Canty.pdf

[11] Agora Energiewende- Neue Preismodelle für Energie: Grundlagen einer Reform der Entgelte, Steuern, Abgaben und Umlagen auf Strom und fossile Energietrager, April 2017

BestRES This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

As with the coordination approach proposed in 4.2.1, there would probably be few options for optimization for aggregators as grid connection costs would probably be a greater portion of the grid charges. Depending on the actual simultaneity function being used, some optimization could be possible but only for consumption capacity lower than defined consumption caps.

4.2.3 Orienting demand in function of the grid congestion

A higher incentive for the time-shifting of loads can be provided by time-variable grid charges or by an explicit remuneration of the grid services.

The time-variant approach (explicit DR) aims to achieve a steering effect in the network usage via tariff components. The grid charges are differentiated for different times meaning that, in times of intensive network utilization, the grid charges should be higher. When the grid is less congested, by contrast, a correspondingly low tariff should be selected. This approach is intended to make network utilization more efficient, since it increases the incentive to shift the power from high-load times to other times. It also strengthens the flexibility on the demand side, including self-consumers.

As a second option, a compensation scheme for grid services (implicit DR) could be introduced that rewards network users when reducing or interrupting their consumption. In this context, a number of special rates are already granted today (for example, § 14a EnWG, § 40 (5) EnWG, § 14 (2) StromNEV, § 19 StromNEV102, etc.). A compensation can be calculated when control over consuming devices is agreed upon and results in the realization of intelligent distribution grids allowing for decentralized generation and local demand to be matched.

Both approaches are compared in Table 1.

BestRES This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

Table 1: Comparison between time-variant tariff components and Compensation for grid services

	Time-variant tariff components	Compensation for grid services
Economic efficiency	• Effective incentives to reduce the load • An efficient grid will lead to less excessive costs the regional end-users.	• Effective incentives to reduce the load • An efficient grid will lead to less excessive costs for regional end-users • Compensation or discount increases the overall grid costs in some cases when no direct system benefits are available
Equitable distribution	• Higher costs for grid users who wish to use the grid at congested times. Time-shifting can lower grid charges.	• Overall rising costs for all grid users, but above all for those who do not benefit from the discount or compensation
Good Governance	• Prices and periods must be predicted upfront in order to ensure planning security for the costs of grid usage. • Geographical differentiation required • Requires a high degree of automation in the distribution network in the medium term	• There is a risk of attracting market-based abuse. • Requires a high degree of automation in the distribution network in the medium term.

In principle, the time-variable tariffing seems to be more advantageous because this system does not entail any additional costs for the network customers, but rather allocates the operational costs economically: the grid usage during grid congestion is more expensive than at the other times when the network is almost not used. From an implementation perspective, this also appears to be more advantageous since no levy mechanisms are necessary, as is the case today.[12]

Both approaches in Table 1 favor active optimization by aggregators as automated arbitrage opportunities are economically incentivized. Additionally, time variable grid tariffs would send signals to aggregators which can than align flexibility measures on TSO and DSO level. Compensation for grid services, on the other hand, could increase the need for communication efforts from aggregators with TSOs and DSOs.

4.2.4 Redistributing regional grid costs geographically

A final potential grid charges modification is the geographical redistribution of regional grid costs. The energy transition in Germany needs a broad acceptance, which is possible when costs are reasonably justified and efficiency is considered. This could be done by applying the *Ausspeisungs*-principle: introducing federal grid charges for TSOs or even at DSO level.

This principle of cost shifting describes the monetary exchange between tariff areas based on the active power flows. In contrast to the principle of today's hierarchical, vertical cost-cutting, this alternative is based on the actual real-time flows between tariff areas. According to the *Ausspeisungs*-principle, subordinated networks, which have a high decentralized supply in the network and feed energy back into upstream network levels, can receive contributions from these upstream network levels. This creates a shift in the bidirectionality of the cost. The differences between a regional mixed network and an urban

[12] Agora Energiewende- Neue Preismodelle für Energie: Grundlagen einer Reform der Entgelte, Steuern, Abgaben und Umlagen auf Strom und fossile Energietrager, April 2017

BestRES This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

network continue to exist, and urban areas cannot reap the benefits from rural areas with high shares of renewables without paying for it.

In the context of this geographical redistribution, a federal grid charge for TSOs would deal with all customers connected to the transmission network equally, regardless of their geographic location or TSO. Already today, specific costs of the grid operation caused by the integration of decentralized plants for generation from renewables can be transferred nationwide (i.e. the cost of offshore connections). A more far-reaching proposal would be to fully compensate the additional or reduced revenues for the TSOs caused by renewable energy integration costs by a nationwide standardization of the transmission grid charges.

Furthermore, in order to get the support from consumers in grid regions which are disadvantaged by the development of renewable energies, a harmonization of grid charges at the DSO level would also be possible. In this context, all the regulated costs of the DSOs would have to be cumulated and divided by the sum of the individual consumption levels in order to determine network-level and voltage-level grid charges.[13]

Applying the *Ausspeisungs*-principle or introducing federal grid charges would however not support additional optimization from an aggregator’s perspective.

[13] Agora Energiewende- Neue Preismodelle für Energie: Grundlagen einer Reform der Entgelte, Steuern, Abgaben und Umlagen auf Strom und fossile Energietrager, April 2017

BestRES This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement N°691689.

5. Implementation support Next Kraftwerke Germany (Italy)

As described in D4.1 “An assessment of the economics of and barriers for implementation of the improved business models” of the BestRES project, Next Kraftwerke is implementing the “Market renewables on multiple market places” BM in Italy. In this context, the consortium especially analysed the potential of valorising volumes on reserve power markets. Although only pilots related to the new market design for reserve power markets are running at the writing of this document, Next Kraftwerke considers existing barriers manageable for the BM to be implemented in the short term. Since the BM is also economically feasible, it is considered to be ready for implementation.

Nevertheless, for implementing the BM, the availability of renewable energy assets on the Italian market will be a very important aspect. The EU's Renewable energy directive sets a binding target of 20% final energy consumption from renewable sources by 2020 whereas this target is at 17% for Italy. Italy has already achieved this target and there is thus a considerable potential to market renewables on different markets.[14]

For mapping this potential, Next Kraftwerke Italy needs a detailed overview of existing asset owners and investors. The consortium’s support was requested in this context. Especially the following information is very valuable, according to Next Kraftwerke Italy:

1. A summary of the evolution in the solar energy sector
2. Documentation on solar assets and investors in Italy
3. A summary of the evolution in the onshore wind energy sector
4. Documentation on onshore wind assets and investors in Italy

For both solar and onshore wind investors, we will elaborate on the profiles of the principal companies. Our research is however based on publicly available information so some overlaps of information might be found in the data sets below. Furthermore, we will also, if the information is publicly available, indicate if the companies are equally investing in other generation technologies that are relevant for Next Kraftwerke Italy such as biomass and hydro power. Finally, in the sections on the evolution of solar and onshore wind energy, we will elaborate on the subsidies as they are important for understanding the potential of valorising flexibility.

[14] Climateobserver.org, Nine EU countries achieved 2020 renewable energy target, February 2016, Available at: http://climateobserver.org/nine-eu-countries-achieved-2020-renewable-energy-target/

BestRES This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement N°691689.

5.1 Solar Energy

5.1.1 The solar energy sector

On 31 December 2014, there were 648 418 photovoltaic installations in Italy (98.8% of total renewable energy systems) with an installed capacity of 18,609 MW and a total renewable energy installed capacity of 50,594 MW. Compared to the previous year, this was an increase of 2.3% in terms of installed capacity and an increase of 8.7% in terms of the number of photovoltaic systems.[15]

Looking at the installed capacity across different regions (2014), 44% is in the north, 37% in the south and 19% in central Italy. With 2,586 MW of installed capacity, Puglia is the Italian region with the highest installed capacity, equal to 13.9% of the national total, followed by Lombardy with 2,067 MW of installed capacity (11.1%). Regarding the number of systems, 54% is situated in the north, 29% in the south and 17% in the regions of central Italy. The region with the highest number of systems is Lombardy with 94,202 systems (14.5% of the national total), followed by Veneto with 87,794 (13.5%).

Finally, with respect to electricity production from solar PV, in 2014, 22,306 GWh were generated, 3.3% more than the previous year. Since 2008, production has increased approx. 116-fold. The contribution of solar to national electricity production in 2014 amounted to 6.7%.

To support the development of renewable energy assets in Italy, a combination of premium tariffs, feed-in tariffs and tender schemes is used (as also described in D3.1 of the BestRES project).[16] For PV plants, there have been important cuts in feed-in support in recent years. Following article 26 of Law Decree ni 91/2014, the so called “Spalma-Incentivi” Decree, feed-in tariffs (FiT) for PV plants with a capacity above 200 kW had to be reduced. Operators had 3 options to choose from and independent studies showed that each of these 3 options can breach producers banking covenants:[17]

1. Extending the FiT period from 20 to 24 years but with costs to the FiT depending on how long the plant had been operating
2. A reduction of the FiT in a first five-year period, but with a corresponding increase in a second period
3. A 6-8% reduction of the original FiT, depending on the plant’s power, but without extending the FiT period for 24 years. This is a flat reduction that negatively affects producers

---

15 Eniscualo, Renewable energy in Italy, February 2016, Available at: http://www.eniscuola.net/en/2016/02/24/renewable-energy-in-italy/

16 RES-legal, Italy: overall summary, February 2017, Available at: http://www.res-legal.eu/search-by-country/italy/

17 Watson Farley & Williams , Briefing: Italy, Update on the Italian “Spalma Incentivi” Decree, February 2017, Available at: http://www.wfw.com/wp-content/uploads/2017/02/WFW-Briefing-Spalms-Incentivi-February-2017.pdf

BestRES This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement N°691689.

Although it is clear that these changes negatively affect the revenues of generators, on 7 December 2016, the Italian Constitutional Court rejected the appeal filed by four solar energy operators against the Decree, thus backing the tariff cuts in the state incentives scheme that were applied with retroactive effect.[18] Furthermore, On 25 January 2017, in its motivations, the Constitutional Court stated that the Italian legislator has acted in the general public interest, balancing two opposite purposes: the state economic support to the renewable energy sector and the best sustainability of the costs through which such support is granted, borne by the electricity end-users.[19]

5.1.2 Solar Investors

In Italy, as well as in certain other European countries, the falling government support, challenging financial outlook and increasing competition have led to a significant reduction in new utility-scale solar power plants. However, this has also created an active secondary market – with a record level of M&A transactions – and a consolidation trend in this very fragmented industry, where fewer owners hold portfolios of large sizes.[20] Table 2 provides the reader with an overview of the most important investors in solar PV in Italy.

Table 2: Overview of most important investors in solar PV in Italy (based on publicly available information)

Name investor	Portfolio (MW)	Role investor
EF Solare Italia	365	Fund
RTR Energy	334	IPP
Tages Helios	157	Fund
FORVEI	90	Fund
Glennmont	85	Investor
Azienda Solare Italiana	85	Fund
KGAL	63	Investor
Graziella Green Power	60	IPP
VEI Green	60	Investor
Etrion	60	Investor
Gransollar Ghella	58	IPP
Solar Ventures	50	IPP
Solar Investment Group	50	Investor

[18] Latham Watkins, Italian Constitutional Court declares the question of constitutional legitimacy on the “Spalma-Incentivi” Decree ‘groundless’, December 2016, Available at: http://www.latham.london/2016/12/italian-constitutional-court-declares-the-question-of-constitutional-legitimacy-on-the-spalma-incentivi-decree-groundless/
[19] Latham Watkins, Italian Constitutional Court Publishes Grounds of its Decision on the Constitutional Legitimacy of the “Spalma-Incentivi” Decree, February 2017, Available at: http://www.latham.london/2017/02/italian-constitutional-court-publishes-grounds-of-its-decision-on-the-constitutional-legitimacy-of-the-spalma-incentivi-decree/
[20] DBRS, The solar Energy Market in Italy, March 2017, Available at: http://dbrs.com/research/307909/the-solar-energy-market-in-italy-presentation-slides.pdf

BestRES This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement N°691689.

EF Solare Italia (Rome and Milan, Italy)

EF Solare Italia is a joint venture between Enel Green Power and F2i to develop and consolidate the solar PV market in Italy. It is operated by Enel Green Power and the fund currently has 109 plants in 14 different regions across the country as Figure 3 illustrates

Figure 3: Solar PV plants EF Solare Italia in Italy (blue)

F2i, the second partner in the joint venture, has been active since January 2007 with investments in the infrastructure sector. It invests in various sectors that are of strategic relevance for the infrastructural development of the country such as airports, motorways, gas distribution, integrated water services, TLC, renewable energies, local public services and social infrastructure. In the second half of 2012, thanks to the support of leading Italian financial institutions, a second F2i Fund was set up to support modernisation and development projects for the Italian infrastructure system.[21]

RTR Energy (Rome, Italy)

RTR is the leading independent power producer in Italy. Since 2011, the company has grown quickly, thanks to eight acquisitions, and currently has an installed capacity of 334MW solar PV. They have projects in 132 locations across Italy. RTR is an Italian business situated in Rome and Rovereto but is supported by the private equity firm Terra Firma, a long-term investor in asset-rich businesses that require fundamental change, namely transformational private equity, operational real estate and infrastructure. Since 1994, Terra Firma has invested over €16 billion in 34 businesses with an aggregate enterprise value of over €48 billion. Their shareholders are drawn from across the world, with two-thirds based outside Europe.[22]

[21] F2i, Available at: http://www.f2isgr.it/en/
[22] RTR Energy, Available at: http://www.rtrenergy.it/en/
DBRS, The solar Energy Market in Italy, March 2017, Available at: http://dbrs.com/research/307909/the-solar-energy-market-in-italy-presentation-slides.pdf

BestRES This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

Tages Helios (London, United Kingdom)

Tages Helios (Italy-based) is Italy's third largest PV fund. They have a PV plant portfolio compromising 60 plants with a combined capacity of 157 MW. All existing assets were acquired in August 2016 when Tages Helios bough two large portfolios: 9REN (56 MW) and SunReserve (101 MW). The company has an aggregated amount of €250 million. 75% comes from insurance companies, 10% is represented by investments made by pension funds whereas the remaining shares are owned by banks, qualified private investors and the firm's management.[23]

ForVEI (London, United Kingdom)

ForVEI S.r.l. is a joint venture set up by VEI Green and Foresight Group. It was established in 2011 to acquire a portfolio of infrastructure assets in the solar photovoltaic sector in Italy. After a consolidation of the company in March 2016, ForVEI manages 31 plants in Piedmont, Emilia Romagna, Marche, Abruzzo, Campania, Calabria, Puglia, and Sicily (Figure 4).

Figure 4: solar PV plants ForVEI in Italy

The total installed capacity is around 90 MW. An extensive geographic footprint, which covers a large part of the country, allows the company to optimise production and generate 130 GwH per year.[24]

VEI Green, the first partner of the joint venture, was incorporated in 2012 to act as investment platform fully dedicated to the renewables, with an initial capital allocation in excess of €130m. Its shareholders are primary Italian institutional investors. During the last five years, VEI Green has invested both in the wind and solar market and alongside joint venture activities in ForVEI and Whysol Investments now holds interests in operating production facilities for a total installed capacity of more than 200MW. [25]

[23] PV Magazine, Italian solar fund Tages Helios raises another €43 million, June 2017, Available at: https://www.pv-magazine.com/2017/06/20/italian-solar-fund-tages-helios-raises-another-e43-million/

[24] ForVEI, Available at: Forvei.com

[25] VEI Green, Available at: http://www.forvei.com/About-ForVEI/VEI-Green

BestRES This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

Foresight Group, the second partner of the consortium, is a leading independent infrastructure and private equity investment manager which has been managing investment funds on behalf of institutions and retail clients for over 30 years. With its origins in private equity and venture capital, Foresight has diversified its activities and today manages institutional funds principally in European Renewable Energy Infrastructure (Solar, Waste to Energy, Flexible Generation, Storage, Smart Data and PPP), and UK small cap Private Equity.
Foresight has £2.6 billion assets under management. Based in the UK, Foresight also has offices in Italy, the USA and Australia.[26]

Glennmont (London, United Kingdom)

Glennmont Partners is a large European fund manager focusing exclusively on investment in clean energy infrastructure. The company raises long-term capital to invest in alternative power generation projects, such as wind farms, biomass power stations, solar parks and small-scale hydro power plants. Their aggregation strategy is to invest in complementary assets in large markets including the UK, Ireland, France, Portugal and Italy. Since 2007, Glennmont Partners has invested over EUR 1.5bn in 32 clean energy infrastructure projects generating ca. 850 MW in total.[27]

Azienda Solare Italiana (Milan, Italy)

Azienda Solare Italiana "ASI" (formerly Antin Solar Investments) is an Italian solar PV investment platform owned by Quercus Swiss Life Italian Solar Srl, a joint venture between Quercus Assets Selection and Swiss Life Asset Managers. Established in 2011, ASI has built-up a sizeable portfolio of large solar ground-mounted plants totalling 85MW (c. 140 GWh/year production), thus emerging as one of the most prominent players in the Italian PV market. The portfolio consists of eleven plants located in the Lazio, Molise, Apulia and Sicily regions of Italy, which are among the highest irradiation regions in Europe. All plants are fully constructed, connected to the grid and operating as planned since 2011.[28]

KGAL (Munich, Germany)

KGAL Group, an asset manager based in Germany, has been managing real assets since 1968. The company provides investment opportunities for institutional investors in the areas of real estate, aviation and infrastructure. While KGAL Capital is responsible for the placements of funds, KGAL Investment Management combines all the KGAL Group asset categories as the regulated investment management company.

Since 2003, KGAL Group has focused on investments in the renewable energy sector and acquired until now 61 photovoltaic parks and 50 wind farms in

[26] Foreseight Group, Available at: http://www.forvei.com/About-ForVEI/Foresight-Group
[27] Glennmont, Available at: http://www.glennmont.com/news-media/
[28] Azienda Solare Italiana, Available at: http://www.asi-spa.com/

BestRES This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

Germany and abroad with an investment volume of 2.3 billion (12/2015). From KGAL´s perspective onshore wind farms and photovoltaics in Germany, France and Great Britain, as well as parts of Scandinavia, are interesting markets for investors at present.[29]

Graziella Green Power (Rome, Italy)

Graziella Green Power has developed PV systems both on the ground and buildings. Today it is a large photovoltaic company with an installed peak power capacity of about 60 MW spread out over 30 sites in operation (2013), with about 90,000 MWh of total energy produced. Graziella Green Power is also involved in the development of geothermal energy, bioenergy and wind power systems.[30]

VEI Green (Milan, Italy)

VEI Green is an investment company dedicated to the renewable energy sector. The company was set up in 2012 and it is controlled by PFH (palladio Holding). VEI Green acquires and directly manages operating assets in both the solar photovoltaic and wind power sectors. VEI Green operates through the typical mechanics of equity investments, combining financial support with professional skills in a specialised team and proposing a sustainable growth model, both from an environmental and financial perspective.[31]

Etrion (Geneva, Switserland)

Etrion Corporation is an independent power producer (IPP) that develops, builds, owns and operates utility-scale solar power generation plants. The company has 7 operating projects across Italy as Figure 5 shows

Figure 5: Solar PV plants Etrion in Italy

[29] KGAL, Available at: https://www.kgal-investment-management.com/infrastructure.html
[30] Graziella Green Power, Available at: http://www.graziellagreen.it/en/home-page.html
[31] VEI Green, Available at: http://www.veigreen.it/en/index.html
http://www.pfh.eu/en/investments/investments-vehicles/vei-green.html

BestRES This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement N°691689.

Gransolar Ghella (Rome, Italy)

Gransolar Ghella designs, develops and manages photovoltaic parks to produce energy from renewable sources. It is a young company and was created from the collaboration/synergy between Gransolar s.l., a company based in Spain and with a long experience in the photovoltaic sector, and Ghella S.p.A., an Italian company with more than 100 years of experience in the construction sector. Figure 6 provides the reader with an overview of the different assets in Italy.[32]

Figure 6: Solar PV plants Solar Ventures in Italy

Solar Ventures (Milan, Italy)

Solar Venture is an Independent Power Producer (IPP) and developer with focus on development, construction and financing of PV utility scale plants on global basis, with a focus on emerging markets. A portfolio diversification in terms of size and geographic location has been completed with different technologies. Since 2008, Solar Ventures has also focused on the development outside Italy (initially in France (27MWp) and subsequently in the emerging markets as Turkey, Jordan and Thailand where have developed 50 MWp, 60 MWp and 82 MWp respectively).[33]

Solar Investment Group (Milan, Italy)

Solar Investment Group is an independent investment company, founded in 2009, that acquires and manages large solar power plants in Italy. The team has built 50 MWp grid-connected solar plants across Italy and has consequently emerged as a leading solar electricity operator in Italy with a power generation of 72 GWh per annum. They have directly invested in renewable energy project in 12 countries worldwide.[34]

[32] Gransolar Ghella, Available at: http://www.gransolarghella.com/en/profile/about-us/
[33] Solar ventures, Available at: http://solarventures.it/en/about-us/
[34] Solar Investment Group, Available at: http://www.solarinvestmentgroup.it/what.html

BestRES This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

5.2 Onshore wind

5.2.1 The onshore wind energy sector

At the end of the year 2014, more than 1,847 wind turbines combining an installed capacity of 8,703 MW were installed across Italy. 80% of these projects are smale-scale projects with a capacity of less than 1 MW whereas 91% of the installed capacity (7,933 MW) is concentrated in 262 wind farms with capacity exceeding 10 MW. In 2014, with an installed capacity of 8,703 MW, onshore wind projects were representing 17% of the entire installed base of renewable systems.

Moreover, wind conditions, topography and site accessibility are a lot more favourable in Southern Italy compared to other parts of the country. By consequence, 96% in terms of installed capacity and 83% in terms of the number of systems are installed in Southern regions. Puglia has the highest installed power (2,339 MW, accounting for 26.9% of the national total), followed by Sicily and Campania, with respectively 1,750 MW (20.1%) and 1,250 MW (14.4%) of installed capacity. 15,178GWh was generated in 2014, an increase of 1.9compared to 2013. The contribution of wind power to national electricity production in 2014 amounted to 4.7%.[35]

For wind projects larger than 0.5 MW, there are several alternative subsidy systems. For wind farms entered into operation before 31st December 2012, operators could choose between a feed-in tariff and a feed-in premium. For plants entered into operation after 1st January 2013, auctions (for feed-in premiums) are organised for projects above 5 MW.[36]

5.2.2 Wind investors

Table 3 provides an overview of the most important investors in onshore wind energy in Italy that the consortium identified based on publicly available information.

[35] Eniscualo, Renewable energy in Italy, February 2016, Available at: http://www.eniscuola.net/en/2016/02/24/renewable-energy-in-italy/
[36] RES-legal, Italy: overall summary, February 2017, Available at: http://www.res-legal.eu/search-by-country/italy
Greentech Energy Systems, Italy, Available at: http://greentech.dk/country/

BestRES This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

Table 3: Overview of most important investors in onshore wind in Italy (based on available information

Name investor	Portfolio (MW)	Role investor
ERG	1094	IPP
Enel Green Power	728	IPP/utility
E2i	600	Fund
Fri El Green Power	481	IPP
EDF-EN	384	IPP
Edison	342	IPP/utility
Glennmont	335	Investor
Falck renewables	299	IPP
E.On	297	IPP/utility
Alerion	270	Investor
CEF 3 Wind Energy	245	Fund
Alpiq	194	IPP
Acciona	156	IPP
EDPR	144	IPP

ERG (Genoa, Italy)

With a market share of 12% (at the end of 2015), ERG is Italy's leading wind energy producer. It is a publicly listed Italian energy company, founded in 1938. Figure 7 provides the reader with an overview of the different assets in Italy.

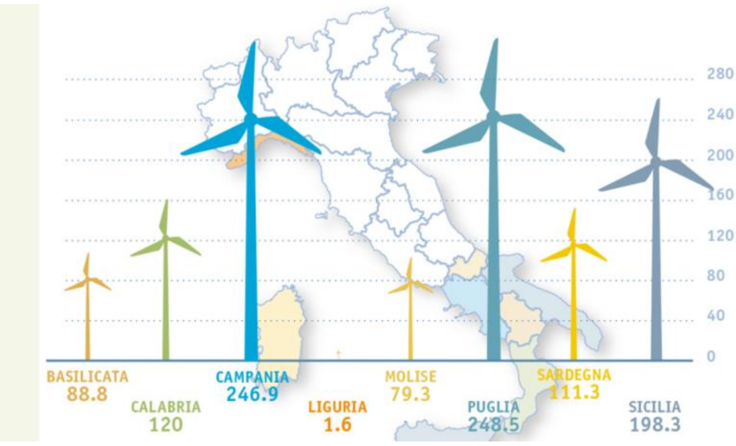


Figure 7: Onshore wind energy plants ERG in Italy

ERG is equally present with 252 MW in France, 168 MW in Germany, in Romania (70 MW), Bulgaria (54 MW) and 82 MW wind farms in Poland.[37]

[37] ERG, Available at: http://www.erg.eu/en/our-energy/wind/our-wind-farms/italy and http://www.erg.eu/home

BestRES This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

Enel Green Power (Rome, Italy)

Enel Green Power S.p.A. is a large renewable energy company, headquartered in Rome. It was created as a subsidiary of the power generation firm in December 2008, grouping its global renewable energy interests. In 2016 it was absorbed back into the general Enel Power company. Enel Green Power had operations in over 16 countries across Europe, North America and South America.[38]

E2i (Milano, Italy)

E2i Energie Speciali was created by 3 partners (F2i, Edison, and EDF EN) who decided to leverage their skills to develop renewable energy projects. With about 600 MW of installed capacity, E2i is the third national operator in the sector. The joint venture between the three partners has allowed for the development of an advanced business model: E2i entrusts energy management and optimization activities to EDF EN, the management and marketing of energy produced and the development of new initiatives to Edison, while F2i manages all financial aspects.[39]

Fri El Green Power (Rome, Italy)

FRI El Green Power is one of the leading companies in the green energy sector in Italy. They develop a wide portfolio of projects, managing every stage from research and planning to the production and sale of electricity. The company invests in a mix of different renewable energy technologies such as wind, biomass and biogas. Thanks to important partners such as the French EDF and the German RWE Innogy, the company is among the first wind energy producers in Italy. Generating electrical energy from wind is currently the main activity of the group. FRI-EL Green Power has currently 21 functioning wind farms, resulting in a total installed capacity of 482 MW. The plan is to increase market share in Italy through an important investment program.[40]

EDF-EN (Paris, France)

EDF Energies Nouvelles is a leader in the production of renewable electricity. The company develops, builds and operates green power plants in 21 countries, for its own account and for third parties.

Edison (Milan, Italy)

Edison is Europe's oldest energy company, and one of the industry leaders in Italy and Europe. They currently operate assets in 10 countries around the world and is part of the French EDF group. Edison is listed on the Italian Stock Exchange and is the second biggest energy producer in both Italy and Greece. With 18.5 TWh of electricity produced in 2015, they cover 6.8% of the power generation market in Italy.[41]

---

[38] Enel Green Power, Available at: https://www.enelgreenpower.com
[39] E2i, Available at: http://www.e2ienergiespeciali.it/
[40] Fri El Green Power, Available at: http://www.fri-el.it/en
[41] Edison, Available at: http://www.edison.it/en

BestRES This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

Glennmont (London, United Kingdom)

A description of the company can be found in section 4.2.5 of this document

Falck Renewables (Milano, Italy)

Falck Renewables is listed on the Italian stock and develops, designs, builds and manages power production plants for wind energy, solar energy, biomass energy, and waste-to-energy. The company is currently present in several countries across Europe (Italy, UK, France and Spain) with a total installed capacity of 858 MW in 2016

The expertise of Falck Renewables covers the entire lifecycle of a project, from preliminary activities up to operation and maintenance and energy portfolio management activities. In addition to the abovementioned activities, Falck Renewables – through the Vector Cuatro Group – provides management services for solar and wind farms in operation.[42]

E.On (Essen, Germany)

E.ON is an international, privately-owned energy supplier. They are focused on renewables, energy networks and customer solutions. On 1st January 2016, their conventional generation and energy trading businesses were combined into a separate company. Uniper has been independently listed since 12th September 2016.[43]

Alerion (Milan, Italy)

Alerion Clean Power is an industrial group listed on the Milan Stock Exchange, specializing in the production of electricity from renewable sources, particularly in the wind sector.[44]

CEF 3 Wind Energy (Genoa, Italy)

CEF 3 Wind Energy S.P.A. owns and operates wind farms that generates electricity through wind energy. The 245 MW of assets CEF 3 Wind Energy owns were bought from the Spanish company Iberdrola in 2016. [45]

Alpiq (Lausanne, Switzerland)

Alpiq is one of the leading energy companies in Switzerland active in the fields of energy trading and energy sales. As an independent energy services company, they serve medium-sized companies, large concerns and public institutions. Their customer base includes energy suppliers, local authorities, industrial

[42] Falck Renewables, Available at: https://www.falckrenewables.eu/?sc_lang=en
[43] EON, Available at: https://www.eon.com/en/about-us/profile.html
[44] Alerion Wind Power, Available at: http://www.alerion.it/technology/wind-power/?lang=en
[45] Iberdrola, Iberdrola announces sale of wind assets in Italy for €193.7 million, June 2016, Available at: https://www.iberdrola.com/press-room/news/detail/iberdrola-vende-activos-eolicos-en-italia-por-un-importe-de-193-7-millones-de-euros-4303022020160615

BestRES This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

corporations and a broad range of institutional and private investors. They operate power stations in Switzerland and abroad in Europe. Figure 8 provides the reader with an overview of the existing onshore wind energy projects of Alpiq in Italy.[46]

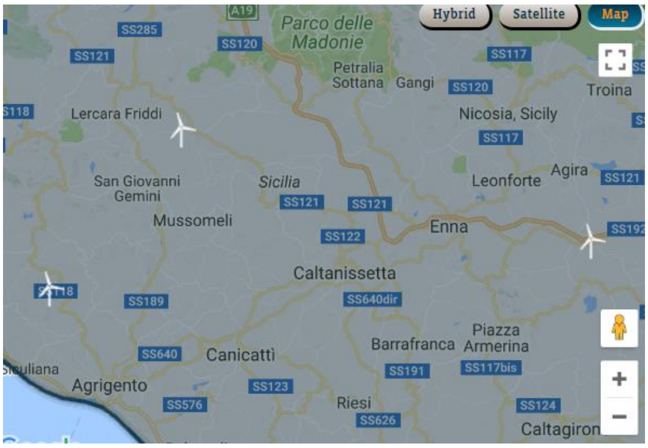


Figure 8: Onshore wind projects Alpiq in Italy

Acciona (Madrid, Spain)

ACCIONA Energy, the Energy Division of the ACCIONA Group, is a world leader in the field of renewable energies. The company develops projects for itself and puts its experience at the service of third-party customers through EPC contracts –particularly in wind and photovoltaic power– and other types of partnership.[47]

EDPR (Madrid, Spain)

EDPR has developed wind farms since 1996 and was first publicly listed in June 2008. EDPR Europe, headquartered in Madrid, manages assets located in the European Union. Energias de Portugal, S.A. ("EDP"), a vertically-integrated utility company, headquartered in Lisbon, Portugal, is the majority shareholder of EDPR. EDP Group is Portugal´s largest industrial group and one of Europe´s primary energy companies. Currently, it is the Iberian Peninsula´s third largest energy operator with business interests in generation, distribution and supply of electricity and gas in Portugal and Spain. EDPR's business consists of developing, building and operating top quality wind farms and solar plants throughout the world. EDPR entered the Italian market in 2010 through the acquisition of a portfolio of wind farm projects under development in the south of the country. EDPR's Italian headquarter is in Milan and a second office in Bari plays an important logistical role in the management of the portfolio in the Apulia region and surrounding areas. EDPR continues to expand its presence in Italy.[48]

---

[46] Alpiq, Available at: http://www.alpiq.com/alpiq-group/our-assets/wind-power-plants/wind-power-plants.jsp
[47] Acciona, Available at: https://www.acciona.com/about-acciona/
[48] EDPR, Available at: http://www.edpr.com/our-company/who-we-are/ and http://www.edpr.com/our-business/our-markets/italy/

BestRES This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

6. Implementation support Next Kraftwerke Belgium (Belgium)

As described in D4.1 of the BestRES project, both improved BMs, “Trading PV and wind power” and “Using flexibility of customers as third party” are ready for implementation and placed in group 1 as defined above.

To be able to gather a sufficiently large portfolio for the implementation of the improved BMs, this report provides Next Kraftwerke with clarifications about the operation of the mechanisms of green and CHP certificates in the regions of Flanders and Wallonia in Belgium (Belgium has regional support systems for renewable energy). This system is based on quota obligations and tradable certificates. A further explication of the system will follow in the sections below.

As described in D3.1 of the BestRES project, this subsidy scheme highly impacts the valorisation of flexibility as curtailment of generators will only happen when negative wholesale or activation prices for reserve power are lower than the negative value of green certificates and opportunity costs of lost green certificates can be recovered. Furthermore, the certificate value is an important element of most PPAs and the value of certificates for 1 MWh produced in general largely exceeds the overall value of the electricity price for 1 MWh.

In particular, the following information is valuable to Next Kraftwerke Belgium:
1. Documentation on the operation of the certificate systems
2. Documentation on the markets and market players for certificates
3. High-level documentation on Power Purchase Agreements (PPAs) and the pricing of green and CHP certificates

The consortium will elaborate on these 3 topics in the document below with a focus on Flanders and Wallonia as activities of Next Kraftwerke in the Brussels region will be very limited in the first years.

Generators will also receive Guarantees of Origin (GoOs), European certificates proving that one MWh of electricity was produced using renewable energy sources[49], for each MWh produced that can be included in PPAs and are important for Next Kraftwerke as an energy supplier. The value of such certificates is however relatively low (less than EUR 0.50/MWh) and will therefore not be the subject of this analysis.

6.1 The operation of certificate systems in Belgium

In Belgium, all electricity from renewable sources is promoted through a quota system based on the trade of certificates. One the one hand, generators receive

[49] EEX, ...EU guideline 2009/28/EC on trading of Guarantees of Origin, Available at: https://www.eex.com/en/goo

BestRES This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement N°691689.

certificates for producing renewable energy. The number of certificates a generator receives for each MWh of production will be different for each technology and project size and will also vary between Flanders and Wallonia. Consequently, if the market price of green certificates is assumed to be at the minimum support value (EUR 93/certificate in Flanders and EUR 65/certificate in Wallonia as explained in section 4.1.2), the remuneration in EUR a generator receives for each MWh of production will diverge for each technology and project size. On the other hand, energy suppliers periodically need to submit certificates to regulators based on quota and the MWh of electricity they supply to clients (a quota of 30% means that for every 100 MWh of electricity supplied to end consumers, the supplier needs to submit 30 certificates). Through certificates, support for all technologies is governed at the regional levels (Flanders, Wallonia, and Brussels) apart from the support for offshore wind power, PV installations that were operating before 1 August 2012 and hydro power. Those technologies are governed at the national level.[50] Certificates can be traded on dedicated markets where energy suppliers buy certificates as they must present green certificates to meet legal requirements.[51]

6.1.1 Federal and regional support systems

If support is managed at the federal level, Elia (the Transmission system operator (TSO)), is required to buy back green certificates from generators of renewable energy in Belgium if those generators request this (there is no market or quota system for certificates on the federal level). This federal support mechanism is valid for 20 years after the facility is commissioned, and green certificates are issued by CREG (Commission for Electricity and Gas Regulation), VREG (Flemish Electricity and Gas Regulatory Body), CWaPE (Wallonia Energy Commission) and BRUGEL (Brussels Energy Regulatory Body).[52]

In Flanders, grid operators (including Elia) must buy green certificates from generators connected to their grid or to closed distribution systems connected to their grid, if the generator requests this. If the generator does not request this, he can also sell the green certificates to another market actor (see further below). Minimum support and duration of support will be different depending on the energy source and generation technology used. For new solar and wind projects, support is awarded for 15 years and certificates are valid for 10 years. Support is also updated every year based on revenues from electricity of the

[50] RESLegal, Belgium: overall summary, Available at: http://www.res-legal.eu/search-by-country/belgium/

[51] Deloitte, European energy market reform, Country profile: Belgium, March 2015, Available at: https://www2.deloitte.com/content/dam/Deloitte/fr/Documents/energie-et-ressources/Publications/deloitte_BE_Energy-market-reform-in%20Europe_mars-2015.pdf

[52] Elia, minimum price and legal frame, Available at: http://www.elia.be/nl/producten-en-diensten/groenestroomcertificaten/Minimumprice-legalframe
Immospector, Elektriciteitsprijs verrekend in groenestroomcertificaten voor windenergie op zee, June 2014, Available at:
http://www.immospector.be/newsview.aspx?contentdomains=IMMORES&id=kl1783440&lang=nl

BestRES This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

project. Furthermore, Flanders has an ecological premium and a net-metering scheme in place and electricity is given priority in both connection to and use of the grid. If a generator is willing to receive green/CHP certificates, he needs to request green certificates at the Flemish Energy Agency (VEA). In a next step, the certificates are awarded or not awarded by the VREG (Flemish Electricity and Gas Regulatory Body).[53]

In Wallonia, generators can sell to Elia, being the operator of the local transmission system, at a guaranteed minimum price (for a period of 10 or 15 years). If the generator does not request this, he can also sell the green certificates to another market actor (see further below). Minimum support and duration of support will be based on the economic coefficient kECO and a parameter Kco2 for taking into account emissions. For new wind and solar project, support will be awarded for 10 years and awarded certificates are valid for 5 years. Also, a correction factor Rho exist for following up the evolution of the electricity price (ENDEX) for hydro, PV and wind projects. The Walloon region also provides support such as investment assistance for companies or for public bodies and net-metering. If a generator is willing to receive green certificates for a new project or is willing to significantly modify a project, he must reserve green certificates on beforehand in an envelope that is fixed per sector. In this context, the administration has 45 days to verify if a request for green certificates enters in an envelope. If the reservation is awarded, the generation asset needs to be certified by an approved organisation who applies on behalf of the generator for green certificates and labels of origin at the Cwape (Wallonia Energy Commission). In a last step, the Cwape takes a decision within 30 days.[54]

[53] Elia, minimum price and legal frame, Available at: http://www.elia.be/nl/producten-en-diensten/groenestroomcertificaten/Minimumprice-legalframe
RESLegal, Belgium: overall summary, Available at: http://www.res-legal.eu/search-by-country/belgium/
VREG, Groenestroomcertificaten, Available at: http://www.vreg.be/nl/groenestroomcertificaten
Vlaams Energieagentschap (VEA), Rapport 2017, Deel 1: Rapport OT/Bf voor projecten met een startdatum vanaf 1 januari 2018, August 2017
Vlaams Energieagentschap (VEA), Rapport 2017, Deel 2: Actualisaties OT/Bf, June 2017, Available at: https://www.energiesparen.be/sites/default/files/atoms/files/201706Rapport_VEA_2017-Deel2-ActualisatiesBfcat2.pdf
VREG, Groenestroomcertificaten, Aanvaardbaarheid van groenestroomcertificaten, Available at: http://www.vreg.be/nl/groenestroomcertificaten#sect3

[54] Elia, minimum price and legal frame, Available at: http://www.elia.be/nl/producten-en-diensten/groenestroomcertificaten/Minimumprice-legalframe
RESLegal, Belgium: overall summary, Available at: http://www.res-legal.eu/search-by-country/belgium/
Certificats verts, la réservation, Available at: https://energie.wallonie.be/fr/la-reservation.html?IDC=9212

BestRES This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement N°691689.

Figure 9 provides an overview of the latest publication on the state of the envelopes for different technologies in Wallonia.

	Nombre initial de CV	Nombre de dossiers réservés	Nombre de CV réservés	Nombre de dossiers en examen	Nombre de CV en examen	Nombre de CV restants dans l'enveloppe	Nombre de dossiers en attente
Panneaux photovoltaïques d'une puissance supérieure à 10 kW	52000 (100%)	164	51917 (99.99%)	10	4381 (8%)	(-4298) en attente ouverture inter-filière	0
Eoliennes toutes puissances	298832	3	92612	3	250	205970	0
Hydroélectricité toutes puissances	16000	17	1309	0	0	14691	0
Biogaz toutes puissances	87200	2	14762	0	0	72438	0
Biomasse solide et liquide toutes puissances	140250	0	0	0	0	140250	0
Cogénération fossile toutes puissances	15880	4	2472	0	0	13408	0
Total	610162	190	163072	10	4381	442459	0

Figure 9: State of the envelopes for green certificates in 2017 on 21 June 2017 [55]

6.1.2 Supplier quota and fines in Flanders and Wallonia

In both Flanders and Wallonia, there is a high surplus of green certificates because the supply of green certificates by generators has been a lot higher than demand by energy suppliers (via the quota obligation) since the system was launched. At the writing of this document, the cumulative surplus is around 6 Mio in Flanders and around 2 Mio in Wallonia but in the mid-term (2020), the cumulative surplus is expected to be around 2 Mio in both Flanders (blue line left part in figure 3) and Wallonia (black line right part figure 2) as Figure 10 illustrates.

Cwape, Communication, coefficients économiques kECO applicables pour les différentes filières de production d'électricité verte à partir du 1er janvier 2015', October 2014, Available at : http://www.cwape.be/?lg=1&dir=3&title=Producteurs
Cwape, Rapport annuel spécifique 2015, L'évolution du marché des certificats verts, 2015
Cwape, Solaire PV > 10 kW, Nouveaux régimes d'octroi de certificats verts, July 2014
Cwape, Information importante sur la péremption des certificats verts anticipés, June 2015, Available at: http://www.cwape.be/?dir=6&news=457
[55] Etat de l'enveloppe, June 2017, Available at: https://energie.wallonie.be/fr/etat-de-l-enveloppe.html?IDC=9201

BestRES This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

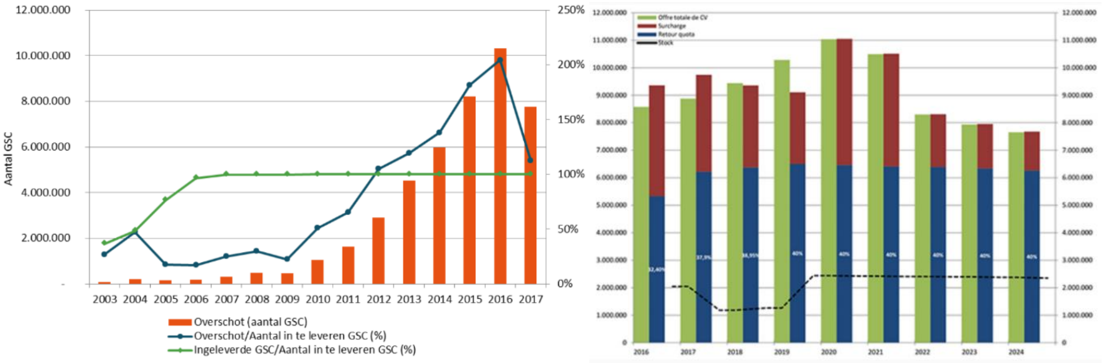


Figure 10: Estimation existing surplus green certificates in Flanders and Wallonia and expected surplus in Wallonia[56]

*Overschot=surplus *Stock= surplus

If we look at the evolution of CHP certificates (Flanders), we see a similar cumulative surplus of certificates as Figure 11 displays.

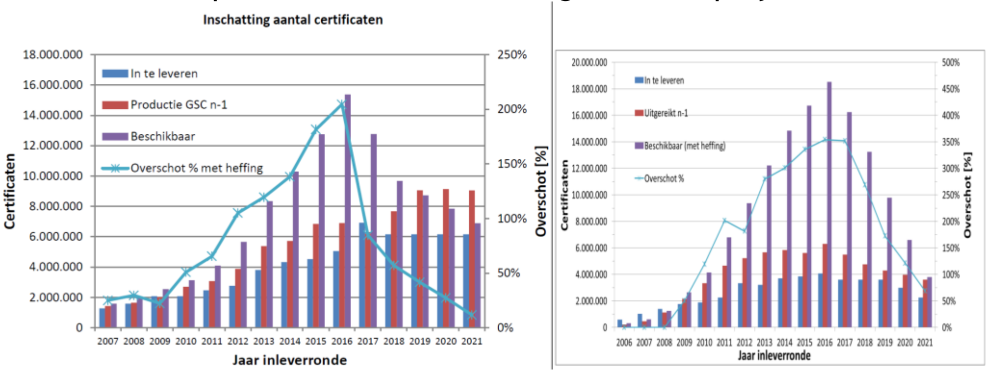


Figure 11: Estimation expected surplus green and CHP certificates in Flanders

*Overschot= surplus

For CHP, the surplus is around 14 Mio and is equally expected to go down to around 2 Mio by 2021.

This surplus of both green and CHP certificates is expected to go down because less certificates are being awarded to generators (as renewable energy technologies are becoming less expensive), as explained in the next section, and the quota obligation of electricity suppliers remains high in the coming years.

---

[56] VREG, Certificatenrapport 2016, August 2017, Available at: http://www.vreg.be/sites/default/files/document/rapp-2017-08.pdf
Vlaams Energieagentschap (VEA), Rapport 2016, Deel 3: Evaluatie quotumpad en productiedoelstellingen, June 2016, Available at: http://www2.vlaanderen.be/economie/energiesparen/milieuvriendelijke/monitoring_evaluatie/2016/20160630-RapportVEA2016-Deel3-Evaluatie.pdf
Tinlot, Panneaux photovoltaïques, le point sur l'évolution des certificats verts, Available at : http://tinlot.blogs.sudinfo.be/archive/2016/09/11/panneaux-photovoltaique-le-point-sur-l-evolution-des-certifi-200840.html

BestRES This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

In both Flanders and Wallonia, energy suppliers need to submit certificates corresponding to a number of MWh delivered to clients multiplied by the quota. In Flanders, this happens on an annual basis whereas in Wallonia it happens on a quarterly basis. In 2017, the quota for green certificates is 23% in Flanders and 34.03% in Wallonia (a quota of 23% means that for every 100 MWh of electricity supplied to end consumers, the supplier needs to submit 23 certificates). For CHP certificates (Flanders), the quota is 11.2% in 2017. Table 4 illustrates the evolution of quota in the first 5 years.

Table 4: Evolution quota certificates in Flanders and Wallonia[57]

Quota	Green certificates Flanders	Green certificates Wallonia	CHP certificates Flanders
2017	23.0%	34.03%	11.2%
2018	20.5%	35.65%	11.2%
2019	20.5%	37.28%	11.2%
2020	20.5%	37.90%	9.3%
2021	20.5%	34.03%	7.0%

In Flanders, the VEA (Flemish Energy Agency) sends an evaluation of the quotas and production of renewable energy to the Flemish government if 1) the number of available certificates is lower than 105% or more than 125% of the number of certificates to be submitted by energy suppliers (in March every year), or 2) if the relation awarded valid certificates to the gross production of renewable energy deviates more than 5% compared to the last evaluation, or 3) if the measured production per renewable energy source deviates more than 10% from the sub target set by the government for that renewable energy source. Based on this evaluation, the Flemish government can propose to increase the quota in certain cases.[58] In Wallonia, quotas are continually fixed for a period of 8 years. Every trimester, the Cwape evaluates the evolution of the offer and demand of certificates with a report. This report is sent to the minister the latest 30 days after the end of the trimester. In case there is an imbalance between the offer and demand, the Cwape will propose a modification of the quota in this report. These quotas can however not exceed 37.9% for the period 2017-2024. Finally, it is important to emphasize that large companies in both Flanders and Wallonia (who have signed an agreement to increase energy efficiency), are entitled to have important reductions on the quota.[59]

[57] Cwape, Rapport annuel spécifique 2015, L'évolution du marché des certificats verts, 2015
Cwape, Quota de CV en Région wallonne, Available at : http://www.cwape.be/?dir=3.4.02
VREG, Mededeling van de Vlaamse Regulator van de Elektriciteits- en Gasmarkt met betrekking tot de quotumberekening en indieningsprocedure, December 2016, Available at: http://www.vreg.be/sites/default/files/document/mede-2016-01_.pdf
[58] Flemish government, Energy policies 7.1.1 and 7.1.10, Available at: http://www.vreg.be/nl/groenestroomcertificaten#sect2 and https://codex.vlaanderen.be/Zoeken/Document.aspx?DID=1018092&param=inhoud
[59] Cwape, Rapport annuel spécifique 2015, L'évolution du marché des certificats verts, 2015
VREG, Mededeling van de Vlaamse Regulator van de Elektriciteits- en Gasmarkt met betrekking tot de quotumberekening en indieningsprocedure, December 2016, Available at: http://www.vreg.be/sites/default/files/document/mede-2016-01_.pdf

BestRES This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

For submitting certificates to regulators so that those certificates can be liquidated, energy suppliers need to set up an account on a platform in each of the regions. If energy suppliers do not comply with the quota obligations and return insufficient certificates (annually in Flanders and quarterly in Wallonia), they must pay fines to respectively Cwape and VREG for each certificate that is missing (Table 5).

Table 5: Evolution fines certificate systems last 5 years Flanders and Wallonia[60]

Green certificates Flanders	Green certificates Wallonia	CHP certificates Flanders
Until 31/03/2012: 125 EUR/certificate	100 EUR/certificate	Until 31/03/2012: 45 EUR/certificate
31/03/2013: 118 EUR/certificate		31/03/2013-31/03/2015: 41 EUR/certificate
After 31/03/2013: 100 EUR/certificate		After 31/03/2015: 38 EUR/certificate

6.1.3 Amount of support in Flanders and Wallonia

As explained before, the number of certificates a generator receives for each MWh (certificates/MWh) of production will be different for each technology and project size and will also vary between Flanders and Wallonia. Consequently, based on a market price in EUR/certificates (which is independent of the technology), the remuneration in EUR/MWh a generator receives for each MWh of production will diverge for each technology and project size in both regions. Table 6 provides the reader with an overview of the estimated support for PV, onshore wind, biomass and CHP.[61]

[60] Cwape, Quota de CV en Région wallonne, Available at: http://www.cwape.be/?dir=3.4.02
IBAM, Les quatre mécanismes de certificats verts en Belgique, 2007, Available at : http://www.cstc.be/homepage/download.cfm?dtype=vision2030&doc=Ait_Hassou.pdf&lang=fr
VREG, Warmte-krachtcertificaten, Available at: http://www.vreg.be/nl/warmte-krachtcertificaten
VREG, Groenestroomcertificaten, Available at: http://www.vreg.be/nl/groenestroomcertificaten

[61] Vlaams Energieagentschap (VEA), Rapport 2017, Deel 1: Rapport OT/Bf voor projecten met een startdatum vanaf 1 januari 2018, August 2018
Cwape, Communication, coefficients économiques kECO applicables pour la filière photovoltaïque de plus de 10 kW pour la période du 1er juillet au 31 décembre 2017', March 2017

BestRES This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

Table 6: Support for renewable energy technologies in Flanders and Wallonia [62]

Support*	Flanders	Wallonia
Onshore wind	> 10 KWE and <= 4 MWE: 58.5 EUR/MWh	65 EUR/MWh
PV	> 10 KVA and <= 250 KVA: 45 EUR/MWh	> 10 KVA and <= 250 KVA: 99 EUR/MWh
	> 250 KVA and <= 500 KVA: 41 EUR/MWh	> 250 KVA and <= 500 KVA: 77 EUR/MWh
	> 500 KVA and <= 750 KVA: 41 EUR/MWh	> 500 KVA and <= 750 KVA: 66 EUR/MWh
	> 750 KVA and <= 1000 KVA: project specific support	> 750 KVA and <= 1000 KVA: 59 EUR/MWh
Biomass	93 EUR/MWh	<162.5 EUR/MWh depending on characteristics project
CHP	High differences between different categories	High differences between different categories

* Support is very different in Wallonia and Flanders as support is awarded for 15 years in Flanders and only for 10 years in Wallonia (for PV and wind)

For the calculations in Table 6, we assumed that a generator sells certificates at minimum support level to grid operators. This is a valid assumption since many generators sell to these grid operators and other market transactions mostly happen at prices very close to the minimum support level due to oversupply (see further). At the writing of this document, minimum support is EUR 93 per green certificate and EUR 31 per CHP certificate in Flanders whereas EUR 65 per green certificate in Wallonia. It is important to highlight that these prices are independent of the technology. The remuneration per MWh of production is only different because the number of certificates per MWH of production is different for each technology and each project size.[63]

6.2 The markets for certificates in Belgium

As previously indicated in this report, generators can sell the certificates they are awarded to grid operators at minimum support level or they can sell them to other market actors. Recent figures (Table 7) show that, in both Flanders and Wallonia, the clear majority of these installations are PV, onshore wind and biomass projects.

[62] We assume that generators sell certificates at minimum support to grid operators
[63] VREG, Bedrag Minimumsteun vanaf 2013, Available at: http://www.vreg.be/nl/bedrag-minimumsteun-vanaf-2013
VREG, Minimumsteun certificaten, Available at: http://www.vreg.be/nl/minimumsteun-certificaten
Elia, prix minimum imposé et cadre légal, Available at : http://www.elia.be/fr/produits-et-services/certificats-verts/Minimumprice-legalframe

BestRES This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

Table 7: Granted green certificates for different renewable energy technologies in Flanders and Wallonia [64]

	Flanders (cumulative at the end of 2016)	Wallonia (cumulative at the end of 2015)
Cumulative installed kWe onshore wind	22.70%	18%
Cumulative installed kWe PV	33.94%	59%
Cumulative installed kWe biomass	32.11%	19%
Others	11.25%	4%
TOTAL	**100%**	**100%**

For CHP, the large majority of the CHP certificates are awarded to internal combustion engines and gas turbines with heat recovery.

6.2.1 Market prices and actors

Figure 12 summarizes the evolution of prices of green and CHP certificates In Flanders over the last 3 years.

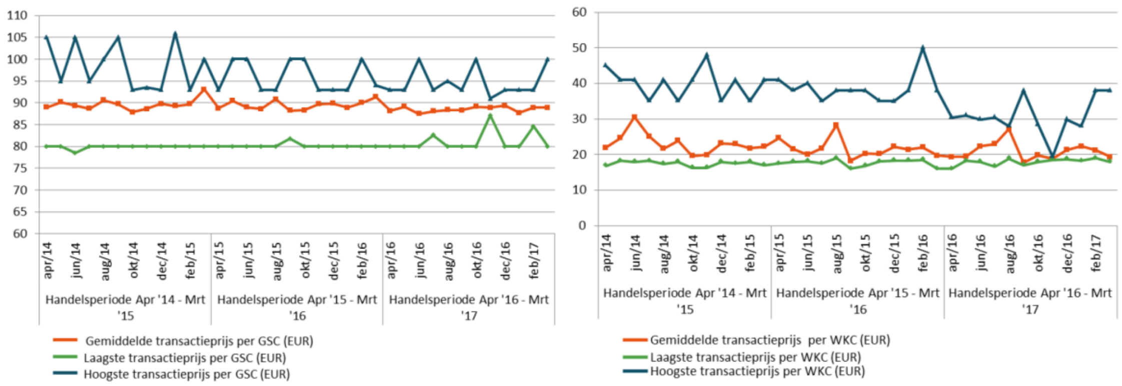


Figure 12: Evolution prices in EUR/certificate green (left figure) and CHP (right figure) certificates over the period 2014-2017

Figure 12 demonstrates that the average transaction price over the period april 2016-March 2017 was 88.46 EUR/certificate (a decrease compared to 90.40 EUR/certificate over the period April 2015-March 2016) whereas the lowest price equals 80 EUR/MWh (EUR/MWh was the minimum support level before 2010 and some PPAs are therefore at this price). This price below the minimum support level might be explained by the fact that buyers of green certificates need to finance the period between buying the certificate from the generator and receiving the compensation from selling to another buyer. If generators directly sell to grid operators, there are important delays in payments of the green certificates: 120 days in Wallonia 120 days and 6 weeks in Flanders (D4.1 of the BestRES project). As previously indicated, a seller of green certificates (generator) can sell to grid operators or to other market actors on the bilateral market. An actor who needs to buy green certificates, always also has 2

[64] VREG, Certificatenrapport 2016, Augustus 2017, Available at: http://www.vreg.be/sites/default/files/document/rapp-2017-08.pdf
Cwape, Rapport annuel spécifique 2015, L'évolution du marché des certificats verts, 2015

BestRES This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

possibilities: participating in an auction organised by the grid operators (Infrax, Eandis or Elia) or buying the certificates on the bilateral market. Information on such auctions can for example be found on the website of Elia.[65] Around half of the awarded green certificates in 2016 were sold to the grid operators whereas the other half was sold through bilateral trading between market actors. Figure 13 shows the high price spread of the certificates that are sold by generators to grid operators at minimum level.

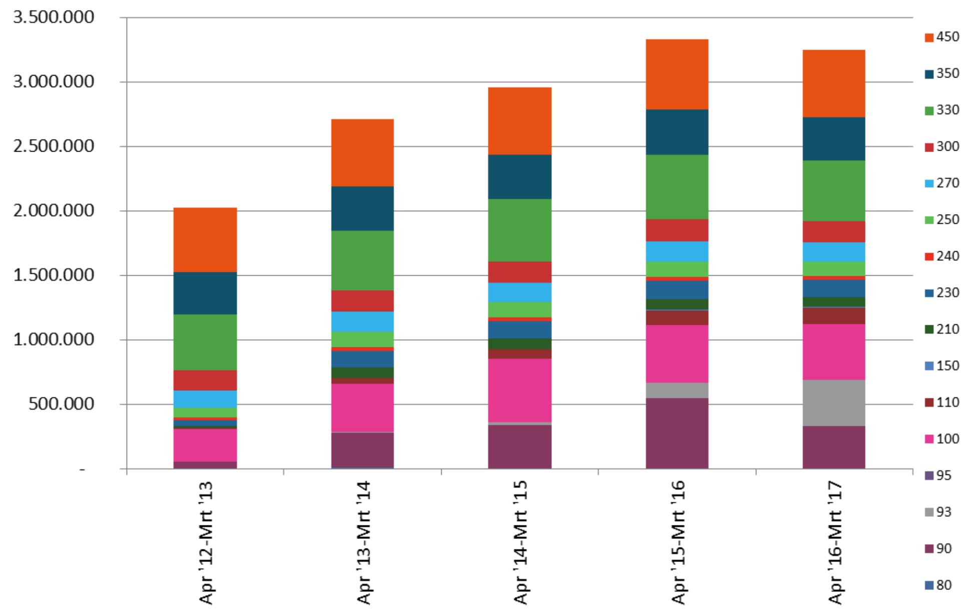


Figure 13: Number of green certificates sold at minimum support level in Flanders over the last 5 years[66]

Other publicly available information furthermore indicates that buying certificates from grid operators has become, in recent years, a lot more important compared to the bilateral transaction as the number of market actors buying green certificates from grid operators has risen from 7 in 2013 to 30 in 2017. It can be expected that the share of certificates sold by grid operators compared to the total number of green certificates will stay important because of the large surplus of certificates. Because of these evolutions, there is pressure on grid operators to sell at low prices but they also need to cover for the costs so minimum prices (grid operators are not allowed to sell under this price to market actors when they organise the auctions) are increasingly observed in the last few years.[67]

[65] Elia, Vente de certificats par Elia, Available at: http://www.elia.be/fr/produits-et-services/certificats-verts/Sale
[66] VREG, Certificatenrapport 2016, August 2017, Available at: http://www.vreg.be/sites/default/files/document/rapp-2017-08.pdf
[67] VREG, Certificatenrapport 2016, August 2017, Available at: http://www.vreg.be/sites/default/files/document/rapp-2017-08.pdf

BestRES This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

Finally, public information indicates that, as could be expected, most potential buyers of green and CHP certificates are energy suppliers and traders. However, also some large industrial companies are registered to trade these certificates.[68]

Looking at price evolutions in Wallonia, Figure 14 summarizes the evolution over the last 3 years.

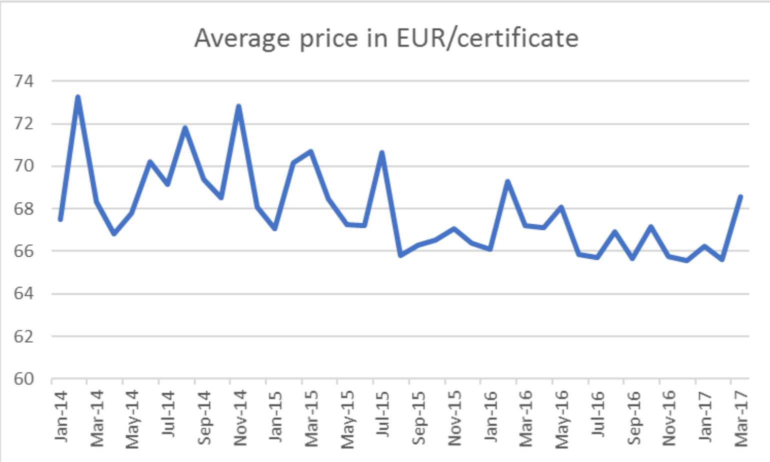


Figure 14: Evolution prices green certificates over the period 2014-2017 in Wallonia[69]

The average price for the year 2016 was 66.7 EUR/certificate being a decrease compared to 2015 with an average price of 67.8 EUR/certificate. We observe that this price is higher than the minimum support level (in Flanders the average price is lower than the minimum support level) and might be explained by the fact that the surplus of green certificates in Wallonia is significantly lower than in Flanders. Around half of the sold certificates in Wallonia in 2013, 2014 and 2015 were certificates sold to Elia at minimum support (EUR 64/MWh). The large majority of these certificates (3598000 out of 4256000 certificates or 85%) were certificates awarded to SOLWATT generators (small-scale PV systems).

Figure 15 also demonstrates the variability of the prices of green certificates over the period 2011-2015 (for installation larger than 10 kW) in Wallonia.

[68] VREG, Lijst potentiële kopers van groenestroomcertificaten, Available at: http://www.vreg.be/sites/default/files/uploads/lijst_potentiele_kopers_van_groenestroomcertificaten.pdf
[69] Cwape, Statistiques prix, Available at : http://www.cwape.be/?dir=3.4.11

BestRES This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

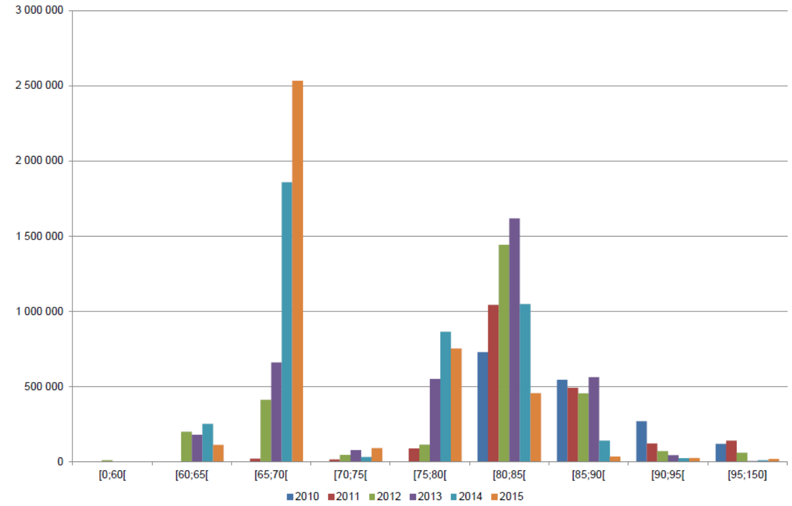


Figure 15: Variability of the prices of green certificates in Wallonia

Like in Flanders, many different buyers and sellers are active in the market for green certificates. Some of these actors are more specialised in buying certificates from domestic clients whereas other are focused on industrial generators. A full list of potential buyers of green certificates is published on the website of the Cwape.[70]

6.2.2 Timing of trading and submitting green certificates

In Flanders, certificates only need to be submitted to regulators by energy suppliers once a year at the end of March (for example for 2017, certificates must be submitted in March 2018). Consequently, Figure 16 indicates that there is a very high number of certificates being bought and sold in the month of this submission.

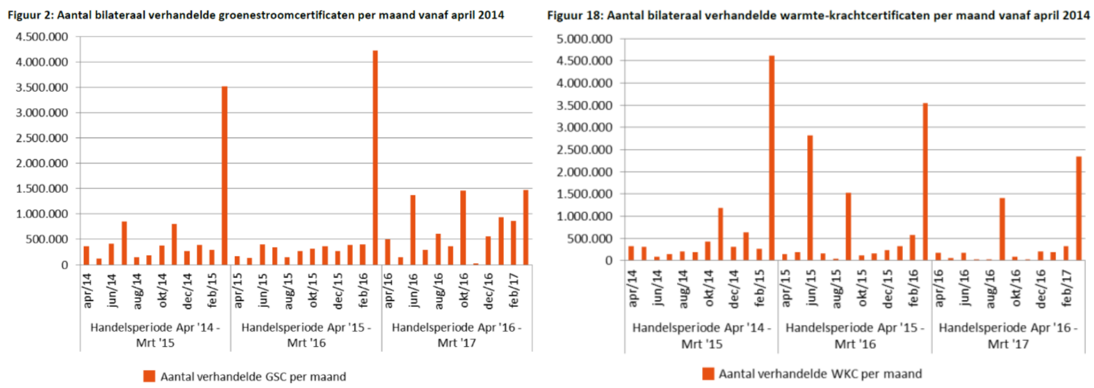


Figure 16: Timing of transactions certificates (left figure green certificates, right figure CHP certificates)

[70] Cwape, Liste des acheteurs des certificats verts, June 2017, Available at: http://www.cwape.be/?dir=3&news=12

BestRES This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

In Wallonia, where certificates are being submitted 4 times per year (quarterly), Figure 17 illustrates that the transaction are spread on a much more regular basis throughout the year.

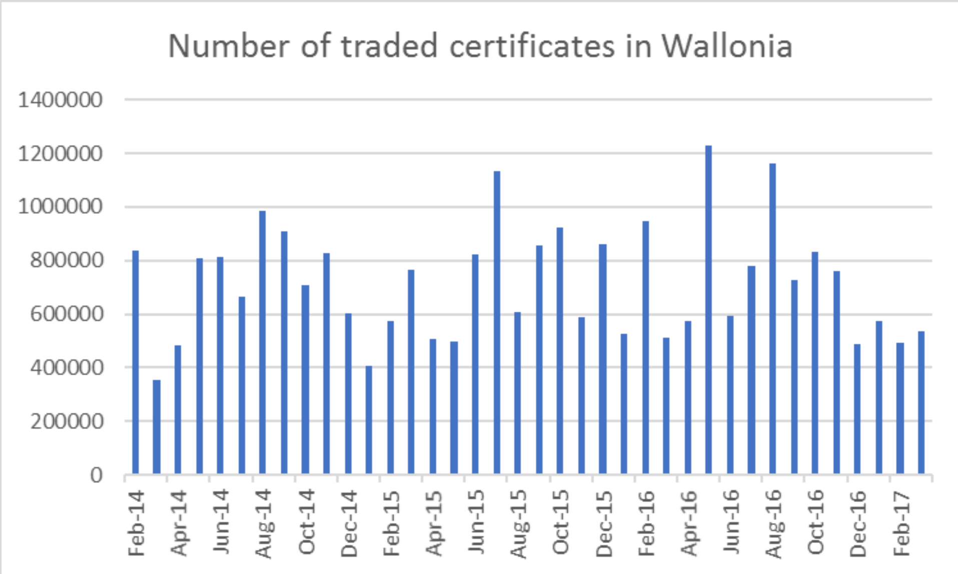


Figure 17: Number of traded certificates in Wallonia

6.3 PPA structure and risks of buying and selling green certificates

If Next Kraftwerke is willing to implement improved business models, the company must set up Power Purchase Agreements (PPAs) with customers. As a result, there will be certain risks so the consortium did a high-level analysis by looking at literature research and information from project developers, energy suppliers and traders. The details of this cannot be disclosed but some very high-level results can be publicly shared.

A first crucial element is that in a PPA, (green and CHP) certificates on the one hand and electricity/Guarantees of Origin on the other hand are sometimes priced separately. This is because generators can directly sell certificates to grid operators as current market prices are below minimum support value so they prefer to sell to grid operators.

A second important observation is that, if certificates are not sold to grid operators at minimum support value, it is a common practice, in a PPA in Flanders and Wallonia, to relate certificate prices to the minimum support and penalty values and/or the level of quotas. Therefore, changes in these minimum support and penalty values can have a huge impact on the value of green certificates in a PPA. If there is for example a PPA where the value of green certificates is prices at 80% of the penalty value for the period 2017-2022, this value will be 80 EUR/certificate at this moment in Wallonia (penalty value 100

BestRES This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

EUR/certificate). If the penalty value changes to 80 EUR/certificate, the value of the certificate in the same contract will only be 64 EUR/certificate (EUR 80*80%). In the same way, the price of green certificates in a PPA can be highly impacted by changes in quota and minimum support values.

BestRES This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

7. Implementation support oekostrom (Austria)

As described in D4.1 “An assessment of the economics of and barriers for implementation of the improved business models” of the BestRES project, only the “Demand side flexibilization of small customers” BM can be directly implemented because of the positive economic assessment and oekostrom’s ability to deal with existing barriers. oekostrom also confirmed that they are currently starting with the implementation of this BM.

This report supports oekostrom with an examination of operational Demand Response (DR) schemes currently in several countries in Europe and the US. This will be of great help to oekostrom for introducing a time-of-use tariff to their customers in Austria. As mentioned in D4.1, this innovative tariff can only be provided to customers with a smart metering system allowing them to benefit from electricity price differences.

First, an introduction to DR mechanisms and benefits is given, followed by the traditional tariff pricing. In a next step, time-of-use tariffs in Austria, Spain, Illinois (United States) and the United Kingdom are presented. Because of the commercially sensitive nature of the underlying tariffs and the differences between these countries in terms of grid charges and levies, a comprehensive comparison of the index basis for prices, granular cost components, or guarantees of transparency to customers cannot be produced. We will however provide an overview of the different tariffs proposed by suppliers in the different countries at the end of the document.

7.1 Demand Response

Increasing penetration levels of intermittent renewable energy generation significantly affects the operation of distribution grids. Ensuring reliable electricity supply requires back-up flexible electric power generation that can be costly. Regulatory authorities are increasingly considering load flexibility, also known as DR, for enhancing system coordination. DR can increase the ability of the demand side to be flexible, responsive and adaptive to economic incentives.

Through price signals, the actual costs of various electricity supply activities are reflected. The positive impact of a demand modification in reaction to the incentives could stimulate efficiency in electricity system operations and markets. DR aims to shift electricity usage from normal consumption patterns in response to market signals. There are two major complementary approaches to demand response:[71]

[71] UK Power Networks, Low Carbon London, Influencing Customer Profiles and New Interactions, 2011, Available at https://www.ofgem.gov.uk/ofgem-publications/90886/2.lclinfluencingcustomerprofilesandnewinteractions.pdf

BestRES This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement N°691689.

1. Explicit DR schemes are compensation mechanism with consumers being compensated with an agreed fee in exchange for their flexibility.

2. Implicit DR schemes are the result of time varying electricity prices reflecting the power market value of electricity in different time periods. Through this access to information, consumers are incentivized to shift their electricity consumption away from times of high prices. Consumers can save on their electricity bill by automating their appliances to these price signals.

7.2 Demand Response benefits

The main benefits of DR can be economic, environmental, or related to system reliability. The economic potential of DR reduces the general cost of energy supply while preserving adequate reserve margins and mitigating price volatility by means of short-term responses to electricity market conditions. The environmental aspect of DR focuses on decreasing the energy usage while trying to match environmentally friendly generation as much as possible and thus reducing greenhouse gas emissions. Finally, DR intends to maintain system reliability by decreasing demand in a short period of time and reducing the need to enhance generation or transmission capacity.

DR benefits can also be categorized in terms of consumption patterns. For the short and medium terms, DR would decrease network peaks and the risk of system breakdown by keeping electricity flows within technical constraints. In the long term, DR could defer generation and network investments as well as relieve from regular grid congestion.[72]

7.3 Traditional and potential new tariff structures

Traditional billing components on electricity bills are the energy charge (€/kWh), a capacity charge (€/kW), an access charge (a onetime payment), and the customer charge (a yearly or monthly payment). Also, there is generally no distinction between consumers and prosumers because of the uniform rate structures. In this context, it is important to note that two thirds of such a EU average retail bill consist of non-energy components (i.e. namely network costs, taxes and other costs) so that there is a need to lower the taxes and network component in the bill and to consider more consumption based charging of these components as well as to carefully examine potential more dynamic charging of these components in addition to the flexibility on the generation

[72] UK Power Networks, Low Carbon London, Influencing Customer Profiles and New Interactions, 2011, Available at https://www.ofgem.gov.uk/ofgem-publications/90886/2.lclinfluencingcustomerprofilesandnewinteractions.pdf

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

components. Finally, the benefits of ToU tariffs will probably not be as cost-effective for DSOs compared to using industrial and commercial DR.[73]

7.4 Country overview

A thorough comparison between countries is difficult as the underlying policies differ but an overview of the evolution towards DR and time-of-use tariffs is discussed in the section below for selected suppliers in 4 target countries: Austria, Illinois (US), Spain, Sweden and the United Kingdom.

7.4.1 Austria

aWattar is currently the only supplier offering an hourly price for customers with smart meters in Austria. The electricity price is adjusted on an hourly basis and depends on the weather. According to aWATTar, customers can save up to 30% of their electricity costs compared to the monthly tariff by shifting consumption. The tariff is only available for a yearly consumption below 10 MWh or else a surcharge of 27% per year is charged for each additional kilowatt hour. The hourly electricity price is calculated based on the German/Austrian Physical Electricity Index, which is traded on the stock exchange for short-term electricity transactions (EPEX) in Paris.[74]

7.4.2 Illinois (US)

The Power Smart Pricing (PSP) and ComEd's Hourly Pricing program are hourly electricity pricing programs for residential customers in Illinois in the United States. Participants pay electricity prices that vary from hour to hour and day to day according to the actual market price. Under the standard residential rate, by contrast, the price only varies between summer and non-summer months. Participants can manage their electricity costs by taking simple actions to conserve energy during hours when prices are higher.

PSP uses "day-ahead" prices, meaning the price for each hour of the day is set the evening in advance, and are available after 6 p.m. Since the program began in 2007, PSP participants have saved more than 15 percent on the electricity supply portion of their electricity bill, as compared with what they would have paid with Ameren's fixed-price rate.

Participants in ComEd's Hourly Pricing program receive customer support and services to help participants manage costs. These services include real-time day-of and day-ahead hourly pricing alerts, an online bill comparison tool, and information to help guide participants' energy decisions. Hourly pricing alerts are sent when electricity prices are trending high or when electricity is expected

[73] UK Power Networks, Low Carbon London, Influencing Customer Profiles and New Interactions, 2011, Available at https://www.ofgem.gov.uk/ofgem-publications/90886/2.lclinfluencingcustomerprofilesandnewinteractions.pdf
[74] Stromliste.at, aWATTar, Available at: http://stromliste.at/versorger/awattar

BestRES This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

to be in high demand the following day. Participants can receive hourly pricing alerts by email, phone, or text message.[75][76]

7.4.3 Spain

Spain has introduced the ‘Voluntary Price for Small Consumer (PVPC)’, determining the cost of energy on the electricity bill, on 1 April 2014. It is applied to the electricity bill of those consumers whose contracted power does not exceed 10 kW. The PVPC replaces the previous Last Resort Tariff (TUR). The TSO Red Eléctrica publishes hourly pricing schedules of ‘energy used’ through its website. Consumers whose contracted power capacity does not exceed 10 kW and have opted for PVPC are being billed on the actual hourly pricing schedules of ‘energy used’.

The impact of these prices on the bill are reflected in the variable energy charge, which represents about 60% of the total for consumers covered by the general tariff and 70% for those with a night-time tariff or a super-valley tariff. In any case, the price per hour will be applied that the user is going to pay for each kWh consumed. The total of the electricity bill is completed by the inclusion of a fixed charge proportional to the power contracted by the user as well as the taxes established by current legislation.[77]

These prices will be used for all residential consumers, whether they have smart meters with hourly metering or if they are yet to have one installed. In the latter case, prices will apply based on the profiles that Red Eléctrica draft with the new methodology approved by the Government and will be published and updated weekly on Red Eléctrica’s “eSios” website. For the user, this means that any household can know the individual price per hour of the electricity and therefore decide which appliances should be consuming or not at what time. Coupled with digital controls this opens opportunities to optimize consumption according to lower prices, producing savings for the user and system optimization for the country.

7.4.4 Sweden

A mature smart metering infrastructure in Sweden has provided residential users with opportunities to access dynamic pricing mechanisms that could encourage

---

[75] Community Energy Cooperative and Summit Blue Consulting, 2006, Available at: http://www.elevateenergy.org/wp/wp-content/uploads/Real-TimePricingIstheRealDeal-AnAnalysisoftheEnergyImpactsofResidentialReal-TimePricing.pdf

[76] Elevate Energy, ComEd’s Hourly Pricing Program, Available at: http://www.elevateenergy.org/home-savings/comed-rrtp/

[77] Red Electrica de Espana, Voluntary price for the small consumer (PVPC), April 2014, Available at: http://www.ree.es/en/activities/operation-of-the-electricity-systemvoluntary-price-small-consumer-pvpc
Red Electrica de Espana, Red Eléctrica begins to publish the new hourly electricity prices, March 2014, Available at: http://www.ree.es/en/press-office/press-release/2014/04/red-electrica-begins-publish-new-hourly-electricity-prices

BestRES This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement N°691689.

them to change energy consumption patterns. For household users in Sweden, total electricity cost comprises the cost of electricity supply itself, electricity transmission as well as energy taxes and VAT. In January 2012, the share of the electricity supply price made up to 49% of the user's electricity bill. 15% corresponded to the network tariff and 36% to energy tax and VAT.

In this context, contract flexibility and options provided by electricity suppliers is one of the main advantages for residential users of a deregulated market together with smart metering technology. In 2012, over 1.6 million households users changed electricity suppliers or entered a new contract, corresponding to 37% of the total amount of residential users in the Swedish electricity market. However, even with a residential sector highly active on the electricity market, users still prefer fixed-price contracts over variable-price ones. In 2013, the majority (42% of all users) still chose to have a fixed-price electricity supply contracts at fixed-term, while only 27% chose to have variable-price electricity supply. Of all users, 24% still had open-ended (contracts that are automatically renewed) contracts, and 7% had other type of agreements.

Nevertheless, the open-ended contracts' customer base is declining rapidly, since users are becoming aware of available flexible options. Furthermore, users choosing fixed-term contracts at a fixed price are moving from three-year contracts to one- and two-year contracts, showing a shift towards shorter-term commitments between users and their service providers. Variable-price contracts, however, remain stagnant since most users are not yet willing to move from the conventional fixed-price electricity supply to a variable price scheme, where unexpected weather changes may induce price fluctuations. During years with predictable conditions, such as a normal rainfall in summer and a mild winter, users using Real-Time Pricing (RTP) had an economical advantage over users with fixed-price contracts. On the contrary, during years with strong winters and with changes on summer rainfall price spikes severely affected users with RTP. As a result, such users ended up with higher annual electricity supply costs compared to users with fixed-price contracts. Furthermore, users with electrical heating experienced the largest differences between the two types of contracts.

In order to make the program more attractive, effective feedback strategies should be adopted that allow users to understand their electricity usage patterns and thus, increase their consumption awareness. Electricity retailers could also provide users with information about the economic impact of adopting different dynamic price mechanisms based on their own historical electricity consumption profiles, rather than just the total annual consumption.

Finally, home-automation and home energy management technologies should work together with dynamic pricing strategies to provide users with large savings

BestRES This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

through automated demand response in order to reduce the payback period of the required investments for the adoption of the smart-metering technologies.[78]

7.4.5 United Kingdom

In the United Kingdom (UK), Green Energy UK , with it TIDE tariff,[79] is the first to offer residential customers an electricity price based on the time of day, in contrast to the traditional dual ToU tariffs such as Economy 7 or Economy 10[80] tariff that are commonplace in the UK.

With the current offer, consumers will pay 4.9p per unit of electricity on weekdays from 11pm-6am, but five times as much between the peak weekday hours of 4-7pm. The average price of electricity in the UK is around 14p per unit.

The tariff is underpinned by smart meters, which the government has pledged to fit in every home by the end of 2020, although official figures recently showed only 9% have been installed so far. Around four in 10 of Green Energy UK's customers already have smart meters, which are a prerequisite for the tariff. Time-of-day tariffs are also seen as a way to solve potential obstacles for the National Grid as more renewable but intermittent sources of power such as wind and solar are brought online.[81]

[78] School of Sustainable Development of Society and Technology (HST), Mälardalen University, Sweden, February 2015, Available at: https://www.researchgate.net/publication/254864389_Economic_impact_of_dynamic_electricity_pricing_mechanisms_adoption_for_households_in_Sweden

[79] Greenenergyuk.com, Tide, Available at: https://www.greenenergyuk.com/Tide?POSTCODE=AL1%203EZ#artTideLookUp

[80] Uswitch.com, What is Economy 7 meter and how does the tariff work?, Available at: https://www.uswitch.com/gas-electricity/guides/economy-7/

[81] The Guardian, Green Energy UK offers first electricity tariff based on time of day, January 2017, Available at: https://www.theguardian.com/money/2017/jan/03/green-energy-uk-launches-first-time-of-day-electricity-tariff

BestRES This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

7.5 Overview of identified time-of use tariffs

An overview of the different tariffs proposed by suppliers in the different countries is presented in Table 8.

Table 8: Overview of countries that implement time-of-use tariffs

	Price structure	Price Basis	Transparency to customers	Potential savings	Time-of-use	Fixed fee
aWattar (Austria) - HOURLY[82]	fixed fee + Spot + 0.1cts/kWh	Phelix	website	30.00%	hourly	depends on length of contract
VPSC - Supervalley tariff (Illinois (US))[83]	fixed (30%) + variable (70%)	OMIE	website + app	N/A	hourly (but almost similar to 2 blocks)	regulated based on the demand capacity
Sweden (N/A)*	N/A	N/A	N/A	N/A	N/A	N/A
PSP/ComEd (Spain)[84]	fixed fee + Spot	MISO	website + SMS alerts	15.00%	hourly	fixed
Green Energy – TIDE (United Kingdom) [85]	fixed tariffs per block	N/A	fixed tariffs per block	N/A	4 blocks in week 2 blocks in week-end	N/A

* No publicly available information could be retrieved for the case of Sweden

[82] Awattar, Hourly, Available at: ttps://cdn.awattar.com/documents/legal/tariff-sheet/hourly.pdf
[83] BOE, Real Decreto 216/2014, de 28 de marzo, por el que se establece la metodología de cálculo de los precios voluntarios para el pequeño consumidor de energía eléctrica y su régimen jurídico de contratación, March 2014, Available at http://www.omel.es/files/r.d_216-2014de_28_de_marzo.pdf
[84] Power Smart Pricing, Current Hourly Prices, Available at: https://www.powersmartpricing.org/prices/
[85] https://www.greenenergyuk.com/Tide

BestRES This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

8. Implementation support EDP (Portugal)

As described in D4.1 "An assessment of the economics of and barriers for implementation of the improved business models" of the BestRES project, EDP is looking into implementation of the "Activation and marketing of end user's flexibility" BM in Portugal and Spain. The consortium has proven, through an analysis of the economics and barriers, that this business model is ready for implementation and placed in group 1 for Portugal (for Spain in group 3 as described in D4.1 of the BestRES project). The business model is further split up in "day-ahead energy sourcing optimization" and "imbalances optimization".

To be able to use the flexibility of flexible processes such as refrigeration systems and batteries in large industrial and commercial entities in an efficient way, load forecasting will be increasingly important. Therefore, as a support for implementation, the consortium will provide such forecasts for some clients in EDP's portfolio. This will allow EDP to better evaluate the flexibility potential of providers of flexibility when implementing the business model.

8.1 Load forecasting

Different load forecasting methods are available in the market, including expert rules based on physical principles, statistical models and machine learning techniques. As part of the Arrowhead project[86], 3E worked on the assessment and development of improved machine learning forecasting techniques so that the electrical energy consumption of commercial buildings based on historical consumption data can be predicted. Further improved methods could be applied if additional data would be available from the different buildings including, among others, temperature and solar irradiation data. The data-driven approach of the machine learning techniques has the main advantage that no clear relationship between input and output needs to be defined upfront.

8.1.1 Selected forecasting methodology

Different machine learning techniques were evaluated for supporting EDP, including among others Support Vector Machines, Artificial Networks and Random Forest Regression. Our experiments showed that Support Vector Machines are best suited for the given prediction task. Therefore, the selected method for this application is the Support Vector Machines Regression (SVR). The main reasons to choose this method for this case are that artificial neural networks come with two drawbacks: 1) The error function usually contains multiple local minimum solutions and 2) the optimal number of neurons in the hidden layer(s) is unknown and needs to be assessed by several training runs. Support vector machines (SVM) avoid these difficulties by translating the problem into a convex optimization

[86] Arrowhead project - Collaborative R&D project, initiated by a consortium of more than 70 European partners, aimed at enabling collaborative automation for networked embedded devices, Available at: http://www.arrowhead.eu/

BestRES This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

problem with a unique solution from which also the model complexity (comparable to the number of hidden neurons) can be derived. SVR methodology is optimized for classification, regression and outliers detection. This methodology is effective in high dimensional spaces and stays effective in situations where number of dimensions is greater than number of samples.

EDP sent anonymized electricity consumption data from some clients in their portfolio to perform the load forecasting. The dataset included electricity consumption during a full year (2016) (at a 15 minutes resolution), for six different types of clients, including the automobile industry, the chemical industry, the food industry, metallurgy, SME's and services.

8.1.2 Selected load profiles

For this first analysis and as a proof of concept, the consortium decided together with EDP to select three different types of clients from the available portfolio (Table 9): one customer from the metallurgy industry (ID 71), one customer from the food industry (ID 214) and one SME (ID 4295). The selected customer segments allow comparing the application of the forecasting methodology under different conditions. The data from all the electricity meters are aggregated to get a total consumption value per client.

Table 9: Selected loads from the portfolio sent by EDP

Load type	ID	Electricity meters
Metallurgy	71	4
Food Industry	214	8
SMEs	4295	113

8.1.3 Baseline forecast

For validation purposes and for demonstrating the added value of the proposed methodology, an expert rule model based on the "comparison day method" is used as a baseline. This method assumes consumption pattern of previous occurrence of same type day to forecast the future consumption. For example, for the prediction of a Sunday, this method uses the previous Sunday (i.e. 7 days ago), for the prediction of Monday the baseline uses the previous Monday, etc…

8.1.4 Training dataset length

The forecasting model needs to be trained on historical data before it can be used. The time series with the electricity consumption data were therefore split in two sets: a training set and an independent test set. The model trained on the training set was then evaluated on the test set to assess its prediction quality and the required period length (number of weeks) to outperform the baseline prediction for each of the selected load profiles.

BestRES This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

8.1.5 Discussion of results

Figure 18, Figure 19, and Figure 20 show the resulting mean absolute error (MAE) between the predicted and the measured values, normalized to the average consumption over the period, for the SVR and baseline methods for the metallurgy industry, food industry and SME case respectively. Figure 18 and Figure 19 show that ca. 13 weeks of training datasets are needed for the SVR method to outperform the baseline. Moreover, a clear improvement in terms of MAE is observed in two cases (metallurgy and food industry). A reduction in MAE of more than 4 percentage points over the entire period compared with the baseline scenario is obtained for the metallurgy industry case (Figure 18) whereas it is in the order of 3% for the food industry case (Figure 19).

For the SME case (Figure 20), the improvement in terms of MAE, normalized to the average consumption over the period, is smaller than for the other two cases but the SVR clearly outperforms the baseline scenario as well, in this case by ca. 1.5 percentage points and requires slightly more weeks of training dataset than the other two cases (ca. 16 weeks). This effect can be explained by the type and behaviour of loads in a SME compared to the two other industry cases. Moreover, results between SMEs can be very different as profiles of SMEs highly vary.

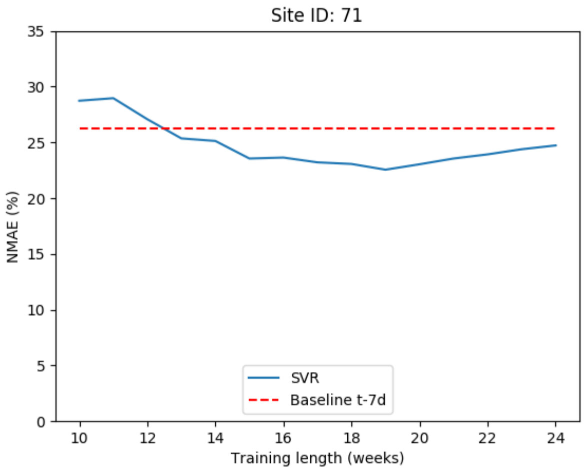


Figure 18: Training length required to outperform the baseline prediction for the metallurgy industry

BestRES This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

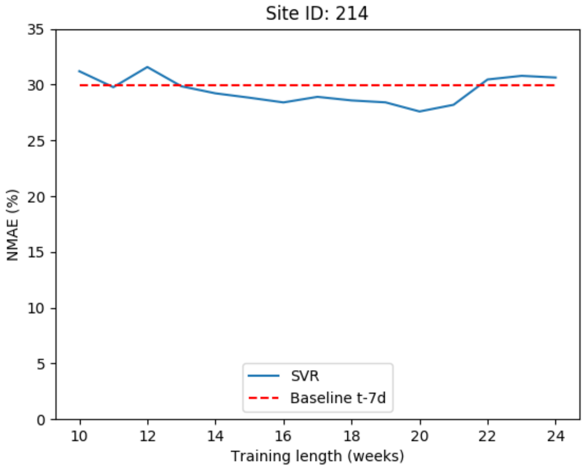


Figure 19: Training length required to outperform the baseline prediction for the food industry

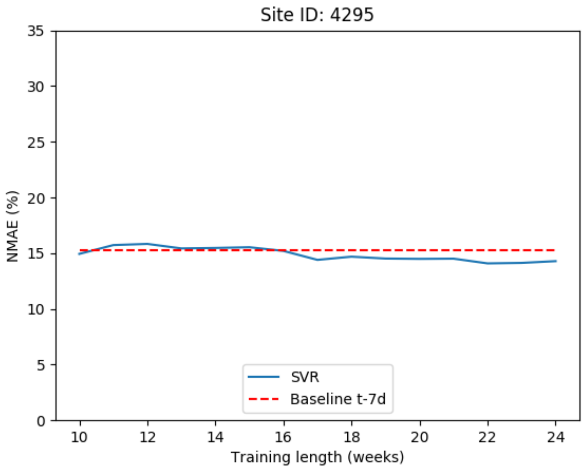


Figure 20: Training length required to outperform the baseline prediction for the SME case

Figure 21 shows the electricity consumption predictions using the SVR methodology compared with the actual electricity consumption during a full week in July 2016 for the three analysed profiles. It shows the very different profiles from the selected cases i.e. metallurgy industry (71), food Industry (214) and SME (4295). Moreover, the results also highlight the particular very good match of the predictions with the actual consumption for the Metallurgy Industry.

BestRES This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

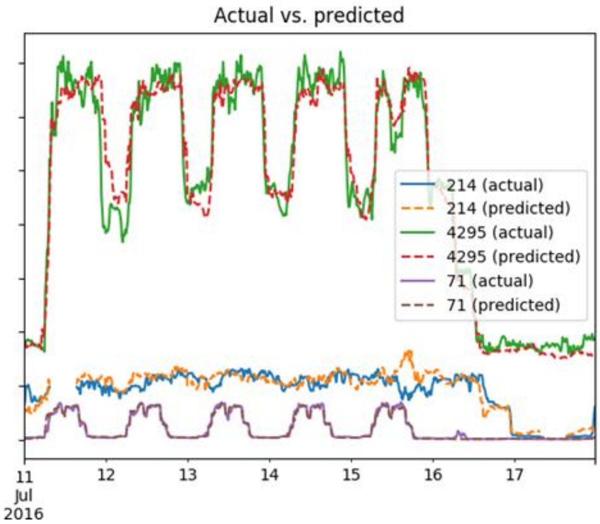


Figure 21: Predictions using SVR method compared with actual consumption for a full week in July 2016 for the three analysed profiles – Metallurgy Industry (71), Food Industry (214), and SME (4295)*

*The scale of data on the y-as (power level) is anonymised as this is no public data

A closer look to the predictions for a specific day in July 2016 is illustrated in Figure 22. In addition to the predictions comparison against the actual load, Figure 22 shows the comparison with the baseline forecast at 15 minutes' resolution. The improvement on predicted consumption for all three cases is clear when compared with the baseline. Quantitative values for this comparison are provided in Table 10.

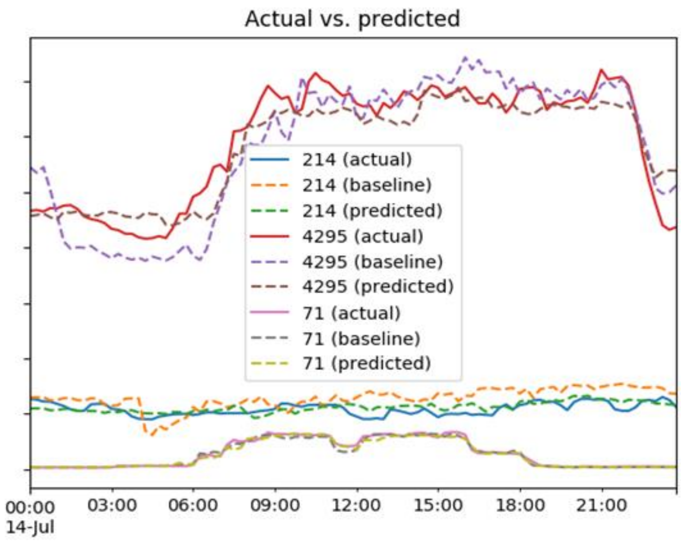


Figure 22: Predictions using SVR method compared with actual consumption for a full day in July 2016 for the three analysed profiles – Metallurgy Industry (71), Food Industry (214), and SME (4295)*

*The scale of data on the y-as (power level) is anonymised as this is no public data

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

Table 10: Mean Absolute Error (normalized to the average consumption over the period) of the baseline and the SVR method for the three analysed profiles during one day in July 2016

Load type	Metallurgy Industry (71)	Food Industry (214)	SME (4295)
Baseline	9.4%	20.4%	6.7%
SVR prediction	8.4%	8.0%	4.8%

One can see from the results presented in Table 10 (results for one day prediction in July 2016) that the proposed method based on support vector machines regression clearly outperforms the baseline method for all three analysed profiles. These results are for one example case of each industry i.e. metallurgy, food and SME. While one could expect that metallurgy and food industry profiles are very similar in other cases, the SME case can strongly vary depending on load profiles. Therefore, it is recommended to do the analysis in a second phase including many other cases to compare the results as described in Section 4.2.

8.2 Outlook

The presented results show that advanced load forecasting methodologies such as machine learning techniques, more specifically Support Vector Machines for Regression (SVR) methods can clearly outperform traditional load forecasting models such as rules based models (explained in Section 4.1.3).

The three selected load profiles i.e. metallurgy industry, food Industry and SME are very different and thus, the obtained results show the broad application of a single methodology to very different profiles without the need of specific model settings for every new different load profile. Nevertheless, the use of additional external variables could potentially further improve the results. Therefore, it is recommended to perform for each of the business model implementation participants, a detailed analysis including the following:

- Larger dataset, containing at least two years of data (i.e. a full year can be used for training purposes and the other(s) for the validation)
- External variables like e.g. ambient temperature and irradiation data

BestRES This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

9. Conclusions and recommendations for further implementation

The objective of this document is to support aggregators with implementation of improved BMs so that operations can start as soon as possible. Such business models have been identified in 6 out of the 9 target countries in the BestRES project. Hereunder, we elaborate on the principal conclusions drawn from the support actions and we develop recommendations for further implementation.

9.1 Conclusions

Table 11 shows the type of support provided to each of the aggregators with BMs ready for implementation together with some key take aways for each country. For each country and aggregator, we repeat the BMs that are ready for implementation so that there is a framework for the reader to understand the type of support.

Table 11: Type of support and key take aways from support for implementation

Good Energy United Kingdom	**BM "Automation and control":** ***Development of a questionnaire for targeting small-scale providers of flexibility*** • For investigating the potential flexibility that can be sourced from providers of flexibility, the consortium mainly included questions related to refrigerators, freezers, water boilers, heat pumps, electric radiators and PV-storage systems
NEXT KRAFTWERKE Germany	**BM "Supplying "mid-scale" customers with time variable tariffs including grid charges optimization":** ***Analysis of the issues with current grid charges and potential grid charges modifications when implementing the BM*** • Current grid charges regulation hampers flexibility, leads to an unfair distribution of costs and does not allow grid operators to cover for costs when self-consumption increases

BestRES This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.

	• The consortium identified 4 important grid charges modifications that are under discussion • Orienting demand in function of the grid congestion with time-variable tariffs is the most relevant option for Next Kraftwerke (and other aggregators)
NEXT KRAFTWERKE Italy	**BM “Market renewables on multiple markets”** ***Analysis of the evolution of the Italian solar and onshore wind energy sector and documentation on solar and onshore wind assets and investors*** • For PV plants, there have been important cuts in feed-in tariffs in recent years. For new large-scale wind projects, auctions for feed-in premiums are organised to support development • There is an active secondary market for utility-scale solar projects and a consolidation trend. The 3 most important identified investors are EF Solare Italia, RTR Energy and Tages Helios • The 3 principal identified onshore wind investors are ERG, Enel Green Power and E2i
NEXT KRAFTWERKE Belgium	**BM “Trading PV and wind power” <u>and</u> BM “Using flexibility of customers as third party”** **Documentation on the operation of the green and CHP certificate systems, related markets and market players and PPAs** • In the regions of Flanders and Wallonia in Belgium, green and CHP certificates are often directly sold to grid operators because market prices are low due to a surplus of certificates • The surplus is expected to go down so the market could function again in the short to medium term • Only generators can sell certificates to grid operators at minimum price so Next Kraftwerke, who does not own assets, can only sell certificates on the bilateral market • Certificates need to be sent to regulators by energy suppliers such as Next Kraftwerke. This

BestRES This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement N°691689.

	happens once a year in Flanders and four times a year in Wallonia • In PPAs, green and CHP certificates on the one hand (sold to grid operators) and electricity/Guarantees of Origin on the other hand (commercial contracts) are sometimes priced seperataly • If certificates are not sold to grid operators, certificate prices are often related to minimum support, penalty values or quotas
oekostrom AG Austria	**BM “Demand Side flexibilization of small customers”** **Analysis of time-of-use pricing for small-scale consumers by energy suppliers in different countries** • Benefits of DR can be economic, environmental or related to system reliability • Analysis of time-of-use tariffs from suppliers in Austria, the United States, Sweden, Spain and the United Kingdom • Tariffs on hourly basis in Austria, US and Spain whereas less blocks per day are used in the United Kingdom • Potential for savings challenging to estimate but expected to be 30% in Austria and 15% in Spain • Key role of smart metering
edp NEWENERGYWORLD 新能源世界 NEW Portugal	**BM “Activation and marketing of end user’s flexibility”** **Support with understanding the potential of adequate load forecasting of loads within the portfolio of EDP** • Advanced forecasting methodologies such as Support Vector Machines for Regression (SVR) can outperform traditional load forecasting models • Effects illustrated for load in the metallurgy industry, food industry and SME

BestRES This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement N°691689.

9.2 Recommendations for further implementation

As already highlighted in D4.1 “An assessment of the economics of and barriers for implementation of the improved business models” of the BestRES project, customer acquisition will be a very crucial aspect for the success of BM implementation in the United Kingdom. Therefore, Good Energy should target as much potential providers of flexibility so that enough revenues are generated to cover for the costs. In this context, the company has to find the most appropriate channel to send the questionnaire.

In Germany, Next Kraftwerke and other aggregators should further investigate the advantages of orienting demand in function of the grid congestion with time variable tariffs. This offers opportunities for active optimization by aggregators who should thus actively approach regulators to stimulate this. Next Kraftwerke should also put efforts in participating in pilot projects on the reserve power market in Italy. If they can progress in this direction, sufficient volumes of the appropriate types of assets should be targeted so that enough flexibility can be provided. We illustrated that interesting players with large portfolios of wind and solar assets are currently active on the market. Furthermore, in Belgium, Next Kraftwerke should take into account green and CHP certificate price increases in the short to medium term when contracting PPAs with generators. PPAs should for example cover risks such as changes in quota and fine values.

In Austria, for implementing time-of-use tariffs for small-scale consumers, oekostrom should further investigate how many consumers are actually interested in the service and estimate the derived flexibility potential. A similar questionnaire such as the one developed for Good Energy could be used for this purpose. Finally, in Portugal, EDP should investigate the potential of load forecasting by including larger datasets and external variables such as ambient temperature and irradiation data.

BestRES This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement N°691689.

Technical References

Project Acronym	BestRES
Project Title	Best practices and implementation of innovative business models for Renewable Energy aggregators
Project Coordinator	Silvia Caneva WIP silvia.caneva@wip-munich.de
Project Duration	March 2016 – February 2019 (36 months)
Deliverable No.	D4.2
Dissemination level*	PU
Work Package	WP4 - Implementation and monitoring of improved business models
Task	T4.2 - Documentation of pilot business model implementation and results
Lead beneficiary	3E
Contributing beneficiaries	All partners
Due date of deliverable	31 August 2017

* 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	Authors
1.0	22/08/2017	3E	Ruben Verhaegen & Raphael Beaumond (3E); Georg Lettner (TUW-EEG), Daniel Schwabeneder (TUW-EEG) & Andreas Fleischhacker (TUW-EEG)
2.0	31/08/2017	3E	Antoon Soete & Carlos Guerrero (3E), Fabian Pause & Stefanie Wizinger (Stiftung Umweltenergierecht)
3.0	31/08/2017	WIP	Silvia Caneva
4.0	08/09/2017	WIP	Silvia Caneva
5.0	11/09/2017	WIP	Silvia Caneva

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°691689.