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

D8.2 Business Model Design and KPI Definition – Use Case 2

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Executive Summary

This document (D8.2) presents further activities of Task 8.1 after the D8.1 document (submitted in April 2017) presenting the local conditions of the Swiss pilot. This document presents ESR's general strategy explaining how the flexibility will be used. It then describes the six different Business Models together with their Key Performance Indicators (KPIs) related to the Swiss pilot. This is followed by details about the Cost-Benefit Analysis approach for each category of prosumers. Finally, this document provides details about the Swiss market and the Swiss regulations to evaluate the feasibility of the implementation of the proposed Business Models.

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1.3	27.10.2017	Ready for submission	Pierre Roduit	Encompass Formal check review

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List of Acronyms and Abbreviations

Abbreviation	Definition
ACER	Agency for the Cooperation of Energy Regulators
BEUC	The European Consumer Organisation
BRP	Balance Responsible Party
CEER	Council of European Energy Regulators
CEMS	Charge Energy Management System
CEN	European Committee for Standardization
CENELEC	European Committee for Electrotechnical Standardization
DoA	Description of Action
DSM	Demand Side Management
DSO	Distribution System Operator
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
ESTI	Eidgenössisches Starkstrominspektorat (Federal Inspectorate for Heavy Current Installations ESTI)
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
FEMS	Factory Energy Management System
GEODE	European independent distribution companies of gas and electricity
HEMS	Home Energy Management System
H2020	Horizon 2020
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
ISGAN	International Smart Grid Action Network
ITI	Intelligent Trading Interface
JRC	Joint Research Centre
LCE	Low-carbon energy (see H2020 competitive low carbon energy call)
MMEE CH	Modèle de marché pour l’énergie électrique Suisse
MURD-CH	Modèle d’utilisation des réseaux de distribution Suisse
MURT-CH	Modèle d’utilisation des réseaux de transport Suisse
RES	Renewable Energy Source
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SCADA	Supervisory control and data acquisition
SEO	Search Engine Optimization

SET-Plan	European Strategic Energy Technology Plan
SM	Smart-meter
TOU	Time of Use (pricing for loads)
TRL	Technology Readiness Level
TSO	Transmission System Operator
VPP	Virtual Power Plant

1 Introduction

1.1 General context introduction

One of the three GOFLEX demonstration sites will be implemented in Valais, Switzerland. Valais is located in the middle of the Alps, where the natural area allows the installation of hydroelectric plants as the main producers. Furthermore, more and more other new type of renewable energy providers (solar, wind, biomass, etc.) are appearing, since Valais benefits from very generous weather conditions. Indeed, Sion (capital of the canton of Valais) enjoys yearly more than 2000 hours of sunshine. Therefore, the construction of photovoltaic installations in Valais is expected to continue, because of grid parity and also in the short term of subsidies by the Federal government.

Energie Sion Région (ESR) is a Swiss utility company located in Sion that serves multiple roles, such as electricity supplier, electricity producer, distribution system operator (DSO), water and gas supplier, internet provider, etc. It possesses more than 54'000 electricity clients and distributes more than 500 GWh of electricity per year. In the scope of this demonstration case, ESR will serve as both energy provider and DSO. In the same city lies the Institute of System Engineering of the University of Applied Sciences and Arts Western Switzerland (HES-SO). One of the two main axes of research of the institute is energy. HES-SO will serve as an integrator, support ESR during the demonstration phase, and coordinate the pilot experiments.

ESR, with more than 50'000 clients, possesses a good basis to get prosumers involved into this project. They registered more than 400 PV producers in the area. Sion possesses numerous small-medium Enterprises (SMEs), an airport, swimming pools, a skating rink, a hospital, a rehabilitation center, and a lot of other big electricity consumers. About 300 electric vehicles are registered in Valais, and numerous renewable power plants exist such as small hydro, biomass, etc. For this demonstration case within GOFLEX project, the general target is to involve 10 industrial partners and between 200 and 250 residential prosumers. Furthermore, 10 electric vehicles charging stations will be installed. In more details, the architecture of the Swiss Demonstration Site will link the GOFLEX system with:

- 200+ residential prosumers directly controlled by a global server
- 20 residential prosumers with a HEMS, with 5 of those having electric vehicles
- 10 factories (FEMS)
- 10 public charging stations (CEMS)

The 10 public charging stations will typically be installed near workplaces to guarantee flexibility. Currently, existing charging stations cannot be regarded as exploitable, since the clients want to start the charging their vehicle immediately. Figure 1 shows the architecture of the Swiss Demonstration Site. On this figure, ITI symbolize the link between the prosumers/consumers and the central GOFLEX solution. A more throughout description of the Swiss Demonstration Site can be found in document D8.1 Report on requirement and Prosumer Analysis – Use Case 2.

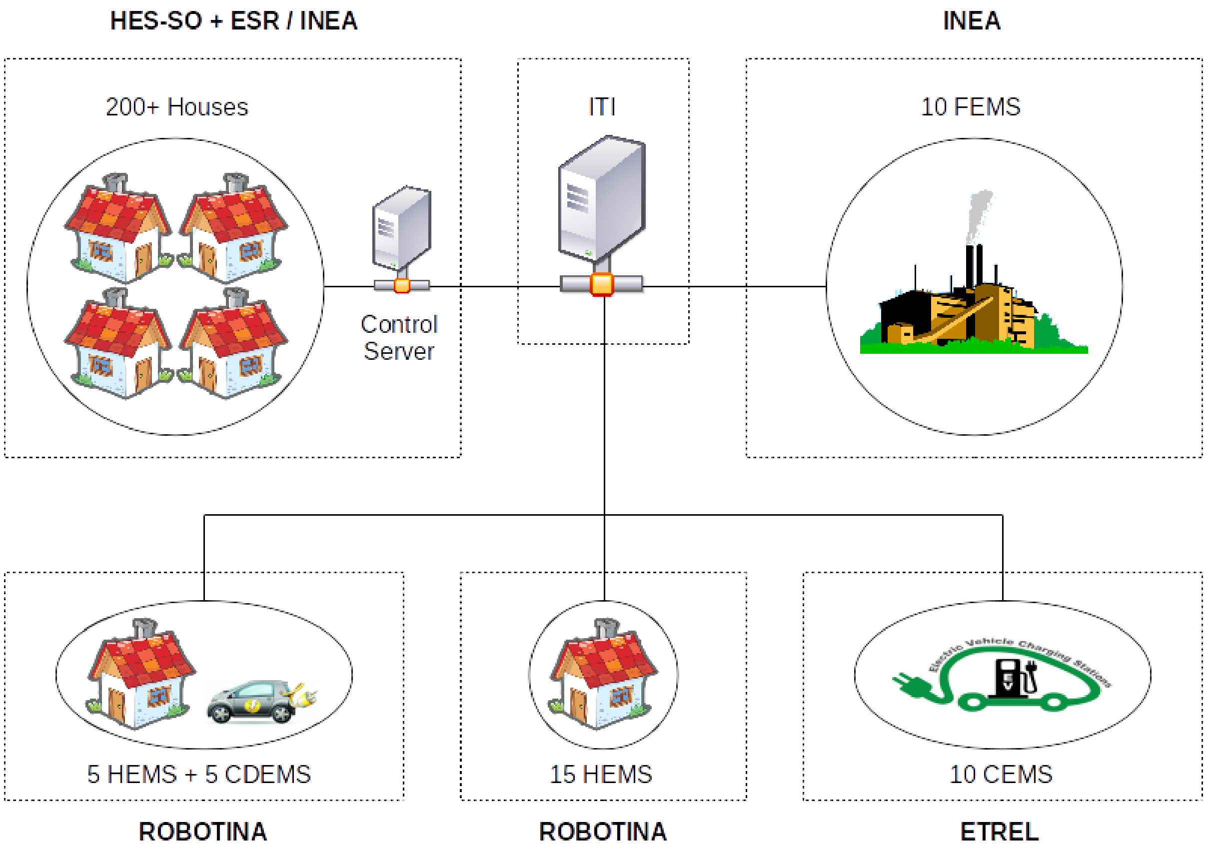

Figure 1: Architecture of the Swiss Demonstration Site

1.2 Purpose

This document provides a progress report regarding the situation and the accomplished work of WP8 – System Deployment & Evaluation – Use Case 2 after 12 months (November 2016 – October 2017). It provides the reader with ESR's general strategy explaining how the flexibility will be used, the different Business Models together with their Key Performance Indicators (KPIs) related to the Swiss pilot, details about the Cost-Benefit Analysis approach for each category of prosumers and details about the Swiss market and the Swiss regulations to evaluate the feasibility of the implementation of the proposed Business Models.

1.3 Related Documents

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

1.4 Document Structure

This document presents the D8.2 deliverable of WP8: Business Model Design and KPI Definition – Use Case 2 [month 12]

Section 2 follows this introduction and presents the GOFLEX Systematic Framework Conditions. This includes a description of Use Case 2, the Canvas Model, the Cost-Benefit Analysis and the definition of the Key Performance Indicators in relation with the Project Impact Key Performance Indicators.

Section 3 presents ESR's General Strategy regarding how the flexibility is understood and will be used. This includes details about ESR's framework, ESR's customers, flexibility in the distribution and flexibility in energy retail.

Section 4 presents the different business models for ESR's services. Six business models are considered: (1) service for PV owners, (2) correction of balance energy, (3) industrial customers, (4) private customers, (5) EV charging and (6) distribution investment deferral.

Section 5 presents the Cost-Benefit Analysis approach for the different services (direct control, industrial, residential).

Section 6 presents the Key Performance Indicator to be implemented in relation with the Project Impact Key Performance Indicators.

Finally, Section 7, followed by a short conclusion, describes the Swiss market and the Swiss regulations to evaluate the feasibility of the implementation of the proposed Business Models.

2 GOFLEX systematic framework conditions

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

- A shared methodology approach,
- A shared understanding of the structure of the future energy system, its roles and processes,
- 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 visualized 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 2: 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, analyzing, 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

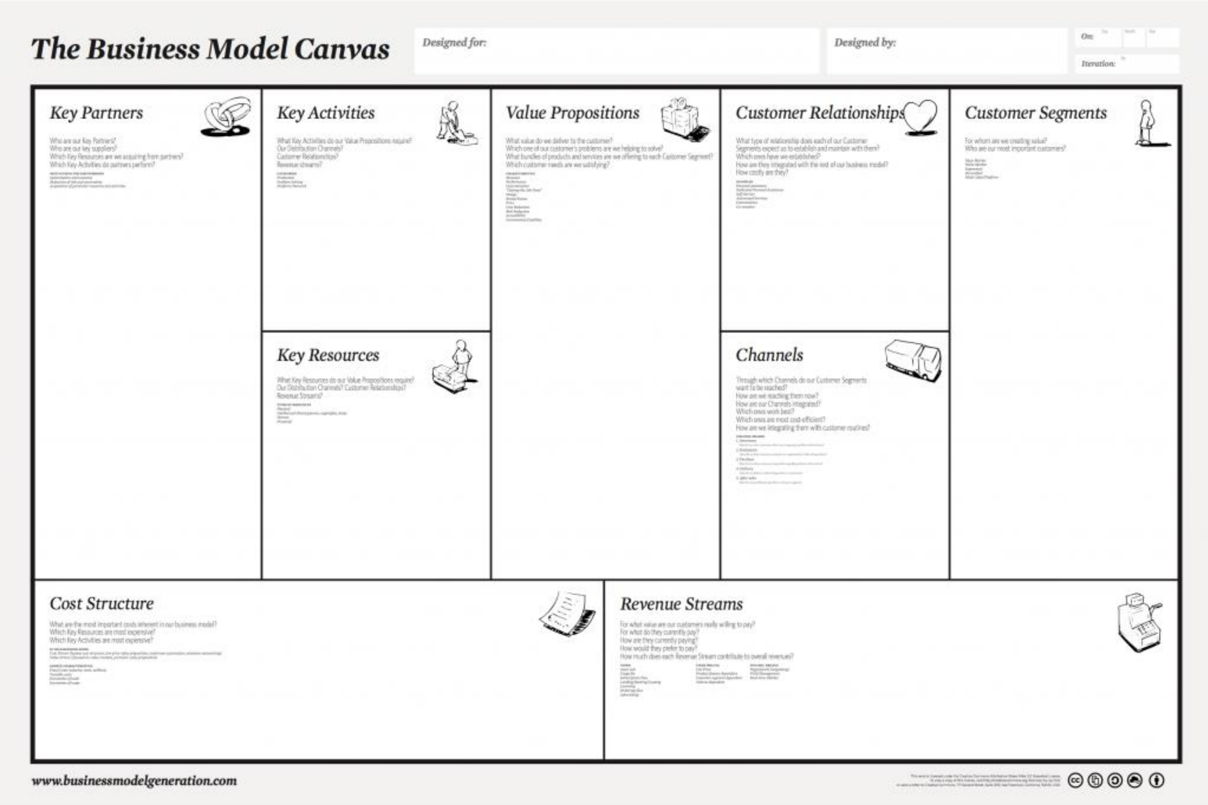

Figure 3: The Business Model Canvas

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”.

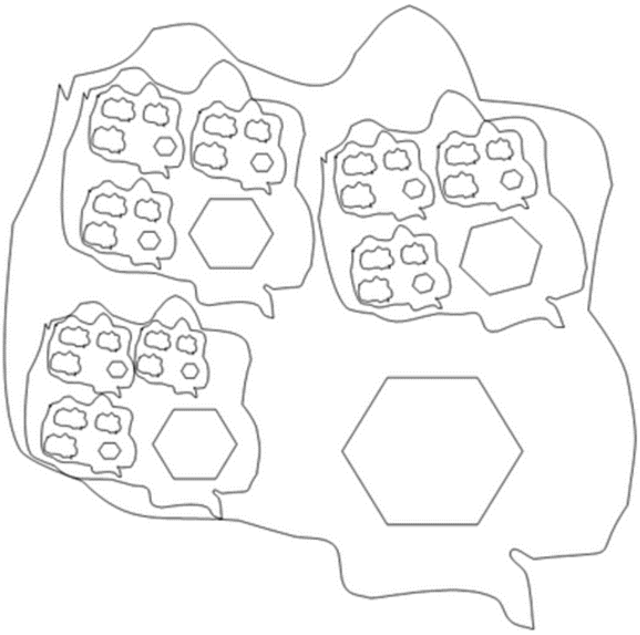

Figure 4: Schematic representation of vertical decomposition of electricity market system into nested fractal-like subsystems

- 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.

Local balancing of energy flows

- 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 un-leashing 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:
    - roles or sub-roles of the Harmonized electricity market model and Mirabel roles and processes model,
    - new roles due to its cellular extension downwards; examples of such roles are Microgrid Responsible Party, Local supplier of energy, and
    - 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

Table 2: Legend GOFLEX roles and processes

Acronym	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 aggregator	
MRP	Microgrid Responsible party	
LSE	Local Supplier of Energy	
LMO	Local Market Operator	Plays out the GOFLEX role FMAR operator
DSO	Distribution System operator	Cellular role of DSO
SDSO	Sub-DSO	Cellular sub-role of DSO
MORB	Market operator for Regional 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	
subDistG	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.

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 (∆MWh /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 (∆MWh /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)** **1 hr (>50% of DR)** **24 hrs (>100% of DR)**	Time required to activate portion of available load flexibility through DR services
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 ESR: Why and how flexibility will be utilized?

What is flexibility for a small to mid-size DSO like ESR? What could be controlled that is not yet? This GOFLEX project gave the opportunity to think about the general strategy related to this topic. General studies about flexibility are available but here we focus on the specificities of ESR.

3.1 ESR framework

In the past, ESR had many roles. It was at the same time a DSO (distribution system operator), an electricity supplier and a producer, mainly with hydro and solar production. Those roles were separated with the unbundling of the electricity suppliers, yet all three different roles are present at ESR group level.

The flexibility is important for each role and in the context of this GOFLEX project, a global vision is necessary. Considering legally separated entities, the roles and the respective interests of each party must not be mixed; it is important to understand this unbundling to keep the various reflections on track so that it can be implemented.

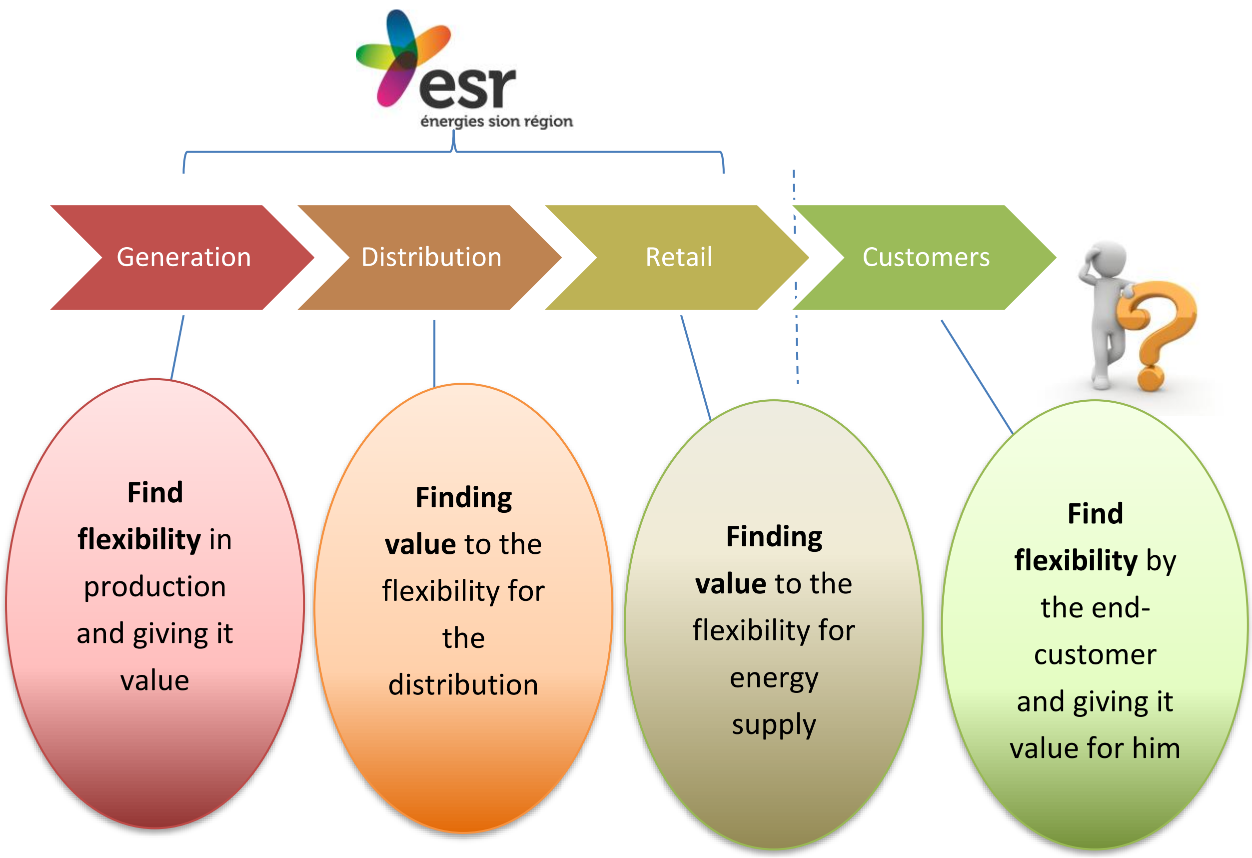

Figure 5: Market players at ESR grid scale

Each four aspects will be detailed in the next sub-chapters (3.2 to 3.6) and the possible business model associated in chapter 4.

Connected to its distribution grid, ESR has: some traditional consumers, the newly come prosumers and production plants. The flexibility must be searched in all elements connected to the grid.

The elements with a large flexibility have generally already been exploited, for example hydroelectric production encompassing some storage. The flexibility left is disseminated between multiple small elements. Those must be aggregated to be usable.

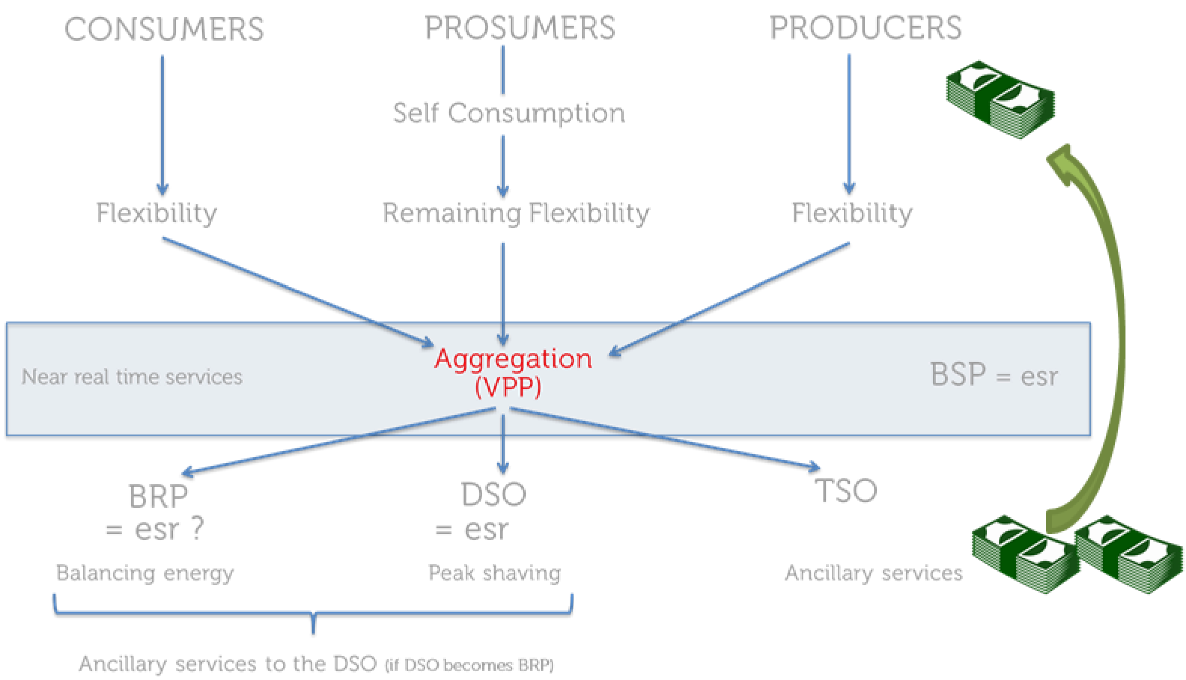

Figure 6: Flexibility is searched in loads a producer, aggregated and valued; a part of the value must be given back to the flexibility provider

On the other, side the flexibility must be valued; otherwise it is useless to deploy a flexibility harvesting infrastructure. A part of the value must be given back to the flexibility owner or some other kind of advantages. Another scenario could be that legal framework forces a consumer to accept a load control system.

In the context of ESR, the flexibility could be valued with:

1) Saved costs for BRP:
2) For energy balancing
    a. For levelling/shifting/shaving peak power at exchange point with TSO
    b. For controlling the reactive power at exchange point with TSO
    c. Reducing electricity cost: there is high price during the day and low price per kWh during the night.
3) Saved cost for DSO:
    a. Investment deferral and reduction for new grid infrastructure (congestion management)
    b. Efficiency improvement
4) New incomes for a service given to the customers:
    a. Visualization of energy data
    b. Automatic management of device
    c. Trading of flexibility
5) New incomes for a service given to the TSO:
    a. Provision of ancillary services

Beside of the direct incomes or cost saving in the short term, the control of flexibility at the customer level can have a strategic importance:

1. Service given to the customer: to keep ESR attractive in a context of a (future) liberalized market:
    a. Visualization tool (web page, app…)
    b. Special prices and flexible tariffs (today only night and day TOU pricing).
    c. Energy management service for
        i. Individual solar installation and self-consumption
        ii. EV charging
2. Preparation of energy transition in the long term.
    a. Energy management at distribution grid scale.

3.1.1 Potential conflicts

Using flexibility is an energy management and it can be done at different levels by different market players as represented on figure below:

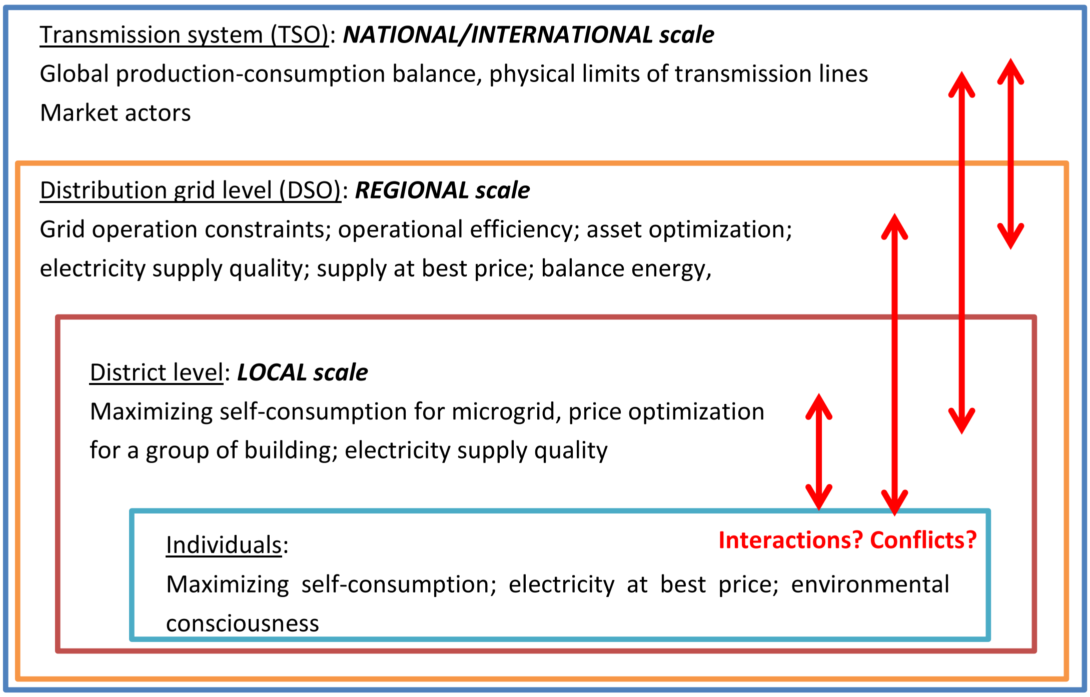

Figure 7: There are different actors from the end customers to the continental grid. Each has different optimization goals with the flexibility

Each level has its own optimization goals and the various goals can be conflictual between each other's. Those must be clearly identified and then the conflicts arbitrated.

An example is a prosumer with PV: he wants to maximize self-consumption because it is the way to give the highest value to his solar energy (grid feeding pays less). Then he wants to put the maximum of loads during the day when sun shines. If a DSO wants to switch off his load during the day, there is a conflict.

A second example is given with the potential conflict between the local and the global management of the grid. A TSO is mainly interested in frequency control, as it is the image of the production-consumption balance of the whole interconnected grid. A DSO is interested in voltage control and power quality at local level. It can be that there is a lack of production at European scale (frequency under 50Hz) but an overproduction in a local grid that would need either production curtailment or load on switching.

3.2 Customers: Who are our customers and what they want for their flexibility?

There are various customer profiles, with specificities regarding flexibility. The segmentation is necessary to set up a coherent business model with each profile.

3.2.1 Citizens / end customers

The simple individual consumers may have dispatchable loads (direct electrical heating, heat pumps, electric cars, etc.). They would share their flexibility because:

- There is a direct compensation or a special price on bought energy.
- They have a local goal for the controllability of the consumption and the system takes it into account.
- There is another advantage/service offered (energy visualization, …).
- There is the will to participate in the energy transition; this fits in their beliefs.
- It is mandatory: grid codes evolve so that the electric loads are systematically under DSO control.

The situation of the customer should be carefully considered before the control system implementation. A consumer should not lose money compared to today. For example, he may have low tariff during night and high tariff during day. Moving loads from one tariff to the other has an impact on his energy bill. The flexibility benefits should at least compensate any bill increase. This aspect should be secured before enrolment of any test site in the GOFLEX project.

Figure 8: Smart-Grid ready icon on a heat-pump

The users with direct electrical heating systems or with “smart-grid ready” appliances will be easier to connect to a DSM system. The installation is simplified. As the savings per controlled point are small, the installation costs must be kept low.

Energies de Sion Région SA has already about 10'000 customers equipped with ripple control receivers. This basic load control system was largely deployed in Switzerland in the 70’s and is still operating. Ripple control (Wikipedia 2017) is made of a central system adding a signal generally between 400 and 1000Hz on the 50Hz sinewave. This signal can be read by all receiver connected on the grid and those connect and disconnect loads in function of coded messages. The customers with a ripple control receiver already installed will be selected first, as they have already controllable loads with the wiring done.

Prosumers with PV solar systems

The active prosumers with PV solar systems may have dispatchable loads, but they may also have set their own goals in energy management. Following the current pricing scheme, or the will to be energy independent, they want to maximize the self-consumption of their own production. This goal has priority in the use of flexibility and only the left flexibility can be used for other purpose.

In the selection process of the prosumers with solar systems, the lists of ESR customers with PV plants has been established. The majority of older installations are subsidized with a fixed price per kWh and the whole production is injected to the grid (Swiss feed-in tariff, RPC: reprise à prix coûtant). Since 2014, self-consumption of PV is allowed by Swiss Law and the new installations are using this scheme. There are about 500 PV plants connected to the ESR grid today. We can divide those prosumers in two categories:

- Prosumers with PV in self-consumption scheme:
  - Directly interested in increasing their self-consumption rate.
  - The load control has a financial impact.
- Prosumers with PV with feed-in-tariffs only:
  - No direct advantages on self-consumption.
  - May be interested in the concept of self-consumption, and interested to the participating in an innovative project.
  - Treated like other simple consumers. The self-consumption optimization has no financial impact on the electricity bill.

According to the metering of those customers, the self-consumption rate is useful to decide who could be interested in participating in the project.

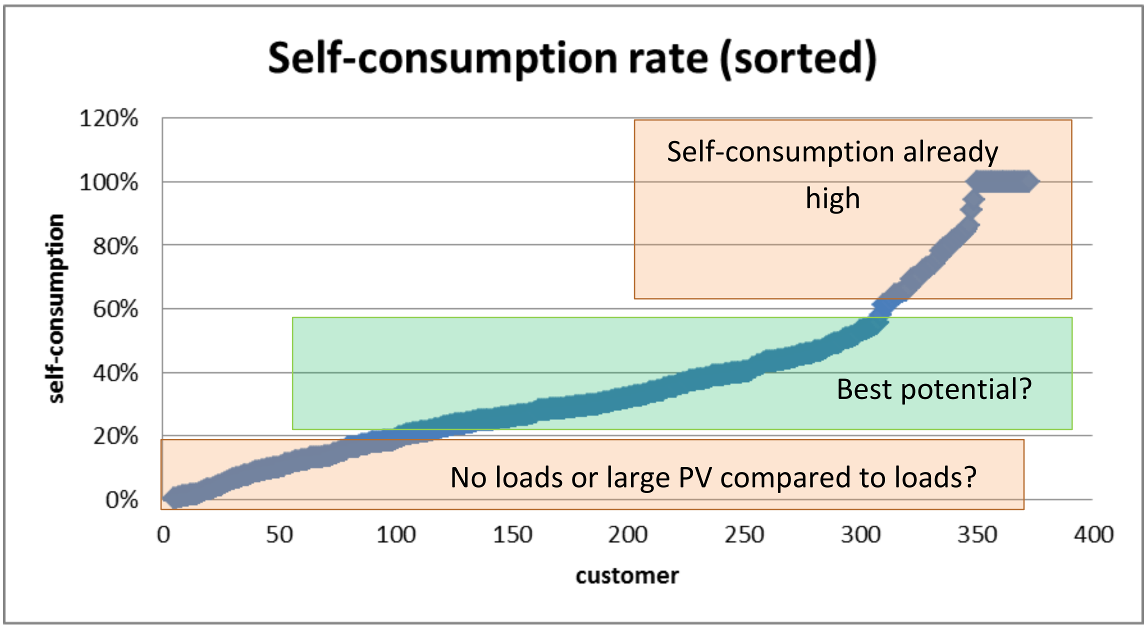

Figure 9: Estimated self-consumption rate of the prosumer with PV connected to ESR

Customers with already 100% or a high self-consumption may not be interested, they have nothing more to optimize and may fear to decrease their performances. Customers with low self-consumption do not perhaps have the required loads to be flexible. Thus, the maximal potential resides perhaps in between.

Customers with EV charging stations

The electric cars offer a great amount of potential flexibility, but have special constraints. EV charging point usage is different depending on the location of the charging station. Control strategies must then be adapted to each case. This can be seen on the figure below with the time of arrival at the charging station. Analyses of the behavior of different type of charging station are available in literature.

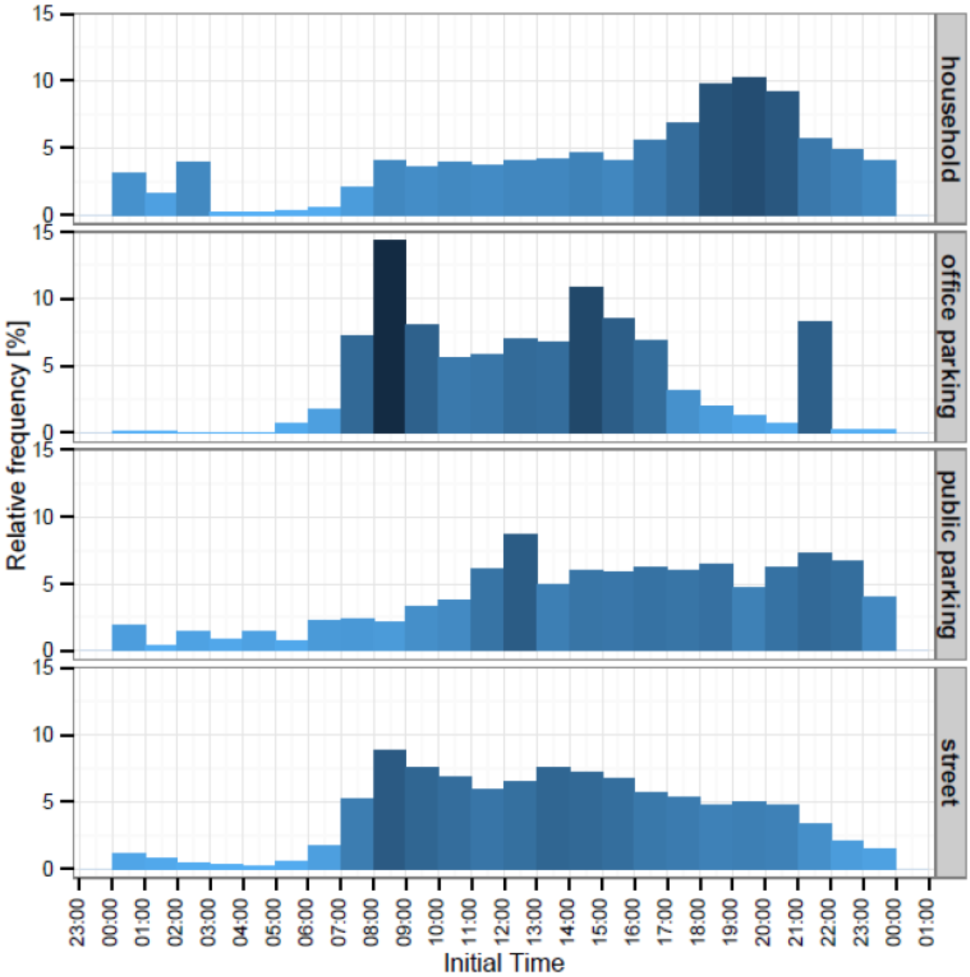

Figure 10: Histograms of charging start time depending on location of the charging point

There will be a segmentation of the categories of charging stations. For example, a recharge station on a highway has no flexibility because the drivers make a short stop and want to recharge the maximum of energy during that time (maybe 15 minutes). On contrary an EV owner that arrives to his house in the evening has the whole night to recharge and there is a lot of flexibility in this case.

The expectations of the user will determine the control patterns. The acceptance by the end user will probably be a key point. The well-known '*range anxiety*', must be considered for the load control strategy. An EV user wants to leave with a certain state of charge of the battery. In order to make the user feel safer and free to choose the flexibility or not, the charging system should propose the options to have:

- Fully flexible charge (default), taking into account departure time.
- Load control can limit (but never stop!) the charging power: this strategy will reassure the client that the battery is not empty when he comes back.
- Limitation levels to define: for example, -30% of available power.
- Forced charge with full power available at the socket: no flexibility case.

Options will be proposed to the CEMS pilots once they are identified and the specific expectations of each are better known.

3.2.2 Industries

The large consumers (industries, commercial and administrative buildings, infrastructure equipment) may have large dispatchable loads. That makes them interesting, since they can trade their flexibility with the DSO.

Industries are characterized by the variety of processes. An important analysis will be necessary to understand the processes, the flexibility available and how to use it without modifying the productivity of the process.

The following points are important from the point of view of the customer:

- Production process is the core of the company activity and has the priority over all other aspects. The GOFLEX system should not disturb this process. Only in cases when large savings are possible, per example with peak shaving, the industries accept to modify their production process.
- Today load control is often already used for peak power shaving to reduce electricity bill. If there is such a system in place, the GOFLEX should harvest it and shouldn't interfere with this local optimization goal.
- Industries have a growing concern about energy use and cost. The interest in energy management system at organizational level is growing (ISO50001). Visibility of the energy is interesting for them.

The complex processes already have control systems, and it can be difficult to interface it to a new control system. The designers of those control systems must be involved (and probably paid).

3.2.3 Buildings

Large buildings, commercial, residential (rented flats), or administrative (schools, public sector, etc.) have large heating systems.

Similar to individuals, they would share their flexibility because:

- There is a direct compensation or a special price on bought energy.
- There is another advantage/service offered (visualization, …).
- There is the will to participate (in the energy transition, in ecology…).
- It is mandatory.

The technical aspects could be complex and require an analysis to understand the systems. The approach to find the flexibility is more similar to the industries in this case. Those could be incorporated to FEMS demonstrators.

3.2.4 Infrastructure

There are public infrastructures and systems that consume electricity and may present interesting flexibility potential.

- Water supply (flexibility in pumping control), example of project (Regelpooling 2017)
- Water treatment installation
- Swimming pools heating and ventilation systems
- Ice rink
- …

The discussions must be held with public authorities to collaborate. They can be interested because:

- There is a direct compensation or a special price on bought energy.
- There is another advantage/service offered (visualization, …).
- There is the will to participate (in the energy transition, in…).

The technical aspects could be complex and require an analysis to understand the systems. The approach to find the flexibility is more similar to the industries in this case. Those could be incorporate to FEMS demonstrators.

3.3 Generation: What are the distributed flexible generation?

There are different types of generation connected to the ESR grid today and there is a good potential of implementing flexibility trading schemes.

3.3.1 Hydroelectric power plant

Large hydro power plants are actively participating in markets. The potential flexibility is explored and production is planned to optimize revenue, taking into account technical constraints. There are possibilities left for ancillary services to the TSO and the potential new DSO ancillary services. Plants qualifications are under discussions, but this will stay outside of the GOFLEX project.

There are also many small hydroelectric plants connected to ESR grid that are not flexible today (27 micro-hydroelectric plants). It could be of great value to make them more flexible. This is closer to DSM than traditional production planning. Due to the small size of the plants, they need an aggregation. Only a large number of small plants can guarantee the availability of flexibility, and coupling with loads DSM in a VPP could be complementary.

One example is a small 4MW hydroelectric situated in Icogne. It has a small water tank and this storage flexibility is unused today. There is a simple hysteresis control on water level and power is produced independently of market or grid needs at a certain time of the day.

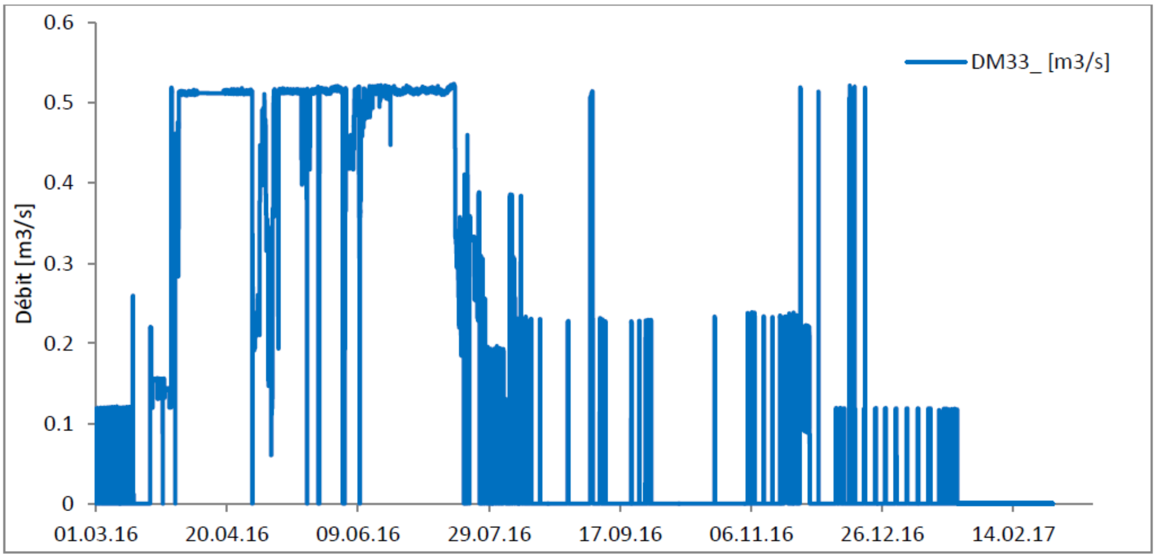

Figure 11: The Icogne hydropower plant is producing with an uncontrolled scheme today, only considering a water reservoir level. It is producing almost permanently when the snow melts (March to July) and intermittently during the rest of the year. Image from (Schmid 2017).

This plant offers a good flexibility potential during parts of the year.

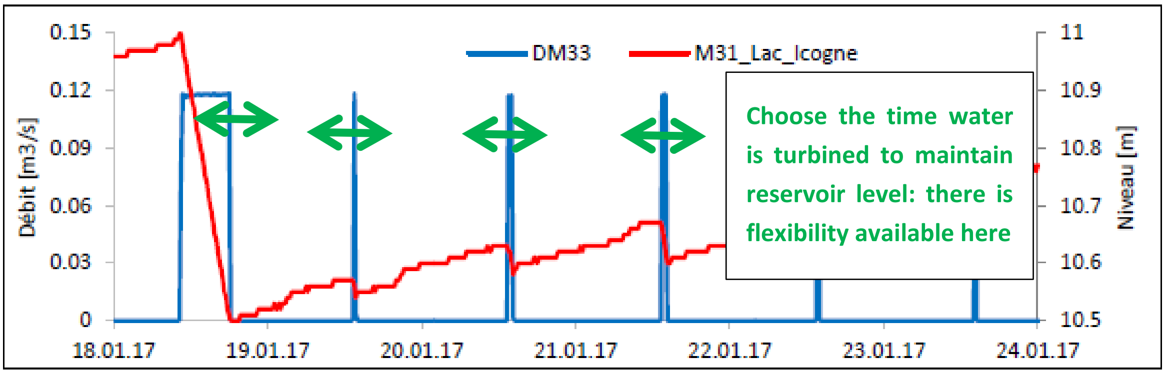

Figure 12: During a part of the years, as water inlet is small, a few hours of production per day are sufficient to maintain the reservoir level. It would be interesting to decide at what the time during the day and couple it with a flexibility need. Image from (Schmid 2017).

This case will be further investigated during the project as it is not a classical DSM case for prosumers (main scope of GOFLEX), but one that combines production with explicit storage and consumption in infrastructural objects. From the grid point of view, there is no difference between load flexibility and generation flexibility. Considering a part of the grid as a black box (for example one feeder on a transformer), none could say if a consumption reduction is caused by a decrease of the load or an increase of the local production.

3.3.2 Solar power plant

ESR has 14MWp of PV plants in its distribution grid, including 2.8 MWp of its own production.

Active power curtailment

A PV plant is not considered today as flexible production. It is said to be intermittent and uncontrollable, but curtailment of production is always possible. It has been proven in many trials that solar can participate to ancillary services (one example is GTM (GTM 2017)) and grid stability.

The PV plant income is based today on energy production and curtailment makes no sense today from the plant owner point of view, thus an agreement must be found with him. The price for a non-produced kWh for ancillary service should be higher than the one of a produced one. Another approach could be to look for the possibility of microgrid pooling with other prosumers and based on the concept of local self-consumption.

Reactive power control

Today solar inverters can produce reactive power on demand. This is also a kind of flexibility that can serve the grid needs. It could be used to optimize the use of reactive power for the distribution grid. A DSO is allowed to set power factor of a plant according to ESTI directive 219 (Confédération Suisse, Directives ESTI 2017):

- Up to $\cos(\varphi_{max1}) = 0.9$ for production larger than 30kVA
- Up to $\cos(\varphi_{max2}) = 0.95$ for production smaller than 30kVA

For 14MWp of solar inverters installed in the ESR distribution grid producing 10MW, this represents a potential between the two limits:

- $10 \cdot \tan(\varphi_{max1}) = 4.84 MVAr$ with $\varphi_{max1} = 25.8°$
- $10 \cdot \tan(\varphi_{max2}) = 3.28 MVAr$ with $\varphi_{max2} = 18.19°$

The 14 large plants belonging to ESR have a cumulated power of 2.8MWp and an associated reactive power of 1.35MW with φ_{max1}. It must be studied if this can have a significant effect on the reactive power penalty paid.

Effect on local voltage and local losses should be studied before any changes on the reactive power production are done.

3.3.3 CHP

There are 8 large combined heat and power plant for a total of 470 kWp. Feasibility of this case will be studied later during the project as a FEMS.

3.3.4 Biogas installations

There are 2 biogas plants for a total of 257kWp.

It will not be studied further.

3.3.5 A waste-to-energy power plant

There is one 4MW plant.

It will not be studied further.

3.4 Distribution: How to value flexibility?

ESR as a DSO, operating a distribution grid could benefit from flexibility and especially DSM for investment deferral and losses reduction.

3.4.1 Investment deferral

This concept has been widely explained and studied (EU-projects Improgres (Improgres 2017) , MetaPV (MetaPV 2017)). A few practical examples have been implemented.

The general concept looks attractive and is easily understandable. When questioning the people really operating the grid about the investment deferral, they are quite reluctant to the idea today. The reason stands in the word reliability: Operating a distribution grid is all about reliability and operators are judged by SAIDI and SAIFI indexes. There is little place for tests and trials involving end-customers.

A grid management solution must be proven and secure for the operators and today a learning curve must still be performed before a flexibility management system is fully trusted. Between the options of reinforcement which is well known and mastered and new smart solutions, technicians will choose the first option. This is the status today.

However, these studies and positions are based on classical situation and technologies and do not take into account the reliability of aggregated supply of energy flexibility locally, with short energy transfers on distribution grids as opposed to single large unit (from the point of view of transfer) transferred over large distances. This necessitates paradigm change that has yet to occur and will have to be motivated by independent research studies.

3.4.2 Grid efficiency

There is a real example of DSM to improve a transformer loading that could be a first step on the learning curve. In a district supplied by a transformer, there are many houses equipped with electrical heating: direct room heater or water-heater. During the winter months the load is high on the transformer at some part of the day, but still it is not overloaded. The peak shaving on this district could diminish the losses on the transformer, hence reduce stress and improve lifetime.

As it is not absolutely necessary, but is an improvement, the case is favorable to start a flexibility trial project. It will be explored further during the project as a potential demonstrator with a part of the 200 direct-control installed in this district.

Another possible optimization is the local compensation of reactive power with distributed producer.

3.5 Energy retail: How to value flexibility?

Conceptually, the provision of flexibility should be remunerated. A flexibility control algorithm should try to minimize costs or optimize revenues. Everything that has a price could be optimized with the help of flexibility. A review helps to find the full potential of savings with flexibility. For this reason, Figure 13 below presents the prices given by the Swiss TSO Swissgrid for its services.

Swissgrid operates in a regulated market under the supervision of the regulatory authority Swiss Federal Electricity Commission (ElCom). The ElCom serves as «price monitor» in the electricity sector and checks the tariffs billed by Swissgrid.

	2018[1]	2017[2]	2016[3]
Grid usage			
Working tariff [cents/kWh]	0.23	0.25	0.25
Power tariff [CHF/MW]	38'200	41'000	41'000
Fixed basic tariff per weighted exit point [CHF/AP p.a.]	365'300	387'700	387'700
General ancillary services (AS)			
General AS tariff for grid operators and end consumers connected to the transmission system [cents/kWh]	0.32	0.40	0.45
General AS tariff for ML operators[4] (SR[5] 734.713.3) [cents/kWh]	0.03	0.04	0.05
Individual ancillary services			
Individual AS tariff for active energy losses for distribution system operators and end consumers connected to the transmission system and for ML operators[4] (SR[5] 734.713.3) [cents/kWh]	0.08	0.08	0.11
Individual AS tariff for reactive energy for active participants non-compliant with requirements (distribution system operators as well as end consumers and power plants in the transmission system, since 1 January 2011) [cents/kvarh]	1.51	1.75	1.32
Individual AS tariff for reactive energy for passive participants (distribution system operators and end consumers in the transmission system, since 1 January 2010) [cents/kvarh]	1.51	1.75	1.32
Remuneration rate for active participants for reactive energy supplied according to requirements (distribution system operators and power plants in the transmission system) [cents/kvarh]	0.30	0.30	0.30
Balance group management			
Balance group registration fee[6] [EUR]	6'250	6'250	6'250 / 3'500

Net tariffs, excl. VAT

The tariffs and rates are given in Swiss francs, unless another currency has been given.

Figure 13: Swissgrid (TSO) tariff (Swissgrid, Tariffs 2017) for grid usage: The flexibility allows modifying many points of this price list, influencing the final bill.

3.5.1 Balancing energy

ESR energy is making a global consumption forecast of its grid every day for the next day. If it doesn't match the real consumption, there is an imbalance cost (Swissgrid 2017) to be paid. Flexibility can be used to adjust the ESR grid consumption to the announced forecast. The result is cost saving on balance energy by decreasing forecast deviation.

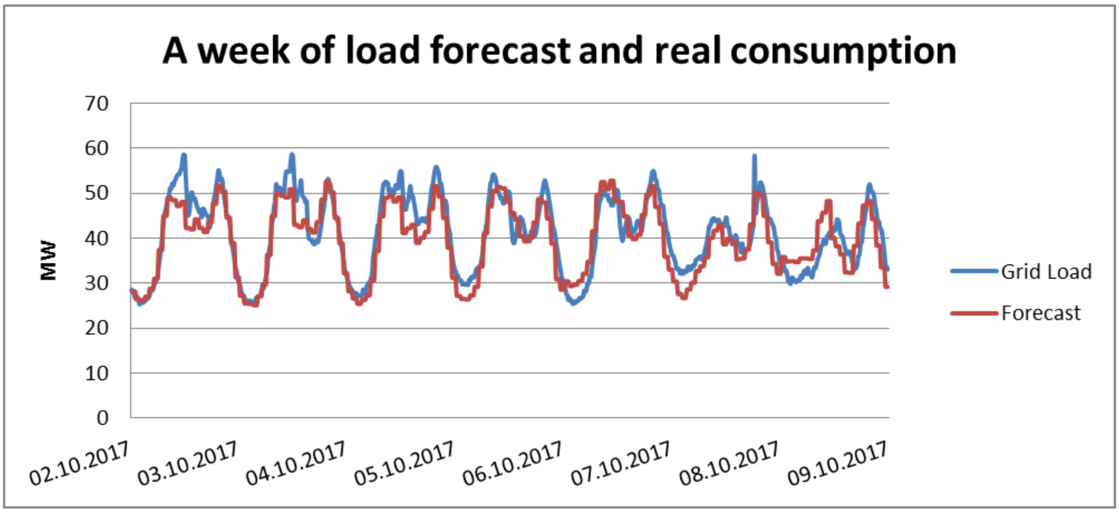

Figure 14: Sample of forecast and grid loading for one week

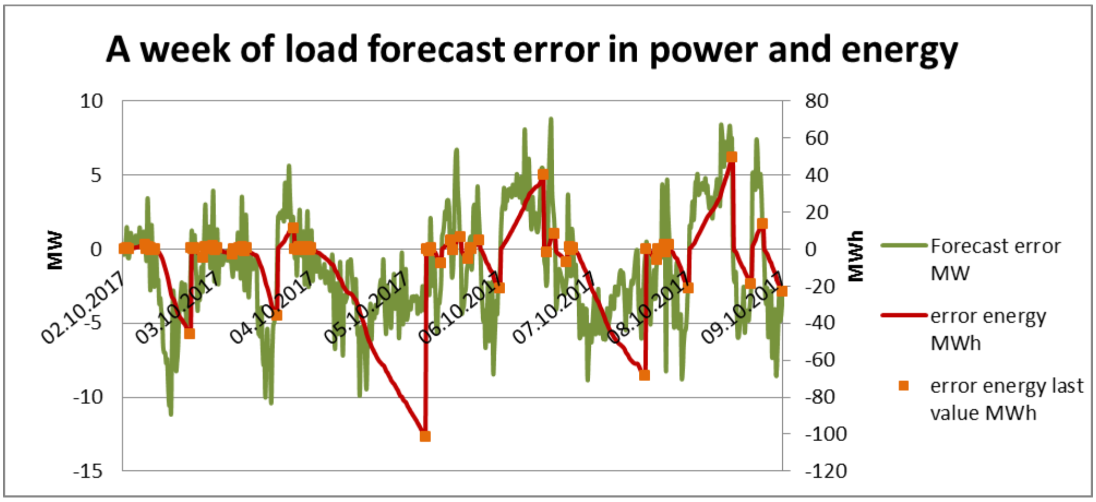

Figure 15: To assess the potential of flexibility for balance energy, we need to know what power and how much energy must be flexible to compensate forecast error.

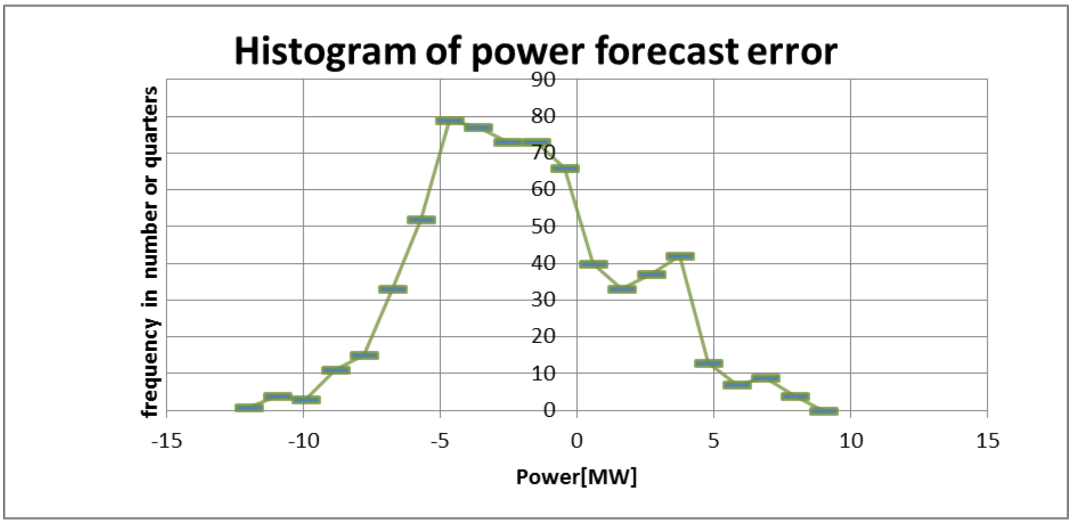

Figure 16: During this week the forecast error is between +5 and -5 MW the majority of time

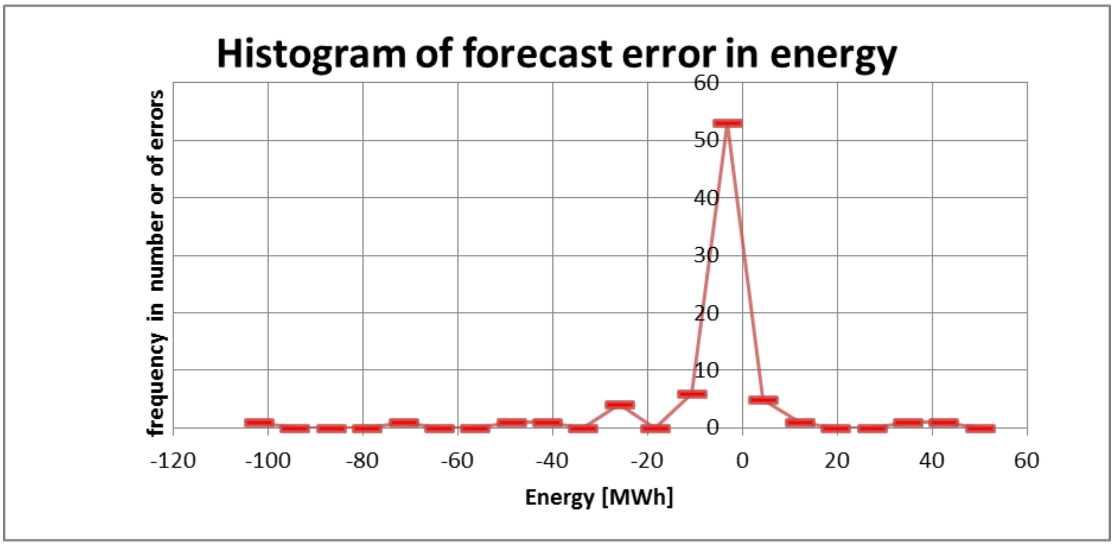

Figure 17: In the majority of cases forecast error represents energy of a few MWh and a shift could compensate it.

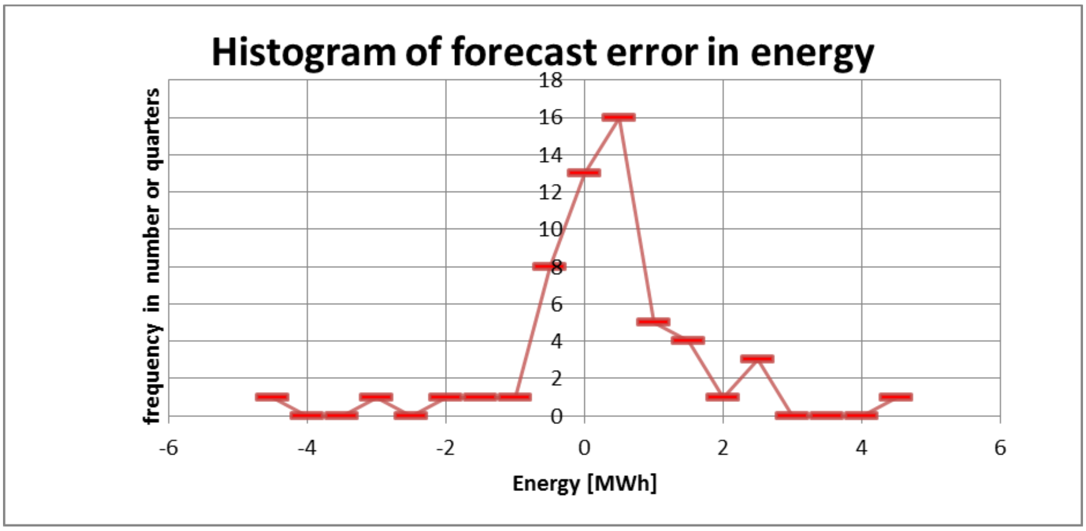

Figure 18: Histogram of energy forecast error between -5MWh and 5 MWh: 49 errors

Here, considering a single week, there are 75 errors in energy counted, 43 of which are between -1 and 1MWh. The analysis on the full 2016 year shows similar results.

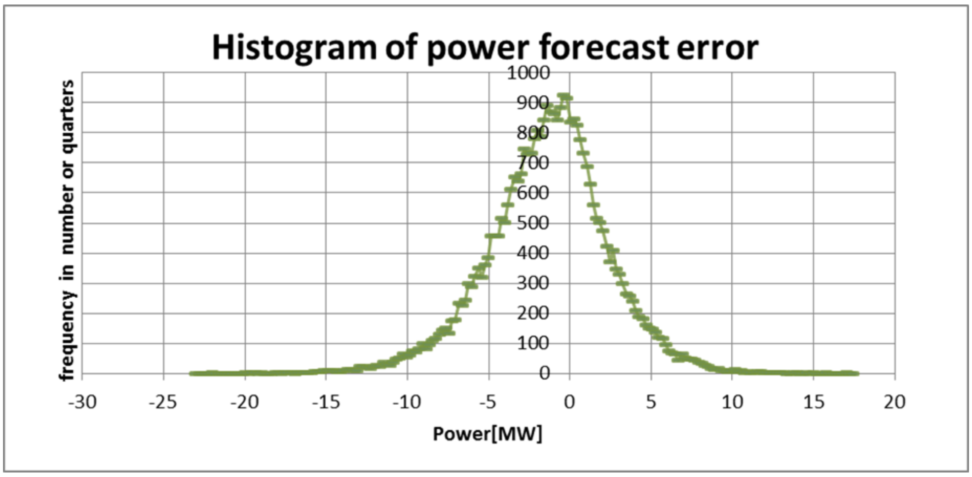

Figure 19: During 2016, the forecast error is between +5 and -5 MW the majority of time (82%) as seen on this histogram

Deeper analysis of the forecast error properties will be done during the project associated with the analysis of the business KPI and cost-benefits analysis.

Error shifting is also an option: imbalance price is varying through the day. It could be profitable to shift an imbalance at low price time. Most controllable loads have a rebound effect to count on. This rebound could be set at a better time. This can be useful with forecast errors with large energy. It could even be imagined to harvest the negative prices cases and making money with errors with a performant flexibility system.

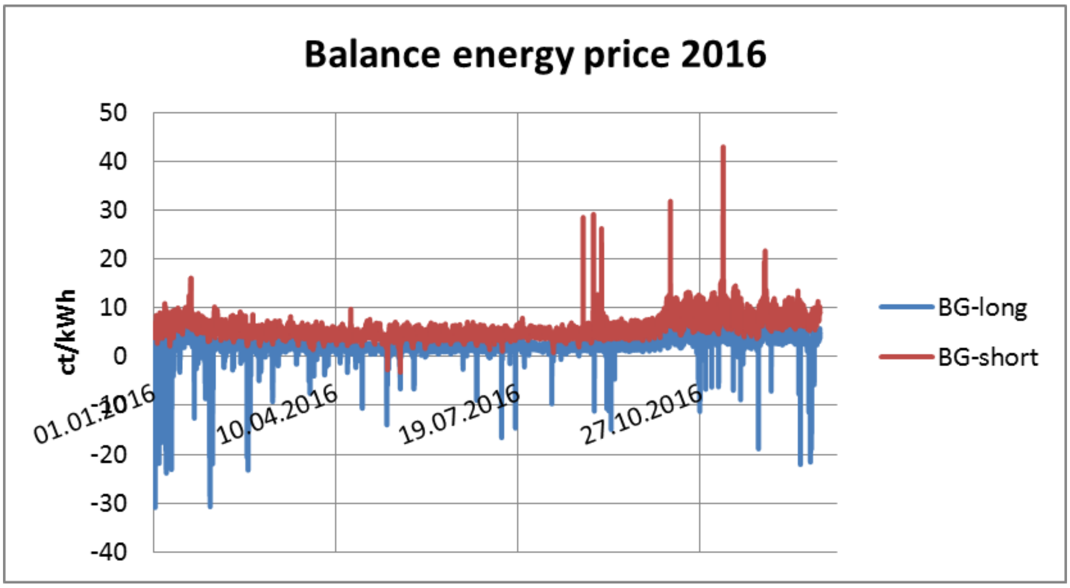

Figure 20: Balance energy price in 2016 in CHF

It is also possible to buy energy in the intraday market to compensate an error of prediction done the day before. This mechanism asks for a good (better than day-ahead) short term forecast and requires time for the agreement. Flexibility could compensate the error until the new schedule for energy consumption is established. Doing so, the rebound effect should be taken into account in the new forecast.

3.5.2 Peak power

The peak power at connection to the TSO is paid with a CHF/MW price. Peak-shaving is a way to value the flexibility.

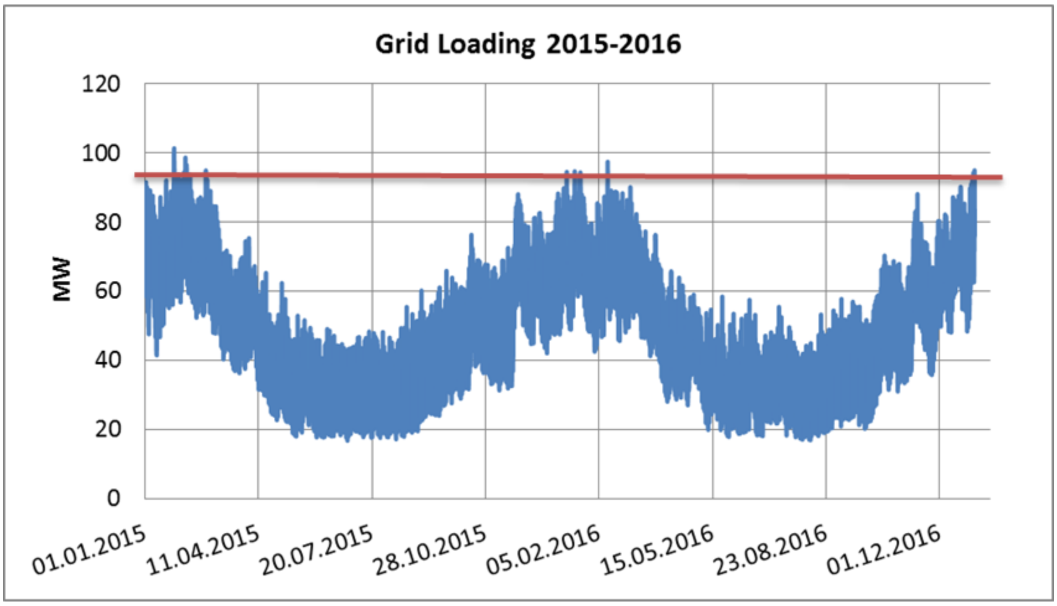

Figure 21: ESR grid loading 2015-2016: the peak loads are only a few hours of a few days per year

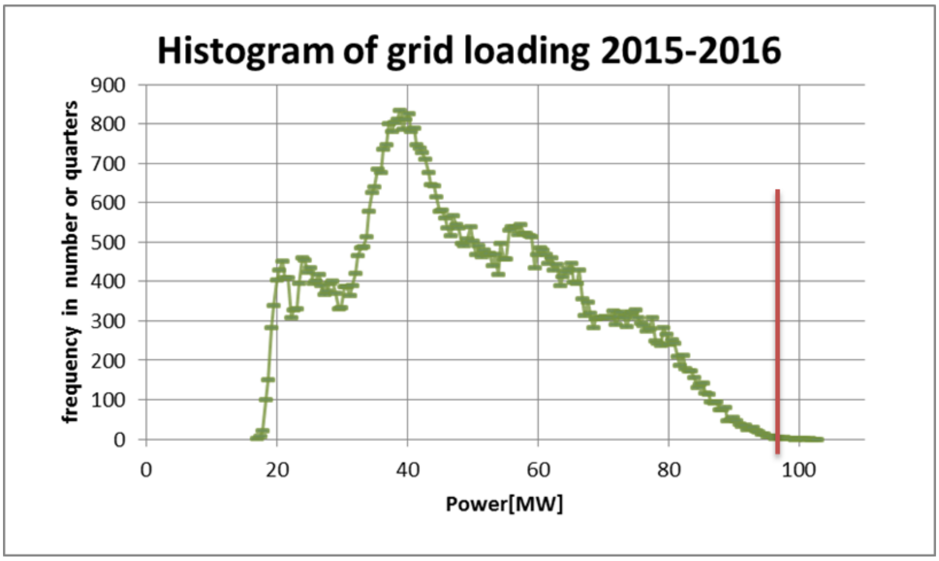

Figure 22: ESR grid loading

3.5.3 Load shifting at low price time

Price of electricity varies through the day. It is generally cheaper during the night today; potentially it could be cheaper during the day at high solar production in the future.

Shifting the consumption to the low-price time with available flexibility is interesting. It must be considered with the energy bought the year before (base and peak).

3.5.4 Reactive power

Reactive power at exchange point with the TSO is payed 15.1 CHF/MVArh if outside of defined limits. Within the tolerance range, there is no penalty billed. The flexible reactive power production could be adapted to compensate and make some savings on reactive energy cost.

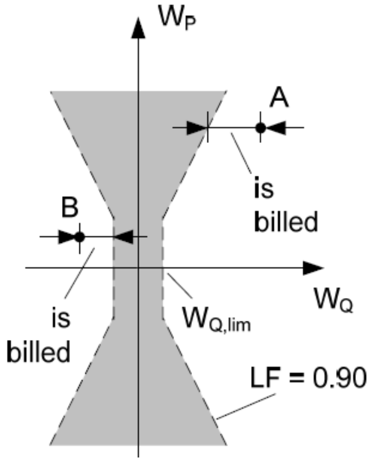

Figure 23: Canvas for billing reactive power to passive participants, image Swissgrid

The tolerance range is important today but if the distributed generation (PV) produces only active power in the future, the reactive power proportion seen from the TSO will increase and may come out of the canvas.

3.5.5 Keeping customers

In the context of liberalization, it will be important to keep customers with attractive products. Flexibility by itself will not help to keep customers but the deployed system of measurement and control can be used to propose new services. Relationship to customers and services are described more in detail in chapter 3.2.

3.6 Collateral benefits of GOFLEX project and flexibilization of the end-consumer

Even if those are not in the announced goals of GOFLEX explicitly, it is worth to mention:

- Increase of the grid visibility: today the operation of the distribution grid is quite blind. There are almost no measurements installed and little feedback of what is happening. Deployment of 200 measurement points will provide data to analyze.
- First deployment of smart-metering services: The devices deployed in the 200 houses for direct control have some of the features that will be found in future Smart-Meters. This is a first test of the services it could bring:
- Visibility of energy consumption as a service for the consumer.
- Possibility to propose energy efficiency measure.
- Possibility to have a PV self-consumption evaluation before a PV plant is planned and installed.
- Having a tool for self-consumption optimization independently of the GOFLEX project (An energy control box).
- Marketing: the occasion to communicate to the public about the participation of ESR in the energy transition.

4 CANVAS Business models for services offered by ESR

4.1 Time scale of flexibility services to be implemented (now and future)

Energies de Sion Région SA has already about 10'000 customers equipped with ripple control receivers. Thus, DSM is not new to the company. The trial during the GOFLEX project investigates new ways of doing DSM and a first coupling with intraday needs. Besides, it investigates flexibility services for the consumers and also energy visualization services, (which is outside of the scope of GOFLEX).

Table 4: Time scale of flexibility services to be implemented

Service	Ripple control	Prosumer flexibilization	Prosumer services	Correction of balance energy	Generation optimization	Large scale deployment
Actor/Role	DSO	BRP, Aggregator	Service provider	BRP	Production responsible party	BRP, Aggregator
Planned time for implementation	Already there, improvement possible during 2018-2019	2018-2019 Trial	2018-2019 Trial	2018-2019 Study and Trial	2018-2019 One case Study/ implementation as FEMS if possible	Depending on results 2020-…
Tested in GOFLEX	N		2018-2019 Trial	y	Y	N

4.2 Business case 1: A service for the PV owners

In this business case, ESR implements control in the house/building of the prosumers.

Table 5: Canvas business case 1

<table>
<tr>
<td rowspan="2">Partners

•Solar installers
•Electrician/installers (from ESR and others)
•Software developers/ solution provider</td>
<td>Activities

Set up and maintain an infrastructure</td>
<td rowspan="2">Value Proposition

•Self-consumption optimization taking into account grid needs
•Energy visualization and data analytics
•Participating in energy transition</td>
<td>Customer relationship
Direct relationship
Automated service (online)</td>
<td rowspan="2">Customer segment
•Prosumers
•Energy community</td>
</tr>
<tr>
<td>Key resources
Marketing
Self-consumption algorithm (knowhow)</td>
<td>Channels
•Flyer given with electricity bill
•ESR website
•communication targeting electricians and solar installers</td>
</tr>
<tr>
<td colspan="2">Cost Structure
CAPEX:
•Hardware: optimization box
•Installation costs
-material
-manpower

OPEX
•Communication cost depending on technology (GSM, fiber, or others…)
•IT infrastructure to maintain
•Administration cost</td>
<td colspan="3">Revenue Streams

•Classical revenue: connection fee, energy sales kept on long term with a build-up of customer loyalty
•Hardware sales: control box, batteries
•Service fee?

(Other revenue if flexibility left: balance energy, peak power reduction, investment deferral)</td>
</tr>
</table>

This is a competitive market. Today PV installers are already selling devices to optimize the self-consumption rate:

- Inverters with integrated switches for connecting/disconnecting loads. Examples:
- Kostal Piko BA Sensor and integrated relay (Figure 24) (KOSTAL Solar Electric GmbH 2017)
- SMA: sunny home manager (Figure 25) (SMA Solar Technology AG, Sunny Home Manager 2017)
- Measurement and decision-making system
- Example Solar-Log (Solare Datensysteme GmbH 2017)

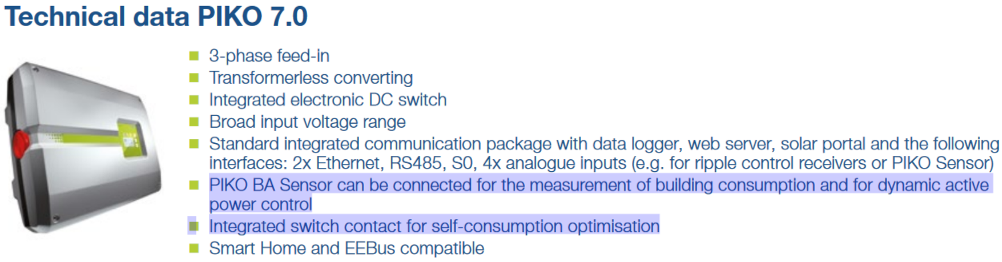

Figure 24: Monitoring of grid current for load control is standard today in solar inverter, image from (KOSTAL Solar Electric GmbH 2017)

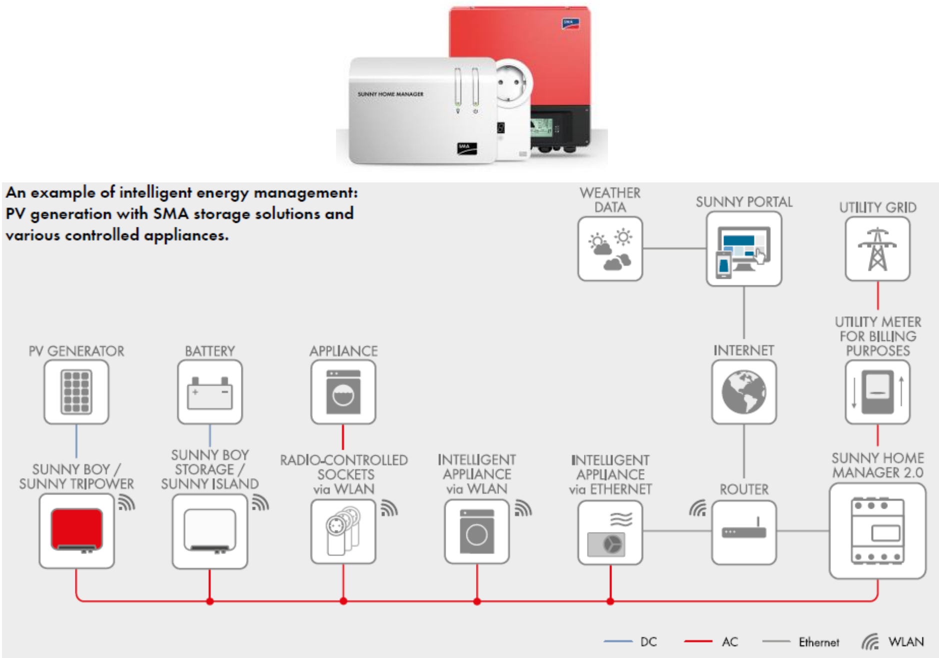

Figure 25: Energy management system by SMA (SMA Solar Technology AG, SMA Solar Technology 2017): supervision of consumption, PV production and self-consumption optimization are all included.

4.2.1 Business case KPI: self-consumption rate

The technical indicator is the self-consumption rate with or without control system.

Depending on what the controllable loads are, the targets for the new self-consumption rate are different. The figure below estimates the self-consumption rate with different kinds of load control. It can be used as a target.

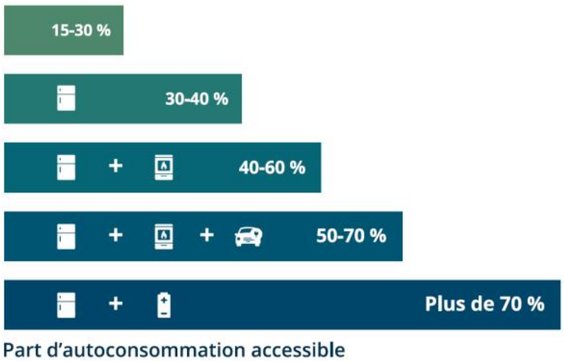

Figure 26: Rise of self-consumption rate with: standard consumption, appliance time of use, heating during the day, electric car charging, battery storage, Image from (VESE 2017)

4.3 Business case 2: Correction of balance energy

One task of ESR as energy supplier is to predict every day the global electrical consumption of the supplied grid for the next day. If the prediction done the previous day is not matching the effective consumption, a penalty is paid for each MWh of error.

The error reduction could be done:

- With an own system such as the one developed during this project.
- With an aggregator system renting its available flexibility (tiko.ch, …)

Table 6: Canvas business case 2

<table>
<tr>
<td rowspan="2">Partners

•Prosumers
•Aggregator</td>
<td>Activities
Make the link between consumption prediction imbalance and DSM</td>
<td rowspan="2">Value Proposition

•reduction of balance energy costs</td>
<td>Customer relationship
ESR internal</td>
<td rowspan="2">Customer segment
• ESR internal</td>
</tr>
<tr>
<td>Key resources
•IT infrastructure
•Intelligent Control algorithm
•network of prosumers</td>
<td>Channels

• ESR internal</td>
</tr>
<tr>
<td colspan="2">Cost Structure
If own DSM system:
•CAPEX and OPEX similar to previous business case + part of revenue shared with prosumers

If done through aggregator
•Aggregator bill
•Interface cost
-material
-manpower
•Administration cost</td>
<td colspan="3">Revenue Streams

• Reduction of balance energy cost
• Reduction of peak power cost</td>
</tr>
</table>

An analysis of the balance energy cost and peak power cost must be performed.

In this business model canvas, we set the prosumers as partners. But why would they collaborate? The service provided to them is described in business model 4.

The basic idea of the relationship to an aggregator is simple: an aggregator has multiple prosumers loads under his control.

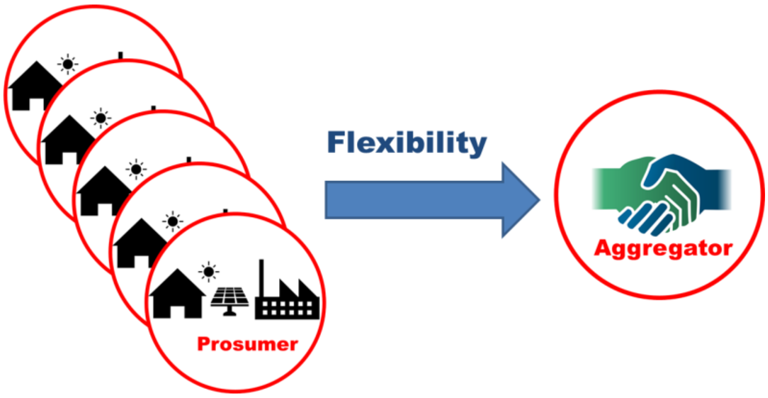

Figure 27: The aggregator harvest flexibility by multiple flexible loads

Then he can market that flexibility to various parties:

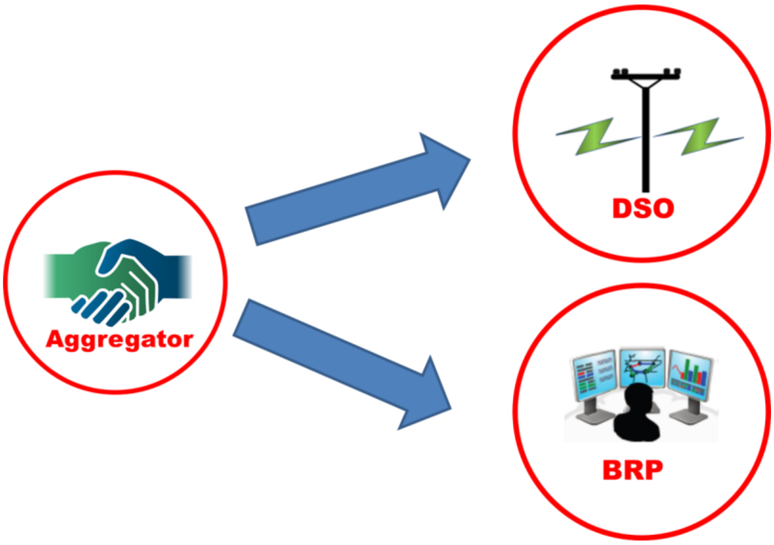

Figure 28: Then he can sell it as a service to different actors

In the case of ESR, there is no established aggregator with a significant number of loads available at the moment. The largest one is probably ESR itself with the ripple control.

At this stage, we must consider if ESR takes the role of aggregator or leaves it to someone else. ESR could very well buy the necessary hardware (hardware development is not its core activity) from an established company and run the aggregator function himself.

4.3.1 Business case KPI: controllability

For the 200 homes+10 factories:

- How much the aggregated consumption profile can be modified?
- How much the peak load can be reduced? In percentage

4.4 Business case 3: Customer segment Industries

Table 7: Canvas business case 3

<table>
<tr>
<td rowspan="2">Partners
•Process Control system responsible party
•Facility management company
•Property management company</td>
<td>Activities
Make the link between consumption prediction imbalance and DSM</td>
<td rowspan="2">Value Proposition

•Reduce electricity cost by giving flexibility
•Paid for the flexibility
•Energy visibility</td>
<td>Customer relationship
direct</td>
<td rowspan="2">Customer segment
• Industries with flexible loads
• Large buildings
• Industries with flexible loads Infra
•Infrastructural objects</td>
</tr>
<tr>
<td>Key resources
•IT infrastructure
•Intelligent Control algorithm
•network of prosumers
•People at energy sales</td>
<td>Channels

• Direct contact (list of industries knows)</td>
</tr>
<tr>
<td colspan="3">Cost Structure
If own DSM system:
•CAPEX and OPEX similar to previous business case + part of revenue shared with industry
If done through aggregator:
•Aggregator bill
•Interface cost
-material
-manpower
•Administration cost</td>
<td colspan="2">Revenue Streams

• Reduction of balance energy cost
• Reduction of peak power cost</td>
</tr>
</table>

It could be discussed if the industries are the partners or the customers.

An analysis of the balance energy cost and peak power cost must be performed.

In that field, there are a few possible partners. One of them is Xamax (Xamax AG 2017), with long experience in energy management for industries. They already established a virtual power plant (VPP) and control it for ancillary services on the grid.

Figure 29: Xamax-ag VPP, from Xamax website

4.4.1 Business case KPI: controllability

For industries the results are measured with the capacity to flexibilize the consumption:

- reduction of peak flexibility (in percentage of total load)
- energy shifting flexibility (in MWh and how many hours)

4.5 Business case 4: Customer segment individuals

This segment contains the traditional individual customers with heat pumps, water heaters, direct heating with or without thermal storage.

There are 10'000 ESR clients equipped with ripple control receiver. Some of them are unused today: per example washing machines are no more interrupted at midday. That is a huge number of customers with already DSM installed. The replacement with a new 'GOFLEX receiver' should be easy and this represents a good potential to quickly find suitable consumer of the direct control pilot.

Table 8: Canvas business case 4

<table>
<tr>
<td rowspan="2">Partners

•Aggregator
•Electrician/ installers (ESR INSIDE and others)
•Software developers</td>
<td>Activities

Set up and maintain an infrastructure</td>
<td rowspan="2">Value Proposition

•Energy visualization and data analytics → energy savings
•Participating in energy transition
•Special energy price for controlled loads</td>
<td>Customer relationship
Direct
Automated service (online)</td>
<td rowspan="2">Customer segment
•all consumers with heat pumps, electric heating, electric water heater
•Energy community
•PPE</td>
</tr>
<tr>
<td>Key resources
Marketing
Attractive design of web interface</td>
<td>Channels
•Flyer with electricity bill
•ESR website
•</td>
</tr>
<tr>
<td colspan="2">Cost Structure
CAPEX:
•Hardware: optimisation box
•Installation costs
-material
-manpower
OPEX
•Communication cost (GSM, …)
•IT infrastructure to maintain
•Administration cost</td>
<td colspan="3">Revenue Streams
•Classical revenue: connection fee, energy selling (if left) kept with a build-up of customer loyalty in liberalized market

•Hardware sale: -control box
•Service subscription fee?

•Other revenue stacked if flexibility left: balance energy, peak power reduction, investment deferral)</td>
</tr>
</table>

The definition of the product/value proposition for the consumers must take into account their expectation. To design this service, the following conclusions from a similar project (Energie Koplopers, Rapporten 2015) on flexibility are good guidelines:

Cited from Flexibility from EnergieKoplopers (Energie Koplopers, Flexibility from residential power consumption: a new market filled with opportunities 2016)*:*

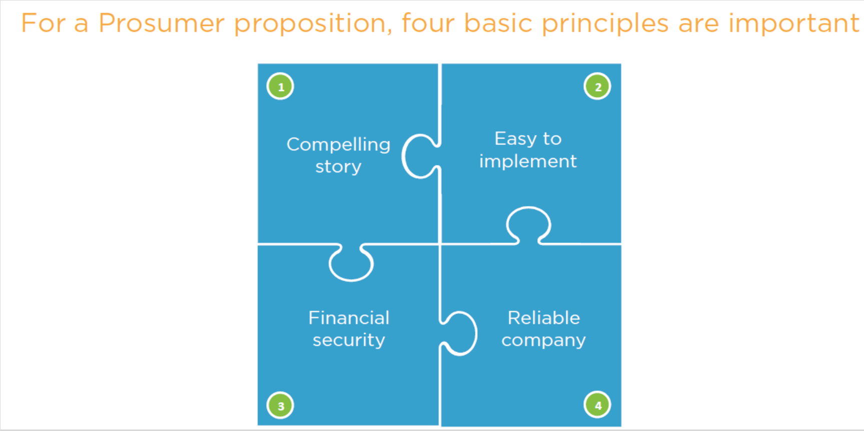

Figure 30: Image from Energie Koplopers (Energie Koplopers, Flexibility from residential power consumption: a new market filled with opportunities 2016)

"The Aggregator needs to have a compelling story. The issue of peak load is a complicated, technical subject for many prospective Prosumers. The project shows that information provision is vital in convincing Prosumers to enter the flexibility market. The Aggregator's story needs to be compelling, and should contain three elements:

- Sustainability has to be the central argument, appealing to people's need to do something good for the world;
- Both the problem of peak load as well as the proposition must be explained in a simple and easy to understand way;
- People who require more information, must be easily able to find additional (technical) information about the appliance operations, the control and the business model.

For most consumers, the energy transition is not an urgent issue. There are higher priority issues, both at individual and society level. The majority of Dutch citizens consider that other themes, such as healthcare, should be prioritized higher on the political agenda4. Dutch citizens consider sustainable energy to be important but the threshold for taking action about this is often too high. That is why it is important that the Aggregator makes it as easy as possible for Prosumers to unlock their flexibility:

Convenience, easy to implement:

- Consumers do not want to make extra time available or have to make any effort to unlock flexibility. The easier the proposition is to implement, the greater the flexibility that can be unlocked amongst consumers;
- Automatic control of smart appliances was seen as logical and easy. People wondered whether this would be possible with other devices too;
- Dynamic tariffs for flexibility are not desirable for most consumers: responding to dynamic tariffs implies too big a behavioral change even for a

group of active and motivated Prosumers.

In addition to minimizing the time and effort for Prosumers, the financial implications should also be kept to a minimum. A small group of Prosumers was prepared to invest in a smart appliance, but the majority lost interest in participation if this meant they had to make an investment, even if the investment was minor.

Financial security:

- Having to make an investment forms a barrier for most Prosumers;
- Cost neutrality (not incurring any costs) turns out to be more important to consumers than the possibility of earning money;
- The financial insecurity associated with dynamic tariffs is an important reason for not wanting these.

The organization that offers a flex proposition should be very reliable. At the start of the project, it was expected that there would be little acceptance amongst Prosumers for automatic control of appliances in the home. Surprisingly, the research shows that if three conditions are met, people's confidence in the organization that controls the appliances is high:

- The organization should have excellent customer service with strong (technical) knowledge.
- It must be clearly explained how the system and the appliance works. The trust in the system and the organization that controls the appliance flows from this. Insight via a portal has a positive influence on this.
- Control: the consumer would ultimately like to have the opportunity to overrule the automatic control of the appliance should they consider this necessary.

If these conditions are met, there is enough trust to accept the proposition. Also, automatic control of the device is considered desirable.

In the field of consumer load control, there is one major player in Switzerland today: Tiko. It could be a partner as aggregator, as it has the control device and the IT infrastructure to perform this task. It should be identified if this company is ready to propose aggregator services or not. After first test in smart home projects and the test deployment of thousands of 'control boxes' (Besmart project), Tiko has found a business model with the stacking of revenue between services for the grid and consumer payment (equipment sale, subscription) (Vinelake Limited 2017).

During the GOFLEX project, the same kind infrastructure will be developed in house to gain experience and then for a wider deployment, the options will be investigated.

Another possible way is to own the DSM infrastructure as the metering infrastructure is owned today. There are products available from the large manufacturer (example Landis+Gyr (Landis+Gyr 2017))

Combination with the smart-meters in the future is to be considered if a rollout is planned. This possible combination is provided in the GOFLEX approach of the communication interface with ITI.

4.5.1 Business case KPI: controllability

For individuals the results are measured with the capacity to flexibilize the consumption and use it:

- Energy shifting flexibility (in kWh and how many hours) for each load.
- Usability after aggregation: describe aggregated load properties:
    - Usable kW/ installed kW
    - Energy available in kWh
    - Time length of shift in hours
- flexibility for peak reduction (in percentage of total load)
- flexibility for energy shifting (in MWh and how many hours)

4.6 Business case 5: EV charging control

The electric cars offer a great amount of potential flexibility. There are basically two types of clients in this business model: the car owner that have their own charging point at home and the charging point owner, per example the company that has many charging points for its employees and visitors.

Table 9: Canvas business case 5

<table>
<tr>
<td rowspan="2">Partners

•Aggregator
•Electrician (from ESR)/ charge station installer
•charge station manufacturers
•Software developers</td>
<td>Activities

Set up and maintain an infrastructure</td>
<td rowspan="2">Value Proposition

•Energy visualization and data analytics.
•Understanding of EV use.
•Reduce electricity cost by choosing charge time.</td>
<td>Customer relationship
Direct
Automated service (online)</td>
<td rowspan="2">Customer segment
•EV owner
•charging point owner (EV owner, company, administration, parking lot owner…)</td>
</tr>
<tr>
<td>Key resources
Marketing
Attractive design of web interface</td>
<td>Channels
•Flyer with electricity bill
•ESR website</td>
</tr>
<tr>
<td colspan="2">Cost Structure
CAPEX:
•Hardware: optimization box
•Installation costs
-material
-manpower
OPEX
•Communication cost (GSM, …)
•IT infrastructure to maintain
•Administration cost
Sharing a part of the revenue with EV owner</td>
<td colspan="3">Revenue Streams
•Energy sales to EV
•Classical revenue: connection fee, energy sales kept with a build-up of customer loyalty in liberalized market.

•Hardware sale:
-control box
•Service subscription fee?

•Other revenue stacked if flexibility left: balance energy, peak power reduction, investment deferral)</td>
</tr>
</table>

4.6.1 Business case KPI: controllability

For each car the results are measured with the capacity to flexibilize the charging and use it:

- Energy shifting flexibility (in kWh and how many hours) for each load.

4.7 Business case 6: distribution investment deferral

When a congestion problem is identified in a given part or simple feeder of the distribution grid it is possible to act on active power curtailment, reactive power control and load adding/shedding.

Table 10: Canvas business case 6

<table>
<tr>
<td rowspan="2">Partners
•Prosumers in a specific feeder
•Producer in a specific feeder
•Aggregator
•Swissgrid (payment for grid reinforcement or smart solution)</td>
<td>Activities
Make the link between consumption prediction imbalance and DSM</td>
<td rowspan="2">Value Proposition
•being paid for load shedding
•paid for kWh non-produced

Services as described earlier:
•Energy visualization and data analytics
•Participating in energy transition</td>
<td>Customer relationship
direct</td>
<td rowspan="2">Customer segment
•Prosumers in a specific feeder
•Producer in a specific feeder</td>
</tr>
<tr>
<td>Key resources
•IT infrastructure
•Intelligent Control algorithm
•network of prosumers</td>
<td>Channels

•ESR internal</td>
</tr>
<tr>
<td colspan="3">Cost Structure
If own DSM system:
•CAPEX and OPEX similar to previous business case + part of revenue shared with prosumers/producer

If done through aggregator
•Aggregator bill
•Interface cost
-material
-manpower
•Administration cost</td>
<td colspan="2">Revenue Streams

•Reduction/deferral of investment
•Reduction of balance energy cost if flexibility left</td>
</tr>
</table>

A model should be set up to pay the non-produced energy (in the case of distributed renewable production.

4.7.1 Business case KPI: peak reduction

The results are measured with the capacity to flexibilize the feeder loading:

- Peak reduction in % of the total load.

4.8 Stacking of benefits

The addition of the various revenue streams may be necessary to make a DSM system profitable. This adds complexity to the global system and multicriteria decision making is necessary for the control algorithm.

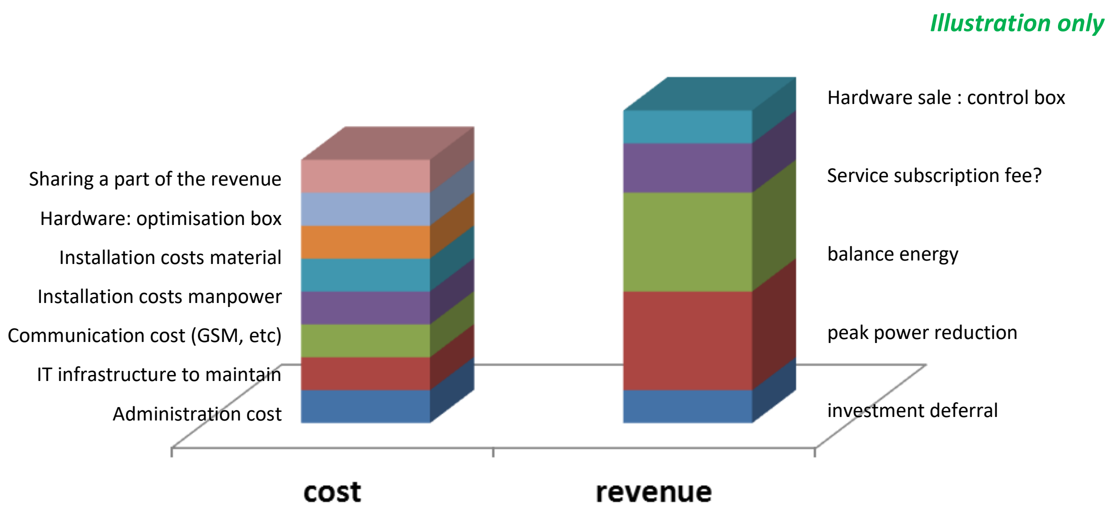

Figure 31: Revenue stacking idea: one simple business model is probably not enough, here hybrid business models are necessary as was shown by Tiko AG

In the unbundling context, stacking of the benefits may be complicate. There must be an infrastructure owner (the aggregator), exchanging his service.

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

There are different types of systems deployed and then different- cost-benefits analysis

The ESR GOFLEX pilot is made up of 3 parts:

1) 200+ Prosumers: Direct control will be applied to at least 230 residential buildings.
2) Industrial: The flexibility of 10 industries will be tackled.
3) HEMS: 20 residential houses will be equipped with HEMS (Home Energy Management System).

5.1 Direct control pilot cost

This is the case that could be deployed to the majority of customers.

We need a clear view of cost per connected point:

- Hardware: Control box
- Manwork: installation, services
- Cost of IT infrastructure
- Cost of IT maintenance
- Cost of human resource and administration

Only with this view, the system could be generalized. Risks with the direct control are given in table below.

Table 11: Risks and mitigation for direct control

Risks	Mitigation
Hardware malfunction	• Perform good burn tests. • Test in a few houses before the 200. • Test procedure for commissioning. • No guarantee given during the trial. • Ask for customer tolerance in trial: you participate in something new!
Software bugs	• Able to update easily (remotely, card, …). • Ask for customer tolerance in trial: you participate in something new!
Deception of the end-customer Examples: He believe that the shower is cold because of the new system	• Clear explanation of the service provided • Leave an option to disable the service • Keep data to show/investigate what happened
Customer bill increases	• Guarantee bill for the trial. • Keep data to show/investigate what happened
Development time and cost underestimated	• Keep solution simple for this trial, even if this could be developed further for all clients (agile approach)

5.2 Industrial pilot cost

Costs:

- Engineering time required per industry
- INEA system costs

Benefits:

- For DSO: capacity charge reduced
- For BRP: lower costs of energy purchase; lower penalties for not keeping the schedules
- For the customers: remuneration of energy flexibility offered

Risks with the FEMS are given in table below.

Table 12: Risks and mitigation for FEMS

Risks	Mitigation
Hardware malfunction	• Robustness strategy: the industry must be able to operate normally if the FEMS is not working. • Explain the risks and clarify responsibilities. • No guarantee given during the trial. • Ask for customer tolerance in trial: you participate in something new! • Test procedure for commissioning.
Software bugs	• Able to update easily (remotely, card, …). • Ask for customer tolerance in trial: you participate in something new!
Damages to the system and production losses.	• Conclude an insurance (civil responsibility) • Don't try to control/find flexibility in very sensible part of the production process.
Industry energy bill increases	• Guarantee bill for the trial. • Include a local goal for the control: minimize customer energy cost. • Keep data to show/investigate what happened.
Development time and cost underestimated	• Choose industries with simple/similar control systems: per example with Siemens PLC with a standard way to communicate. • Select similar industries to build up experience. • Keep simple solution for this trial, even if more flexibility could be harvested. • Keep an agile approach.

5.3 HEMS pilot cost

Costs:

- Engineering time required per customer

Benefits:

- For the customers: energy bill decreases

Risks with the HEMS are very similar to the ones with direct control as it involves end-customers. Risks and risks mitigation are given in table below:

Table 13: Risks and mitigation for HEMS

Risks	Mitigation
Hardware malfunction	• Perform good burn tests (by ETREL). • No guarantee given during the trial. • Ask for customer tolerance in trial: you participate in something new!
Software bugs	• Able to update easily (remotely, card, …). • Ask for customer tolerance in trial: you participate in something new!
Deception of the end-customer Examples: He believe that the shower is cold because of the new system	• Clear explanation of the service provided • Leave an option to disable the service simply • Keep data to show/investigate what happened
Customer bill increases	• Guarantee bill for the trial. • Keep data to show/investigate what happened
Development time and cost underestimated	• Keep solution simple for this trial, even if this could be developed further for all clients (agile approach)

5.4 Balance energy benefits

A review of the forecast error and imbalance energy cost over the last years will be done:

- The imbalance energy will be quantified in quantity, in duration of error and in value (varying price over the day for the balance energy paid).
- Simulations will be performed to assess the potential corrections with different types of flexible loads.
- Simulation will be performed to assess the potential correction with the mixing of flexible loads and intraday corrections

5.5 Customers benefits

The satisfaction of the customers involved in the trials must be assessed. Their feedback for a larger scale deployment is important.

6 Business Key Performance Indicators for services to be implemented

Here is a summary of the indicators used to quantify results for the various business models:

We have no benchmark at the moment, except for self-consumption rate improvement by individual prosumers with PV.

Table 14: KPIs for services to be implemented

Service	Business KPIs	Target value during GOFLEX test phase
Service 1: A service for the PV owners	Self-consumption rate	Rise of 20%
Service 2: Correction of balance energy	Reduction of imbalance cost	Modify the control to achieve the best
Service 3: Industries	Flexibility obtained for each case	Depends on the process
Service 4: Individuals	•energy shifting flexibility (in kWh and how many hours) for each load. •usability of aggregation. •customer satisfaction with interface	•Depends on the process •total controllability should be as high as possible •customer satisfaction with interface
Service 5: EV	•energy shifting flexibility (in kWh and how many hours) for each type of charging station.	Measured indicator. Modify the control to achieve the best.
Service 6: Investment deferral	Saved money	Hard to impossible during the project time frame/ no real case today

Comment: the small amount of power available, even with 200 homes, may not have a significant impact of the total consumption of ESR grid.

7 Correlation of trial business KPIs and Project Impact KPIs

The global project impact described in the project description is

"The EU power network will be capable of integrating large share of renewables exceeding 50% by 2030, in particular variable energy sources, in a stable and secure way"
The project specified KPIs that were presented in section 2 (

Table 3: GOFLEX project KPIs).

This is a mapping, how the individual business KPI supports the Project Impact KPIs.

Table 15: Mapping between individual business KPIs and project impact KPIs

Service	**Business KPI**	**Related Project Impact KPI**
Service 1: A service for the PV owners	Self-consumption rate	•Capable of integrating large share of renewables
Service 2: Correction of balance energy	Reduction of imbalance cost	• Electricity load adaptability level • Benefits for DSO
Service 3: Industries	Flexibility obtained for each case	
Service 4: Individuals	•energy shifting flexibility (in kWh and how many hours) for each load. •usability of aggregation. •customer satisfaction with interface	• Increase of prosumer involvement
Service 5: EV	•energy shifting flexibility (in kWh and how many hours) for each type of charging station.	•Flexibility range •peak power reduction
Service 6: Investment deferral	Saved money, efficiency improvement for the identified case.	•Avoid congestion: reduction of peak demand

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

The importance of legal frame is essential in the definition of the business cases. What is allowed? What is not? What can be done? One can play only knowing the rules.

The importance of legal framework is particularly strong in the context of the natural monopolistic position of the distribution grid. Regulators set strict rules on companies about the ways of doing thing and billing costs.

8.1 Swiss laws

The legal framework is given by Swiss laws, especially laws on energy the dependent execution rules (*ordonnances* in French).

The main laws are given in the energy law (Confédération Suisse, Energie 2017) and the LPD (Confédération Suisse, Loi fédérale sur la protection des données 2017). Within the energy law, the activities of the DSO are framed by the LApEl (Confédération Suisse, Loi sur l'approvisionnement en électricité 2017).

8.2 Swiss Distribution Code

The Swiss legal framework about electricity is summarized in documents edited by the Swiss Electrical Companies Association (VSE-AES (VSE, Verband Schweizerischer Elektrizitätsunternehmen 2017)) called CODES, which are generally taken as reference in Switzerland. The codes are easier to read than laws texts and application laws texts.

The Distribution Code (DC-CH) is the main document regarding the distribution system. The Metering code (MC-CH) explains what’s possible or not in terms of measurement of electricity. There are also general documents to understand the electricity market (MMEE CH: Modèle de marché pour l’énergie électrique; MURD-CH: Modèle d’utilisation des réseaux de distribution). The relationship to the TSO is given in the MURT-CH (Modèle d’utilisation des réseaux de transport).

Those are available here (VSE, Dokument 2017).

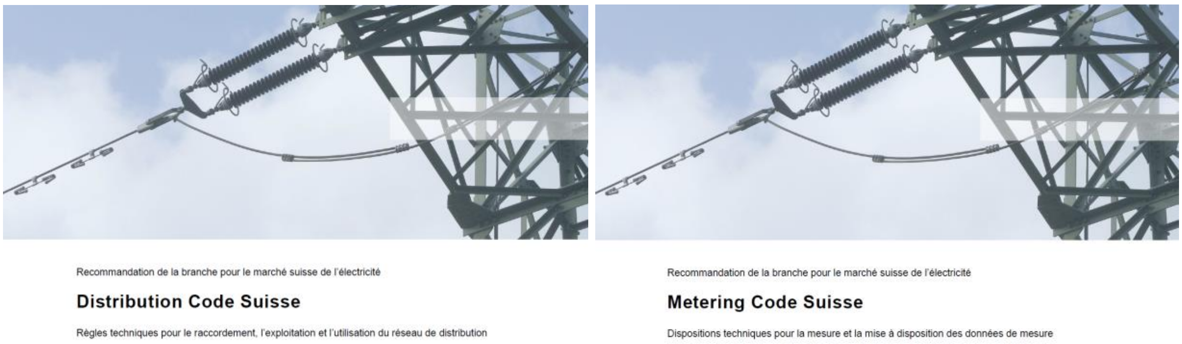

Figure 32: Transmission, Distribution and Metering codes summarize the various Swiss laws for the activities of DSOs

Demand Side Management is treated in DC in chapter 5.6. DSM is allowed, according to the Distribution Code.

> ***5.6 Gestion de la charge***
> *(1) La gestion de la charge englobe la commande d'équipements consommateurs interruptibles par le GRD et sert par exemple à éviter des congestions ou à mieux répartir la charge des réseaux de distribution.*
>
> *(2) Les équipements consommateurs interruptibles au sens du Distribution Code sont des équipements d'un consommateur final dont l'approvisionnement en énergie électrique peut être interrompu ou réduit sans préavis par le GRD selon un plan et des critères prédéfinis pour une période limitée (par ex. chauffe-eau, chauffage électrique à accumulation, pompes à chaleur).*
>
> *(3) La commande d'équipements consommateurs interruptibles peut s'effectuer par ex. par télécommande ou sur directives directes du GRD.*
>
> *(4) Le GRD définit si et dans quelle mesure:*
>
> *– des équipements consommateurs interruptibles peuvent être raccordés à son réseau de distribution en accord avec le consommateur final et si les utilisateurs finaux concernés peuvent recevoir un dédommagement*
>
> *– le réseau de distribution peut être utilisé par lui-même ou par des tiers (au bénéfice d'une autorisation émanent de lui) pour la transmission de signaux ou pour d'autres fonctions*
>
> *(5) Afin d'éviter toute variation de charge brusque et importante dépassant les tolérances, les GRD doivent échelonner les interruptions de charge par télécommande de façon à ce qu'il se produise une variation plus ou moins linéaire de la charge sur une durée définie.*
>
> *(6) Les installations qui ne sont pas (télé)commandées par le GRD ne sont pas concernées par les règles du chapitre 5.6.*

In 5.7.3 it is said that the DSO can use DSM as a tool to manage grid overloading.

> ***5.7 Gestion des congestions***
> *(3) Afin d'éliminer une congestion en cours d'exploitation, le GRD peut effectuer des modifications de couplages (dispositions topologiques) et de la gestion de charge.*

The cost of DSM installation cannot be covered by grid cost if it is used for other purpose than grid stability. Balance of energy, system services and other liberalized services can be implemented, but the costs cannot be taken on the grid fees.

This is also given in a document (!not a legal text yet) about the Smart-Metering (OFEN, Bases pour l'introduction de systèmes de mesure intelligents 2014):

> ***7.3 Phase transitoire de gestion de la charge***
>
> *L'optimisation du réseau par la gestion de la charge, largement répandue dans les zones de desserte de la Suisse, est disponible sous une forme rudimentaire avant même l'introduction des systèmes de mesure intelligents. Des installations de télécommande centralisées, qui assurent cette fonctionnalité sur presque*

toute la surface du territoire, verrouillent et gèrent les chauffe-eau et les chauffages. Ces installations de télécommande centralisées ne doivent pas, en principe, être remplacées par des systèmes de mesure intelligents. La propriété visée ne se trouve pas non plus parmi les exigences minimales (cf. en particulier chap. 4.2 B) et n'est donc pas imputable en soi aux coûts du réseau.

On peut encore optimiser les installations de télécommande centralisées en mettant le logiciel à niveau, de manière à ce qu'elles puissent par exemple réagir aux fluctuations météorologiques. Il est possible de poursuivre l'exploitation de ces installations parallèlement à la modernisation de l'infrastructure du réseau. Néanmoins, il se peut que la durée de vie de ces vieilles installations soit échue dans telle ou telle zone de desserte et que le moment de leur remplacement soit arrivé. En pareil cas, il peut être judicieux de remplacer l'installation de télécommande centralisée et de compléter le système de mesure intelligent par d'autres propriétés. Les coûts de ces propriétés supplémentaires à intégrer dans le système de mesure intelligent sont imputables aux coûts du réseau pour autant qu'ils assurent les fonctions de l'installation de télécommande centralisée au seul service du réseau (pour l'exploitation et la planification des réseaux, respectivement pour répercuter la réduction des rémunérations de l'utilisation du réseau) et qu'ils répondent aux dispositions de l'art. 15, al. 1, LApEl57. Les prestations fournies dans le domaine libéralisé, par exemple les services-système, les optimisations concernant l'énergie d'ajustement, voire l'optimisation interne de portefeuille lors de l'achat d'énergie, doivent être refacturés aux demandeurs de ces prestations, à tout le moins en fonction d'une clé de répartition des coûts. Les installations de télécommande centralisées, respectivement les dispositifs de gestion de la charge ne doivent pas servir à créer des barrières commerciales envers les tiers.

The mentioned LApEL art 15 al 1:

Art. 15 Coûts de réseau imputables

1 Les coûts de réseau imputables englobent les coûts d'exploitation et les coûts de capital d'un réseau sûr, performant et efficace. Ils comprennent un bénéfice d'exploitation approprié.

2 On entend par coûts d'exploitation les coûts des prestations directement liées à l'exploitation des réseaux. Les coûts comprennent notamment les coûts des services-système et de l'entretien des réseaux.

3 Les coûts de capital doivent être déterminés sur la base des coûts initiaux d'achat ou de construction des installations existantes. Sont seuls imputables en tant que coûts de capital:

a.les amortissements comptables;
b.les intérêts calculés sur les valeurs patrimoniales nécessaires à l'exploitation des réseaux.

4 Le Conseil fédéral fixe:

a.les bases de calcul des coûts d'exploitation et de capital;
b.les principes régissant la répercussion des coûts ainsi que des redevances et des prestations fournies à des collectivités publiques de manière uniforme et conforme au principe de l'origine des coûts, en tenant compte de l'injection d'électricité à des niveaux de tension inférieurs.

Art. 15a1Coûts facturés individuellement pour l'énergie d'ajustement

1 La société nationale du réseau de transport facture individuellement aux groupes-bilan les coûts de l'énergie d'ajustement.

2 Elle fixe le prix de l'énergie d'ajustement de manière à promouvoir l'engagement efficace de l'énergie de *réglage et de la puissance de réglage dans tout le pays et à empêcher les abus. Les prix de l'énergie d'ajustement sont définis en fonction des coûts de l'énergie de réglage.*

3 Si la vente d'énergie d'ajustement se solde par un bénéfice, le montant en question est pris en compte dans le calcul des coûts des services-système.

8.3 Data privacy

Data privacy importance will increase in the future. With DSM we plan to have an extensive use of customer's data.

Meetings were organized with the Préposé cantonal à la protection des données du Canton du Valais (Data protection commissioner for the Valais Canton) and with specialized lawyers to clarify the data privacy aspects of the Swiss pilot. Today the Swiss law given by the LPD (Confédération Suisse, Loi fédérale sur la protection des données 2017) that is quite different than European laws on that subject. From the laws, participants have to be informed about which data are collected as well as the purpose of their use (research on DSM in the context of GOFLEX project). In addition, a contact has to be given, who could answer to more specific question, and also erase a participant data if he requires it. This information will be done through a document (similar to a consent form) describing the aforementioned elements.

Moreover, all sensible data will be handle with care and only by a few defined people by ESR and HES-SO. Only anonymized data will be provided to the other GOFLEX partners. Sensible data will be stored in Switzerland.

As ESR and HES-SO could also be concerned by the new EU law on Data privacy, they both decided that no sensible data from the other partners will be used and stored. As each pilot site is storing his own data and only non-sensible data will be stored globally on IBM cloud services (such as weather forecasts), it will not be a problem.

Finally, as the new EU law will certainly have an impact on the Swiss law, a special care will be taken by both ESR and HES-SO during the duration of the project to follow the evolution of the Swiss law framework.

8.4 Market framework

8.4.1 General

The Swiss electricity market framework is described in the MMEE (VSE, Modèle de marché pour l'énergie électrique 2016). The actors of this market are given on the picture below:

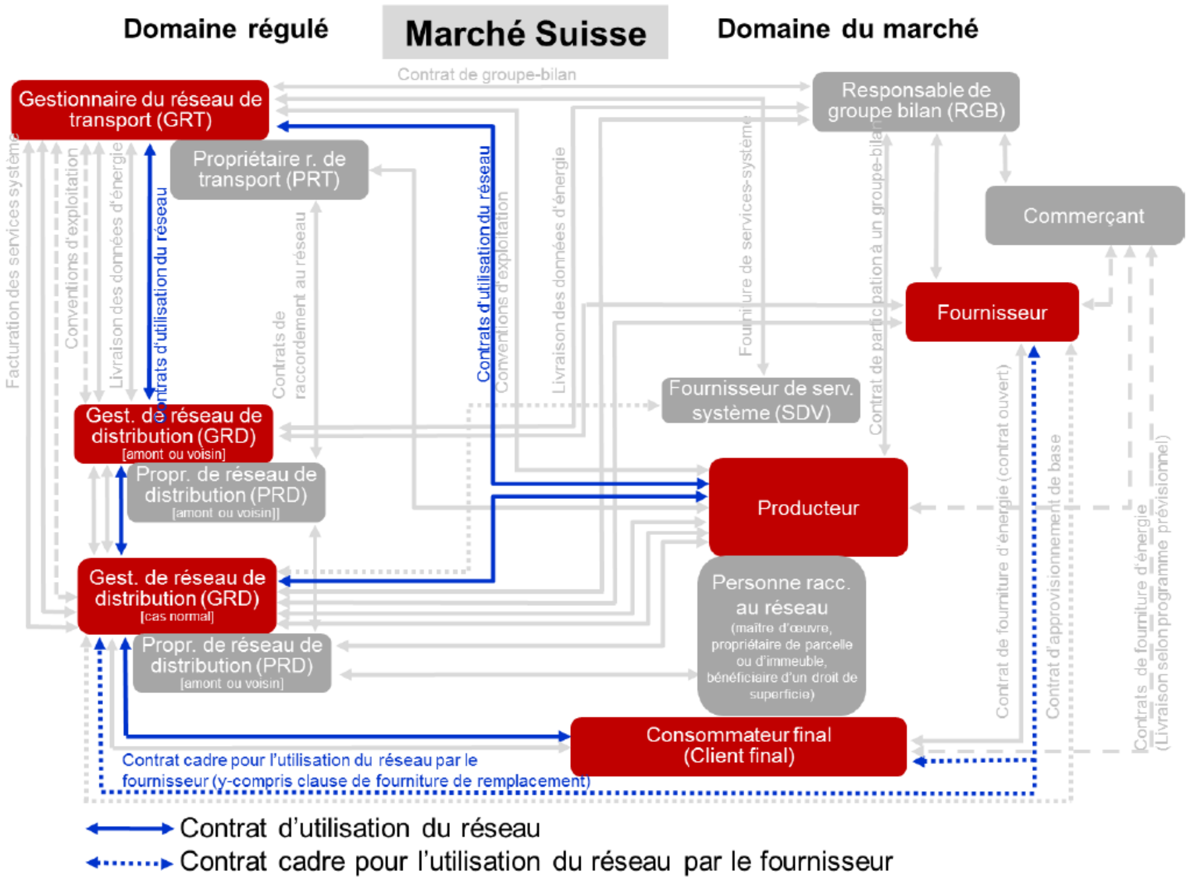

Figure 33: Image MMEE

8.4.2 Control pooling

Since 2013, aggregation of small flexible actors to provide ancillary services is possible.

That means the aggregation of flexible loads could be valued on the ancillary service market. Essentially primary control could be considered as DSM could give the 15 minutes reserve.

From Swissgrid (Swiss TSO) website (Swissgrid, Control pooling 2017):

Control pooling

In 2013, Swissgrid and the VSE industry association published a document on control energy pooling to enable ancillary services to be provided from any balance groups. Swissgrid introduced two key changes:

Technical systems at Grid Levels 5 and 7 can be grouped into virtual generating units for supplying control energy. All sizes and types of technical systems can be included in virtual generating units.

Technical systems can be integrated into balance-group-neutral control energy portfolios across Switzerland regardless of their balance group affiliation.

These changes enable players in the ancillary service market to consolidate their generating and consumption units. They also open up the market to a new group of providers. This sets the stage to broaden the range of providers and reduce dependency on hydraulic generating units.

This issue has sparked intense debate in Europe's control areas as well. The Swissgrid approach has proven to be thorough and innovative. Its complexity, however, was a challenge for Swissgrid and the industry representatives. This ambitious project came to successful conclusion in September 2013 with the signing of the revised balance group and AS contracts with all Swissgrid partners.

8.4.3 Free access and aggregator role

One important point in the design of a flexibility harvesting system is the possibility to be open to other actors of the market.

If complete liberalization happens, the final consumer/prosumers are free to choose their energy provider. The DSM system should be designed according to this market framework. That means the necessary infrastructure should be owned by the DSO or another party but not the energy supplier.

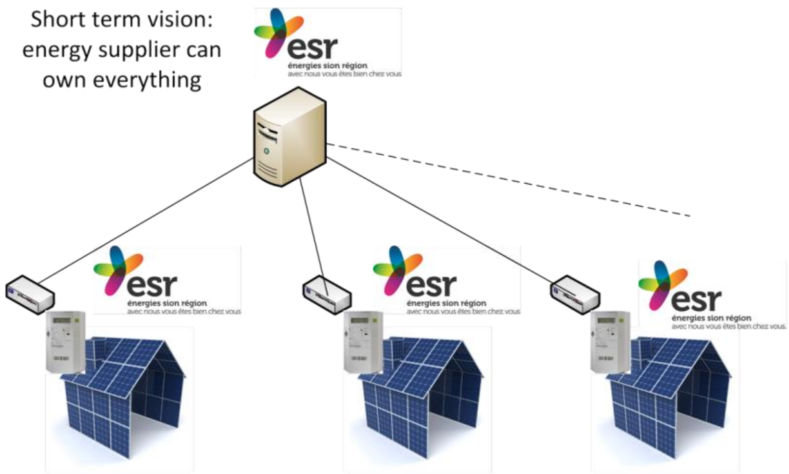

Figure 34: DSM system owned by ESR as energy provider

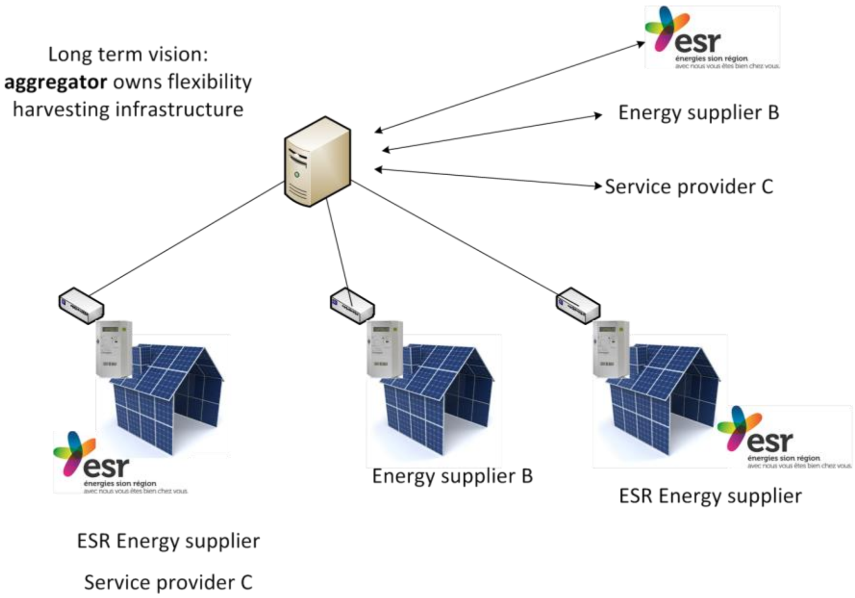

Figure 35: Access to the DSM service should be open to other energy supplier in case of liberalization

The liberalization scenario justifies the central role of the aggregator as provider of open services for distribution and transmission services, as well as services for end customers.

It must be investigated who's best placed to take the aggregator role:

- The historical owner of the metering system? Future operator of the smart-metering network
- The DSO
- A third-party company (example Tiko in Switzerland).

8.4.4 Reactive power control

According to the ESTI directive 219 (ESTI 2017) the reactive power of production units must be controllable.

Compensation de la puissance réactive

Les IPE > 30 kVA doivent être en mesure, dans les conditions d'exploitation normales, de délivrer et d'absorber une puissance réactive inductive ou capacitive dans les domaines de facteur de puissance énumérés ci-dessous. Les valeurs divergentes (par ex. pour les machines synchrones) doivent être réglées par contrat.

800 VA < $\Sigma S_{Emax} \leq$ 30 kVA $\cos\phi = 0.95_{\text{sous-excité}}$ à $\cos\phi = 0.95_{\text{surexcité}}$

La valeur de réglage ou la courbe caractéristique est fixée par l'exploitant de réseau en fonction du type d'installation.

30 kVA < $\Sigma S_{Emax} \leq$ 100 kVA $\cos\phi = 0.9_{\text{sous-excité}}$ à $\cos\phi = 0.9_{\text{surexcité}}$

L'exploitant de réseau détermine dans ce contexte les types de réglages et de commandes suivants :

a) facteur de déphasage fixe cosϕ

b) facteur de déphasage cosϕ (P)

c) puissance réactive constante Q

d) courbe de puissance réactive/tension Q (U)

ΣS_{Emax} > 100 kVA $\cos\phi = 0.9_{\text{sous-excité}}$ à $\cos\phi = 0.9_{\text{surexcité}}$

Un raccordement peut être effectué au poste de conduite de l'exploitant de réseau par lequel celui-ci régule le cosϕ en fonction de la situation. L'exploitant de réseau détermine dans ce contexte les types de réglages et de commandes suivants :

a) facteur de déphasage fixe cosϕ

b) facteur de déphasage cosϕ (P)

c) puissance réactive constante Q

d) une courbe de puissance réactive/tension Q (U)

That means, today the reactive power control is in the hands of the GRD and distant control can be done by the GRD.

From MURT-CH-2013 (modèle d'utilisation du réseau de transport, swissgrid)

> 5.1.3.3. Tarif de l'énergie réactive
>
> (1) Concernant les échanges d'énergie réactive avec le réseau de transport, une distinction est opérée entre participants actifs et passifs au maintien de la tension.
>
> a) Quantité d'énergie déterminante
>
> (1) Tous les gestionnaires de réseau et consommateurs finaux avec raccordement au réseau de transport sont de manière générale des participants passifs. Les participants passifs devraient démontrer leur intérêt à un comportement tel qu'il en découle le moins de répercussions possibles sur le maintien de la tension dans le réseau de transport. Dans ce contexte, une distinction est faite entre les quantités échangées, selon qu'elles sont supérieures ou inférieures à un facteur de puissance défini (0,9 en 2012), et la quantité d'énergie réactive selon qu'elle se situe à l'intérieur ou à l'extérieur d'une plage de gratuité pour l'énergie réactive.

8.5 Future trends

In May 2017 the Energy Strategy 2050 (OFEN, Stratégie énergétique 2050 2017) was accepted in popular vote. The legal framework will be modified in the future to adapt the new possibilities (cheap PV, affordable batteries…) market conditions and market design.

This legal framework is evolving continuously, especially in the energy domain. But we consider here the state of 2017 for our reflections.

The document from OFEN (OFEN, Bases pour l'introduction de systèmes de mesure intelligents 2014) sets technical requirement for smart-meters (SM). In those requirements, bidirectional communication with SM is asked and load control is expected from the SM. It is not required that the Smart Metering replaces today's ripple control.

The rollout of Smart Meters is just a matter of time.

9 Conclusions

In this report the general reflection about flexibility for ESR has been done. We see that flexibility harvesting at end consumer is strongly influenced by the service that we can provide to him. For simple consumers, the service must be identified and presented clearly. For prosumers with PV, the services must first meet the self-consumption goals and then the DSO/BRP goals.

The flexibility harvesting at industries is mainly influenced by the process specificities. This process is essential for the industries and must not be disturbed except if large gains are possible (typically peak-shaving).

The potential conflicts between the local goal and the global goal is a key point to identify. The business model canvas helps to identify the customer goals/desires, included in the value proposition and the way to make the flexibility profitable.

The market framework analysis points out the central role of the aggregator. ESR will consider if he will try to equip his customers with DSM system as a DSO. But in any case, the aggregator role cannot be taken by ESR energy retail because of the liberalization process. If other energy suppliers are taking the customers, the aggregator service must be done independently.

The defined KPI will be evaluated during this project. Even if the trial is small with 250 customers compared to 50’000, this will give a good idea of the possible performances and help to decide if a general deployment will be planned. For this, a clear assessment of the CBA will be necessary. They were defined in this report, but the final value can only be found with a real-world installation of a few systems.

Technical developments are necessary but are only one part of the job in setting up the flexibility system. In order to have a chance that the GOFLEX pilot is followed by a successful large-scale deployment of flexibility services, the business framework must be carefully considered. This document presents a first study, but concepts will evolve along with the feedbacks received during the GOFLEX project.

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