Generalized Operational FLEXibility for Integrating Renewables in the Distribution Grid (GOFLEX)

D7.2 Business Model Design and KPI Definition – Use Case 1

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Executive Summary

The report D7.2 is the second deliverable of WP7. In this document, the effects of the GOFLEX project and the respective consequences of the trading of flexibility in Cyprus have been examined. For this reason, different actual and future Business Models have been taken into consideration, while the respective KPIs for monitoring the success have been proposed. Two different test cases are examined: the microgrid at the university campus and the dispersed prosumers within Cyprus.

For the Cyprus demonstration cases, four (4) different business cases have been identified and analysed. For each one business case, the performance indicators are initially presented, in order to measure the respective effectiveness. Furthermore, the details of each test case are illustrated through functional models, UML diagrams, while a Business Canvas shows in brief the stakeholders with the respective roles in each business model.

After the presentation of the different business cases, the methodology of the Cost-Benefit Analysis for assessing the proposed Business Models is introduced. This part is very important in order to elaborate the most promising business model. Finally, the current situation for introducing the business models in the electricity market in Cyprus is discussed. The several barriers together with opportunities are highlighted, resulting in the business cases that can be implemented in Cyprus.

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List of Acronyms and Abbreviations

Abbreviation	Definition
ACER	Agency for the Cooperation of Energy Regulators
BEMS	Building Energy Management System
BEUC	The European Consumer Organisation
BRP	Balance Responsible Party
CEER	Council of European Energy Regulators
CEMS	Central Energy Management System
CEN	European Committee for Standardization
CENELEC	European Committee for Electrotechnical Standardization
CERA	Cyprus Energy Regulation Authority
DoA	Description of Action
DR	Demand Response
DSO	Distribution System Operator
EAC	Electricity Authority of Cyprus
EASE	The European Association for Storage of Energy
EASME	Executive Agency for SMEs
EDSO	European Distribution System Operators' Association for Smart Grids
EEGI	European Grids Initiative
EERA	Technology Platforms and the European Energy Re-search Alliance
EIIs	European Industry Initiatives
ENTSO-E	European Network of Transmission System Operators for Electricity
ESMIG	European voice of smart energy solution providers
ETIP SNET	The European Technology and Innovation Platform "Smart Networks for the Energy Transition”
ETIPs	European Technology and Innovation Platforms
ETSI	European Telecommunications Standards Institute
EV	Electric Vehicle
GEODE	European independent distribution companies of gas and electricity
H2020	Horizon 2020
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
ISGAN	International Smart Grid Action Network

JRC	Joint Research Centre
kWp	Kilo-Watt peak
LCE	Low-carbon energy (see H2020 competitive low carbon energy call)
MWp	Mega-Watt peak
RES	Renewable Energy Source
SCADA	Supervisory control and data acquisition
SEO	Search Engine Optimization
SET-Plan	European Strategic Energy Technology Plan
ToU	Time Of Use
TRL	Technology Readiness Level
TSO	Transmission System Operator
VPP	Virtual Power Plant

1 Introduction

1.1 Purpose

1.1.1 General context

Within the next years, a remarkable energy transition in terms of technology and business processes is expected. This development from traditional to smart electricity system challenges the present model of a centrally managed electricity system, paving the way for the introduction of a new electricity concept that enables the cost-effective use of energy flexibility in the distribution grid. Till to date, several analysis have been conducted dealing with the business model of the flexibility, however GOFLEX goes a step beyond by comparing three different demonstration cases in electricity markets with different maturity and liberation level.

Initially, a business model describes the ways that a company will create and capture value, by selling a product to customers. However, apart from the financial segment of a business model, its most comprehensive part consists of the operational and strategic levels. A comprehensive business model should also include elements that describe a company's or a product's value proposition, value network, customer network and key activities.

Key Performance Indicators (KPIs) are important metrics used to monitor performance based on business objectives. They measure the improvement or deterioration of the performance of an activity that plays an important role for the successful operation of a business and they vary depending on the business. KPIs are based on business objectives. As business objectives are quantifiable, measurable and result-oriented, they can be transformed into a KPI index which is used by an organization in order to measure a certain dimension of the process in terms of set targets, goals or objectives.

KPIs do not relate to a specific execution of a process but are calculated using data from multiple execution blocks. Within GOFLEX, a list of identified KPIs will be used to evaluate the different use cases that are to be tested within the project. This set of KPIs will be used for the definition of the innovative business models that support the objectives of the project.

1.1.2 Business models in GOFLEX

This document consists of one of the deliverables of the demonstration sites. More specifically refers to the Cyprus demonstration case (WP 7), where two different type of prosumers are identified: the university campus microgrid and the dispersed prosumers within Cyprus. This deliverable (D7.2) is the second deliverable of WP7, 12 months after the beginning of GOFLEX

(November 2016 – October 2017). The reader will find an extended analysis of the business models for the Cyprus demonstration cases with their Key Performance Indicators and details about the Cost-Benefit Analysis approach. Finally, the electricity market in Cyprus with the respective obstacles for adopting the proposed solutions is presented.

1.2 Related Documents

This document is related to the similar deliverables of the other WPs.

1.3 Document Structure

The structure of this document is as follows:

Section 2 described in detail the use cases, including the Canvas Model, the Cost-Benefit Analysis and the definition of Business Model KPIs.

Section 3 focuses on the general strategy of the Business Cases in Cyprus. The two type of prosumers (university campus microgrid and dispersed prosumers within Cyprus) are included.

Section 4 presents the Canvas Business Models for the services offered by Cyprus demonstration site. Four (4) different business case scenarios are analysed in detail.

Section 5 presents the cost-benefit analysis and how it will be implemented in the Cyprus demonstration site.

Section 6 describes the business Key Performance Indicators for the implemented services with all the metrics.

Section 7 deals with the correlation of the trial business KPIs and the project impact KPIs.

Section 8 analyses the current regulation framework in Cyprus and discusses the obstacles for adopting the presented business solutions.

Finally, Section 9 summarizes the deliverable by highlighting the most prominent business solution.

2 GOFLEX systematic framework conditions

There are three GOFLEX systemic framework conditions which are shared and used for all trial sites:

1. A shared methodology approach,
2. A shared understanding of the structure of the future energy system, its roles and processes,
3. A shared approach how to the individual KPIs of the trial sites support the KPIs of the GOFLEX project.

2.1 GOFLEX Methodology Approach

In GOFLEX new business models will be demonstrated and verified in all trial sites. To ensure a common language and the comparability of results, a specific set of methodologies will be used

1. The intended interactions between actors for the business model to work out will be described as use cases and visualised as UML Diagrams using Grady Boochs understanding of UML diagrams (Booch, 1999).
2. To describe the business models the Osterwalder business model Canvas will be used (Osterwalder, 2010)
3. No business model will be implemented if there is not the assumption of a positive business case. Though the data for this assessment are actually produced within the trial phase of this project, the financial figures will be assumed based on existing predictions and other pilot projects and a simplified projected Cost-Benefit-Analysis will be carried out per business model.

2.1.1 Use Case Descriptions/ UML diagrams

A use case is a methodology used in system analysis to identify, clarify, and organize system requirements. The use case is made up of a set of possible sequences of interactions between systems and users in a particular environment and related to a particular goal. The use case should contain all system activities that have significance to the users.

A use case diagram is a graphic depiction of the interactions among the elements of a system.

Use case diagrams are typically employed in UML (Unified Modelling Language), a standard notation for the modelling of real-world objects and systems.

A use case diagram usually contains four components.

- The boundary, which defines the system of interest in relation to the world around it.
- The actors, usually individuals involved with the system defined according to their roles.

- The use cases, which relate to the specific roles played by the actors within and around the system.
- The relationships between and among the actors and the use cases.

Figure 1 Use Case diagram example "Microgrid and DER owners offering ancillary services to each other and the overlay grid (FINESCE 2013)"

2.1.2 The CANVAS Model

The Business Model Canvas is a tool for describing, analysing, and designing business models It consists of 9 building blocks.

1. Customer Segments

The Customer Segments Building Block defines the different groups of people or organizations an enterprise aims to reach and serve

2. Value Propositions
   The Value Propositions Building Block describes the bundle of products and services that create value for a specific Customer Segment
3. Channels
   Value propositions are delivered to customers through communication, distribution, and sales channels. The Channels Building Block describes how a company communicates with and reaches its Customer Segments to deliver a Value Proposition.
4. Customer Relationships
   Customer relationships are established and maintained with each Customer Segment. The Customer Relationships Building Block describes the types of relationships a company establishes with specific Customer Segments.
5. Revenue Streams
   Revenue streams result from value propositions successfully offered to customers.
6. Key Resources
   Key resources are the assets required to offer and deliver the previously described elements.
7. Key Activities
   The Key Activities Building Block describes the most important things a company must do to make its business model work.
8. Key Partnerships
   Some activities are outsourced and some resources are acquired outside the enterprise. The Key Partnerships Building Block describes the network of suppliers and partners that make the business model work
9. Cost Structure
   The business model elements result in the cost structure. The Cost Structure describes all costs incurred to operate a business model

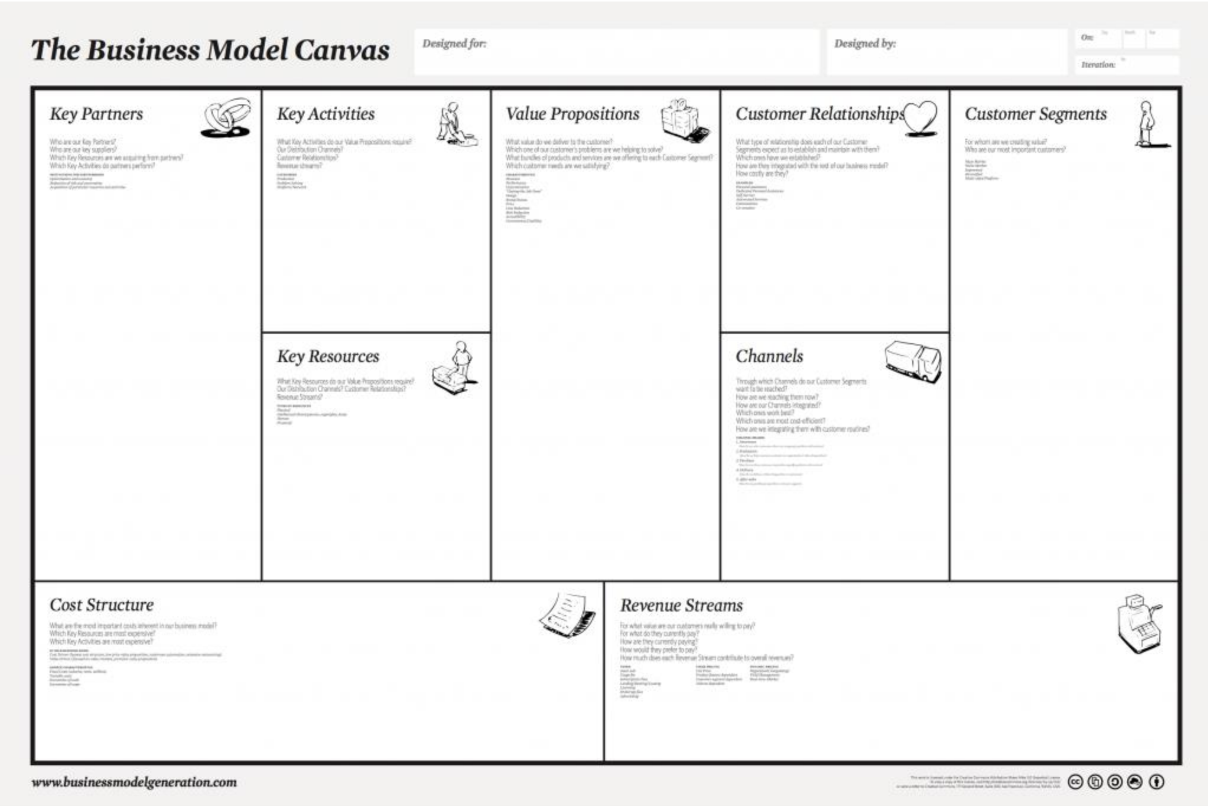

Figure 2 The Business Model Canvas

2.1.3 Cost-Benefit-Analysis

The CBA is defined as a systematic process for calculating and comparing benefits and costs of a decision, or project. In GOFLEX the CBA has the purposes to determine if an investment/decision is sound verifying whether its benefits outweigh the costs, and by how much. “Benefit” in this case is measured as the revenue flowing in from customers using the specific service.

The CANVAS building blocks 5 “Revenue Streams” and 9 “Cost Structure” will be further assessed based on past data available or assumed data:

2.1.3.1 **Costs**

There are two main cost categories to be assessed:

Fixed costs

Costs that remain the same despite the volume of goods or services produced. This cost category applies for example to the costs to establish a market platform for flexibility. The development costs are independent of the number of market actors using this platform.

Variable costs

Costs that vary proportionally with the volume of goods or services produced. This cost category applies for example to costs directly involved with the provided access to markets for prosumers. Each prosumer needs equipment and software.

2.1.3.2 Revenue streams

There are several ways to generate revenue streams from GOFLEX business models which needs to be assessed.

Asset sale

The most widely understood Revenue Stream derives from selling ownership rights to a physical product. In GOFLEX this revenue stream can be applied to selling equipment (PV, EMS, batteries) to the prosumers to support their self-consumption and to enable them to participate in the flexibility trading.

Lending/Renting/Leasing

This Revenue Stream is created by temporarily granting someone the exclusive right to use a

particular asset for a fixed period in return for a fee. For the lender this provides the advantage of recurring revenues. Renters or lessees, on the other hand, enjoy the benefits of incurring expenses for only a limited time rather than bearing the full costs of ownership.

In GOFLEX this can be applied by utilities renting out equipment (PV, battery, EMS etc.) to prosumers for example as part of a tariff model (comparable to the tariff models for mobile phones).

Usage fees

This Revenue Stream is generated by the use of a particular service. The more a service is used, the more the customer pays. In GOFLEX a usage fee can be applied to the usage of the flexibility trading platform by the market actors (to be paid by transaction). It also applies to the actors purchasing the flexibility of other actors.

Subscription fees

This Revenue Stream is generated by selling continuous access to a service. In the example of the market actors getting access to the flexibility platform this could be also implemented as monthly or yearly subscription fee.

Licensing fees

This Revenue Stream is generated by giving customers permission to use protected intellectual property in exchange for licensing fees. Licensing allows rightsholders to generate revenues from their property without having to manufacture a product or commercialize a service.

In GOFLEX this model can be used for software suppliers (flexibility market applications, aggregator platforms) offering their products to utilities as licensed “white label” products.

2.2 GOFLEX Systemic Roles and Processes

The GOFLEX Use cases are the use cases for trading energy flexibilities of parties connected to the grid - (active) consumers, producers and prosumers, in which the trading takes place in one cellular subsystem or between two cellular subsystems in electricity market system, according to the GOFLEX roles and process model.

The GOFLEX roles and process model is based on the Harmonized Electricity Market model in Europe (ENTSO-E, 2009, ENTSO-E 2015), and its adaptation by Mirabel project (Mirabel 2013).

The GOFLEX roles and process model is presented in deliverable D6.2 but briefly explained here; the explanation is intended to be reasonably self-contained.

The main characteristics and assumptions of GOFLEX roles and process model are:

<u>The electricity system:</u>

- The electricity market system in Europe is vertically structured into vertically nested fractal- like systems. This means that the subsystems into which a system is decomposed are fully contained in the original system (“parental” system), and that the new subsystems have essentially the same functions as their parental system (“fractal-like”); for convenience within GOFLEX project we term such systems also »cellular« systems and such vertical structure as “cellular structure”.

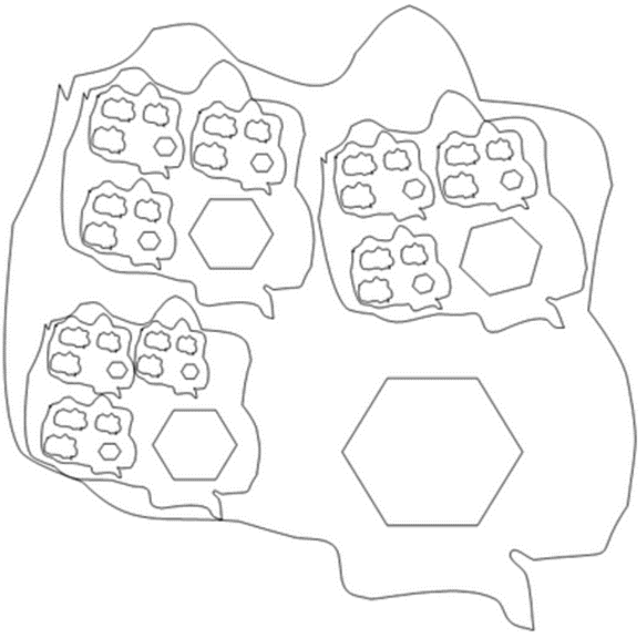

Figure 3: Schematic representation of vertical decomposition of electricity market system into nested fractal-like subsystems

- The vertical structuring, defined in the Harmonized electricity market model to Balance Group level, is carried downwards to (Local Community) Microgrid systems and (Local) Energy community systems. The shared property of these two subsystems is that they are in the cross-section of Balance Group (BG) or sub-balance group (SBG) and the territory of DSO (or sub-DSO); and that they can be separated from the grid and optimize its electricity supply and consumption tending to balanced operation and thus to self-supply (the limiting case would be islanding operation). The difference is that the latter subsystem tries to extend this approach to include all energy carrying media.
- The electricity grid system, which is presently not organized in a cellular structure, will be harmonized by structuring it into cellular subsystems;
    - the first level of structuring is DSO subsystem within the TSO system. This implies a new business model for DSO vs TSO, with DSO becoming responsible for all functions for controlling the grid on its level, including the responsibility for local balancing of energy flows on the grid. TSO system becomes parental system of DSO subsystem.
    - The next level of structuring can be sub-DSO subsystem (taking care of the lower voltage levels) within the DSO parental system. The same cellular characteristics are applied – sub-DSO becomes responsible for all functions for controlling the grid on its level.

<u>Local balancing of energy flows</u>

- The challenges of achieving the target of 100% RES on the grid will to large extent be based on local (dispersed) generation of energy. The techno-economic optimum in balancing the local production and consumption is local balancing of energy flows on the distribution grid. In order to be able to do this effectively, avoided costs (long term & short term marginal costs) principle is the governing principle for business evaluation of the business models, in particular in use cases where DSO is the user of energy flexibilities.

Dynamic prices of energy flexibilities

- the price of energy flexibilities is dynamic – it changes in trading intervals based on local conditions on the grid. Such dynamic price is the necessary prerequisite for unleashing the full potential of energy flexibilities in prosumers and for local cost-effective investments into explicit energy storage systems.
- The dynamic prices are communicated in GOFLEX trading process by Flex-Offers, issued by prosumers for selling flexibilities, and issued by the flexibility users such as DSO for purchasing energy flexibility.
- Roles in GOFLEX
- The roles used in GOFLEX roles and process model are:
    - i) roles or sub-roles of the Harmonized electricity market model and Mirabel roles and processes model,
    - ii) new roles due to its cellular extension downwards; examples of such roles are Microgrid Responsible Party, Local supplier of energy, and
    - iii) new roles due to proposed cellular structuring of the electricity grid system, i.e. DSO (new "cellular" role), sub-DSO.
- Additionally, some roles are structured further to make use of the GOFLEX technologies, which makes them scalable to various use cases. These are "GOFLEX roles"
- The GOFLEX roles are "unit roles" – they can be integrated in different use cases to suit the business models of actual players. This is an important characteristic adding to GOFLEX operational scalability and adaptability. An example of GOFLEX role is FMAR operator (Flexibility Market Operator); this role is scalable to all the use cases where GOFLEX technology is used. The actual role in each use case is termed according to the use case, e.g. Local market operator plays out the GOFLEX role FMAR operator in the use case with descriptive name "Local Balancing market for energy flexibilities for DSO".

To ease understanding, all new roles are labelled using descriptive names. Coded names will be introduced in next stage of definition of business models.

GOFLEX Processes

The processes in GOFLEX are structured according to the Harmonized model and following Mirabel roles and process model:

- The primary process in the electricity market and grid system consists of energy production, transmission – flow of energy, consumption and trading. This process is broken down into unit processes
- Joint and supportive processes are processes necessary for operation of the electricity market, mainly processes for maintaining the electricity grid They are also structured into unit processes

The use cases

The GOFLEX use cases are those use cases in the Market Balance Area (MBA) that are enabled by GOFLEX integrated solution using the GOFLEX roles and process model. They comprise

- The use cases within the Harmonized electricity market model
- The new use cases made possible through further vertical structuring of the electricity market and harmonization of joint and supportive processes of the electricity grid system, as explained above in the section "Roles in GOFLEX"

The GOFLEX project focus is local, with DSO as the dominant user of energy flexibility for avoiding congestion and local balancing of the grid. The list of these use cases as given in the Table 1 below:

Table 1 The list of Use Case for local levels of electricity market and grid system for GOFLEX roles and process model

UC no.	Use Case	EM sub-system	driving case role		grid sub-system	type of trading
			Business role	Grid operator		
UC1	Tertiary reserves of TSO	MBA	BRP_{AGG}	TSO	TransG	many:1
UC2	Optimized operation of microgrid	LCM	MRP	(S-)DSO	(sub-)DistG	1:many
UC2-1	Islanding operation of microgrid	LCM	MRP	(S-)DSO	(sub-)DistG	many:many
UC5	Local energy community	LEC	LSE	(S-)DSO	(sub-)DistG	1:many
UC5-1	Islanding operation local energy community	LEC	LSE	(S-)DSO	(sub-)DistG	many:many
UC4	Congestion management at DSO	BG	BRP_{AGG}	DSO	DistG	1:many
UC4-1	Local Balancing market for en.flex for DSO (Local Flexibility market)	BG	LMO	DSO	DistG	1:many
UC6	Regional Balancing Market for en.flex for DSOs (Regional Flexibility market)	MBA	MORBO	DSOs	DistG/ TransG	many:many

Legend:

Table 2 Legend GOFLEX roles and processes

Acro-nym	Name	Note
MBA	Market Balance Area	
BG	Balance Group	
LCM	Local community micro-grid	
LEC	Local Energy community	Also known as Virtual Power System.
MO	Market operator	The role in Market Balance Area for energy trading between BRPs
BRP	Balance Responsible Party	
BRP_{AGG}	BRP in the role of an aggre-gator	
MRP	Microgrid Responsible party	
LSE	Local Supplier of Energy	
LMO	Local Market Operator	Plays out the GOFLEX role FMAR operator
DSO	Distribution System opera-tor	Cellular role of DSO
SDSO	Sub-DSO	Cellular sub-role of DSO
MORB	Market operator for Re-gional Balancing Market for DSOs	Plays out the GOFLEX role: FMAR operator
TransG	Transmission Grid of TSO in MBA	
DistG	Distribution Grid of a DSO in MBA	

sub-DistG	Sub-Distribution Grid of a DSO	Grid belonging to SDSO
FMAR	Flexibility Market Platform	Building block of the GOFLEX solution

In the Table, UC1 is the Use case that is not a case on local but MBA level system, but it is directly accessible to roles involved in local trading of energy flexibilities.

It is important to note that these use cases are based on different level of assumptions as regards the necessary regulatory framework for carrying them out. Accordingly, they must be positioned at different times in future horizon.

A scenario for deployment of these use cases has to be elaborated based on specific conditions applicable to different Demonstration cases.

2.3 Definition of Business Model KPIs supporting the Project Impact KPIs

Key performance indicators (KPI) are a set of quantifiable measures that a trial uses to gauge its performance over time. These metrics are used to determine the trials' progress in achieving its strategic and operational goals, and also to compare the trial's finances and performance against other trials within GOFLEX (e.g. if they implement the same business model).

For each KPI a goal is supposed to be set which refers to the goals of the business model of each trial.

In GOFLEX all trial sites will define their own quantifiable KPIs and match them with the KPIs of the project depending on the specific business model they are focusing on to measure how the individual trial site has contributed to the overarching objectives of the GOFLEX project as a whole.

List of Project KPIs:

Table 3 GOFLEX project KPIs

Project Performance Indicator	Quantification	Measurement unit
Integration of Renewables		
Capable of integrating large share of renewables	**>15 %**	Safe increase of installed capacity (MW) with respect to initial capacity margins with no available demand response. ***(*)***
Electricity load adaptability level	**>15 %**	Energy demand variation (ΔMWh /h) with respect to peak demand (MWh/h)
Demand Response		
Demand response generated by virtual energy storage in demonstrated use cases in the project (during 3 months' testing & evaluation period)	**≥15%**	Energy demand variation (ΔMWh /h) with respect to peak demand (MWh/h)
Increase of prosumer involvement	**≥15%**	Augmented DR (%)
Benefit for aggregator	**≥ 35.000 EUR/MW/year + 200 €/MWh (1)**	Increased business in supply of DR
Benefit for DSO	**1.0 mio EUR/MW**	The reduced cost of congestion avoidance (2)
Grid Stability		
Avoid congestions: reduction of peak demand	**>15%**	Reduction of MWh/h
Lessen the burden of power grids through self-consumption	**>10 %**	MWh/h of self-consumed energy
Distribution grid stability through responsiveness of flexibility services	**30 min (>25% of DR)**	Time required to activate portion of available load flexibility through DR services

	1 hr (>50% of DR) **24 hrs (>100% of DR)**	
Operational DR ready prosumer		
Prosumers with implemented virtual energy storage in processes	**≥ 15 prosumers**	No of established operational DR ready prosumers
Prosumers with implemented charging/discharging EV battery storage (with parked EV)	**≥ 5 prosumers**	No of established operational DR ready prosumers
Public charging (CEMS)		
Flexibility range at average occupancy of charging spots	**+10 / -30 %**	% of charging load variation (without violation of user needs) compared to baseline
Charging/discharging EV Station in house (CDEMS)		
Flexibility range for varying parking time	**2 hours: ±10%** **8 hours: ±25%**	% of charging load variation (without violation of user needs) compared to baseline
Gain for EV prosumers		
Charging timing reduction (battery buffer)¸and peak power need reduction (covering peaks from storage)	**>15%**	% of peak load reduction

3 General strategy of Cyprus demonstration site: Why and how will flexibility be utilised?

The Cyprus demonstration site will test two different case studies. The first case study concerns the microgrid within the campus of University of Cyprus (UCY), while the second one regards dispersed prosumers within Cyprus island.

3.1 University Microgrid test case

Concerning the first case, currently there are PV installations of more than 400 KWp, which are installed on both rooftops and in the terrain of the university. Furthermore, many buildings of the university campus have Building Energy Management Systems (BEMS) for mainly controlling the heating/cooling needs, while the construction of a large PV park (10 MWp generation) and a battery storage bank (more than 1 MWh capacity) is planned to be installed within the university campus within the coming years. Moreover, new buildings (library, school of engineering, biology and school of medicine) are also under construction and will be gradually completed until 2021. Therefore, new BEMSs are going to be installed to control the new buildings. In order to increase the efficient operation of the whole microgrid, a monitoring system of the microgrid will be installed, integrating the several BEMSs, the respective sensors and the advanced smart metering infrastructure in a single point of control through a full blown broad band system that is connected to the servers of the Distribution System Operator (DSO) through dedicated glass fiber.

As it is described, the university will utilize a centralized energy management system, that will track the energy consumption of all the university buildings and related loads, and will predict the amount of available energy flexibility by taking into account weather data and PV generation forecasts. The microgrid operation will be enabled by the single point of control that will collect all measurements and will take the respective control decisions. By operating in such a way, the university will maximize its self-consumption / minimize energy cost and will be available to dynamically match its energy demand against the grid's available capacity. Furthermore, FOSS acting as the local BRP of the microgrid will use all these data in order to trade the flexibility according to the needs of the DSO (Electricity Authority of Cyprus – EAC, in Cyprus case).

Furthermore, the case of including in the flexibility offers the EV charging/discharging station is also included. The EV station will be installed within the university campus (close to FOSS lab facilities) and the respective energy management system provided within GOFLEX will be utilised in order to facilitate trading of the flexibility provided by the EVs within the local parking station. Since the current EV manufacturer does not allow the discharging for the provision of flexibility offers (the guarantee of the battery does not include this operation), the discharging operation of the EV charging/discharging station will take place by placing a battery at the installation point of the EV station. In this way, the battery will emulate the aggregated storage of the EVs, being able to offer the flexibility of the discharging and injecting energy into the grid. Therefore, the control signals for the discharging will be directly transferred in the converter of the installed battery.

3.2 Dispersed prosumers within Cyprus

In the second case, the dispersed prosumers within Cyprus will be used. Three different categories of prosumers are identified:

1. prosumers with rooftop PV installation and HEMS installed by Robotina
2. prosumers with rooftop PV installation, energy storage system (battery) and HEMS installed by Robotina
3. prosumers with one controllable load

The prosumers will have direct access to their respective consumption via the installed smart metering infrastructure. They will be able to trade the flexibility of their loads either through the HEMS or through the controllable load. The BRP for this case is emulated by the DSO (EAC in Cyprus), which will analyse the utility grid and will take decisions about the activation of the respective flexibility offers. Thus, the emulated BRP by the DSO will act as a centralized controller, the aggregator, who will interact with the DSO operation section and the flexible prosumers, in order to handle the energy services that can be derived from their consumption patterns and provide regulating power to the grid.

For the DSO, these two pilot cases will demonstrate to what extent flexibility can be an alternative to grid reinforcement, by reducing electricity peaks, preventing congestion issues, contain quality of supply diversions and proving the solution’s reliability in the long term.

4 CANVAS Business models for services offered by Cyprus demonstration site

This Section analyses the business cases of the university microgrid case and the dispersed prosumers case. Consequently, the services that can be deduced from these business cases are described.

4.1 University microgrid case

The first business model concerns the university campus microgrid. In Table 4, the canvas of the business model is described.

Table 4 Business model canvas for the university microgrid case

Key Partners	*Key Activities*	*Value Proposition*	*Customer Relationships*	*Customer Segments*
• DSO EAC emulating the BRP role • University of Cyprus • Cyprus Energy Regulatory Authority	• Promotion of concept of flexibility to the local electricity market • Enhanced controllability and visibility up to the lower level (e.g. sensors) • Enhanced	• Access to the future flexibility market for University • Rewards for flexibility provision • Optimisation of the energy usage within the university with reduced energy cost • Enhancement of	• Automated DR services upon request of the DSO • Cooperation among the existing BEMS and the GOFLEX solutions	• DSO – Planning • DSO (BRP) – Operation (acting as an Aggregator) • Technical Services of UCY • Administration of UCY • FOSS Research Centre acting as a BRP • CERA office for

	energy management • Load Profiling & Segmentation of UCY microgrid buildings • Energy production and consumption forecasting • Flexibility forecasting • Energy scheduling and optimization of energy flows • Enhancement of the overall microgrid efficiency	the environmental footprint – become more environmental-friendly • Deferral of investments for new grid reinforcement • Reduction of grid losses • Improve frequency and voltage profiles, short-term operation under grid unavailability • Reduce energy cost but retain the same level of comfort • Creation of research	• Send/receive flexibility offers via an automated platform • Analyze and respond to the DSO needs for flexibility	pricing the ancillary services

	• Better usage of local resources (PV, storage) • Profit from providing the flexibility as an ancillary service to the utility grid	hubs for research/academic purposes • Increase self-consumption		
	Key Resources • University with rooftop and ground PV installation • Central and decentralized storage units • BEMS of each building of the UCY campus		*Channels* • CEMS, BEMS • Smart metering infrastructure • Installed sensors • Energy bills • Handheld devices and websites	

<table>
<tr><td></td><td>microgrid
• Microgrid control and monitoring tool for optimal energy management system
• Access to university's Centralized Energy Management System locally or via web</td><td></td><td>for energy feedback (app to display energy consumption data, advices, requests and trading data)
• University ICT including broad band connection with the DSO</td><td></td></tr>
<tr><td colspan="2">Cost Structure
• Installation, operational and maintenance costs of the PV and storage infrastructure
• Installation of central control energy management system</td><td colspan="3">Revenue Streams
• Increase of University's self-consumption
• Decrease of the total cost of electricity for the university
• Trade the flexibility of the university microgrid with the DSO</td></tr>
</table>

• MRP (BRP equivalent) infrastructure for controlling the flexibility offers and communicating with the DSO • Installation of smart meters, sensors, etc. • Staff cost • Technology development costs (within GOFLEX) • Distribution network operating costs	• Reduction of overall electricity generation and distribution costs for the DSO (avoided costs) • Enhancement of the overall energy efficiency of the electrical system (both microgrid and distribution grid) • Reduction of power losses due to the local energy production and consumption • Deferral of investments for new grid infrastructure (avoided costs) • Optimal use of grid infrastructure (avoided costs)

4.2 Dispersed prosumers case

The other business model of Cyprus concerns the dispersed prosumers within Cyprus. Table 5 presents the canvas of this business case.

Table 5 Business model canvas for the case of dispersed prosumers within Cyprus

Key Partners • DSO • BRP emulate by the DSO • Prosumers • Cyprus Energy Regulatory Authority	*Key Activities* • Marketing promotion of concept of flexibility to prosumers, as well as training them • Provision of Technology infrastructure • Prosumer Load Profiling & Segmentation • Energy production and consumption Load, forecasting • Flexibility forecasting	*Value Proposition* • Access to the flexibility market for prosumer through aggregation • Increase of network observability and management ability at local level • Flexibility services	*Customer Relationships* • Trade flexibilities between the prosumer and the DSO • Communication between the prosumer and the DSO (access to frequently	*Customer Segments* • DSO – Planning • DSO – Operation • DSO – acting as a BRP (including Aggregation) • CERA Office for pricing the ancillary

<table>
<tr>
<td rowspan="2"></td>
<td>• Scheduling and optimization
• Enhancement of the controllability of the energy production and consumption (and storage where applicable)
• Increase self-consumption</td>
<td rowspan="2">procurement from DSO
• Rewards to prosumer for flexibility provision
• Reduction of the total cost of electricity
• Adopt more grid-friendly habits
• Enhancement of the environmental footprint
• Deferral of investments for new grid reinforcement
• Reduction of power losses in the distribution grid</td>
<td>acquired data)
• Exchange of local energy production data for enhancing the operation of the forecasting tool (of the DSO)</td>
<td rowspan="2">services DSO
• Residential prosumer
• Local Energy communities (in the future)</td>
</tr>
<tr>
<td>Key Resources
• Households with Distributed Energy Resources from RES (mainly PV)
• Possible involvement of prosumers with energy storage systems
• HEMS (Home Energy Management System) at prosumers' premises in order to optimize efficient energy use and turn any available flexibility into tangible gains</td>
<td>Channels
• CEMS, HEMS
• Smart metering infrastructure
• Installed sensors
• Energy bills
• Handheld devices and websites for energy</td>
</tr>
</table>

	• Communication infrastructure between the prosumer and the BRP • Smart flexibility management locally, via web or via smart phones • Smart plug appliances		feedback (app to display energy consumption data, advices, requests and trading data) • Communication infrastructure with DSO (GPRS, Ethernet)	
Cost Structure • Installation, operational and maintenance costs of the PV and storage infrastructure (where applicable) • Installation of home energy management system • BRP/Trading infrastructure for controlling the flexibility offers and communicating with the DSO • Installation of smart meters, sensors, etc. • Smart meters head-on operational costs		*Revenue Streams* • Increase of prosumer's self-consumption • Decrease of the total cost of electricity for the prosumer • Trade the flexibility with the DSO • Reduction of overall electricity generation and distribution costs for the DSO • Enhancement of the overall energy efficiency of the electrical system (both microgrid and distribution grid) • Reduction of power losses due to the local energy production and consumption • Deferral of investments for new grid infrastructure • Optimal use of grid infrastructure		

• Communication costs for smart metering and distribution feeders operational data • Staff cost • Technology development costs (within GOFLEX) • Distribution network operating costs	

4.3 Time Scale of flexibility services to be implemented (now and future)

After analysing the business models in Cyprus, four (4) different services have been identified that can be applied in these business models. Table 6 presents these services, with the respective timeline for the implementation. In the next paragraphs, each service is analysed separately.

Table 6 Timeline of Services

Service	Microgrid offering flexibility to the DSO (through its BRP)	Prosumers offering flexibility to the DSO (through its BRP)	Provision of forecasted data to the DSO	Grid congestion relief
Actor/Role	Microgrid: send flex-offers for trading flexibility BRP: use the flexibility for reducing energy costs DSO: more predictable load without many peaks/less de-	Prosumers: send flex-offers for trading flexibility BRP: use the flexibility for reducing energy costs DSO: more predictable load without many peaks/less de-	Prosumers/Microgrid: send intra-day forecasting data BRP: use the forecasting data for updating the power and energy balance DSO: use the data for a more	Prosumers/Microgrid: send flex-offers for trading the flexibility BRP: use the flexibility to mitigate local congestions DSO: optimize grid management/deferral of grid investments

	mand for reserves / lower energy cost	mand for reserves / lower energy cost	efficient dispatch of the distributed sources at distribution level	
Planned time for implementation	2020	2020	2020	2020
Tested in GOFLEX	Y	Y	Y	Y

4.4 Microgrid offering flexibility to the DSO

4.4.1 Use case description

In this test case, the microgrid will utilize all the information provided by the integrated point of control in order to trade the flexibility with the DSO. The target is to reduce the total energy cost of the university campus by effectively controlling the several BEMS located in the different buildings within the campus. Furthermore, the energy production from the existing and future PV installation will be taken into consideration together with the energy storage systems. The enhanced microgrid capability of operating as a single controllable entity that will be enabled through the application of the various Dispatchable DERs and flexible loads, allows for the BRP to respond effectively to economic and emergency incentives.

4.4.2 Canvas Drawing

Table 7 presents the business canvas for the Service 1.

Table 7 Business Canvas of Service 1

Key Partners • DSO • University ad-	*Key Activities* • Offering flexibility solutions to the DSO, e.g. load profiling and load segmentation	*Value Proposition* • Access to the flexibility market for the microgird	*Customer Relationships* • Trade flexibilities between	*Customer Segments* • DSO – Planning

ministration • Local Aggregator / BRP	• Energy production and consumption Load, forecasting • Flexibility forecasting • Scheduling and optimization • Enhancement of the controllability of the energy production, consumption and storage • Increase self-consumption	• Trade flexibility with the DSO • Reduction of the total cost of electricity • Become more grid-friendly • Enhancement of the environmental footprint (due to the decrease of the energy consumption) • Deferral of investments for new grid reinforcement • Reduction of power losses in the distribution grid	the microgrid and the DSO • Communication between the microgrid and the DSO (access to closely to real-time data) • Exchange of local energy production data for enhancing the operation of the forecasting tool (of the DSO)	• DSO – Operation Aggregator) • DSO – acting as a BRP • BEMS • EMS for the EV charging/discharging station
	Key Resources • BEMS of the several buildings within the microgrid • EMS for the EV charging/discharging station		*Channels* • CEMS, BEMS • Smart metering in-	

	• Communication infrastructure between the prosumer and the BRP • Smart flexibility management locally, via web or via smart phones		fra-structure • Installed sensors • Energy bills • Handheld devices and websites for energy feedback (app to display energy consumption data, advices, requests and trading data) • Communication infrastructure with DSO (GPRS, ethernet)	

Cost Structure	*Revenue Streams*
• Installation, operational and maintenance costs of the PV and storage infrastructure • Installation of BEMS and a central controller for the BEMS • BRP infrastructure for controlling the flexibility offers and communicating with the DSO • Installation of smart meters, sensors, etc. • Staff cost • Technology development costs (within GOFLEX) • Distribution network operating costs	• Increase of self-consumption of the microgrid • Decrease of the total cost of electricity for the microgrid • Trade the flexibility with the DSO • Reduction of overall electricity generation and distribution costs for the DSO • Enhancement of the overall energy efficiency of the electrical system (both microgrid and distribution grid) • Reduction of power losses due to the local energy production and consumption • Deferral of investments for new grid infrastructure • Optimal use of grid infrastructure

4.4.3 UML diagram

Figure 4 presents the UML diagram for the Service 1.

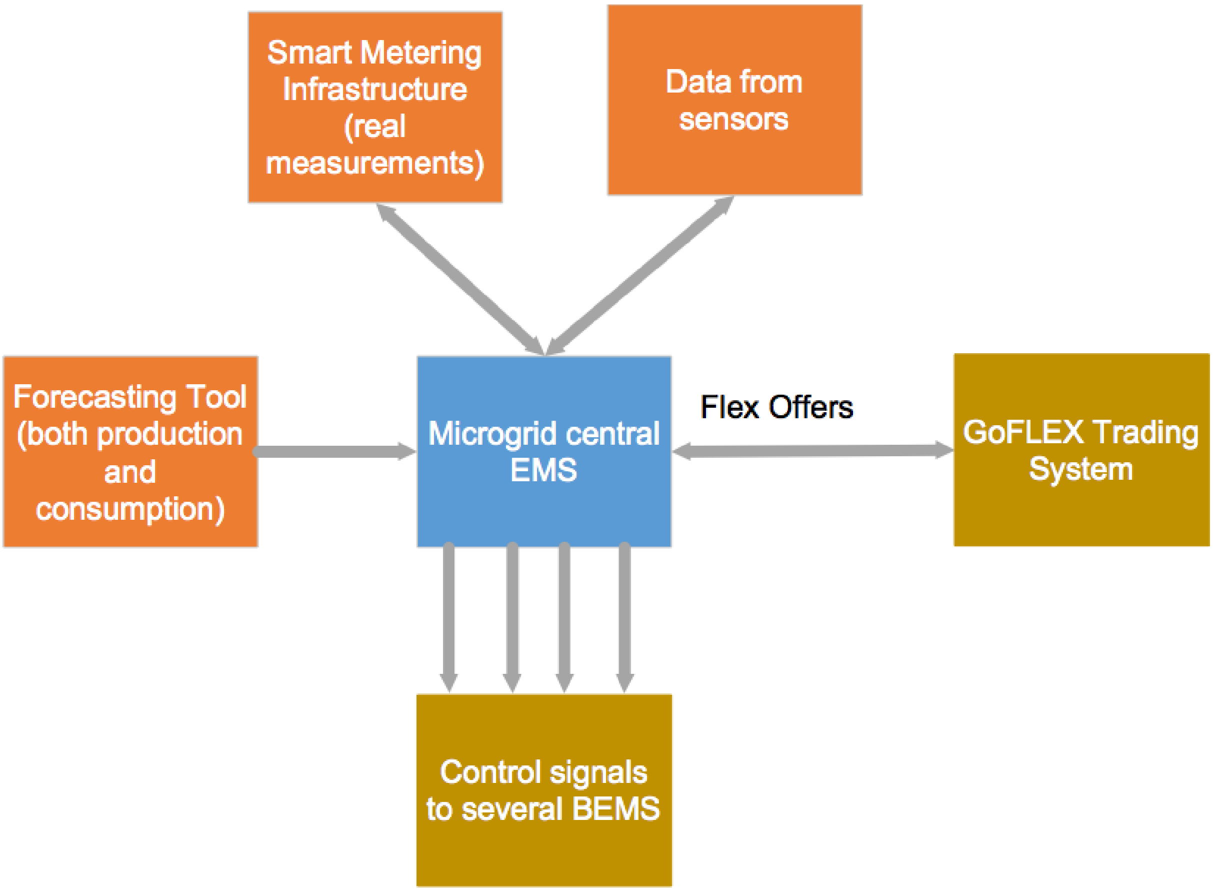

Figure 4 UML diagram for Service 1

4.4.4 Involved Actors

The involved actors of the Service 1 are described in Table 8.

Table 8 Involved actors in Service 1

Actor	Role in the case study	Objectives
Microgrid	The microgrid will be controlled in order to provide and trade flexibility offers with the DSO (through FMAR operator) by utilizing effectively the several BEMS. Furthermore, the energy production from the PV installations and the energy stored	The target is to increase the self-consumption and reduce the total cost of electricity. Furthermore, the efficiency will be increased.

	in the energy storage systems will be taken into consideration. The role of the university campus will change from a passive energy consumer to a controllable microgrid.	
Local Aggregator / Balance Responsible Party	Acts as the intermediate between the microgrid and the DSO. Aggregates flexibility provided from the microgrid, and trade it to the DSO or market players.	Maximize the value of local flexibility under his portfolio, by increasing his client list Maximize profit
DSO	Distributes electricity at LV and MV levels, and ensures quality of supply, reliability and stability of the grid. Acts as a buyer of flexibility, by trading flexibility in order to avoid congestion issues or for voltage control.	Use MV flexibility as a tool to avoid grid congestion Improve network capacity scheduling Delay or postpone investments in grid infrastructure

4.4.5 KPIs to measure the success of the service

KPI 1.1: Number of flexibility offers traded with the DSO. Value 1.1: 10 flexibility offers/day

KPI 1.2: Activation of demand response strategies through the BEMS. Value 1.2: 10/day

KPI 1.3: Reduction of the total cost of electricity. Value 1.3: 20% reduction compared with the current situation

4.5 Prosumers offering flexibility to the DSO

4.5.1 Use case description

In this use case, the prosumers can decide to offer their flexibility as a product to the other actors involved, the BRP and the DSO. Flexibility in this case can be derived from all the active energy-consuming appliances that have the ability to shift, increase or decrease their energy consumption. The driver of the prosumer's involvement in this use case is the reduction of the cost of the energy bill, thus there needs to be some form of remuneration as a reward for the provision of flexibility to the BRP.

4.5.2 Canvas drawing

The business canvas for the Service 2 is described in Table 9.

Table 9 Business Canvas for Service 2

Key Partners	*Key Activities*	*Value Proposition*	*Customer Relationships*	*Customer Segments*
• DSO • Prosumers	• Trading the energy flexbiliby • Provision of Technology infrastructure • Prosumer Load Profiling & Segmentation • Energy production and consumption Load, forecasting • Flexibility forecasting • Scheduling and optimization • Enhancement of the controllability of the energy production and consumption (and storage	• Access to the flexibility market for prosumer • Trade flexibility with the DSO • Rewards to prosumer for flexibility provision • Reduction of the total cost of electricity • Become more grid-friendly	• Trade flexibilities between the prosumer and the DSO • Communication between the prosumer and the DSO (access to closely to real-	• DSO – Planning • DSO – Operation Aggregator) • DSO – acting as a BRP • Residential prosumer • Local Energy communities (in the future)

	where applicable) • Increase self-consumption	• Enhancement of the environmental footprint • Deferral of investments for new grid reinforcement • Reduction of power losses in the distribution grid	time data) • Exchange of local energy production data for enhancing the operation of the forecasting tool (of the DSO)	
	Key Resources • Households with Distributed Energy Resources from RES (mainly PV) • Possible involvement of prosumers with energy storage systems • HEMS (Home Energy Management System) at prosumers' premises in order to optimize efficient energy use and turn any available flexibility into tangible gains		*Channels* • CEMS,HEMS • Smart metering infrastructure • Installed sensors • Energy bills • Handheld devices and websites for energy feedback	

	• Communication infrastructure between the prosumer and the BRP • Smart flexibility management locally, via web or via smart phones • Smart plug appliances		(app to display energy consumption data, advices, requests and trading data) • Communication infrastructure with DSO (GPRS, ethernet)	

Cost Structure • Installation, operational and maintenance costs of the PV and storage infrastructure (where applicable) • Installation of home energy management system • BRP infrastructure for controlling the flexibility offers and communicating with the DSO • Installation of smart meters, sensors, etc. • Staff cost • Technology development costs (within GOFLEX) • Distribution network operating costs	*Revenue Streams* • Increase of prosumer's self-consumption • Decrease of the total cost of electricity for the prosumer • Trade the flexibility with the DSO • Reduction of overall electricity generation and distribution costs for the DSO • Enhancement of the overall energy efficiency of the electrical system • Reduction of power losses due to the local energy production and consumption • Deferral of investments for new grid infrastructure • Optimal use of grid infrastructure

4.5.3 UML diagram

The UML diagram for the Service 2 is illustrated in Figure 5.

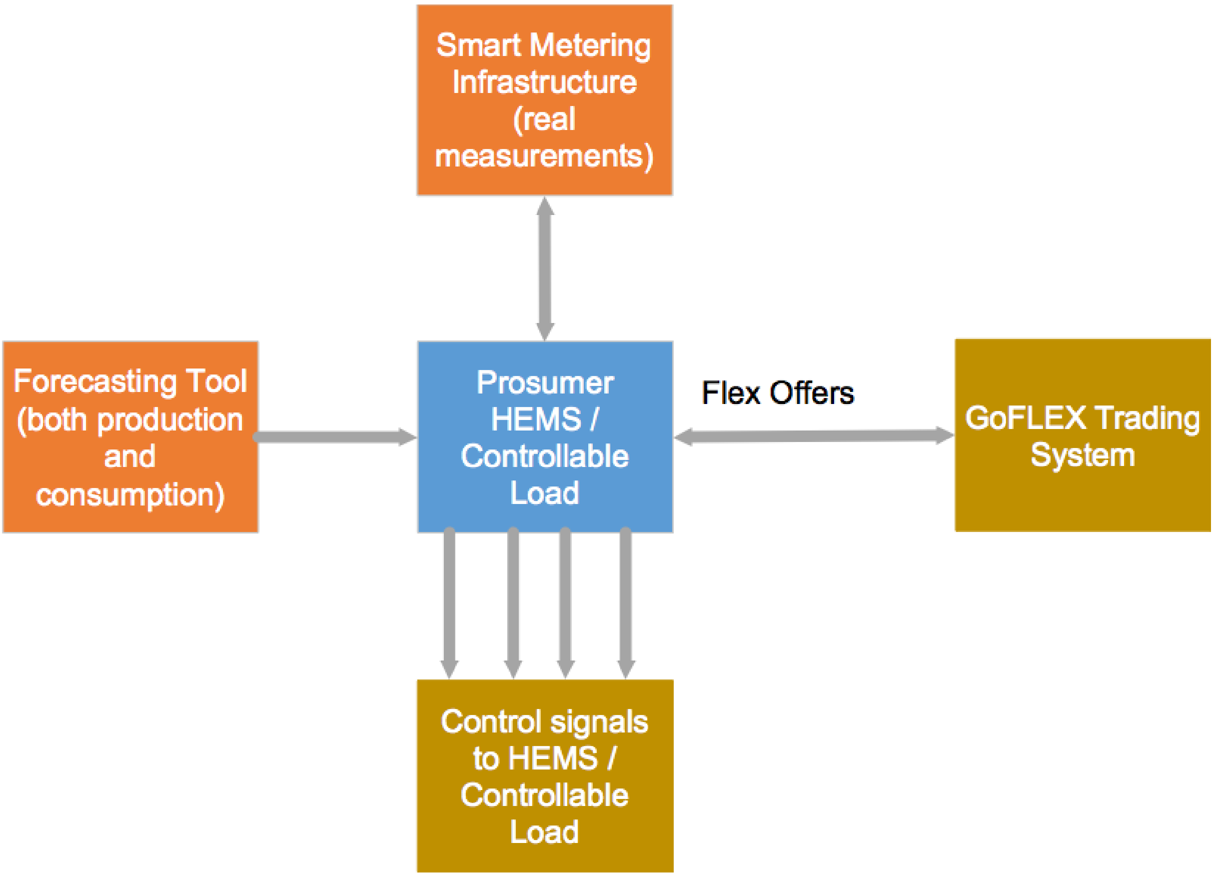

Figure 5 UML diagram for Service 2

4.5.4 Involved Actors

The actors involved in Service 2 are presented in Table 10.

Table 10 Involved actors in Service 2

Actor	Role in the case study	Objectives
Prosumer	End-user who provides flexibility through the load of the active energy-consuming appliances. Produces energy through PV installations, and can use electricity to self-	Save money and reduce the cost of electricity bill. His comfort should be respected and the various appliances should be operated under the condition that

	consume it, store it or feed it back to the grid His role changes from a passive consumer towards an active participant of the electricity market	comfort parameters are not violated Become more eco-friendly and reduce greenhouse emissions
Local Aggregator / Balance Responsible Party	Acts as the intermediate between the Prosumers and the DSO or, in the future, between the Prosumers and the electricity market Aggregates flexibility provided from his clients / prosumers, and sells it to the DSO or market players.	Maximize the value of local flexibility under his portfolio, by increasing his client list Maximize profit
DSO	Distributes electricity at LV and MV levels, and ensures quality of supply, reliability and stability of the grid. Acts as a buyer of flexibility, by trading flexibility in order to avoid congestion issues or for voltage control.	Use LV flexibility as a tool to avoid grid congestion Improve network capacity scheduling Delay or postpone investments in grid infrastructure

4.5.5 KPIs to measure the success of the service

KPI 2.1: Number of flexibility offers traded with the DSO. Value 2.1: 10 flexibility offers/day

KPI 2.2: Activation of demand response strategies through the HEMS/Controllable load. Value 2.2: 10/day

KPI 2.3: Reduction of the total cost of electricity. Value 2.3: 10% reduction compared with the current situation

4.6 Provision of forecasted data to the DSO

4.6.1 Use case description

In this use case, both the microgrid and the prosumers will send the forecasted data to the DSO, which will utilize DOMS in order to program the distribution resources more effectively. This will help the DSO increase the accuracy of the day ahead generation forecast and improve the accuracy of related analysis of the interconnected utility grid in order to facilitate more informed decisions for offering their flexibility as a product to the other actors involved, the BRP and the DSO. Flexibility in this case can be derived from all the active energy-consuming appliances that have the ability to shift, increase or decrease their energy consumption. The driver of the prosumer's involvement in this use case is the reduction of the cost of the energy bill, thus there needs to be some form of remuneration as a reward for the provision of this flexibility to the BRP.

4.6.2 Canvas drawing

The Canvas drawing for the Service 3 is presented in Table 11.

Table 11 Business Canvas for Service 3

Key Partners	*Key Activities*	*Value Proposition*	*Customer Relationships*	*Customer Segments*
• DSO • Prosumers • University microgrid campus	• Provide measurements from real installations • Provision of Technology infrastructure • Energy production and consumption Load, forecasting • Flexibility forecasting • Scheduling and optimization • Enhancement of the controllability of the energy production and consumption	• Better scheduling of the several resources • Reduction of the total cost for balancing energy resources • Deferral of investments for installing more weather stations	• Communication between the prosumer and the DSO (access to closely to real-time data) • Exchange of local energy	• DSO – Planning • DSO – Operation Aggregator) • DSO – acting as a BRP • Residential prosumer • Local Energy

	(and storage where applicable) • Increase self-consumption	• Reduction of power losses in the distribution grid	production data for enhancing the operation of the forecasting tool (of the DSO)	communities (in the future)
	Key Resources • Households with Distributed Energy Resources from RES (mainly PV) • Microgrid with RES installations and energy storage systems • Prosumers with energy storage systems • Communication infrastructure between the prosumer and the BRP		*Channels* • CEMS, BEMS • Smart metering infrastructure • Installed sensors • Communication infrastructure with DSO (GPRS, Ethernet)	

Cost Structure	*Revenue Streams*
• Installation, operational and maintenance costs of the PV and storage infrastructure (where applicable) • Installation of HEMS and BEMS • Installation of smart meters, sensors, etc. • Staff cost • Technology development costs (within GOFLEX) • Distribution network operating costs	• Reduction of overall electricity generation and generation costs for the DSO • Enhancement of the overall energy efficiency of the electrical system (both microgrid and distribution grid) • Reduction of power losses due to the local energy production and consumption • Optimal use of grid infrastructure • Decreased needs for energy balancing resources

4.6.3 UML diagram

The UML diagram for the Service 3 is illustrated in Figure 6.

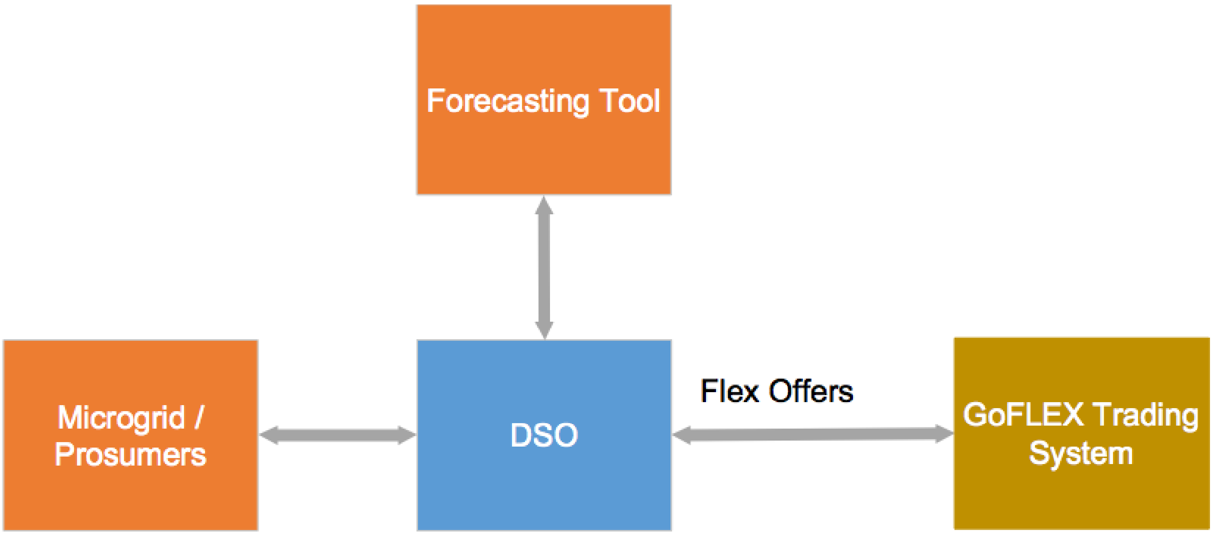

Figure 6 UML diagram for Service 3

4.6.4 Involved Actors

The actors involved in Service 3 are presented in Table 12.

Table 12 Involved actors in Service 3

Actor	Role in the case study	Objectives
Microgrid / Prosumers	Gather and send the individual real-time data of energy production and consumption to the Aggregator / BRP	Get more accurate flex offers from the DSO
Local Aggregator / Balance Responsible Party	Gathers and sends the data from the energy production and consumption to the DSO	Creating individual production profiles of all clients in order to enable a flexible operational planning of aggregator managed portfolio
DSO	Utilizes the data from the microgrid/prosumers together with the forecasted tool in order to analyse the utility grid and provide more accurate flexibility offers to the prosumers/microgrid. Checks whether forecasts of the participants of the electric power system balance the power system. Sends signals requesting flexibility from aggregators in order to enable the smooth operation of the whole system, when there is a possibility of grid congestion.	Avoiding possible grid congestions and stabilizing the electric power grid at an early stage
DOMS	The DOSM (provided within GOFLEX) is responsible for analysing the utility grid in order to program the distribution resources more effectively	Analysis of the utility grid

4.6.5 KPIs to measure the success of the service

KPI 3.1: Increase the accuracy of the forecast. Value 3.1: 20% reduction in the imbalance between the forecasted and actual dispatch

4.7 Grid congestion relief

4.7.1 Use case description

In this use case, the identified grid congestion will be relieved by activating the flexibility offers. The DSO will analyse the parameters of the system through the GOFLEX platform (DOMS) in order to identify any possible grid congestion issue. Then, the DSO will send the flexibility offers to the Aggregator / BRP in order to activate the trading with the respective nodes and resolve the congestion issue.

4.7.2 Canvas drawing

The business canvas for Service 4 appears in Table 13.

Table 13 Business Canvas for Service 4

Key Partners	*Key Activities*	*Value Proposition*	*Customer Relationships*	*Customer Segments*
• DSO • Prosumers • Microgrid	• Provision of Technology infrastructure • Prosumer Load Profiling & Segmentation • Energy production and consumption Load, forecasting • Flexibility forecasting • Scheduling and optimization • Enhancement of the controllability of the energy production and	• Access to the flexibility market for prosumer • Trade flexibility with the DSO • Rewards to prosumer for flexibility provision • Reduction of the total cost of electricity	• Trade flexibilities between the prosumer and the DSO • Communication between the prosumer and the DSO (access	• DSO – Planning • DSO – Operation Aggregator) • DSO – acting as a BRP • Residential prosumer • Microgrids

	consumption (and storage where applicable) • Increase self-consumption	• Adopt more grid-friendly habits • Enhancement of the environmental footprint • Deferral of investments for new grid reinforcement • Reduction of power losses in the distribution grid	to closely to real-time data) • Exchange of local energy production data for enhancing the operation of the forecasting tool (of the DSO)	• Local Energy communities (in the future)
	Key Resources • Households with Distributed Energy Resources from RES (mainly PV) • Possible involvement of prosumers with energy storage systems • HEMS (Home Energy Management System) at prosumers' premises in order to optimize efficient energy use and turn any available flexibility into tangible gains		*Channels* • CEMS, BEMS • Smart metering infrastructure • Installed sensors • Energy bills • Handheld devices and websites for	

	• Communication infrastructure between the prosumer and the BRP • Smart flexibility management locally, via web or via smart phones • Smart plug appliances		energy feedback (app to display energy consumption data, advices, requests and trading data) • Communication infrastructure with DSO (GPRS, ethernet)	

Cost Structure • Installation, operational and maintenance costs of the PV and storage infrastructure (where applicable) • Installation of HEMS and BEMS • BRP infrastructure for controlling the flexibility offers and communicating with the DSO • Installation of smart meters, sensors, etc. • Staff cost • Technology development costs (within GOFLEX)	*Revenue Streams* • Increase of prosumer's self-consumption • Decrease of the total cost of electricity for the prosumer • Trade the flexibility with the DSO • Reduction of overall electricity generation and distribution costs for the DSO • Enhancement of the overall energy efficiency of the electrical system (both microgrid and distribution grid) • Reduction of power losses due to the local energy production and consumption • Deferral of investments for new grid infrastructure • Optimal use of grid infrastructure

• Distribution network operating costs	

4.7.3 UML diagram

Figure 7 presents the UML diagram for Service 4.

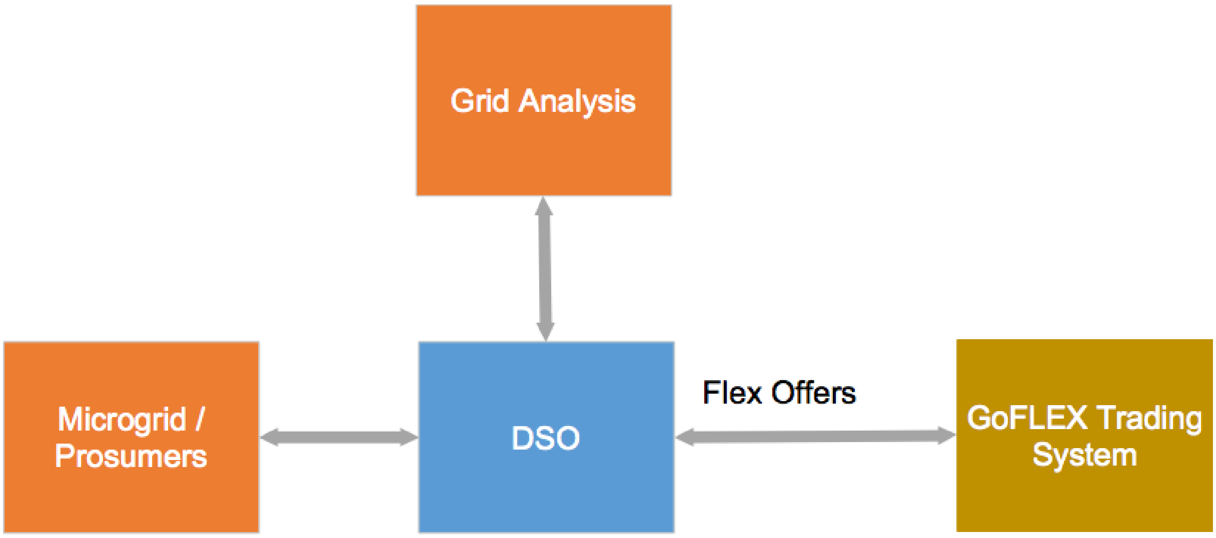

Figure 7 UML diagram for Service 4

4.7.4 Involved Actors

The involved actors for Service 4 appear in Table 14.

Table 14 Involved actors in Service 4

Actor	Role in the case study	Objectives
Microgrid / Prosumers	Activate the submitted flexibility offers according to DSO demands	Activation of flexibility offers
Local Aggregator / Balance Responsible Party	Gather the flexibility offers by the microgrid / prosumers	Trade of flexibility among the microgrid/prosumers and the DSO

	Activate the flexibility offers according to the needs of the DSO	
DSO	Analyse the utility grid in order to identify the grid congestion issue (utilising DOMS) Send flexibility offers to the Aggregator / BRP in order to resolve the raised issue	Relief of the grid congestion issues Reduce the total cost of investments for grid reinforcement and new grid infrastructure

4.7.5 KPIs to measure the success of the service

KPI 4.1: Number of activated flexibility offers for grid congestion relief. Value 4.1: 5 offers/day

KPI 4.2: Reduction in the total cost of new grid infrastructure. Value 4.2: 20% reduction

5 Cost-Benefit-Analysis approach for services to be implemented

In order to evaluate the aforementioned business models, a detailed cost-benefit analysis should take place. The cost for installing the flex offer system, required number of smart meters, monitoring systems, energy management systems and sensors will be identified. The benefit concerns the deferral of investments for new grid infrastructure, the reduced cost of generation cover as a result of improved forecasts, cost avoidance from not investing in quality improvement infrastructure, reduction of the energy mix cost due to peak shifting and reduced consumption in real terms due to improved energy consciousness of end users in the cases of time of use (ToU) tariffs introduction or adaptation of a more dynamic pricing scheme with real time information on energy usage.

5.1 Microgrid business case

In the Microgrid pilot case, an evaluation of the factors that influence the costs and benefits of the Microgrid, in terms of construction, planning and operation, should be performed.

Regarding the cost analysis of the microgrid the costs and factors that should be taken into account are the following:

- **Capital investments.** The costs of the microgrid development should be associated with an initial capital investment, which should be made to purchase and install the equipment that will be incorporated into the microgrid. The cost that the organization pays to raise funds, for example, through bank loans should be estimated.
- **Construction and operational costs.** The construction cost of the microgrid should be calculated, according to the actual composition of the system, including centralized energy management system costs, installed capacity of storage and PV generation, and control devices. Cost of labor to operate and monitor the system, as well as operational costs, such as Photovoltaic degradation rate and performance degradation of the Energy Storage systems should be taken into account.

Furthermore, comprehensive benefits of the microgrid operation are presented in Table 15.

Table 15 Benefits and beneficiaries of microgrid operation

Benefit	How it is achieved	Beneficiary
Financial benefits	Sale of generated electricity is the main source of financial benefits. The yield rate of this investment is determined by the income	Microgrid operator / BRP

	achieved through the sale of electricity, the provision of ancillary services, the cost of daily maintenance as well as the cost of electricity bought and the charges for the use of the grid	
Benefits in energy saving and emission reduction	One of the Microgrid components is the large PV installation, whose construction and renewable energy provision serves to EU's long-term goal of power sector decarbonisation and helps to reduce the CO2 and SO2 emissions. Its benefits in terms of energy savings and emission reduction can be estimated by calculating the reduced emissions of pollutants	Microgrid operator, Society
Benefits from improvement of electricity reliability and power quality	Quality and reliability of electricity can be improved through the operation of the microgrid, by preventing sustained outages and providing ancillary services, such as frequency support, voltage support, black start or peak load support and balancing services. In this analysis, costs of emergency measures that may be necessary while using backup generators or in the event of a total loss of power should be taken into account.	DSO and TSO, Microgrid Operator

Reduction of distribution grid losses	Through the operation of the BEMS of the microgrid, self-consumption is optimized and the amount of electricity that is imported from and exported to the grid is minimized. This electric benefit can be estimated by calculating the difference between the grid losses before and after the microgrid operation.	DSO and TSO, Microgrid Operator
Capacity cost savings / Deferral of grid investments	Capacity cost savings can be estimated by identifying the grid investments in terms of energy generation, transmission, or distribution system, that are postponed because of the microgrid operation	DSO and TSO, Microgrid Operator

5.2 Prosumers business case

Regarding the prosumers case, the cost benefit analysis to be implemented should be based on the assumption that the prosumers are involved in an incentive-based demand response scheme, which is currently not applied in Cyprus, as no wholesale electricity market exists, thus market prices cannot be explicitly modelled.

The most important cost items involved in this pilot case are the following:

i. Investment costs

- Investments in smart metering infrastructure
- Installation costs of the smart metering devices
- Communication costs at both the consumer side and the grid, in order to remotely send flexibility offers and instructions of DR provision
- Costs of meter data management systems that will verify that DR is applied and load reduction is achieved
- Investments in control equipment in order to carry out load reductions automatically and provide demand response upon receipt of a signal

ii. Annual fixed costs

- Information costs
- Transaction costs
- Control costs
- Grid costs

iii. Variable costs

- Costs of PV generation
- Costs of flexibility provision

The most important benefits of the prosumer case are summarized below in Table 16:

Table 16 Benefits for the prosumer

Benefit	**How it is achieved**	**Beneficiary**
Peak-load Shifting	Prosumers contribute to the proper planning and operation of the grid by reducing or shifting their electricity usage during peak periods in response to financial incentives	DSO, TSO, Prosumer, Aggregator / BRP
Electricity bill savings	Prosumers can benefit financially by responding to flexibility offers during peak hours, by optimizing their energy consumption and maximizing their self-consumption. Aggregator can also benefit financially by aggregating the prosumers flexibility and selling it to the DSO or the market	Prosumer, Aggregator
Capacity cost savings / Deferral of grid investments	Capacity cost savings can be estimated by identifying the grid investments in terms of energy generation, transmission, or distribution system, that are postponed because of the aggregation	DSO and TSO, Aggregator

6 Business Key Performance Indicators for services to be implemented

The business KPIs are summarized in Table 17, following the afore-presented analysis.

Table 17 Business Key Performance Indicators (KPIs)

Service	Business KPIs	Target value during GOFLEX test phase
Service 1: Microgrid offering flexibility to the DSO	KPI 1.1 - Number of flexibility offers traded with the DSO	Value 1.1 - 10 flexibility offers/day
	KPI 1.2 - Activation of demand response strategies through the BEMS.	Value 1.2 - 10/day
	KPI 1.3 - Reduction of the total cost of electricity	Value 1.3 - 20% reduction compared with the current situation
Service 2: Prosumers offering flexibility to the DSO	KPI 2.1 - Number of flexibility offers traded with the DSO	Value 2.1 - 10 flexibility offers/day
	KPI 2.2 - Activation of demand response strategies through the HEMS/ Controllable load	Value 2.1 - 10/day
	KPI 2.3 - Reduction of the total cost of electricity	Value 2.3 - 10% reduction compared with the current situation
Service 3: Provision of forecasted data to the DSO	KPI 3.1 - Increase the accuracy of the forecast	Value 3.1 20% reduction in the imbalance between the forecasted and actual dispatch
Service 4: Grid congestion relief	KPI 4.1 - Number of activated flexibility offers for grid congestion relief	Value 4.1 - 5 offers/day

	KPI 4.2 - Reduction in the total cost of new grid infrastructure	Value 4.2 - 20% reduction

In order to get the targets for each specific KPI, the measurements from the real installations will be considered. For this reason, the data from the installed sensors, BEMS, HEMS and smart metering infrastructure will be gathered and compared with the data before the installation of the equipment from GOFLEX.

Regarding the university campus, historical data from the energy consumption and the PV installation are available. Concerning the dispersed prosumers, historical data from the DSO will be used in order to address the KPIs.

The risks for not adopting the presented services are the following:

Risk 1:

- The prosumers/microgrid operator will deny to trade the flexibility with the DSO, if the pricing of energy balancing is not attractive.

Remedial actions:

- The maturity of the market and the need for balancing, especially in the islanded distribution grid of Cyprus will form a fair pricing scheme, in order to make a "win-win" operation.

Risk 2:

- The data protection will discourage the prosumers to trade the flexibility.

Remedial actions:

- The UCY has already made a contact with the Office of the Commissioner for Personal Data Protection in Cyprus.

Risk 3:

- The prosumers/microgrids are not willing to participate in the flexibility.

Remedial actions:

- The dissemination of the GOFLEX project results will inform the prosumers / microgrid operators about the advantages and the profits for the active participation in the balancing market.

7 Correlation of trial business KPIs and Project Impact KPIs

The Table 18 presents the correlation among the trial business KPIs (as they have been analysed so far) in respect to the project impact KPIs.

Table 18 Correlation of trial business KPIs and Related Project Impact KPIs

Service	Business KPI	Related Project Impact KPI
Microgrid offering flexibility to the DSO	KPI 1.1: Number of flexibility offers traded with the DSO. KPI 1.2: Activation of demand response strategies through the BEMS. KPI 1.3: Reduction of the total cost of electricity.	Electricity load adaptability level: >15% (Energy demand variation with respect to peak demand) Demand response generated by virtual energy storage in demonstrated use cases in the project: ≥15% (Energy demand variation with respect to peak demand) Lessen the burden of power grids though self-consumption: >10% (MWh/h of self-consumed energy) Distribution grid stability through responsiveness of flexibility services: 10min/1hr/24hrs (Time required to activate portion of available load flexibility through DR services) Flexibility range at average occupancy of charging spots: +10/-30% Charging time reduction (battery buffer) and peak

		power need reduction (covering peaks from storage)
Prosumers offering flexibility to the DSO	KPI 2.1: Number of flexibility offers traded with the DSO. KPI 2.2: Activation of demand response strategies through the HEMS/Controllable load. KPI 2.3: Reduction of the total cost of electricity.	Electricity load adaptability level: >15% (Energy demand variation with respect to peak demand) Demand response generated by virtual energy storage in demonstrated use cases in the project: ≥15% (Energy demand variation with respect to peak demand) Lessen the burden of power grids though self-consumption: >10% (MWh/h of self-consumed energy) Increase of prosumer involvement: ≥15% (Augmented DR) Distribution grid stability through responsiveness of flexibility services: 10min/1hr/24hrs (Time required to activate portion of available load flexibility through DR services)
Provision of forecasted data to the DSO	KPI 3.1: Increase the accuracy of the forecast.	Benefit for DSO: 1.0 mio EUR/MW (the reduced cost of congestion avoidance) Grid state observability: near-real time and forecast

Grid congestion relief	KPI 4.1: Number of activated flexibility offers for grid congestion relief. KPI 4.2: Reduction in the total cost of new grid infrastructure.	Benefit for DSO: 1.0 mio EUR/MW (the reduced cost of congestion avoidance) Avoid congestions – reduction of peak demand: >15% (Reduction of MWh/h) Lessen the burden of power grids though self-consumption: >10% (MWh/h of self-consumed energy) Grid state observability: near-real time and forecast Likelihood of Prediction of congestion (voltage/power-flow limit violation): >90%

8 Can the business models be implemented under current market conditions and current regulation?

In the current form of the electricity market in Cyprus, there is no Aggregator or BRP. Therefore, the flexibility offers can be traded only directed with the DSO for both the microgrid and the dispersed prosumer case; but in both cases the DSO has to emulate the BRP function role. Regarding the smart meters' availability, it can be noted that adequate prosumers within Cyprus are equipped with a smart meter in their premises. Regarding the university microgrid, the smart meters are in the pipeline for being installed.

Concerning the forecasting infrastructure, EAC has installed its own infrastructure in cooperation with FOSS and facilities are operational for providing measurements from 17 weather stations installed selectively throughout Cyprus. The data provided within GOFLEX will help the DSO to take better decisions and calculate more accurately the energy flows within the distribution grid.

Therefore, currently only parts of the aforementioned business models can be implemented. More specifically:

Service 1

- The current PV installation is about 350 kWp, while within the next 2 years 10 MWp are going to be installed.
- The central energy management system, which gathers the BEMS in a single point of control will be implemented within the next few months. The smart metering points will also be installed within the next few months.
- The trade of flexibility with the DSO is unavailable under the current structure of the electricity market.

Service 2

- The trade of flexibility with the DSO is unavailable under the current structure of the electricity market.
- Only few prosumers own an energy management system, while many prosumers have rooftop PV installations. Furthermore, the energy storage installation is not common in the prosumers in Cyprus.

Service 3

- Communication with the DSO is implemented in a large timestamp (30 minutes).

Service 4

- The trade of flexibility with the DSO is unavailable under the current structure of the electricity market.

9 Conclusions

This deliverable deals with the business cases for the Cyprus demonstration site. Two different test cases are examined: the university microgrid case and the dispersed prosumers case. For each business case, different services are analysed, while the respective KPIs have been presented and analysed in order to reach the declared targets.

Following the analysis of the current situation in Cyprus, the closer date for adopting these services is is 2020. However, a service that sounds as the most promising is the gathering of forecasting data. The DSO will be able to plan the energy balancing resources more effectively, since the volatile RES (mainly PV) installed within Cyprus will send their energy production information directly to a database at DSO's premises. This service is also interconnected with the other three services. Since the DSO will have access to this data, it will be able to trade the flexibility with the microgrid operator and the prosumers, when the electricity market in Cyprus will allow such services. Furthermore, the grid congestion relief will also be supported.