BestRES

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

Documentation of virtual business model implementation and results

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

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List of abbreviations and acronyms

aFRR	Automatic Frequency Restoration Reserve
B2B	Business-to-business
BEMS	Building Energy Management Systems
BM	Business Model
BRP	Balance Responsible Party
DR	Demand Response
DSM	Demand Side Management
DSO	Distribution System Operator
EAC	Electricity Authority of Cyprus
EV	Electric Vehicle
FCR	Frequency Containment Reserve
FOSS	Research Centre for Sustainable Energy (University of Cyprus)
HEMS	House Energy Management Systems
HVAC	Heating, ventilation, and air conditioning
KPI	Key Performance Indicators
kWh	Kilowatt hour
kWp	Kilowatt peak
mFRR	manual Frequency Restoration Reserve
MO	Market Operator
MW	Megawatt
MWh	Megawatt hour
n.a.	Not applicable
NKW DE	Next Kraftwerke Germany
PPEC	Plan to Promote Efficiency in Electric Energy Consumption
PV	Photovoltaic
tCO_2	tonne CO_2

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TSO	Transmission System Operator
TUW	Technical University Vienna
VAT	Value Added Tax
VPP	Virtual Power Plant
yr	year

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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 sources can significantly accelerate the integration of variable electricity sources, complement demand flexibility and decrease the reliance on renewable energy support schemes. Aggregators of demand and/or generation are therefore expected to have an increasingly important role to play in the future.

The BestRES project investigates the current barriers for aggregator business models (BMs) and suggests ways of improving the role of aggregators in future electricity market designs. In this report "Documentation of virtual business model implementation and results" of the BestRES project, the improved BMs for which the economic case is positive but that face practical implementation barriers, are virtually implemented using real customer data. These are the so-called 'Group 2' BMs, as categorised in the BestRES report "An Assessment of the Economics of and Barriers for the Implementation of the Improved Business Models"[1].

This report investigates the BM's implementation plan and KPIs of the virtual BM portfolio. Based on input from the aggregators, several implementation considerations are discussed.

Four BMs are analysed in this way:

- **BM1:** "Dispatch flexible generation under changing market design on multiple markets" by Next Kraftwerke Germany in Germany
- **BM2:** "Valorise distributed generation of customers in apartment buildings" by oekostrom in Austria
- **BM3:** "Activation and marketing of end user's flexibility" by EDP in Spain
- **BM4:** "Pooling flexibility for local balancing market and energy service provision" by FOSS in Cyprus

The main results and conclusions per BM are discussed below

Next Kraftwerke Germany

BM1: Dispatch flexible generation under changing market design on multiple markets (Germany)

Under this BM, Next Kraftwerke Germany uses its portfolio's flexibility to participate on the automatic Frequency Restoration Reserve market (aFRR) in Germany. Recently, the aFRR market design has changed, with shorter procurement periods and mixed pricing bid evaluation. These changes have a large impact on Next Kraftwerke's opportunities on this market.

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The main implementation tasks in the virtual implementation include adapting the price forecast algorithms and availability planning to the new market design, performing a long-term assessment of the BM's performance and integrating the process in the existing infrastructure.

The virtual portfolio KPIs are given in Table 1. Next Kraftwerke Germany can pre-qualify 800 MW of capacity that is biddable on the aFRR market. Depending on whether the offered flexibility is upward or downward, the revenue per MW of capacity for one year of availability is respectively €15 000 - €25 000 and €5 000 – €10 000.

The main implementation consideration is that the impact of the recent changes in market design must stabilise before a long-term assessment can be made.

oekostrom AG oekostrom

BM2: Valorise distributed generation of customers in apartment buildings (Austria)

Under this BM, oekostrom intends to expand its current portfolio by enabling customers living in apartment buildings to install collective PV installations. Recently the regulations on community generation units in Austria has changed, which can lead to new opportunities for oekostrom in this segment.

Oekostrom expects a triple-phased implementation that strongly depends on the rollout of smart meters in the country. In the first place, only existing customers are addressed, while in later stages also the attraction of new customers is foreseen.

The virtual portfolio KPIs are given in Table 1. In the growth phase, oekostrom foresees a total number of 4900 customers for this BM with an annual consumption of 17 400 MWh. This results in an annual revenue of up to €432 500.

The main implementation consideration is that the market role of oekostrom must be clearly defined before any implementation can take place.

edp EDP

BM3: Activation and marketing of end user's flexibility (Spain)

Under this BM, EDP activates and markets the flexibility of its medium-sized customers through two mechanisms: electricity sourcing optimisation and

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imbalance reduction. This is similar to the BM that it is implemented in Portugal in real life conditions under the BestRES project, as documented in [2]

The main implementation tasks include developing the specifications of the solution, recruiting potential customers, analysing and selecting the received applications and launching the demonstration trial.

The virtual portfolio KPIs are given in Table 1. Based on EDP's actual customer portfolio, the virtual implementation leads to a portfolio size of 117 MW across 257 customers with an annual consumption of 517 500 MWh/yr. The annual revenue is €10 650 000 per year.

The main implementation consideration is that the lessons learnt and best practices from the Portuguese use case should be used to identify the potential improvements for the implementation in Spain.

FOSS

BM4: Pooling flexibility for local balancing market and energy service provision (Cyprus)

Under this BM, FOSS offers grid services to the Cypriot transmission/distribution grid by pooling flexibility from the university of Cyprus campus and residential prosumers. As the market conditions in Cyprus do not allow advanced market participation, the analysis of the virtual implementation is limited to the mechanism of self-consumption maximisation.

The main implementation tasks include connecting the existing assets on the university campus, constructing and installing new assets on the university campus and at the prosumers' places, monitoring of the pilot sites and evaluation of the pilot results.

The virtual portfolio KPIs are given in Table 1. Based on a research project that is currently ongoing at FOSS, the virtual implementation portfolio consists of 3.25 MW of capacity across 46 connection points with an annual consumption of 12 074 MWh. The annual savings due to self-consumption add up to €1 268 300 between the two pilot sites and the payback time of the necessary investment is less than 7 years.

The main implementation consideration is that the Cypriot market should be opened to enable the DSO to pay for grid services provided by distributed generation. Only then the available flexibility will optimally be used.

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Table 1: Virtual BM Implementation KPIs for all business models

	BM1 NWK DE	BM2 oekostrom	BM3 EDP	BM4 FOSS
Number of units/customers	950	4900	257	46
Portfolio size * Consumption * Capacity	* n.a. * 800 MW	* 17 400 MWh/yr * 4.9 MW_{peak} (PV)	* 517 500 MWh/yr * 117 MW	* 12 074 MWh/yr * 3.25 MW
Annual revenue	Upwards (€/MW/yr): * 15 000 - 25 000 Downwards(€/MW/yr): * 5 000 – 10 000	€432 500/yr	€10 650 000/yr	€1 268 300/yr
CO_2 reduction	n.a.	5300 tCO_2/yr	n.a.	381 tCO_2/yr
Amount of shifted load	n.a.	n.a.	51 750 MWh/yr	366 MWh/yr

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1. Introduction

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

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

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

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1.1 The BestRES project

The main objective of the BestRES project is to investigate the current barriers and to improve the role of Energy Aggregators in future electricity market designs. In the first stage, the project focused on existing European aggregation business models taking into account technical, market, environmental and social benefits. In the second stage, improved business models were developed that are replicable in other countries in the EU considering market designs and with a focus on competitiveness and LCA. These improved business models have then been 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 lasted three years. It entered into force on March 1st, 2016 and ended on February 28th, 2019.

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

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

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

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

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

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

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WIP - Renewable Energies (WIP)

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

3E

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

Technische Universitaet Wien (TUW-EEG)

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

Stiftung Umweltenergierecht (SUER)

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

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technical and economical questions, are of particular importance. Website: http://stiftung-umweltenergierecht.de/

Good Energy

Good Energy is a pioneering clean energy company, powering the choice of a cleaner, greener future together with its people, customers and shareholders. Having led the way in renewable energy development since 1999 in areas including small and larger scale wind turbines, solar panels, biogen and hydro, and now in technologies like battery storage and electric vehicles, Good Energy is making it easier for people and businesses to make renewable energy part of their lives. Good Energy powers homes and businesses with 100% renewable electricity from a community of over 1,400 UK generators and owns and operate two wind farms, including the UK's first commercial wind farm, and eight solar farms. In addition, Good Energy offers a green gas product which contains 6% biomethane — gas produced here in the UK from food waste. To make it completely carbon neutral, emissions from the rest of the gas its customers use is balanced through supporting verified carbon-reduction schemes in Malawi, Vietnam and Nepal. As of 30 December 2017, Good Energy had over 250,000 domestic and business customers. Website: www.goodenergy.co.uk

Next Kraftwerke Belgium (NKW BE)

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

Next Kraftwerke Germany (NKW DE)

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

Oekostrom

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

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

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

Centre for New Energy Technology (EDP-CNET)

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

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

Youris.com (Youris)

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

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1.2 Structure of the document

The objective of this report is to simulate a virtual business model implementation for the improved BestRES business models that are economically viable but face barriers that prevent direct implementation. The business models are described in the BestRES report “Improved business models (BMs) of selected aggregators in target countries” [3] and they are classified according to their implementation readiness in the BestRES report “An Assessment of the Economics of and Barriers for Implementation of the Improved Business Models” [1]. In total, the virtual implementation of four improved BMs are discussed, as shown below.

BM1 Dispatch flexible generation under changing market design on multiple markets **Next Kraftwerke Germany** Germany	**BM2** Valorise distributed generation of customers in apartment buildings **Oekostrom** Austria
BM3 Activation and marketing of end user’s flexibility **EDP** Spain	**BM4** BM4: Pooling flexibility for the local balancing market and energy service provision **FOSS** Cyprus

The remainder of the document is structured as follows:

- Section 2 describes the methodology that was used for the virtual business model implementation.
- Section 3 discusses the virtual implementation of the improved BM “Dispatch flexible generation under changing market design on multiple markets” by Next Kraftwerke Germany in Germany.
- Section 4 discusses the virtual implementation of the improved BM “Valorise distributed generation of customers in apartment buildings” by oekostrom in Austria.
- Section 5 discusses the virtual implementation of the improved BM “Activation and marketing of end user’s flexibility” by EDP in Spain.
- Section 6 discusses the virtual implementation of the improved BM “Pooling flexibility for the local balancing market and energy service provision” by FOSS in Cyprus.

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- Section 7 concludes with an overview of the virtual implementations for each of the analysed BMs and draws a set of conclusions.

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2. Methodology

2.1 Virtual business model implementation

2.1.1 Analysed Business Models

In the BestRES report "An Assessment of the Economics of and Barriers for the Implementation of the Improved Business Models" [1], the improved business models are classified in three groups according to their implementation readiness. The group they are allocated to determines how the BMs are analysed in the next phases of the BestRES project. The group classification is based on the BM's expected economic performance, the legal, regulatory and technical barriers obstructing their implementation and social or political issues because of which the aggregators would face implementation difficulties.

Economically viable business models that face one or more legal, social and/or technical barriers are placed in group 2. These business models are not ready to be implemented in real-life, though under different market conditions they could be feasible. These BMs are analysed in this report through a virtual business model implementation based on scenario modelling with actual customer data.

The result of the classification exercise is shown in Figure 1. Two BMs are placed in group 2: Next Kraftwerke Germany's "Dispatch flexible generation under changing market design on multiple markets" and oekostrom's "Valorise distributed generation of customers in apartment buildings". In both cases the major barrier for implementation was that the necessary regulatory changes did not come early enough to consider a real-life BM implementation as part of the BestRES project. For the BM "Dispatch flexible generation under changing market design on multiple markets" (Germany), an updated favourable market design was implemented in the German balancing market only in 2018, whereas for the BM "Invest and market distributed generation of customers in apartment houses" (Austria), a new favourable law was passed in Austria 2018.

Besides these two 'group 2' BM, it was decided that also EDP's BM "Activation and marketing of end user's flexibility" (Spain) and FOSS's BM "Pooling flexibility for local balancing market and energy service provision" (Cyprus) are analysed through a virtual BM implementation.

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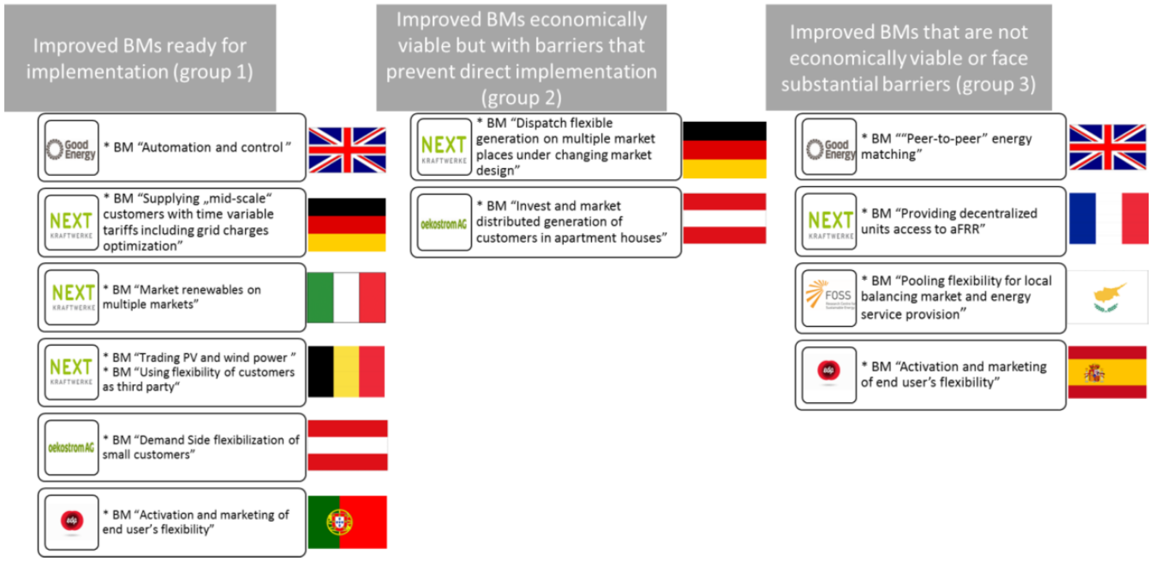

Figure 1: Improved Business Model classification [1]

2.1.2 Virtual implementation, portfolio size and KPIs

The aim of the virtual implementation is to develop a scenario for the hypothetical implementation of the improved business model. This scenario consists of three parts: developing an implementation plan, identifying the customer segments that the aggregator can address for the rollout of the BM, and describing the expected implementation issues and practices based on the aggregator's prior experience.

An **implementation plan** is developed that identifies each of the implementation phases and estimates their duration. It proposes a timeline for the virtual implementation and includes the main tasks, the tools that will be used and the most important actors involved. When possible, it is presented graphically as a Gantt chart.

The starting point of the **addressable customer segment** is the aggregator's current customer portfolio. Based on assumptions regarding the applicability of the BM on this portfolio, values for the total number of customers and portfolio size (in MW or MWh) are derived. The assumptions and their shortcomings are clearly described. To the extent possible, other technical, social and economic implementation KPIs are calculated such as the annual revenue, CO_2 emissions reduction and amount of shifted load.

The section **Implementation considerations** covers the aggregator's comments on the following implementation topics. Each of the topics is further explained through additional guiding questions. These questions differ depending on the specific activity in each improved BM.

- *Customer acquisition*

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What customer groups within the current portfolio can be targeted? What is their potential? What markets does the BM address and how saturated are they in the considered country?

- *Software/Hardware*
  What technology is necessary for the rollout of the improved BM? Is this technology available or does it need to be developed? Can this development happen internally?
- *Revenue and implementation cost*
  What are the ways that the BM could generate revenue? What is the value of the offered flexibility?
- *BM market roles*
  In case there are regulatory boundaries that prevent the implementation of the BM, what is the ideal framework that would allow this BM to be developed? What are the new market roles that the BM creates?
- *Integration in existing activities*
  What issues can arise when integrating this BM in the aggregator's existing activities? Does the BM offer benefits towards the aggregator's existing activities?

The input is collected through a BM-specific survey and an individual interview per aggregator.

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3. Next Kraftwerke Germany (Germany)

3.1 Dispatch flexible generation under changing market design on multiple markets (BM1)

Next Kraftwerke Germany (NKW DE) markets a portfolio of more than 3000 controllable renewable installations such as biogas and hydro plants. The flexibility of the portfolio is used to provide balancing services and to create additional revenues from price spreads on spot markets. In particular, the technology that NKW DE has developed to provide flexibility services is theoretically able provide automatic Frequency Restoration Reserve (aFRR) from decentral units. In July 2018, the German TSOs introduced daily procurement and 4-hour products instead of weekly procurement and Peak/Off Peak products for aFRR. The shorter products and procurement periods provide new opportunities for controllable renewables to increase the revenues by doing arbitrage between the spot markets and balancing services. However, this BM was categorized as group 2 ('economically viable business models that face one or more legal, social and/or technical barriers') because of the timing mismatch between the BestRES real life implementation and the introduction of the relevant market design changes in Germany. The BM is therefore not implemented within the BestRES project and the analysis is limited to a virtual business model implementation.

The results outlined here can deviate from the actual implementation that NKW DE may undertake in the future.

3.1.1 Implementation plan

Once the decision is made to go ahead with the rollout of this BM, the implementation will consist of the following tasks:

- **Task 1: Adapt price forecast**
  A study is done to adapt the current aFRR price forecasts to the market design changes that took place in July 2018 (from weekly procurement and Peak/Off-Peak products to 4 Hours products and Daily procurement). This task consists of a portfolio analysis and can be done by a technical project manager. The analysis of the expected price changes is done by NKW's traders and analysts.
- **Task 2: Adapt availability planning**
  The availability planning of the assets is adapted from weekly to daily.
- **Task 3: Adapt algorithms**
  The trading and forecasting algorithms are adapted to consider optimisation based on the 4-hour balancing products. This is done by NKW's software development team and requires input from the traders.
- **Task 4: Economic assessment**
  An economic assessment is made to evaluate the BM's performance.

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- **Task 5: Process implementation**
  Process integration is part of pool management and entails NKW's trading services.
- **Task 6: Adaptation of billing procedures**
  Similar to the process implementation, the billing procedures are adapted to reflect the change in procurement period.

3.1.1 Virtual implementation KPIs

A virtual portfolio is constructed based on real customer data from NKW DE. The number of potential customers for the BM is estimated based on the prequalification potential of NKW DE's portfolio. The results of this exercise are shown in Table 2.

Table 2: Virtual implementation KPIs BM1 (NKW DE)

	Current Portfolio Entire NKW DE[1]	Potential Portfolio Virtual Implementation
Aggregated units of clients	6 412	950
Portfolio size (MW)	5 406	800
Annual revenue for asset owner *Upward capacity (€/MW/yr) * Downward capacity (€/MW/yr)	* n.a. * n.a.	* 15 000 - 25 000 * 5 000 – 10 000

Out of NKW DE's total current portfolio of 4583 MW, it is assumed that 800 MW is suitable to be pre-qualified to provide aFRR services. Considering an average unit size of 843 kW, the virtual aFRR portfolio consists of 950 contributing units. Note that not the entire 800 MW that is pre-qualified necessarily participates in the market; this is the maximum volume that can be bid on the market. NKW DE did a price analysis of aFRR products for 2017 and estimates that 1 MW of upward capacity that is made available for one year will generate between €15 000 and €25 000 of revenues. One MW of downward capacity will generate between €5 000 and €10 000.

3.1.2 Implementation considerations

Customer acquisition
Customers that are already contracted for NKW DE's balancing services or peak load operation will profit from this BM, as it will add a new revenue source to their assets. It is theoretically possible to attract new customers for this BM. However, the aFRR market in Germany is already quite mature, which means that the amount of newly acquired customers is likely to be limited.

Software/hardware

[1] Data publicly available on the Next Kraftwerke Germany website

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NKW DE internally develops remote control units (their so-called 'Next Box'). This control solution is well suited to be used for the implementation of this BM. An overview of the data flows in a general flexibility BM as implemented by NKW DE is shown in Figure 2. The central control system registers information from the assets that are communicated through the Next Box. This real-time information is processed through an asset dispatch system that calculates the optimal asset dispatch schedule. The introduction of daily procurement of aFRR products mainly impacts the optimized asset dispatch process. Based on the optimized result, statistics, asset data, information provided by the customer and the requirements of the TSO, NKW calculates how much capacity is available for aFRR. The processes and optimization techniques need to be adapted to accommodate the changed market design. The optimised schedules are communicated to the assets through the control system and the Next Box. The schedules and available flexibility are simultaneously translated into balancing capacity bids and communicated to the TSO.

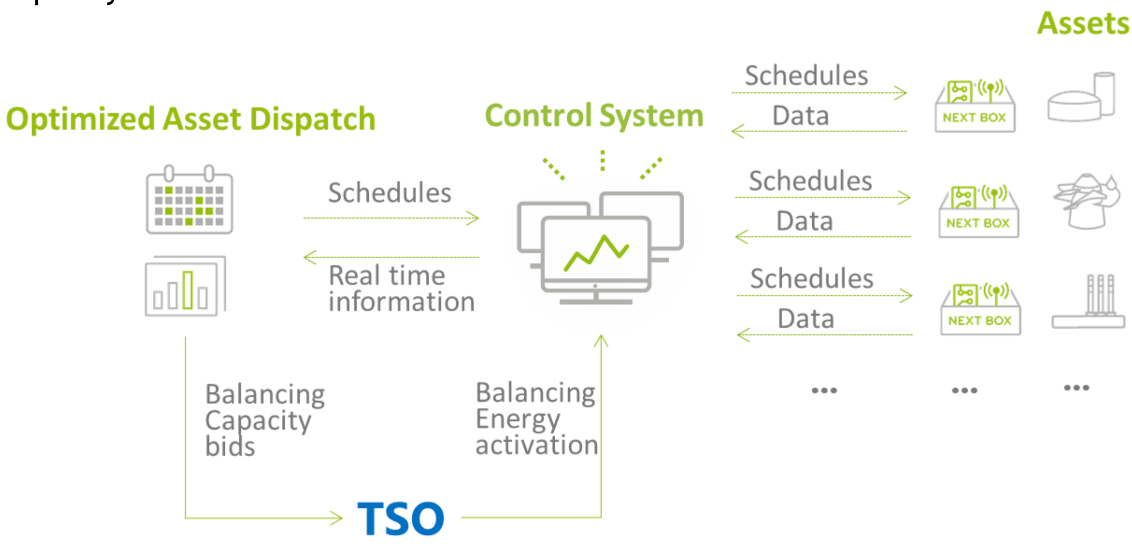

Figure 2: Overview of the data flows in the implementation of BM1

Revenue and implementation cost

There were two major changes in the German aFRR market design in 2018, both of which having a significant impact on the aFRR market price (energy prices and capacity prices) and on the revenues of this BM. The shift towards the daily procurement and the 4-hour products, as mentioned above, was part of a long-term change process. The introduction of the so called 'Mischpreisverfahren' (mixed price method), however, was planned in the short term. Under this second change, balancing capacity is awarded by considering not only the capacity price, but also the energy price. Various modifications been made since the new market design was introduced in July 2018, some of which were withdrawn again shortly afterwards. NKW DE reports that this has created a situation in which aFRR market prices are very volatile. As a result, a valid long-term trend cannot be estimated at the current stage. As a general prediction, NKW DE expects that the 4-hour products and the daily procurement will cause

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more capacity to be available on the market, which will probably lead to lower aFRR prices.

Integration in existing activities
The market design changes require the redefinition of various processes in Trading, Pool Management as well as Billing. In addition, it is required to adapt the coordination between the departments. NKW DE identifies that the BM's interdisciplinarity combined with its high complexity are the most challenging aspects. On the other hand, the BM brings the planning and acting closer to real time, which could be useful for other services related to trading renewables.

3.1.3 Conclusion

The implementation of this BM could be an important addition to NKW DE's current activities, considering that about 15% of its current portfolio is able to participate in the aFRR market. The results of the virtual implementation indicate that once the aftereffects of the recent market design changes have subsided, this BM can become an additional source of revenue for NKW DE's flexibility portfolio.

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4. oekostrom (Austria)

4.1 Valorise distributed generation of customers in apartment buildings (BM2)

The aim of this BM is to enable households that live in apartment buildings to collectively invest in a PV installation. Until recently, it was impossible to install solar panels on collective urban roofs in Austria because each installation needed to be allocated to a single metering point. Changes in the Austrian regulatory framework now explicitly allow for community generation units to be installed. This means that there is a large untapped potential for PV development on urban roofs.

The Amendment of the Electricity Management and Organisation Act 2010 from 26th July 2017 includes several provisions to promote community generation facilities. The topic of Community production facilities is specifically regulated in paragraph 16a. It states that network access beneficiaries shall have the right to operate collectively-owned generation assets, as long as the end consumers is not restricted from choosing its supplier. However, oekostrom reports that the legal framework is generally superficial and does not focus on specific requirements for practical implementation.

4.1.1 Implementation plan

Once oekostrom has chosen a business strategy to exploit this market, the implementation of the BM can be structured in three phases:

- Start-up phase
- Growth phase
- Maturity phase

Depending on the possibilities within the regulatory framework, it is expected that the start-up phase could go ahead as soon as 2019. The BM could enter the growth phase after about a year. After 5 years, the BM could be considered mature. This timeline is shown in Figure 3.

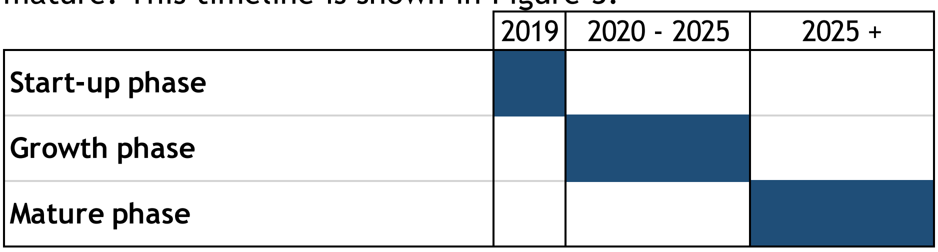

Figure 3: Virtual implementation plan BM2 (oekostrom)

Start-up Phase

In the first phase, addressed customers are those who already have smart meters in place and who live in apartment buildings where a PV system is easy to install.

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The main tasks in this phase are preparing the energy data and billing system, setting up and automating processes, and actively acquiring customers.

Growth Phase
With a higher degree of smart meter roll-out and more PV systems on apartment buildings, the business model will become better established and accepted by customers. Here, the focus lies on reducing the process cost through automation and standardisation.

Maturity Phase
Once the national smart meter rollout is completed and PV systems on newly built and renovated apartment buildings become a standard, the business model will also become a standard product in the range of suppliers. It is likely that high shares of the total potential of customers will be tapped. In this phase, it is important that the quality of the implemented processes and offered services is continuously assured.

4.1.2 Virtual implementation KPIs

A virtual portfolio is constructed based on real customer data from oekostrom. The number of potential customers for the apartment-PV-model is estimated based on the current number of oekostrom customers and additional parameters regarding dwelling type, smart meter rollout and PV suitability of the building. These parameters are based on a customer survey that was carried out in 2018. An outlook for these parameters for the periods 2020–2025 and 2025+ is used to estimate the future potential. These values are shown in Table 3.

Table 3: Estimation of parameters for potential number of customers

	2019 Startup	2020-2025 Growth	2025+ Maturity
oekostrom customers	59 000	78 529	104 522
% in appartment buidlings	44.2%	44.2%	44.2%
smart meter roll-out phase	20.1%	70%	95%
suitable for PV	10%	20%	30%

Additional assumptions are made to translate the number of potential customers into portfolio KPIs. These values are given in Table 4. A fixed specific demand and average peak load per household are assumed. Furthermore, the net revenue per customer per year is also fixed and constant in time (this does not account for the uncertainty in future wholesale electricity prices). The reduction in CO_2 emissions is estimated based on the assumption that new customers previously had an electrical supply with the average carbon content of the Austrian grid.

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Table 4: Virtual portfolio assumptions BM2 (oekostrom)

Customer		
Specific Demand	3.58	MWh/household/year
Specific average peak load	1.3	kW/household
PV Model assumptions		
Net revenue	89	€/customer/year
Acquisition cost: * Start-up phase * Growth phase * Maturity phase	 * 200 * 150 * 120	€/customer
PV capacity / customer	0.4	kW_{peak}/customer
CO_2 reduction		
Emission factor oekostrom	0	kg/MWh
Emission factor Austria	302	kg/MWh

The resulting virtual implementation KPIs are shown in Table 5. While in 2019, there are be 524 potential customers, oekostrom expects this number to grow to 4900 during the period 2020-2025. When the BM has reached the maturity phase, the total number of potential customers has increased to 13 200. The portfolio size, annual revenue and installed PV power grow according to the assumptions outlined above. The total revenue of the BM in the maturity phase is in the order of magnitude of one million. The BM will lead to acquisition and transaction costs that also grow throughout the phases.

Table 5: Virtual implementation KPIs BM2 (oekostrom)

	2019 ***Start-up***	**2020-2025** ***Growth***	**2025+** ***Maturity***
Number of customers	524	4900	13 200
Portfolio size (MWh)	1877	17 400	47 100
Annual revenue (€)	46 651	432 500	1 171 800
Acquisition cost (€)	104 834	108 380	166 145
Yearly transaction cost (€)	10 483	97 187	263 333
Installed power (MW_{peak})	0.2	1.9	5.3
CO_2 reduction (tCO_2/year)	567	5300	14 200

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4.1.3 Implementation considerations

Customer acquisition

In the **start-up** phase, the first customers will have to be identified and directly addressed, which means that these early adopters will cause considerable process costs. In the first stage, it is foreseen that only oekostrom customers will be attracted to this BM. Once the business model becomes more popular, through advertisement and media coverage, it is likely to attract more early adopter customers with environmental-friendly attitude. The innovation of this BM ideally convinces customers from other suppliers to join oekostrom. This will result in additional revenues through savings on acquisition cost.

In the **growth** phase, the model will have to become economically competitive compared to the classical supply model in order to address larger customer groups. In this phase, the model will shift from an exotic solution for a small customer group to a standard product. This means that the distribution channels become more similar to other products and less active acquisition effort will be required. As a result, a decrease of acquisition and implementation costs is expected.

In the **maturity** phase, when smart meters are almost 100% rolled out and a considerable share of apartment buildings is equipped with PV systems, the model becomes a standard product in the range of end user power tariffs. At this point, customers will be attracted by the economic benefit rather than by environmental motives.

Software/hardware

The key challenge in this business model is the data exchange process between the stakeholders within the model: the distribution grid operator, the PV operators, the supplier and the customer. The DSO is responsible for metering equipment yet depends on the PV operator for detailed input on the PV production. The DSO supplies the data to the supplier, who processes it for billing the customer. A uniform data standard is required to coordinate the data exchanges.

Once this standard is defined and the exchange processes are implemented, the energy data management systems and billing systems can be adapted to the new requirements.

BM market roles

Oekostrom identifies the following roles in the regulatory model:

- **Participants:** These participating beneficiaries may designate one operator of the community production facility who is contracted to operate the community generating facility for the participating beneficiaries and notified to the network operator.
- **Operator**: as plant manager for the community production facility: communication with the grid operator; billing with the participants.
- **Grid operator**: Data management and data processing of the energy data of the community production facility and the facilities of the participating beneficiaries.

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Even though the mentioned amendment opens up viable options for the rollout of this BM, oekostrom identifies several barriers that are inherent to the situation in apartment buildings. In many cases, apartment buildings are inhabited by tenants rather than property owners, which means that the PV installation must be included in a long-term contract between the owner and occupier. In case an occupier decides to move, there is the uncertainty whether the new tenant will be willing to take over this contract. Even when the respective property-owner inhabits the dwelling there can be complications to this BM's implementation: it is possible that mortgage lenders do not accept a third-party or collectively owned installation on the mortgaged property.

For this reason, oekostrom prefers a regulatory framework where the PV system is an independent player in the building that can offer its generated power to the suppliers that supply the apartment's individual flats. While oekostrom would not necessarily be the operator or investor of the PV facility, it could optionally offer the locally produced PV power to its customers. In the case that a customer opts for the PV self-supply option, oekostrom gets allocated a defined share of the PV feed-in. In that case oekostrom buys the PV power and resells it to the customer in the building. This scenario is shown in Figure 4. The PV installation has a separate meter that communicates with the DSO. Each of the flats in the apartment building can choose a different supplier, as is required in a liberalised electricity market. Depending on the contractual agreement between the households, the DSO and the supplier, the generated PV power is distributed to the different suppliers.

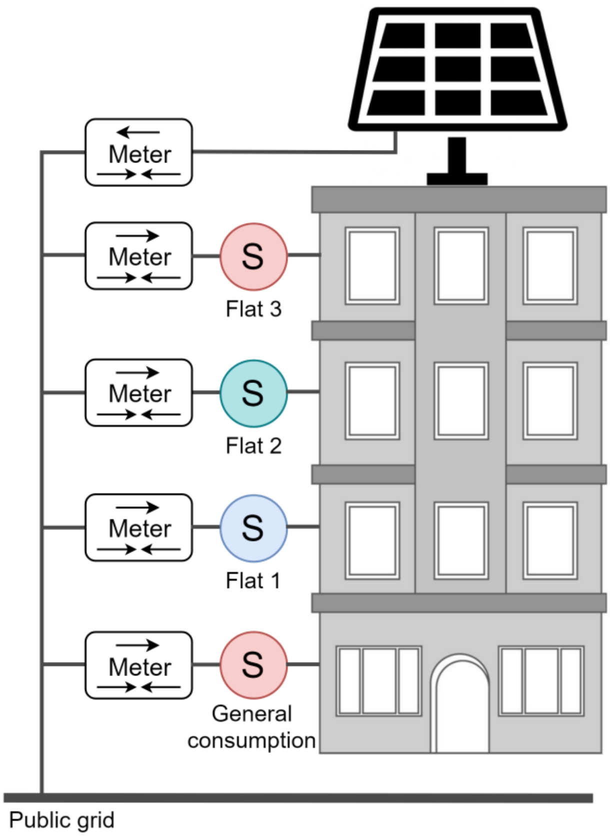

Figure 4: Market roles for oekostrom in BM2

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Revenue and implementation cost
In the preparation of the product launch there will be considerable costs for implementation: the energy data management and billing systems have to be adapted to the new requirements, which means extra personnel costs in the IT- and billing-department and costs for external software services and licenses. In the start-up phase, there will be higher costs for acquisition and processing of customers. First, customers will have to be addressed directly and the product has to be promoted face to face. Also, there will be higher costs in customer processing due to lack of automatization and the higher need of manual troubleshooting. There is no additional investment cost for metering: given that smart meters are rolled out, no further metering equipment should be required. oekostrom could generate additional revenue by increasing its sales volume through the acquisition of new customers.

4.1.4 Conclusion

The results of the virtual BM implementation indicate that the apartment building customer segment is one with a high potential for oekostrom. Considering the recent legal changes, an increase in collective PV installations on Austrian apartment buildings can be foreseen in the future. By offering a product that gives benefits to the households in those buildings, oekostrom could address a new market. However, it is important that the role of a supplier in the BM is clearly defined.

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5. EDP (Spain)

5.1 Activation and marketing of end user's flexibility (BM3)

Analogously to EDP Portugal's BM, EDP Spain plans to market the flexibility of their costumers to optimise electricity sourcing and reduce the imbalance in their entire portfolio. The BM is primarily aimed at facility managers of office buildings, though also medium to large consumers in the agro-industrial sector can be considered.

The primary reason why the BM was categorised in group 1 in Portugal, but not in Spain, is because of Spain's low imbalance prices. In Portugal, there was also an important subsidy available for the project through the PPEC program (Plan to Promote Efficiency in Electric Energy Consumption) that aims to support pilot projects on demand response (DR) and demand side management (DSM) technologies in industrial and agro-industrial companies. Other than these two reasons there were no substantial legal, social or technical barriers for the implementation of the BM. The analysis below presents the virtual implementation of the BM in Spain and a comparative analysis with the situation in Portugal.

5.1.1 Implementation plan

The virtual implementation plan is shown in Figure 5. It is estimated that the implementation would take a total of 16 months. The presented timeline is similar to the timeline for the real-life implementation in Portugal. As EDP can build on the project experience from the Portuguese use-case, it can be expected that several tasks can go quicker. However, since some tasks depend on external parties, e.g. software and equipment suppliers, there could be slight differences in timing. Furthermore, the real-life implementation in Portugal has faced severe delays, mainly due to EDP's withdrawal from the PPEC program, and client acquisition is going slower than planned. It will be important for EDP to evaluate the Portuguese project and identify the potential improvements. However, EDP reports that the implementation strategies for both countries would be similar and foresees no major differences in the implementation plans.

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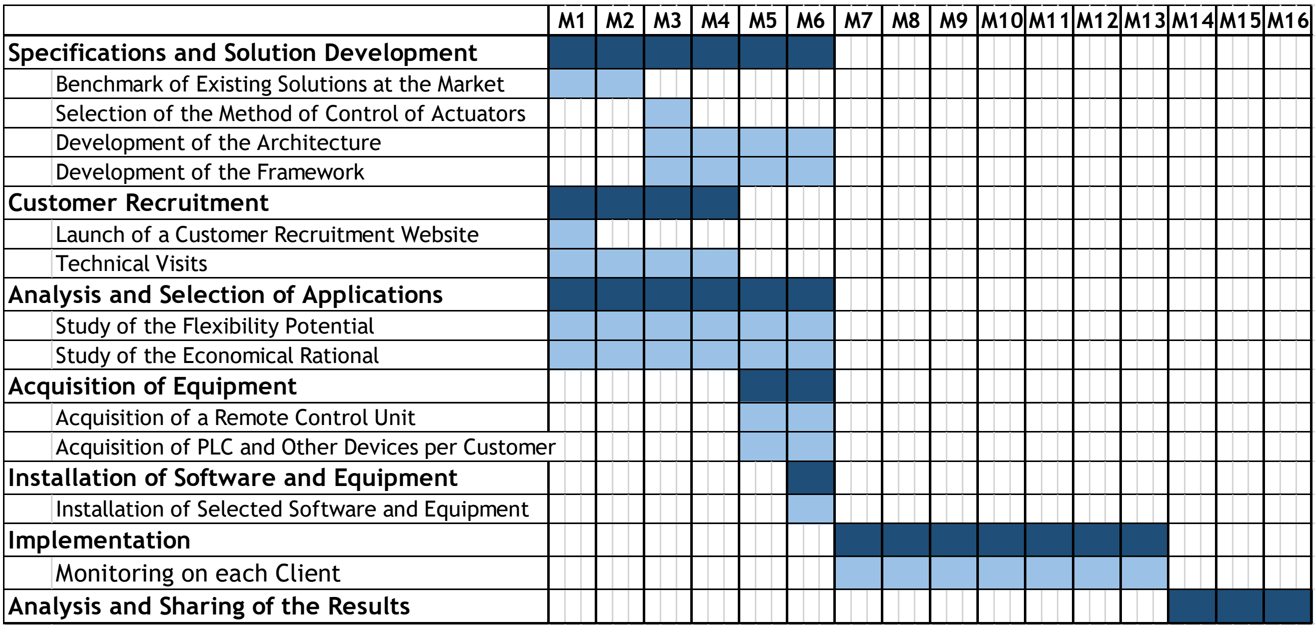

Figure 5: Virtual implementation plan BM3 (EDP Spain)

In the task **Specifications and Solution Development**, the most important involved actor is EDP's internal IT team that is responsible for the software and hardware specifications of the platform. If necessary, external consultants could be part of the solution development to adapt the software and hardware to the Spanish context.

Similarly to the BM in Spain, **Customer Recruitment** consists of two tasks: development of a recruitment website where potential customers can pre-register and technical visits to evaluate the business potential of the pre-registered customers. The most important actors involved are the commercial team (mainly the account managers) who are responsible for client acquisition and the technicians who are responsible for the technical visits.

After the technical visits, the technicians write technical reports to **analyse and select the BM applications.** A financial team studies the flexibility potential and the economical rational for each client based on the technical reports.

A procurement team is responsible for the **acquisition of equipment**. They find the best supplier for a technology solution with the right specifications.

Subsequently, an installation team **installs the software and hardware** at the consumer side. The software and equipment include the remote-control unit, the PLC and all the necessary software and equipment to create an IT platform to control and monitor all clients. The installation team can either be internal or external. In the **demonstration phase,** a technical team monitors the system, including all the control schemes, the control actions and activities of the platform. Finally, an analytics team performs a technical and economic analysis of the demonstration results.

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5.1.2 Virtual implementation KPIs

The number of potential (virtual) customers for this BM is estimated based on real customer data of EDP's current portfolio in Spain. The virtual portfolio is derived using a top-down approach that starts from EDP's total number of B2B customers and an assumption regarding the business potential of the BM in this customer segment. It is assumed that 5% of EDP's business customers have assets that are compatible with this BM. This is used to derive the portfolio capacity, and the annual consumption. It is assumed that 10% of the annual consumption can be shifted. These assumptions are summarized in Table 6. The resulting portfolio KPIs are shown in Table 7.

The virtual portfolio consists of 257 clients with each an average annual consumption of 2000 MWh and an average capacity of 0.455 MW. The consumption of one average customer corresponds to the electricity consumption of an office building of about 13 000 square meters[2]. It is assumed that an average client offers 201.4 MWh of load flexibility per year. EDP estimates a revenue potential due to flexibility of €41 000 per customer per year. This means that one MWh of flexibility creates about €200 of value. This leads to a total annual revenue due to flexibility of €10 650 000.

Table 6: Virtual portfolio assumptions BM3 (EDP Spain)

BM potential in B2B segment: - Annual consumption - Maximum capacity	 5% of total 5% of total
Load shifting	10% of portfolio's annual consumption

Table 7: Virtual implementation KPIs BM3 (EDP Spain)

	EDP Portfolio in Spain	Estimated Potential
Number of clients	5 149	257
Annual consumption (MWh)	10 350 000	517 500
Capacity (MW)	2 340	117
Annual revenue (€/year)	n.a.	10 650 000
Amount of shifted load (MWh/year)	0	51 750

CO_2 emission reduction

The average carbon content per MWh of electricity on the Spanish market at a certain time depends on the generation units that are online at the time. Since the generation mix will at the same time influence the electricity price, there is a correlation between the instantaneous electricity price and the carbon content

[2] Considering an annual consumption of 150 kWh/m²/year.

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of the produced power. Low carbon content correlates with low electricity prices, which reflects the low marginal cost of renewable energy sources. If the BM would only optimize energy sourcing on the day-ahead market, this correlation could be used to derive an estimate for the effect of load shifting on the CO_2 content of the consumed power: a certain percentage of sourced electricity shifts from time of high prices and carbon footprint to time of low prices and footprint. However, since imbalance prices are also included in the optimization, a decision to shift load is not only based on the market price and this price/carbon correlation does no longer accurately represent the algorithm. More advanced techniques that consider the specific time of load shifting are thus necessary to assess the impact of this BM on the carbon content of the consumed power. The reader is referred to BestRES report “Quantitative Analysis of Improved BMs of Selected Aggregators in Target Countries” [4] for the results of detailed simulations for this BM in Portugal.

5.1.3 Implementation considerations

Customer acquisition

This BM is initially mainly aimed at the building segment of EDP’s portfolio in Spain. A priori, there are no particular requirements that the building must fulfil, though in the acquisition step its flexibility potential and the economic rational are evaluated on a case-by-case basis. The implementation will only take place if the asset is sufficiently controllable and the flexibility is economically lucrative. In a second stage, when this solution has been fully developed, the implementation could be widened to include other types of clients such as chemical industries and metallurgies.

Even though EDP has a much smaller portfolio in Spain compared to Portugal, the acquisition approach would not differ substantially between the two countries. In both cases, the BM would mainly target existing customers who are offered this solution alongside current EDP services through the relevant account managers. Other strategies such as marketing solutions to expand the current portfolio would also be considered to increase the amount of available flexibility. The value proposition of this BM is that it allows to valorise the customers’ flexibility. Flexible clients can in this way be offered a lower electricity price. Additionally, the unlocked value of flexibility allows EDP to offer its clients customised services such as a dedicated account manager, energy monitoring solutions and maintenance. However, EDP identifies that the BM’s acquisition cost can be high since the technical and economic flexibility potential have to be evaluated on a case-by-case basis. There is also a significant hardware cost. The financial risk of these operations is taken by the retailer. There is thus a need for accurate flexibility models and a standardised method to efficiently evaluate the potential costs and benefits for each customer.

Software/hardware

The functionality of the technology would be identical to the service used in Portugal since the market and the targeted B2B portfolio clients are the same. EDP therefore doesn’t expect any relevant differences between both solutions or any special adaptions from the technology developed for Portugal. The

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hardware equipment and the IT platform are specified by EDP and acquired and developed by external suppliers. Interoperable and off-the-shelf technologies are used to reduce the necessary development time and to limit the risk of single supplier dependence. However, internal delays in this approach can be caused by the selection and qualification of the providers.

Market roles

EDP's assumed market roles in this BM are shown in Figure 6. EDP is the intermediate between the wholesale market and their electricity clients. They take the combined role of supplier-aggregator in which they supply electricity to their clients and provide them with aggregation services in the form of load set points. This flexibility is used to optimise electricity sourcing imbalances for EDP's entire portfolio. The revenue streams are indicated at the bottom of the figure. The optimised market participation through flexibility leads to indirect revenues in the form of a cost reduction for EDP. Part of the saving is passed on to the flexibility providers (the electricity clients) in the form of flexibility payments.

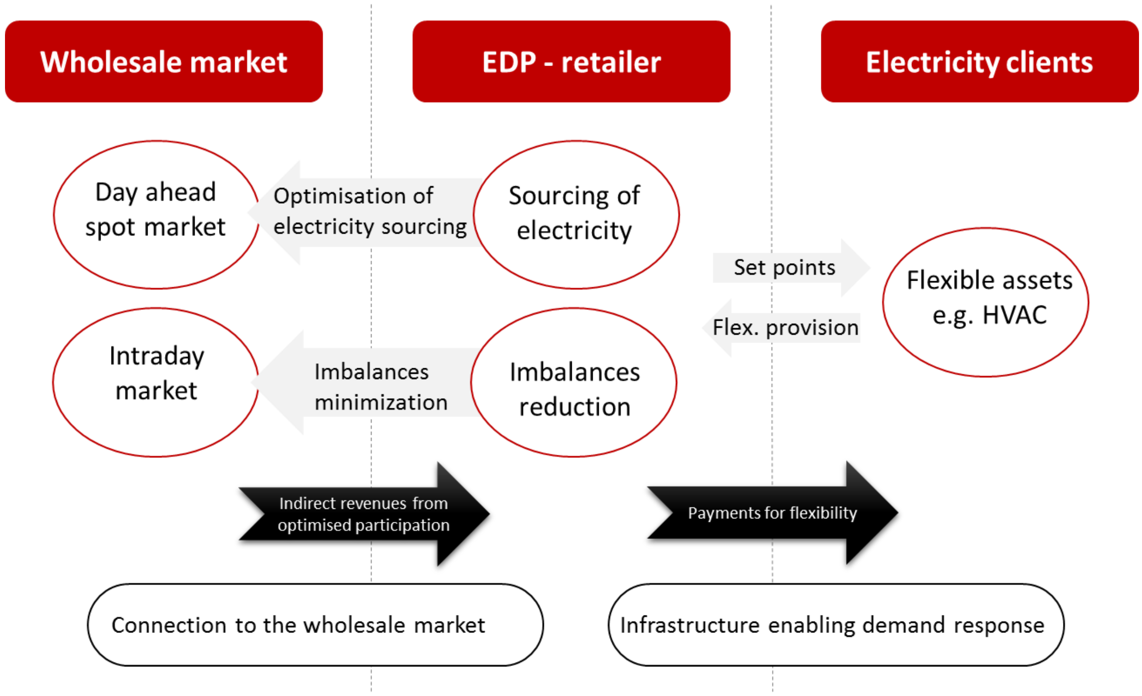

Figure 6: Market roles for EDP Spain in BM3

5.1.4 Conclusion

The implementation experiences that EDP is gaining through the BM's rollout in Portugal could be used as a starting point for the BM's implementation in Spain. The results of the virtual implementation exercise indicate that the controllability of the assets is an important parameter in the performance of the

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BM. Considering EDP's large B2B customer portfolio in Spain, this BM could significantly increase the valorisation of the portfolio flexibility.

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6. FOSS (Cyprus)

6.1 Pooling flexibility for local balancing market and energy service provision (BM4)

The improved BM proposed by FOSS has the aim to offer grid services to the Cypriot transmission/distribution grid by pooling flexibility from the residential and public sectors. At the moment in Cyprus, it is still impossible to go ahead with real-life implementation of aggregation since the necessary market rules are not yet in place. There are no separate BRPs and the transmission system operator has full responsibility for grid balance. Cyprus is in this sense not a mature market and therefore the BM was classified in group 3 “BM that are not economically viable or face substantial barriers”.

The starting point of the virtual implementation are the results of the GOFLEX[3] project that is currently taking place in Cyprus. GOFLEX is a demonstration project across two pilot sites in Cyprus that looks at the potential of smart grid technologies in providing flexibility to the distribution grid. The first pilot site is a microgrid on the campus of the University of Cyprus, and the second site is a collection of residential consumers. Compared to the virtual implementation of the other improved BMs, the pilot sites offer the advantage that measured data of technical parameters can be used. The virtual implementation discusses the implementation of the pilot project as it is, focussing on the potential of self-consumption optimisation.

6.1.1 Implementation plan

An overview of the implementation plan is given in Figure 7. The pilot implementation is expected to take a total of 2.5 years (ten quarters).

The development of the University of Cyprus Microgrid consists of three main tasks: installing and connecting the existing assets, constructing new assets and developing a mini-grid controller. It is expected to take several years before the microgrid, the large PV and storage will be operational. Installing and connecting the prosumers in Cyprus is expected to be finished after one year. Monitoring of the pilot sites is a constant process that lasts until the end of the project. At the end, it is foreseen that the pilot results are analysed through studies on the flexibility potential and economic rational.

[3] https://www.goflex-community.eu/location/7/GOFLEXTrialsiteNicosia.html

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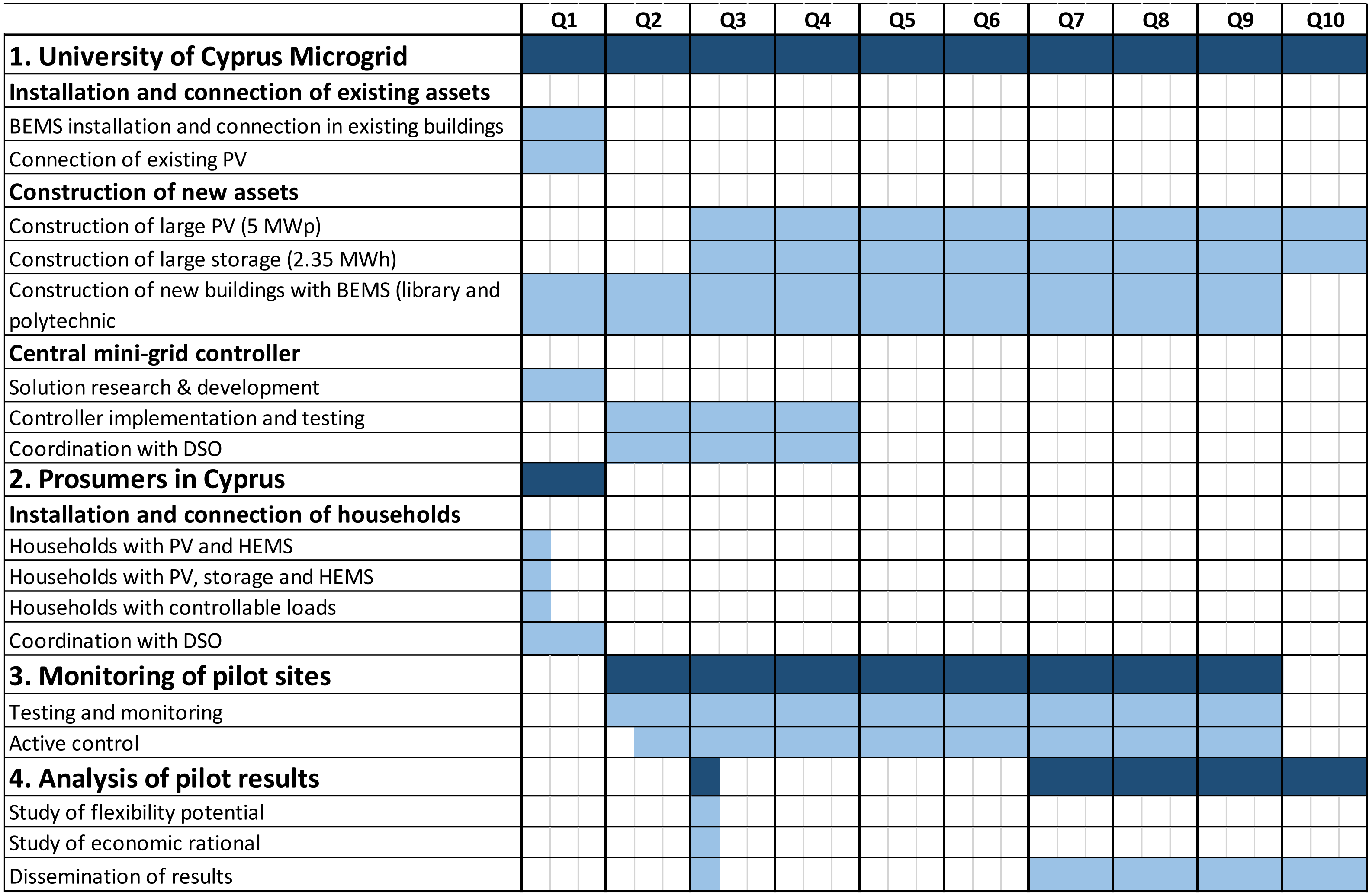

Figure 7: Virtual implementation plan BM4 (FOSS)

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6.1.2 Virtual implementation KPIs

The first pilot site consists of the electrical loads and generation units at the University of Cyprus campus. These include rooftop and ground-mounted PV installations, and several buildings on the campus with Building Energy Management Systems (BEMS) to control the HVAC systems. Furthermore, the construction of a large PV park (10 MWp generation) and a battery storage bank (more than 1 MWh capacity) is planned within the coming years. To increase the efficient operation of the individual assets, the virtual BM implementation assesses the possibilities to operate the university campus as a centrally-controlled microgrid. This is possible since the campus is fed from a single point connected to the external grid, with various internal medium voltage substations that supply the university buildings. The microgrid controller tracks the energy consumption of all the university buildings and predicts the amount of available energy flexibility by considering weather data and PV generation forecasts. It has been identified that the main sources of flexibility are the university's air conditioning units. The microgrid control is based on a central point of control that collects all measurements and takes centralised decisions. It is furthermore connected to the servers of the DSO through a dedicated glass fibre connection. By operating in such a way, the university can maximize its self-consumption, minimize energy cost and is available to dynamically match its energy demand against the available grid capacity.

The second use case of flexibility are 30 dispersed prosumers within Cyprus. Three different categories of prosumers are identified: prosumers with a rooftop PV installation and House Energy Management Systems (HEMS), prosumers with a rooftop PV installation, energy storage system (battery) and HEMS and prosumers with one controllable load using smart controllers. The prosumers have direct access to their consumption via the installed smart metering infrastructure. The flexible appliances in the prosumers' homes will be centrally controlled by the DSO's operational division. The DSO regulates the households' power exchange with the grid by shifting the consumers' consumption patterns.

The implementation KPIs, based on the GOFLEX trial project, are summarised in Table 8. The total portfolio size is 3.25 MW with a total annual consumption of 12 074.36 MWh. The amount of flexibility provision is around 10%, meaning that this percentage of capacity can act as flexible load responding to DR needs of the local DSO. This possibility leads to a total of 366.3 MWh of load that can be shifted annually.

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Table 8: Virtual implementation KPIs BM4 (FOSS)

	Test site 1: UCY Microgrid	Test site 2: Residential Consumers	Total
Number of connection points	16	30	46
Annual consumption (MWh)	11 858	216.12	12 074
Peak power (MW)	3.12	0.13	3.25
Amount of flexibility provision	11%	10 %	10.9 %
Annual shifted load (MWh)	358	8.3	366.3
Self-consumption	54.5%	61%	55.4%
CO_2 reduction (tCO_2/year)	374	6.8	380.8

6.1.3 Implementation considerations

Customer acquisition

Since the GOFLEX pilot project is an initiative of the University of Cyprus, customer acquisition for this project is different from the commercial BMs covered in this report. The university made the decision to switch its electricity supply entirely to renewable energy sources. As part of this commitment, they started to develop a centralised system that efficiently manages all local energy resources. The aim is to minimise energy costs and maximise services to the local grid. It is thus the university's interest and initiative to develop the project.
The trial with residential prosumers targets to create a test bed for residential grid services through household flexibility. It was identified that trained personnel is a very important factor to acquire the necessary household portfolio. Various technologies are included in this aggregated mix of prosumers and the selected prosumers therefore had to be informed of the trial implications. To this end, specially designed forms with relevant questions were used. Furthermore, meetings were organised between the selected prosumers and the researchers to identify possible flexible loads in the households. Technical clarifications were conducted to identify the suitability and applicability of the hardware and communication infrastructure. The benefits to the prosumers were always clearly communicated throughout the acquisition process, which helped to convince them of the general benefit of their participation. FOSS identified that the implementation could not move forward unless there was formal acceptance by the prosumer.

Software/hardware dependency

Through the GOFLEX project, both software and hardware are developed to facilitate flexibility trade that serves the entire system: from the prosumer up to aggregators, BRPs, MOs, DSOs, Microgrid operators / Energy Community operators etc. All the hardware and software developed under GOFLEX is

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company bound and agreements are in place to use the developed products for commercial applications that will follow.
In addition, the University of Cyprus is working with INEA, a company from Ljubljana, to build an open protocol central management system that will unify all existing Building Energy Management Systems, communicate with storage management systems, smart meters and other field sensors. All controls are merged at a single point; thus, they are in a position to act as a local BRP that can manage flexibility and optimise resources.

BM market roles
The virtual market roles in the case of the university microgrid are shown in Figure 8, while Figure 9 shows the roles for the case of the residential prosumers.

In both the presented schemes, the **Distribution System Operator** (DSO) is the *end-user* of the generated and offered demand response. In the bundled electricity sector in Cyprus, the role of DSO is fulfilled by the Electricity Authority of Cyprus (EAC). The use of DR is intended for congestion management on the distribution grid, and the offered service can thus be considered an ancillary service to the DSO. In the case of a commercial rollout of the BM, special provisions would have to be formulated to enable the DSO to pay for the grid services.

The role of the **Balance Responsible Party (BRP)** must be fulfilled by an actual player on the territory of the DSO, that nominates energy volumes for its portfolio and sells ancillary services to the DSO. The role of aggregator is either contained in the BRP's role, or the aggregator is an external party from which the BRP engages services.

The **Aggregator** aggregates the DR of all the connected prosumers and the aggregated DR of the microgrid. The role can be played by the BRP (aggregator-BRP model), or the aggregator's role can be played by a party that is not connected to the DSO.

In the case of the microgrid campus, several additional roles can be identified:

Microgrid responsible
- The role can be played by the existing facility manager as the campus operator with the support of FOSS.
- They aggregate the DR of all connected prosumers in the microgrid and trade it as a local BRP.
- The campus operator, acting as the local BRP of the microgrid, will use the available data to trade the flexibility according to the DSO needs.

Campus prosumers (10-15, and currently at least 5)
- EV charging/discharging station for several EVs in parallel (currently one existing).
- One PV production installation (350KW).

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- Several buildings on the campus that have separate metering points and are equipped with smart meters.

In the case of residential prosumers, the situation is slightly different since the prosumers are on the DSO territory. There is therefore no operator that stands between them and the BRP.

Residential prosumers

- Prosumers have two smart meters installed. The PV installation is measured separately because these measurements are used in other research projects.
- They have an energy management system installed that can control the processes and devices (consumption, production, storage).
- In an advanced scenario, they are willing to give the BRP access for external direct control of individual devices.

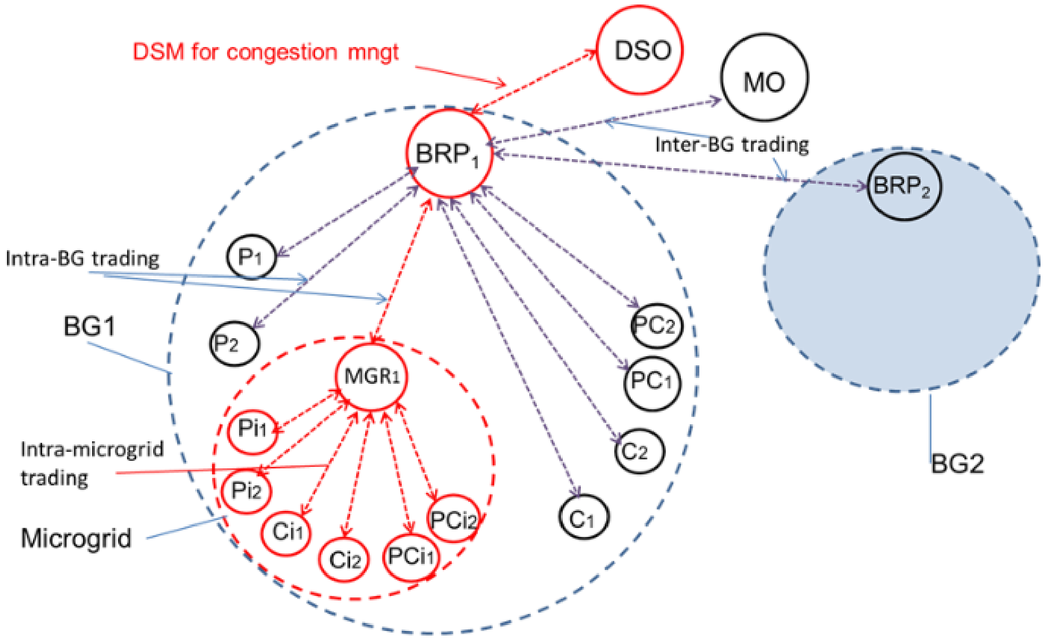

Figure 8: Market roles in BM4 (University microgrid)

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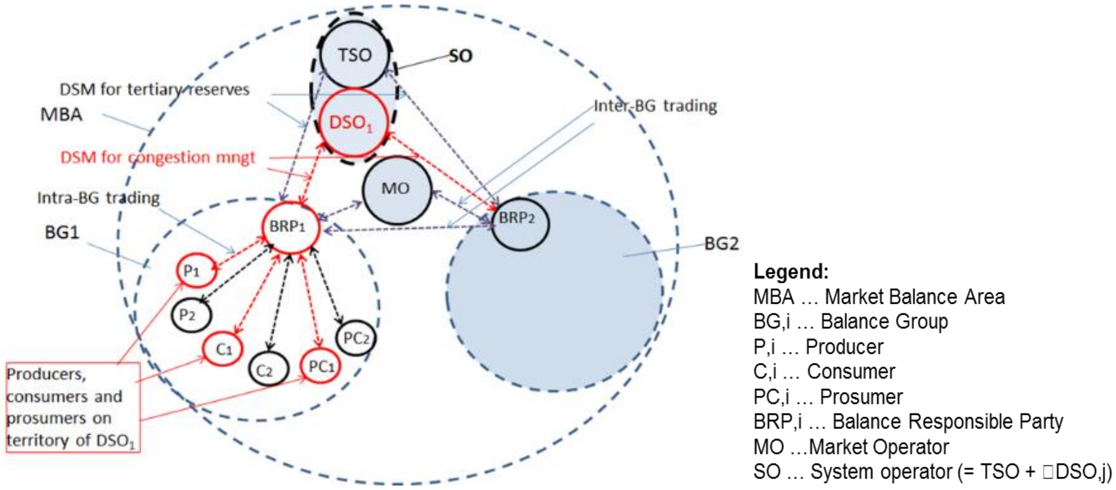

Figure 9: Market roles in BM4 (Residential prosumers)

Revenue and Implementation cost and revenue

In an unbundled electricity sector with well-functioning, liberalised markets, the offered availability would be valorised by maximizing self-consumption and through the applicable market mechanisms. However, in the Cypriot case only the self-consumption revenue mechanism is possible since open electricity markets do not exist. This means that the monetary value that the offered flexibility is able to create is significantly less than that in other regulatory contexts. The financial analysis in this report focuses on self-consumption as the only revenue mechanism. We differentiate between the two cases: the university campus and residential households.

The tariff that is currently being used for the **university** as a commercial consumer on the medium voltage system is based on five components:

- An energy charge in c€/kWh,
- A network charge in c€/kWh,
- An ancillary service charge in c€/kWh,
- A monthly meter reading charge,
- A monthly supply charge.

The charges are different between peak and off-peak time-of-use and the time ranges for each period depend on the season. Due to Cyprus' dependency on oil as a primary energy source, the tariffs are coupled to the cost of heavy fuel oil and the prices are adjusted every payment period. Currently, the adjustment price amounts to 2.731 c€ per kWh.

The consumption tariff did not change when renewables were first integrated on the university campus. The remuneration for locally produced power is however based on a new tariff mechanism called net billing which entails the following:

1. The university is directly connected to the grid and utilizes the grid as a physical storage in case there is an excess or deficit in generation on-site.

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2. When energy is consumed from the grid, the applicable tariff is the one described above depending on time of the year, week and day.
3. When energy is injected in the grid, the university is paid at the prevailing RES price that is periodically approved by the Regulator. Currently, this price stands at 10.02 c€/kWh.
4. Any energy generated and used either for direct consumption or charging the battery the university will pay the following levies and charges:
    a. Support for low income family + VAT.
    b. Net billing charge for being connected to the system and getting support + VAT.
    c. Green tax.

FOSS carried out a financial analysis based on this tariff to check the investment cost and expected revenue to install the 5 MW PV system and the 2.35 MWh storage system that is foreseen in the project. The results are summarized in Table 9. The above costs and figures do not consider any other DR possibilities apart from efficiently managing the storage flexibility regarding self-consumption.

Table 9: Financial analysis of university campus BM4 (FOSS)

	Test site 1: UCY Microgrid
Annual load of the university	13 056.890 MWh
Annual generation from PV	8 910 000 kWh
Annual cost of electricity without PV and storage	€2 413 969
Annual cost of electricity with PV and storage	€1 179 485
Annual savings	€1 234 484
Cost of investment	€6 410 000
Years to pay back (including all running costs)	Six to seven years

The **domestic prosumers** in this trial are currently on a net metering tariff allowing installation of PV systems up to 10 kWp. Since this tariff allows selling and buying at the same price, prosumers are free to use the grid as a physical storage, provided that their generated energy is not more than what they consume in a year. If it is more than the amount they consume, then they do not get any money for the surplus. However, they are entitled to pass their surplus from month to month throughout the year, starting in February. The prosumer is charged an annual capacity payment for every kWp he has installed. This consists of the following components:

- The system cost including all services: €37.03 + VAT / kWp.
- A green tax.

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- A levy for the handicapped people + VAT.

The above costs amount to about €65/kWp per year including all taxes and levees. Considering the described tariff scheme and an optimally sized PV-system (annual production is equal to annual consumption), this tariff results in the financial results as shown in Table 10.

Table 10: Financial analysis of residential prosumers BM4 (FOSS)

	Test site 2: Residential prosumers Single prosumer	Test site 2: Residential prosumers Entire portfolio
Annual consumption	7.2 MWh (1 household)	216 MWh (30 households)
Cost per kWp for residential systems	€1500	€1500
Annual production per kWp PV	1500 kWh/kWp	1500 kWh/kWp
Optimal PV size and cost	4.8 kWp at €7200	144 kWp at €216 000
Annual cost of electricity without PV	€1440	€43 200
Annual cost of electricity with PV	€312	€9360
Annual savings	€1128	€33 840
Payback period	Less than 7 years	Less than 7 years

6.1.4 Conclusion

The virtual implementation results present several possible frameworks for flexibility provision on the local balancing market and electricity markets in Cyprus. The current market design is not ready to fully use the available flexibility for grid services and future changes will require a clear definition of market roles. Considering only self-consumption maximisation as a revenue mechanism, PV installations are profitable investments.

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7. Conclusions

The objective of this report is to evaluate the improved BestRES BMs that are economically viable but face barriers that prevent direct implementation by means of a virtual BM implementation. The covered improved business models are:

- **BM1:** "Dispatch flexible generation under changing market design on multiple markets" by Next Kraftwerke Germany in Germany
- **BM2:** "Invest and market distributed generation of customers in apartment buildings" by oekostrom in Austria
- **BM3:** "Activation and marketing of end user's flexibility" by EDP in Spain
- **BM4:** "Pooling flexibility for local balancing market and energy service provision" by FOSS in Cyprus

This theoretical exercise covers three areas: an implementation plan that indicates a possible timeline for the BM implementation, the development of a virtual BM portfolio based on real customer data, and a description of the implementation practices based on the aggregator's prior experience. The principal observations are summarised hereunder.

7.1 Due to the wide variety of BMs, the implementation can take from several months to several years.

Depending on whether the BM requires the installation of physical generation assets, implementation can take from several months to several years. BM1 (NKW DE) and BM3 (EDP Spain) use the available flexibility from the customers' assets to create extra value through market mechanisms (respectively aFRR and imbalance mechanisms). The aggregators in these BMs have already developed control and communication solutions in the past, which means that they proceed more quickly to the implementation and monitoring phase of their BMs. In the case of BM2 (oekostrom) and BM4 (FOSS), the implementation plan includes an installation phase for generation and storage units. This phase takes up a significant amount of the implementation schedule.

7.2 The aggregators plan to target existing clients

One of the main conclusions of the virtual implementation considerations is that all the aggregators plan to target existing customers in the first phase of the implementation. The existing customer base is an easily accessible customer segment to market new products. This can, for example, lead to pilot projects that are set up.

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7.3 Because of the diversity in the analysed BMs, the virtual portfolio KPIs vary widely and are highly BM-specific.

The virtual portfolios give an estimate of the implementation potential based on the aggregators' real customer data. Because of the variety of activities per analysed BM, the KPIs regarding portfolio size are hard to compare: the portfolio size in BM1 (NKW DE) is used to participate on the aFRR market, while BM2 (oekostrom) and BM4 (FOSS) refer to self-consuming power from PV assets using local loads and BM3 (EDP Spain) considers flexibility of medium-sized consumers. It is possible to compare the portfolios when considering the annual revenue, which varies from €432 500 per year for BM2 (oekostrom) up to €10 650 000 per year in the case of BM3 (EDP)

7.4 Revenue uncertainty and undefined market behaviour are major limitations for the rollout of the BM.

In all of the discussed BMs, either regulatory changes are necessary to allow for an actual BM rollout, or the effects of recent regulatory changes need to be assessed before implementation can take place. In the case of BM1 (NKW DE) and BM2 (oekostrom), the regulatory framework has changed recently, and it is still uncertain which opportunities the changes create for the aggregators. The main issue that these aggregators face is the uncertainty of revenue due to unpredictable market prices. In the case of BM3 (EDP Spain) and BM4 (FOSS), the current market design does not allow to fully valorise the available flexibility. This means that the financial incentives are not strong enough to go ahead with the real BM implementation.

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Technical references

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Dissemination level*	PU
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Lead beneficiary	3E
Contributing beneficiary/ies	Next Kraftwerke Germany, oekostrom, EDP, FOSS
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* PU = Public

PP = Restricted to other programme participants (including the Commission Services)

RE = Restricted to a group specified by the consortium (including the Commission Services)

CO = Confidential, only for members of the consortium (including the Commission Services)

v	Date	Beneficiary	Author
1.0	09/10/2018	3E	Simon De Clercq and Carlos Guerrero Lucendo
1.1	03/12/2018	3E	Revision by the project partners
1.2	12/12/2018	3E	Antoon Soete and Odilia Bertetti
1.3	13/12/2018	WIP	Silvia Caneva

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2.0	19/12/2018	3E	Simon De Clercq

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