interoperable solutions connecting smart homes, buildings and grids

WP1 – Use Cases, Business Models and Services

D1.3

System use cases for smart buildings and grids

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EXECUTIVE SUMMARY

The goal of this document is to detail the outputs of the Interconnect task 1.4 and which method has been used to do so.

The task 1.4 aims to produce System Use Cases for smart buildings and grids from Interconnect Pilot's High-Level Use Cases. These High-Level Use Cases constitute outputs of the Task 1.3 and consequently inputs of the Task 1.4 of the Interconnect project.

A commonality study among all the Interconnect's pilots is also provided to identify clear rules of engagement/interaction between all parts of the Interconnect ecosystem.

Both System Use Case Specification and Commonalities Analysis results will provide strong basements to feed the Interconnect WP2 to derive the proper ontologies and pilots' implementations that will come next.

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ABBREVIATIONS AND ACRONYMS

Actor	entity that communicates and interacts[1]
Business Use Case	A Business Use Case details business processes organized to satisfy a business goal
BUC	Business Use Case
Domain (SGAM)	group of related subjects of standardization[2]
Functional requirement	descriptions of what the system must do[3]
High Level Use Case	Use case which describes a general requirement, idea or concept independently from a specific technical realization like an architectural solution[4]
HLUC	High Level Use Case
IoT	Internet of Things
Non-functional requirement	descriptions of what qualities the system must contain from an execution and performance perspective[5]
Primary Use Case	Use case which describes in detail the functionality of (e part of) a business process[6]
PUC	Primary Use Case
Requirement	provisions that convey criteria to be fulfilled[7]
Role	type of actor which has responsibilities and represents the external intended behaviour of a party[8]
SAREF	Smart Applications REFerence (*SAREF*) ontology
Scenario	possible sequence of interactions[9]

1 Source IEC/IS 62559-2

2 Source IEV 901-01-03

3 Source IEC PAS 62559 Edition 1, §7.2.6.2

4 SG-SC/M490/E, 2012-12, definition 3.4

5 Source IEC PAS 62559 Edition 1, §7.2.6.2

6 Source SG-CG/M490/E, 2012-12, definition 3.5

7 Source IEV 901-05-05

8 Source SG-CG/M490/C, 2012-12

9 Source SG-CG/M490/E, 2012-12, definition 3.10

Service	specific transaction satisfied by a business processes involving two or more roles
SGAM	Smart Grid Architecture Model, the SGAM framework and its methodology are intended to present the design of Smart Grid use cases in an architectural but solution- and technology-neutral manner[10]
Smart Grid	electric power system that utilizes information exchange and control technologies, distributed computing and associated sensors and actuators[11]
SUC	A System Use Case is a formalized way to detail a HLUC or a PUC from a system point of view
System	set of interrelated elements considered in a defined context as a whole and separated from their environment[12]
UC	Use case
UML	Unified Modelling Language[13], graphical modelling language for the specification, construction and documentation of parts of software and other systems
Use case	specification of a set of actions performed by a system, which yields an observable result that is, typically, of value for one or more actors or other stakeholders of the system[14]
UCR	Use Case Repository, database based on a given use case template, for editing, maintenance and administration of use cases, actors and requirements including their interrelations[15]
Use case template	a form which allows the structured description of a use case in predefined fields[16]
Zone (SGAM)	The SGAM zones represent the hierarchical levels of power system management

10 Source IEC SRD 63200

11 Source IEV 617-04-13

12 Source IEC IS 62559-2

13 UML 2.5.1 specifications, https://www.omg.org/spec/UML

14 Source SG-CG/M490/E; 2012-12

15 Source based on SC-CG/M490, 2012-12, definition 3.13

16 Source SC-CG/M490/E, 2012-12, definition 3.2

1. INTRODUCTION

1.1 OVERALL INTRODUCTION

The Interconnect D1.3 deliverable mainly constitutes smart building and grid System Use Case Specifications for the Interconnect's pilots.

The D1.3 has a double goal of standardization and harmonization to transform High-Level Use Cases to System Use Case standardized specifications and to provide standardized representations of interoperable architectures. This double goal has been managed by the Work Package 1, Task 1.4.

Non-harmonized High Level Use Cases were created by a previous Interconnect innovating process dealing with Personas, Needs, Ideas, Epics and Service Concepts to provide a selection of High-Level Use Cases that constitute the input of the Task 1.4.

A methodology has been built, based on existing standards such as IEC-62559 or IEC-62913 and fundamental concepts such as roles, actors, functional and non-functional requirements, to define a System Use Case Modeling Process that was used by the Interconnect's pilots to produce their Standardized System Use Case specifications.

The D1.3 also provides a Commonality study among all the Interconnect's pilots. Commonalities were identified during the System Use Case Specification review phase that came next to the Use Case Modeling Process phase. Commonalities such as objectives popularity, main beneficiaries, predominant roles, predominant functions and combinations of those criteria's have been highlighted.

1.2 OBJECTIVES FOR T1.4

The Interconnect grant agreement stated the task 1.4 with the following words:

System use cases *writing of selected services*

This task will conduct a general categorization, considering customer and grid-centric business cases, to group and classify them, and therefore facilitate the development of clear rules of engagement/interaction between all parts of the ecosystem. These rules will then be described in terms of SUC, with the corresponding functions and interactions. In this way, common functionalities can be provided by the same SUC, contributing to prove the modularity and interoperability not only at a lower ICT level but also, when possible, at the functional layer among the different pilots. Results will be summarized to feed WP2, to derive the proper ontologies. Note that SUC identification is needed not only for the implementations in WP3-7, but also for the addition of services through the cascade funding of WP8, making this rather analytical task a very important task of the project.

The task 1.4 is subdivided into three sub-tasks:

- *Subtask 1.4.1 Categorization:*
  - *The broad overview resulting from tasks 1.1 to 1.3 will be analyzed to find commonalities in the way of interactions, the stakeholders engaged and their roles.*
- *Subtask 1.4.2 From human-centric business case to human-centric system use cases:*
  - *EEBUS will coordinate the work for human-centric use cases, departing from IEC TC62746-2 ("Use Cases and Requirements") and EN50631 ("Household Appliances Network and Grid Connectivity"), and various working*

groups on white goods, HVAC, e-mobility with all relevant manufactures developing human-centric use cases.

- *Subtask 1.4.3 From grid-centric business case to grid-centric system use cases:*
    - *TRIALOG will coordinate the detailed description of SUC following IEC 62559, which ensures a complete compatibility with both normalization and EU work in a comprehensive manner. Specific KPIs will also be proposed for each SUC, re-using methodologies considered in other FP7 and H2020 projects*

The objectives for T1.4 was quite clear concerning sub-tasks 1.4.2 and 1.4.3. However, the sub-task 1.4.1 that should come first before the two other sub-tasks raised a crucial question: How can we find commonalities among the use cases in terms of interactions without having them detailed into system use cases.

This is why the sub-task 1.4.1 has been managed as the last sub-task considering that we will be full of system details at the end of sub-tasks 1.4.2 and 1.4.3 and consequently more able to treat the objectives of the 1.4.1 sub-task.

1.2.1 SYSTEM UC FOR BOTH BUILDING DOMAIN & GRID DOMAIN

Specifying Interconnect system use cases from high level use cases is a long run and requires an unneglectable number of efforts from both building and grid stakeholders. Thus, it was initially required to clarify first, what was the Start point and End point for the task, what was its inputs and outputs and finally what the responsibilities of the stakeholders were.

The Interconnect D1.2 deliverable provided the task 1.4 with the inputs such as pilot's selected HLUCs and all details gathered without sufficient harmonisations. The outputs of the task 1.4 will provide System UC harmonized specifications which is the purpose of the deliverable 1.3, this present document. Stakeholder's responsibilities had to be defined as well with a common agreement.

The Figure 1 depicts 1.4.1, 1.4.2 and 1.4.3 sub-tasks articulation forming as a whole the task 1.4.

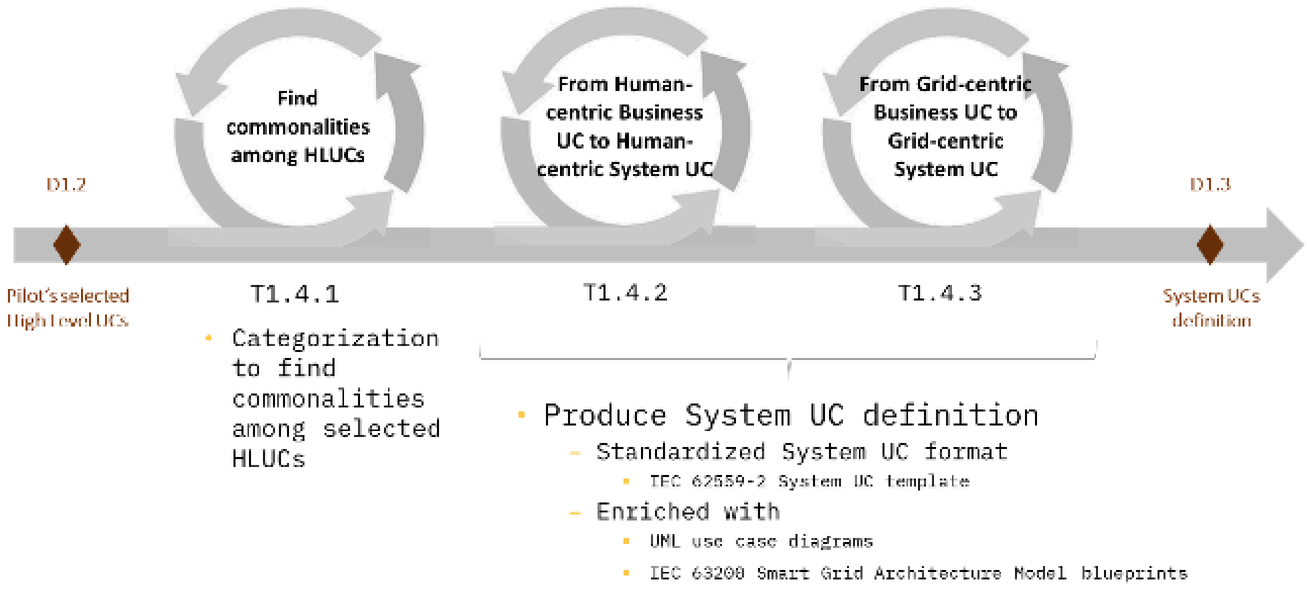

FIGURE 1 – T1.4 START POINT & END POINT

As shown in Figure 1, the production of Interconnect System UC definitions is based on several existing standards that will be further detailed:

- IEC-62559 – Use case methodology
- UML diagrams
- IEC-63200 – Smart Grid Architecture Model

The stakeholder's responsibilities were stated as follow in a common agreement:

1. T1.4 leaders define and provide a method for the System UC definition process, basically:
    - Transform HLUCs to System UCs
    - Create UML diagrams
    - Create SGAM blueprints
2. T1.4 leaders approve and validate the method
3. T1.4 leaders provide the pilot leaders with the method
4. Each Pilot team follows the method to produce its own System UCs definition
    - Each pilot leader is responsible of the content, the consistence and feasibility of its pilot team production
5. T1.4 leaders provide supports on the methodology to the pilots during the step #4
6. T1.4 leaders manage pilot leaders to get their System UCs definition on time
7. T1.4 leaders prepare the D1.3 document structure and method inputs

8. Pilot leaders are responsible to fill out D1.3 respective § and the integration of all pilot's specifications
9. D1.3 is reviewed and validated by T1.4 leaders for delivery

To close this overall introduction and to illustrate how long the task 1.4 runs and requires this unneglectable number of efforts to produce a tremendous quantity of documents with quality of content, the Figure 2 depicts the used method including references on both step-by-step productions and standards-based productions leading to this present deliverable, the D1.3.

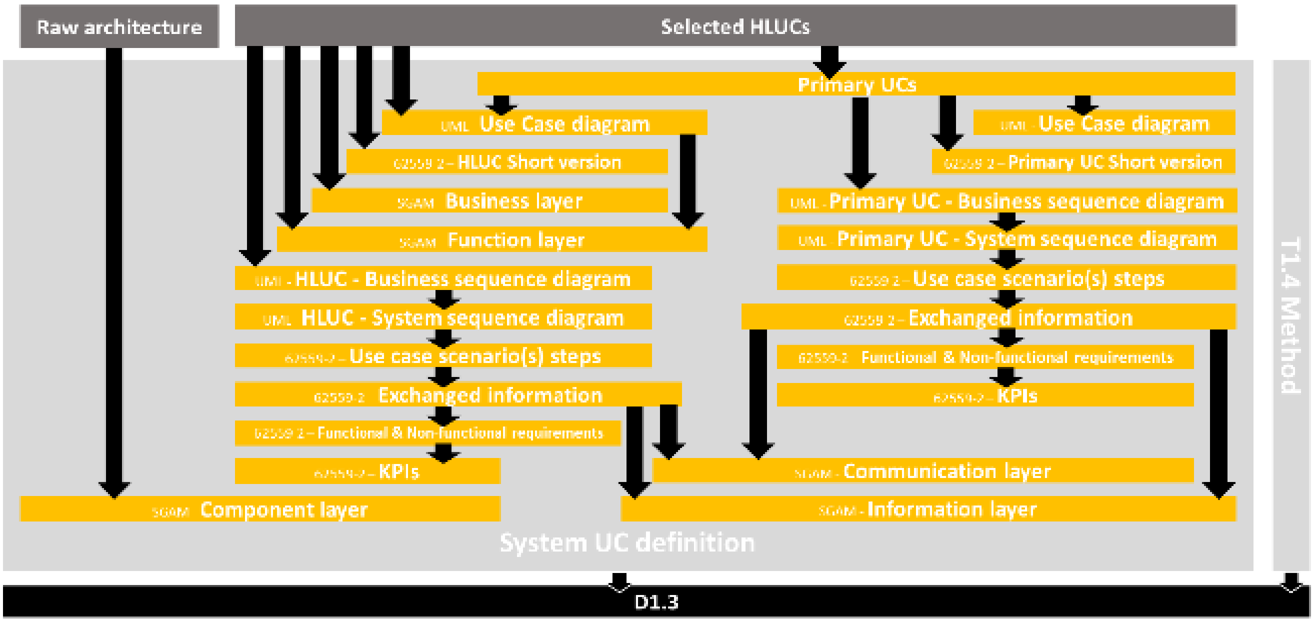

FIGURE 2 - THE T1.4 METHOD & ITS PRODUCTIONS LEADING TO D1.3

2. CONTEXT DESCRIPTION

2.1 REMIND PREVIOUS PROCESSES USED TO GET HLUCS, PILOTS INVOLVED, D1.1 & D1.2 RESULTS

2.1.1 INNOVATION PROCESS OVERVIEW

Interconnects' process is starting with the first innovative ideas and leads finally to systems use case specification which define the services implemented in the pilots.

The following figure shows the agile innovation process.

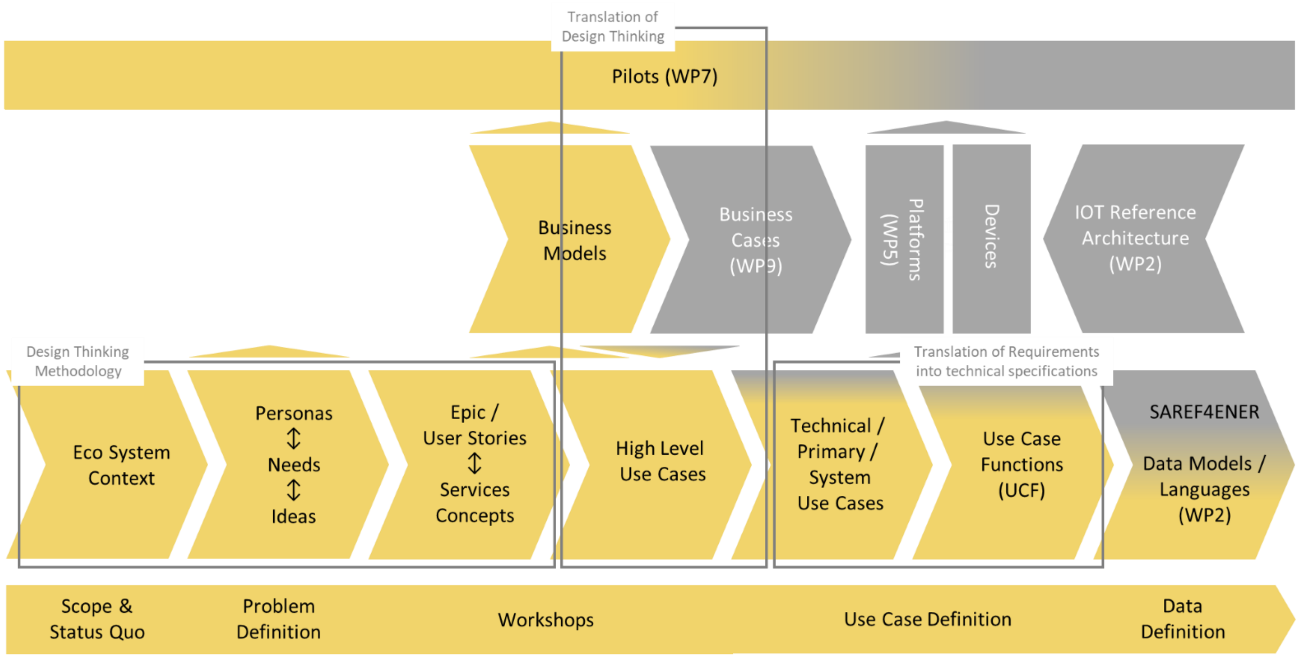

FIGURE 3 : INNOVATION PROCESS

The 3 main elements of the process are the design thinking methodology, the translation of design thinking results through High Level Use Cases and the translation of requirements into technical system use case specifications.

A High-Level Use Case is the base for a Business Canvas to detail out the Business Case.

2.1.2 FOSTERING INNOVATION THROUGH DESIGN THINKING METHODOLOGY

Design Thinking is a formal method for creative problem solving, with the intent of fostering innovation. It is characterized by

1. the leverage of creativity as a driver of innovation,
2. a human centered perspective, where innovators build empathy with users
3. and an intense use of experimentation as a rapid and effective source of communication and learning among stakeholders

The following shows the main steps of the design thinking methodology.

FIGURE 4: STEPS IN DESIGN THINKING METHODOLOGY

At first the problem and the vision of the pilot were described by the manifesto.

FIGURE 5 : MANIFEST ITALY PILOT

From there the people's needs were analyzed and the corresponding personas were defined.

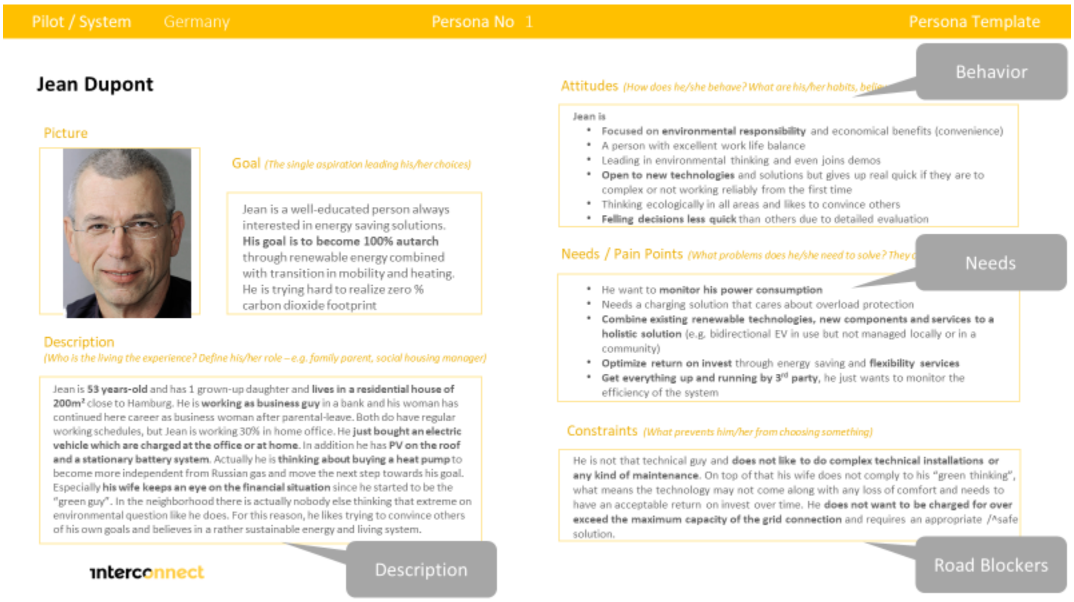

FIGURE 6 : PERSONA DESCRIPTION

In the next step the group was doing ideation to identify new values and discover solutions for the personas defined.

The corresponding eco system map shows the stakeholders, data flows and functionalities. This is an abstracted view what feature the pilot will implement and test.

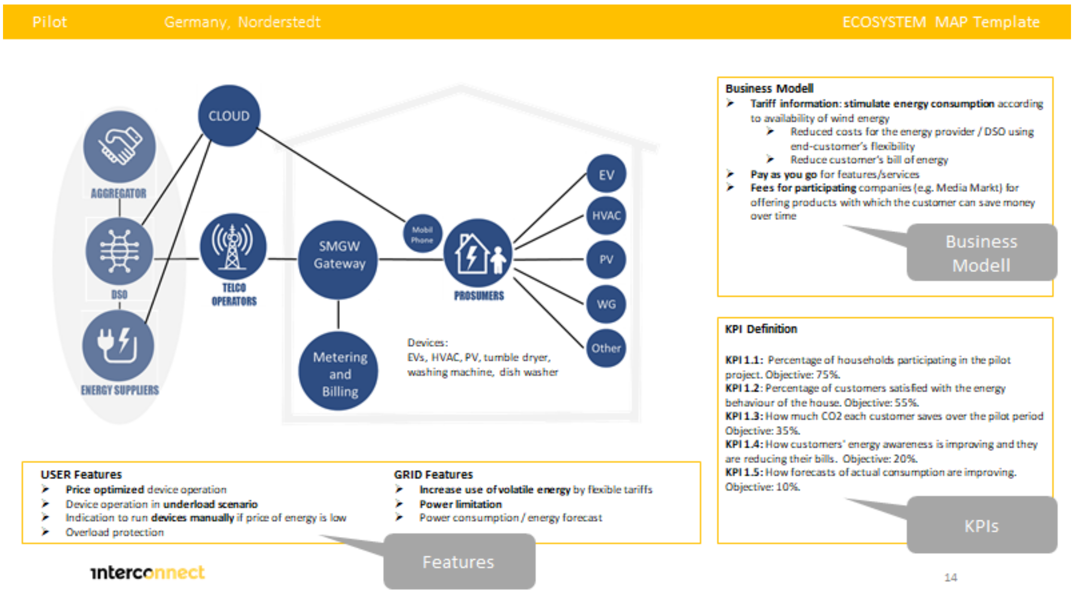

FIGURE 7: ECO SYSTEM MAP OF NORDERSTEDT PILOT

In addition, a country analysis was performed to make sure all known legal items were covered.

After selection of the most interesting solutions specific service ideas which fulfill the user' needs have been defined. The initial service ideas were translated into service concepts describing the detailed customer journey.

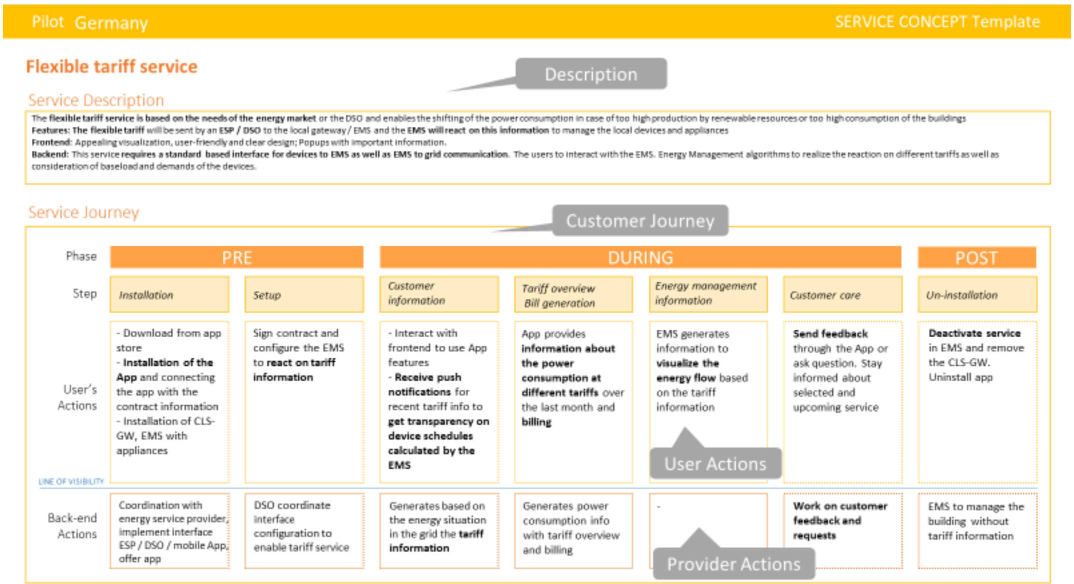

FIGURE 8: SERVICE CONCEPT

The service concepts were detailed out through EPICs and user stories. All involved personas were stating their needs specific values they will get. Though this the service concepts were refined considering all aspects.

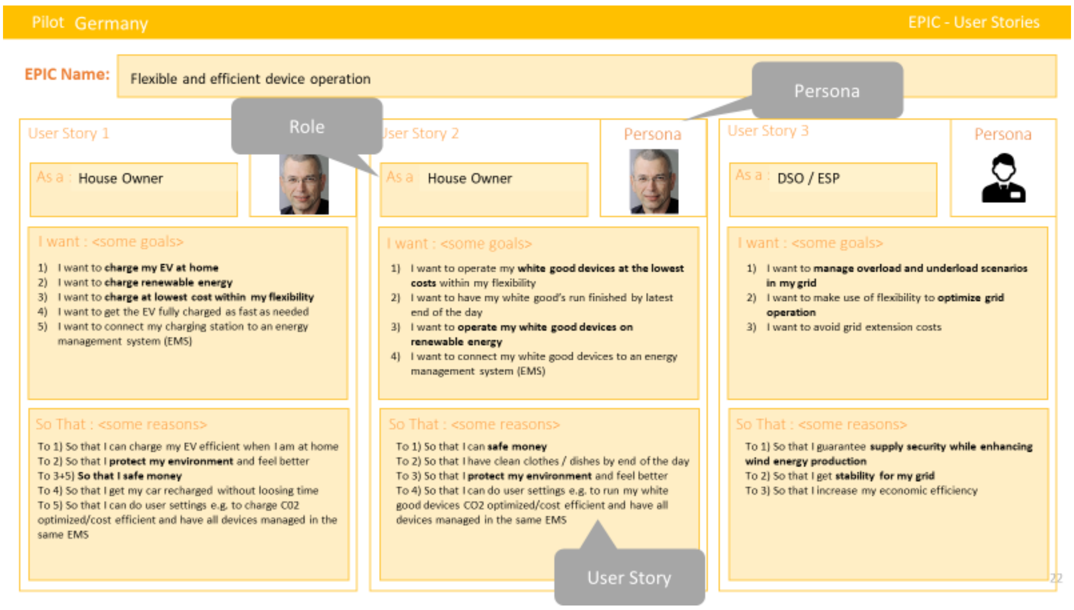

FIGURE 9 : EPIC

Several user stories were combined on the one hand in an EPIC to detail out the complete service but may be used in different high-level use cases with describe a part of the solution. The following figure shows the interrelationships.

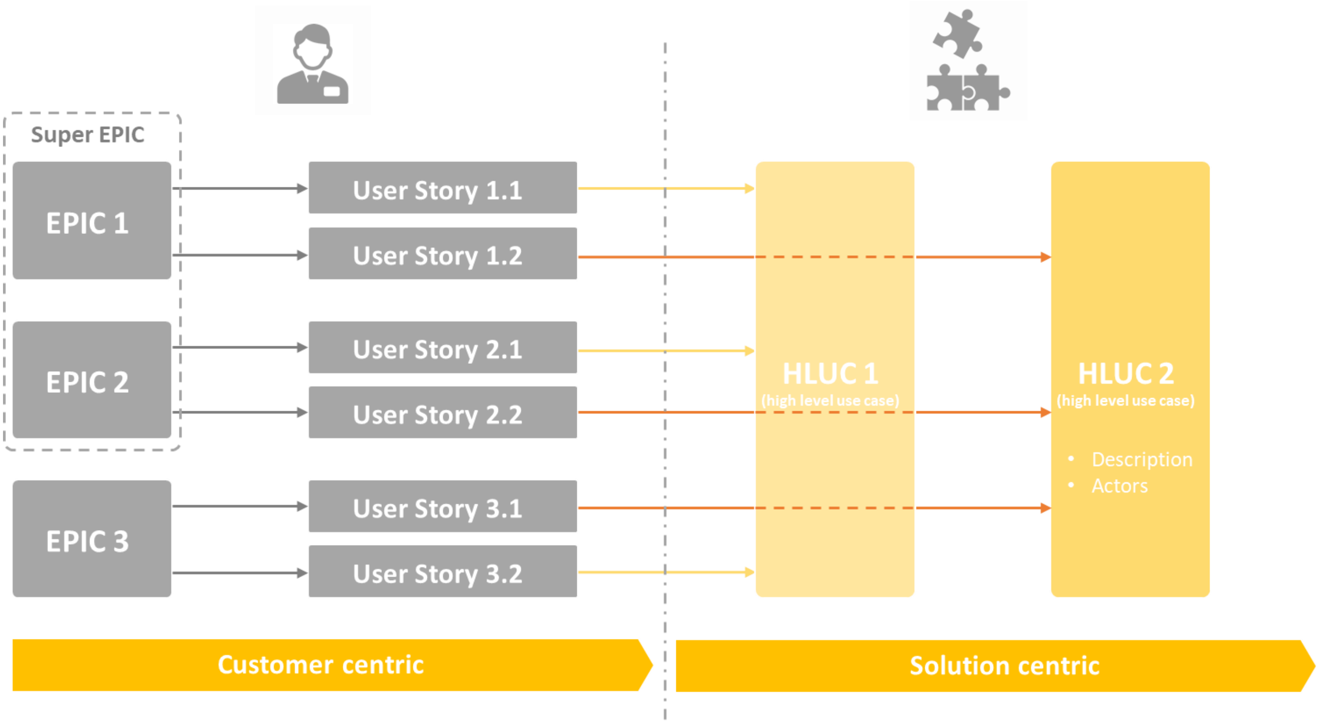

FIGURE 10 : CUSTOMER / SOLUTION CENTRIC VIEW

On top of that a high-level business canvas has been created to point out the value of the service, the invest, the market situation and revenue stream.

At this point the customer centric view was fully described and the process was changing to solution centric.

2.1.3 TRANSLATION OF RESULTS THROUGH HIGH LEVEL USE CASES

The high-level use case was the first process step which described the solution what covers all customers' needs. The goal of the use case and all involved actors weather technical or business were defined. The high-level use case description itself were explaining the features and interaction of the actors at high level as is considered as the envelope of the technical use case specifications named primary use cases.

A pilot is fully described by high-level use cases and primary use cases, based on which the reference architecture design and device implementation can be started.

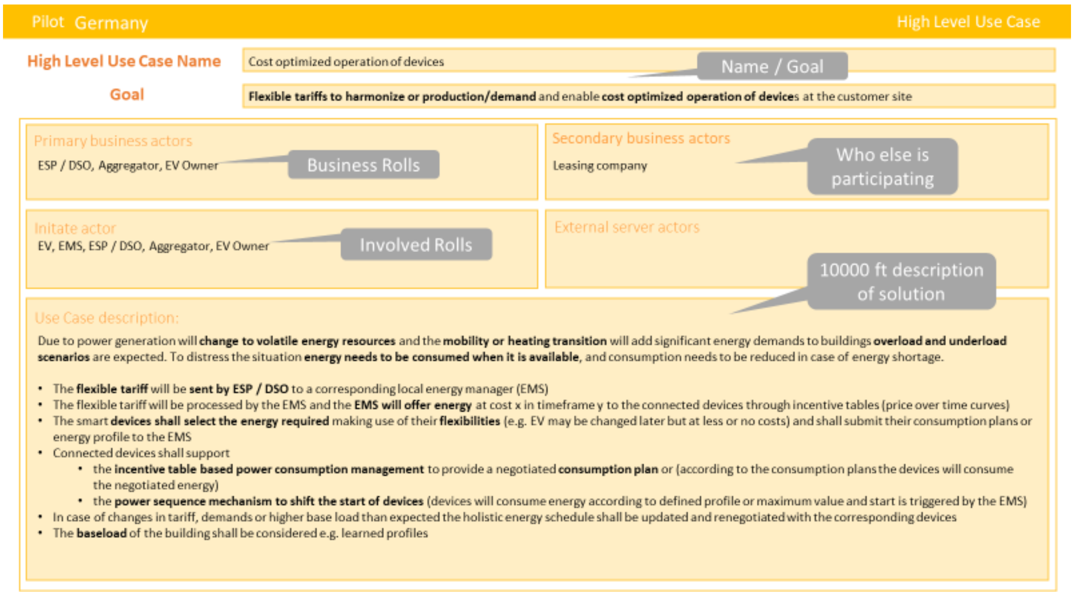

FIGURE 11 : HIGH LEVEL USE CASE

2.1.4 TRANSLATION OF REQUIREMENTS INTO TECHNICAL SYSTEM USE CASE SPECIFICATIONS

A high-level use case combines multiple technical use case functions or so-called primary use cases (PUC). A PUC contains a description of the functions, actor descriptions, sequence diagrams, scenarios, information exchange details and KPIs. To follow lean implementation by reuse the primary use case specification is considered as the smallest specification unit to make sure other high-level use cases may use the same primary use case. Some partners may detail out the PUC through use case functions to be more aligned with the SAREF definition.

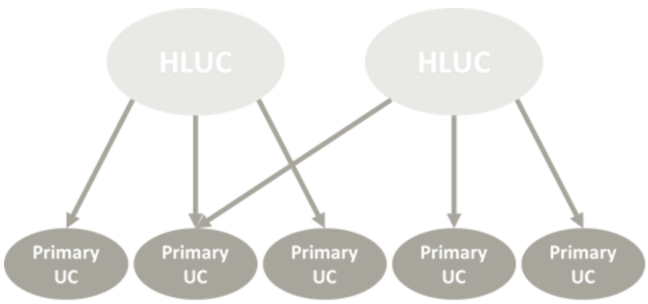

FIGURE 12 : PRIMARY USE CASE

The specification of the primary use case function is done though IEC 62559-2 template. For details please see chapter 3.5.3.

3. FROM HIGH-LEVEL USE CASE TO SYSTEM USE CASE METHODOLOGY

The Interconnect High-Level Use Cases to System Use Cases methodology aims to produce harmonized System Use Cases for further standardisation work. It uses as inputs a common approach from IEC 62913 and IEC 62559 to extract, from a high-level vision from pilots, functional and non-functional system requirements. The IEC 62559-2 associated with UML use case diagrams, UML sequence diagrams and SGAM blueprints provide a harmonization of System Uses Cases specifications for all pilots within Interconnect.

The following figure shows how the High-Level Use Case to System Use Case Methodology takes place into the InterConnect workflow.

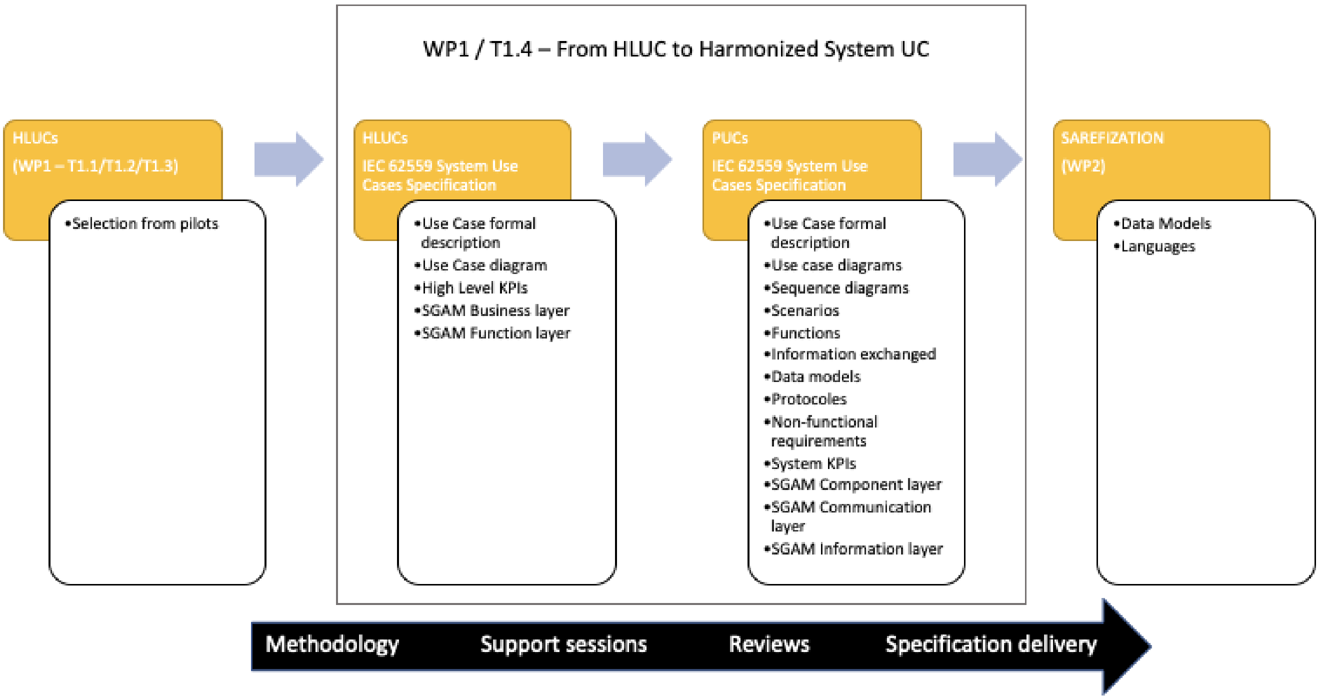

FIGURE 13 : T1.4 WORKFLOW WITHIN THE INTERCONNECT WORKFLOW

It is first essential to achieve a consistent and homogeneous description of all preliminary concepts used in this methodology such as:

- Differentiation between High-Level Use Cases and System Use Cases
- Standards used as a basement of this methodology
- Roles and Actors
- Requirements
- System Use Cases modelling process

All those concepts are detailed in the following chapters.

3.1 DIFFERENTIATE HIGH-LEVEL USE CASE AND SYSTEM USE CASE

Specifying system requirements for both Smart Grid and Smart Cities is a really challenging process that requires to manage many domains of expertise in a way of sharing ideas and finally technical requirements. People with various background such as business, energy systems, home automation or other IT specialists have to brainstorm in technical workshops to define how the future system will be interconnected and will exchange information leading to specifying the system functionalities, the system behaviour, its interfaces, its used protocols and data models in a secure and privacy compliant manner.

In this context High-Level Use Cases and System Use Cases are defined as follow:

- High-Level Use Case (HLUC)
  - It describes how roles interact to execute a high-level process
    - These processes are derived from services which have previously been identified
- System Use Case (SUC)
  - It describes how System and/or Business Roles of a given system interact to perform a function required to enable / facilitate the high-level processes
  - Its purpose is to detail the execution of those processes from an Information System perspective

As depicted in Table 1, HLUC and SUC are compared including the roles involved in both types of use case.

TABLE 1 – HIGH-LEVEL USE CASE VERSUS SYSTEM USE CASE

	High-Level UC	System UC
Description	Depicts a high-level process Expected to be system agnostic	Depicts a function or sub-function supporting one or several high-level processes
Roles involved	Business Roles • Organizations • Organizational entities • Physical persons	Business Roles <u>and</u> System Roles • Same as Business roles • Devices • Information System The roles involved are considered as actors

3.2 TOWARD SYSTEM USE CASE AND STANDARDIZATION

The Interconnect High-Level Use Case to System Use Case methodology is based on several standards that have been used to specify functional and non-functional requirements into System Use Cases.

The IEC 62913-1 provides guideline and a Use Case methodology to define generic smart grid requirements, the IEC 62559-2 provides Use Case definition template recommendations from the European Smart Grids Task Force which is a group of experts for 'Standards and Interoperability for Smart Grids Deployment' (EG1) and towards Interoperability within the EU for Electricity and Gas Data Access & Exchange.

Special add-ons for Interconnect have been added to provide harmonized graphical views into the System Use Cases specifications including UML use case diagrams, UML sequence diagrams and SGAM layers.

Even though the Smart Grid Architecture Model is dedicated to the grid domain, it has been used to produce harmonized pilot architecture blueprints providing the interoperability viewpoint that you cannot get with conventional disparate architecture drawings.

Lists of standardized roles and non-functional requirements were also provided to the pilots to get harmonized items identification along the specification process.

3.3 ROLE VERSUS ACTOR

Roles are mostly used to define High-Level Use cases. Since use cases become more and more detailed during the High-Level Use Case to System Use Case specification process, roles are replaced by the actors playing the roles.

An important step in the System Use Cases specification process is to properly identify the roles involved in the High-Level Use Cases and to map with the corresponding actors that will play the roles in the future system implementation. Thus, lists of roles and actors are created by the pilots and if a role doesn't exist as a standard reference, it is created as a new identified role.

The difference between roles and actors is detailed just below.

3.3.1 ROLE

Roles may be defined as "an intended behavior of a business party". In other words, a business party, when carrying out a business transaction, takes on a certain role. A Role is associated with responsibilities.

Within a given system, a Role is a type of actor which has responsibilities for a Business Role. It is also a type of actor which has functionalities for a System Role such as information systems and devices.

The Figure 14 bellow depicts the interactions between Parties, Roles, Actors and responsibilities.

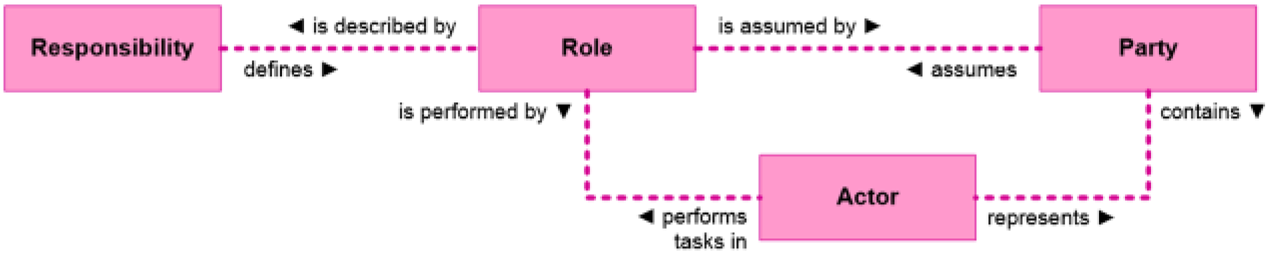

FIGURE 14 - ROLES & ACTORS INTERACTION MODEL

Roles relating Grids is a regulated domain and references were provided to the pilots:

- HARMONISED ELECTRICITY MARKET ROLE MODEL
  - https://eepublicdownloads.azureedge.net/clean-documents/EDI/Library/HRM/Harmonised_Role_Model_2020-01.pdf
- Roles from USEF
  - https://www.usef.energy/app/uploads/2016/12/USEF_TheFrameworkExplained-18nov15.pdf

Roles relating Human/Home are not already regulated and IOT work groups start to define them.

3.3.2 ACTOR

Actors are entities that communicate or interact with a given system.

Roles involved in a High-Level Use Case are business roles such as organizations, organizational entities which are functional entities of an organization (company department, project teams, etc.) and physical persons.

Actors involved in a System Use Case include business roles and system roles such as devices and Information System.

An actor may also play multiple roles.

Interconnect pilots were provided with a list of actors that was extracted from the DISCERN H2020 project and a mapping between roles and actors were also provided from the SG-CG/M490/E - Part E: Smart Grid Use Case Management Process.

3.4 REQUIREMENT

Requirements can be separated into two categories: Functional requirements and Non-Functional requirements. These two categories are detailed in the following chapters.

3.4.1 FUNCTIONAL REQUIREMENT

It describes what the system must do:

- They are actions in response to events, or actions performed autonomously
- They represent operations and features provided
- Mainly concern interfaces supporting all applications
- Mainly focus on capabilities of the interfaces of the different roles / functions

They constitute each step of a System Use Case scenario.

3.4.2 NON-FUNCTIONAL REQUIREMENT

It describes what qualities the system must contain from mainly an execution and performance perspective:

- These are also known as “constraints”, “behavior”, “criteria”, “performance targets”, etc.
- They set limits or controls on how well the system performs the functional requirements.
- They include reliability, security, usability, upgradeability, expandability, scalability, deployment, compatibility, safety, performance, conformance and can also include abstract requirements such as equity and fairness
- The Interconnect pilots were provided with a list of non-functional requirements as defined in IEC PAS 62559 and FP7 DISCERN project.

Non-Functional requirements are referenced and detailed in dedicated fields of the IEC 62559-2 for both scenario steps and information exchanges. Non-functional requirements define additional common services that will have to be implemented by the pilots or as a common service package provided by the project.

3.5 SYSTEM USE CASE MODELING PROCESS

High Level Use Cases constitute the input of this System Use Case modelling process. HLUC were defined in the task 1.1 and detailed in the task 1.2 of Interconnect.

The overall modelling process to formalize the HLUC is made of the following steps:

- Identify functional processes commonly called Primary Use Cases that can be common to several HLUC as depicted Figure 15

- Create UML Use Case Diagram (relations between HLUC, Primary UCs & Roles)
- Use IEC 62559-2 for HLUC formal description
- Draw SGAM Business layer
- Draw SGAM Function layer

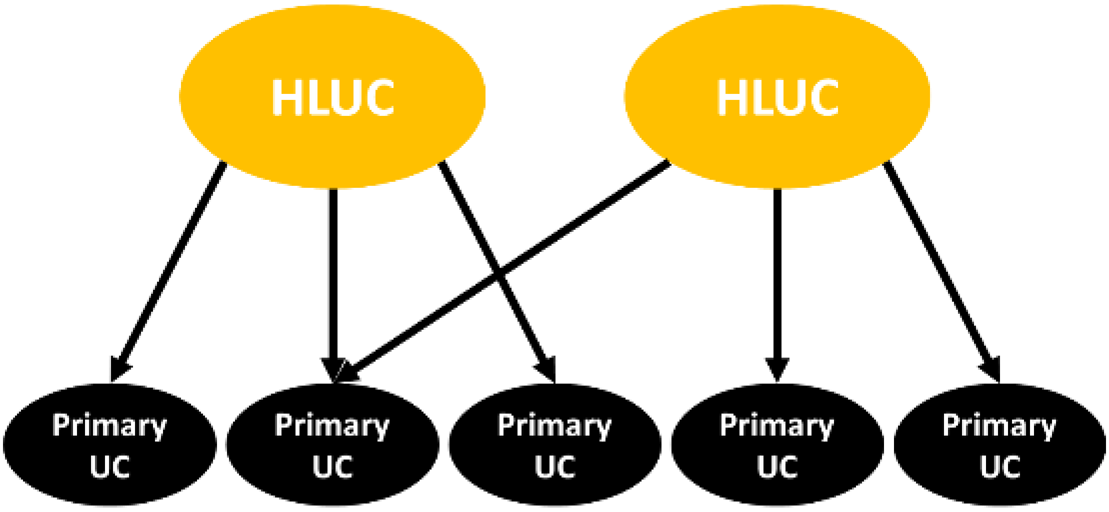

FIGURE 15 – IDENTIFY PRIMARY USE CASES FROM HIGH LEVEL USE CASES

The overall modelling process to formalize the Primary Use Cases is made of the following steps:

- Describe functional processes including “elemental” functions which are functional requirements
- Use IEC 62559-2 for System Use Case formal description
- Draw SGAM Component layer
- Draw SGAM Communication layer
- Draw SGAM Information layer

The Figure 16 depicts the entire process showing the normalized documents production following standards on those the Interconnect High-Level Use Case to System Use Case methodology is based on. All produced specifications will constitute the inputs for WP2, WP3 and WP4.

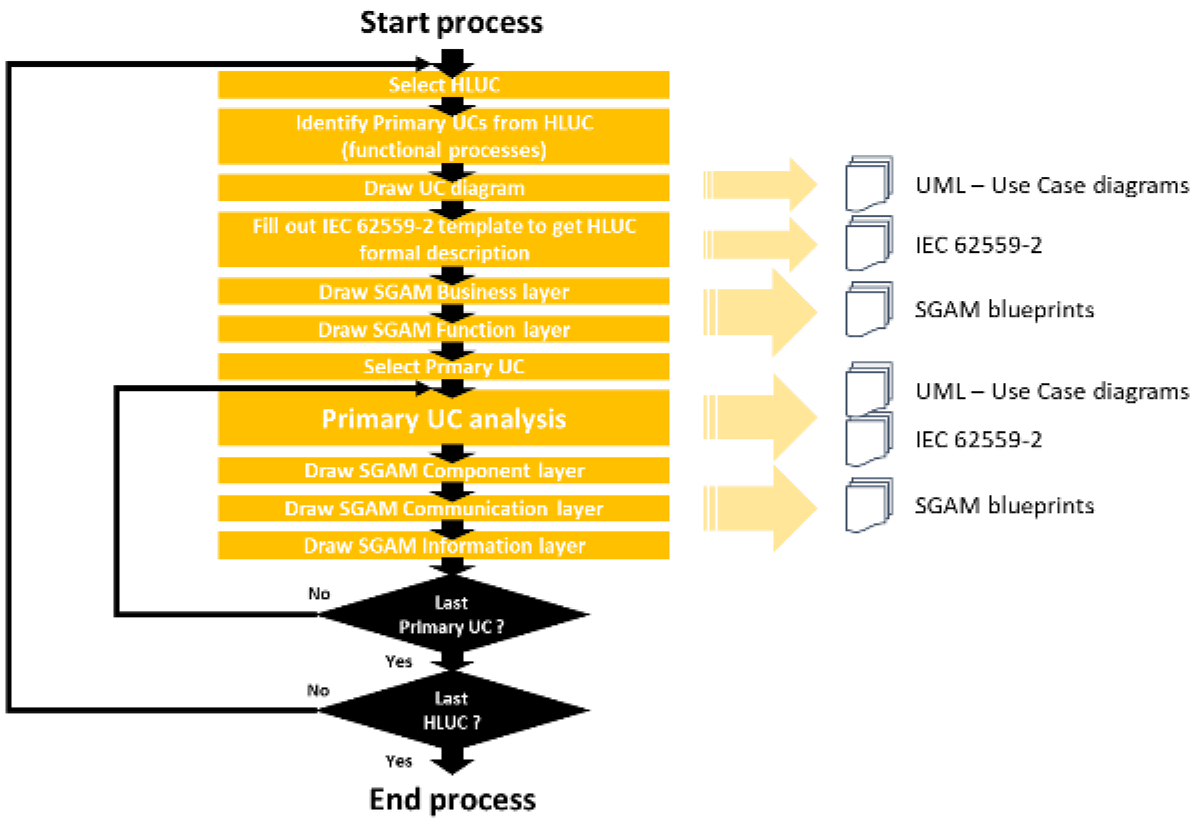

FIGURE 16 - STEP BY STEP MODELING PROCESS WITH A NORMALIZED PRODUCTION

3.5.1 IDENTIFY PRIMARY USE CASE FROM HIGH LEVEL USE CASE

Identifying Primary Use Cases (PUC) from High Level Use Cases (HLUC) is a fundamental step of the entire process. It consists of identifying the functional processes that will be used to answer a high-level objective. In this step all relevant professional backgrounds including business backgrounds, energy system backgrounds, home automation profile backgrounds, IT specialist backgrounds, Security and Privacy specialist profile backgrounds have to brainstorm in technical workshops to identify which functional solutions will be used and interconnected to answer to the High-Level Use Cases requirements. The workshops are organized by the pilot leaders for pilot team brainstorming. To do so, making the difference between High Level Use Case and Primary Use Case ecosystem is also fundamental and can be detailed as follow:

- A HLUC provides a high-level process answer to a business goal
  - Involved actors are mainly roles
  - High-level requirements are identified
  - It describes a high-level process often related to a service
  - A HLUC will be depicted in the SGAM business layer

- A PUC provides a functional process answer to satisfy a part of the high-level process, functions and sub-functions are used
  - Involved actors are systems, other functions, human operators, etc.
  - Requirements for a field implementation of the solution are identified, they describe a function, or a sub-function related to a part of the business or high-level process
  - A Primary Use Case will be depicted in the SGAM function layer

Once all PUCs of a HLUC have been identified a Primary Use Case Analysis is required.

3.5.2 PRIMARY USE CASE ANALYSIS

A Primary Use Case Analysis provides for each PUC the ability to translate a high-level process function into a System Primary Use Case Specification.

The PUC is developed first as a system sequence diagram with involvement of all relevant pilot partners. According to the objectives of the PUC, the system sequence diagram will detail the interactions between the actors involved in each action constituting the functions such as requests / responses. For each function, the information exchanged will be provided but limited to a high level of detail.

The System Sequence Diagram is then translated into an IEC 62559-2 System Use Case template by detailing each function into scenario steps. Depending on the way the PUC will be staged by the HLUC multiple scenarios can be required. Each step of a scenario will provide one action or exchange between actors, the exchanged information will be detailed, and potentially additional non-functional requirements will be added at the scenario step level and/or at the information detail level.

The System Use Case will then be provided with additional activity such as error treatments or alternative processing and the IEC 62559-2 PUC will be refined till reaching a sufficient level of detail and satisfaction.

The Figure 17 depicts the Primary Use Case Analysis process.

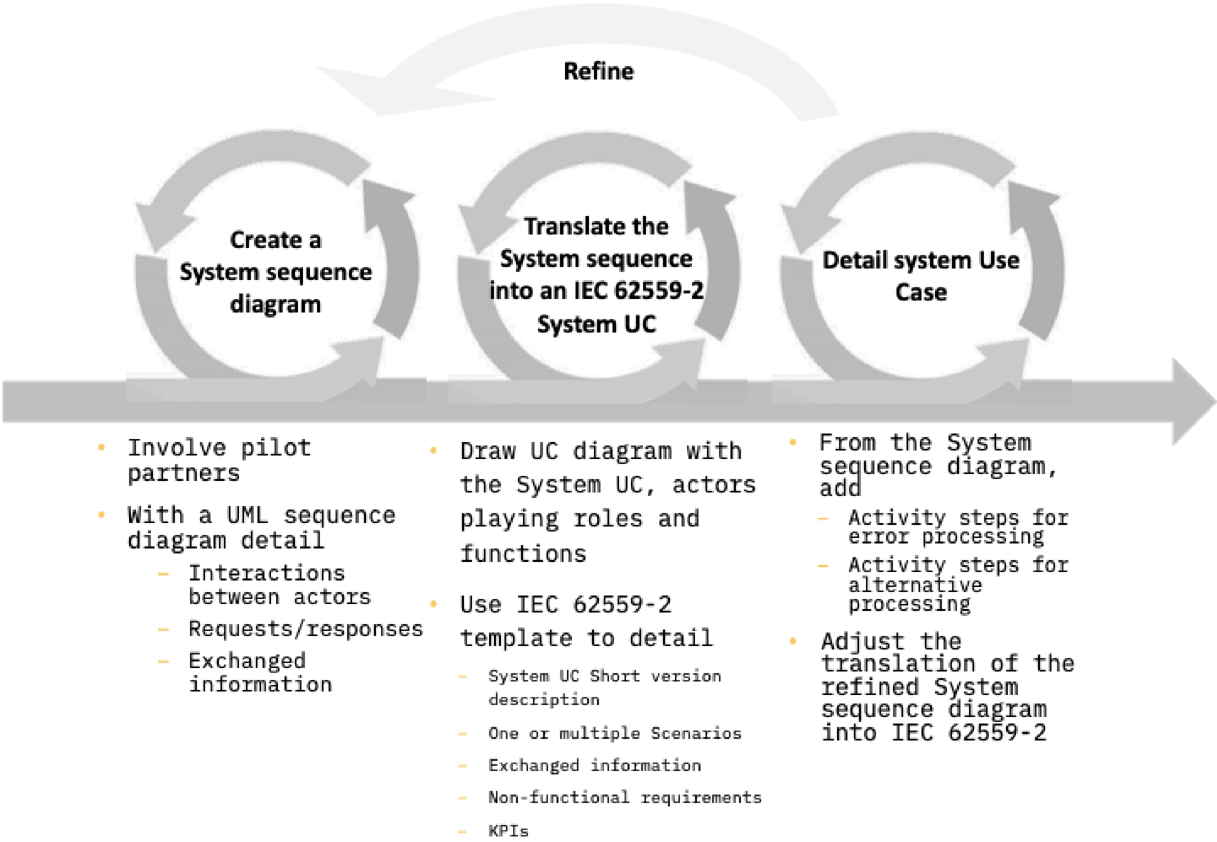

FIGURE 17 - THE PRIMARY USE CASE ANALYSIS PROCESS

3.5.3 IEC 62559-2 TEMPLATE OVERVIEW

The IEC 62559-2 template is depicted Figure 18.

This document is a Microsoft Word format document that provide a way to dispatch each Use Case specified information into dedicated chapters and tables in a formatted manner.

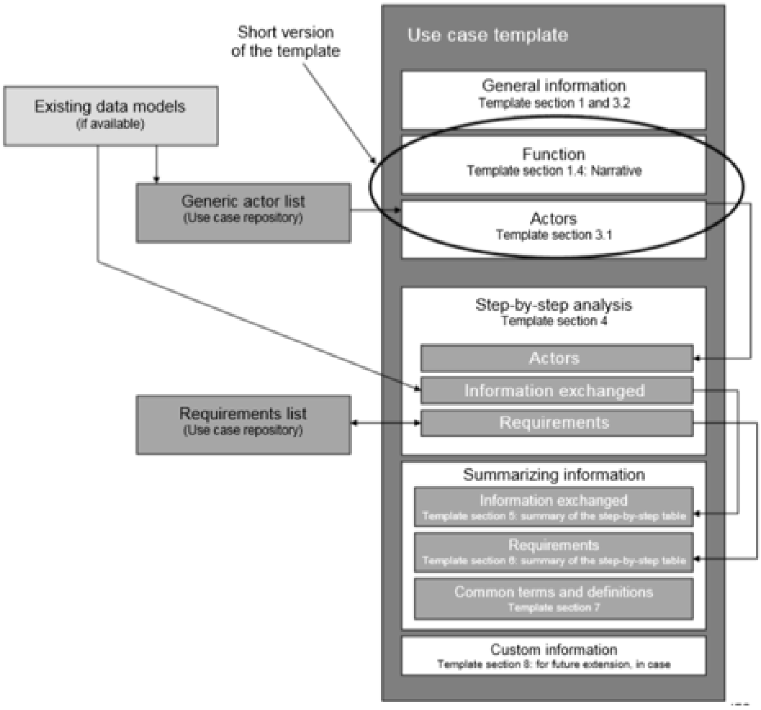

FIGURE 18 - OVERVIEW OF THE IEC 62559-2 TEMPLATE

In a double goal of standardisation and harmonisation, for Interconnect, additional information was added such as:

- a UML Use Case Diagrams providing a standardized viewpoint of the PUCs articulation for a HLUC,
- a UML Sequence Diagrams providing a standardized graphical viewpoint of the UC's scenarios,
- a SGAM Business layer providing a standardized viewpoint of a business detailed in a HLUC,
- a SGAM Function layer providing a standardized viewpoint of the main functions or PUCs identified in a HLUC,
- a SGAM Communication layer providing a standardized viewpoint of the communication protocols used in a PUC,
- a SGAM Information layer providing a standardized viewpoint of the data models used in a PUC and,
- a SGAM Component layer providing a standardized viewpoint of the components of the system architecture. This layer was used as a layout for the other layers that are mapped on it.

4. HIGH LEVEL USE CASES PRESENTATION

4.1 PILOTS HLUC SELECTION AS INPUT OF THE SYSTEM USE CASE PRODUCTION PROCESS

During the T1.4 HLUC and PUC definition process for the pilots of the Interconnect project, all partners of the WP1 team have continued to work on the design of the pilot objectives, realisations and solutions. Therefore, some pilots have updated their HLUCs definitions from D1.2 document which are now described in the D1.3 document.
The table below compares the HLUCs of the pilots from the D1.2 and D1.3 document:

TABLE 2 – LIST OF PILOT HLUC'S FROM D1.2 AND D1.3 DOCUMENT

Pilot name	Sub-Pilot name	HLUC List D1.3 document		HLUC-List out of D1.2 document	
		UC Id	HLUC Name	UC ID	HLUC Name
Belgian	Cordium	HLUC1	Community cost optimization	BE-7	Community optimization of efficient heat generation
				BE-8	Peak shaving via direct control of heat pump
	Genk ThermoVault	HLUC 1	Peak shaving and self-consumption by optimizing household boilers at community and household level	BE-11	Smartifying my local energy community
	Green Energy Park Zellik	HLUC 1	Energy community based on P2P energy trading	BE-12	Energy flexibility service for spot prices electricity tariffs
	Imec	HLUC 1	Gamification of use of common appliances	BE-3	"Gamification" of the use of common appliances
	Nanogrid	HLUC 1	"Connectionless" maximization of flexibility in Energy Community	BE-2	Aggregation of energy in local energy community through local controller with focus on grid interaction
		HLUC 2	Voluntary (non-) participation in Energy Community	BE-1	Voluntary (non-) participation in energy community
		HLUC 3	Peer to peer exchange between (virtual) Energy Community		new
	Oud Heverlee	HLUC 1	Community Energy Management	BE-11	Smartifying my local energy community

<table>
<tr><th rowspan="2">Pilot name</th><th rowspan="2">Sub-Pilot name</th><th colspan="2">HLUC List D1.3 document</th><th colspan="2">HLUC-List out of D1.2 document</th></tr>
<tr><th>UC Id</th><th>HLUC Name</th><th>UC ID</th><th>HLUC Name</th></tr>
<tr><td rowspan="2">Belgian</td><td>Thor Park</td><td>HLUC 1</td><td>Community cost optimization of efficient heat generation</td><td>BE-7</td><td>Community optimization of efficient heat generation</td></tr>
<tr><td>Niewe Dokken</td><td>HLUC 1</td><td>Optimal combined asset management</td><td>BE-7</td><td>Community optimization of efficient heat generation</td></tr>
<tr><td>Dutch</td><td>-</td><td>HLUC 1</td><td>Optimize sustainability</td><td>NL-3.2</td><td>Information, control (optimize) sustainability</td></tr>
<tr><td rowspan="5">Italian</td><td rowspan="5">-</td><td rowspan="5">HLUC 1</td><td rowspan="5">Digital Platform for End-User Control and Awareness</td><td>IT-1</td><td>Provide consent to data transfer</td></tr>
<tr><td>IT-2</td><td>Enable flexibility program</td></tr>
<tr><td>IT-3</td><td>Exchange of aggregated flexibility data</td></tr>
<tr><td>IT-4</td><td>Time of use tariffs</td></tr>
<tr><td>IT-5</td><td>Awareness and notifications</td></tr>
<tr><td rowspan="9">Portuguese</td><td rowspan="9">-</td><td>HLUC 1</td><td>Monitoring Energy Consumption</td><td>PT-1</td><td>Monitoring energy consumption</td></tr>
<tr><td>HLUC 2</td><td>Subscription of Services for Domestic Energy Management</td><td>PT-2</td><td>Subscription of services for domestic energy management</td></tr>
<tr><td>HLUC 3</td><td>Data Sharing via Consumer Enabled Preferences and Profiling</td><td>PT-3</td><td>Data sharing via consumer enabled preferences and profiling</td></tr>
<tr><td>HLUC 5</td><td>DSO Data Sharing 4 New Energy Services</td><td>PT-5</td><td>DSO open data for consumer and market</td></tr>
<tr><td>HLUC 7</td><td>Flexibility Aggregation of Commercial Buildings</td><td>PT-7</td><td>Flexibility aggregation of commercial buildings</td></tr>
<tr><td>HLUC 8</td><td>Convenient Smart EV charging at Commercial Buildings</td><td>PT-8</td><td>Convenient smart EV charging at commercial buildings</td></tr>
<tr><td>HLUC 9</td><td>Enabling P2P flexibility sharing within renewable energy community via Blockchain enablers for SAREF services</td><td>PT-9</td><td>Enabling P2P flexibility sharing within renewable energy community via blockchain</td></tr>
<tr><td>HLUC 10</td><td>Flexibility Management for Distribution Grid Support</td><td>PT-10</td><td>Flexibility management for distribution grid support</td></tr>
<tr><td>HLUC 11</td><td>Enhancing Distribution Grid observability with end user data</td><td>PT-11</td><td>Enhancing distribution grid observability with end user data</td></tr>
</table>

Pilot name	Sub-Pilot name	HLUC List D1.3 document		HLUC-List out of D1.2 document	
		UC Id	HLUC Name	UC ID	HLUC Name
Greek	-	HLUC 1	Energy Monitoring & Management	GR-1	Energy monitoring and management
		HLUC 2	Home Comfort	GR-2	Home comfort
		HLUC 3	Flexibility Provision	GR-3	Flexibility provision
		HLUC 4	Data Analytics Services	GR-4	Data analytics
		HLUC 5	Security Services	GR-5	Security
		HLUC 6	Increase CO2 savings and become eco-friendly	GR-6	Increase CO2 savings and become eco-friendly
		HLUC 7	User Engagement	GR-7	User engagement
		HLUC 8	Unified User Interface Application	GR-8	Unified user interface application
		HLUC 9	Appliances Energy Efficiency	GR-9	Appliances' energy efficiency
French	-	HLUC 1	Max RES	FR-2	Maximize use of local RES
		HLUC 2	Dynamic tariff	FR-1	Dynamic tariff & usage management
German	-	HULC 1	Maximize utilization of renewable -wind- energy @grid connection point (general generation)	GE-1	Maximize utilization of renewable -wind- energy at grid connection point
		HULC 2	Maximize utilization of DER energy consumption in premises (local generation by myself)	GE-2	Maximize utilization of DER energy consumption in premises
		HULC 3	Grid stability via power limitation at grid connection	GE-3	Grid stability via power limitation at grid connection
		HULC 4	Maximize flexible energy consumption in premises	GE-4	Maximize flexible energy consumption in premises
		HULC 5	Provide dashboard to inform user about status and stimulate to use opportunities	GE-5	Provide dashboard to inform user about status and stimulate to use opportunities

From the table you can see which HLUCs from Belgium are assigned to the different sub-pilots and which planned HLUC was changed between the collection of pilot information for the D1.2 and D1.3 document. For example, in the Belgian sub-pilot Nanogrid , a new HLUCs was defined and other Belgium pilots have combined similar HLUCs into one HLUC.
But Thor Park reduce 6 HLUCs from D1.2 document to only one HLUC now.

In Belgium pilots the HLUCs from D1.2 document
BE-04: **Manage peak load to avoid increases in the electricity invoice (peak shaving)**,
BE-05: **Building level services: RES self-consumption à reduce electricity invoice**,
BE-06: **Building level services: EV smart charging pricing for flexibility use**,
BE-09: **Increase RES for self-consumption**,
BE-10: ***Community Car sharing*** ,
and in the Netherland pilot the HLUC
NL-1.1: ***Devices that can be controlled to free up time***
are now not needed anymore and were not described in detail with the IEC 62559-2 template.
Through the characterisation of the pilots and the adaptation of the goals towards the possibilities of the architecture the HLUCs and PUCs have been adapted. This leads to an overall goal to realize 37 HLUCs and 130 PUCs and is considered as the input to the other working packages to enable the specified features for the pilots. All future HLUC or PUC definitions will not be considered in the systems architecture.

As stated in D1.2 document the harmonization of similar use cases into one common use case was not followed up in order not to slow down innovation. This was mostly driven by the partners and agreed with the project lead.

5. SYSTEM USE CASE IEC 62559 FORMALIZATION PROCESS

5.1 PROCESS STEPS

The System Use Case IEC 62559 formalisation process took place between month 9 to month 18 of the Interconnect project. It is based on the High-Level Use Case to System Use Case Methodology presented in chapter 3.

The process got a kind of “industrial project management” with tasks divided into sub-tasks, milestones, deadlines, follow-ups and reviews.

The methodology was presented to the pilot leaders and their team at the beginning of the process. It got approvals and enthusiasms from the partners and the provided tasks/sub-tasks timeline was clear and welcome.

Support sessions were provided to the pilot partners all along the process to illustrate by multiple examples and trainings the methodology and its process to produce the requested information on time. The process steps of this organisation are provided in Figure 19Figure 19 to illustrate the duty the Interconnect partners went through to produce their IEC 62559 formalized System Use Cases.

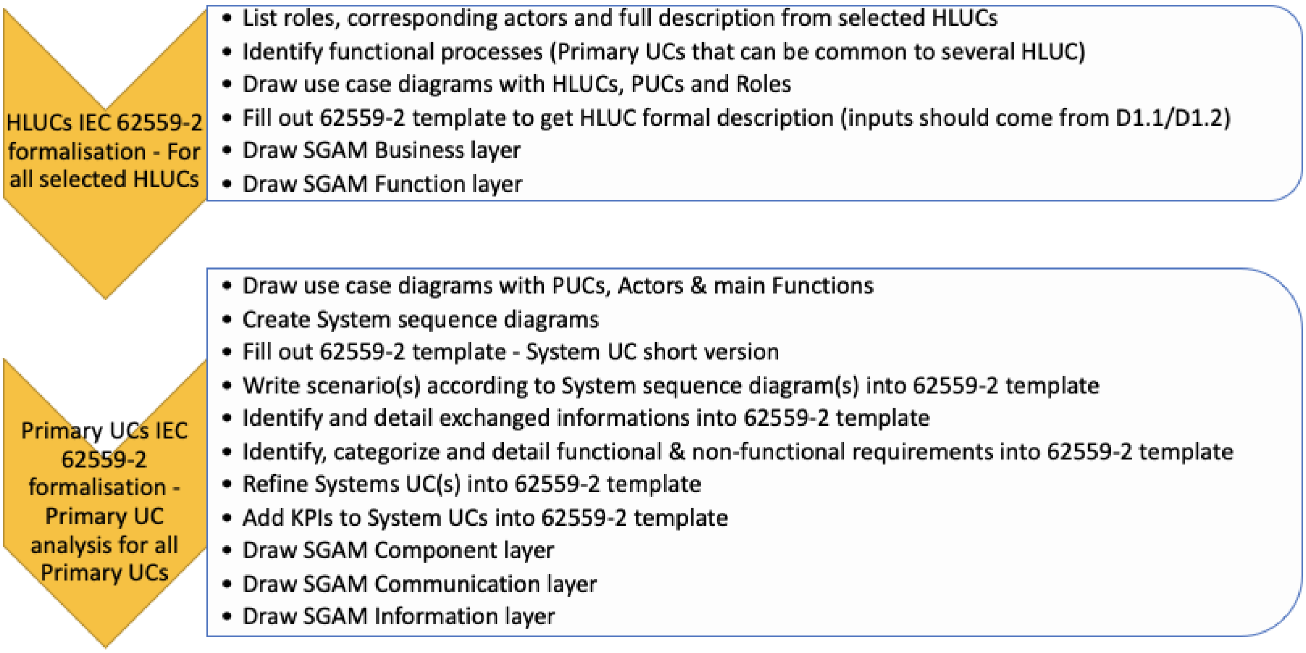

FIGURE 19 - SYSTEM USE CASE IEC 62559 FORMALIZATION PROCESS STEPS

5.2 SYSTEM USE CASE REVIEWS

Before the final System Use Case pilot’s delivery two consecutive reviews were leaded with more than a month between both.

The aim of the first review was to evaluate the level of production of each pilot versus the expected production level targeted by the methodology, the support session, the trainings and the T1.4 management team. This review was mainly a compliance review versus the IEC 62559, UML diagrams and the SGAM layers.

The aim of the second review was to measure the rework done by the pilots next to the first review to check the production corrections and improvements. Recommendations, additional targeted supports and close follow-ups were provided by the T1.4 management team between both reviews to reach 100% harmonized production for all pilots.

6. INTERCONNECT - ALL PILOTS SYSTEM USE CASE SPECIFICATIONS

Since the production of the System Use Case Specifications from all Interconnect Pilots represent a very large amount of information, each pilot is provided with a separate dedicated annex file.

The annexes are organized as shown in Table 3.

TABLE 3 - ANNEXES FOR PILOTS SYSTEM USE CASE SPECIFICATIONS

Pilot	System Use Case Specification document
Belgian	InterConnect - D1.3 - System use cases for smart buildings and grids - Annex 1 - Belgian Pilot - V1.0.3
Dutch	InterConnect - D1.3 - System use cases for smart buildings and grids - Annex 2 - Dutch Pilot - V1.0.3
Italian	InterConnect - D1.3 - System use cases for smart buildings and grids - Annex 3 - Italian Pilot - V1.0.3
Portuguese	InterConnect - D1.3 - System use cases for smart buildings and grids - Annex 4 - Portuguese Pilot - V1.0.4
Greek	InterConnect - D1.3 - System use cases for smart buildings and grids - Annex 5 - Greek Pilot - V1.0.5
French	InterConnect - D1.3 - System use cases for smart buildings and grids - Annex 6 - French Pilot - V1.0.4
German	InterConnect - D1.3 - System use cases for smart buildings and grids - Annex 7 - German Pilot - V1.0.4

7. IDENTIFIED COMMONALITIES AMONG HLUC & PUC FROM PILOTS

This chapter presents the results of the analysis we performed on HLUC System Specification documents collected. This was done in order to find commonalities between pilots. The analysis was done purely on quantitative terms. We based our analysis on the intentions explicitly declared in the use-cases documents by each pilot, without going into the details of their solutions.

7.1 APPROACH AND METHODOLOGY

7.1.1 CHOICE OF HLUC COMMONALITIES OVER PUC COMMONALITIES

During the assessment process of commonalities, it appeared that commonalities are mostly relevant for HLUCs. Indeed, the HLUCs focus on generic areas, objectives and roles, without going into the details of a specific system, as it is done in the PUCs. Therefore, analysing the HLUCs makes more sense in order to assess the objectives, roles or function that are common throughout the pilots, and between various systems. Moreover, the roles in particular have been normalised in the HLUCs, enabling to clearly show the commonalities of roles, while the PUCs actors use denominations that are specific to a particular component or company.

Additionally, HLUCs are described at the scale of the whole system of the pilot, while PUCs generally represent a subsystem, or a specific function, making it more difficult to show the common features of the overall system.

Therefore, only HLUCs will be analysed in the following chapter. Out of all 37 HLUCs defined by pilots, 36 were included in this study (the Niewe Dokken pilot was not considered because its HLUC was provided after the calculation of statistics).

7.1.2 DEFINITION OF NORMALIZED ROLES

In order to find commonalities between pilots, normalized roles representing every unique role from every pilot are needed. Those roles are defined in the 62559 documents provided by the pilots (chapter *3.1. Actors*).

As mentioned earlier, references regarding roles were provided to the pilots:

- Harmonized Electricity Market Role Model
    - https://eepublicdownloads.azureedge.net/clean-documents/EDI/Library/HRM/Harmonised_Role_Model_2020-01.pdf
- Roles from USEF
    - https://www.usef.energy/app/uploads/2016/12/USEF_TheFrameworkExplained-18nov15.pdf

As a result, most pilots were already aligned in their definition of each roles used in the use-case. And so, the normalization process consisted of regrouping the few roles not aligned with the references into pre-existing roles. The following list was defined:

- DPO
- Aggregator
- EMS
- User
- Energy service provider
- Energy trader market
- Information aggregator
- Electricity supplier
- Forecaster
- Devices
- System operator
- Monitoring system
- Smart meter
- Interoperability layer
- Graphical user interface
- DER
- IoT network (home)
- Metering Data Management System
- External Service Provider
- External Information Provider
- APP – GUI
- Building owner/operator

7.1.3 DEFINITION OF NORMALIZED OBJECTIVES

In order to find commonalities between pilots, normalized objectives representing every unique objective from every pilot are needed. Those objectives are described in the 62559 documents provided by the pilots (chapter *1.3 Scope and objective of use case*).

The normalization process consisted of regrouping similar and popular objectives into uniformed objectives. The following list was defined:

- Peak Shaving
- Minimize Invoice
- Maximize RES consumption
- Provide Flexibility
- Optimization of consumption
- Flexible Tariffs
- Consumer Involvement (Gamification, Recommendations, User Interface, Visualization, empowerment, …)

- Energy Community
- Monitoring (of consumption, devices, …)
- Manual mode (user control through GUI)
- Automated mode for appliance (Rules-based device management)
- Consumption Prediction

7.1.4 DEFINITION OF NORMALIZED FUNCTIONS

In order to find commonalities between pilots, normalized functions representing every unique function from every pilot are needed. Those functions were extracted from the scenarios described in the 62559 documents provided by the pilots (chapter *4. Step by step analysis of use case*).

Functions, which can be defined as solutions implemented in order to achieve the scenario's objective, were extracted and then regrouped into uniformed function covering every pilot's needs. The following list was defined:

- EV charging
- User preferences
- Enrolment
- Forecast (production, consumption)
- Optimization (consumption, flexibility, Building level, district level)
- Monitoring
- EMS operation
- Flexible Tariffs
- Manual mode (appliances)
- Automated mode (appliances)
- Data Storage in Cloud
- User interface (gamification)
- Alerting (security, notifications)
- Overload protection

Note that some functions can be similar to some objectives. This is because objectives can be functions aiming to achieve other objectives. For example, establishing a system that provide reliable consumption forecast is an objective in itself, but it can also be a mean to achieve peak shaving.

7.2 COMMONALITIES ANALYSIS RESULTS

7.2.1 GLOBAL STUDY

This section concerns statistics that were calculated using data from all considered pilot without selection.

7.2.1.1 POPULARITY OF EACH NORMALIZED OBJECTIVES

The popularity of each normalized objectives was calculated in order to identify the issues most often considered by pilots. The calculation was done by simply counting the number of occurrences of each objective among all 36 HLUC.

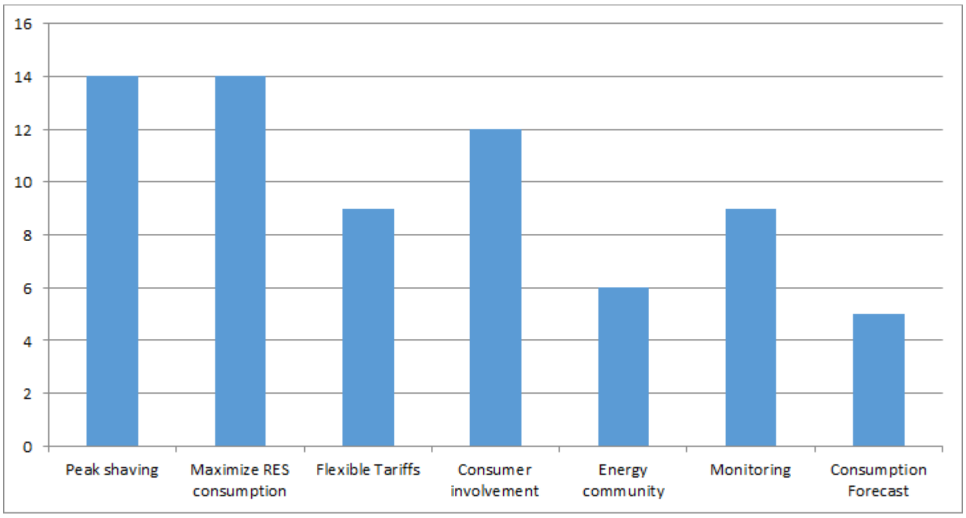

FIGURE 20 - POPULARITY OF EACH NORMALIZED OBJECTIVE (BY HLUC)

The diagram above shows that among all pilots, Peak Shaving, Maximization of RES consumption and Consumer Involvement are primary concerns that all appears in more than 12 HLUCs. Flexible Tariffs and Monitoring of the Smart Home are secondary objectives that each appear in 9 HLUCs. Other objectives are more specific.

However, these first statistics are biased by the fact that the different pilots have very different numbers of HLUCs, which results in the over-representation of the objectives of a few pilots. In order to mitigate this issue, the following graph have been drawn, in which the objective of each pilot is counted once. It shows the same tendencies as in the previous one, though more equally distributed.

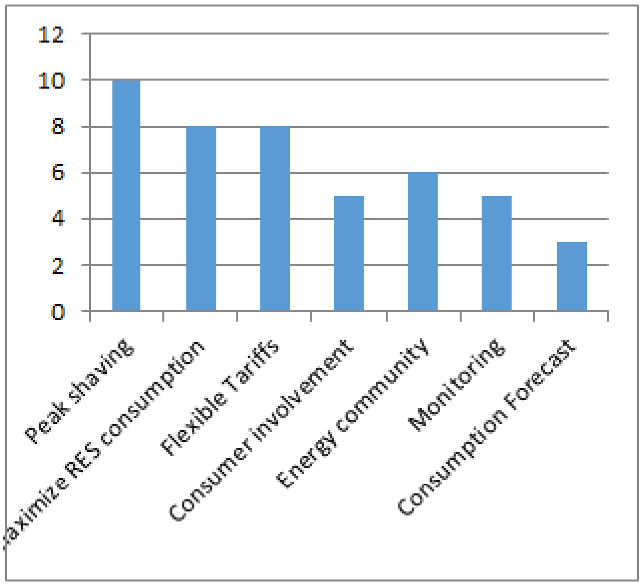

FIGURE 21 - POPULARITY OF EACH NORMALIZED OBJECTIVE (BY PILOT)

Here we can see this new distribution, apart from the Energy Community objective, the number of occurrences of all objectives dropped. This is because some pilots have different HLUCs with objectives that fall into the same category. For example, the Portuguese pilot has 2 HLUCs aiming for Peak shaving, one specific for commercial building and one for grid support.

The most popular objectives among pilots are Peak Shaving, Maximization of RES Consumption and Flexible Tariffs, which seems more important here with 8 out of 13 pilots focusing on it. On the other hand, consumer involvement seems less important here with only 5 pilots making it an objective. Other than that, the general trend stays the same, but differences have been flatten.

7.2.2 MAIN BENEFICIARIES

The study of the main beneficiaries is an important matter, as it shows what is driving the actions. However, it is a delicate line to be drawn, since all actors are in some way beneficiaries from the UCs they are involved in. Here, the main beneficiaries have been considered to be the actors to whom the main objectives of the UC are addressed.

The main beneficiaries have been established by comparing the objectives and the actors involved, in order to answer the question: “Whom, among the present actors, is this objective addressed to?”.

Based on this selection, the statistics have been calculated by counting in how many HLUCs a specific actor is beneficiary. This enables to highlight the drivers of the Interconnect business model.

The diagram below shows the repartition of the main beneficiaries across the 36 HLUCs of the Interconnect project.

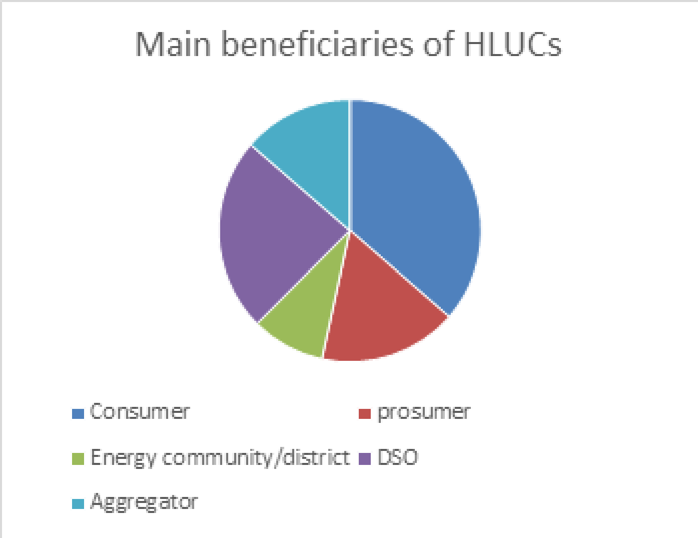

FIGURE 22 - MAIN BENEFICIARIES OF INTERCONNECT HLUCS

The diagram above shows that the first beneficiary of the Interconnect activities is indeed the consumer, with 32 out of the 36 HLUCs benefiting them. Indeed, it is a role that is present in all HLUCs and can benefit from the activities in several ways: through secure energy supply, reduction of invoices, customer empowerment or additional services (house security for instance). Additionally, the prosumers and energy communities are also very present as beneficiaries across the HLUCs (respectively 15 and 8 HLUCs). The prosumers benefit from maximisation of RES, while the energy communities mostly benefit from peer-to-peer, district heating optimisation and reduction of Hydrocarbon-base energy schemes.

On the other hand, industrial actors also highly benefit from the activities of Interconnect. The DSO is the second beneficiary, with 21 out of 36 HLUCs addressed to it. They benefit from various activities, from load management such as peak shaving, flexible tariffs or power limitation to power quality and monitoring. Moreover, the Aggregator is also a major beneficiary, with 12 HLUC having flexibility provision, optimisation or demand response as objectives.

However, these first statistics are indeed biased by the fact that the different pilots have very different numbers of HLUCs, which results in the over-representation of the vision of little number of pilots. In order to mitigate this issue, the following graph have been drawn, in which the beneficiaries of each pilot is counted once. It shows the same tendencies as in the previous one, though more equally distributed.

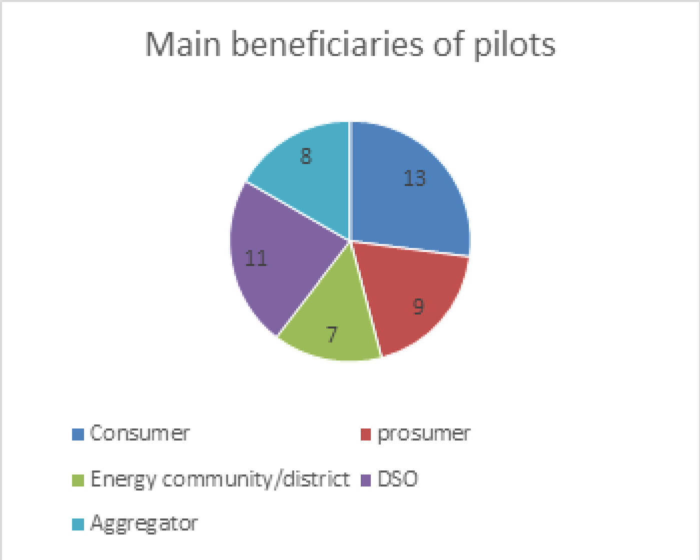

FIGURE 23 - Main beneficiaries of Interconnect pilots

Obviously, both representations show a very simplified vision of the very complex mechanisms leading to the various benefits of the Interconnect schemes, however it aims to help highlight the most preeminent roles in this ecosystem.

7.2.3 PER OBJECTIVE STUDY

This section concerns statistics that were calculated by isolating HLUC according to the objective they were aiming for. For example, every use-case aiming to maximize RES consumption was isolated in order to calculate specific statistics for this objective.

For each objective, we calculated the percentage of appearance of each normalized role in order to identify which roles were the biggest contributor to this objective. We also calculated the percentage of appearance of each normalized function in order to identify which solutions were most often developed in order to achieve this objective.

7.2.3.1 OBJECTIVE: PEAK SHAVING

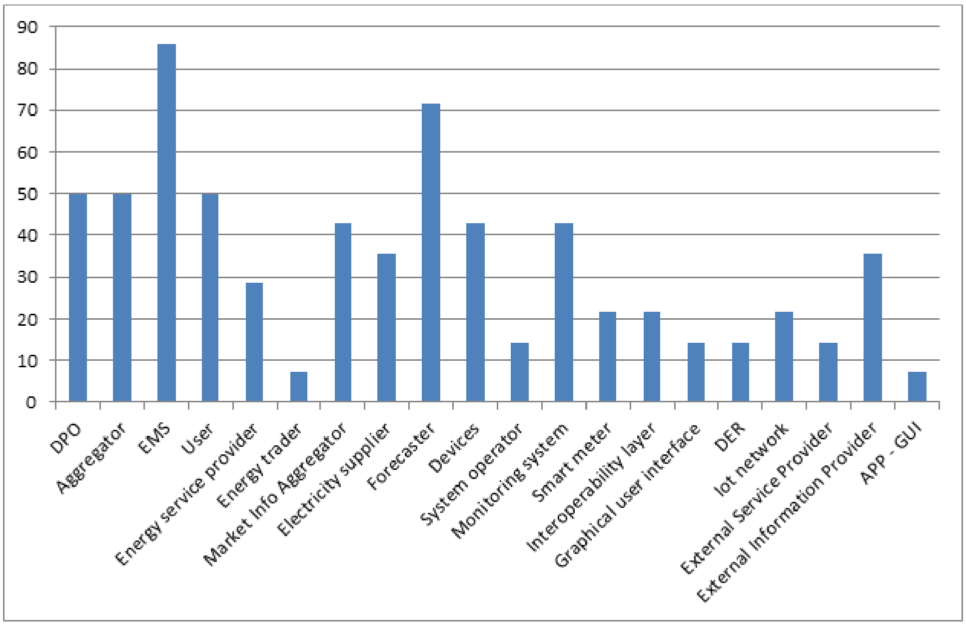

FIGURE 24 - ROLE PERCENTAGE OF APPEARANCE (PEAK SHAVING)

In the diagram above, the user and its Devices are the two roles that most often appear in HLUCs aiming to achieve Peak Shaving. This is explained by the necessity of participation from these two roles to Peak Shaving programs. Next in line are the EMS which coordinates devices for Peak shaving, the Aggregator and the Energy Service Providers, which are the roles benefitting from the Peak Shaving.

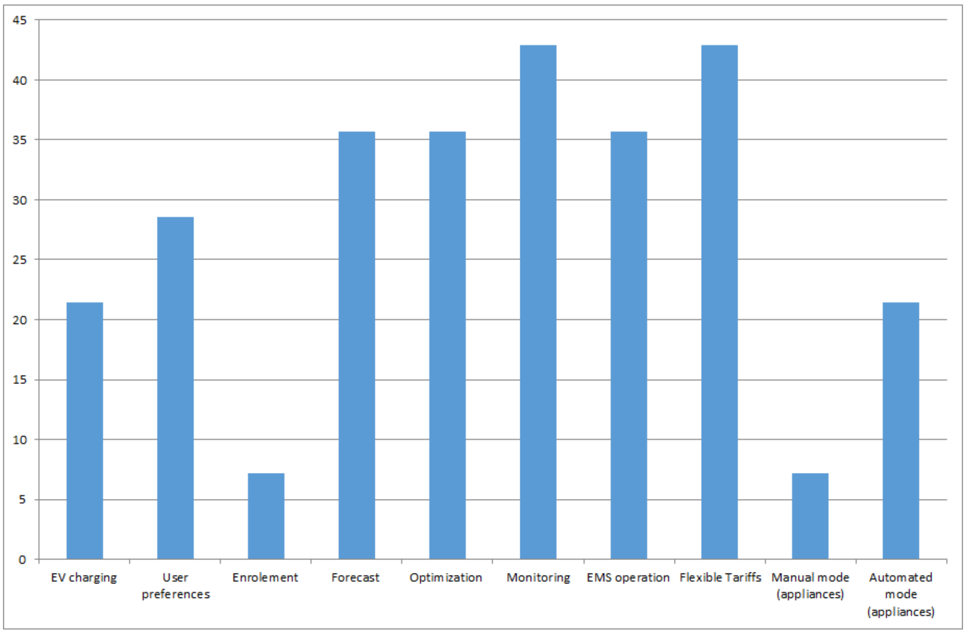

FIGURE 25 - FUNCTION PERCENTAGE OF APPEARANCE (PEAK SHAVING)

As expected, Flexible tariffs is the primary solution for Peak Shaving in the diagram above. Monitoring, Forecast, Consumption Optimization and EMS Operation are also important aspects of the system. Lastly, User Preferences are taken into account in 30% of cases.

7.2.3.2 OBJECTIVE: MAXIMIZE RES CONSUMPTION

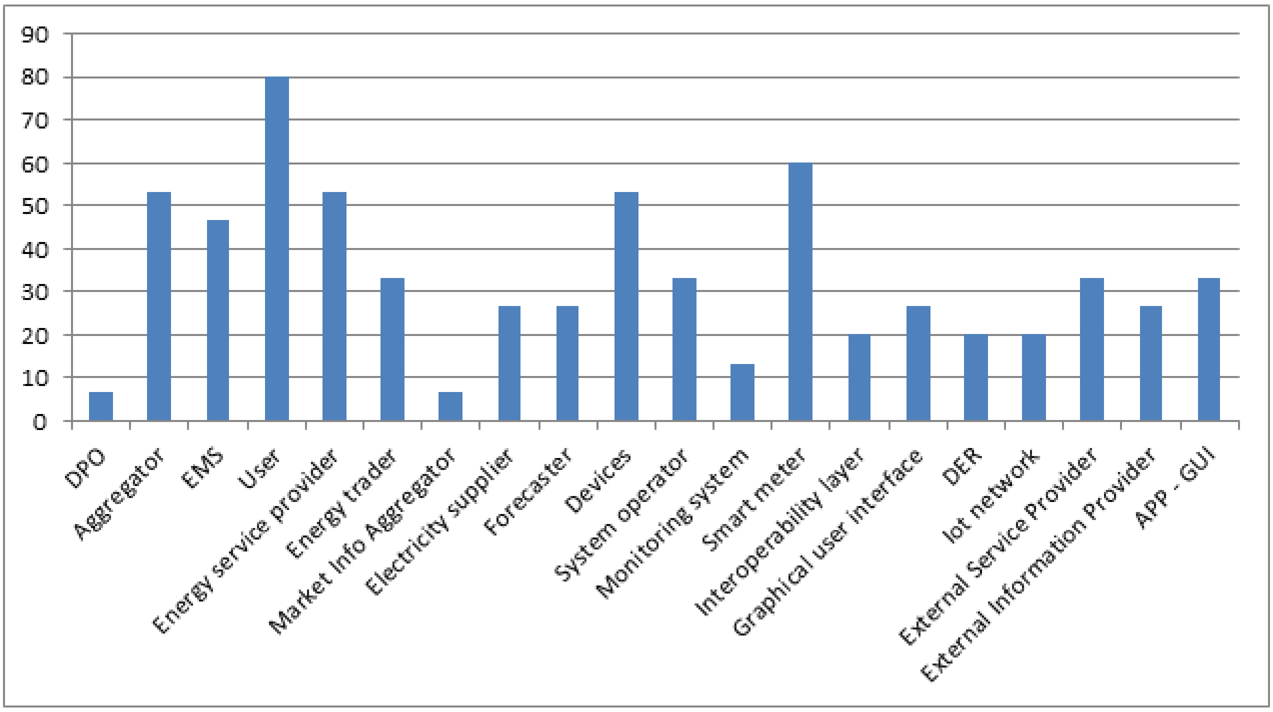

FIGURE 26 - ROLE PERCENTAGE OF APPEARANCE (MAXIMIZE RES CONSUMPTION)

The repartition of roles is similar to the Peak Shaving objective in the diagram above. The User is however the most solicited role.

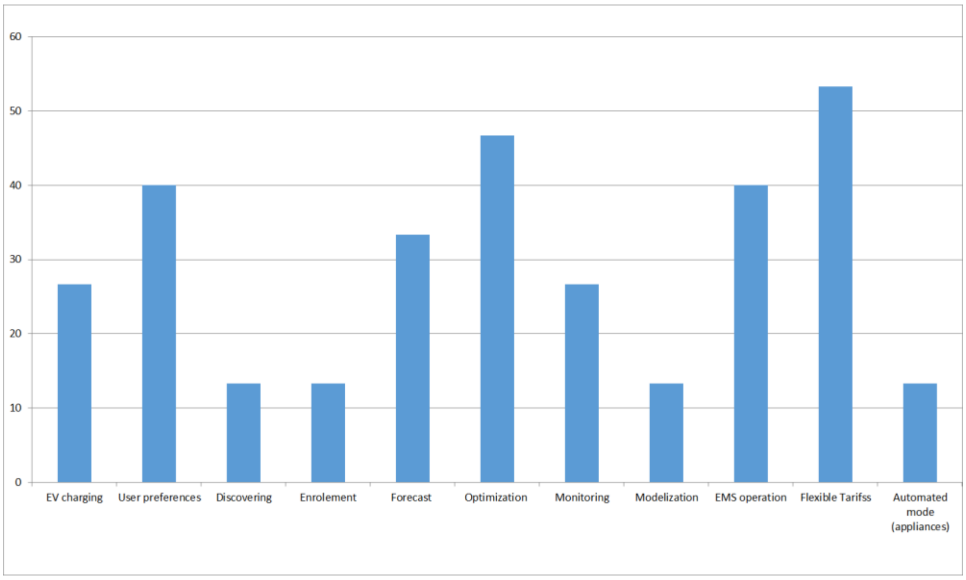

FIGURE 27 - FUNCTION PERCENTAGE OF APPEARANCE (MAXIMIZE RES CONSUMPTION)

Flexible Tariffs and Optimization are the two most considered functions for this objective in the diagram above. User Preferences also play a large part in 40% of HLUCs. Despite the fact that most roles are common with the Peak Shaving objective, the distributions of function largely differ.

7.2.3.3 OBJECTIVE: PROVIDE FLEXIBILITY

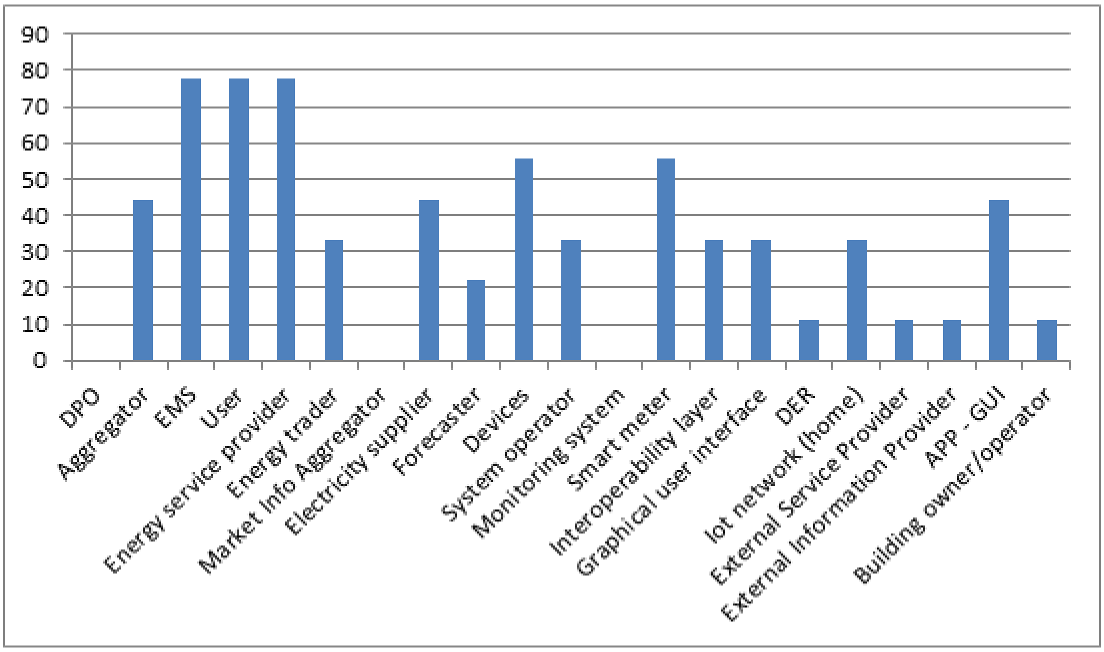

FIGURE 28 - ROLE PERCENTAGE OF APPEARANCE (PROVIDE FLEXIBILITY)

The distribution of roles in the diagram above is similar to the Peak Shaving and Maximize RES Consumption objectives with the EMS, the User, the Energy Provider and the Devices being the primary roles concerned.

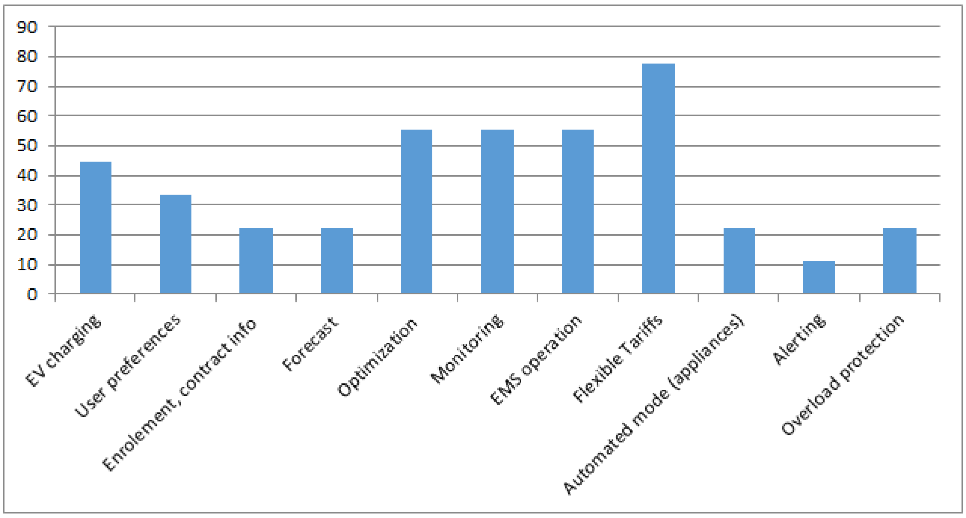

FIGURE 29 - FUNCTION PERCENTAGE OF APPEARANCE (PROVIDE FLEXIBILITY)

The diagram above shows that Flexibility Provision is mainly achieved through Flexible Tariffs, Optimization of consumption and production while the Monitoring of the system and the EMS operations coordinate operations and prevent problems. Despite the fact that most roles are common with the Peak Shaving and Maximize RES Consumption objectives, the distributions of function differ.

7.2.3.4 OBJECTIVE: FLEXIBLE TARIFFS

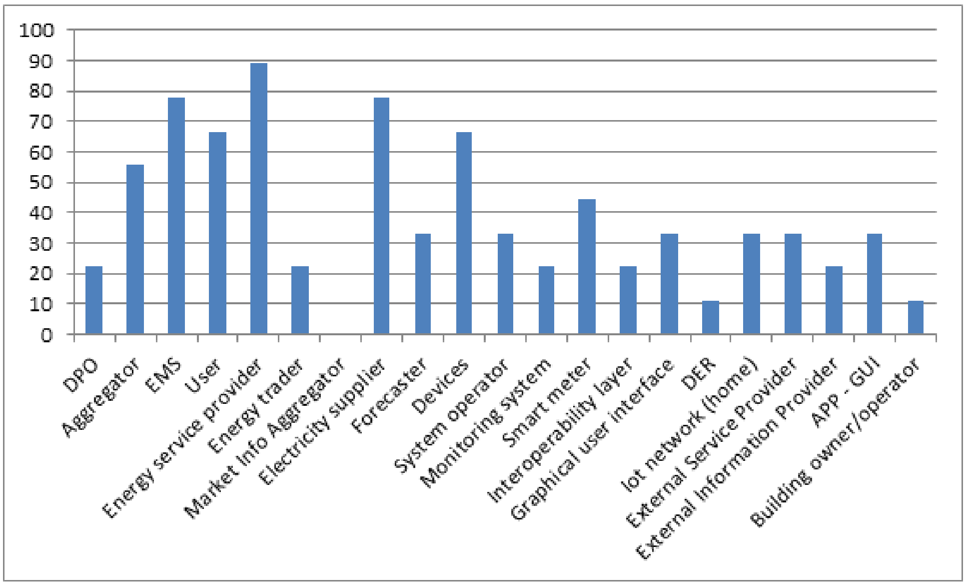

FIGURE 30 - ROLE PERCENTAGE OF APPEARANCE (FLEXIBLE TARIFFS)

The diagram above shows that the roles most important to a Flexible Tariffs system are the Energy Service Provider, the User, its EMS and devices and the Electricity Supplier.

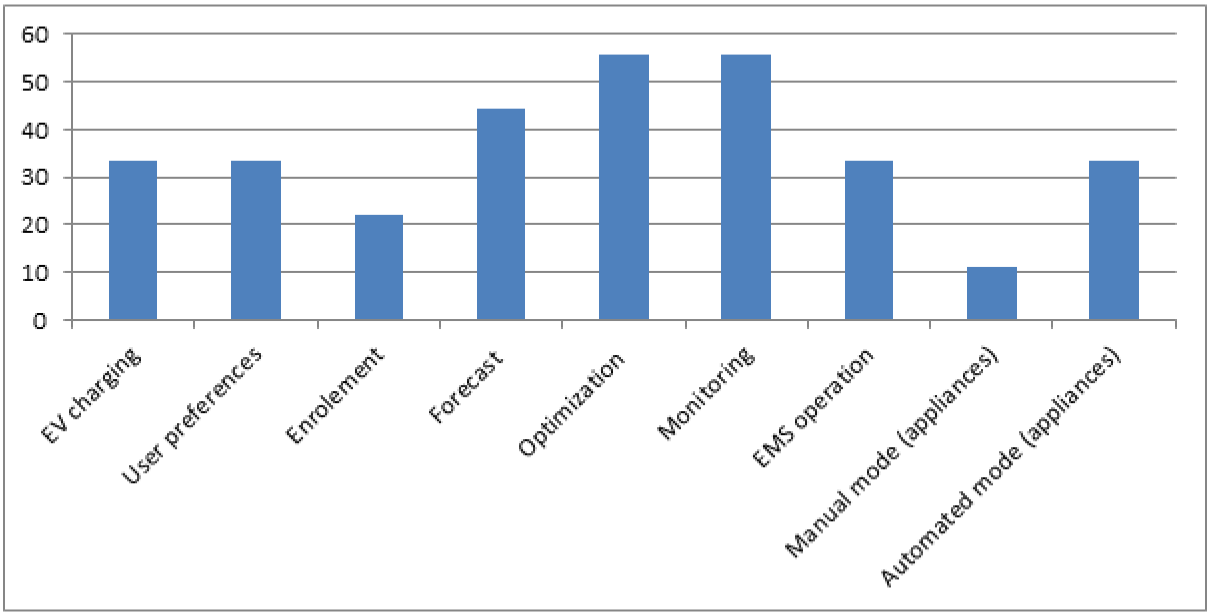

FIGURE 31 - FUNCTION PERCENTAGE OF APPEARANCE (FLEXIBLE TARIFFS)

Here the function Flexible Tariffs has been excluded from the study. As explained in chapter 8.1.4, some objectives are similar to functions. This is the case here and considering Flexible Tariffs as an enabler for Flexible Tariffs is redundant. The graph above shows that a Flexible Tariffs system is mainly made possible by the forecast and the monitoring of the grid and devices functions. HLUC aiming for Flexible Tariffs also define how that tariff is used, hence the large proportion of Optimization appearance.

7.2.3.5 OBJECTIVE: CONSUMER INVOLVEMENT

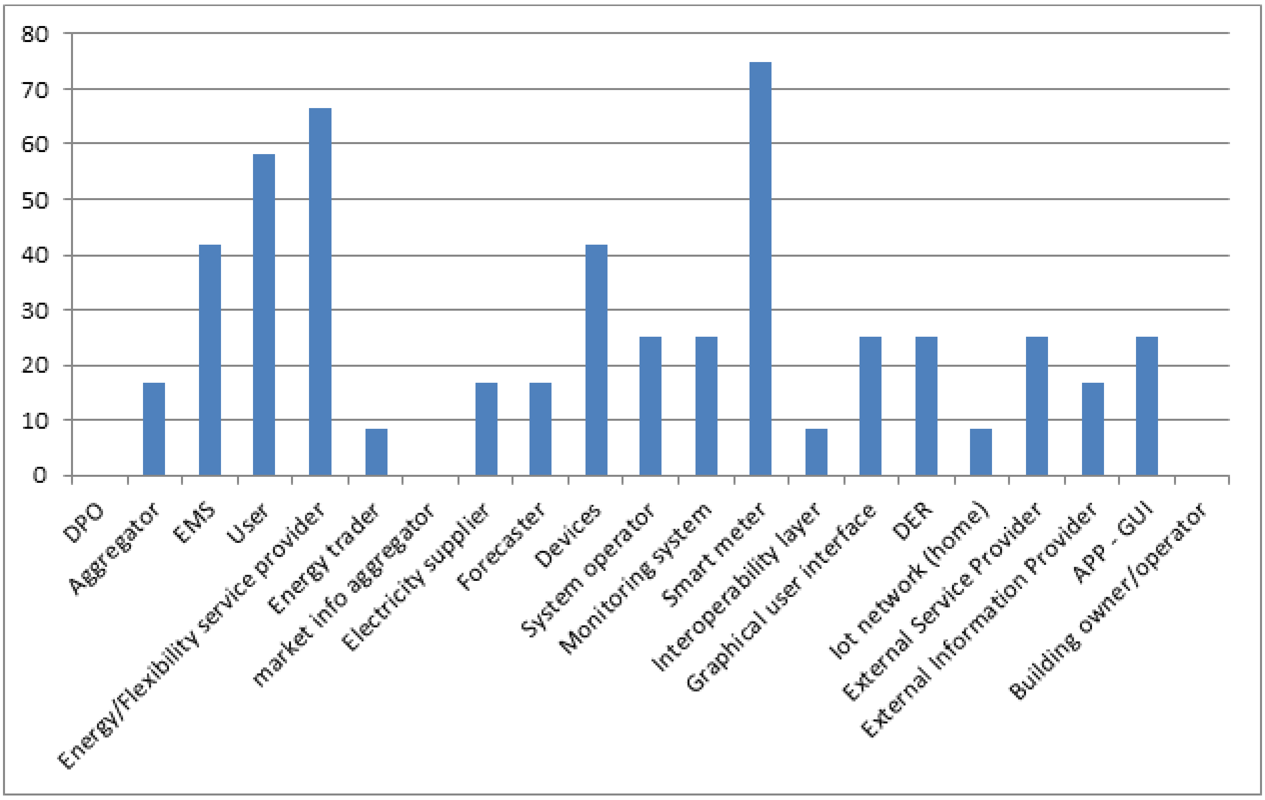

FIGURE 32 - ROLE PERCENTAGE OF APPEARANCE (CONSUMER INVOLVEMENT)

The consumer involvement programs mainly rely on the Smart Meter, the Energy Service Provider and the User himself in the diagram above. The EMS and the devices are also taken into account in 40% of all HLUC.

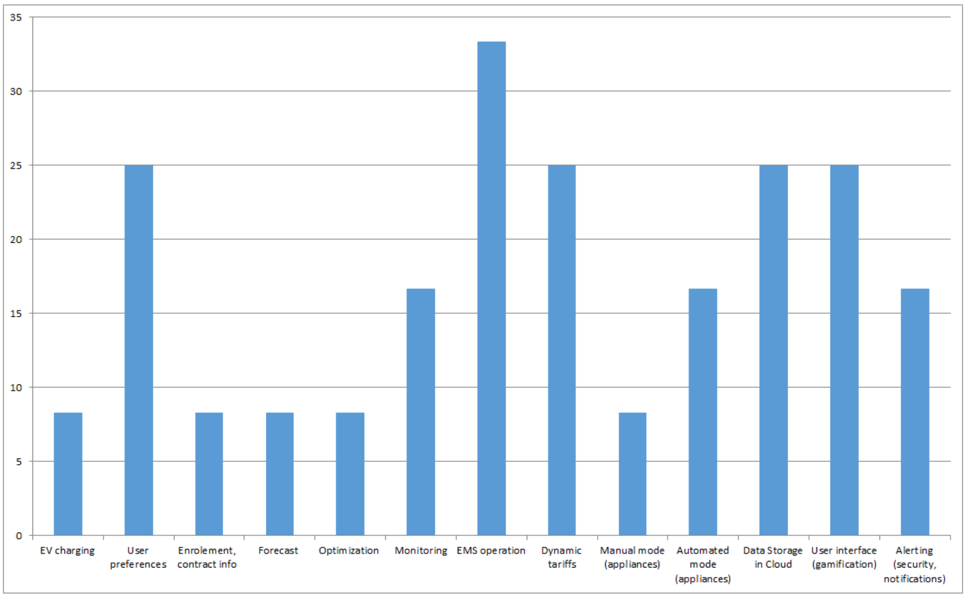

FIGURE 33 - FUNCTION PERCENTAGE OF APPEARANCE (CONSUMER INVOLVEMENT)

The customer is involved with its EMS operations which take into account its User Preferences, especially for the use of the Flexible Tariffs in the diagram above. The involvement of the customer is encouraged by the User Interface.

7.2.3.6 OBJECTIVE: MONITORING

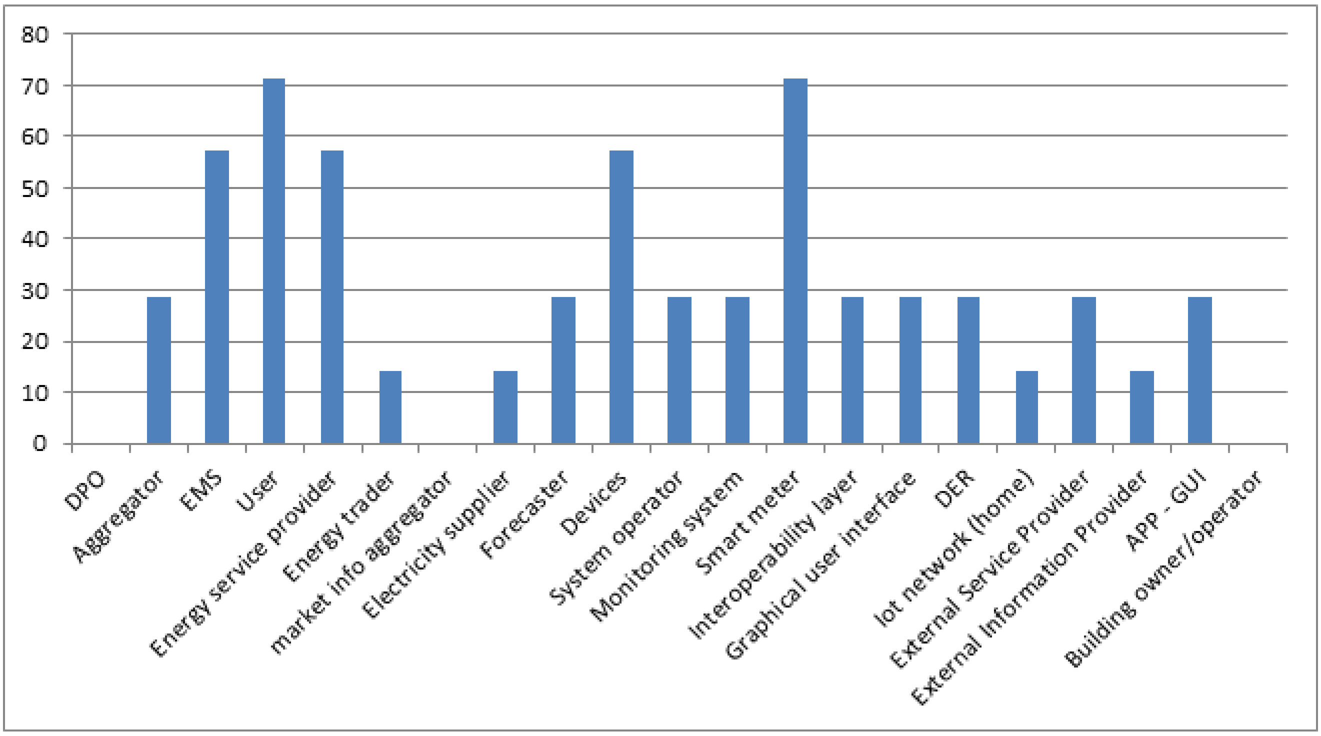

FIGURE 34 - ROLE PERCENTAGE OF APPEARANCE (MONITORING)

The graph above shows that the monitoring of the home relies mostly on the Smart meter, the User, the EMS, the Energy Service Provider and the Devices, as they are the most present roles.

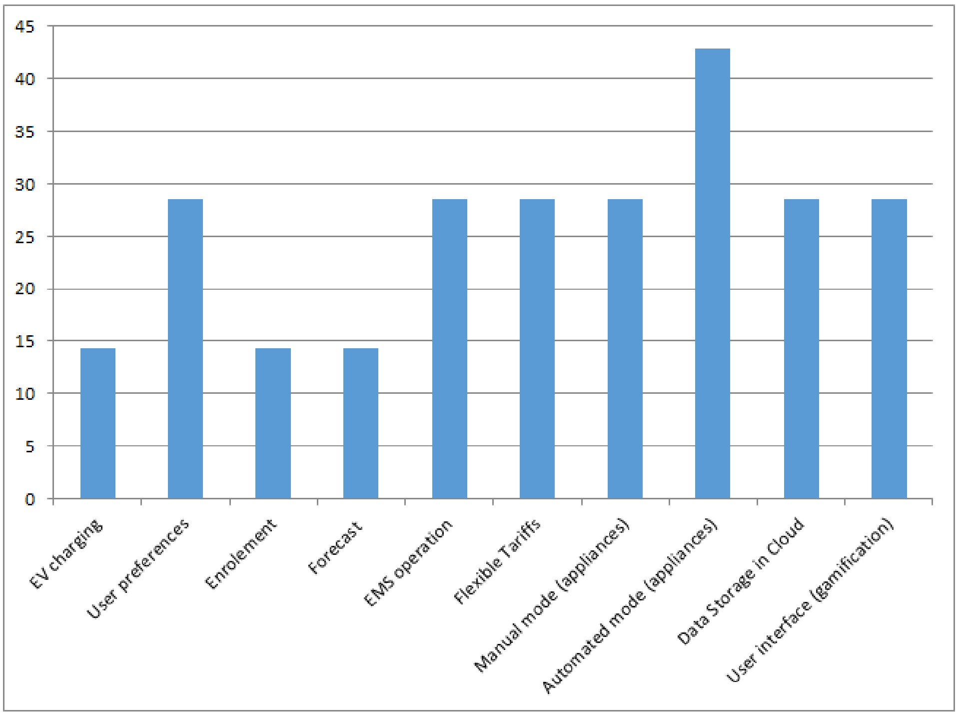

FIGURE 35 - FUNCTION PERCENTAGE OF APPEARANCE (MONITORING)

Here, the Monitoring function has been excluded from the study (for similarity purposes, as explained in chapter 8.2.2.4).

The function that is most often used is Automated Mode for appliances in the diagram above. This function enables to automatically operate a device, for instance by an EMS or by a rules-based system. This makes sense since the appliances are controlled according to the preferences of the customer and the state of the grid.

7.2.3.7 OBJECTIVE: CONSUMPTION FORECAST

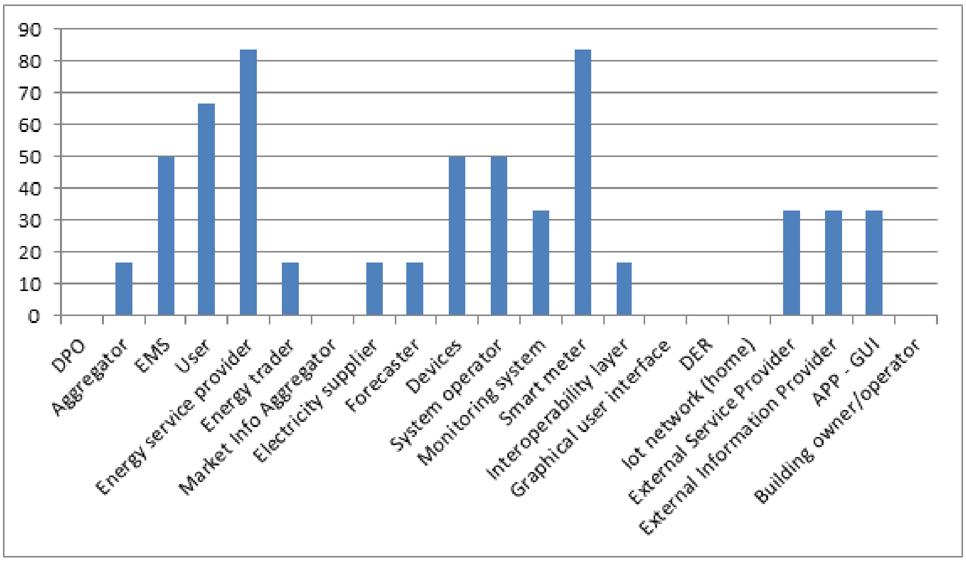

FIGURE 36 - ROLE PERCENTAGE OF APPEARANCE (CONSUMPTION FORECAST)

The Forecast is either done by the Energy service provider, an external Forecaster or the EMS in the diagram above. The data for the forecast comes from the User through its Smart Meter, depending on the pilot system.

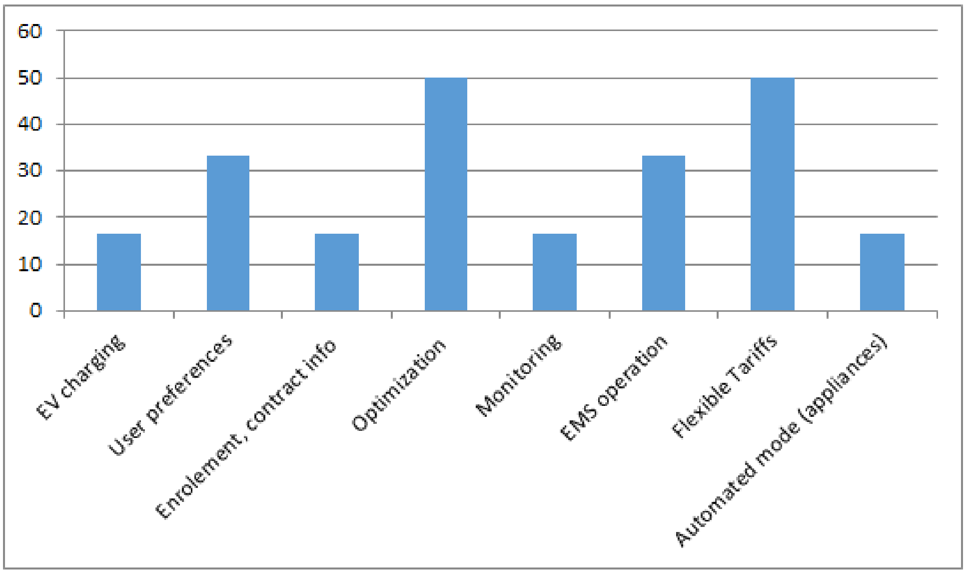

FIGURE 37 - FUNCTION PERCENTAGE OF APPEARANCE (CONSUMPTION FORECAST)

Here, the Forecast function has been excluded from the study (for similarity purposes, as explained in chapter 8.2.2.4).

The diagram above shows that the Forecast is in most cases used for the generation of Flexible Tariffs and the Optimization of consumption.

7.2.3.8 OBJECTIVE: ENERGY COMMUNITY

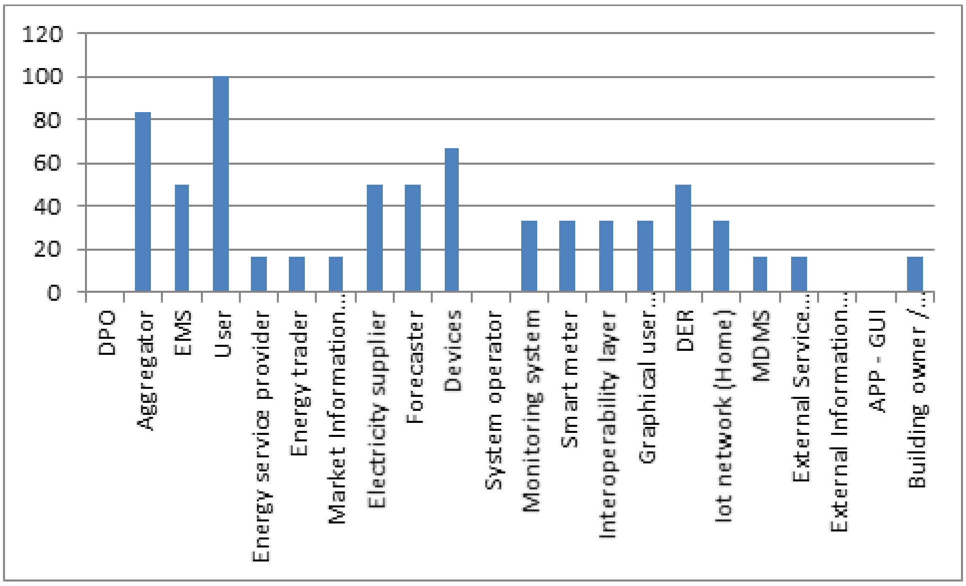

FIGURE 38 - ROLE PERCENTAGE OF APPEARANCE (ENERGY COMMUNITY)

The Energy Communities largely involve the Users, and the Aggregator in the diagram above. Other main contributors are the DER, the Devices, EMSs, Electricity Suppliers and Forecasters.

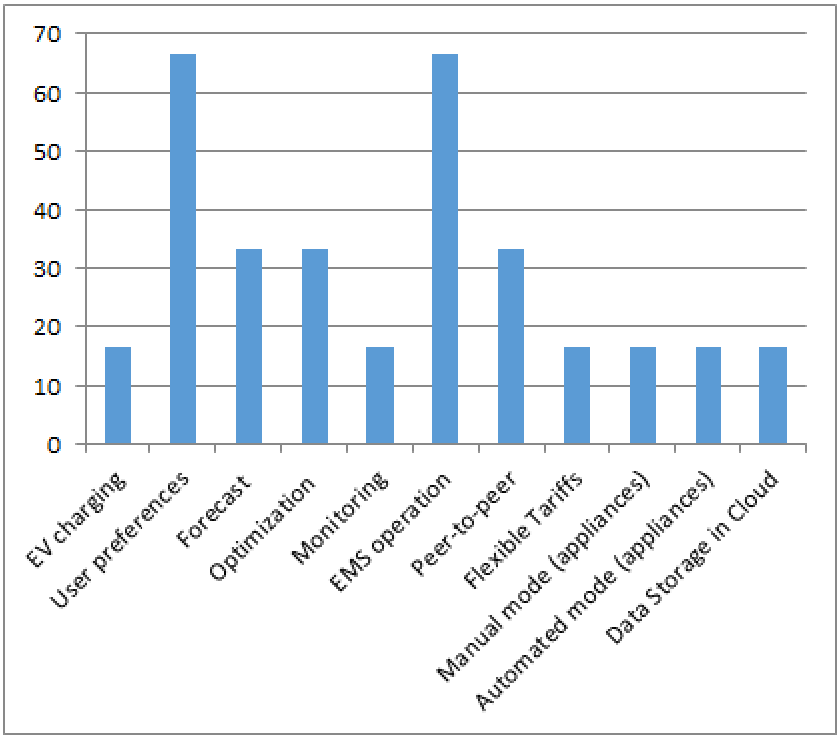

FIGURE 39 - FUNCTION PERCENTAGE OF APPEARANCE (CONSUMPTION FORECAST)

The diagram above shows that the Energy Communities have a large use of user preferences and EMS operation functions. Peer-to-peer is also present in larger proportion than usual, along with Forecasting and Optimization.

7.3 CONCLUSION ON COMMONALITIES

The study of commonalities enabled to highlight the most predominant roles, beneficiaries, objectives and functions, that were found in different pilots across the project. In order to do so, the previously described HLUCs of each pilot were analysed and these elements were extracted, in an effort to harmonize the denominations. However, even though the names of functions were harmonized, the implementation of the different functions can't be harmonized, because it heavily depends on the components used and the partners involved, who each have their own implementation approaches. Through this process, a few interesting points were highlighted:

- The consumer is at the centre of the attention. It is a role that is present in almost all UCs, and several objectives are dedicated to him. The grid actors, such as DOS, aggregator or energy services providers are also very present through the project.
- The main objectives, throughout the project, were peak shaving, and maximizing the use of renewable energy sources. These are grid-centric issues and show that the optimized operation of the grid is a central issue. Moreover, the predominance of peak-shaving over other issues such as consumption goes to show that the consumption of peak periods is one the biggest challenges faced today by the electricity grid.
- A few functions were found to be important for all objectives, such as monitoring, EMS operation, user preferences, optimization or forecast. It shows that they are core building blocks of the Interconnect systems of any pilot, which are important for any smart grid system at consumer premises.

Here is a list of the main role and function for each normalized objective. It shows the driver and core functionality for each of these building blocks.

TABLE 4 – LIST OF OBJECTIVES FOR ROLES AND FUNCTIONS

OBJECTIVE	Most present role	Most present function
PEAK SHAVING	EMS	Monitoring / Flexible Tariffs
MAXIMIZE RES CONSUMPTION	User	Flexible Tariffs
PROVIDE FLEXIBILITY	EMS / User / Energy Service Provider	Flexible Tariffs
TIME OF USE TARIFFS	Energy Service Provider	Optimization / Monitoring
CONSUMER INVOLVEMENT	Smart Meter	EMS Operations
MONITORING	User / Smart Meter	Automated mode for appliances

CONSUMPTION FORECAST	Energy Service Provider / Smart Meter	Optimization / Flexible Tariffs
ENERGY COMMUNITY	User	User Preferences / EMS Operation

REFERENCES

External documents

[1] CEN-CENELEC-ETSI Smart Grid Coordination Group – Sustainable Processes, November 2012

[2] IEC TS 62913-1 ED1 Generic Smart Grid Requirements – Part 1: Specific application of the Use Case methodology for defining Generic Smart Grid Requirements according to the IEC System approach, April 2018

[3] European Smart Grids Task Force Expert Group 1 – Standards and Interoperability – Towards Interoperability within the EU for Electricity and Gas Data Access & Exchange, March 2019

[4] IEC 62559-2 Use case methodology – Part 2: Definition of the templates for use cases, actor list and requirements list, April 2015

[5] SG-CG/M490/E - Part E: Smart Grid Use Case Management Process, https://ec.europa.eu/energy/sites/ener/files/documents/xpert_group1_sustainable_processes.pdf

Interconnect documents

[1] InterConnect Grant Agreement number 857237

[2] D1.2 Mapping between use cases and large-scale pilots – V1.1

[3] InterConnect - D1.3 - System use cases for smart buildings and grids - Annex 1 - Belgian Pilot - V1.0.3

[4] InterConnect - D1.3 - System use cases for smart buildings and grids - Annex 2 - Dutch Pilot - V1.0.3

[5] InterConnect - D1.3 - System use cases for smart buildings and grids - Annex 3 - Italian Pilot - V1.0.3

[6] InterConnect - D1.3 - System use cases for smart buildings and grids - Annex 4 - Portuguese Pilot - V1.0.4

[7] InterConnect - D1.3 - System use cases for smart buildings and grids - Annex 5 - Greek Pilot - V1.0.5

[8] InterConnect - D1.3 - System use cases for smart buildings and grids - Annex 6 - French Pilot - V1.0.4

[9] InterConnect - D1.3 - System use cases for smart buildings and grids - Annex 7 - German Pilot - V1.0.4