Definition of use cases and KPIs

D3.1

Authors:

Kris Kessels (VITO)

Jacob Mason (VITO)

Bram Van Dun (CAMPINA Energy)

Geert Smits (Fluxys)

Annick Hespel (IDETA)

Joffrey Hardy (IDETA)

Rudy Marien (KBC)

Steven Laurijssen (Klimaan)

Dieter Jong (re.alto)

Anton Gerits (REScoop Vlaanderen)

Tom Willems (SeaCoop)

Tom Engels (Virya Energy)

Responsible Partner	VITO
Checked by WP leader	Joffrey Hardy, Annick Hespel, 1/10/2024
Approved by Project Coordinator	Kris Kessels, 16/10/2024
Dissemination level	Public

This project has received funding from Energy Transition Fund 2023 FPS Economy, SMEs, Self-employed and Energy.

Issue Record

Planned delivery date	30/09/2024 (M12)
Actual date of delivery	16/10/2024
Status and version	Final version

Version	Date	Author(s)	Notes
0.1	01/09/2024	Jacob Mason (VITO) Kris Kessels (VITO)	Initial draft creation
0.2	25/09/2024	All Test Case owners	BUC population, deliverable review
1.0	01/10/2024	Kris Kessels (VITO) Jacob Mason (VITO)	Final review
1.1	16/10/2024	Kris Kessels (VITO) Jacob Mason (VITO) Dieter Jong (Re.alto)	Last updates BUC 10 and BUC 11

About ReInvent

In 2030 and beyond, multiple energy vectors (electricity, gas, heat, green molecules) will play a role in an interconnected energy system. Increased electrification will support sector integration between end user segments. To benefit maximally from the advantages of sector coupling, a fundamental rethinking of market design, business models and financing models is needed. ReInvent will define a roadmap for sector coupling in Belgium. The ReInvent approach is based on **4 pillars** and is a combination of 1) conceptual analysis, 2) sound modelling, 3) proofing of concepts by relevant test cases, and 4) an ambitious impact assessment and replication strategy.

The **first pillar** will analyse the role of different energy vectors (gas, power, heat, green molecules…) in the Belgian energy mix. This includes the impact on infrastructure, market design and business models for different energy end user groups. Based on discussions with project partners and relevant stakeholders, different concepts for both supply-side and demand-side sector integration will be proposed. In addition to the operational implications of sector integration, the financial implications in terms of risk, return, and uncertainty will be analysed.

The **second pillar** will develop the ReInvent modelling and simulation. This multi-sectoral simulation environment will capture the different dynamics of different vectors in multiple timeframes, for multiple scenarios, for multiple market design options, for multiple services, including different end-use sectors and different layers of the physical networks and their interconnection. Innovations modelled in ReInvent aim at the overarching goal of augmenting and realizing the potential of sector coupling in providing key flexibility, balancing, and adequacy services to the multi-energy system and the electric grid.

The **third pillar** will look at a selection of reference test cases that represent main use cases of sector coupling/integration. These applications will provide real data that allow proofing of the developed models in the second pillar. In addition, the models of the second pillar will provide necessary insights to the test cases about the impact of the ReInvent solutions on the operational and financial stability of the presented solution. The ReInvent test cases address different vectors, end user segments and applications and are selected based on the technologies and applications that will play a central role in a future integrated system but still face barriers today that hinder their expected breakthrough.

The **fourth pillar** will define a roadmap for improved sector coupling and sector integration for Belgium. This includes an impact assessment of a wide roll-out of the solutions for the Belgian energy system, in particular the implications for security of supply and system balancing.

Table of Contents

List of Figures

List of Tables

List of Abbreviations and Acronyms

Acronym	Meaning
5GDHC	5th Generation District Heating and Cooling
API	Application Programming Interface
ATES	Aquifer Thermal Energy Storage
BESS	Battery Energy Storage System
BRP	Balance Responsible Party
BUC	Business Use Case
CAPEX	Capital Expenditure
CCGT	Combine Cycle Gas Turbine
CCS	Carbon Capture and Storage
CEC	Citizen Energy Community
CH4	Methane
CO2	Carbon Dioxide
CPO	Charge Point Operator
DA	Day Ahead
DHC	District Heating and Cooling
DNO	Distribution Network Operator
DSF	Demand-Side Flexibility
DSO	Distribution System Operator
ENTSO-E/G	European Network of Transmission System Operators (Electricity/Gas)
ETF	Energie Transitie Fonds
EV	Electric Vehicle
FSP	Flexibility Service Provider
GHG	Greenhouse Gas
H2	Hydrogen
H2O	Water
HC (H/C)	Heating and Cooling
HEC	Hybrid Energy Community
HEMRM	Harmonized Electricity Market Role Model
ID	Intraday
IoT	Internet of Things
IRR	Internal Rate of Return

IT	Information Technology
KPI	Key Performance Indicator
MES	Multi-Energy System
MSP	Mobility Service Provider
NPO	Non-Profit Organization
O2	Oxygen
OEM	Original Equipment Manufacturer
OPEX	Operational Expenditure
PPA	Power Purchase Agreements
PEM	Proton Exchange Membrane
PV	Photovoltaic
REC	Renewable Energy Community
RES	Renewable Energy Sources
RFI	Request for Information
RLP	Real Load Profile
RF	Residue Factor
SME	Subject Matter Expert
SPV	Special Purpose Vehicle
TSO	Transmission System Operator
TYNDP	Ten Year Network Development Plan
V2G	Vehicle to Gas
VE	Full Electric Vehicles
VH	Hydrogen Vehicles
WP	Work Package

Executive Summary

This deliverable outlines 17 Business Use Cases (BUCs) linked to various real-life test cases within the ReInvent project. A standardized use case methodology, based on the IEC-62559 standard, has been applied to ensure the replicability of these use cases. The BUCs will guide the project's research activities throughout its duration, with each test case having one or more associated BUCs. These BUCs are connected to one or more research topics within the ReInvent project, such as business model evaluation, financing and smart billing solutions, and energy system and market modelling. The BUCs tied to the test cases will be evaluated qualitatively and/or quantitatively, using concepts developed in Work Package 1 (WP1) and, where relevant, relying on assessments carried out as part of Work Package 2 (WP2) with the ReInvent modelling environment.

The ReInvent Business Use Cases (BUCs) have been divided into five distinct groups, each with a specific focus. The first group focuses on the development of business models for certain test cases, particularly those involving cross-sectoral and collective activities. The second group centres on business models related to mobility applications, with a specific emphasis on long-haul trucks. The third group examines the energy system as a whole, with particular attention to the role of hydrogen within it. The fourth group investigates the flexibility potential of specific technologies and assesses how this flexibility can impact the energy market. The fifth and final group concentrates on smart billing solutions for electric vehicle (EV) sharing. A total 17 BUCs have been defined in the aforementioned groups:

- Group 1 Business models for cross-sectoral and collective activities.
    - BUC1a Collective, cross-sectoral business model for sharing of heat and cooling in a business park with a 5GDHC network
    - BUC1b Collective, cross-sectoral business models for the provision of flexibility to the electricity system by a 5th generation DHC network
    - BUC2a Collective, cross-sectoral business models for the integration of a BESS in a REC
    - BUC2b Collective, cross-sectoral business models for the provision of flexibility to the electricity system by BESS in a REC
    - BUC3a Collective, cross-sectoral business models for car sharing in an Energy Community consisting of social housing
    - BUC3b Collective, cross-sectoral business models for flexibility enhanced car sharing in an Energy Community consisting of social housing
    - BUC4 Integration of collectively owned offshore wind energy production in the electricity grid, by means of demand side management at REC level and the use of a large-scale battery
    - BUC5a Collective, cross-sectoral business models for Business Renewable Energy Communities (without flexibility)

  - BUC5b Collective, cross-sectoral business models for Business Renewable Energy Communities with flexibility solutions
- Group 2 Business models for long-haul trucks.
  - BUC6a Cross sectoral business models for long haul trucks on Hydrogen.
  - BUC6b Cross sectoral business models for long haul trucks mobility from local green power.
- Group 3 Whole energy system view
  - BUC7 The role of hydrogen in the Belgian energy system
  - BUC8 INTEGRATION extended to North Sea region: impact of North Sea wind potential and offshore electrolysis.
- Group 4 flexibility potential
  - BUC9 Potential for flexibility provision with a large-scale electrolyser
  - BUC10 Potential for flexibility provision with a portfolio of EVs
- Group 5 Billing solutions for electric vehicle (EV) sharing.
  - BUC11 Smart billing solutions for EV charging (focus on a large fleet of EVs)
  - BUC12 Smart billing solutions for EV charging (focus on collective car sharing)

The BUCs will be further refined in the upcoming tasks within WP3, using the concepts developed in WP1 and supported by WP2's modelling activities, specifically through the ReInvent modelling environment. Key Performance Indicators (KPIs) defined in each BUC will be further detailed and calculated in Task 3.4.

1 Introduction

By 2030 and beyond, multiple energy vectors (electricity, gas, heat, and green molecules) will play a crucial role in an interconnected energy system. Increased electrification will support sector integration across various end-user segments. To fully capitalize on the advantages of sector coupling, a fundamental rethinking of market design, business models, and financing models is required. ReInvent will define a roadmap for sector coupling in Belgium, based on advanced modelling and robust test cases. These reference test cases have been selected based on the technologies and applications expected to play a central role in the future integrated system, but which currently face barriers hindering their breakthrough. This deliverable will define business use cases (BUC) for each test case, linked to their main research questions.

1.1 Objectives of the Work Reported in this Deliverable

This deliverable will define one or more business use cases (BUC) for the different real-life test cases that are executed by different entities across Belgium. These BUC define the research objectives of the test cases which, combined with the data collected from them (outlined in T3.2), will support, and be supported by, the simulation studies performed in work package 2 (Figure 1-1).

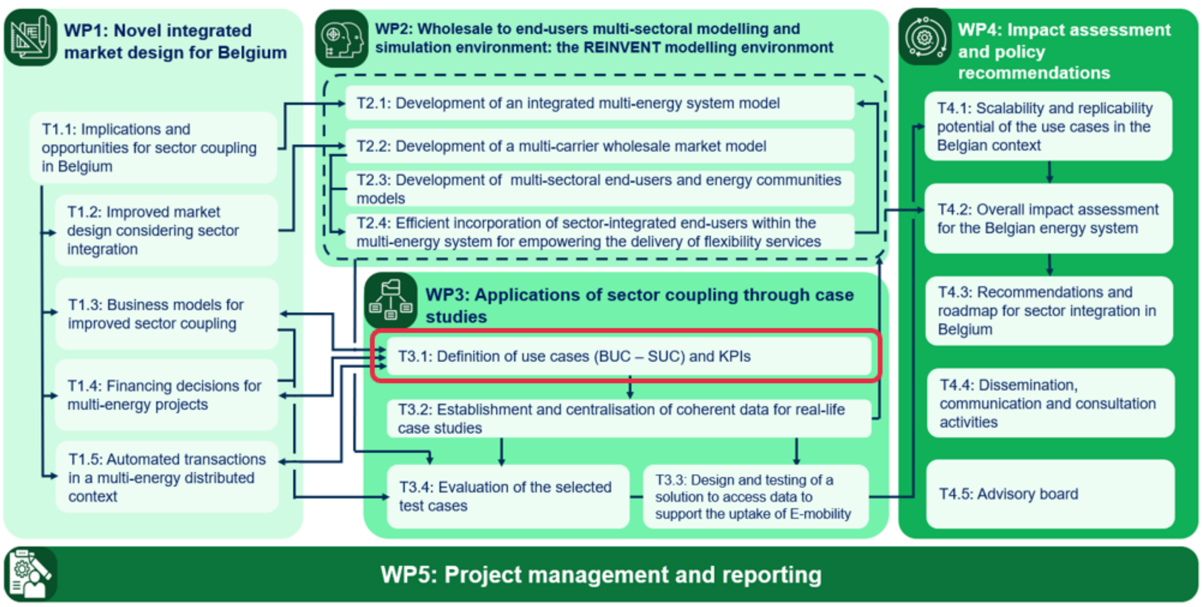


Figure 1-1: Flowchart of the task distribution within ReInvent, T3.1 is outlined in red.

A standardized use case methodology (based on the IEC-62559 standard) has been applied to support replicability of the use cases. The business use case starts from the research questions each of the test cases is aiming to address. The BUC will describe business processes/activities and the needed interactions between the involved stakeholders. The description of the business use cases will use a role model that will include the different roles involved covering the several considered end-use sectors and energy vectors. The BUCs include the identification of relevant key performance indicators (KPIs) for the evaluation of the test cases. The KPIs defined in each BUC will be further defined in detail in the follow up tasks in WP3.

1.2 Outline of the Deliverable

Following the introduction, this deliverable is divided into five chapters. Chapter 2 gives some additional information on the Use Case Methodology, insights into the ReInvent test cases and how the BUCs were developed from these different cases. It also provides overviews for the roles actors play in the BUCs. Each of the BUCs are described in Chapter 3 using the template found in Annex B. While section 4 is dedicated to describing the Re.alto platform that will be part of the ReInvent E-mobility demonstration case, which will serve as a data source for different ReInvent research activities. Finally, chapter 5 concludes the deliverable with a high-level summary of the BUCs.

2 Definition of use cases

As mentioned above, this deliverable outlines the Business Use Cases for the ReInvent test cases which will guide the research activities throughout the duration of the project. Each test case has one or more BUCs associated with it, which will be studied within the ReInvent project. Each of these BUCs can be linked to one or more of the research topics of the ReInvent project. In this chapter we will explain the use case methodology and identify the relevant BUC(s) for each of the test cases based on their main research questions.

This chapter is structured in five distinct parts. Section 2.1 explains the use case methodology that was applied. Next, section 2.2 gives an overview of the different ReInvent test cases, while section 2.3 explains the mapping of test cases to research topics, leading to the definition of the ReInvent BUCs. Finally, section 2.4 provides on overview of the different roles relevant to the ReInvent BUCs. KPIs described in the BUCs will be further completed and detailed in the following WP3 tasks and in consultation with WP1 and WP2 activities.

2.1 Use Case Methodology

This section describes the methodology followed to define the use cases to implement in ReInvent. A use case is defined as a sequence of actions that are taken by one or more users to utilize a particular system in order to achieve observable result. A system is set of related elements that can be considered independent from and separate to their surrounding environment [1]. Within the scope of the ReInvent project, a system may describe a test case in its entirety or a specific subset, or branch, of the test case. Use cases are typically used to describe systems at distinct levels, such as the function, business, or system level.

A request for information (RFI) has provided the test cases with an initial opportunity to define their systems and the research objectives they aim to accomplish within the project. The full template and all the responses from the individual test cases can be found in Annex A. These templates, in combination with the research objectives of the tasks from work packages (WP) 1 and 2, reveal that, within ReInvent, the scope of the research activities requires the test cases to describe their system interactions only at the business level since there will be no demonstrations linked to most of the BUC. As a result, only BUCs are developed. The only exception applies to the functionalities that will be developed and tested using the re.alto platform. These activities are associated with task 3.3, "Design and testing of a solution to access data to support the uptake of E-mobility" (see Figure 1-1). Chapter 4 explains the operation of the re.alto platform and provides a high-level overview of the required functionalities and applications. These aspects will be further developed as part of task 3.3.

The IEC 62559 standard provides a methodology and template for detailing a use case, including the description of objectives, actors, requirements (including KPIs), and the relationships between them. This template is further adapted and simplified to better suit the needs of the project, the result of which can be found in Annex B. The ReInvent BUC template consists of the following subsections:

- Description of the Use Case
    - General Information on the test case

    - Name of Use Case
    - Scope and Objectives of Use Case
    - Narrative of Use Case
    - Use Case Conditions
    - General Remarks
- Structure
    - Actors and Roles
    - Drawing or Diagram of Use Case
- Key Performance Indicators

It is important to note that the development of the BUCs for the project is an iterative process with the versions presented in Chapter 3 being the result of numerous discussions between the test case owners and members of WP1 and 2. This allows for the descriptions and diagrams to be developed over time as the test cases better understand the unique aspects of their systems that will be the focus of the research over the course of the project.

The key performance indicators are utilized to quantify the results of each BUC regarding specific key metrics. Initially, the KPIs were developed independently for each BUC, allowing them to focus on what metrics are most important to that specific case. Due to the close relationship of the test cases with the ongoing tasks within work packages 1 and 2, the KPIs were further harmonized with these tasks to ensure comparability of results from across the project. The KPIs for each BUC can be found in their respective outlines in Chapter 3 and include a brief description of what the KPI will measure. A domain is assigned to each KPI to classify them based on what impact they best measure: economic, environmental, regulatory, social, or technical.

2.2 The ReInvent Test Cases

The ReInvent project has 9 test cases, as can be seen in Figure 2-1. These test cases represent different components and applications of sector coupling. They will provide real data that allows proofing of the developed concept and models within the ReInvent project. In addition, these concepts and models will provide necessary insights into the test cases. The test cases have been selected based on the technologies and applications that will play a central role in a future integrated energy system and they address different energy vectors, end-user segments and applications.

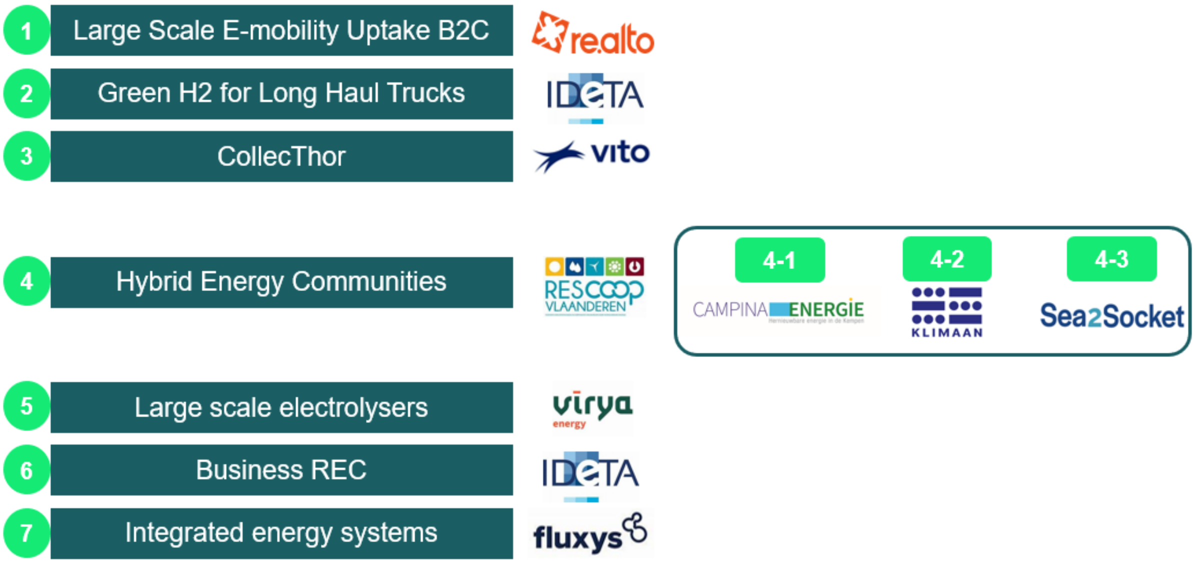


Figure 2-1: Overview of the ReInvent test cases.

Full descriptions of the test cases can be found in the RFI responses in Annex A, a brief overview for each can be found below.

- TC1: Building upon its existing data platform, **re.alto** will provide access to data from 200 EVs and 1000 smart meters for the ReInvent simulation environments and will develop and test different solutions related to E-mobility.
- TC2: **IDETA** will investigate viable business and financial models for the development of a green hydrogen transport facility, where electrolysers will convert energy generated from nearby solar and wind to produce hydrogen that will be used by a small fleet of transportation trucks.
- TC3: Utilizing a newly developed first-of-its-kind district heating and cooling (DHC) network at ThorPark, **VITO** will study the unique business and operational aspects of this innovative system.
- TC4: **REScoop Vlaanderen** overseas three smaller test cases that all relate to hybrid energy communities (HEC).
    - TC4-1: **CAMPINA Energie** will analyse the impact of integrating of battery energy storage systems (BESS) into different of their renewable energy communities (REC).
    - TC4-2: **KLIMAAN** aims to increase the transparency, accessibility and affordability of shared electric vehicles (EVs) and communal EV charging.
    - TC4-3: **Sea2Socket** builds on the work of the EnergieTransitieFonds (ETF) project of the same name, with the focus in ReInvent shifting to how large-scale batteries can aid in reducing profiling and balancing costs at the REC level.
- TC5: **Virya Energy** aims to better understand the needs and impacts of sector coupling on the hydrogen value chain, specifically surrounding the flexibility potential of renewable-powered large-scale electrolysers.

- TC6: Expanding upon their previous REC (HospiGREEN) connecting hospitals, small business, government buildings and care homes, **IDETA** will continue to test how new regulations in Wallonia impact the development of RECs involving also large enterprises in Picardy Wallonia.
- TC7: Building upon the previous ETF-funded INTEGRATION project, **Fluxys** will maintain their efforts to develop an integrated multi-energy system model for long-term multi-sectoral planning.

As more actors enter the market utilizing different energy vectors as producers, consumers, or prosumers, the need for improving cross-sectoral engagement increases. The test cases have been selected to study the overlaps of energy vectors and consumers as they pertain to different business models, regulatory areas, and technological applications. The energy vectors covered by ReInvent are electricity and natural gas, as well as heating and cooling and green molecules like hydrogen. On the consumption side, these cases look at industries, transport (both passenger EVs and long-haul trucks), and hybrid energy communities (HEC) (both residential and any combination of residential, commercial, and industrial). The overlap of these sectors within the test cases is displayed in Figure 2-2 and Figure 2-3. A detailed list of the technologies and energy vectors and networks integrated into each test case can be found in their responses to the RFI in Annex A.

	1	2	3	4-1	4-2	4-3	5	6	7
	realto	IDETA	vito	CAMPINA ENERGIE	KLIMAAN	Sea2Socket	virya energy	IDETA	fluxys
Electricity	●	●	●	●	●	●	●	●	●
Heat/Cool			●						●
Green Molecules		●					●		●
Gas									●

Figure 2-2: Overlap of energy vectors investigated in the ReInvent test cases.

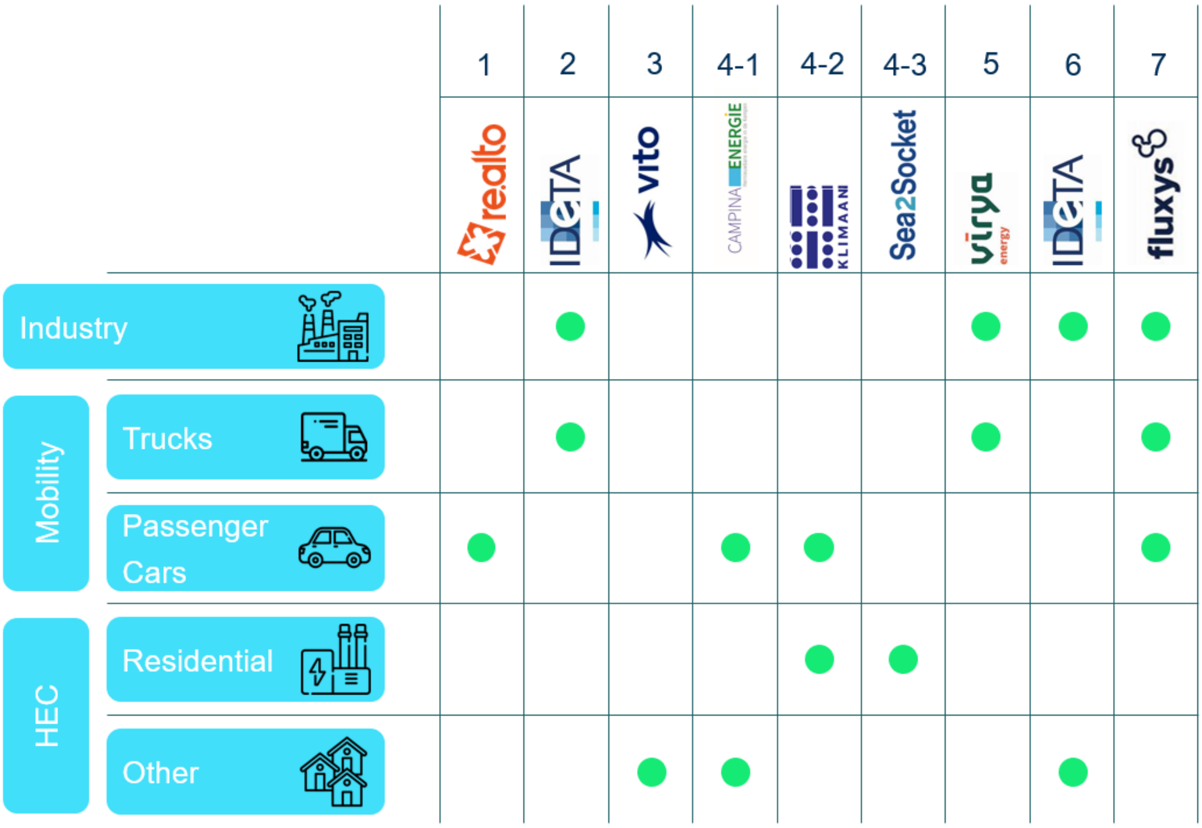


Figure 2-3: Overlap of end-uses investigated within the ReInvent test cases.

2.3 Test Case to Use Case Mapping

The BUCs connected to the test cases will be assessed qualitatively and/or quantitatively by using the concepts developed in WP1 and, if appropriate, by relying on the evaluations which will be done as part of WP2 using the ReInvent modelling environment. Depending on the problem statement of the use cases, one or multiple models might be needed. In particular, following ReInvent research activities will be able to provide insights to answer the research questions of the test cases[1].

- Business models concepts

  As part of task 1.3 business models for improved sector coupling will be worked out. This task will develop innovative archetypes of cross-sectoral business models for different end-use segments by means of data-driven consumer segmentation techniques. The resulting consumer archetypes and the business model features will be then used to build up tailored business models to support the diversity of consumers in the different segments. The findings of this task can be used to advise test cases on certain business model features.

- Financing solutions

[1] To see how the different mentioned tasks are linked to each other, we refer to Figure 1-1.

Task 1.4 will study how financing decisions for multi-energy projects are being made and can thus give inputs the test case how investments decisions are made in the context of multi-energy projects. These projects typically consist of new technologies, combination of different solutions, sectors and end-uses in a rapidly changing environment and it is therefore not straightforward to assess the bankability of this type of investments due to the lower maturity, high risk and the complexity of the solutions. Smart billing solutions

The energy system of the future will be more and more distributed. In this context, an exponentially growing number of transactions will take place between different distributed resources driven by system requests. Transactions should be settled automatically and autonomously. In task 1.5, we will develop smart billing solutions which can have a lower cost and lower risk compared to traditional transactions, and which are needed to realize the concepts put forward by some of the test cases.

- Role of technologies in the energy system

  Task 2.1 will develop an integrated multi-energy system model. The development will include the modelling of complex features within the different energy systems as well as the integration between systems, while incorporating an advanced integration of (collective) distributed energy resources and multi-sectoral energy communities. The model can be used to advise on cost-effective and system-secure investment planning decisions and can be used to support some of the test cases on the role of certain technologies or energy vectors in the Belgian energy system.

- Impact of technologies on the market

  Task 2.2 focuses on developing improved market designs at the wholesale level, taking into account sector coupling opportunities. The models developed in this task can be used to evaluate the impact of certain cross-sectoral technologies proposed by some of the test cases on existing or improved markets, including the revenue potential of their market participation.

- Quantitative support to business models

  The ReInvent project and in particular task 2.3 explores the multi-sector integration potential at the end-user side, considering individual end-users and multi-sector energy communities. The task aims at identifying the coupling potential between sectors at the end-users' level through an integrated multi-energy system modelling environment, considering a variety of sectors. This modelling environment can support the test cases by advising on how to optimize their operations or quantify the impact of specific investment decisions, both at the individual and collective end-user levels, thereby contributing to the quantitative business model evaluation of the cases.

- Quantification of flexibility potential

  The models which will be developed as part of task 2.4 can be used to assess the potential of the test case to provide flexibility to the electricity grid for the support of secure system operation and grid balancing needs. Similar as for task 2.3, this can serve as an input for the business model evaluation of the cases.

The BUCs have been developed following an iterative process between the test case owners and task leaders from the above tasks in WP 1 and 2. Using the research objectives outlined by the test case owners as a starting point, connections were made to the different research activities mentioned above. The result of this mapping exercise between the test cases and research activities can be found in Figure 2-4. This created the backbone upon which the BUCs began to be built. Through discussions between the test case owners and representatives of the connected tasks, the BUCs were defined and refined to ensure that they fully captured the expected overlap of empirical data from the test cases and the scope of the ReInvent research activities in WP1 and WP2. These discussions resulted in five groups of BUCs, each with a different focus.

A first group of BUCs (indicated with a red square in Figure 2-4) focuses on the elaboration of business model for some of the test cases (i.e., for TC3, TC4.1, T4.2, TC4.3 and TC6). For all of these test cases, a BUC has been defined for the internal optimization of the test case (version a), while a separate BUC (version b) has been defined to elaborate the impact of adding and valorising flexibility on the business model. For TC4.3 we only focus on the impact of flexibility as the internal optimization is already covered in a previous ETF project Sea2Socket. **This first group therefore consists of 9 BUCs: BUC1a/b, BUC2a/b, BUC3a/b, BUC4, BUC5a/b.**

A second group (indicated with a blue square) also focuses on business models, but this time focused on mobility, i.e., long-haul trucks. Here we distinguish between two BUCs linked to TC2: one which focuses on the use of hydrogen to fuel the long-haul trucks **(BUC6a)**, while the second use cases will compare the use of hydrogen versus direct usage of green electricity to fuel the trucks (**BUC6b**).

A third group of BUCs (indicated with a purple square) takes the perspective of the whole energy system. **BUC7** linked to TC2 will investigate the role of hydrogen for the Belgian energy system, considering the use of hydrogen for long haul trucks, but also all other potential uses of hydrogen. **BUC8** linked to TC7 will focus on the impact of offshore wind and offshore electrolysis.

The fourth group of BUCs (indicated with an orange square) will study the flexibility potential of certain technologies and the impact of this flexibility on the market. **BUC 9** (linked to TC5) focuses on flexibility provision with a large-scale electrolyser, while **BUC 10** (linked to TC1) focuses on EV flexibility.

The final group of use cases (indicated with a yellow square) focuses on smart billing solutions for EV sharing, with a focus on a large fleet of EVs (**BUC 11** linked to TC1) and collective car sharing (**BUC 12** linked to TC4.2) respectively.

As can be seen in Figure 2-4 all test cases also have questions linked to the financing of their energy concept. For these questions, we did not define specific BUCs, but instead we will evaluate the bankability of all the different test cases as part of task 1.4.

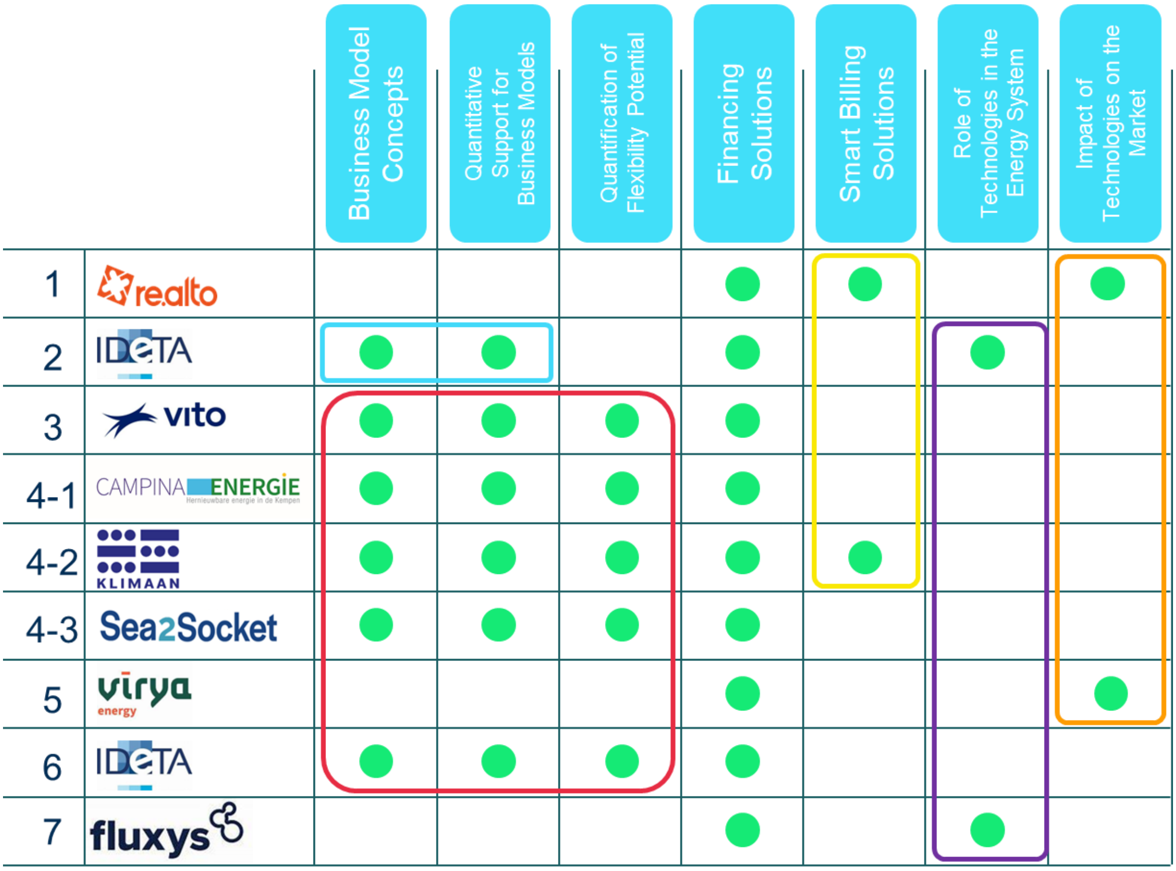


Figure 2-4: Mapping of test cases to the ReInvent research activities.

The full list of ReInvent BUC can be found in Table 2-1 with an indication of the test case that is linked to it, the partner within ReInvent that is responsible to it and which tasks will support the elaboration of the BUC.

Table 2-1: Overview of ReInvent BUC

New #	Name	Test case	Test case owner	Linked tasks
BUC1a	Collective, cross-sectoral business model for sharing of heat and cooling in a business park with a 5GDHC network	TC3	VITO	T1.3, 2.3
BUC1b	Collective, cross-sectoral business models for the provision of flexibility to the electricity system by a 5th generation DHC network	TC3	VITO	T1.3, 2.4
BUC2a	Collective, cross-sectoral business models for the integration of a BESS in a REC	TC4.1	CAMPINA	T1.3, 2.3
BUC2b	Collective, cross-sectoral business models for the provision of flexibility to the electricity system by BESS in a REC	TC4.1	CAMPINA	T1.3, 2.4
BUC3a	Collective, cross-sectoral business models for car sharing in an Energy Community consisting of social housing	TC4.2	KLIMAAN	T1.3, 2.3
BUC3b	Collective, cross-sectoral business models for flexibility enhanced car sharing in an Energy Community consisting of social housing	TC4.2	KLIMAAN	T1.3, 2.4
BUC4	Integration of collectively owned offshore wind energy production in the electricity grid, by means of demand side management at REC level and the use of a large-scale battery	TC4.3	SEACOOP	T1.3, 2.4
BUC5a	Collective, cross-sectoral business models for Business Renewable Energy Communities (without flexibility)	TC6	IDETA	T1.3, 2.3
BUC5b	Collective, cross-sectoral business models for Business Renewable Energy Communities with flexibility solutions	TC6	IDETA	T1.3, 2.4
BUC6a	Cross sectoral business models for long haul trucks on Hydrogen.	TC2	IDETA	T1.3, 2.3
BUC6b	Cross sectoral business models for long haul trucks mobility from local green power.	TC2	IDETA	T2.4
BUC7	The role of hydrogen in the Belgian energy system	TC2	IDETA	T2.1
BUC8	INTEGRATION extended to North Sea region: impact of North Sea wind potential and offshore electrolysis.	TC7	Fluxys	T2.1
BUC9	Potential for flexibility provision with a large-scale electrolyser	TC5	Virya	T2.2, T2.4
BUC10	Potential for flexibility provision with a portfolio of EVs	TC1	Re.alto	T2.2, T2.4
BUC11	Smart billing solutions for EV charging (focus on a large fleet of EVs)	TC1	Re.alto	T1.5
BUC12	Smart billing solutions for EV charging (focus on collective car sharing)	TC 4.2	KBC	T1.5

2.4 List of Roles

In order to operate within the BUCs as outlined in Chapter 3, each test case allocates one or more roles to an actor within their system. Here, as was proposed in the harmonised electricity market role model, a role is defined as the intended external behaviour of a party. The actors within a BUC represent a party in a role to perform a specific task. An actor is able to perform multiple roles within a market.

Role definitions have been developed initially from the Harmonized Electricity market Role Model (HEMRM) [2]. These have then been supplemented with additional roles and expanded definitions from Senergy Nets [3] and MAGNITUDE [4]. When necessary, the definitions have been further adjusted to accommodate the unique nature of multisector markets and systems. Additional new roles have also been developed and included whenever no existing role adequately encompasses the responsibilities needing to be addressed. The full list of roles and their definitions utilized in the different ReInvent BUCs can be found below in Table 2-2. An abbreviated list of the roles, as well as the actors specific to each BUC, are also included in their respective descriptions in Chapter 3.

Table 2-2: ReInvent role model.

Role	Role Description
(Resource) Aggregator	A party that aggregates resources for usage by other market participants, frequently for flexibility in which case this party is also known as a Flexibility Service Provider. Comment: This role is currently only applied within the electricity sector.
Balance responsible party (BRP)	A party financially accountable for any imbalances it causes to a network. Comment: This is currently only applied within the electricity sector but could potentially be applied to other sectors as their networks and markets mature.
Charge Point Operator	A party responsible for installing, managing and maintaining charging stations for electric vehicles (EVs). It ensures that the charging infrastructure is operational and handles the distribution of electricity to these stations.
Consumer	A party that consumes energy from one or more sector (electricity, gas, thermal, hydrogen).
Data provider	A party that has a mandate to provide information to other parties in the energy market.
Distribution System / Network Operator (DSO/DNO)	A party responsible for operating, maintaining, and developing (where necessary) the system within a defined area (and its interconnection to other systems/areas) to ensure the long-term ability of the system to meet reasonable demands for the distribution of energy from one sector. Comment: Currently, the role of a DSO is only applied to the electricity, gas, and heat/cooling sectors.
Fleet manager	The fleet manager manages a fleet of EVs and is responsible for overseeing the operation, maintenance, and logistics of a fleet of vehicles.
Flexibility Service Provider	A party that offers flexibility services based on acquired (sometimes aggregated) resources within a sector. Comment:

	Like Aggregators, this role is currently only applied within the electricity sector.
Heat Network Owner	A party that owns the physical and technological assets of a heating/cooling network. Comment: May be the same party as the Heat Network Operator.
Market Operator	A party that provides a service where other parties are able to offer energy that is matched with bids to buy energy.
Meter Data Administrator	A party responsible for storing and distributing validated measured data.
Meter Data Aggregator	A party responsible for the establishment and qualification of measured data from the metered data responsible. This data is aggregated according to a defined set of market rules.
Meter Data Collector	A party responsible for meter reading and quality control of the reading.
Meter Operator	A party responsible for installing, maintaining, testing, certifying and decommissioning physical meters.
Metered Data Responsible	A party responsible for the establishment and validation of measured data based on the collected data received from the metered data collector. The party is responsible for the history of metered data for a metering point.
Metering Point Administrator	A party responsible for administrating and making available the metering point characteristics, including registering the parties linked to the metering point.
Mobility Service Provider	A party responsible for services related to electric vehicles (EVs) use, such as access to charging stations, managing billing and payments, and providing apps or cards for locating and using charging points.
Multi-Energy System (MES) Operator	A party that maintains and operates a multi-energy system (i.e., a system that incorporates assets, both technological and physical, from more than one energy sector). These assets may be consumption, generation, network, or storage, depending on the situation.
Producer	A party that generates energy for one or more sector (electricity, gas, thermal, hydrogen).
Prosumer	A party that both produces and consumes energy for one or more sector. In the context of cross sector coupling, a prosumer can consume energy from one sector and produce energy of another.
Regulator	A party responsible for the efficient organization and working of the energy markets.
Renewable Energy Community	A party responsible for operating and invoicing the energy that is shared and collectively self-consumed by its members. The party must be created as an energy community legal entity and must receive authorisation from the DSO and Regulator to operate the REC operations.
Resource Provider	A role that manages a resource and provides production/consumption schedules for it, if required.
Storage Provider	A party that can store energy for use at a later time period. The storage medium can be a different sector than the origin and/or end-use (e.g., electricity produces hydrogen (H2) via electrolysis which is stored and then converted into thermal energy via combustion).
Supplier/Retailer	A party that delivers energy to or takes energy from consumers/prosumers connected to the grid.
Transmission System Operator (TSO)	A party responsible for operating, maintaining, and developing (where necessary) the system within a defined area (and its interconnection to other systems/areas) to ensure the long-term ability of the system to meet reasonable demands for the transmission of energy from one sector. Comment:

	Traditionally, the role of a TSO was only applied to the electricity and gas sectors. Recently the role of a TSO for hydrogen was added.

3 The ReInvent Use Cases

In this chapter, all the BUCs of the different Test Cases are presented following the template provided in Annex B. In total 17 BUCs have been elaborated.

3.1 BUC 1a

1 Description of the Use Case

1.1 General Information

Test Case ID	*Name of Test Case*
3	CollecThor
Maturity of Test Case *– in business operation, realized in demonstration project, realised in R&D, in preparation, visionary*	
The 5th-generation heating and cooling (5GHC) network is currently in development and is expected to be operational by February 2025. As from that time it will be in business operation.	
Classifications According to ReInvent Cross-Sectoral Categories	
Energy Sectors: ☒ Electricity ☐ Gas ☐ Fuels ☒ Heating/Cooling ☐ Bioenergy ☐ Other:	**End-Use Sectors:** ☐ Industry ☐ Residential ☒ Commercial ☐ Transport & Mobility ☐ Agriculture ☐ Other:

1.2 Name of Use Case

ID	*Name of Use Case*
BUC 1a	Collective, cross-sectoral business model for sharing of heat and cooling in a business park with a 5GDHC network

1.3 Scope and Objectives of Use Case

Research Question(s)	*Test Case*
What is the appropriate business model for sharing of thermal energy via a 5th generation DHC network in a business park with multiple consumers?	CollecThor
Scope	
This use case aims at developing and testing potential business models for H/C (heating/cooling) exchange within a business park, Thor Park (Genk). The intention is to heat and cool the buildings in a sustainable manner via shallow geothermal energy and by allowing the buildings to exchange energy between each other. Heat and cooling are provided as a service to the consumers in the business park. Thor Park will be the first pilot site to roll-out 5GDHC in Flanders. The business park will have a 5GDHC network, which will supply heat/cold for different buildings on the site. In a first stage, four existing buildings will be connected to the DHC network. The four buildings mostly host offices, research labs and some other commercial activities (e.g., restaurants, bars). The DHC network will use aquifers thermal energy storage (ATES) to provide heating and cooling to the connected buildings within the network, with thermal step-ups provided by heat pumps located within the different buildings powered via renewable electricity (photovoltaics [PV] on the rooftops of the buildings) or electricity from the grid. The three ATES systems allow to provide long-term storage of heat and cold. The concept is modular and allows the system to grow in the future.	
Objectives	
• To optimize the operation of the DHC network for efficient and economical H/C provision to the connected buildings.	
• To propose fair and transparent H/C sharing and pricing mechanisms which support this efficient and economical energy provision.	
View *- Technical / Business*	

This use case mainly focuses on the business aspects, while considering the technical possibilities/limitations of the 5th generation DHC network.

1.4 Narrative of Use Case

***Short description** – max 3 sentences (focus on key points of the use case)*
This use case aims to optimize the DHC network's operation to provide H/C to connected buildings in a cost-efficient manner. Additionally, it will propose fair and transparent H/C sharing and pricing mechanisms that support this efficient and cost-effective H/C provision.
***Complete description** – detail all steps and components of use case*
The use case will examine potential H/C sharing and pricing models considering cost-efficient H/C delivery to the different buildings. Since the different buildings have the option to share H/C between them via the DHC network, it is important to optimize the H/C supply over the whole business park, but also foresee a plausible business model and arrangements for the fair settlement of this H/C between the different buildings. We therefore foresee a two-step approach. 1. In a first step we will investigate how H/C can be generated and distributed to the different buildings at lowest cost, i.e., by producing H/C for the different buildings with the most cost-efficient means, considering the operational characteristics of the DHC network, the thermal demand of the different buildings and the available storage in the network. 2. In a second step we will propose pricing / energy sharing mechanisms to ensure it) cost efficient H/C supply (i.e., to realize the outcome of step 1) and ii) a fair distribution of the related costs and revenues across the building owners. The use case will investigate different heat sharing and pricing mechanisms and their potential impact on the business model of the different actors involved.

1.5 Use Case Conditions

Assumptions
• For this BUC, we assume that all heat is generated by IFTech, the heat producer.
Prerequisites
• Thor Park is the first regulatory sandbox in Flanders, and it is allowed to exchange energy between different buildings on the site.

1.6 General Remarks

General Remarks

2 *Structure*

2.1 Actors and Roles

Roles	
☒ Consumer	☐ Green Molecules ☒ Electricity ☒ Heating/Cooling ☐ Gas
☒ Producer	☐ Green Molecules ☒ Electricity ☒ Heating/Cooling ☐ Gas
☒ Prosumer	☐ Green Molecules ☒ Electricity ☒ Heating/Cooling ☐ Gas
☒ Storage Provider	☐ Green Molecules ☐ Electricity ☒ Heating/Cooling ☐ Gas
☐ Multi-Energy System (MES) Operator	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☒ DSO/DNO	☐ Green Molecules ☒ Electricity ☒ Heating/Cooling ☐ Gas
☒ Network/Grid user	☐ Green Molecules ☒ Electricity ☒ Heating/Cooling ☐ Gas
☐ TSO	☐ Green Molecules ☒ Electricity ☐ Gas
☒ H/C Network Owner	
☐ Market Operator	
☐ Balance Responsible Party (BRP)	
☒ Supplier/Retailer	☐ Green Molecules ☒ Electricity ☒ Heating/Cooling ☐ Gas
☐ Aggregator	
☐ Regulator	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ Flexibility Service Provider (FSP)	

☐ Data Provider ☐ Meter Operator ☐ Meter Data Administrator ☐ Meter Data Aggregator ☐ Meter Data Collector ☐ Metered Data Responsible ☐ Metering Point Administrator ☐ Other: ________________________ ☐ Other: ________________________ ☐ Other: ________________________ ☐ Other: ________________________	

Actor Name	*Actor Description*	*Role(s)*
EnergyVille 1	Research institute(s) with labs and offices within one of the buildings in the DHCN.	Consumer (H/C) Consumer/producer/prosumer (electricity)
Thor Central	Restored mine building with mixed function which is one of the buildings in the DHCN.	Consumer (H/C) Consumer/producer/prosumer (electricity)
Incubathor	Building housing different SMEs which is one of the buildings in the DHCN.	Consumer (H/C) Consumer/producer/prosumer (electricity)
EnergyVille 2	Research institute with labs and offices within one of the buildings in the DHCN.	Consumer (H/C) Consumer/producer/prosumer (electricity)
IFTech	Expert in geothermal energy (design, building and operating).	Storage provider Producer (H/C) Supplier H/C
Fluvius	Fluvius is a network company that operates in all Flemish cities and municipalities. Fluvius owns and operates the DHCN at ThorPark and the electricity distribution network where the business park is located.	H/C Network Owner DNO (H/C) DSO (Electricity)

2.2 Drawing or Diagram of Use Case

Drawing or Diagram of Use Case – recommended "context diagram" and "sequence diagram" in UML
The first diagram shows a typology of the Use Case (type of consumers and local generation for the different sectors) and shows the main energy flows. An ATES system provides thermal energy storage in the aquifer for the CollecThor heating and cooling network. Commercial buildings within the Thor Business Park CollecThor heat network (e.g., EnergyVille 1, EnergyVille 2, Incubathor, etc.) access this heating and cooling network via the use of a substation including heat exchanger, pumps and a heat pump. These substations are powered either by solar panels on the roofs of each building, or in the event of a lack of solar energy by the electrical grid.

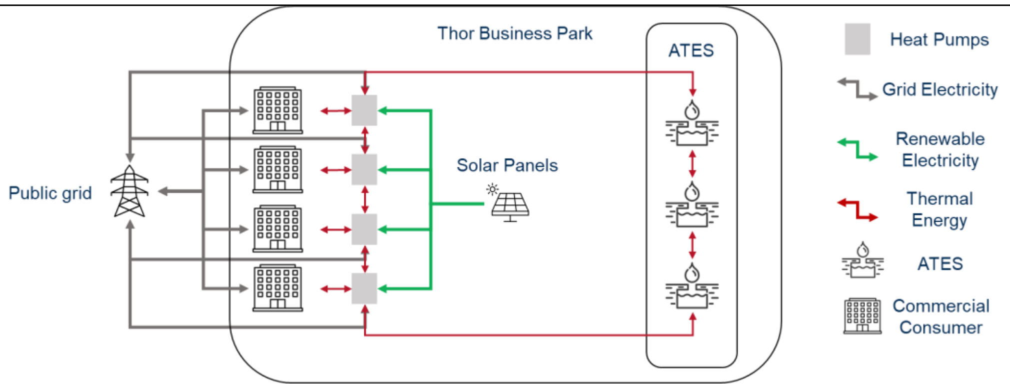


Figure 3-1: Diagram of the main energy flows within BUC 1a.

The second diagram shows the contractual relationships between the different actors. The CollecThor heating and cooling (H/C) network is operated by Fluvius (H/C Network Operator), who is also the regional electricity DSO. They maintain an access contract with the H/C supplier, IFTECH, to be granted access rights to the district heating network. The H/C Network Operator has connection agreements with the connected grid users, i.e., the H/C Producer (also IFTECH) and the H/C Network User, the entities who own/manage the buildings in the Thor Business Park connected to the district heating and cooling network. The latter also have a one-time installation contract with the H/C Producer to obtain the heat installation at their premises. A H/C Consumer, who is either the same entity as the H/C Network User or a tenant within their building(s), has a heat delivery contract with the H/C Supplier for the purchase of H/C.

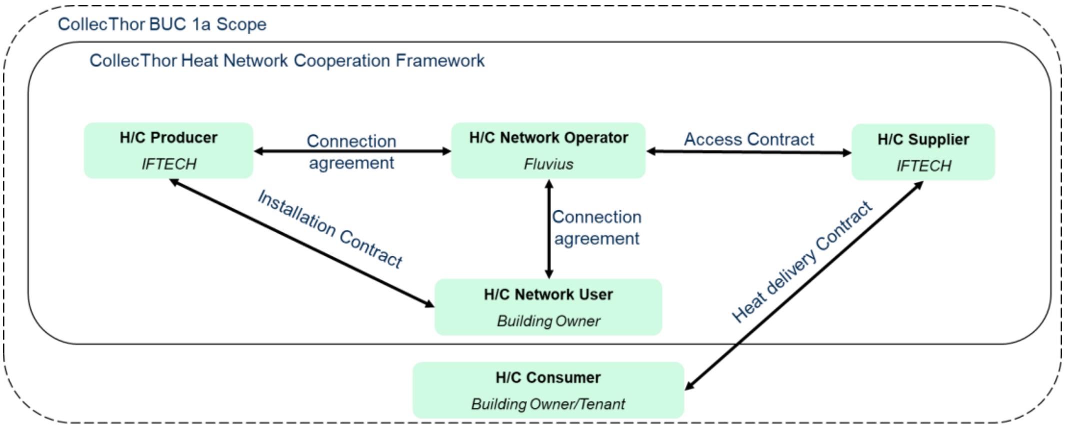


Figure 3-2: Diagram of the contractual relations within BUC 1a.

3 *Key Performance Indicators*

Name	*Description*	*Domain*
Total cost for heat provision	Cost to produce heat for and distribute heat from and to the four buildings [€]	Economic
Primary energy used for heat generation	Primary energy used for the generation of heat for the four buildings [MWh]	Environmental
Heat costs for the different consumers	Final heat costs / building [€]	Economic
Share of heat produced by local RES	Share of heat which is produced from local renewable energy sources [%]	Environmental
Total cost for heat provision	Cost to produce heat for and distribute heat from and to the four buildings [€]	Economic

3.2 BUC 1b

1 Description of the Use Case

1.1 General Information

Test Case ID	Name of Test Case
3	CollecThor
***Maturity of Test Case** – in business operation, realized in demonstration project, realised in R&D, in preparation, visionary*	
The 5th-generation heating and cooling (5GHC) network is currently in development and is expected to be operational by February 2025. As from that time it will be in business operation.	
Classifications According to ReInvent Cross-Sectoral Categories	
Energy Sectors: ☒ Electricity ☐ Gas ☐ Fuels ☒ Heating/Cooling ☐ Bioenergy ☐ Other:	**End-Use Sectors:** ☐ Industry ☐ Residential ☒ Commercial ☐ Transport & Mobility ☐ Agriculture ☐ Other:

1.2 Name of Use Case

ID	Name of Use Case
BUC 1b	Collective, cross-sectoral business models for the provision of flexibility to the electricity system by a 5th generation DHC network.

1.3 Scope and Objectives of Use Case

Research Question(s)	Test Case
How can the flexibility of a 5th generation DHCN be valorised in the electricity and flexibility markets?	CollecThor
Scope	
This use case aims at how flexibility within a 5GDHC network can be valorised to improve the overall business model. The 5GDHC network is located within the business park, Thor Park (Genk). The intention is to heat and cool the buildings in a sustainable manner via shallow geothermal energy and by allowing the buildings to exchange energy between each other. Heat and cooling are provided as a service to the consumers in the business park. Thor Park will be the first pilot site to roll-out 5GDHC in Flanders. The business park will have a 5GDHC network, which will supply heat/cold for different buildings on the site. In a first stage, four existing buildings will be connected to the DHC network. The four buildings mostly host offices, research labs and some other commercial activities (e.g., restaurants, bars). The DHC network will use aquifers thermal energy storage to provide heating and cooling to the connected buildings within the network, with thermal step-ups provided by heat pumps located within the different buildings powered via renewable electricity (PV on the rooftops of the buildings) or electricity from the grid. The heat pumps are a source of flexibility which can be valorised within electricity and flexibility markets, which is the main focus of this use case.	
Objectives	
• To optimize the operation of the DHC network for efficient and economical H/C provision to the connected buildings while considering the provision of flexibility to the electricity system.	
***View** - Technical / Business*	
This use case mainly focuses on the business aspects, while considering the technical possibilities/limitations of the 5th generation DHC network.	

1.4 Narrative of Use Case

***Short description** – max 3 sentences (focus on key points of the use case)*
This use case aims to optimize the DHC network's operation to provide H/C to connected buildings in a cost-efficient manner while considering the provision of flexibility to the electricity system. Different markets segments will be considered, i.e., participation to the day ahead (DA) and intraday (ID) electricity markets, offering balancing services to the TSO and offering local services to the DSO.

Complete description – detail all steps and components of use case
The use case will examine the valorisation potential of the flexibility within a 5GDHC network towards the electricity system, while considering cost-efficient H/C delivery to the different buildings. We will analyse how the combined flexibility of the buildings can be offered to the different electricity market segments. To provide flexibility to the electricity system, the operation of the DHCN will deviate from the optimal operation which was determined in BUC1a. The flexibility will mainly come from the heat pumps, but also other potential sources of flexibility could be considered. We foresee several steps for the analysis of the use case: 1. Identification of the flexibility potential for the electricity system. In this first step, we will analyse which flexible resources can offer flexibility and we will characterize their flexibility (amount of flexibility, certainty, impact of seasonality). 2. Mapping of flexibility potential with the requirements of the flexibility markets. In this step, we will analyse qualitatively which market segments can be targeted from a technical point of view and which ones are most interesting to target considering the revenue potential. Based on this, we will select the market segments we will analyse in detail. Since the amount of flexibility will be moderate, we assume an aggregator will be needed as an intermediary to offer the flexibility to the market. 3. Analysis of the impact of flexibility provision with the 5GDHC network on the revenues / costs. This analysis will be done using the models of WP2.

1.5 Use Case Conditions

Assumptions
• The test case is not located in a constrained area, so for services towards the DSO we will assume certain constraints. • Volume of flexibility within the DHCN is not sufficient to access the markets directly, so an aggregator would be needed.
Prerequisites
• Thor Park is the first regulatory sandbox in Flanders, and it is allowed to exchange energy between different buildings on the site.

1.6 General Remarks

General Remarks

2 Structure

2.1 Actors and Roles

Roles	
☒ Consumer	☐ Green Molecules ☒ Electricity ☒ Heating/Cooling ☐ Gas
☒ Producer	☐ Green Molecules ☒ Electricity ☒ Heating/Cooling ☐ Gas
☒ Prosumer	☐ Green Molecules ☒ Electricity ☒ Heating/Cooling ☐ Gas
☒ Storage Provider	☐ Green Molecules ☐ Electricity ☒ Heating/Cooling ☐ Gas
☐ Multi-Energy System (MES) Operator	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☒ DSO/DNO	☐ Green Molecules ☒ Electricity ☒ Heating/Cooling ☐ Gas
☒ Network/Grid user	☐ Green Molecules ☒ Electricity ☒ Heating/Cooling ☐ Gas
☒ TSO	☐ Green Molecules ☒ Electricity ☐ Gas
☒ H/C Network Owner	
☒ Market Operator	
☒ Balance Responsible Party (BRP)	
☒ Supplier/Retailer	☐ Green Molecules ☒ Electricity ☒ Heating/Cooling ☐ Gas
☒ Aggregator	
☐ Regulator	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ Flexibility Service Provider (FSP)	
☐ Data Provider	
☐ Meter Operator	

☐ Meter Data Administrator ☐ Meter Data Aggregator ☐ Meter Data Collector ☐ Metered Data Responsible ☐ Metering Point Administrator ☐ Other: ________________________ ☐ Other: ________________________ ☐ Other: ________________________ ☐ Other: ________________________	

Actor Name	*Actor Description*	*Role(s)*
EnergyVille 1	Research institute(s) with labs and offices within one of the buildings in the DHCN.	Consumer (H/C) Consumer/producer/prosumer (electricity)
Thor Central	Restored mine building with mixed function which is one of the buildings in the DHCN.	Consumer (H/C) Consumer/producer/prosumer (electricity)
Incubathor	Building housing different SMEs which is one of the buildings in the DHCN.	Consumer (H/C) Consumer/producer/prosumer (electricity)
EnergyVille 2	Research institute(s) with labs and offices within one of the buildings in the DHCN.	Consumer (H/C) Consumer/producer/prosumer (electricity)
IFTech	Expert in geothermal energy (design, building and operating).	Storage provider Producer (H/C) Supplier H/C
Fluvius	Fluvius is a network company that operates in all Flemish cities and municipalities. Fluvius owns and operated the DHCN at ThorPark and the electricity distribution network where the business park is located. In the future, Fluvius could also be interested to acquire flexibility.	H/C Network Owner DNO (H/C) DSO (Electricity)
Elia	Elia is the transmission system operator for electricity in Belgium and acquires different flexibility services.	TSO (Electricity)
To be defined	The flexibility can also be provided to a BRP which uses this flexibility to optimize its portfolio.	BRP
To be defined	The flexibility available within the DHCN will have to be provided through an intermediary.	Aggregator

2.2 Drawing or Diagram of Use Case

Drawing or Diagram of Use Case – recommended "context diagram" and "sequence diagram" in UML
The first diagram shows a typology of the Use Case (type of consumers and local generation for the different sectors) and shows the main energy flows. An ATES system provides thermal energy storage in the aquifer for the CollecThor heating and cooling network. Commercial buildings within the Thor Business Park CollecThor heat network (e.g., EnergyVille 1, EnergyVille 2, Incubathor, etc.) access this heating and cooling network via the use of a substation including heat exchanger, pumps and a heat pump. These substations are powered either by solar panels on the roofs of each building, or in the event of a lack of solar energy by the electrical grid. The diagram is the same as for BUC1a. The flexibility provision will only impact the amount of electricity off-take to / injection in the public distribution grid at certain times.

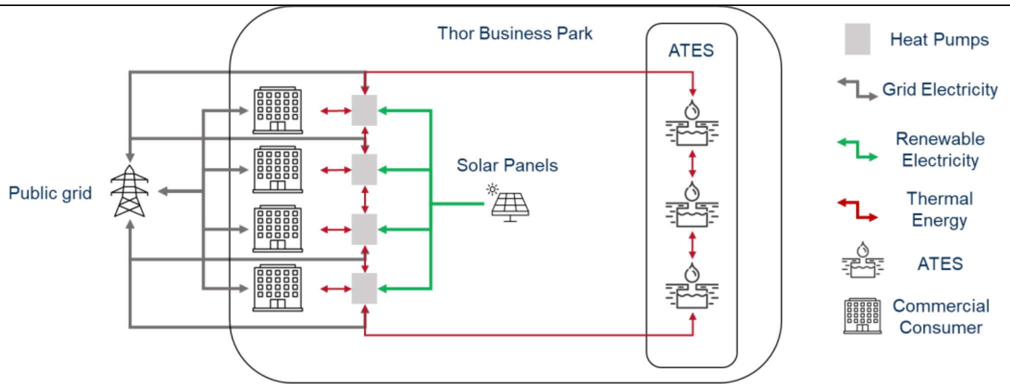


Figure 3-3: Diagram of the main energy flows within BUC 1b.

The second diagram shows the contractual relationships between the different actors.
Most of the contractual relationships are the same as for BUC1a. The CollecThor heating and cooling (H/C) network is operated by Fluvius (H/C Network Operator), who is also the regional electricity DSO. They maintain an access contract with the H/C supplier, IFTECH, to be granted access rights to the district heating network. The H/C Network Operator has connection agreements with the connected grid users, i.e., the H/C Producer (also IFTECH) and the H/C Network User, the entities who own/manage the buildings in the Thor Business Park connected to the district heating and cooling network. The latter also have a one-time installation contract with the H/C Producer to obtain the heat installation at their premises. A H/C Consumer, who is either the same entity as the H/C Network User or a tenant within their building(s), has a heat delivery contract with the H/C Supplier for the purchase of H/C.
There are however also some additional relationships:

- The H/C producer has a flexibility provision contract to offer flexibility to the aggregator.
- In addition, the aggregator has several FSP (Flexibility Service Provider) contracts with the different buyers of flexibility (DSO, TSO, BRP, etc.)

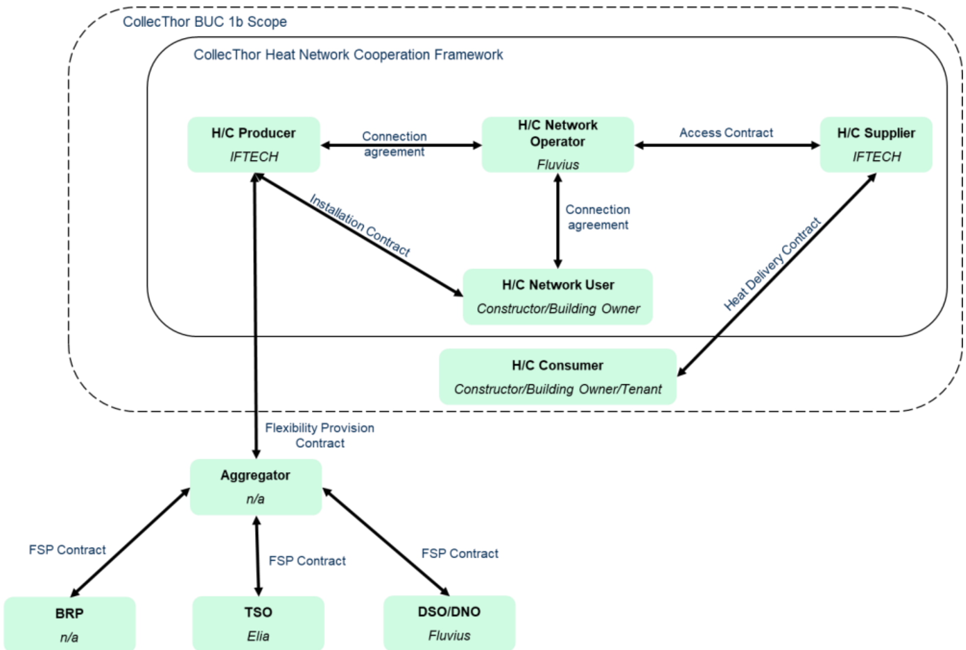


Figure 3-4: Diagram of the contractual relations within BUC 1b.

3 *Key Performance Indicators*

Name	Description	Domain
Total cost for heat provision	Cost to produce heat for and distribute heat from and to the four buildings [€]	Economic
Primary energy used for heat generation	Primary energy used for the generation of heat for the four buildings [MWh]	Environmental
Heat costs for the different consumers	Final heat costs / building [€]	Economic
Share of heat produced by local RES	Share of heat which is produced from local renewable energy sources [%]	Environmental
Available flexibility	Volume of flexibility offered to the aggregator [MW] or [MWh]	Technical
Accepted flexibility	Volume of flexibility accepted on the markets [MWh]	Technical
Flexibility revenues	Revenues from flexibility provision [€]	Economic

3.3 BUC 2a

1 *Description of the Use Case*

1.1 *General Information*

Test Case ID	***Name of Test Case***
4.1	Hybrid Energy Communities (Campina Energie)
Maturity of Test Case *– in business operation, realized in demonstration project, realised in R&D, in preparation, visionary*	
In business operation	
Classifications According to ReInvent Cross-Sectoral Categories	
Energy Sectors: ☒ Electricity ☐ Gas ☐ Fuels ☐ Heating/Cooling ☐ Bioenergy ☐ Other: Thermal	**End-Use Sectors:** ☒ Industry ☐ Residential ☒ Commercial ☒ Transport & Mobility ☐ Agriculture ☒ Other: Governmental

1.2 *Name of Use Case*

ID	***Name of Use Case***
BUC 2a	Collective, cross-sectoral business models for the integration of a BESS in a REC

1.3 *Scope and Objectives of Use Case*

Research Question(s)	***Test Case***
How does investment in BESS impact the risk and return of the portfolio of an energy cooperative?	Hybrid Energy Communities (Campina Energie)
Scope	
Campina Energie has a portfolio of 70+ PV installations (6 MWp) on industrial, commercial and governmental buildings and (shared ownership of) 9 wind turbines (25+ MW) in Flanders, all renewable energy produced in a renewable energy cooperative (REC). Campina Energie's business model is based on Power Purchase Agreements (PPAs) with maximised local self-consumption and injection of remaining solar electricity. With current trends of increasingly negative injection prices and subsequent curtailment of PV production, it is essential local self-consumption is increased. One solution is the use of Battery Energy Storage Systems. Campina Energie has access to detailed (quarter-hour interval) electrical production, injection and consumption data. By running simulations on the available data with fictional BESS, the contribution of BESS to the stability of the current REC portfolio can be assessed, and projections can be made for the future. Additionally, the integration of EV charging stations and heat pumps with PV and BESS can be assessed as it is an additional way to increase local self-consumption. Finally, the use of curtailment hardware can be assessed to limit the impact of negative electricity injection prices.	
Objectives	
To evaluate the effect of BESS on the risk and return of the portfolio of a REC.	
View *- Technical / Business*	
This use case mainly focuses on the business aspects, while considering the technical possibilities/limitations of using storage technologies.	

1.4 *Narrative of Use Case*

Short description *– max 3 sentences (focus on key points of the use case)*
Using the available data from the portfolio of a large-scale REC, assess the contribution of BESS to the financial stability of said portfolio.
Complete description *– detail all steps and components of use case*
The use case will source all available detailed electrical production, injection and consumption data from its PV and wind portfolio. The use case will also estimate future injection prices and the expected future local self-consumption due to the increase of heat pumps instead of natural gas-based heating, EV charging

stations and curtailment hardware. The use case will assess the effect of BESS on the internal rates of return (IRRs) of the different installations in Campina Energie's portfolio. As the entire portfolio cannot be modelled due to resource constraints, the analysis will be limited to a limited number of sites.

1.5 Use Case Conditions

Assumptions
N/A
Prerequisites
Data of PV and wind portfolio is available for analysis.

1.6 General Remarks

General Remarks

2 Structure

2.1 Actors and Roles

Roles	
☒ Consumer	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☒ Producer	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☒ Prosumer	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☒ Storage Provider	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☐ Multi-Energy System (MES) Operator	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ DSO/DNO	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ Network/Grid user	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ TSO	☐ Green Molecules ☐ Electricity ☐ Gas
☐ H/C Network Owner	
☐ Market Operator	
☐ Balance Responsible Party (BRP)	
☒ Supplier/Retailer	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☐ Aggregator	
☐ Regulator	
☐ Flexibility Service Provider (FSP)	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ Data Provider	
☐ Meter Operator	
☐ Meter Data Administrator	
☐ Meter Data Aggregator	
☐ Meter Data Collector	
☐ Metered Data Responsible	
☐ Metering Point Administrator	
☐ Other: ______________________	
☐ Other: ______________________	
☐ Other: ______________________	
☐ Other: ______________________	

Actor Name	*Actor Description*	*Role(s)*
Campina Energie customers	Consumer using PV electricity directly on site.	Consumer
Campina Energie	REC with a PV and wind portfolio.	Producer
Campina Energie	In the case EV charging stations are provided, Campina Energie is a prosumer (local production and consumption of PV energy).	Prosumer
Campina Energie	BESS owner	Storage Provider
Ecopower / EBEM	Purchases injected PV energy.	Supplier/Retailer

Eneco / Aspiravi	Purchases wind energy.	Supplier/Retailer

2.2 Drawing or Diagram of Use Case

Drawing or Diagram of Use Case – recommended "context diagram" and "sequence diagram" in UML
Campina Energie has a portfolio of 70+ PV installations (6 MWp) on industrial, commercial and governmental buildings and (shared ownership of) 9 wind turbines (25+ MW) in Flanders, all renewable energy produced in a renewable energy cooperative (REC). Campina Energie's business model is based on Power Purchase Agreements (PPAs) with maximised local self-consumption (potentially through energy sharing with other sites) and injection of remaining solar electricity. PV-produced electricity is sold directly to on-site consumers through a PPA. Any remaining electricity is sold to Ecopower or EBEM through a PPA. Similarly, Campina Energie is part of a special purpose vehicle (SPVs) (with e.g., Eneco or Aspiravi) which own wind turbines producing electricity (sold through PPAs).

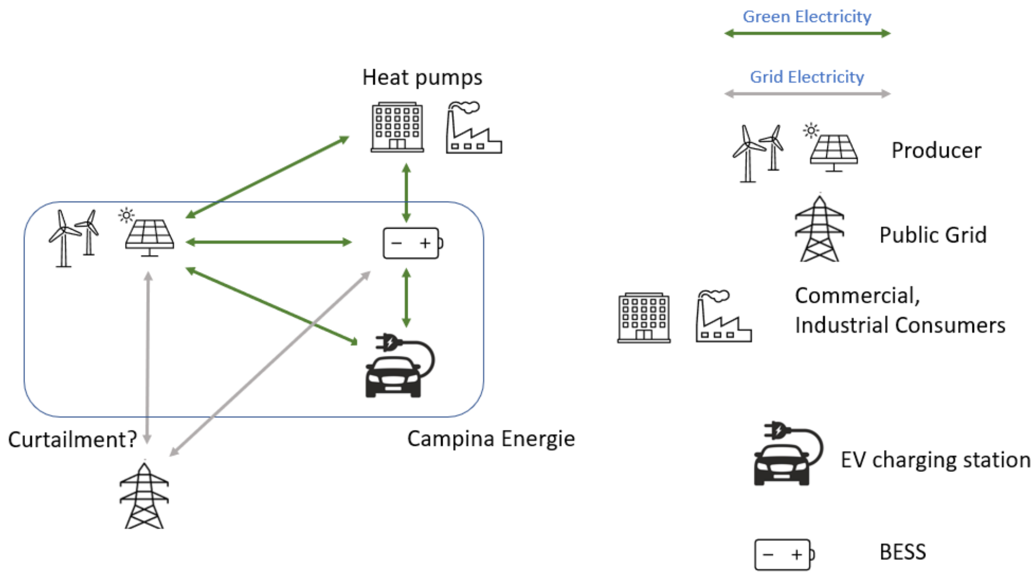


Figure 3-5: Diagram of the main energy flows within BUC 2a.

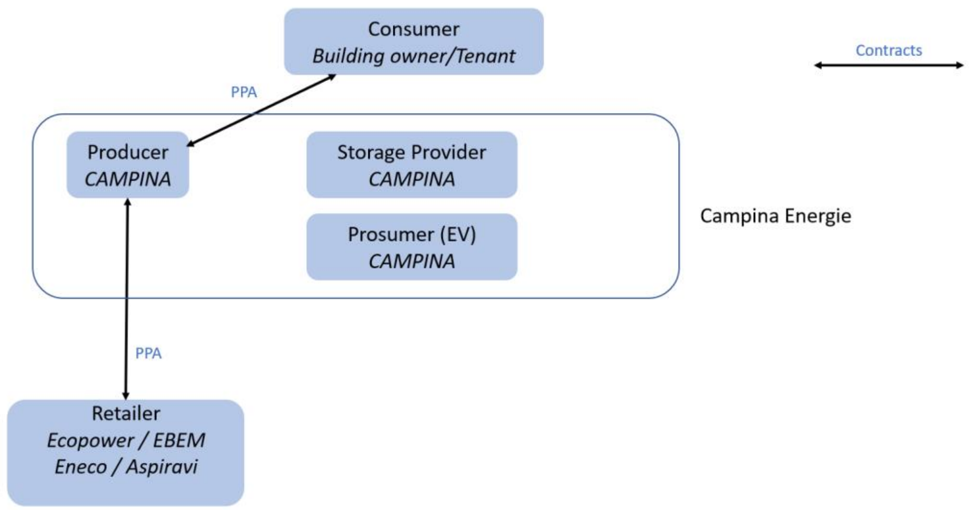


Figure 3-6: Diagram of the contractual relations within BUC 2a.

3 *Key Performance Indicators*

Name	*Description*	*Domain*
REC site IRR	IRR of REC site with and without BESS, EV charging stations, heat pumps and curtailment hardware [%]	Economic
Self-consumption rate	Total amount of locally consumed energy [MWh and %]	Technical
Community savings	Site and REC savings [€]	Economic
CO_2 savings	The amount of CO_2 saved by the REC [kg CO2]	Environmental

3.4 BUC 2b

1 Description of the Use Case

1.1 General Information

Test Case ID	Name of Test Case
4.1	Hybrid Energy Communities (Campina Energie)
Maturity of Test Case *– in business operation, realized in demonstration project, realised in R&D, in preparation, visionary*	
In business operation	
Classifications According to ReInvent Cross-Sectoral Categories	
Energy Sectors: ☒ Electricity ☐ Gas ☐ Fuels ☐ Heating/Cooling ☐ Bioenergy ☐ Other: Thermal	**End-Use Sectors:** ☒ Industry ☐ Residential ☒ Commercial ☒ Transport & Mobility ☐ Agriculture ☒ Other: Governmental

1.2 Name of Use Case

ID	Name of Use Case
BUC 2b	Collective, cross-sectoral business models for the provision of flexibility to the electricity system by BESS in a REC

1.3 Scope and Objectives of Use Case

Research Question(s)	Test Case
How can using the flexibility of a BESS to offer services to the electricity system improve the risk and return profile of an energy cooperative's portfolio?	Hybrid Energy Communities (Campina Energie)
Scope	
Campina Energie has a portfolio of 70+ PV installations (6 MWp) on industrial, commercial and governmental buildings and (shared ownership of) 9 wind turbines (25+ MW) in Flanders, all renewable energy produced in a renewable energy cooperative (REC). Campina Energie's business model is based on Power Purchase Agreements (PPAs) with maximised local self-consumption and injection of remaining solar electricity. With current trends of increasingly negative injection prices and subsequent curtailment of PV production, it is essential local self-consumption is increased. One solution is the use of Battery Energy Storage Systems (BESS). Campina Energie has access to detailed (quarter-hour interval) electrical production, injection and consumption data. By running simulations on the available data with fictional BESS, the contribution of BESS to the stability of the current REC portfolio while also considering the provision of flexibility to the electricity system can be assessed, and projections can be made for the future. Additionally, the integration of EV charging stations with PV and BESS can be assessed as it is an additional way to increase local self-consumption. Finally, the use of curtailment hardware can be assessed to limit the impact of negative electricity injection prices.	
Objectives	
To evaluate the effect of BESS on the risk and return of the portfolio of an REC by increasing flexibility and providing flexibility to the electricity system.	
View *- Technical / Business*	
This use case mainly focuses on the business aspects of flexibility, while considering the technical possibilities/limitations of using storage technologies.	

1.4 Narrative of Use Case

Short description *– max 3 sentences (focus on key points of the use case)*
Using the available data from the portfolio of a large-scale REC, assess the contribution of novel technologies to the stability of the portfolio and investigate additional revenue streams arising from the provision of flexibility to the electricity system

***Complete description** – detail all steps and components of use case*
The use case will source all available detailed electrical production, injection and consumption data from its PV and wind portfolio. The use case will also estimate future injection prices and the expected future local self-consumption due to the increase of heat pumps instead of natural gas-based heating, EV charging stations and curtailment hardware. The use case will assess the effect of BESS on the internal rates of return (IRRs) of the different installations in Campina Energie's portfolio, while also considering additional revenue streams from the provision of flexibility to the electricity system. As the entire portfolio cannot be modelled due to resource constraints, the analysis will be limited to a limited number of sites.

1.5 Use Case Conditions

Assumptions
N/A
Prerequisites
Data of PV and wind portfolio is available for analysis.

1.6 General Remarks

General Remarks

2 Structure

2.1 Actors and Roles

Roles	
☒ Consumer	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☒ Producer	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☒ Prosumer	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☒ Storage Provider	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☐ Multi-Energy System (MES) Operator	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ DSO/DNO	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ Network/Grid user	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ TSO	☐ Green Molecules ☐ Electricity ☐ Gas
☐ H/C Network Owner	
☒ Market Operator	
☒ Balance Responsible Party (BRP)	
☒ Supplier/Retailer	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☐ Aggregator	
☐ Regulator	
☐ Flexibility Service Provider (FSP)	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ Data Provider	
☐ Meter Operator	
☐ Meter Data Administrator	
☐ Meter Data Aggregator	
☐ Meter Data Collector	
☐ Metered Data Responsible	
☐ Metering Point Administrator	
☐ Other: ______________________	
☐ Other: ______________________	
☐ Other: ______________________	
☐ Other: ______________________	

Actor Name	***Actor Description***	***Role(s)***
Campina Energie customers	Consumer using PV electricity directly on site.	Consumer
Campina Energie	REC with a PV and wind portfolio.	Producer

Campina Energie	In the case EV charging stations are provided, Campina Energie is a prosumer (local production and consumption of PV energy).	Prosumer
Campina Energie	BESS owner	Storage Provider
Ecopower / EBEM	Purchases injected PV energy.	Supplier/Retailer; BRP
Eneco / Aspiravi	Purchases wind energy.	Supplier/Retailer; BRP
Elia	Elia is the transmission system operator for electricity in Belgium and acquires different flexibility services.	Market operator

2.2 Drawing or Diagram of Use Case

Drawing or Diagram of Use Case – recommended "context diagram" and "sequence diagram" in UML

Campina Energie has a portfolio of 70+ PV installations (6 MWp) on industrial, commercial and governmental buildings and (shared ownership of) 9 wind turbines (25+ MW) in Flanders, all renewable energy produced in a renewable energy cooperative (REC). Campina Energie's business model is based on Power Purchase Agreements (PPAs) with maximised local self-consumption (potentially through energy sharing with other sites) and injection of remaining solar electricity. PV-produced electricity is sold directly to on-site consumers through a PPA. Any remaining electricity is sold to Ecopower or EBEM through a PPA. Similarly, Campina Energie is part of SPVs (with e.g., Eneco or Aspiravi) which own wind turbines producing electricity (sold through PPAs).
Flexibility can be achieved through BESS. The BESS can be used for an internal optimization but can also be used to offer flexibility services to Elia. Campina would offer these services through an aggregator.

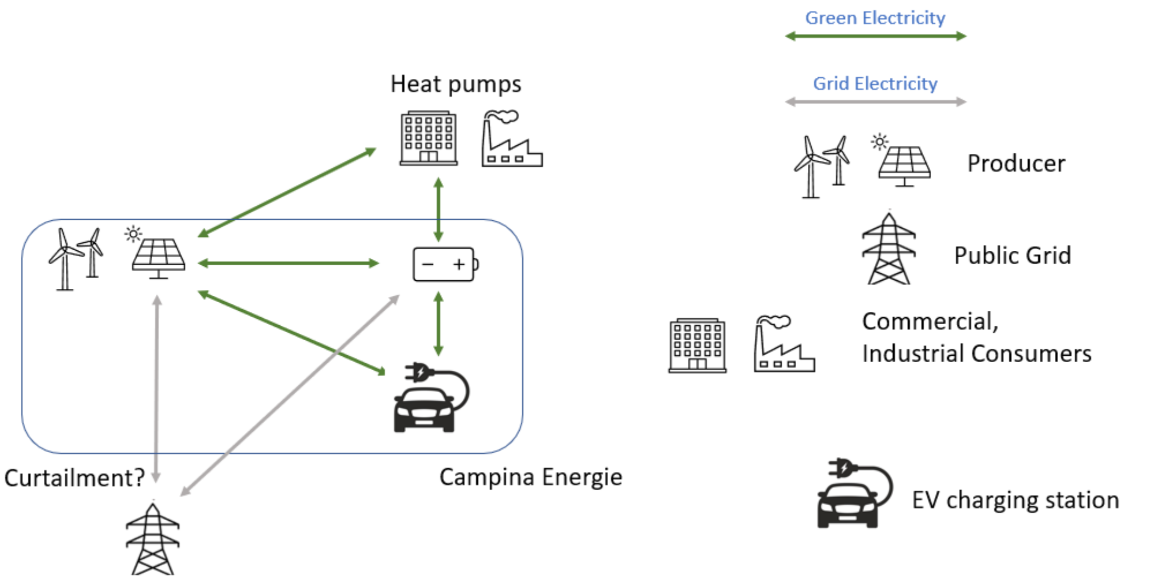


Figure 3-7: Diagram of the main energy flows within BUC 2b.

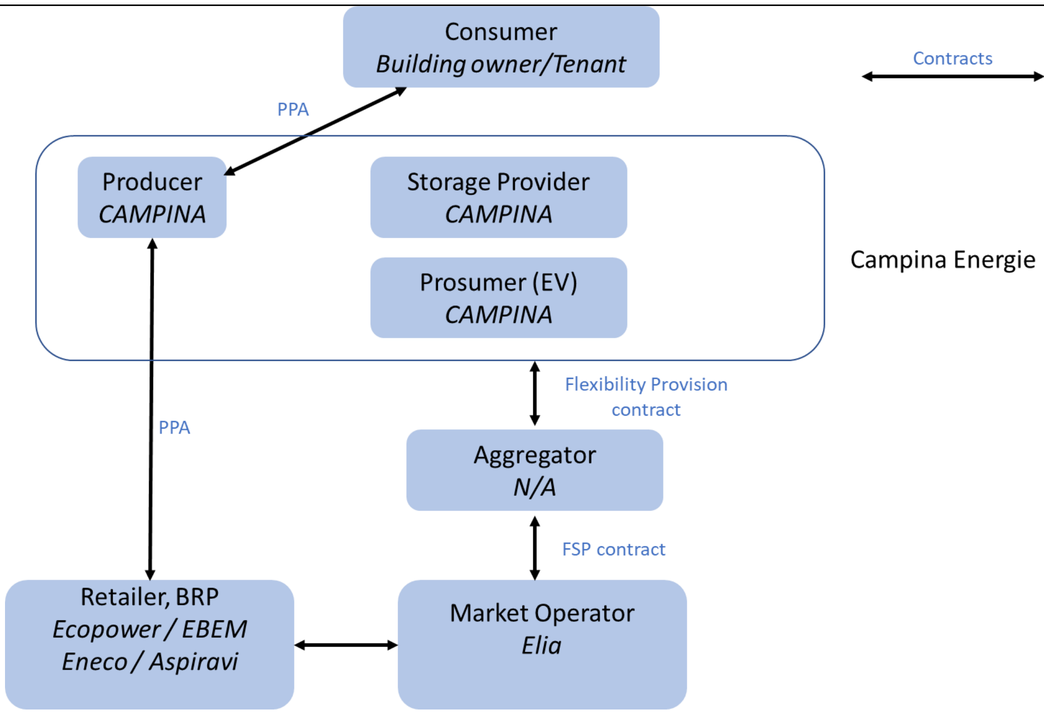


Figure 3-8: Diagram of the contractual relations within BUC 2b.

3 *Key Performance Indicators*

Name	*Description*	*Domain*
REC site IRR	IRR of REC site with and without BESS, EV charging stations, heat pumps and curtailment hardware [%]	Economic
Self-consumption rate	Total amount of locally consumed energy [MWh and %]	Technical
Total amount of stored energy	Total amount of stored energy at site [MWh]	Technical
Community savings	Site and REC savings [€]	Economic
CO_2 savings	The amount of CO_2 saved by the REC [kg CO2]	Environmental
Available flexibility	Volume of flexibility offered to the market operator [MW] or [MWh]	Technical
Accepted flexibility	Volume of flexibility accepted on the markets [MWh]	Technical
Flexibility revenues	Revenues from flexibility provision [€]	Economic

3.5 BUC 3a

1 Description of the Use Case

1.1 General Information

Test Case ID	Name of Test Case
4.2	Social Charging Shared EVs

Maturity of Test Case *– in business operation, realized in demonstration project, realised in R&D, in preparation, visionary*	
The solar installations are installed throughout the neighbourhood of Otterbeek and are thus in business operation. Setup of local shared EVs and charge infrastructure is visionary.	
Classifications According to ReInvent Cross-Sectoral Categories	
Energy Sectors: ☒ Electricity ☐ Gas ☐ Fuels ☐ Heating/Cooling ☐ Bioenergy ☐ Other:	**End-Use Sectors:** ☐ Industry ☒ Residential ☐ Commercial ☒ Transport & Mobility ☐ Agriculture ☐ Other:

1.2 Name of Use Case

ID	Name of Use Case
BUC 3a	Collective, cross-sectoral business models for car sharing in an Energy Community consisting of social housing.

1.3 Scope and Objectives of Use Case

Research Question(s)	Test Case
What would be the appropriate business model for optimized EV sharing in a social district, using locally produced solar power?	Social Charging Shared EVs
Scope	
The energy community of Otterbeek (Mechelen, Belgium) is the first of its kind in attempting to maximise the benefits of rooftop solar production and sharing the excess solar electricity in a social housing district. The excess energy produced here must be valorised maximally to safeguard the viability of this energy community. As there is no complete certainty however (especially with regard to existing Flemish concessions), Klimaan initially regards a list of districts that could also be fit for the project and is in contact with the social housing company and the Municipality. The former is actively engaged in providing additional mobility solutions to its tenants, the latter can grant special purpose exemptions to the public tender.	
Objectives	
To optimize the valorisation of excess PV production using a shared EV as a mobile storage device.	
• To translate this optimized business model to an optimal social sharing tariff for EV charging.	
View *- Technical / Business*	
This use case focuses on the business case of self-managed charge infrastructure combined with optimized pricing and tariff differentiation for shared EVs.	

1.4 Narrative of Use Case

Short description *– max 3 sentences (focus on key points of the use case)*
This use case aims to optimize the local self-consumption of excess solar power by installing charging infrastructure and coupling it with shared EVs. The intention is to increase the value of solar power production, optimize the OPEX of the EVs, and thereby lower the costs specifically for end-users in a social context.
Complete description *– detail all steps and components of use case*

The use case will examine potential optimizations to both valorisation of excess solar production and EV car sharing. Social tenants using the EVs would be able to benefit in the form of a lower cost price for their transport. In a first step we will investigate how EVs can be charged with solar power at the lowest cost, considering the cost to deploy a local charging station. We will also consider whether an additional storage device would be beneficial to this end. In a second step we will formulate pricing mechanisms to optimize the charging costs.

1.5 Use Case Conditions

Assumptions
In our analysis we assume that Klimaan owns all the assets. In case of a public charge station, a special permission from the municipality should be obtained. As both the city and the social housing company must abide public procurement rules, we also consider the possibility of deploying the EVs under a public tender (offtake guarantee). It could be done under the already existing framework agreement of the local intermunicipal organisation IGEMO, or through an in-house tendering process, the latter being more likely. Another option would be to organize the charging infrastructure in a semi-public manner.
Prerequisites
Acquiring an exception to the public charge point offer for local pilots (Flemish government. – MOW) Support from the city of Mechelen and the local social housing company.

1.6 General Remarks

General Remarks

2 Structure

2.1 Actors and Roles

Roles	
☒ Consumer	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☒ Producer	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☐ Prosumer	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ Storage Provider	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ Multi-Energy System (MES) Operator	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☒ DSO/DNO	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☒ Network/Grid user	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☐ TSO	☐ Green Molecules ☐ Electricity ☐ Gas
☐ H/C Network Owner	
☐ Market Operator	
☐ Balance Responsible Party (BRP)	
☒ Supplier/Retailer	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☐ Aggregator	
☐ Regulator	
☐ Flexibility Service Provider (FSP)	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ Data Provider	
☐ Meter Operator	
☐ Meter Data Administrator	
☐ Meter Data Aggregator	
☐ Meter Data Collector	
☐ Metered Data Responsible	
☐ Metering Point Administrator	
☒ Other: Charge point operator	
☒ Other: Mobility Service Provider	
☐ Other: ________________________	

☐ Other: ___________________________	

Actor Name	*Actor Description*	*Role(s)*
Woonland	Social housing company, owner of the Solar PV equipped buildings (renting these out to the direct consumers).	Consumer (self-consumed solar power)
KlimaanSolar PV	Klimaan as owner and responsible of the solar PV assets.	Green energy producer
City of Mechelen	Local municipality, in charge of public domain. Offtake of excess solar PV injection.	Enabler Green energy consumer
Klimaan charge stations	Klimaan as owner and responsible of the charge points.	Charge point owner
Klimaan shared EVs	Klimaan as owner and responsible of the shared EVs.	Green energy consumer
To be defined	The CPO owns and operates the charge points (TBD).	Charge point Operator (CPO)
To be defined	The MSP operates the charging subscriptions and enables charging on more than one charge station. Currently using ROAD BV as MSP, but no flexibility.	Mobility Service Provider (MSP)

2.2 Drawing or Diagram of Use Case

Drawing or Diagram of Use Case – recommended "context diagram" and "sequence diagram" in UML

The first diagram shows the different components of the BUC: Klimaan currently has 70 domestic solar PV installations with 197 more to come in the Otterbeek social housing district in Mechelen, Belgium. Solar power was installed with maximal roof area usage to maximize solar production, resulting in a significant amount of excess solar power. Klimaan aims to optimize the valorisation of this injected power, and one way to achieve this is by deploying charging stations to generate additional local offtake at a stable price. The social tenants would be able to benefit from this energy through the use of shared EVs.

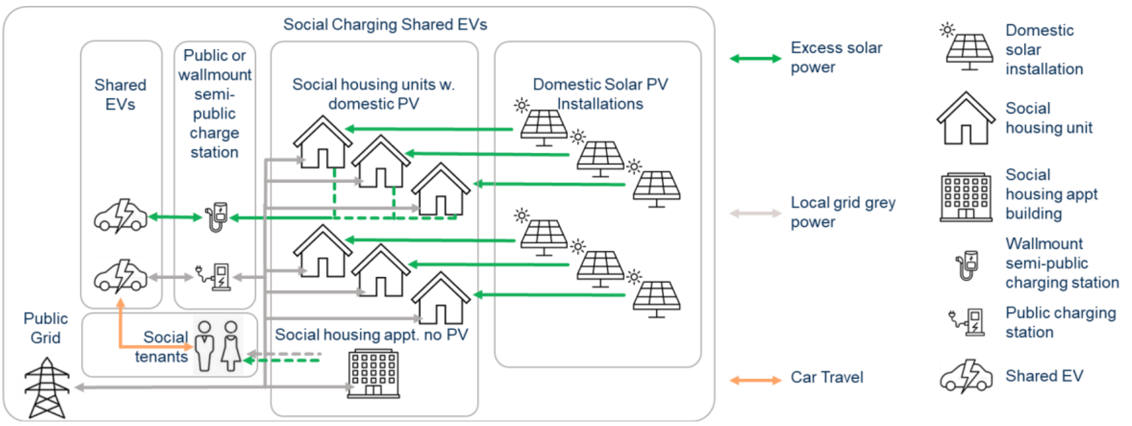


Figure 3-9: Diagram of the main energy flows within BUC 3a.

The second diagram shows the contractual relations in this setup:
Klimaan produces local solar power on social houses and has an injection contract for each of the network access points. The locally consumed electricity is sold to Woonland and then charged to the social tenants individually. In order for a charge point to be deployed in the neighbourhood as well, permission must be granted from the relevant authority (Woonland if wall mounted semi-public, City of Mechelen that needs an exemption for the MOW public tender if public). The charge point, which would be operated by Klimaan, would need offtake from an energy supplier. In order to be able to deploy an EV Klimaan will have a mobility service contract with the social housing company and would also require a charging card subscription. Klimaan would close mobility plans with all social tenants individually.

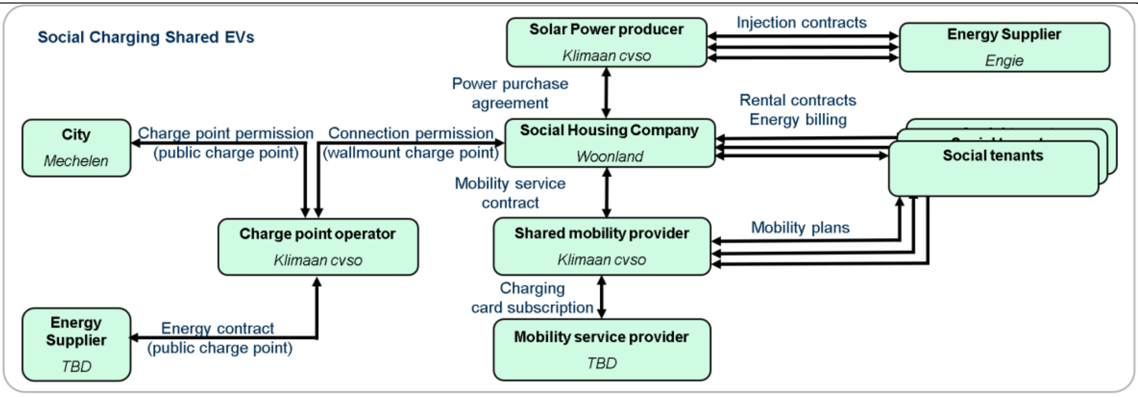


Figure 3-10: Diagram of the contractual relations within BUC 3a.

3 *Key Performance Indicators*

Name	*Description*	*Domain*
Total cost of driving	Cost the end-user should pay [€/km]	Economic
Total cost of EV exploitation	Cost to keep the EV in operation (e.g., insurance, cleaning…). Energy cost depends on actual use [€/month]	Economic
Cost of Mobility services	Cost of MSP service [€/month] service fee (could be outsourced or Klimaan could do it, but always costs)	Economic
Energy costs for charging	Cost for charging the shared EVs, cost charged by MSP [€/kWh]	Economic
Cost of Charge point exploitation	Cost to keep charge point in operation [€/month]	Economic
Total cost of Solar Energy	Cost to produce the local Solar power [€/MWh]	Economic

3.6 BUC 3b

1 Description of the Use Case

1.1 General Information

Test Case ID	Name of Test Case
4.2	Social Charging Shared EVs
Maturity of Test Case *– in business operation, realized in demonstration project, realised in R&D, in preparation, visionary*	
The solar installations are installed throughout the neighbourhood of Otterbeek and are thus in business operation. Setup of local shared EVs and charge infrastructure is visionary.	
Classifications According to ReInvent Cross-Sectoral Categories	
Energy Sectors: ☒ Electricity ☐ Gas ☐ Fuels ☐ Heating/Cooling ☐ Bioenergy ☐ Other:	**End-Use Sectors:** ☐ Industry ☒ Residential ☐ Commercial ☒ Transport & Mobility ☐ Agriculture ☐ Other:

1.2 Name of Use Case

ID	Name of Use Case
BUC 3b	Collective, cross-sectoral business models for flexibility enhanced car sharing in an Energy Community consisting of social housing

1.3 Scope and Objectives of Use Case

Research Question(s)	Test Case
What would be the appropriate business model for flexibility-optimized EV sharing in a social district, using locally produced solar power?	Social Charging Shared EVs
Scope	
The energy community of Otterbeek (Mechelen, Belgium) is the first of its kind in attempting to maximise the benefits of rooftop solar and sharing the excess solar electricity in a social district. The excess energy produced here has to be valorised maximally to safeguard the viability of this energy community. This BUC will investigate how flexibility can improve the benefits of rooftop solar PV. As there is no complete certainty however (especially with regard to existing Flemish concessions), Klimaan initially regards a list of districts that could also be fit for the project and is in contact with the social housing company and the Municipality. The former is actively engaged in providing additional mobility solutions to its tenants, the latter can grant special purpose exemptions to the public tender.	
Objectives	
• To optimize the valorisation of excess production using a shared EV as a dynamic mobile storage device	
• To translate this optimized business model to an optimized social sharing tariff for EV sharing, enhanced using flexibility measures	
View *- Technical / Business*	
This use case focuses on the business case of self-managed charge infrastructure combined with optimized pricing, flexibility and tariff differentiation for shared EVs.	

1.4 Narrative of Use Case

Short description *– max 3 sentences (focus on key points of the use case)*
This use case aims to optimize the local self-consumption of excess solar power by installing charging infrastructure and coupling it with shared EVs. The intention is to increase the value of solar power production, optimise the OPEX of the EVs, and thereby lower the costs specifically for end-users in a social context.

***Complete description** – detail all steps and components of use case*
The use case will examine potential optimizations to both valorisation of excess solar production and EV car sharing. Social tenants using the EVs would be able to benefit in the form of a lower cost price for their transport. Dynamically charging the EVs based on pricing impulses and local distribution network conditions could add additional value to this business use case. In a first step we will investigate how EVs can be charged with solar power at the lowest cost, considering the cost to deploy a local charge station. We will also consider whether an additional storage device would be beneficial to this end. In a second step we will formulate pricing mechanisms to optimize the charging costs.

1.5 Use Case Conditions

Assumptions
In our analysis we assume that Klimaan owns all the assets. In case of a public charge station, a special permission from the municipality is obtained. As both the city and the social housing company have to abide public procurement rules, we also consider the possibility of deploying the EVs under a public tender (offtake guarantee). It could be done under the already existing framework agreement of the local intermunicipal organisation IGEMO, or through an in-house tendering process, the latter being more likely. Another option would be to organize the charging infrastructure in a semi-public manner.
Prerequisites
Acquiring an exception to the public charge point offer for local pilots (Flemish government. – MOW) Support from the city of Mechelen and the local social housing company.

1.6 General Remarks

General Remarks

2 *Structure*

2.1 Actors and Roles

Roles	
☒ Consumer	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☒ Producer	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☐ Prosumer	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ Storage Provider	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ Multi-Energy System (MES) Operator	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☒ DSO/DNO	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☒ Network/Grid user	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☐ TSO	☐ Green Molecules ☐ Electricity ☐ Gas
☐ H/C Network Owner	
☐ Market Operator	
☐ Balance Responsible Party (BRP)	
☒ Supplier/Retailer	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☐ Aggregator	
☐ Regulator	
☐ Flexibility Service Provider (FSP)	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ Data Provider	
☐ Meter Operator	
☐ Meter Data Administrator	
☐ Meter Data Aggregator	
☐ Meter Data Collector	
☐ Metered Data Responsible	
☐ Metering Point Administrator	
☒ Other: Charge point operator	

☒ Other: Mobility Service Provider ☐ Other: ________________________ ☐ Other: ________________________	

Actor Name	*Actor Description*	*Role(s)*
Woonland	Social housing company, owner of the Solar PV equipped buildings (renting these out to the direct consumers).	Consumer (self-consumed solar power)
KlimaanSolar PV	Klimaan as owner and responsible of the solar PV assets.	Green energy producer
City of Mechelen	Local municipality, in charge of public domain Offtake of excess solar PV injection	Enabler Green energy consumer
Klimaan charge stations	Klimaan as owner and responsible of the charge points	Charge point owner
Klimaan shared EVs	Klimaan as owner and responsible of the shared EVs	Green energy consumer
To be defined	The CPO owns and operates the charge points (TBD).	Charge point Operator (CPO)
To be defined	The MSP operates the charging subscriptions and enables charging on more than one charge station. Currently using ROAD, but no flexibility.	Mobility Service Provider (MSP)
Elia	Elia is the transmission system operator for electricity in Belgium and acquires different flexibility services.	TSO (electricity)
Fluvius	Fluvius is the distribution system operator in Belgium and will be acquiring different flexibility services for the electricity distribution network soon.	DSO (electricity)

2.2 Drawing or Diagram of Use Case

Drawing or Diagram of Use Case – recommended "context diagram" and "sequence diagram" in UML
The first diagram shows the different components of the BUC: Klimaan currently has 70 domestic solar PV installations with 197 more to come in the Otterbeek social housing district in Mechelen, Belgium. Solar power was installed with maximal roof area usage to maximize solar production, resulting in a significant amount of excess solar power. Klimaan aims to optimize the valorisation of this injected power, and one way to achieve this is by deploying charging stations to generate additional local offtake at a stable price. The social tenants would be able to benefit from this energy through the use of shared EVs. This diagram is the same as in BUC3a, as it uses the same situational approach.

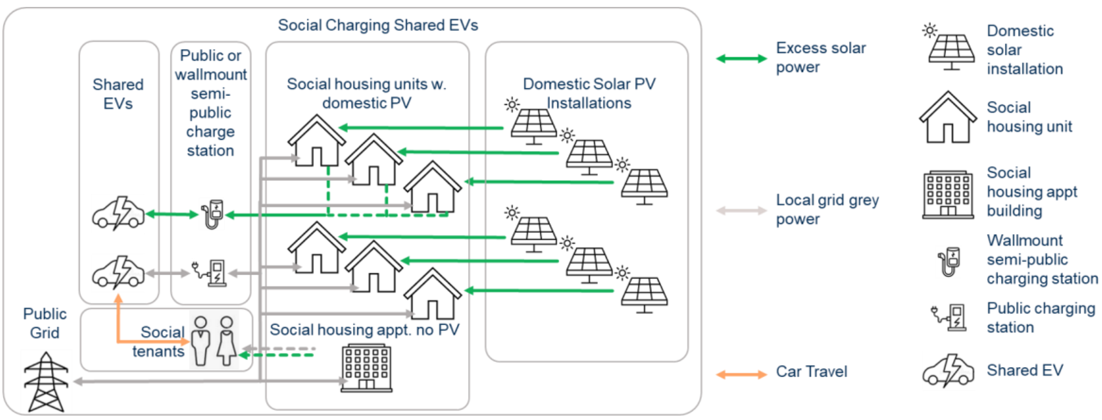


Figure 3-11: Diagram of the main energy flows within BUC 3b.

The second diagram shows the contractual relations in this setup, in which most of the contractual relationships are the same as in BUC3a:
Klimaan produces local solar power on social houses and has an injection contract for each of the network access points. The locally consumed electricity is sold to Woonland and then charged to the social tenants individually. In order for a charge point to be deployed in the neighbourhood as well, permission has to be granted from the relevant authority (Woonland if wall mounted semi-public, City of Mechelen that needs an exemption for the MOW public tender if public). The charge point, which would be operated by Klimaan, would need offtake from an energy supplier. In order to be able to deploy an EV Klimaan will have a mobility service contract with the social housing company and would also require a charging card subscription. Klimaan would close mobility plans with all social tenants individually.
There are some additional relationships added with reference to BUC3a: ·
The Solar power producer and Charge Point Operator both have a flexibility provision contract to offer flexibility to the aggregator. ·In addition, the aggregator has several FSP (Flexibility Service Provider) contracts with the different buyers of flexibility (DSO, TSO, BRP, etc.)
There is a clear difference between the flexibility offered by the Charge Point Operator and the MSP (Mobility Service Provider). The MSP adjusts its calculations independently and autonomously. This means that the MSP can adjust the tariff to specific charging point users. For example, if a lot of solar energy is produced, the prices can go down. Or there can be social correction. For example, if a Klimaan member is charging.
The flexibility that CPO can use is highly dependent on the electricity market. Flexibility services that can be used are those of Elia and in the future Fluvius will also request flexibility. In addition, it can be used to charge at optimal times based on, for instance, day-ahead prices. Every EV user gets a wallet. This needs to be charged to be able to charge. When the user needs to charge very quickly, he will pay more. When the CPO can decide for itself when to charge (cheapest time slot), the price is much lower. This solution will be explained more in detail in BUC 10b.

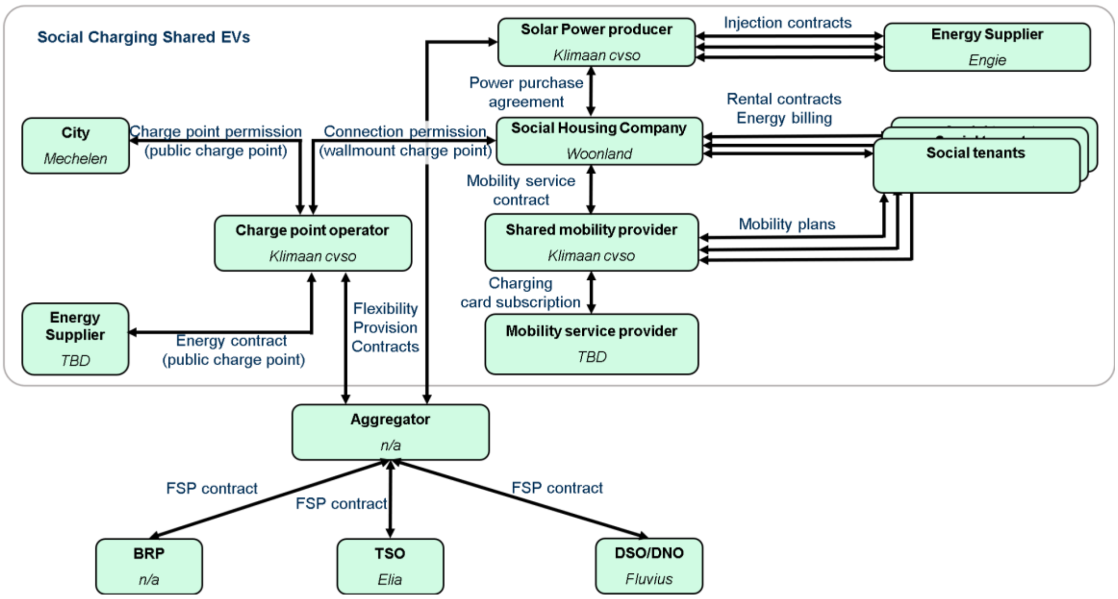


Figure 3-12: Diagram of the contractual relations within BUC 3b.

3 *Key Performance Indicators*

Name	***Description***	***Domain***
Total cost of driving	Cost the end-user should pay [€/km]	Economic

Total cost of EV exploitation	Cost to keep the EV in operation (e.g., insurance, cleaning…). Energy cost depends on actual use [€/month]	Economic
Cost of Mobility services	Cost of MSP service [€/month] service fee (could be outsourced or Klimaan could do it, but always costs)	Economic
Energy costs for charging	Cost for charging the shared EVs, cost charged by MSP [€/kWh]	Economic
Cost of Charge point exploitation	Cost to keep charge point in operation [€/month]	Economic
Total cost of Solar Energy	Cost to produce the local Solar power [€/MWh]	Economic
Flexibility revenues	Revenues from flexibility provision [€/kWh]	Economic
Cost of smart charging	Revenue from smart charging considering dynamic pricing [€/kWh]	Economic

3.7 BUC 4

1 Description of the Use Case

1.1 General Information

Test Case ID	Name of Test Case
4.3	Hybrid Energy Communities - SeaCoop
***Maturity of Test Case** – in business operation, realized in demonstration project, realised in R&D, in preparation, visionary*	
Visionary	
Classifications According to ReInvent Cross-Sectoral Categories	
Energy Sectors: ☒ Electricity ☐ Gas ☐ Fuels ☐ Heating/Cooling ☐ Bioenergy ☐ Other:	**End-Use Sectors:** ☐ Industry ☒ Residential ☐ Commercial ☐ Transport & Mobility ☐ Agriculture ☐ Other:

1.2 Name of Use Case

ID	Name of Use Case
BUC4	Integration of collectively owned offshore wind energy production in the electricity grid, by means of demand side management at REC level and the use of a large-scale battery.

1.3 Scope and Objectives of Use Case

Research Question(s)	Test Case
In which way can the use of a large-scale battery connected with the Elia grid help to reduce the profile and balancing cost of offshore wind production on the level of the REC? How can this reduction in costs be translated to potential benefits for the electricity billing towards the REC-members?	Hybrid Energy Communities (SeaCoop)
Scope	
Sea2Socket aims to connect the electricity production from an offshore wind farm with the electricity demand of many households in Belgium, united in a Renewable Energy Community. In the supply chain, from sea to socket, profiling and balancing risks have to be tackled in a cost-effective way. In the Sea2Socket model those costs for different types of end users (with or without heat pump, PV or EV) are simulated. This business use case investigates further in which way the use of large-scale battery connected with the Elia grid can help to reduce the profile and balancing cost on the level of the REC with potential benefits for the electricity billing of the REC-members. The BUC will be based on theoretical calculations.	
Objectives	
• To evaluate the business case of a large-scale battery on REC-level to mitigate imbalance costs of offshore wind production	
***View** - Technical / Business*	
This use case mainly focuses on the business model, while considering the technical limitations of the technologies considered.	

1.4 Narrative of Use Case

***Short description** – max 3 sentences (focus on key points of the use case)*
The Sea2Socket model evaluates the profiling and imbalance costs associated with offshore wind production in relation to residential consumption profiles. Profiling costs arise from differences between the wind production forecast and the baseload profile, while imbalance costs occur when actual wind production deviates from the forecast, with both costs influenced by increased renewable energy in the grid and creating opportunities for flexibility providers. This BUC will therefore investigate the impact of adding a large-scale battery on the profiling and imbalance costs of a REC.
***Complete description** – detail all steps and components of use case*

The Sea2Socket model investigates the profiling and imbalance costs to be taken into account for offshore wind in relation to residential consumption profiles.

Profiling costs refer to the difference in value between a wind production profile and a "baseload" profile where every hour produces a uniform amount of electricity. The reference for the profiling cost is the day ahead market. The auction for this market closes every day at 12h for power delivered every hour the next day. Due to this time constraint, the wind profile used in this evaluation is the forecasted wind profile at that time, and not the actual measured wind profile. This approach mimics an offshore power producer selling the power he expects to produce every hour the next day. The market value of that forecasted/expected wind profile is the weighted average of the hourly spot prices weighted according to the expected wind production for every hour.

The actual wind production may differ from the forecasted wind production. In that case, the offshore power producer who sold the expected production on the day ahead market will face "imbalance". In that case, ELIA will charge an imbalance fee for the difference between the volume the producer sold day ahead and the actually measured volume. If the wind turbine generates less power than forecasted, the producer sold too much power day ahead and has to buy the difference at the imbalance price. If the wind turbine generates more power than forecasted, the producer did not sell enough day ahead and has to sell the difference at the imbalance price.

ELIA publishes data on offshore wind forecast and measured production profiles. Spot prices are taken from the day ahead market (available on NordPool or EPEX spot) and imbalance prices are also published by ELIA. Based on this historical data the profiling and imbalance costs for an offshore wind profile can be calculated. The baseload value is the unweighted average of all spot prices. The value of the forecasted profile includes the profiling costs for offshore wind. The value of the measured profile also includes the imbalance costs.

The increase in profiling and imbalance costs is mainly driven by the increased share of renewable and intermittent electricity production in the energy mix. With an increased share in the mix, the fluctuations in production become more strongly correlated to the market prices themselves, which automatically increases profiling and imbalance costs.

However, these larger market variations are also opportunities for flexibility providers. The business case for such flexibility providers, for instance storage facilities using batteries, relies on fluctuations in market prices; a battery stores electricity when it is cheap to again use it when it is more expensive. The large market swings that cause high profiling and imbalance costs for offshore wind, automatically also trigger new investments in flexibility and storage. Therefore, in a stabilized and harmonized path, investments in new renewable generation and flexibility will go hand in hand, resulting in an equilibrium where market fluctuations caused by new renewables will be offset by new investments in flexibility.

The interest in market flexibility has also increased. Wind turbines themselves also participate in the reserve markets organized by ELIA (in the "aFRR down" reserve, wind turbines already participate to temporarily turn down production when the power system is over-supplied). Demand side flexibility will become more important with dynamic pricing. Some examples are smart charging of electric vehicles or the smart steering of appliances such as heat pumps. These actions will dampen the market price fluctuations.

The approach to value the profiling and imbalance costs of a typical residential consumption profile is similar to the approach described above for offshore wind. The assumption is that the forecasted profile is settled on the day ahead market and that the difference between the actual consumption profile and that forecast is settled at imbalance prices.

The REC aims to combine production, consumption, demand side management and storage of electricity in a large-scale battery in a cost-effective manner.

1.5 Use Case Conditions

Assumptions
• The BUC is based theoretical calculations, using on the supply side wind production data, on the demand side different synthetic load profiles, different scenarios about energy market and imbalance prices and characteristics of large-scale battery connected with the high-tension grid.
Prerequisites
• Data concerning offshore wind production, real load profiles, day ahead market prices and imbalance prices are publicly available.

1.6 General Remarks

General Remarks

2 Structure

2.1 Actors and Roles

Roles	
☒ Consumer	☐ Green Molecules ☒ Electricity ☒ Heating/Cooling ☐ Gas
☒ Producer	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☒ Prosumer	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☒ Storage Provider	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☐ Multi-Energy System (MES) Operator	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ DSO/DNO	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ Network/Grid user	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ TSO	☐ Green Molecules ☐ Electricity ☐ Gas
☐ H/C Network Owner	
☐ Market Operator	
☒ Balance Responsible Party (BRP)	
☒ Supplier/Retailer	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☐ Aggregator	
☐ Regulator	
☐ Flexibility Service Provider (FSP)	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ Data Provider	
☐ Meter Operator	
☐ Meter Data Administrator	
☐ Meter Data Aggregator	
☐ Meter Data Collector	
☐ Metered Data Responsible	
☐ Metering Point Administrator	
☒ Other: Renewable Energy Community	
☐ Other: ________________________	
☐ Other: ________________________	
☐ Other: ________________________	

Actor Name	Actor Description	Role(s)
Citizens	Citizens that financially participate in ownership of offshore windfarm by membership in a renewable energy community that is member of SeaCoop.	Consumer
SPV Offshore Wind Farm	Consortium that owns and operates the offshore windfarm. SeaCoop is member of this consortium.	Producer

SeaCoop	SeaCoop is shareholder in an offshore windfarm and in the meantime offtaker of 10% of the produced energy and is also responsible for the profile and balance costs.	Storage provider
External party - BRP	Balancing responsibility for SeaCoop (transforming an offshore wind profile into a baseload profile) as well as for Ecopower/Cociter (transforming a baseload profile into a real load profile) is outsourced to another party recognized as balancing responsible party by Elia.	BRP
SeaCoop	SeaCoop is a secondary cooperative whose members are cooperatives of citizens. SeaCoop is erected to organize the direct citizen participation in offshore wind energy. SeaCoop is shareholder in the offshore windfarm, but also offtaker of 10% off the energy production. The energy profile is transformed by transactions on the energy market and sold to Ecopower and Cociter who both have a supply licence.	Retailer
Ecopower and Cociter	Ecopower and Cociter are both members of SeaCoop with a supply licence. They offer this supply service to the members of SeaCoop, which are other energy cooperatives who co-invest in offshore wind, in that way that their participating citizens can conclude a supply contract for the offshore wind to be delivered at their home.	Supplier/retailer
SeaCoop	SeaCoop, and also all the members of SeaCoop, can be defined as a Renewable Energy Community along the principles and definition in the European Renewable Energy Directive. SeaCoop is secondary cooperative whose members are cooperatives of citizens.	REC

2.2 Drawing or Diagram of Use Case

Drawing or Diagram of Use Case – recommended “context diagram” and “sequence diagram” in UML
SeaCoop owns 10% of the offshore windfarm and has access to 10% of the energy production. This offshore wind profile will be injected in the high voltage grid, which is managed by Elia. On some hours, the total offered energy injection (at zero marginal cost) in the Elia grid is higher than the demand so that prices will become negative on the day ahead market (EPEX). That is a signal to curtail wind turbines or to load a large-scale battery. This BUC investigates the opportunity for SeaCoop to invest in and operate a battery. The battery is connected with the Elia grid and can also be used to offer grid services to Elia. After all, Elia has to manage the difference between the real time production and consumption relative to the forecast of energy production and consumption the day ahead. So, the battery can be used to solve this imbalance for Elia. The final consumers are the participating citizens who are member of a REC. The REC not only aims to supply their electricity consumption over the distribution grid, but also to modify their energy consumption away from fossil fuels towards green electricity, by promoting electrical vehicles, electric boilers and heat pumps and also by promoting demand side management. The energy profile is transformed by transactions on the energy market and sold to Ecopower and Cociter who both have a supply licence. The two figures below show respectively the energy flows and the contractual relationships.

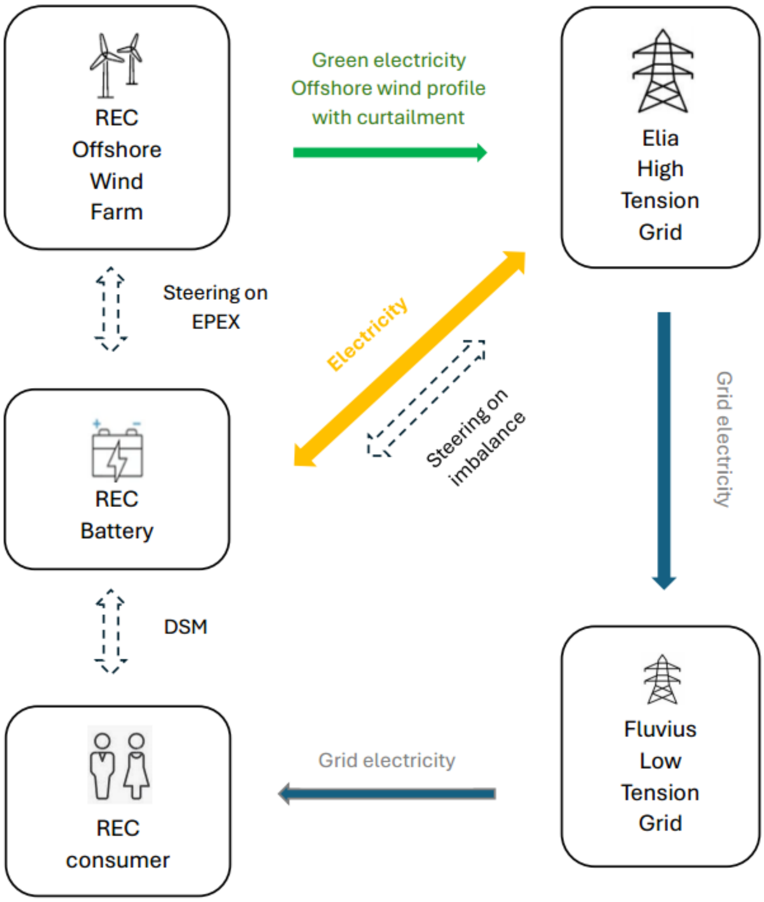


Figure 3-13: Diagram of the main energy flows within BUC 4.

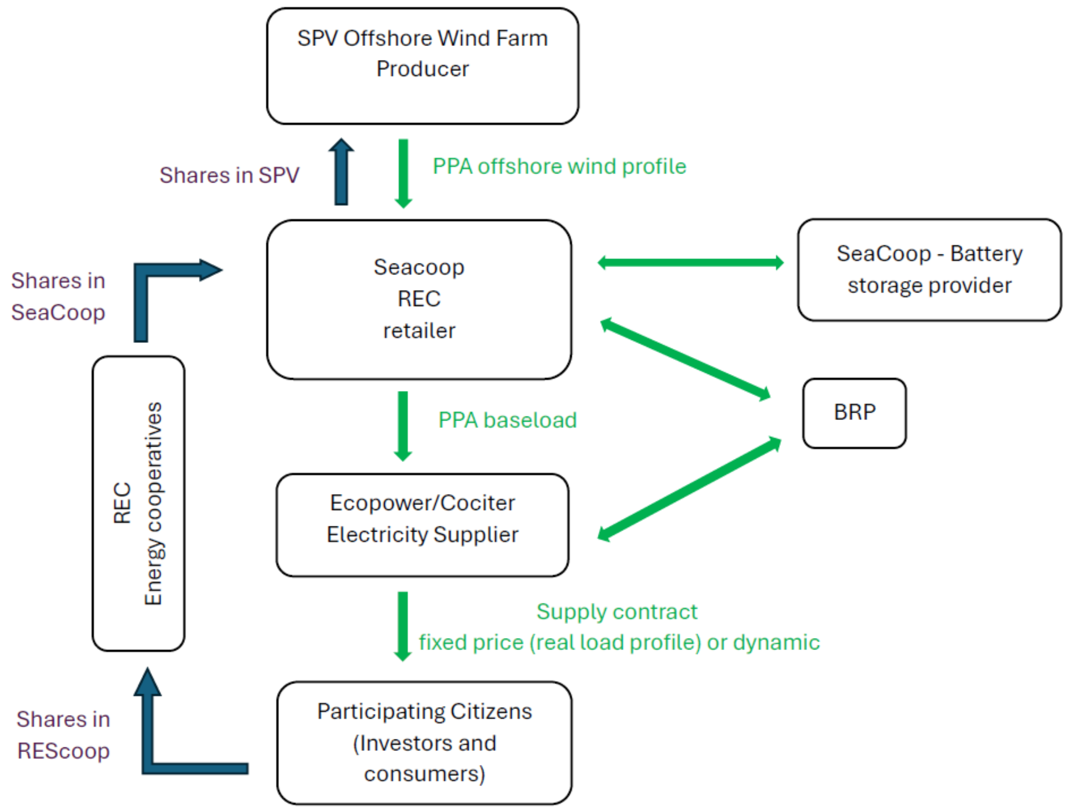


Figure 3-14: Diagram of the contractual relations within BUC 4.

SeaCoop is a secondary cooperative whose members are cooperatives of citizens. SeaCoop organizes the direct citizen participation in offshore wind energy. SeaCoop will become shareholder in the SPV who owns and operates the offshore windfarm.
SeaCoop aims to use 10% off the energy production. To achieve this, SeaCoop wants to conclude a Power Purchase Agreement with the SPV offshore wind farm. The PPA is sold 'power as produced' so that SeaCoop is responsible for the profile and balance costs. To manage those costs in an efficient manner, the use of a large-scale battery connected with the Elia grid is investigated.
Balancing responsibility as well for SeaCoop (transforming an offshore wind profile into a baseload profile) as well for Ecopower/Cociter (transforming a baseload profile into a real load profile) is outsourced to another party recognized as balancing responsible party by Elia.
Ecopower and Cociter are both members of SeaCoop with a supply licence. They offer this supply service to the members of SeaCoop, which are other energy cooperatives who co-invest in offshore wind, in a way that their participating citizens can conclude a supply contract for the use of the offshore wind.
Finally, with citizens acting as both shareholders and end users, the cycle is complete. This represents the core principle of direct citizen participation.

3 *Key Performance Indicators*

Name	*Description*	*Domain*
REC-offshore wind coverage rate	% offshore wind energy production at REC-level in real time used by REC (members + battery)	Technical
REC-offshore wind imbalance cost	Total imbalance cost at REC level [€]	Economic

Battery loading	Number of Load cycles of the battery	Technical
IRR investment battery	Final Internal Rate of Return of the investment in a large-scale battery [%]	Economic

3.8 BUC 5a

1 Description of the Use Case

1.1 General Information

Test Case ID	Name of Test Case
6	Business Renewable Energy Communities (from HospiGREEN to WapiGREEN)
***Maturity of Test Case** – in business operation, realized in demonstration project, realised in R&D, in preparation, visionary*	
HospiGREEN was realized in a demonstration project. WapiGREEN is currently in development. The business renewable energy community (REC) HospiGREEN was a pilot project in Tournai between 01/11/2020 and 28/02/2023. It integrated enterprises, public institutions, and hospitals and demonstrated best practices in the business operation to share and self-consume local renewable energy between its members. Since the end of the project, the new Walloon legal framework has been published. A new business energy community called WapiGREEN is being created for businesses (industries, enterprises, hospitals, public authorities) in Picardy Wallonia. It will start in 2024 and will evolve gradually.	
Classifications According to ReInvent Cross-Sectoral Categories	
Energy Sectors: ☒ Electricity ☐ Gas ☐ Fuels ☐ Heating/Cooling ☐ Bioenergy ☐ Other:	**End-Use Sectors:** ☒ Industry ☐ Residential ☐ Commercial ☐ Transport & Mobility ☐ Agriculture ☒ Other: Enterprises, Public Authorities, Hospitals

1.2 Name of Use Case

ID	Name of Use Case
BUC 5a	Collective, cross-sectoral business models for Business Renewable Energy Communities (without flexibility)

1.3 Scope and Objectives of Use Case

Research Question(s)	Test Case
What is the most-efficient business model for sharing and self-consuming electricity from local photovoltaic and/or wind turbine installations via the DSO network by (the members of) a business energy community?	Business RECs
Scope	
The HospiGREEN REC shared solar and wind locally produced electricity with its members (hospital, caring homes, local authorities and SME businesses) using the DSO's network. The project was operational thanks to a regulatory derogation obtained from the CWaPE. During the project, different allocation keys of green energy between the members were tested, and some new REC members, subject matter experts (SMEs), were added. Invoicing was also done. The members received two invoices: one from the REC for the self-consumed electricity, one from their supplier for the electricity that was consumed on top of the self-consumption. When the project ended, the REC stopped sharing renewable energy in order to bring its operations in line with the new Walloon REC regulation. This new regulation sets some different rules as those that were used during the pilot project. A new legal entity/project called "WapiGREEN" is being created in Picardy Wallonia. The goal is to share and self-consume renewable energy as a community of businesses (industries, enterprises, hospital and public authorities), as from 2024-2025. Around 35 consumption sites are currently being studied. The project will grow progressively in size, with the gradual addition of members and production resources. The energy source will be local solar and wind power. The photovoltaic production for the community will involve producers and prosumers with direct injection on the grid or surplus that is not directly self-consumed. Any supply or consumption of electricity will take place via the distribution network.	
Objectives	

- To optimise the size of the local renewable electricity sources (RES: photovoltaic panels and wind turbine) with the size of the REC membership for a cost-efficient electricity provision to the members collectively.
- To optimise the operation of the REC for a cost-efficient electricity provision to each member through electricity sharing mechanisms (distribution key models) and pricing mechanisms involving the different actors of the value chain (members><REC, REC><suppliers, REC><DSO, etc..)

***View** - Technical / Business*

This use case focuses on both technical and business aspects. The technical aspects focus on the sizing of the RES and distribution keys. The business aspects focus on the operational aspects such as pricing and invoicing.

1.4 Narrative of Use Case

***Short description** – max 3 sentences (focus on key points of the use case)*

This use case aims to optimise the size and operations of the Business energy community in a profitable model. This is to ensure the REC members receive a fair share of the electricity for a fair price and that the REC legal entity can be cost-efficient. The REC members are businesses that share green electricity via the DSO grid for collective self-consumption in Picardy Wallonia.

***Complete description** – detail all steps and components of use case*

The use case will examine optimal sizing of the RES installations for the business REC in Picardy Wallonia that will be set-up with large industries, enterprises, hospitals and public authorities.

It will need to first assess the membership, and consumption needs and then identify the RES installations that could be coupled with the REC. During a previous pilot (HospiGREEN), the RES installations belonged to certain members and consisted in photovoltaics as well as a wind turbine part of a larger multi-owned wind park. This wind turbine is no longer allowed in the REC with the new Walloon regulation as it is part of a larger wind park that is linked to a single electrical cabin. For the new business REC, the use case will examine the best RES solutions (wind and/or solar and the best proportion between both) while considering the permitted regulation.

After these steps, the use case will examine the optimal operational set-up to maximise the benefits for the REC members and for the REC legal entity. It will be important to seek high collective self-consumption rates and high collective supply/coverage rates by setting-up fair and transparent distribution key models.

Moreover, it will be important to find the best pricing mechanisms to ensure REC members and the REC legal entity continue operations in the long-term. The cost-efficient pricing mechanism will need to consider the prices for the commodity: producers and consumers/prosumers in the REC but also suppliers who will buy the excess electricity that is not self-consumed. The costs of Walloon DSO grid usage and the fees and taxes will also need to be considered in the business models. The use case will investigate different electricity sharing and pricing mechanisms and their potential impact on the business model of the different actors involved.

Use Case Conditions

Assumptions

The RES are already installed in Picardy Wallonia and are owned by the REC members (prosumer or producer). All members have smart meters allowing the DSO to measure real-time injection and collection of electricity. In this use case, WapiGREEN is constituted as a CEC (Citizen Energy Community) that allows large businesses to actively participate in the operations. The contractual set-up as CEC or REC does not affect the operational aspects of the use case. For this use case, CEC and REC are both being called REC.

Prerequisites

Follow the new Walloon legal framework for sharing and self-consuming electricity between members of a REC using the DSO network. The metering for the collective self-consumption is measured on a 15-minute basis in Wallonia.

1.5 General Remarks

General Remarks

The REC members will remain anonymous. The membership is not yet finalised.

2 Structure

2.1 Actors and Roles

Roles	
☒ Consumer	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☒ Producer	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☒ Prosumer	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☐ Storage Provider	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ Multi-Energy System (MES) Operator	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☒ DSO/DNO	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☒ Network/Grid user	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☐ TSO	☐ Green Molecules ☐ Electricity ☐ Gas
☐ H/C Network Owner	
☐ Market Operator	
☐ Balance Responsible Party (BRP)	
☒ Supplier/Retailer	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☒ Regulator	
☐ Flexibility Service Provider (FSP)	
☐ Data Provider	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ Meter Operator	
☐ Meter Data Administrator	
☐ Meter Data Aggregator	
☐ Meter Data Collector	
☐ Metered Data Responsible	
☐ Metering Point Administrator	
☒ Other: Renewable Energy Community	
☐ Other: ___________________________	
☐ Other: ___________________________	
☐ Other: ___________________________	

Actor Name	Actor Description	Role(s)
WapiGREEN	Legal entity – non-profit organization (NPO) - created to operate the sharing of local green electricity amongst industries in Picardy Wallonia.	Renewable Energy Community
REC members	REC members are businesses (industries, enterprises, hospitals, public authorities) located in Picardy Wallonia. They may have RES installations (as direct producer and/or prosumer) to provide electricity to share in the REC. They may individually self-consume. They will take part in the collective self-consumption within the REC using the DSO electricity grid. The REC members will also include public authorities to support networking and operations.	Consumer/producer/ prosumer/grid user
CWaPE	Walloon energy regulator.	Regulator
ORES	DSO that validates the collective self-consumption operation and invoices REC grid fees to the REC members' suppliers. Owner of the electricity network in the Tournai region (largest DSO in Wallonia).	DSO
Electricity suppliers	The REC members' suppliers that invoice the REC grid fees and taxes to the REC members and that invoice the electricity bill that is not part of the REC operations.	Supplier

2.2 Drawing or Diagram of Use Case

Drawing or Diagram of Use Case – recommended “context diagram” and “sequence diagram” in UML

The first diagram shows a typology of the Use Case (type of consumers and local generation of electricity). It shows the main energy flows that are distributed through the DSO’s electricity grid.

The renewable production which can be shared is produced by solar panels, or wind turbines. For the solar electricity source, 2 cases are possible: either the full production is available for injection and sharing to the community, OR only the non-self-consumed surplus (prosumer case) is made available to the community. At a certain time, a prosumer is either a supplier to the community OR a consumer of shared electricity.

The REC members/consumers are businesses, not fully known presently. This will be finalized during the project. WapiGREEN, which focuses on large industries located in Picardy Wallonia. The diagram is the same as for BUC5b but without the flexibility mechanism.

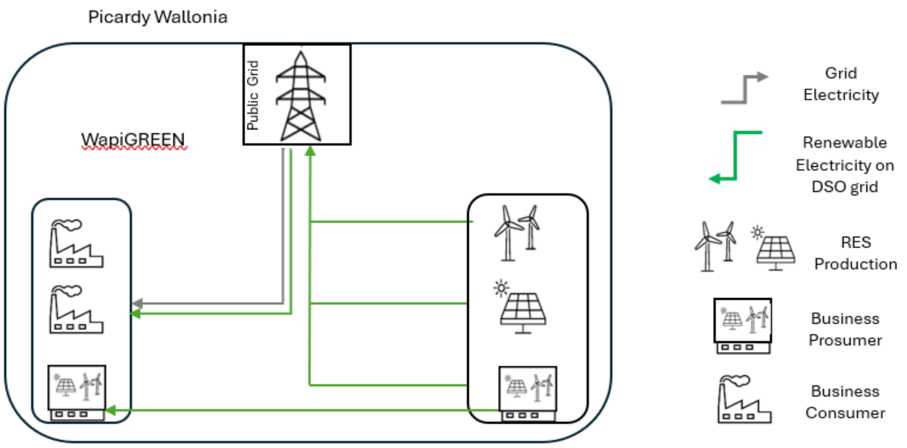


Figure 3-15: Diagram of the main energy flows within BUC 5a.

The second diagram shows the contractual relationships between the different actors. The community’s electricity is distributed through the DSO network operated by ORES. The REC members have a contract with WapiGREEN for the shared self-consumed energy and a contract with a normal supplier for the additional electricity needed. The Business REC invoices the commodity to the REC members. The suppliers invoice the REC fees and taxes as well as a second normal invoice for the extra needs in electricity. The NPO legal entity has a contract with a supplier to sell any excess electricity. WapiGREEN will also buy RES production. Regional authorities may grant green certificates while the REC has to provide a share of green certificates as a supplier.

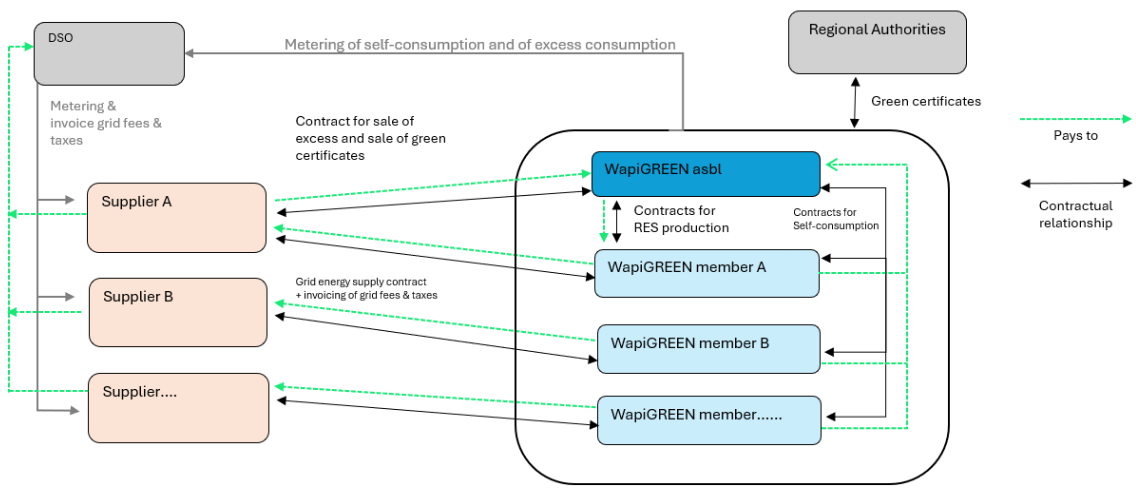


Figure 3-16: Diagram of the contractual relations within BUC 5a.

3 *Key Performance Indicators*

Name	*Description*	*Domain*
Volume of self-consumed electricity (by the REC and each member)	Amount of electricity that is produced and directly self-consumed by the REC and its individual members [MWh]	Technical
Self-consumption rate (collective and individual for each member)	Rate of electricity that was internally available and directly self-consumed by the REC and its members [%]	Technical
Volume of total electricity consumed (by the REC and each member)	Total amount of electricity consumed by the REC members, from external or internal energy sources [MWh]	Technical
Coverage rate (collective and individual for each member)	Rate of REC and members' total consumption covered by the internal self-consumption within the community [%]	Technical
Surplus rate (collective and individual for each member)	Rate of REC electricity that was internally available but not directly self-consumed [%]	Technical
Self-consumption cost (collective and individual for each member)	Cost of the self-consumed energy bought by each REC member from the REC, including fees and taxes [€]	Economic
Total consumption cost (collective and individual for each member)	Cost of the total energy bought by each REC member from the REC and from the supplier, including fees and taxes [€]	Economic
Gain realised	Cost difference between energy bought by REC member compared to full supply on the market [€]	Economic
CO_2 reduction	CO_2 emissions avoided thanks to the REC process [tCO_2]	Environmental

3.9 BUC 5b

1 Description of the Use Case

1.1 General Information

Test Case ID	Name of Test Case
6	Business Renewable Energy Community (from HospiGREEN to WapiGREEN)
***Maturity of Test Case** – in business operation, realized in demonstration project, realised in R&D, in preparation, visionary*	
HospiGREEN was realized in a demonstration project. WapiGREEN is currently in development. The business renewable energy community (REC) HospiGREEN was a pilot project in Tournai between 01/11/2020 and 28/02/2023. It integrated enterprises, public institutions, and hospitals and demonstrated best practices in the business operation to share and self-consume local renewable energy between its members. Since the end of the project, the new Walloon legal framework has been published. A new business energy community called WapiGREEN is being created for businesses (industries, enterprises, hospitals, public authorities) in Picardy Wallonia. It will start in 2024 and will evolve gradually.	
Classifications According to ReInvent Cross-Sectoral Categories	
Energy Sectors: ☒ Electricity ☐ Gas ☐ Fuels ☐ Heating/Cooling ☐ Bioenergy ☐ Other:	**End-Use Sectors:** ☒ Industry ☐ Residential ☐ Commercial ☐ Transport & Mobility ☐ Agriculture ☒ Other: Enterprises, Public Authorities, Hospital

1.2 Name of Use Case

ID	Name of Use Case
BUC 5b	Collective, cross-sectoral business models for Business Renewable Energy Communities with flexibility solutions

1.3 Scope and Objectives of Use Case

Research Question(s)	Test Case
What is the appropriate business model for sharing and self-consuming electricity from local photovoltaic and/or wind turbine installations via the DSO network by a business energy community that can use flexibility solutions?	Business REC
Scope	
The HospiGREEN REC shared solar and wind locally produced electricity with its members (hospital, caring homes, local authorities and SME businesses) using the DSO's network. The project was operational thanks to a regulatory derogation obtained from the CWaPE. During the project, different allocation keys of green energy between the members were tested, and some new REC members (SMEs) were added. Invoicing was also done. The members received two invoices: one from the REC for the self-consumed electricity, one from their supplier for the electricity that was consumed on top of the self-consumption. When the project ended, the REC stopped sharing renewable energy in order to bring its operations in line with the new Walloon REC regulation. This new regulation sets some different rules as those that were used during the pilot project. A new legal entity/project called "WapiGREEN" is being created in Picardy Wallonia. The goal is to share and self-consume renewable energy as a community of businesses (industries, enterprises, hospital and public authorities), as from 2024-2025. Around 35 consumption sites are currently being studied. The project will grow progressively in size, with the gradual addition of members and production resources. The energy source will be local solar and wind power. The photovoltaic production for the community will involve producers and prosumers with direct injection on the grid or surplus that is not directly self-consumed. Any supply or consumption of electricity will take place via the distribution network.	

The BUC 5b is the same as BUC 5a except that it includes flexibility solutions to optimise and increase self-consumption of the REC members. Several flexibility solutions can be considered: adapting consumption pattern of members and adding additional storage to the REC. The flexibility solutions for the industrial processes under consideration include shifting consumption needs, such as those for cooling systems (e.g., refrigerators/freezers) or water pumping operations (e.g., pumping water from rock quarries).

Objectives

- To optimise the size of the local renewable electricity sources (RES: photovoltaic panels and wind turbine) and the size of batteries with the size of the REC membership for a cost-efficient electricity provision to the members.
- To assess the industrial processes' flexibility solutions that the REC members have available to optimise the operations: measure their feasibility and cost impact in relation to gains in self-consumption and reduction in energy costs for the members.
- To optimise the operation of the REC including the flexibility solutions for a cost-efficient electricity provision to each member through electricity sharing mechanisms (distribution key models) and pricing mechanisms (members><REC, REC><suppliers, REC><DSO, etc..)

***View** - Technical / Business*

This use case focuses on both technical and business aspects. The technical aspects focus on the sizing of the RES, flexibility solutions and distribution keys. The business aspects focus on the operational aspects such as pricing and invoicing.

1.4 Narrative of Use Case

***Short description** – max 3 sentences (focus on key points of the use case)*

This use case aims to optimise the size and operations of the Business energy community in a profitable model, while considering the use of flexibility solutions. This is to ensure the REC members receive a fair share of the electricity for a fair price and that the REC legal entity can be cost-efficient. The REC members are businesses that share green electricity via the DSO grid for collective self-consumption in Picardy Wallonia.

***Complete description** – detail all steps and components of use case*

The use case will examine optimal sizing of the RES installations and flexibility solutions (extra batteries on production sites and demand-side flexibility (DSF) of industrial processes) for the business REC in Picardy Wallonia that will be set-up with large industries, enterprises, hospitals and public authorities.

It will need to first assess the membership and consumption needs, the available flexibility in the processes, and then identify the RES installations and needed additional storage (batteries) that could be coupled with the REC. During a previous pilot (HospiGREEN), the RES installations belonged to certain members and consisted in photovoltaics as well as a wind turbine part of a larger multi-owned wind park. This wind turbine is no longer allowed in the REC with the new Walloon regulation because it is part of a larger wind park that is linked to a single electrical cabin. For the new business REC, the use case will examine the best RES solutions (wind and/or solar / storage capacity / DSF) while considering the permitted regulation.

After these steps, the use case will examine the optimal operational set-up to maximise the benefits for the REC members and for the REC legal entity. It will be important to seek high collective self-consumption rates and high collective coverage rates by setting-up fair and transparent distribution key models. The DSF that the REC members can offer by adapting industrial processes can be used to increase collective self-consumption, but also to offer flexibility services to the market (via an aggregator).

It will be important to find the best pricing mechanisms to ensure REC members and the REC legal entity continue operations in the long-term. The cost-efficient pricing mechanism will need to consider the prices for the commodity: producers and consumers/prosumers in the REC but also suppliers who will buy the excess electricity that is not self-consumed and the revenue streams from flexibility services. The costs of Walloon DSO grid usage and the fees and taxes will also need to be considered in the business models.

The model will study how to optimise the sharing operations and define the best pricing mechanism while considering the flexibility potential and its impact on the net benefits/profitability model of the REC as a whole, but also on the different actors involved.

1.5 Use Case Conditions

Assumptions
The RES are already installed in Picardy Wallonia and are owned by the REC members (as prosumer or producer). The batteries are not (yet) installed. The industrial processes that can be operated in a flexible manner will need to be assessed but are probably related to cooling or water pumping processes. All members have smart meters allowing the DSO to measure real-time injection and collection of electricity. In this use case, WapiGREEN is constituted as a CEC (Citizen Energy Community) that allows large businesses to actively participate in the operations. The contractual set-up as CEC or REC does not affect the operational aspects of the use case. For this use case, CEC and REC are both being called REC.
Prerequisites
Follow the new Walloon legal framework for sharing and self-consuming electricity between members of a REC using the DSO network. The metering for the collective self-consumption is measured on a 15-minute basis in Wallonia.

1.6 General Remarks

General Remarks
The REC members will remain anonymous. The membership is not yet finalised.

2 Structure

2.1 Actors and Roles

Roles	
☒ Consumer	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☒ Producer	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☒ Prosumer	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☒ Storage Provider	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☐ Multi-Energy System (MES) Operator	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☒ DSO/DNO	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☒ Network/Grid user	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☒ TSO	☐ Green Molecules ☒ Electricity ☐ Gas
☐ H/C Network Owner	
☐ Market Operator	
☒ Balance Responsible Party (BRP)	
☒ Supplier/Retailer	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☐ Aggregator	
☒ Regulator	
☒ Flexibility Service Provider (FSP)	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☐ Data Provider	
☐ Meter Operator	
☐ Meter Data Administrator	
☐ Meter Data Aggregator	
☐ Meter Data Collector	
☐ Metered Data Responsible	
☐ Metering Point Administrator	
☒ Other: Renewable Energy Community	
☐ Other: ____________________________	
☐ Other: ____________________________	
☐ Other: ____________________________	

Actor Name	*Actor Description*	*Role(s)*

WapiGREEN	Legal entity – NPO - created to operate the sharing of local green electricity amongst industries in Picardy Wallonia.	Renewable Energy Community
REC members	REC members are businesses (industries, enterprises, hospitals, public authorities) located in Picardy Wallonia. One or more members may have RES installations (as direct producer and/or prosumer) to provide electricity to share in the REC. The REC or one or more members may have batteries to store electricity. They may individually self-consume. They will take part in the collective self-consumption within the REC using the DSO electricity grid. The REC members will also include public authorities to support networking and operations.	Consumer/producer/ prosumer/grid user/storage provider
CWaPE	Walloon energy regulator.	Regulator
ORES	DSO that validates the collective self-consumption operation and invoices REC grid fees to the REC members' suppliers. Owner of the electricity network in the Tournai region (largest DSO in Wallonia).	DSO
Electricity suppliers	The REC members' suppliers that invoice the REC grid fees and taxes to the REC members and that invoice the electricity bill that is not part of the REC operations.	Supplier
To be defined	Entity that may contract with the REC to act as an intermediary to offer the flexibility to the RES to different actors (e.g., the TSO).	Aggregator FSP (aggregator)

2.2 Drawing or Diagram of Use Case

Drawing or Diagram of Use Case – recommended "context diagram" and "sequence diagram" in UML
The first diagram shows a typology of the Use Case (type of consumers and local generation of electricity). It shows the main energy flows that are distributed through the DSO's electricity grid. The renewable production which can be shared is produced by solar panels, or wind turbines. For the solar electricity source, 2 cases are possible: either the full production is available for injection and sharing to the community, OR only the non-self-consumed surplus (prosumer case) is made available to the community. At a certain time (quarter measure), the prosumer either supplies the community with electricity or consumes from the community. The REC members are businesses, not fully known presently. WapiGREEN focuses on large industries located in Picardy Wallonia. The diagram is the same as for BUC5a but with the flexibility options that will affect the self-consumption rate, that is the quantity of energy flows at a certain time.

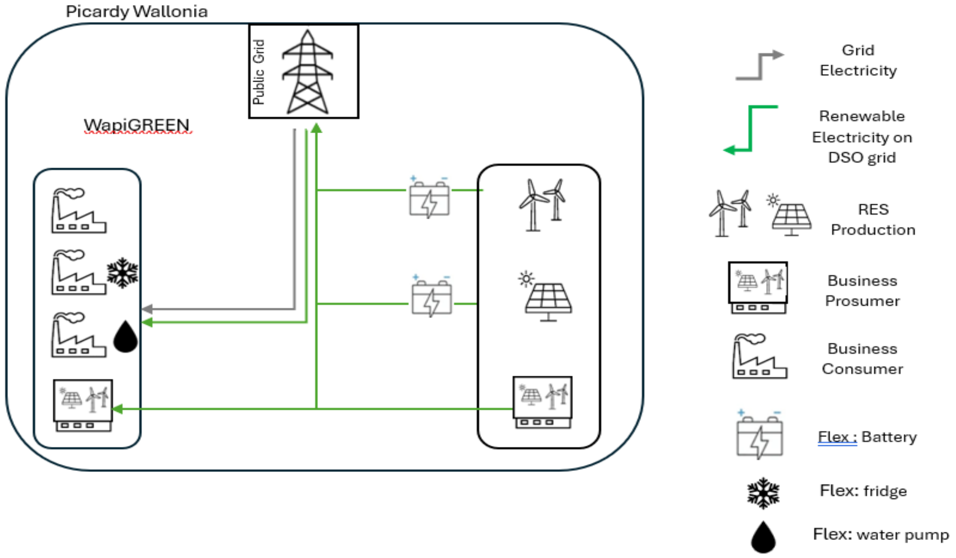


Figure 3-17: Diagram of the main energy flows within BUC 5b.

The second diagram shows the contractual relationships between the different actors. The community's electricity is distributed through the DSO network operated by ORES. The REC members have a contract with WapiGREEN for the shared self-consumed energy and a contract with a normal supplier for the additional electricity needed. The Business REC invoices the commodity to the REC members. The suppliers invoice the REC fees and taxes as well as a second normal invoice for the extra needs in electricity. The NPO legal entity has a contract with a supplier to sell any excess electricity. WapiGREEN will also buy RES production. Regional authorities may grant green certificates while the REC must provide a share of green certificates as a supplier. The flexibility contracts would be signed with an aggregator. The contractual relationships are the same as for BUC5b but with an additional contractual relation to the aggregator for the flexibility provision.

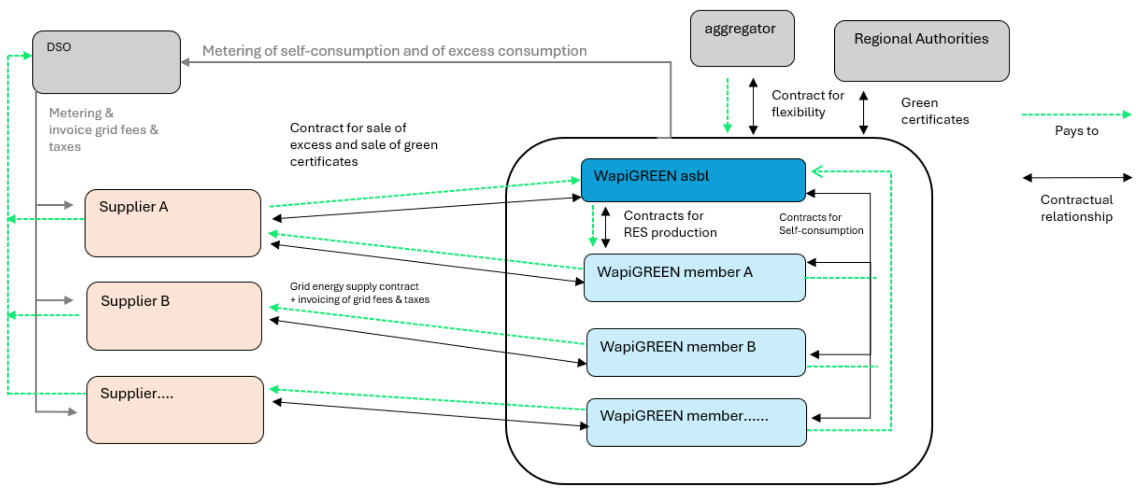


Figure 3-18: Diagram of the contractual relations within BUC 5b.

3 Key Performance Indicators

Name	Description	Domain
Volume of self-consumed electricity (by the REC and each member)	Amount of electricity that is produced and directly self-consumed by the REC and its individual members [MWh]	Technical

Self-consumption rate (collective and individual for each member)	Rate of electricity that was internally available and directly self-consumed by the REC and its members [%] -	Technical
Volume of total electricity consumed (by the REC and each member)	Total amount of electricity consumed by the REC members, from external or internal energy sources [MWh]	Technical
Coverage rate (collective and individual for each member)	Rate of REC and members' total consumption covered by the internal self-consumption within the community [%]	Technical
Surplus rate (collective and individual for each member)	Rate of REC electricity that was internally available but not directly self-consumed [%]	Technical
Self-consumption cost (collective and individual for each member)	Cost of the self-consumed energy bought by each REC member from the REC, including fees and taxes [€]	Economic
Total consumption cost (collective and individual for each member)	Cost of the total energy bought by each REC member from the REC and from the supplier, including fees and taxes [€]	Economic
Gain realised	Cost difference between energy bought by REC member compared to full supply on the market [€]	Economic
Flexibility volume	The volume of electricity that has been moved or stored due to the flexibility solutions [MWh]	Technical
Flexibility gains	Revenues from flexibility mechanisms [€]	Economic
CO2 reduction	CO2 emissions avoided thanks to the CER and its flexibility mechanism [tCO2]	Environmental

3.10 BUC 6a

1 Description of the Use Case

1.1 General Information

Test Case ID	*Name of Test Case*
2	From "Wind to Trucks": Green Hydrogen for heavy-duty vehicles

Maturity of Test Case – in business operation, realized in demonstration project, realised in R&D, in preparation, visionary
The 'Wind to trucks" project is currently being studied on technical, profitability, and market demand aspects. A decision will confirm whether the whole value chain can be considered as a cost-efficient investment over time. The filling station should supply hydrogen by the end of 2027.

Classifications According to ReInvent Cross-Sectoral Categories	
Energy Sectors: ☒ Electricity ☐ Gas ☒ Fuels (hydrogen) ☐ Heating/Cooling ☐ Bioenergy ☐ Other:	**End-Use Sectors:** ☒ Industry ☐ Residential ☐ Commercial ☒ Transport & Mobility ☐ Agriculture ☐ Other:

1.2 Name of Use Case

ID	*Name of Use Case*
BUC6a	Cross sectoral business models for long haul trucks on Hydrogen.

1.3 Scope and Objectives of Use Case

Research Question(s)	*Test Case*
What is the most appropriate techno-economic model to run heavy vehicles on hydrogen (trucks/industrial vehicles) produced from local green electricity, while considering the required profitability and competitiveness of the ecological fuel?	GREEN H2 for trucks

Scope
This use case aims at defining a cost-efficient business model to locally operate a production, storage and distribution unit for green hydrogen mainly dedicated to heavy transport. Currently, the test case focuses on supplying eco-friendly fuel to long-haul trucks, but it could also extend to supplying heavy vehicles used at local industrial sites. H2 will be produced in a sustainable manner by electrolysis of water, and power will be supplied from an existing 2MW wind turbine and a complementary photovoltaic park (1-1.7 MW) to be built. The renewable energy production tools are located on – or next to – the H2 station where a direct grid connection is possible. Electricity will be used primarily to supply trucks with hydrogen while extra generation will be injected into the grid. In the first stage of the pilot, the demand-side reflects the needs of a fleet of 10 hydrogen-powered trucks which corresponds to about 80-85 tons of H2 per year. Each truck is running about 110.000 km/year. The electrolyser (1.25 MW) has been dimensioned accordingly but the equipment can make the most of its capacity as it also includes, in addition to the trucks filling station, the possibility to sell excess hydrogen to industry via tube trailers. A storage capacity of high-pressure hydrogen is implemented to cover periods of low renewable energy production. The project is modular in time; a second phase foresees the replacement of the existing wind turbine at its end of life (+/-2036) by a more powerful equipment that could meet a greater demand. The operation is contractually secured by the creation of a project company holding the green power assets and which will invest in the electrolysis equipment and the distribution station. Two Business Units are created in the company to respect the profitability requirements of each unit: the green production unit and the hydrogen unit. An intermediate site operator with authorizations as fuel distributor will organize site

maintenance and the sale of hydrogen. The project also benefits from a partnership with a transport company that will own 10 trucks representing the demand-side of hydrogen usage. At this stage it seems however complex to factor the extra price of hydrogen into transport costs to final customers, even with the regional support obtained in capital investment.
Objectives
Optimize the techno-economic model for profitable local hydrogen production, to supply local enterprises using heavy vehicles (long haul trucks or industrial vehicles) with a competitive fuel. • Check the technical specifications of the production facilities and energy coupling according to current market demand and pricing mechanisms. • Identify and measure all valuation opportunities related to energy markets and related pricing mechanisms that could enhance the profitability of the model and reduce the extra cost of hydrogen in trucks mobility (adapted production timing according to green energy availability and market prices combined with storage capacity on site, best share between different green energy sources, possible refilling patterns for trucks, valuation of CO2 reductions...) • Determine the most appropriate production and business model to enhance competitiveness of hydrogen as an alternative green fuel for long haul trucks and ensure a cost-efficient solution for the company (investors).
View *- Technical / Business*
This use case focuses on technical, business and profitability aspects across the whole value chain of locally produced green hydrogen as truck fuel. It will first check the technical aspects of the energy-coupled production model and combine it with market aspects and pricing mechanism to set up a profitable model for selling H2 fuel.

1.4 Narrative of Use Case

Short description *– max 3 sentences (focus on key points of the use case)*
This use case aims at determining a cost-efficient business model to supply hydrogen produced locally from distribution water with solar and wind power, as ecological fuel for heavy-duty vehicles and long-haul trucks. The potential for increased profitability will be analysed across the whole value chain of hydrogen, given technical flexibility aspects in its production process, the T/DSO network and pricing mechanisms for electricity, and the value of decarbonization to improve competitiveness of hydrogen as a fuel for mobility.
Complete description *– detail all steps and components of use case*
The use case aims at determining the most appropriate model to operate in a cost-efficient manner the local production, storage and distribution of green hydrogen dedicated to heavy transport or industry. It will first investigate how H2 can be produced and supplied locally at the lowest cost considering the operational characteristics of the assets and energy conversion technologies implemented in the pilot. This should enable to determine the best product pricing given different constraints: assets costs, local H2 fuel demand, H2 required compression according to trucks technology, necessary intermediate storage, profitability requirements for the company (shareholders' return and service station operator fee). The potential of profitability arising from market pricing mechanism as well as from flexibility in the production process should be evaluated and combined: best share between wind and solar use for electricity sourcing, appropriate H2 storage capacity on site, ideal pattern for refuelling trucks, optimal production timing, ... Different simulations involving cross-sectoral market gains should be implemented to assess the impact on the model profitability and determine the best H2 final net cost price. The simulations will consider the market value of decarbonization (CO2 gains), grid fees and market pricing methodologies, optimal production timing and storage, ...

The simulations should help to determine a suitable model for a competitive fuel from "wind to trucks" while guaranteeing a minimum profitability to investors, site operators and retailers involved in the marketing chain.

1.5 Use Case Conditions

Assumptions
Prerequisites
Local production enables direct coupling of electricity assets to the H2 filling station with only surplus injection to the DSO grid, saving grid fees and balancing charges in costing. This point may not be realizable similarly in all regions of Belgium. This is possible in Wallonia with specific authorisation from CWAPE.

1.6 General Remarks

General Remarks

2 *Structure*

2.1 Actors and Roles

Roles	
☒ Consumer	☒ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☒ Producer	☒ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☒ Prosumer	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☒ Storage Provider	☒ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ Multi-Energy System (MES) Operator	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☒ DSO/DNO	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☒ Network/Grid user	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☐ TSO	☐ Green Molecules ☐ Electricity ☐ Gas
☐ H/C Network Owner	
☐ Market Operator	
☒ Balance Responsible Party (BRP)	
☒ Supplier/Retailer	☒ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☐ Aggregator	
☐ Regulator	
☐ Flexibility Service Provider (FSP)	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ Data Provider	
☐ Meter Operator	
☐ Meter Data Administrator	
☐ Meter Data Aggregator	
☐ Meter Data Collector	
☐ Metered Data Responsible	
☐ Metering Point Administrator	
☐ Other: ________________________	
☐ Other: ________________________	
☐ Other: ________________________	
☐ Other: ________________________	

Actor Name	*Actor Description*	*Role(s)*
ELECTRICITY SUPPLIER.SA	Grid supplier - Supplier and buyer of electricity on the grid Acts as BRP for the injection part.	Supplier (electricity) BRP (electricity)
ASSETS.SA - Business Unit GREEN POWER	Special purpose company created with shareholders directly involved in the project to own all production assets.	Producer (electricity)

	Separate Business Units (BU) are foreseen in function of the type of energy production. • Producer of green electricity WIND and SOLAR • Grid user for electricity consumption, and electricity injection • Assets.Sa, - all BU included - can be considered as a prosumer.	Grid user (electricity) Prosumer (electricity)
ASSETS.SA - Business Unit H2	Special purpose company created with shareholders directly involved in the project to own all production assets. Separate Business Units are foreseen in function of the type of energy production. • Consumer of green and grey electricity • Producer of Hydrogen • Storage of compressed hydrogen	Consumer (electricity) Producer (Hydrogen) Storage (Hydrogen)
SERICESTATION.SA	Filling station operator Supplier/retailer of compressed hydrogen to heavy-duty vehicles Consumer of electricity on site to run the dispenser equipment.	Supplier/retailer (hydrogen) Consumer (electricity)
TRANSPORT.SA	Transport company with trucks on hydrogen Consumer/buyer of hydrogen	Consumer (hydrogen)
INDUSTRY.SA	Industry consuming / buying hydrogen	Consumer (hydrogen)
ORES	Public grid operator - Company operating the distribution network in a major part of Wallonia, but not exclusively.	DSO

2.2 Drawing or Diagram of Use Case

Drawing or Diagram of Use Case – recommended “context diagram” and “sequence diagram” in UML
The diagram represents the ENERGY flows of the test case as currently designed. However, the dimensioning, flexibility options and direct grid connections may bring relevant variants. The wind and solar power production equipment is located next to the hydrogen plant and industry/transporter site. It is connected to the public electricity grid for injection of excess production. The hydrogen production is powered directly from green energy while additional needs can come from the grid. Compressed hydrogen is stored on site to supply either long haul trucks delivering transport services, or tube trailer filling for hydrogen transport for industry use.

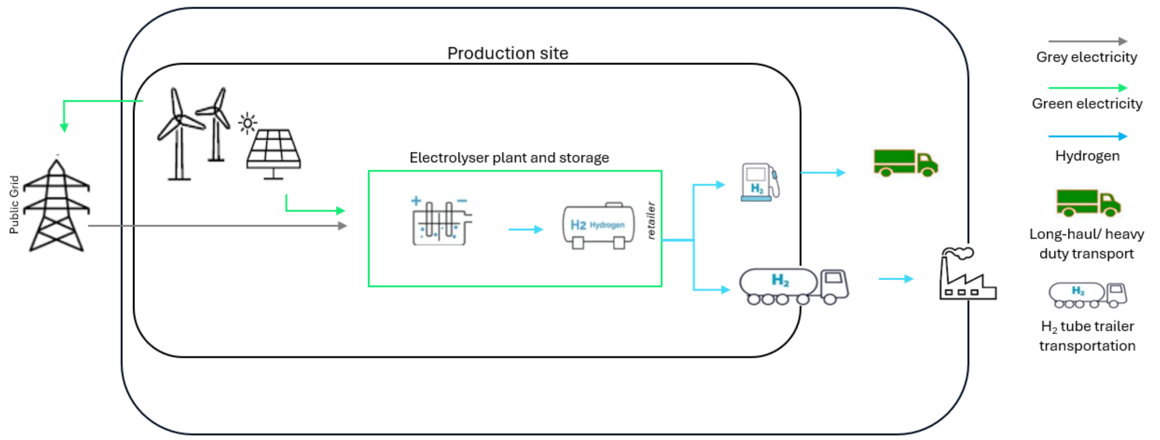


Figure 3-19: Diagram of the main energy flows within BUC 6a.

CONTRACTUAL and FINANCIAL relations: In the current scenario, 5 different legal entities have contractual relationships. The Electricity supplier and the Assets owner have a contract for buying grid electricity and a power purchase agreement (PPA) for selling injection and green certificates. The PPA includes the BRP services. The Assets owner is divided in two Business Units, with an internal agreement to supply the hydrogen plant with the internal electricity. The green power unit expects however a similar revenue compared to full grid injection. Extra electricity to the H2 plant can come from the grid in case of insufficient green production. Hydrogen is made available to the retailer for sale to transport or industrial companies.

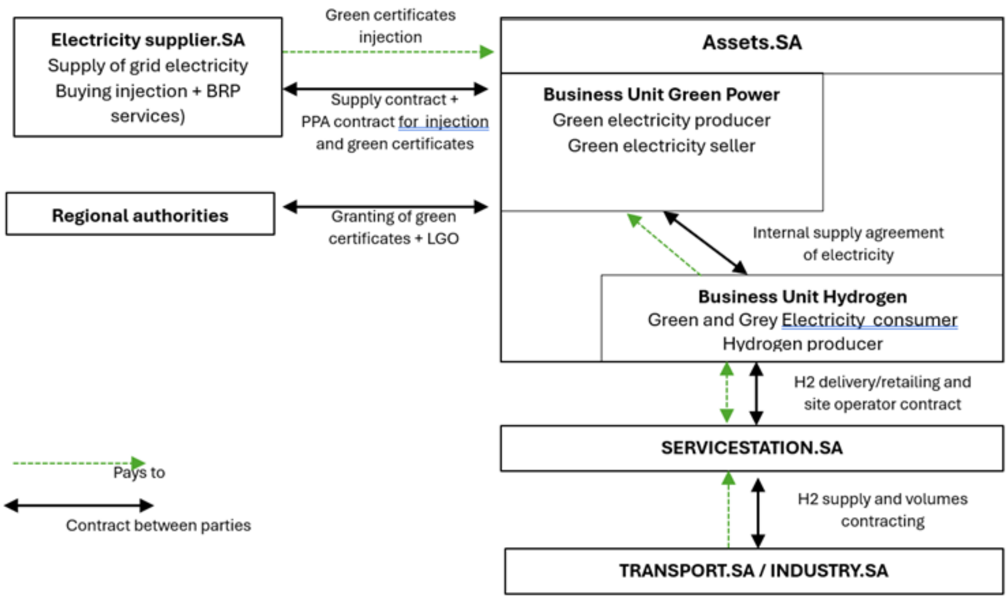


Figure 3-20: Diagram of the contractual relations within BUC 6a.

3 *Key Performance Indicators*

Name	*Description*	*Domain*
CO2 valuation	Estimated gains from CO2 reductions [€ / 100 km]	Economic
Investment profitability	% ROI - for Assets.sa - per Business Unit	Economic

Fuel net cost price	Final cost price of H2 [€ / kg H2]	Economic
Fuel net sales price	Final selling price of H2 [€ / kg H2]	Economic
Share of electricity sources in H2 production	The share of each electricity source used to produce H2 (share of wind electricity [%], share of solar electricity [%], share of grid electricity [%])	Technical
Production cost of auto-consumed electricity	Total production cost of auto-consumed green electricity provided to the H2 plant [€ / MWh]	Economic
H2 Storage capacity	H2 storage capacity on site (at a certain pressure) [kg H2]	Technical
Quantity of injected electricity	Total quantity of green electricity injected into the grid [MWh]	Technical
Quantity of auto-consumed electricity	Total quantity of green electricity auto consumed for H2 production [MWh]	Technical
Total Capex	Total Capex costs for Assets.SA (+ transport related investments) [€]	Economic
Transport cost price	Final cost price of road transport [€/100 km]	Economic
Opportunity cost of auto-consumed electricity	Revenues that would have been generated if the auto-consumed electricity was injected on the grid (net sales price and GOs included) [€/MWh]	Economic
Share and volume of produced H2 sold to transport and to industries (extra demand)	Share of H2 production sold to transport [%] Share of H2 production sold to extra demand [%]	Technical

3.11 BUC 6b

1 Description of the Use Case

1.1 General Information

Test Case ID	Name of Test Case
2	From "Wind to Trucks": (Green Hydrogen) for heavy-duty vehicles
***Maturity of Test Case** – in business operation, realized in demonstration project, realised in R&D, in preparation, visionary*	
The 'Wind to trucks" project is currently being studied on technical, profitability, and market demand aspects. A decision will confirm whether the whole value chain can be considered as a cost-efficient investment over time. The filling station should supply hydrogen by the end of 2027. A variant may be studied to directly run the trucks on green electricity given the important barriers identified in the design phase of the hydrogen project.	
Classifications According to ReInvent Cross-Sectoral Categories	
Energy Sectors: ☒ Electricity ☐ Gas ☒ Fuels (hydrogen) ☐ Heating/Cooling ☐ Bioenergy ☐ Other:	**End-Use Sectors:** ☒ Industry ☐ Residential ☐ Commercial ☒ Transport & Mobility ☐ Agriculture ☐ Other:

1.2 Name of Use Case

ID	Name of Use Case
BUC6b	Cross sectoral business models for long haul trucks mobility from local green power.

1.3 Scope and Objectives of Use Case

Research Question(s)	Test Case
What is the most appropriate model to run long haul trucks / heavy vehicles on locally produced green energy, the hydrogen or electric variant?	GREEN H2 for trucks
Scope	
This use case aims at defining the most cost-efficient energy model to run long haul trucks from green local production. At this point, the initial test case - which was optimized in BUC 6A - foresees a conversion of wind and solar green power to hydrogen to supply the transport company. Given the rapid evolution of electric truck technologies and electric range, this use case will compare the optimal hydrogen model with a fully electric option as a low-carbon alternative. In the initial test case, H2 is produced in a sustainable manner by electrolysis of water, and power is supplied from an existing 2MW wind turbine and a complementary photovoltaic park (1-1.7 MW) to be built. The renewable energy production tools are located on – or next to – the H2 distribution station where a direct grid connection is possible. Electricity is used primarily to supply trucks with hydrogen while extra generation is injected into the grid. In the first stage of the pilot, the demand-side reflects the needs of a fleet of 10 hydrogen-powered trucks which corresponds to about 80-85 tons of H2 per year. Each truck is running about 110.000 km per year. The electrolyser (1.25 MW) has been dimensioned accordingly but the equipment can make the most of its capacity as it also includes, in addition to the trucks filling station, the possibility to sell excess hydrogen to industry via tube trailers. A storage capacity of high-pressure hydrogen is implemented to cover periods of lower renewable energy production. The project is modular in time; a second phase foresees the replacement of the existing wind turbine at its end of life (+/-2036) by a more powerful equipment that could meet a greater demand. The operation is contractually secured by the creation of a project company (SPV) holding the green power assets and which will invest in the conversion / storage equipment and the distribution station. Two Business	

Units are created in the company in order to respect the profitability requirements of each unit: the green power production unit and the fuel distribution unit. An intermediate site operator with authorizations as fuel distributor will organise site maintenance and sale. The project also benefits from a partnership with a transport company that will own 10 trucks representing the demand-side. At this stage it seems however complex to factor the extra price of the alternative fuel into transport costs to final customers, even with the regional support obtained in capital investment. Given the technical and economic barriers identified in the project design phase and the current unavailability of adapted hydrogen long haul powered trucks and given the quick development of full electric mobility, an alternative model without hydrogen conversion will be studied in this BUC.
Objectives
Determine the most suitable techno-economic model – with or without hydrogen conversion - to supply long haul transport services using a low carbon fuel produced from local wind and solar power or by direction use of the renewable electricity to charge the trucks. • Provide a comparative analysis between the optimized hydrogen fuel production solution determined in BUC 6a and an equivalent full electric option, considering technical aspects, costing variations, optimized pricing solutions and global return on investment. • In addition to the fuel production aspects, include in the comparative analysis all parameters, benefits and costs related to the transport itself to determine the best option form the end-user point of view.
View *- Technical / Business*
This use case focuses on technical, business and profitability aspects across the whole value chain of locally produced green fuel for running long haul trucks. It will first provide a technical variant of BUC 6a with a different fuel production pattern and also evaluate the new business and profitability aspects related to this modification.

1.4 Narrative of Use Case

Short description *– max 3 sentences (focus on key points of the use case)*
The current use case will analyse the most efficient option to provide road heavy-duty transport services from local green power. As a variant to BUC 6a, it will compare the wind-to hydrogen-to trucks (VH) version with a full electric option (VE), starting from the optimized parameters determined in BUC 6a. The technical, costing, investments and market pricing aspects will be analysed. It will consider the fuel production as well as transport equipment costs and decarbonation gains in the model to provide a comparison to the end-user of the transport services.
Complete description *– detail all steps and components of use case*
The use case aims at determining the most appropriate techno-economic energy model to run long haul trucks with a low-carbon fuel supplied from local green power. Two options will be compared: the wind-to hydrogen-to trucks version (VH) and the wind-to trucks (full electric) version (VE). The analysis will first focus on the fuel production models. For the VH, it will use the optimized solution determined in BUC 6a. The technical modifications for VE will be simulated and their impact on global costs and profitability will be evaluated. Similarly, to BUC 6a, an optimisation of the electric business case can be proposed while considering the best advantage of market pricing mechanism as well as flexibility potential in this alternative production process (best share between wind and solar production, appropriate storage capacity versus capex costs and production planning, ...) The comparative analysis will then focus on the final transport price to the end-user by including the whole transport investments costs and potential benefits as the valuation of CO_2 reductions in both variants. As a result, the most efficient model for road freight transport will be determined and the two variants will be compared in terms of return to the investors for the fuel production and final cost to the consumer.

1.5 Use Case Conditions

Assumptions
Prerequisites
Local production enables direct coupling of electricity assets to the charging station with only surplus injection to the DSO grid, saving grid fees and balancing charges in costing. This point may not be realizable similarly in all regions of Belgium. This is possible in Wallonia with specific authorisation from CWAPE.

1.6 General Remarks

General Remarks

2 Structure

2.1 Actors and Roles

Roles	
☒ Consumer	☒ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☒ Producer	☒ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☒ Prosumer	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☒ Storage Provider	☒ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☐ Multi-Energy System (MES) Operator	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☒ DSO/DNO	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☒ Network/Grid user	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☐ TSO	☐ Green Molecules ☐ Electricity ☐ Gas
☐ H/C Network Owner	
☐ Market Operator	
☒ Balance Responsible Party (BRP)	
☒ Supplier/Retailer	☒ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☐ Aggregator	
☐ Regulator	
☐ Flexibility Service Provider (FSP)	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ Data Provider	
☐ Meter Operator	
☐ Meter Data Administrator	
☐ Meter Data Aggregator	
☐ Meter Data Collector	
☐ Metered Data Responsible	
☐ Metering Point Administrator	
☐ Other: ________________________	
☐ Other: ________________________	
☐ Other: ________________________	
☐ Other: ________________________	

Actor Name	Actor Description	Role(s)
ELECTRICITY SUPPLIER.SA	**VH / VE**: Grid supplier - Supplier and buyer of electricity on the grid Acts as BRP for the injection part.	Supplier (electricity) BRP (electricity)
ASSETS.SA - Business Unit GREEN POWER	**VH / VE:** • Special purpose company created with shareholders directly involved in the project to own all production assets. Separate Business Units are	Producer (electricity) Grid user (electricity)

	foreseen in function of the type of energy production Producer of green electricity WIND and SOLAR. • Grid user for electricity consumption, and electricity injection. • Assets SA for all business units considered as a prosumer.	Prosumer (electricity)
ASSETS.SA - Business Unit fuel production and Distribution	**VH:** Special purpose company created with shareholders directly involved in the project to own all production assets. Separate Business Units are foreseen in function of the type of energy production or distribution. • Consumer of green and grey electricity • Producer of Hydrogen • Storage of compressed hydrogen **VE** Special purpose company created with shareholders directly involved in the project to own all production assets. Separate Business Units are foreseen in function of the type of energy distribution. • Consumer of green and grey electricity • Storage of electricity	Consumer (electricity) Producer (Hydrogen) Storage (Hydrogen) Consumer (electricity) Storage (electricity)
SERICESTATION.SA	**VH** Filling station operator Supplier/retailer of compressed hydrogen to heavy-duty vehicles Consumer of electricity on site to run the dispenser equipment. **VE** Filling/distribution station operator Supplier/retailer of electricity to heavy-duty vehicles Consumer of electricity on site to run the dispenser equipment.	Supplier/retailer (hydrogen) Consumer (electricity) Supplier/retailer (electricity) Consumer (electricity)
TRANSPORT.SA	**VH** Transport company with trucks on hydrogen Consumer/buyer of hydrogen **VE** Transport company with trucks on electricity Consumer/buyer of electricity	Consumer (hydrogen) Consumer (electricity)
INDUSTRY.SA	**VH / VE:** Industry consuming transport services Consumer/buyer of road heavy-transport services	Consumer (transport services)
ORES	**VH / VE:** Public grid operator - Company operating the distribution network in a major part of Wallonia, but not exclusively	DSO

2.2 Drawing or Diagram of Use Case

Drawing or Diagram of Use Case – recommended "context diagram" and "sequence diagram" in UML
The diagram represents the ENERGY flows of the test case as currently designed. It integrates (in the grey part) the production alternative of electric fuel for heavy transport to industry.

The wind and solar power production equipment is located next to the hydrogen/distribution plant and industry/transporter site. It is connected to the public electricity grid for injection of excess production. The hydrogen production is powered directly from green energy while additional needs can come from the grid. Compressed hydrogen is stored on site to supply long haul trucks delivering transport services to the industry, on a market with several competing fuels. The comparative scenario for low carbon fuel (full electric) is represented in the grey frame.

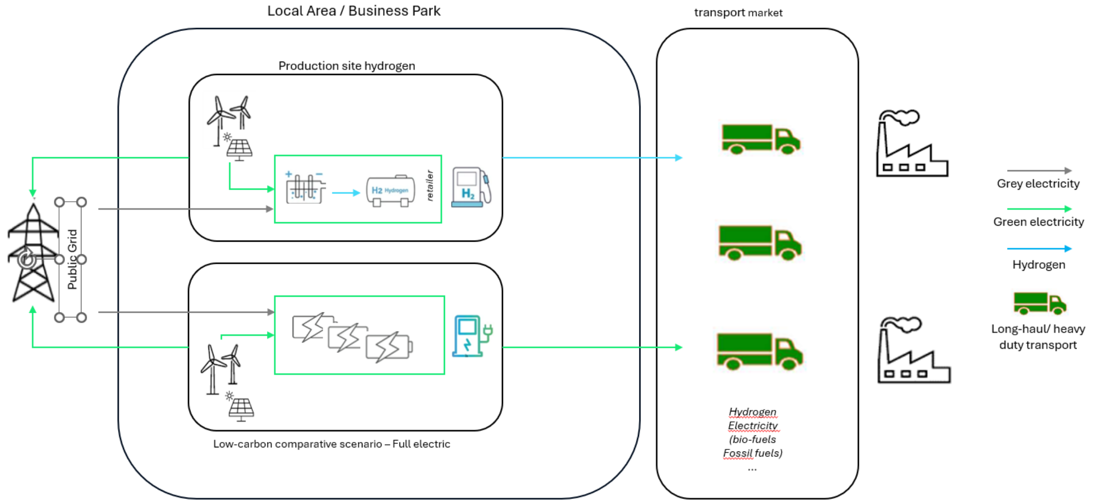


Figure 3-21: Diagram of the main energy flows within BUC 6b.

CONTRACTUAL and FINANCIAL relations: In the current scenario, six different legal entities have contractual relationships. The Electricity supplier and the Assets owner have a contract for buying grid electricity and a power purchase agreement (PPA) for selling injection and green certificates. The PPA includes the BRP services. The Assets owner is divided in two business units, with an internal agreement to supply the distribution plant with the internal electricity. The green power unit expects however a similar revenue compared to full grid injection. The fuel is made available to the retailer for sale to transport or industrial companies.

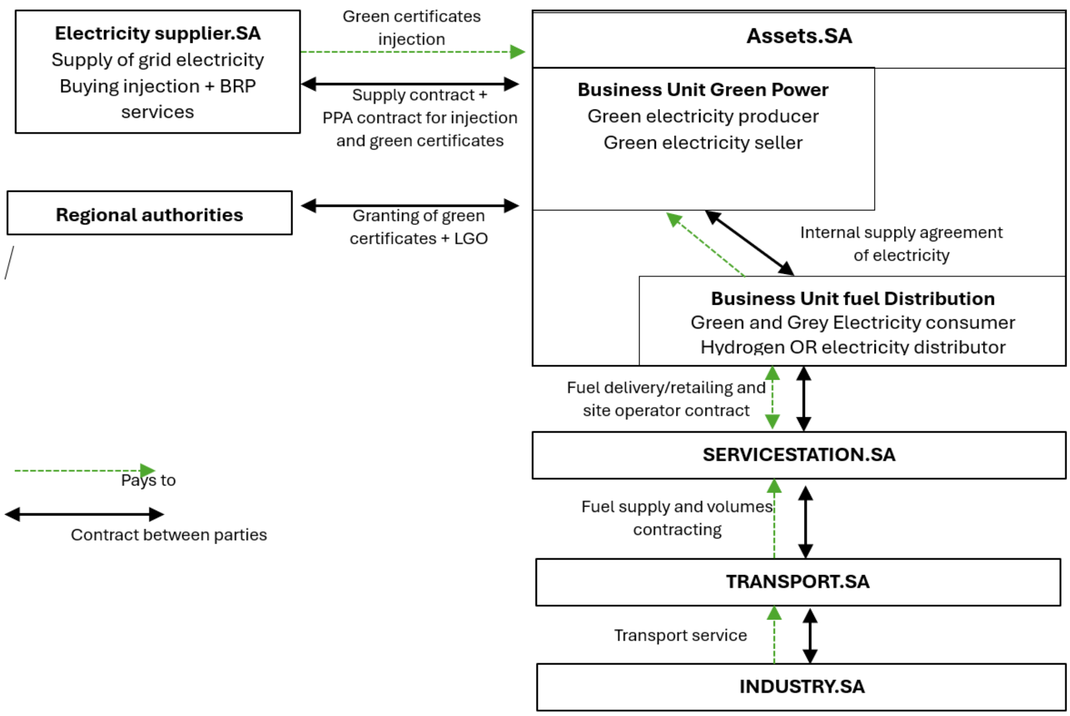


Figure 3-22: Diagram of the contractual relations within BUC 6b.

3 *Key Performance Indicators*

Name	Description	Domain
CO_2 valuation	Estimated gains from CO_2 reductions [€ / 100 km]	Economic
Investment profitability	% ROI for Assets.sa - per Business Unit	Economic
Fuel net cost price - Energy	VE: Final cost of electric 'fuel' [€ / MWh]	Economic
Fuel net cost price - Mass	VH: Final cost price of H_2 [€ / kg H_2]	Economic
Share of electricity sources in fuel production	The share of each electricity source used to generate H_2 fuel (VH) OR electric fuel (VE) (Share of wind electricity [%] – Share of solar electricity [%] – Share of grid electricity [%])	Technical
Quantity of injected electricity	Total quantity of green electricity injected on the grid [MWh]	Technical
Quantity of auto-consumed electricity	Total quantity of green electricity auto consumed for H_2 production [MWh]	Technical
Fuel Storage Capacity - Energy	VE: Storage on site [MWh]	Technical
Fuel Storage Capacity - Mass	VH: H_2 storage capacity on site (at a certain pressure) [kg H_2]	Technical
Total Capex	Total Capex costs for Assets.SA (+ transport related investments) [€]	Economic
Transport cost price	Final cost price of freight road transport [€ / 100 km]	Economic
Opportunity cost of auto-consumed electricity	Revenues that would have been generated if the auto-consumed electricity was injected on the grid (net sales price and GOs included) [€ / MWh]	Economic
Production cost of auto-consumed electricity	Total production cost of auto-consumed green electricity for the fuel distribution unit [€ / MWh]	Economic

3.12 BUC 7

1 Description of the Use Case

1.1 General Information

Test Case ID	Name of Test Case
2	From "Wind to Trucks": green Hydrogen for heavy-duty vehicles

***Maturity of Test Case** – in business operation, realized in demonstration project, realised in R&D, in preparation, visionary*
The 'Wind to H2-trucks" project is currently being studied on technical, profitability, and market demand aspects. A decision will confirm whether the whole value chain can be considered as a cost-efficient investment over time. The filling station should supply hydrogen by the end of 2027.
Classifications According to ReInvent Cross-Sectoral Categories

Energy Sectors:	End-Use Sectors:
☒ Electricity	☒ Industry
☐ Gas	☒ Residential
☒ Fuels (hydrogen)	☒ Commercial
☐ Heating/Cooling	☒ Transport & Mobility
☐ Bioenergy	☒ Agriculture
☐ Other:	☐ Other:

1.2 Name of Use Case

ID	Name of Use Case
BUC 7	The role of hydrogen in the Belgian energy system

1.3 Scope and Objectives of Use Case

Research Question(s)	Test Case
• Can green hydrogen, play a role in advancing the Belgian energy system towards climate neutrality? • Under what conditions and for which applications will green hydrogen be beneficial for the Belgian energy system?	GREEN H2 for trucks

Scope
This use case aims at evaluating the role and added value of green hydrogen within all of its end-use sectors. These sectors include hydrogen as a fuel alternative in the transportation sector (private, commercial, and long-haul), as a sustainable fuel for industry in case certain processes are difficult to electrify, as a feedstock for the production of chemicals or in other industries, etc. Both large-scale electrolysers (e.g., connected to large scale offshore wind farms) and smaller-scale electrolysers (e.g., connected to a H2 station to fuel trucks) are in scope. With green hydrogen we mean hydrogen produced from renewable electricity.
Objectives
• To assess the role of hydrogen in the transition towards a climate neutral Belgian energy system • To determine under which conditions the different end-uses of hydrogen could become beneficial for the Belgian energy system
***View** - Technical / Business*
This use case mainly focuses both on technical and economic aspects, in evaluating potential benefits of hydrogen applications for the Belgian energy system.

1.4 Narrative of Use Case

***Short description** – max 3 sentences (focus on key points of the use case)*
The production cost of green hydrogen is highly dependent on electricity prices. In this BUC, we will assess the extent to which Belgium can access low-cost green hydrogen and, as a result, determine for which applications and under what conditions green hydrogen will be the most viable option. To address these questions, different energy scenarios for Belgium will be examined, and the role of hydrogen in these scenarios will be evaluated.

***Complete description** – detail all steps and components of use case*
This use case aims to determine the added value of hydrogen for the Belgian energy system and evaluate its potential and competitiveness across various end-use applications. Since the production cost of green hydrogen is heavily influenced by electricity prices, this BUC will assess Belgium's ability to access low-cost green hydrogen and, consequently, identify the most viable applications and conditions for its use. To explore these questions, different energy scenarios for Belgium will be examined, with a focus on evaluating hydrogen's role in each scenario. All end-use sectors will be considered, from power and industry to mobility, buildings, agriculture, and more. Belgium is one of Europe's most energy-intensive regions, but its geographic location and solar capacity factors limit access to renewable energy sources (RES). Despite these challenges, Belgium's strategic position makes it a potential energy-carrier import hub for Europe. Ongoing innovations in energy and industry are creating new opportunities to reduce carbon intensity across various sectors. This BUC seeks to provide insights into the future role of green hydrogen through a comprehensive system analysis approach. For this analysis, the Belgian TIMES model (TIMES-BE) [5] will be utilized to assess the energy and industrial system, including feedstock. The TIMES model is an energy system model that prioritizes cost efficiency in its scenario-based techno-economic modelling framework. Given its input parameters and boundary conditions, the model will always produce a cost-optimal solution. The TIMES-BE model has been adapted to represent the entire hydrogen value chain, from imports and local production to final use. As part of this BUC, several scenarios will be explored, along with sensitivity analyses.

1.5 Use Case Conditions

Assumptions
Demand for final products (transport, residential heat, industrial output), maximum renewable potentials (PV & wind capacity). Renewable and demand time-series, and techno-economic parameters need to be assumed upfront. Electricity import and export potentials are derived from TYNDP scenarios.
Prerequisites

1.6 General Remarks

General Remarks

2 Structure

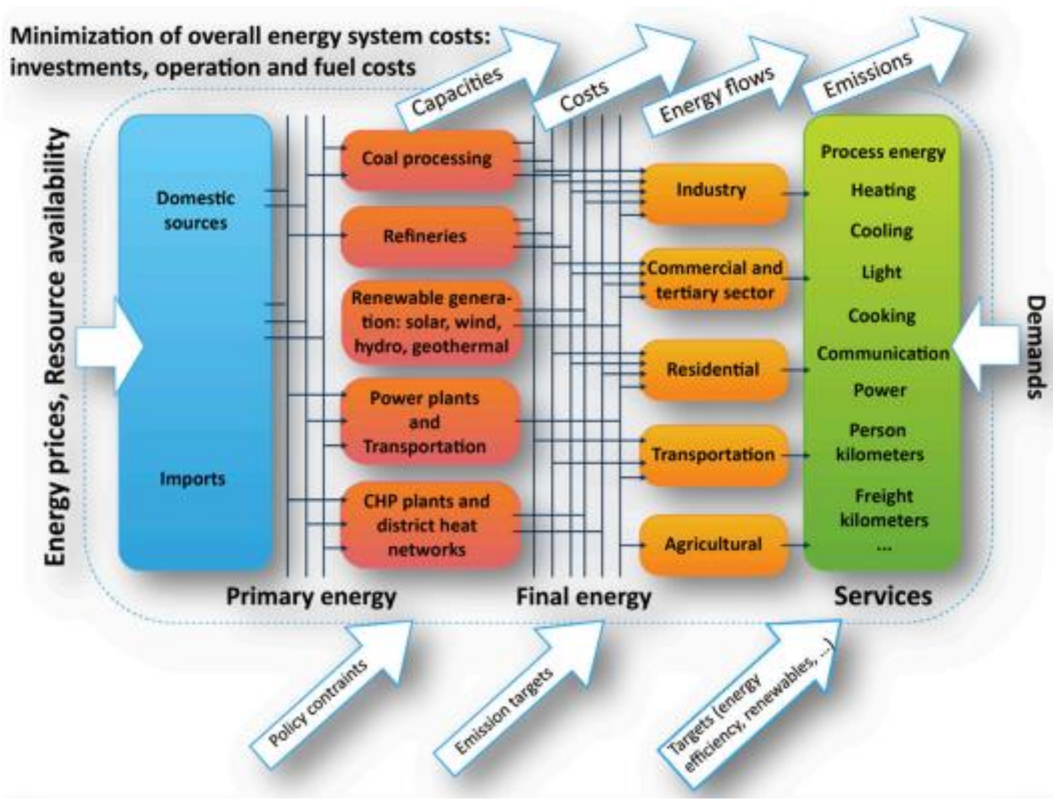
2.1 Actors and Roles

Roles	
☒ Consumer	☒ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☒ Producer	☒ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☒ Prosumer	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☒ Storage Provider	☒ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ Multi-Energy System (MES) Operator	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☒ DSO/DNO	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☒ Network/Grid user	☒ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☒ TSO	☒ Green Molecules ☒ Electricity ☐ Gas
☐ H/C Network Owner	
☐ Market Operator	
☐ Balance Responsible Party (BRP)	
☒ Supplier/Retailer	☒ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☐ Aggregator	
☐ Regulator	
☐ Flexibility Service Provider (FSP)	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ Data Provider	

☐ Meter Operator ☐ Meter Data Administrator ☐ Meter Data Aggregator ☐ Meter Data Collector ☐ Metered Data Responsible ☐ Metering Point Administrator ☐ Other: ________________________ ☐ Other: ________________________ ☐ Other: ________________________ ☐ Other: ________________________	

Note: A detailed table with the different actors and roles involved in this BUC will not be provided in this UC as this UC takes a whole system perspective.

2.2 Drawing or Diagram of Use Case

Drawing or Diagram of Use Case – recommended “context diagram” and “sequence diagram” in UML
The figure below gives an overview of the main inputs and outputs of the TIMES model.  *Figure 3-23: Diagram of the main energy flows within BUC 7.* The TIMES model optimizes the investment requirements and operation of our future energy system in order to minimize the total cost. Demand services are imposed as an exogenous assumption, and the model then determines the optimal route to fulfil these requirements. Steel can, for instance, be produced through blast furnaces and blast oxygen furnaces using coal, or through the reduction of iron oxide through a hydrogen route. The model determines which one of these routes is preferable whilst taking into account interactions with other processes and energy vectors. As such, the model is perfectly placed to examine the most valuable uses for hydrogen. Indeed, TIMES-BE endogenously considers that hydrogen consumed by one particular application cannot be leveraged in another. These different applications hence compete for hydrogen and the model allocates hydrogen to where it is most valuable under certain assumptions (i.e., hydrogen import costs).

Over recent years, TIMES-BE has been fundamentally improved to better represent import and export of electricity (ETF EPOC project), the technical potential of onshore wind and PV and flexibility options (ETF BREGILAB project), and the production and imports of clean molecules such as hydrogen and derivates (ETF PROCURA project). The complete documentation can be found here: https://perspective2050.energyville.be/sites/energyoutlook/files/inline-files/Full-Fledged%20Report_1.pdf

3 *Key Performance Indicators*

Name	*Description*	*Domain*
Total system cost	Total cost of supplying energy, including (annualized) investment costs, fixed & variable OPEX and cost of molecules imported [MEUR/year]	Economic
CO_2 emissions	Total net greenhouse gas (GHG) emissions per country [kt/year]	Environmental
Installed capacities (absolute and vs. potential)	Installed capacities for each technology and each country. renewable electricity and electrolyser capacity [GW]	Technical
Hourly marginal prices	[EUR/MWh] for each vector	Economic
Marginal CO_2 abatement cost	[EUR/tCO_2]	Environmental
Production, consumption and import volumes	[TWh/year or kt/year] for each carrier. Most relevant will be hydrogen consumed per application under different assumptions on import costs	Technical

3.13 BUC 8

1 Description of the Use Case

1.1 General Information

Test Case ID	Name of Test Case
TC7	INTEGRATION "North Sea Model"
***Maturity of Test Case** – in business operation, realized in demonstration project, realised in R&D, in preparation, visionary*	
Extension of functionalities of pilot developed under the framework of ETF project "INTEGRATION".	
Classifications According to ReInvent Cross-Sectoral Categories	
Energy Sectors: ☒ Electricity ☒ Gas (methane / hydrogen & derivatives) ☐ Fuels ☒ Heating/Cooling ☒ Bioenergy (biomass) ☒ Other: CO_2	**End-Use Sectors:** ☒ Industry ☒ Residential ☒ Commercial ☒ Transport & Mobility ☒ Agriculture ☐ Other:

1.2 Name of Use Case

ID	Name of Use Case
BUC 8	INTEGRATION extended to North Sea region: impact of North Sea wind potential and offshore electrolysis.

1.3 Scope and Objectives of Use Case

Research Question(s)	Test Case
1) What is the optimal way for transporting the offshore wind energy potential in the North Sea towards the continent? 2) Can offshore electrolysis help in deploying the offshore wind potential by reducing curtailment and/or total system cost by offering demand-side flexibility to the electricity system?	INTEGRATION "North Sea Model"
Scope	
The INTEGRATION model aims to identify the optimal, carbon-neutral multi-energy system for North-West Europe. The initial version of the model has been built for Belgium only by ULiège & Fluxys during an ETF project financed by SPF Economie and was further developed by Fluxys to cover North-West Europe. The model is used to simulate the interactions between electricity, methane (CH_4), H_2 and CO_2 for the energy systems of countries bordering the North Sea. A specific 'North Sea Cluster' has also been added to better understand the optimal way of transporting the available offshore wind energy to the continent. New energy vectors are also being added to the model (ammonia, methanol, coal & liquids). It is proposed to include part of the developments related to the new vectors and to improve the 'North Sea cluster' approach in the ReInvent project, as well as applying this updated model for studies related to the aforementioned research questions. Additionally, the Integration model can be used to complement and/or challenge certain results of the scenario testing that will be done as part of WP 2.	
Objectives	
• To create a better understanding of the key parameters allowing the best (cheapest) way to exploit the North Sea wind potential, by performing sensitivity analyses for different demand scenarios. Amongst others, the optimal transport of offshore wind energy will be studied for several scenario's and/or sensitivities (demand scenarios, offshore wind potential, allowance of carbon capture and storage [CCS], molecule import costs…). The optimum must here be seen as a 'system optimum', not a local optimum for any given technology. • An additional objective could be to analyse the impact of measures developed in ReInvent WP2 on the North-Sea simulation outcomes.	
***View** - Technical / Business*	

The use case mainly focuses on the technical parameters having an impact on offshore wind deployment in the North Sea.

1.4 Narrative of Use Case

***Short description** – max 3 sentences (focus on key points of the use case)*
Further develop the North Sea component of the INTEGRATION model, and to investigate the key parameters favouring the offshore wind deployment in the North Sea, under the form of electricity and/or H2 pipelines. The specific role of offshore electrolysis will be especially investigated.
***Complete description** – detail all steps and components of use case*
The Fluxys extension of the ETF 'INTEGRATION' model will be used. This model includes 10 countries around Belgium and the North Sea and allows to study the best way to use the North Sea wind potential while considering the availability of electricity imports for Belgium (which a "Belgium-as-an-island" model cannot capture). We propose to use different final demand scenarios for the horizon 2050, and to conduct sensitivity analyses for each one of them in order to better understand the role of offshore electrolysis and molecules in the optimal deployment of the wind potential in the North Sea. As such, the Global Ambition and the Distributed Energy scenarios from ENTSO-E and ENTSOG's Ten-Year Network Development Plans (TYNDP) 2024 [6] will be used for final heat, industry & transport demand for the considered energy vectors, but we could also look to other demand scenarios resulting from other ReInvent work packages. An illustrative, non-exhaustive set of parameters to be studied may include: • impact of offshore wind potential (total) and dedicated to Belgium only. • impact of distance between the Belgian coastline and dedicated offshore wind farms. • impact of offshore electrolysis: allowed (yes/no), dedicated (yes/no), CAPEX & OPEX costs. • eventually, impact of hydrogen import price (low import prices may reduce the need for hydrogen produced by electrolysers – and reversely). • eventually, impact of hydrogen vs. hydrogen derivatives demands for some consumption sectors (adding ammonia to the model may reduce the need for pure hydrogen produced by electrolysers). • eventually, impact of allowing CCS or not (forbidding CCS may favour hydrogen need of power dispatchable capacity from hydrogen).

1.5 Use Case Conditions

Assumptions
Final energy & feedstock demand (for heating, industry and transport) and maximal potentials (for renewable, biomethane & nuclear) will be assumed upfront, using TYNDP 2024 scenarios (Global Ambition & Distributed Energy). Technology techno-economic parameters will be mainly based on data from Danish Energy Agency.
Prerequisites

1.6 General Remarks

General Remarks

2 Structure

2.1 Actors and Roles

Roles	
☒ Consumer	☒ Green Molecules ☒ Electricity ☒ Heating/Cooling ☒ Gas
☒ Producer	☒ Green Molecules ☒ Electricity ☒ Heating/Cooling ☒ Gas
☒ Prosumer	☒ Green Molecules ☒ Electricity ☒ Heating/Cooling ☒ Gas
☒ Storage Provider	☒ Green Molecules ☒ Electricity ☐ Heating/Cooling ☒ Gas

☒ Multi-Energy System (MES) Operator	☒ Green Molecules ☒ Electricity ☐ Heating/Cooling ☒ Gas
☒ DSO/DNO	☒ Green Molecules ☒ Electricity ☐ Heating/Cooling ☒ Gas
☐ Network/Grid user	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☒ TSO	☒ Green Molecules ☒ Electricity ☒ Gas
☐ H/C Network Owner	
☐ Market Operator	
☐ Balance Responsible Party (BRP)	
☐ Supplier/Retailer	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ Aggregator	
☐ Regulator	
☐ Flexibility Service Provider (FSP)	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ Data Provider	
☐ Meter Operator	
☐ Meter Data Administrator	
☐ Meter Data Aggregator	
☐ Meter Data Collector	
☐ Metered Data Responsible	
☐ Metering Point Administrator	
☐ Other: ________________________	
☐ Other: ________________________	
☐ Other: ________________________	
☐ Other: ________________________	

Note: A detailed table with the different actors and roles involved in this BUC will not be provided in this UC as this UC takes a whole system perspective.

2.2 Drawing or Diagram of Use Case

Drawing or Diagram of Use Case – recommended "context diagram" and "sequence diagram" in UML
A good overview of the initial ETF INTEGRATION model, a linear optimization model under constraint for the Belgian multi-energy (integrated) system in 2050, can be found on the official demonstrator (https://integrationdemonstrator.github.io/). The goal of this model is to co-optimize the investments and dispatch for all technologies related to electricity, methane, hydrogen and CO2 that allow to achieve carbon neutrality. Fluxys has extended this model to the 10 countries around Belgium and the North Sea: Austria, Belgium, Denmark, France, Germany, Ireland, Luxembourg, the Netherlands, Norway and UK. A specific 'North Sea Cluster' has also been added to represent all offshore zones further than 40km of any coastlines, regardless of the 'nationality' of those waters.

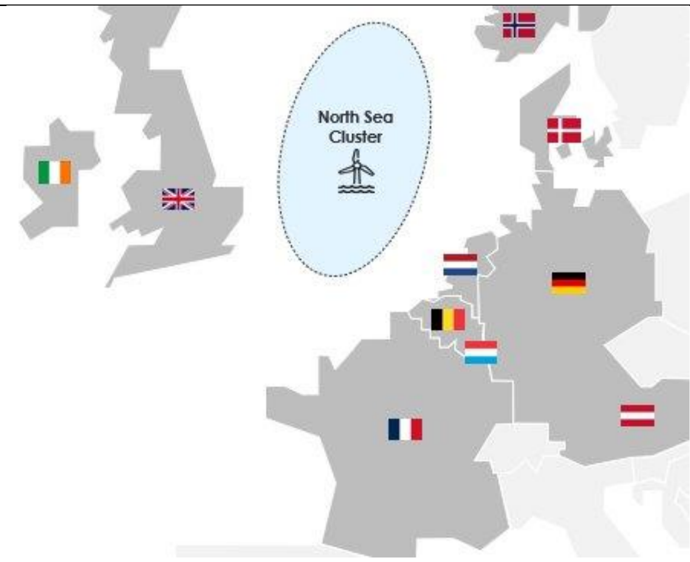


Figure 3-24: Countries connected to the North Sea Cluster.

As further additions, Fluxys added the notion of transmission and distribution capacities and costs to take those into account in the global system optimum. Electrolysers have been refined to add the distinction between alkaline and proton exchange membrane (PEM) technologies, and H2 combine cycle gas turbines (CCGTs) have also been added compared to the version of the model developed as part of the ETF project INTEGRATION.
Below a schematic of the technologies currently in the model – and new ones may be added (like nuclear Small Modular Reactors, ammonia and methanol related technologies,).

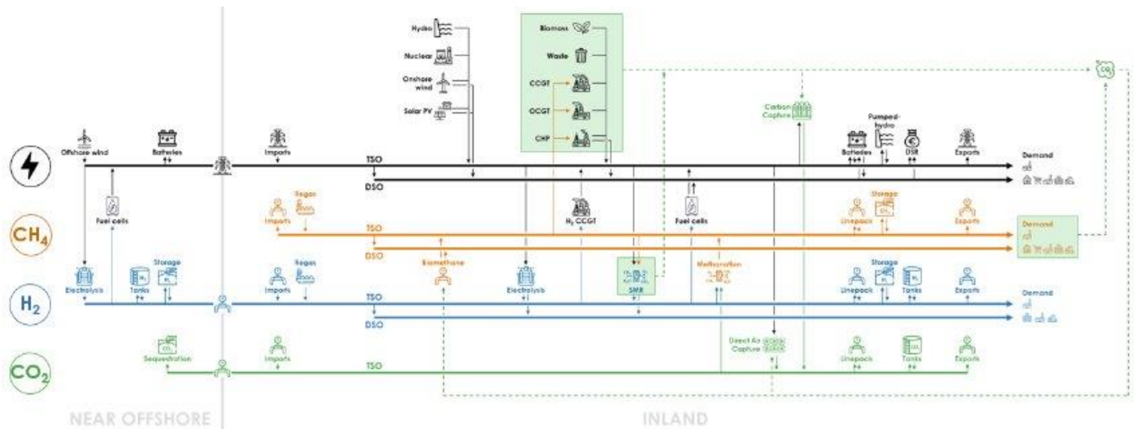


Figure 3-25: Diagram of the main energy flows within BUC 8.

Below an overview of the inputs needed by the model to run, and the outputs that it does provide. Final (energy) demand hourly time series must be provided to the model for heating, industry and transport.

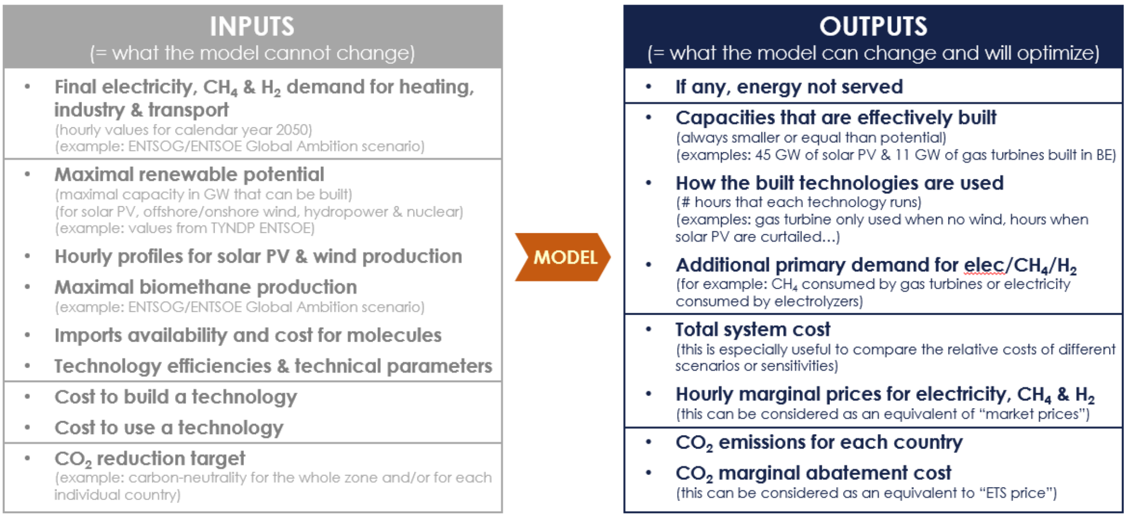


Figure 3-26: Overview of the inputs and outputs of the model from BUC 8.

3 Key Performance Indicators

Name	*Description*	*Domain*
Total system cost	[MEUR/year] Total cost of supplying energy, including (annualized) investment costs, fixed & variable OPEX and cost of molecules imported. Of most importance will be the relative values between scenarios.	Economic
CO_2 emissions	[kt/year] Total net greenhouse gas (GHG) emissions per country	Environmental
Installed capacities (absolute and vs. potential)	[GW] Installed capacities for each technology and each country. Of most importance for this BUC are wind offshore energy, electrolyser, HVDC cables and/or pipelines between the North Sea Cluster and demand zones, batteries…	Technical
Energy curtailed	[GWh] or [% of potential production] for each RES technology	Technical
Load of electrolysers	[hours/year] for each location (offshore, onshore per country)	Technical
Hourly marginal prices	[EUR/MWh] for each vector and each country. Of most importance will be the differences between scenarios, and the volatility of electricity prices.	Economic
Marginal CO_2 abatement cost	[EUR/tCO_2]	Environmental

3.14 BUC 9

1 Description of the Use Case

1.1 General Information

Test Case ID	***Name of Test Case***
5	Large scale electrolysers
Maturity of Test Case *– in business operation, realized in demonstration project, realised in R&D, in preparation, visionary*	
FID (Final Investment Decision) taken for 25MW electrolyser to be operational as from end of 2026.	
Classifications According to ReInvent Cross-Sectoral Categories	
Energy Sectors: ☒ Electricity ☒ Gas ☒ Fuels ☐ Heating/Cooling ☐ Bioenergy ☐ Other:	**End-Use Sectors:** ☒ Industry ☐ Residential ☐ Commercial ☒ Transport & Mobility ☐ Agriculture ☐ Other:

1.2 Name of Use Case

ID	***Name of Use Case***
9	Potential for flexibility provision with a large-scale electrolyser

1.3 Scope and Objectives of Use Case

Research Question(s)	***Test Case***
How is the business case of large-scale electrolysers impacted by providing flexibility to the energy system? What is the infrastructure needs to support different end applications?	Large scale electrolysers
Scope	
Virya Energy will build a 25MW electrolyser in Zeebrugge to produce green hydrogen based on renewable energy. Production will be online by end of 2026. As the capacity of the electrolyser is not at full power in the first years, some flexibility exists to assist in e.g., ancillary services or steer at imbalance prices. The produced hydrogen will be delivered to customers via tube trailers. A connection to the gas grid or to a (future) hydrogen backbone is also foreseen.	
Objectives	
• To evaluate the possibilities of offering flexibility to the electricity system.	
• To analyse infrastructure requirements (e.g., pipe diameters, …) to realize the whole hydrogen value chain.	
View *- Technical / Business*	
This BUC covers both technical (infrastructure requirements) and business aspects (improvements to the business case).	

1.4 Narrative of Use Case

Short description *– max 3 sentences (focus on key points of the use case)*
This use case aims to investigate whether the profitability of the installation can be increased by participating in specific electricity markets or by providing ancillary services from the electrolyser to the power system. The BUC will therefore analyse whether the electrolyser's operation can be optimized through flexible operation, while considering technical constraints, existing contracts for the procurement and sale of the involved vectors, the hydrogen demand and agreements with hydrogen customers, and the additional revenue streams generated from this flexibility. Various market opportunities may be explored, such as optimizing based on wholesale market prices or offering balancing services to the TSO.
Complete description *– detail all steps and components of use case*
As long as the electrolyser is not running at full capacity, the electrolyser can be operated in a flexible manner (powering up or down).

The use case will examine the valorisation potential of the flexibility of the electrolyser towards the electricity system, while considering cost-efficient hydrogen delivery. We foresee several steps for this analysis: 1. Identification of the flexibility potential for the electricity system. In this first step, we will analyse and characterize the flexibility potential of the large-scale electrolyser (amount of flexibility considering hydrogen demand, certainty, impact of seasonality). 2. Mapping of flexibility potential and characteristics with the requirements of the energy and flexibility markets. In this step, we will analyse qualitatively which market segments can be targeted from a technical point of view and which ones are most interesting to target considering the revenue potential. Based on this, we will select the market segments we will analyse in detail. The electrolyser, just as any other flexible demand, can benefit from having access to hourly wholesale electricity prices by scheduling its electricity consumption in response to the hourly changing prices, i.e., convert power into hydrogen when day-ahead electricity prices are low. In addition, the flexibility of the electrolyser could be used to offer balancing services to Elia. 3. Analysis of the impact of flexibility provision on the profitability of the large-scale electrolyser for selected market segments. This analysis will be done using the models of WP2. Other elements could also be considered, such as assessing whether flexibility can be provided to a gas or hydrogen grid. The intention is to inject hydrogen produced through flexible operations into the gas grid. An analysis of whether the gas grid can handle this capacity-wise would be necessary.

1.5 Use Case Conditions

Assumptions
There will be an EMS (Energy Management System) so that the electrolyser can be operated in a flexible manner.
Prerequisites
Technical data can be shared to build the electrolyser model.

1.6 General Remarks

General Remarks

2 Structure

2.1 Actors and Roles

Roles	
☒ Consumer	☒ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☒ Producer	☒ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ Prosumer	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ Storage Provider	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ Multi-Energy System (MES) Operator	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ DSO/DNO	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ Network/Grid user	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ TSO	☐ Green Molecules ☐ Electricity ☐ Gas
☐ H/C Network Owner	
☐ Market Operator	
☒ Balance Responsible Party (BRP)	
☒ Supplier/Retailer	☒ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☐ Aggregator	
☐ Regulator	
☒ Flexibility Service Provider (FSP)	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☐ Data Provider	
☐ Meter Operator	
☐ Meter Data Administrator	
☐ Meter Data Aggregator	
☐ Meter Data Collector	
☐ Metered Data Responsible	

☐ Metering Point Administrator ☐ Other: ______________________ ☐ Other: ______________________ ☐ Other: ______________________ ☐ Other: ______________________	

Actor Name	*Actor Description*	*Role(s)*
Virya Energy	Virya Energy is an electricity consumer as the electrolyser uses electricity to produce hydrogen.	Consumer (Electricity)
Virya Energy	Virya energy produces hydrogen by means of electrolysis.	Producer (Electricity)
Virya Energy	Virya energy supplies hydrogen to different consumer groups.	Supplier/Retailer (Hydrogen)
To be defined	Virya energy will deliver the hydrogen to different hydrogen consumers.	Consumer (Hydrogen)
To be defined	Virya energy has a PPA contract with an electricity supplier for the offtake of electricity.	Supplier/Retailer (Electricity)
Elia	Elia is the transmission system operator for electricity in Belgium and acquires different flexibility services.	TSO (Electricity)
To be defined	The flexibility can also be provided to a BRP which uses this flexibility to optimize its portfolio.	BRP
To be defined	The flexibility will be provided through an intermediary.	FSP

2.2 Drawing or Diagram of Use Case

Drawing or Diagram of Use Case – recommended "context diagram" and "sequence diagram" in UML

The first diagram shows different physical flows and shows the relationship between the electricity consumption on one hand and the H2 production on the other hand. The electrolyser uses renewable electricity (offshore wind power) and water (H2O) to produce hydrogen (H2) and oxygen (O2). H2 can be used for different purposes, i.e., for industry in case certain processes are difficult to electrify, as a feedstock for the production of chemicals or in other industries and as a fuel for transport (e.g., heavy transport, ships). Different means can be used to supply the hydrogen to the final consumers, i.e., via tube trailers, via injection into the gas grid or via a (do be developed) H2 backbone.

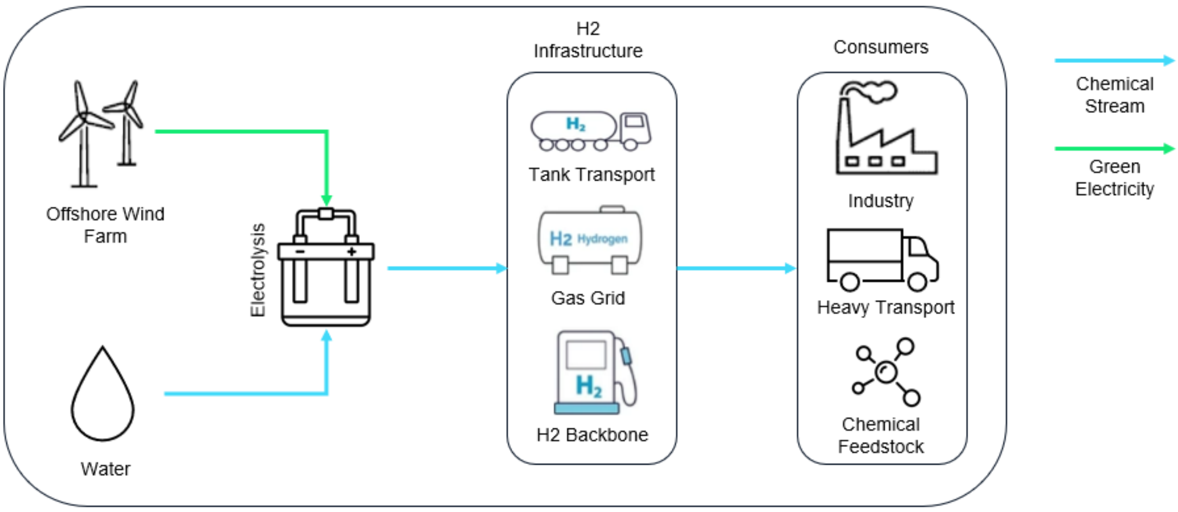


Figure 3-27: Diagram of the main energy flows within BUC 9.

The second diagram shows the contractual relationships between the different actors.
Virya Energy has a contract with the electricity supplier for the offtake of renewable electricity (i.e., offshore wind power). The electricity needed for the process, in the 'normal' production setting, is at a price agreed

between the electricity supplier and Virya Energy via a PPA. In addition, Virya energy has supply contracts with different hydrogen consumers. There are some additional contractual relationships when the provision of flexibility is considered, i.e.:

- Virya energy has a flexibility provision contract to offer flexibility to a BRP (for its own portfolio optimization) or an FSP.
- The FSP has a (Flexibility Service Provider) contract with the TSO to offer balancing services.

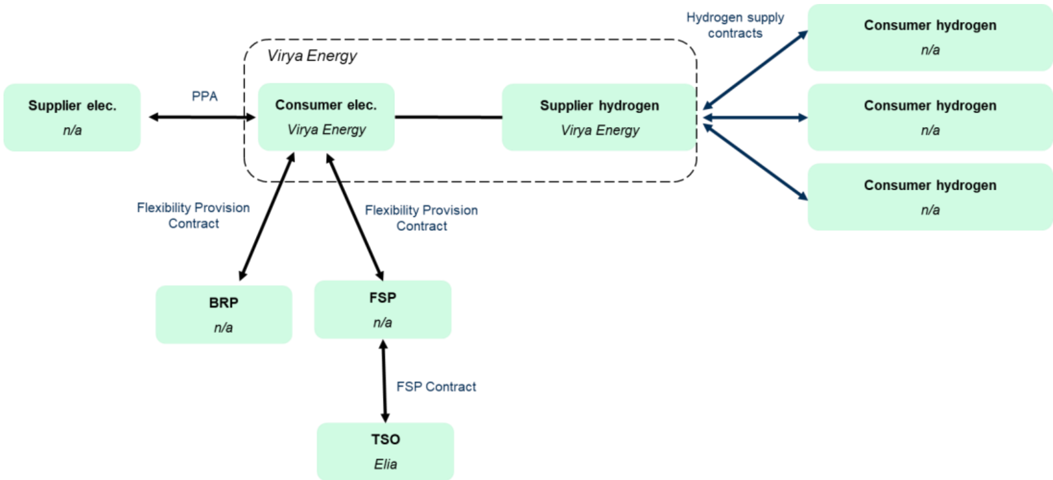


Figure 3-28: Diagram of the contractual relations within BUC 9.

3 *Key Performance Indicators*

Name	***Description***	***Domain***
Hydrogen production cost	Average cost to produce hydrogen [€/MWh]	Economic
Available flexibility	Volume of flexibility offered to the aggregator [MW] or [MWh]	Technical
Accepted flexibility	Volume of flexibility accepted on the markets [MWh]	Technical
Flexibility revenues	Revenues from flexibility provision [€]	Economic

3.15 BUC 10

1 Description of the Use Case

1.1 General Information

Test Case ID	Name of Test Case
11	Re.alto vehicle IoT
***Maturity of Test Case** – in business operation, realized in demonstration project, realised in R&D, in preparation, visionary*	
Version 2 of the Re.alto platform to retrieve raw vehicle Internet of Things (IoT) data was launched beginning of May 2024. For the flexibility potential, data needs to be gathered on the localisation of the EV, the state of charge, and the plug-in time. Re.alto already gathers this information from EV but is continuously expanding the range of compatible car models to test the data quality differences between various models. For the flexibility activation potential, Re.alto has to develop a command functionality that allows to upload schedules or start/stop commands to the vehicle.	
Classifications According to ReInvent Cross-Sectoral Categories	
Energy Sectors: ☒ Electricity ☐ Gas ☐ Fuels ☐ Heating/Cooling ☐ Bioenergy ☐ Other:	**End-Use Sectors:** ☐ Industry ☒ Residential ☐ Commercial ☒ Transport & Mobility ☐ Agriculture ☐ Other:

1.2 Name of Use Case

ID	Name of Use Case
BUC 10	Potential for flexibility provision with a portfolio of EVs

1.3 Scope and Objectives of Use Case

Research Question(s)	Test Case
How do novel market design options enable a safe and secure participation of flexibility from E-mobility to the overall system, avoiding a correlated charging behaviour? How much flexibility in terms of energy and power can be derived from a fleet of EVs? What is the expected value of this flexibility at the level of an EV portfolio and for an individual EV user?	Re.alto
Scope	
Re.alto will onboard a fleet of about 200 EVs to track the flexibility potential. Drivers will be asked to allow smart charging control on their vehicles both for technical tests in terms of activation limitations and compatibility, but also with respect to behavioural and economic tests as to what the driver expects and how it could be delivered. The outcome of these tests will be used to characterize the flexibility potential of a fleet of EVs and, finally, to analyse the value of this flexibility.	
Objectives	
• To identify charging and mobility patterns • To develop a smart charging solution • To estimate the flexibility potential of a (fleet of) EV • To estimate the value of this flexibility	
***View** - Technical / Business*	
A combined technical and business use case, looking at how vehicle IoT technology can help improve the business model of EV integration in the electricity system.	

1.4 Narrative of Use Case

***Short description** – max 3 sentences (focus on key points of the use case)*
The flexibility of electric vehicles (EVs) can significantly contribute to balancing the energy system, but challenges like expensive smart charging infrastructure and interfacing issues have hindered its potential. The Re.alto business case aims to overcome these barriers by leveraging existing in-car IoT connectivity, drastically

lowering entry costs and shortening payback periods, making EV flexibility more attractive; the ReInvent project will further analyse and evaluate the flexibility potential and its profitability.
***Complete description** – detail all steps and components of use case*
Flexibility of EV will be a major contributor to the overall balance of the system. Estimates range from 300 to 500 €/car/year in terms of cost savings compared to traditional low voltage energy contracts. So far, unlocking this flexibility has proven to be difficult. Charge poles need to be smart (= expensive), and interfacing problems between charge poles and the back-end IT systems as well as between charge poles and vehicles, create entry barriers that often render the overall business case to a negative result. The Re.alto business use case aims to minimize the entry barrier by reusing the existing IoT connectivity of the vehicles. Every car in Europe since 2018 has got a sim card on board for E-call use cases and has to be made available to 3rd parties through a machine readable interface by October 2025 (the EU data act, article 5 [7]). Hence, connecting to a vehicle promises to be as simple as clicking a few times on your mobile phone. That could significantly reduce the entry barrier to flexibility from EV. From a few 1000 euro of installation costs (smart charge pole mainly) down to a few euro in software support. This makes the business case of EV flexibility way more attractive. The payback can be reduced from years to months for an individual. Re.alto wants to test and develop the potential of this technology as described above as part of task 3.3, given the current market maturity. To support the analysis of the smart charging business case, an evaluation will be done of the flexibility potential and inherent value of this flexibility as part of the ReInvent project. This evaluation will include the following steps: 1. Identification of the flexibility potential for the electricity system. In this first step, we will analyse and characterize the flexibility potential of a fleet of EVs based on the outcome of the technical tests, data provided via the Re.alto platform and (possibly) additional inputs from the Re.alto user community. 2. The flexibility of EVs can both be used to react to implicit price signals (dynamic retail pricing, capacity-based or other future more dynamic distribution grid tariffs) and can be offered to different electricity market segments. In this step, we will map the EV flexibility potential and characteristics with the different options to valorise the flexibility. This includes a qualitative analysis of which market segments can be targeted from a technical point of view and which ones are most interesting to target considering the revenue potential. Based on this, we will select the flexibility mechanisms (which can be a combination of implicit and explicit mechanisms) which we will analyse in detail. 3. Analysis of the impact of flexibility provision on the profitability for selected explicit and implicit flexibility mechanisms. This analysis will be done using the models of WP2.

1.5 Use Case Conditions

Assumptions
Prerequisites
1. The car needs to have connectivity enabled. 2. The car original equipment manufacturer (OEM) should allow the manipulation of the car charging process remotely.

1.6 General Remarks

General Remarks

2 *Structure*

2.1 Actors and Roles

Roles	
☒ Consumer	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☐ Producer	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ Prosumer	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ Storage Provider	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ Multi-Energy System (MES) Operator	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☒ DSO/DNO	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas

☐ Network/Grid user	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☒ TSO	☐ Green Molecules ☒ Electricity ☐ Gas
☐ H/C Network Owner	
☐ Market Operator	
☒ Balance Responsible Party (BRP)	
☒ Supplier/Retailer	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☐ Aggregator	
☐ Regulator	
☐ Flexibility Service Provider (FSP)	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☒ Data Provider	
☒ Meter Operator	
☐ Meter Data Administrator	
☐ Meter Data Aggregator	
☐ Meter Data Collector	
☐ Metered Data Responsible	
☐ Metering Point Administrator	
☐ Other: ________________________	
☐ Other: ________________________	
☐ Other: ________________________	
☐ Other: ________________________	

Actor Name	***Actor Description***	***Role(s)***
To be defined	We consider a group of EV users. These EV users consume electricity to charge their EVs.	Consumer (Electricity)
To be defined	Every EV user has a contract with a supplier for the offtake of their electricity. Depending on their situation, they can also have an injection supply contract (e.g., for the injection of PV surplus). The consumer is free to select a supplier of their choice.	Supplier/Retailer (Electricity)
Elia	Elia is the transmission system operator for electricity in Belgium and is responsible for managing the balance between consumption and production.	TSO (Electricity)
To be defined	The flexibility can be provided to a BRP which uses this flexibility to optimize its portfolio.	BRP
EPEX SPOT	Market on which transactions regarding products are concluded and/or registered which are settled within a period of two settlement days. Settlement can take place immediately (Intraday), the following day (Day-Ahead) or two days ahead.	Spot market
Re.alto	Re.alto is an IoT platform operator. The platform facilitates the GDPR compliant onboarding of energy appliances (EV, heat pumps, smart meters, PV inverters, batteries…), the management and monitoring of these appliances, the data capture and storage, and the manipulation of the data into useful data statistics and controllable assets.	IoT platform provider

2.2 Drawing or Diagram of Use Case

Drawing or Diagram of Use Case – recommended "context diagram" and "sequence diagram" in UML
The first diagram shows different physical flows. In this BUC we consider a portfolio of EVs which are spread in Belgium, and which can charge at different locations (i.e., at home, at work, at public charging points, at other locations). We will build a realistic (future) portfolio for our analysis, differentiating between different type of EV owners / drivers (e.g., different behaviours, with and without a PV installation, some EVs might allow V2G other not, etc.).

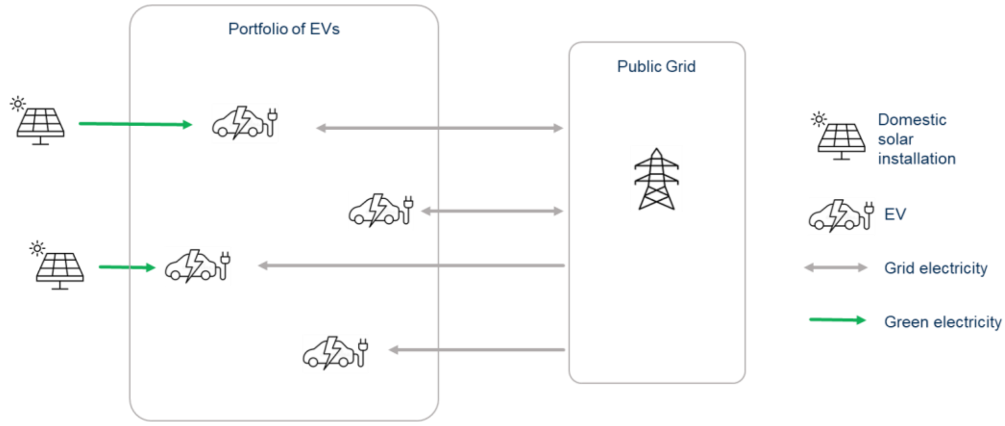


Figure 3-29: Diagram of the main energy flows within BUC 10.

The diagram below shows the contractual relationships between the different actors.
The EV owners have a contract with an electricity supplier for the off take of electricity. In addition, they can have a contract directly with a BRP for offering flexibility. The BRP is the single operator that can commercialize the flexibility in the market, using either the spot market (day-ahead/intraday) or the balancing market to sell/buy the energy volumes at the right moment in time.

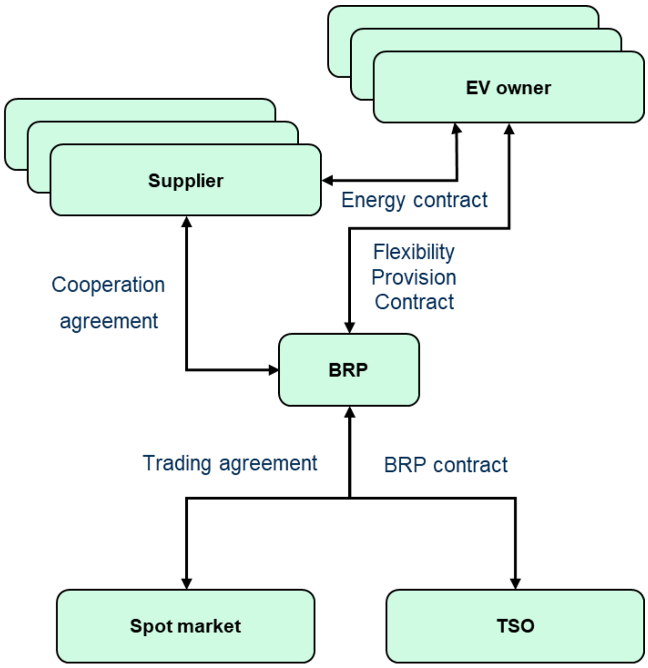


Figure 3-30: Diagram of the contractual relations within BUC 10.

3 ***Key*** Performance Indicators

Name	*Description*	*Domain*
Impact on energy bill	Change in final energy cost by charging an EV in a flexible manner [€]	Economic
Impact on grid tariffs	Change in final distribution cost by charging an EV in a flexible manner [€]	Economic
Available flexibility	Volume of flexibility offered to the aggregator [MW] or [MWh]	Technical
Flexibility revenues	Revenues from flexibility provision [€]	Economic
CAPEX for smart charging	Investment costs to allow smart charging capability [€/MWh]	Economic
IRR	Overall profitability of the smart charging business case [%]	Economic
Reliability of the data	Reliability of the data accuracy and update frequency for the use in flexibility and energy use cases	Technical
Coverage	Coverage and market penetration of the technology, in terms of scalability of the business use case towards the market in general	Technical

3.16 BUC 11

1 Description of the Use Case

1.1 General Information

Test Case ID	Name of Test Case
1	Re.alto vehicle IoT
***Maturity of Test Case** – in business operation, realized in demonstration project, realised in R&D, in preparation, visionary*	
Version 2 of the Re.alto platform to retrieve raw vehicle IoT data was launched beginning of May 2024. To allow smart billing solutions, charge data records need to be derived from the raw data. As there is no electricity meter on board of a vehicle, ither calculation methods should be used.	
Classifications According to ReInvent Cross-Sectoral Categories	
Energy Sectors: ☒ Electricity ☐ Gas ☐ Fuels ☐ Heating/Cooling ☐ Bioenergy ☐ Other:	**End-Use Sectors:** ☐ Industry ☒ Residential ☐ Commercial ☒ Transport & Mobility ☐ Agriculture ☐ Other:

1.2 Name of Use Case

ID	Name of Use Case
BUC11	Smart billing solutions for EV charging (focus on a large fleet of EVs)

1.3 Scope and Objectives of Use Case

Research Question(s)	Test Case
What impact can smart billing solutions have on the charging behaviour of a driver? How does it relate to his home energy consumption/bill?	Re.alto
Scope	
Most EVs today are deployed on the road as a company car. Company cars are characterized by the split between the user who decides when and how to charge the vehicle, and the company who pays the bill of the electricity charged. First field observations have shown that various drivers in such a scheme display different charging behaviours. The use case aims at identifying these different behaviours and categorizing them. Furthermore, a smart billing solution will be developed that informs the user and fleet manager about the (real time) cost of the session. In combination with the household bill, this can provide user-specific incentives, to be defined, to better align the driver behaviour to the system needs.	
Objectives	
• Identify charging patterns.	
• Develop a smart billing solution, informing the driver in real time about the cost.	
***View** - Technical / Business*	
A combined technical and business use case, looking at how vehicle IoT technology can help improve the business model of EV integration in the electricity system.	

1.4 Narrative of Use Case

Short description – max 3 sentences (focus on key points of the use case)
The EV landscape today is a complicated multi-stakeholder environment. A correct incentive scheme should consider all the possible stakeholder setups and provide for a comprehensive settlement of those incentives in order to result in the optimal dispatch of the resources by the contributing agents.
***Complete description** – detail all steps and components of use case*
EVs are bought by private individuals who are in charge of choosing their EV, the charging infrastructure, and the mobility service provider and/or charge pole operator, as well as the energy supplier and possible other services as they see fit. The individual also pays for the use of the vehicle and the consumption of the electricity by it, and can choose to privately charge, publicly charge or fast charge as he sees fit.

EVs are also bought by companies as a component of the salary. In this setup, the EV is owned by a company, but driven by an individual. The choices where to charge and how are done by the individual, who is not exposed to the cost resulting from his decisions (as they are reimbursed by the company). This creates a more complicated setup to ensure an economic optimal behaviour can be obtained. EVs are also bought by companies as utility vehicles. White vans or light weight duty vehicles are used as professional tools to move people or goods around. The driver is often less involved in the actual charging decisions, although he could be, whereas the company faces privacy issues among others to control the charging cost and behaviour. In all of the above high-level scenarios, any incentive scheme should consider the potentially different outcomes it might produce in other situations. To obtain this type of insight, charging profiles are to be identified and created to model the agent's behaviour correctly. To that extent, charging patterns will be analysed over the course of the project to identify the various archetypes that could be obtained from real life observations. The correct settlement of the incentive scheme is also important. The use of vehicle IoT technology will be analysed in this regard, focusing on its applicability and potential areas for improvement or attention.

1.5 Use Case Conditions

Assumptions
Prerequisites
To identify the charging patterns, especially related to the home energy consumption: - Cars will need to be connectable. - Smart meters will need to be installed. - Those smart meters are enabled to share data (MijnFluvius or a P1 dongle).

1.6 General Remarks

General Remarks

2 Structure

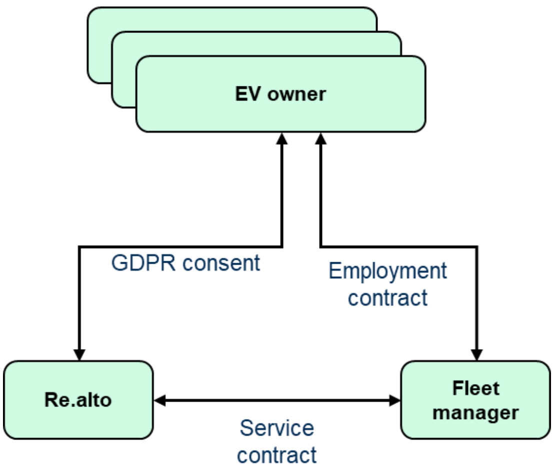
2.1 Actors and Roles

Roles	
☒ Consumer	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☐ Producer	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ Prosumer	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ Storage Provider	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ Multi-Energy System (MES) Operator	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ DSO/DNO	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ Network/Grid user	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ TSO	☐ Green Molecules ☐ Electricity ☐ Gas
☐ H/C Network Owner	
☐ Market Operator	
☐ Balance Responsible Party (BRP)	
☐ Supplier/Retailer	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ Aggregator	
☐ Regulator	
☐ Flexibility Service Provider (FSP)	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☒ Data Provider	
☐ Meter Operator	
☐ Meter Data Administrator	
☐ Meter Data Aggregator	
☐ Meter Data Collector	
☐ Metered Data Responsible	
☐ Metering Point Administrator	

☒ Fleet manager ☐ Other: ___________________________ ☐ Other: ___________________________ ☐ Other: ___________________________	

Actor Name	*Actor Description*	*Role(s)*
To be defined	We consider a group of EV users. These EV users consume electricity to charge their EVs.	Consumer (Electricity)
To be defined	Every EV user has a contract with a supplier for the offtake of their electricity. Depending on their situation, they can also have an injection supply contract (e.g., for the injection of PV surplus). The consumer is free to select a supplier of their choice.	Supplier/Retailer (Electricity)
Re.alto	Re.alto is an IoT platform operator. The platform facilitates the GDPR compliant onboarding of energy appliances (EV, heat pumps, smart meters, PV inverters, batteries…), the management and monitoring of these appliances, the data capture and storage, and the manipulation of the data into useful data statistics and controllable assets.	IoT platform provider
To be defined	The fleet manager manages a fleet of EVs and is responsible for overseeing the operation, maintenance, and logistics of a company's fleet of vehicles.	Fleet manager

2.2 Drawing or Diagram of Use Case

Drawing or Diagram of Use Case – recommended "context diagram" and "sequence diagram" in UML
The EV owner has an employment contract with his fleet manager (employer). This provides him with an EV, as well as the right to be reimbursed for home charging sessions. The fleet manager needs to know how much the car has charged at home, and contracts Re.alto to fetch the data from the car and create charge data records (billing relevant volumes). The data is enriched with the applicable tariff (either the CREG rate or the home user tariff). Re.alto gets the GDPR consent from the driver to use the data of his car.  *Figure 31: Diagram of the contractual relations within BUC 11.*

3 *Key Performance Indicators*

Name	*Description*	*Domain*

Cost	The cost of the technology will be assessed against the cost of currently existing alternatives.	Economics
Reliability	The reliability of the solution to provide the expected result (billing relevant data) will be benchmarked against the needs of the sector	Technology
Accuracy	The accuracy of the billing relevant data will be benchmarked against market standard practices.	Technology
Applicability	The applicability of the solution in the current market will be analysed. What coverage can be provided as part of the overall fleet of vehicles?	Economics

3.17 BUC 12

1 Description of the Use Case

1.1 General Information

Test Case ID	Name of Test Case
4.2	Social Charging Shared EVs

***Maturity of Test Case** – in business operation, realized in demonstration project, realised in R&D, in preparation, visionary*
The solar installations are installed throughout the neighbourhood of Otterbeek and are thus in business operation. Setup of local shared EVs and charge infrastructure visionary.

Classifications According to ReInvent Cross-Sectoral Categories	
Energy Sectors: ☒ Electricity ☐ Gas ☐ Fuels ☐ Heating/Cooling ☐ Bioenergy ☐ Other:	**End-Use Sectors:** ☐ Industry ☒ Residential ☐ Commercial ☒ Transport & Mobility ☐ Agriculture ☐ Other:

1.2 Name of Use Case

ID	Name of Use Case
BUC 12	Smart billing solutions for EV charging (focus on collective car sharing)

1.3 Scope and Objectives of Use Case

Research Question(s)	Test Case
How can we reward users to charge their EV at the most optimal times? How can we limit payment risks?	Social Charging Shared EVs

Scope
The energy community of Otterbeek (Mechelen, Belgium) is the first of its kind in attempting to maximise the benefits of rooftop solar and sharing the excess solar electricity in a social district. The excess energy produced here must be valorised maximally to safeguard the viability of this energy community. An increase in self-consumption can be realized, by adding shared EVs and flexibility to the social district (see BUC 3a and 3b). This BUC will specifically look at smart billing solutions in this context of shared EVs in a social housing district. More specifically, this case aims to find out what professional software we can use to support CPO (Charge Point Operator) and MSP (Mobility Service Provider) functions. Besides investigating and testing all possible traditional payment methods like KBC debit card, Apple/Google pay, Payconiq, Wero, and other type of cards, this use case will further explore the usage of virtual wallets and coins vs those traditional payments methods (see also AFIR European law). This new settlement method using ‘coins’ has several advantages such as a faster processing, more powerful system, higher availability and lower transaction costs.
Objectives
• To limit payment risks and reward users for charging their EV at times when electricity is cheapest or solar energy is available. • To explore and test new billing solutions for EV charging based on wallets and smart coins.
***View** - Technical / Business*
In this case we mostly focus on technical aspects as we will explore the settlement with blockchain technology for MSP (smart contracts and wallets).

1.4 Narrative of Use Case

***Short description** – max 3 sentences (focus on key points of the use case)*
This use case will develop and test intelligent MSP (Mobility Service Provider) functions in the context of EV sharing in a social district. These ensure that we can optimally involve users in the energy transition and also eliminate payment risks (prepaid charging). We use blockchain wallets and smart contracts for this.

Complete description – *detail all steps and components of use case*
This use case aims to develop and test intelligent Mobility Service Provider (MSP) functions for EV sharing within a social district and how these functions can be integrated with the financial settlement needed for transactions for EV charging. These functions are designed to maximize user participation in the energy transition while eliminating payment risks through prepaid charging. Blockchain wallets and smart contracts will be employed to facilitate this process: • Every EV user gets a blockchain wallet. A blockchain wallet is an electronic wallet that holds coins, each valued at €1. This needs to be charged to be able to charge the EV. When the user needs to charge very quickly, he will pay more. When the CPO can decide for itself when to charge (cheapest time slot), the price is much lower. • Smart contracts ensure that the price of a kWh is determined in a transparent way. This can change frequently. The user knows the price in advance. The smart contract is used to involve users in the energy transition. When there is a lot of power available, he is encouraged to charge (cheaper). When he charges at times when there is little power available, charging becomes much more expensive. Since there is a pre-payment, there is no risk of payment.

1.5 Use Case Conditions

Assumptions
• In this case, we are using one charging station and a technical environment that is shielded. That means it is not scalable in this phase. However, we will make sure that this possibility will exist. • Blockchain was chosen as a technical solution to allow its distributed use. In other words, the party that wants to use this solution must set up a "node" for this purpose.
Prerequisites
• Technical environment is in place. • Regarding legal and compliance there are no concerns

1.6 General Remarks

General Remarks

2 Structure

2.1 Actors and Roles

Roles	
☒ Consumer	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☒ Producer	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☐ Prosumer	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ Storage Provider	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ Multi-Energy System (MES) Operator	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☒ DSO/DNO	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☒ Network/Grid user	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☐ TSO	☐ Green Molecules ☐ Electricity ☐ Gas
☐ H/C Network Owner	
☐ Market Operator	
☐ Balance Responsible Party (BRP)	
☒ Supplier/Retailer	☐ Green Molecules ☒ Electricity ☐ Heating/Cooling ☐ Gas
☐ Aggregator	
☐ Regulator	
☐ Flexibility Service Provider (FSP)	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ Data Provider	
☐ Meter Operator	
☐ Meter Data Administrator	
☐ Meter Data Aggregator	
☐ Meter Data Collector	
☐ Metered Data Responsible	

☐ Metering Point Administrator ☒ Other: Charge point operator ☒ Other: Mobility Service Provider ☐ Other: ________________________ ☐ Other: ________________________	

Actor Name	***Actor Description***	***Role(s)***
Woonland	Social housing company, owner of the Solar PV equipped buildings (renting these out to the direct consumers)	Consumer (self-consumed solar power)
KlimaanSolar PV	Klimaan as owner and responsible of the solar PV assets	Green energy producer
City of Mechelen	Local municipality, in charge of public domain Offtake of excess solar PV injection	Enabler Green energy consumer
Klimaan charge stations	Klimaan as owner and responsible of the charge points	Charge point owner
Klimaan shared EVs	Klimaan as owner and responsible of the shared EVs	Green energy consumer
To be defined	The CPO owns and operates the charge points (TBD)	Charge point Operator (CPO)
To be defined	The MSP operates the charging subscriptions and enables charging on more than one charge station. Currently using ROAD, but no flexibility.	Mobility Service Provider (MSP)
Elia	Elia is the transmission system operator for electricity in Belgium and acquires different flexibility services	TSO (electricity)
Fluvius	Fluvius is the distribution system operator in Belgium and will be acquiring different flexibility services for the electricity distribution network soon.	DSO (electricity)

2.2 Drawing or Diagram of Use Case

Drawing or Diagram of Use Case – recommended "context diagram" and "sequence diagram" in UML
The first diagram shows the different components of the BUC: This diagram is the same as in BUC3a and 3b, as it uses the same situational approach. Klimaan currently has 70 domestic solar PV installations, with 197 more planned in the Otterbeek social housing district in Mechelen, Belgium. By maximizing roof usage, they generate excess solar power. Klimaan aims to optimize the value of this surplus energy by deploying charging stations for local offtake at stable prices. Social tenants would benefit from this energy through shared EVs. **This business use case focuses on a specific element of this test case, i.e., providing a smart billing solution to enable EV sharing.**

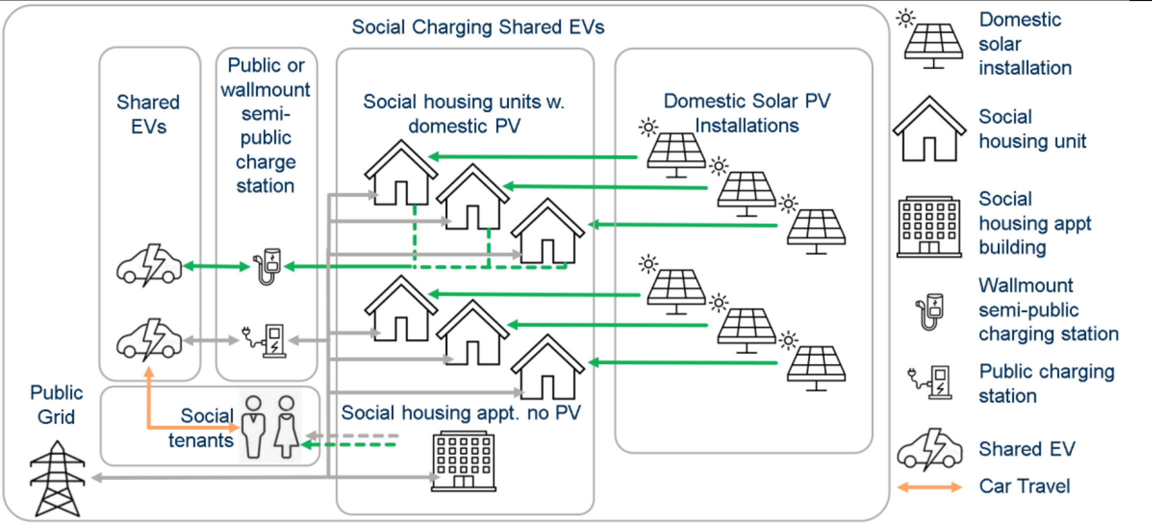


Figure 3-32: Diagram of the main energy flows within BUC 12.

The second diagram shows the contractual relations in this setup**. The contractual relationships are the same as those in BUC3b.** Klimaan produces solar power for social housing and holds injection contracts for each network access point. Locally consumed electricity is sold to Woonland and billed to individual tenants. To install a charge point, permission is required from Woonland (for semi-public) or the City of Mechelen (for public). Klimaan would operate the charge point, needing an energy supplier and an EV mobility service contract with the social housing company, along with charging card subscriptions. Additionally, both the solar power producer and Charge Point Operator have flexibility contracts with the aggregator, who holds Flexibility Service Provider (FSP) contracts with various buyers (DSO, TSO, BRP). There is a clear difference between the flexibility offered by the Charge Point Operator and the MSP (Mobility Service Provider). The MSP adjusts its calculations independently and autonomously. This means that the MSP can adjust the tariff to specific charging point users. For example, if a lot of solar energy is produced, the prices can go down. Or there can be social correction. For example, if a Klimaan member is charging.

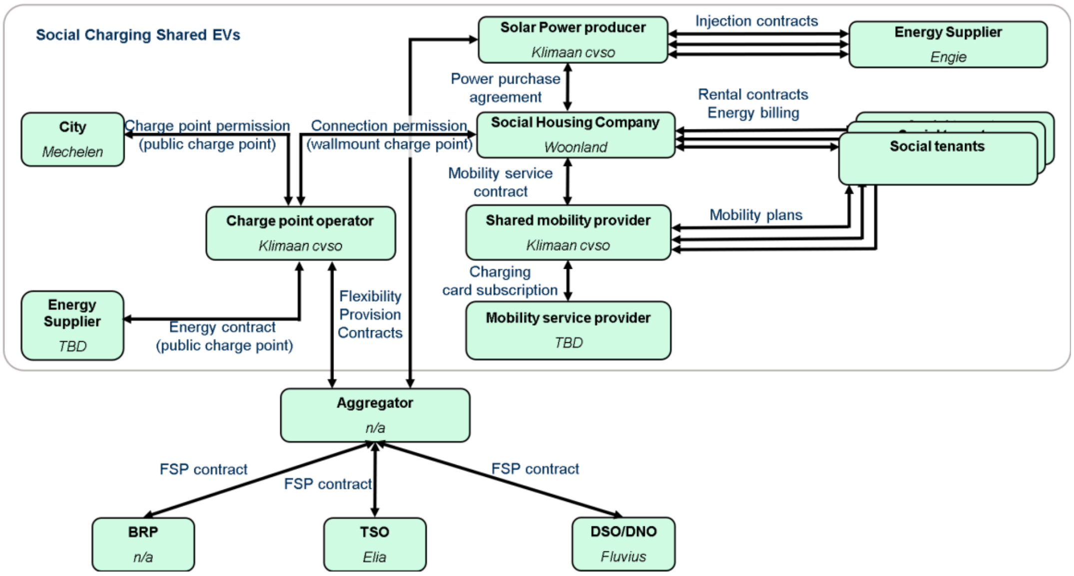


Figure 3-33: Diagram of the contractual relations within BUC 12.

The figure below gives some more insights on the current interactions between the different roles for billing EV loading sessions. The current setting requires multiple transactions, which increase the complexity and entail additional costs (“upcharges”).

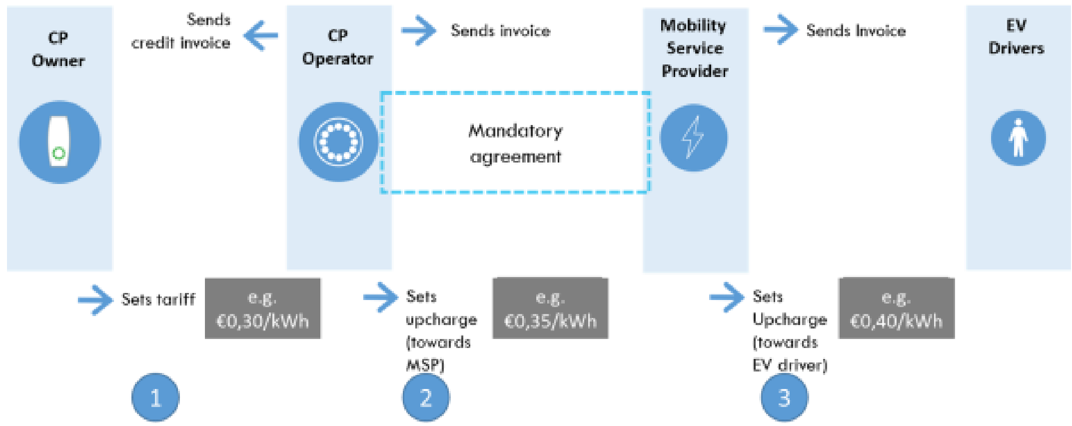


Figure 3-34: Flowchart of the current billing procedures utilized in practice.

There are several problems with the current approach this UC aims to address, i.e.

- Tariffs are not always communicated by a proper technical connection and protocol.
- Inefficiency exists because of the large number of tariffs.
- Issue with changing tariffs/variable tariffs at a station before charging.
- Issue with changing tariffs but keeping same Tariff ID
- Issue with many tariff components in CPO-MSP tariffs
- Protocol conformity
- Complexity of processes
- No clear settlements
- Payment risks between all parties

Within this BUC, we therefore want to explore the situation depicted below, i.e., how the operational management/settlement of charging stations can be automated. The solution should be adaptable for use by other organizations, such as Charge Point Operators (CPOs), and support other energy cost payments. The use case will deliver a comprehensive business case comparing different solutions and optimize existing processes, such as EV charging.

The concept is to provide each electric vehicle (EV) user with a digital wallet. When the vehicle is charged, the transaction is handled through a smart contract. Several checks are performed, such as:

- Ensuring the user has enough funds (coins) in their wallet.
- Verifying that the price set by the charging station owner is within a normal range, avoiding unusually high or low rates.
- Any additional fees are clearly communicated to the user before the transaction is completed.

The system also manages energy consumption. For example:

- Users who want faster charging will pay a higher rate.
- If charging occurs during times with ample network capacity, users will pay less for charging.

The entire system operates on a blockchain node. By replicating this node, the technique can be adopted by any mobility service provider (MSP).

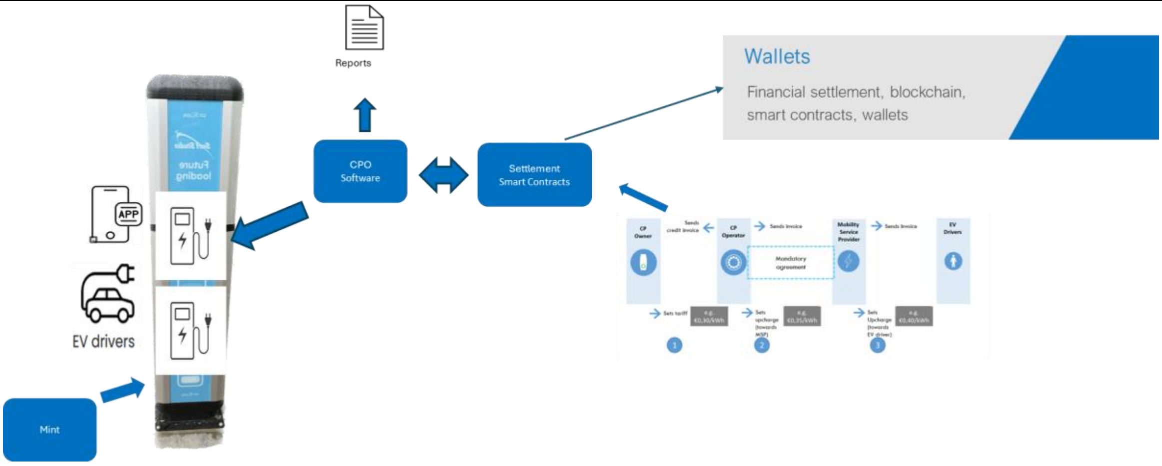


Figure 3-35: Flowchart of the billing procedures utilized in BUC 12.

3 ***Key*** Performance Indicators

Name	***Description***	***Domain***
Cost for MSP functions	Cost for the MSP functions (i.e., setting up wallets, funding and defunding wallets) [€/kWh charged]	Economic

4 Re.alto platform

As previously mentioned, new functionalities for the re.alto platform will be developed and tested during the ReInvent project. This chapter outlines the operation of the re.alto platform and offers a high-level overview of potential applications, which will be further developed as part of task 3.3.

4.1 Functionalities

The re.alto platform aggregates the internet of things (IoT) connectivity available today to energy related assets on the low voltage grid. The platform focuses today on 3 asset classes: EV, smart meters and PV, yet foresees an architecture that will enable heat pumps and batteries to be integrated as well.

The platform streams data at a frequency of between 1 and 15 minutes, relying on 2 different technology stacks. The first technology stack is the official application programming interface (API) connectivity offered by the OEM. A number of OEM today offer 3rd party access to their IoT back-ends which enables the retrieval and sometimes also control of those devices. OEM will be obliged to offer this 3rd party access following the EU data act (article 5). The 2nd technology stack is reverse engineering of the mobile applications deployed by the OEM. While the 2nd stack allows a broader scope of devices today, because of the availability of mobile applications being larger than the official API connections, it has certain drawbacks in terms of legal constraints and cyber security.

The re.alto platform uses these connections of both technology stacks to acquire data and send control parameters to the devices from a microservice API first cloud-based architecture. The architecture is designed for real time data communication in an energy related environment, meaning small data packages at high frequency with low economic value per package. Hence the cost effectiveness of the platform at scale is a continuous strive. The platform relies on a containerized setup, that allows a flexible up- and downscaling depending on the performance requirements to enable the most cost-effective setup.

The re.alto platform furthermore has an onboarding service available that allows a smooth user journey to identify and ensure the right appliance is coupled to the platform for the right customer. Most of the appliances generate rather sensitive privacy related data, and it is therefore of the utmost importance that the platform ensures not only proper consent of the individual is received, but also that only the right appliances are shared towards the users. In this respect, re.alto maintains an ISO27001 certification on the development of the platform.

4.2 Applications

One of the main challenges in unlocking flexibility at the low voltage level, is that multiple stakeholders will have varying use cases for the appliances at play. A consumer might be focused on his immediate use (‘need to drive car by 9:00 to…’), a grid operator might be focused on the peak load at the local grid, a system operator might be concerned about macro-economic movements (‘what if all cars drive to the coast for a sunny Sunday’), a balancing service provider might buy the flexibility of the device, the energy supplier might apply price signals to it to lower the bill,…

Key to this multi-stakeholder data and control necessity, is to reuse the existing connectivity as much as possible to avoid multiple end2end connections possibly conflicting with each other. This is where the re.alto platform comes in. Re.alto aggregates the existing connectivity in a single platform that can allow a user to share his data with various counterparties. Such a centralized setup facilitates especially the low value use cases, which can be of significant societal value, but which cannot afford the setup of an infrastructure that enables large scale connectivity.

The obvious value from flexibility is the straightforward use case of energy management services, that has been analysed quite abundantly. A balance responsible party, a trader, a supplier, a balancing service provider… who would like to engage an appliance (like an EV) into a direct market participation. The re.alto platform can provide access and control to appliances in this setup without the need to install any additional hardware. It reduces the entry barrier (as hardware still mounts to a couple 100 euro to get installed) and replaces it with an operational cost (maintenance of the cloud services) of a couple of euro/month. As such, it also facilitates easy switches between service providers for the consumer as it involves just a few clicks on a mobile app, instead of installing new hardware of the new service supplier of choice.

Yet the main value of this entry point use case is that when this high value use case has onboarded the appliance, it can be made available to 3rd parties at almost no additional cost. A distribution grid operator could apply local peak balancing services, with only an approval to manage from the end consumer. A system operator or trader could get a view on the macro data regarding the displacement of vehicles and their state of charge, detailing an important flexibility reserve availability (or upcoming peak load).

More importantly, if the use of the appliances happens through a central platform, the user would be able to set priorities between the various stakeholders. This allows the management of conflicting signals (grid operator wants to shut down the charging, while user wants to leave soon), based on user preference settings (or any stakeholder in the ecosystem). The current standard today is to have various pathways to the appliance, with a typical LIFO setup (last received signal sets the status of the device).

5 Conclusions

This deliverable outlines 17 Business Use Cases (BUCs) linked to various real-life test cases within the ReInvent project, executed by different entities across Belgium. A standardized use case methodology, based on the IEC-62559 standard, has been applied to ensure the replicability of these use cases. The BUCs will guide the project's research activities throughout its duration, with each test case having one or more associated BUCs. These BUCs are connected to one or more research topics within the ReInvent project, such as business model evaluation, financing and smart billing solutions, and energy system and market modelling.

The BUCs tied to the test cases will be evaluated qualitatively and/or quantitatively, using concepts developed in Work Package 1 (WP1) and, where relevant, relying on assessments carried out as part of Work Package 2 (WP2) with the ReInvent modelling environment.

The BUCs have been categorized into five groups, each with a distinct focus:

- Group 1 focuses on the development of business models for certain test cases, particularly those involving cross-sectoral and collective activities.
- Group 2 centres on business models related to mobility applications, specifically long-haul trucks.
- Group 3 examines the entire energy system, with an emphasis on hydrogen’s role within it.
- Group 4 investigates the flexibility potential of specific technologies and the impact of this flexibility on the energy market.
- Group 5 concentrates on smart billing solutions for electric vehicle (EV) sharing.

The BUCs will be further refined in the upcoming tasks within WP3, using the concepts developed in WP1 and supported by WP2’s modelling activities, specifically through the ReInvent modelling environment. Key Performance Indicators (KPIs) defined in each BUC will be further detailed and calculated in Task 3.4.

References

[1] IEC, “IEC 62559: Use case methodology,” IEC, International Standard, Apr. 2015.

[2] “Role Models.” Accessed: Aug. 30, 2024. [Online]. Available: https://www.entsoe.eu/data/cim/role-models/

[3] C. Schuster, “High-level Requirements for SENERGY NETS solutions, demonstrators, and case studies”.

[4] “Magnitude D1.1 - Cartography of the flexibility services provided by heating/cooling, storage and gas technology and systems to the electricity system.” Nov. 15, 2018. [Online]. Available: https://www.magnitude-project.eu/wp-content/uploads/2019/03/MAGNITUDE_D1.1_MDH_R2.0_submitted.pdf

[5] EnergyVille, “PATHS2050 | Energy outlook.” Accessed: Sep. 30, 2024. [Online]. Available: https://perspective2050.energyville.be/

[6] ENTSOs, “ENTSO-E and ENTSOG TYNDP 2024 Draft Scenarios Report.” Accessed: Sep. 30, 2024. [Online]. Available: https://2024.entsos-tyndp-scenarios.eu/

[7] European Parliament, *REGULATION (EU) 2023/2854 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 13 December 2023 on harmonised rules on fair access to and use of data and amending Regulation (EU) 2017/2394 and Directive (EU) 2020/1828 (Data Act)*, vol. 2023/2854. 2023. Accessed: Sep. 30, 2024. [Online]. Available: https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=OJ%3AL_202302854

Annex A Test Case Questionnaire

A.1 Request for Information Template

This questionnaire is developed as part of WP3 within project ReInvent, which focuses on real applications of sector coupling. The information provided here will be used in T3.1 as the first step of the 3-step approach to define the business use cases (BUCs) and system use cases (SUCs). As a result, this survey is only intended to provide a first picture of the test cases. Development of the specific details for the BUCs/SUCs will occur after the completion of this survey by all test case owners.

This questionnaire is to be completed by each test case owner for each individual test case and sent to VITO by the **8th of April 2024**. For Test Case 4, this survey should be completed separately for each of the three smaller test cases. Please save the completed document in the following naming format: *ReInvent_Test Case #*, where the number (#) corresponds to the following table:

#	Test Case	Consortium Member	
1	Large scale E-mobility uptake B2C	Re.alto	
2	Green hydrogen for long haul trucks	IDETA	
3	CollecThor	VITO	
4-1	Hybrid energy communities Test Case 1	REScoop	CAMPINA
4-2	Hybrid energy communities Test Case 2	REScoop	KLIMAAN
4-3	Hybrid energy communities Test Case 3	REScoop	SEACOOP
5	Large scale electrolysers	Virya	
6	Business renewable energy communities	IDETA	
7	Integrated energy systems for gas and electricity	Fluxys	

Feedback & Questions

For feedback or questions about this questionnaire, please contact:

Jacob Mason – jacob.mason@vito.be

Kris Kessels – kris.kessels@vito.be

Test case:	

Test case owner Who is responsible for this test case? (Company)	
Location Where is the test case located (address & region Flanders, Wallonia, Brussels)	
Status Is this test case in a regulatory derogation situation (pilot) or following existing regulation. Is this test case active, since how long, or is it in development phase, or a closed pilot.	
Test case description Brief description of the test case and how it contributes to the project	
Objectives Explain the target objective(s) of the test case.	
Sectors List the energy sectors present in the test case: electricity, gas, heating, cooling, green molecules, biofuels.	
End-uses List the end-users / consumer groups which are present in the test case: individual vs. collective consumers; residential, commercial, industrial, transport.	
Energy assets Describe the main energy assets present or to be added in the test case (type, capacity, power rating, number, etc.). This can be energy generation, end-use, conversion, storage.	

Energy networks Short description of the energy networks that are part of the case study.	
Sector coupling Explain the primary couplings between sectors and/or end-users that can be realized by the test case.	
Flexibility Detail what flexibility can be provided by the test case to the energy system and any additional technology that will be used (i.e., Energy Management System)	
Does this test case build on the work of previous projects? (If yes, please list projects)	

A.2 Responses: Test Case 1

Test case:	1
Title:	Large Scale E-mobility Uptake B2C
Test case owner	Re.alto
Location	Flanders for the smart meters EV can be in all 3 Belgian regions
Status	Following existing regulation It will be initiated for ReInvent (new test case)
Test case description	We will onboard 1000 households with a P1 interface, and 150 cars (EV) through vehicle IoT. We will make that real time data available to the project. To test some of the new market design ideas, the test community will be available for surveys, messaging, signals through our mobile app, to see how and if they respond to the incentives in real life. We can also start/stop charging sessions of EV remotely (for about 2/3rd of the brands) to test automated control of the incentives. 4
Sectors	Electricity, mobility
End-uses	Individuals, Fleet managers
Energy assets	Smart meters: P1 interfaces, 1 min real time data, 1000 households EV: IoT onboarded, 3-5min data granularity, 150 cars
Energy networks	None
Sector coupling	Interaction between mobility and energy, as on the low voltage consumer level, the EV represents the biggest asset to enable smart demand side management.
Flexibility	150 EV are expected to deliver about 750 kW of flexibility. 4
Does this test case build on the work of previous projects?	No

A.3 Responses: Test Case 2

Test case:	2
Title:	Green Hydrogen for Long Haul Trucks
Test case owner	IDETA
Location	Wallonia, city of Leuze-en-Hainaut
Status	This project is following the existing regulation. The case is currently in a development phase.
Test case description	This project aims to construct and operate a production unit, storage and distribution of green hydrogen dedicated to road transport in order to initially supply around ten of the company's trucks Transports Fockedey and, secondly, to extend the distribution of this fuel to other transport companies in the Region.
Sectors	Electricity: Wind and solar renewable energy connected, via a direct power line or the Grid to the electrolyser
End-uses	Trucks companies, 10 trucks initially and more if the production site allows it.
Energy assets	Wind turbine 2 MW Solar panels 1.7 MW Electricity from the grid
Energy networks	Electrical energy Network - local grid (ORES) and transport grid (ELIA) A direct power line is also studied between the electricity production assets and the production site of hydrogen.
Sector coupling	This project aims to decarbonize the heavy transport sector through the use of green hydrogen.
Flexibility	Is currently studied
Does this test case build on the work of previous projects?	No

A.4 Responses: Test Case 3

Test case:	3
Title:	CollecThor
Test case owner	VITO
Location	SciencePark Thor Park André Dumontlaan 67, 3600 Genk Flanders
Status	CollecThor operates in the first regulatory sandbox in Flanders. It comprises a 5th generation neutral-loop/open-collector DHC network. It is expected to be operational by February 2025.
Test case description	CollecThor is an innovative 5GDHC network that will connect the 4 existing buildings of the ThorPark complex. It will use the ATES system to provide heating and cooling for the network. And there will be exchange of energy between the buildings.
Sectors	Electricity District Heating/Cooling
End-uses	Commercial/industrial CollecThor is a business park made up of primarily office buildings and research facilities, with a small number of commercial entities operating onsite.
Energy assets	Geothermal heating and cooling (ATES) • 450 kW installed power (per pair of wells). o 3 pairs foreseen in the project Residual heating and cooling • The amount of residual heating cannot be calculated until the system begins operation, a value of 15% of total energy needed is assumed o Total demand for cooling: 1000 MWh/yr o Total demand for heating: 1200 MWh/yr Substations (Heat pumps + HEX) IncubaThor EnergyVille 1 EnergyVille 2 Thor Central Heating (kW) 141 240 - 300 Cooling (kW) 200 400 170 225
Energy networks	A 5th generation district heating network that utilizes aquifers thermal energy storage (ATES) to provide heating and cooling to the connected buildings within the network, with thermal step-ups provided by heat pumps powered via PV panels. The buildings also exchange energy (thermal and electrical) between them.
Sector coupling	Sector couple exists via electrical heat pumps within the system to step up the heat provided by the ATES system for use within the buildings.
Flexibility	Through the interaction between the thermal and electrical systems, an EMS implemented into the network will enable the system to provide more flexibility to the electrical network. (Dampen peaks of electrical consumption – peak shifting/shaving)
Does this test case build on the work of previous projects?	D2GRIDS – provided learnings for 5G networks (KPIs, design)

A.5 Responses: Test Case 4-1

Test case:	4-1
Title:	Hybrid Energy Communities Test Case 1
Test case owner	Campina Energie erkende cv
Location	Provinciaal Centrum Duurzaam Bouwen & Wonen Kamp C Britselaan 20, 2260 Westerlo, Flanders
Status	The test case is in development phase.
Test case description	Campina Energie (a renewable citizen energy cooperative, represented by REScoop Vlaanderen) and Provinciaal Centrum Duurzaam Bouwen & Wonen Kamp C (Westerlo) are setting up a project with the aim to establish an innovative Renewable Energy Community (REG) at the site of Kamp C to accelerate the energy transition in Flanders. As the first energy community to share energy between citizens, businesses and government institutions this project will be an ambitious example for Flanders. The main focus of this project is on removing obstacles to working in cooperation with an energy community for citizens in order to promote renewable energy in business parks. Together, we invest in sustainable energy solutions, such as joint procurement of solar panels, charging infrastructure, electrical (heat-pump driven) heating/cooling, energy sharing with residential, commercial, governmental and industrial sites, and a (district) second-life (recovered) battery. The test case focuses on said second-life, with the major contributor of the test case residing in the second-life nature of the battery system, and its connection with different stakeholders.
Sectors	Electricity, heating, cooling.
End-uses	Collective consumers, residential, commercial, governmental, industrial, transport.
Energy assets	PV: +/- 600 kWp Battery system: >1 MWh; >1 MW Heating/cooling: TBD Charging stations: > 110 kW Energy community: surrounding residential, commercial, industrial end-users within 1 km radius
Energy networks	Low and medium electrical voltage networks
Sector coupling	Electrical sector and residential, commercial, industrial end-users via citizen renewable energy cooperatives.
Flexibility	Using the second-life battery system in combination with an EMS: - storage of excessive electricity from the PV system, increasing self-consumption and peak shaving - financial incentives by monetising the day ahead and imbalance markets - load balancing of vehicle chargers - smart steering of heating and cooling systems - energy sharing with stakeholders in the energy community - smart monitoring of individual battery cells to identify those cells that need to be replaced

Does this test case build on the work of previous projects?	No

A.6 Responses: Test Case 4-2

Test case:	4-2
Title:	Hybrid Energy Communities Test Case 2
Test case owner	Klimaan CVSO
Location	Mechelen (several addresses), Flanders, Belgium
Status	The test case finds itself in a preliminary research stage. It should follow existing regulation but explore first types of collaboration between new actors and sectors. The preparatory development phase will last during 2024, implementation is planned in 2025. The test case builds further on the pilot energy community in the social district Otterbeek (started in 2022).
Test case description	The test case will explore participatory flexibility models deriving from charging infrastructure for social households. In order to reach a viable business case, we will test several complementary models in multi-dwelling social apartment blocks, privately owned apartment blocks, individual charging stations in social districts and charging hubs. charging hubs in mixed residential areas.
Sectors	Only electricity but various target groups: • public (charging infrastructure), • private assets (maximalizing roofs) • mix of residential users
End-uses	End-users will be collective consumers (within the energy community, as already established within Otterbeek) as well as new residential areas (social district and mixed districts). A special focus will be given to apartment blocks.
Energy assets	• PV panels on roofs that will be maximalized (total production estimated: 500 MWh) • Charging infrastructure (type (normal, V2G, V2H, ...) and capacity to be investigated • Batteries
Energy networks	Low voltage distribution grid. Distribution Grid operator in Flanders: Fluvius system operator.
Sector coupling	The primary coupling will take place by privately owned assets, such as maximized solar panels on roofs and charging infrastructure, with social households as end-users. A profound collaboration between the energy cooperative, the social housing company, the supplier of charging infrastructure and the social services of the city of Mechelen will be needed for this goal. The benefits will be: • Affordability of electric mobility for social tenants by leveraging the use of solar panels (making the EV's more attractive than their fossil counterparts). • The knowledge increases dynamic pricing to reduce the charging costs. • Community empowerment: the social households will get better insight in the valorisation of renewable energy and electric mobility. Together we will explore how they can 'book' the shared vehicles at the lowest cost (depending on dynamic pricing). This

	will include several workshops and training sessions. • The energy cooperative Klimaan will explore the business model of to improve the valorisation of the additional PV panels, charging infrastructure and the availability of shared electric cars (and secondly electric cargo bikes) . • We aim to promote social inclusion by ensuring that underserved communities have equitable access to clean energy technologies and transportation solutions, bridging socio-economic disparities. Overall, coupling privately owned renewable energy assets with social households as end-users not only addresses energy affordability and sustainability challenges but also fosters community resilience, empowerment, and economic development, contributing to a more inclusive and environmentally conscious society.
Flexibility	This focuses mainly on dynamic EV charging. The coupling of electric vehicle charging infrastructure with social households allows for dynamic EV charging strategies, where charging patterns can be optimized based on factors such as grid congestion, renewable energy availability, and electricity prices. This flexibility maximizes the use of renewable energy, minimizes grid impacts, and provides cost savings for EV owners. 1. We need to explore which incentives could be useful for our target group (social housing) for participating in demand-side responses; reacting on price signals to make most use of the shared vehicles at the right time. 2. We will investigate how to build a viable business case for the energy cooperative to store surplus electricity in the shared vehicles for later use. Potentially, models can be researched in collaboration with Fluvius and ELIA for grid balancing and ancillary services. Through advanced control and optimization algorithms, our case could offer grid balancing services by dynamically adjusting energy consumption, generation, and storage in response to grid fluctuations. This flexibility contributes to grid stability, enhances reliability, and supports the integration of variable renewable energy resources. However, within the pilot, there will not be sufficient scale to actually implement this. An Energy Management System (EMS) serves as the central control platform for monitoring, optimizing, and managing energy flows within the pilot project. • The EMS integrates with various components of the energy system, including solar panels in Otterbeek, electric vehicle chargers, and household appliances, to coordinate their operation efficiently. • Advanced algorithms within the EMS optimize energy usage based on real-time data, weather forecasts, grid conditions, and user preferences, maximizing the utilization of renewable energy, minimizing costs, and ensuring grid stability. • The EMS facilitates demand forecasting, load scheduling, and

	predictive analytics to anticipate energy demand patterns, optimize energy production and consumption schedules, and proactively manage grid interactions. • User-friendly interfaces and mobile applications allow social households and system operators to monitor energy performance, adjust settings, and receive insights on energy usage, savings, and environmental impact, promoting energy awareness and engagement.
Does this test case build on the work of previous projects?	Yes, the energy community in Otterbeek, the implementation of which is/was done in the TANDEMS project.

A.7 Responses: Test Case 4-3

Test case:	4-3
Title:	Hybrid Energy Communities Test Case 3
Test case owner	SeaCoop
Location	The Belgian Economic Zone in the North Sea. SeaCoop physical address: Posthoflei 3, 2600 Berchem
Status	The investment by SeaCoop in a consortium for the Princess Elisabeth Zone (PEZ) is in development phase. SeaCoop, a joint cooperation of 34 Belgian citizen cooperatives for energy is going to enter the PEZ-bidding in September 2025. The offshore wind park would be built between 2026 and 2030.
Test case description	Sea2Socket explores a disruptive business model where citizens both own offshore wind and are customers of a cooperative supplier. This project explores the feasibility of securing the supply of affordable renewable energy from the sea to the home. Participants in this renewable energy community are both owners of offshore wind turbines and customers of a cooperative supplier. This case further explores integration at the end-user level to maximize offshore electricity use before the electricity would be used for other vectors. The fair cooperative electricity tariff will promote the energy transition as consumers start using heat pumps and electric vehicles. However, offshore electricity supply and consumer demand are not in sync. Demand-side management can increase instantaneous electricity consumption at sea, keep the added value of additional wind farms high and prevent cannibalisation of the value of current wind farms. This follow-up case further explores integration at the end-user level to achieve adequate and effective demand-side integration. Solutions could be energy management systems that activate EV charging and heat pumps, or storage such as EV, home or community batteries, ... The test case researches how other energy vectors can be integrated in the electricity system and vice versa: 1) Electrify mobility and heating 2) Research how large amounts of offshore electricity can be absorbed by the electricity market via flexibility and demand side management, and how then still existing surpluses can be transformed to hydrogen or others.
Sectors	Electricity, electric heating, hydrogen
End-uses	For SeaCoop, the end users are mainly citizens. It can also be small enterprises, cities and organisations as universities or hospitals.
Energy assets	The Princess Elisabeth Zone 1 is a wind park of 700 MW. SeaCoop aims for 20% equity participation and 20% energy use. This 20% energy use amounts to +/- 600 GWh electricity per year.
Energy networks	Wind park offshore, cables to onshore and high voltage lines onshore

Sector coupling	Electrification of mobility and heating, and only go to other vectors when there are surpluses that cannot be absorbed by the electric network system and demand for electricity.
Flexibility	Promoting Demand Side Management at end user level and storage.
Does this test case build on the work of previous projects?	Yes, - ETF Citizen Offshore Power 2021 – COP21 - ETF Sea2Socket

A.8 Responses: Test Case 5

Test case:	5
Title:	Large Scale Electrolysers
Test case owner	Virya Energy
Location	Several large-scale electrolyser plants are developed. Focus: Hyoffwind 25 MW electrolyser plant: Aziëstraat Zeebrugge (Flanders)
Status	Existing regulation. Hyoffwind plant will be operational end of 2026 (if FID taken, June '24).
Test case description	Hyoffwind electrolyser plant will convert renewable energy to produce hydrogen (optimization RFNBO according to delegated act). This hydrogen will be transported via tube trailers to the offtakers or can be directly injected into the gas grid (or a future hydrogen backbone).
Sectors	Electricity, gas, hydrogen, green molecules
End-uses	Transport and industrial users.
Energy assets	25MW electrolyser (conversion of electricity into hydrogen).
Energy networks	Electricity grid, gas grid, hydrogen backbone.
Sector coupling	Electricity market, hydrogen market
Flexibility	This plant can provide flexibility to assist in e.g., electricity grid balancing (powering up or down). To check if flexibility can be provided for a gas or hydrogen grid. An EMS will be available to automatically steer the plant.
Does this test case build on the work of previous projects?	No.

A.9 Responses: Test Case 6

Test case:	6
Title:	Business Renewable Energy Communities (WapiGREEN)
Test case owner	IDETA
Location	Wallonia, city of Tournai
Status	WapiGREEN is a newly established business Renewable Energy Community (REC) that began operations in 2024 and is steadily growing. The initiative builds upon the foundations of the HospiGREEN pilot project, which ran in Tournai from November 1, 2020, to February 28, 2023, under a regulatory exemption granted by the CWaPE. With the conclusion of HospiGREEN and the introduction of a new legal framework in Wallonia, WapiGREEN is now operating under this updated regulatory environment.
Test case description	WapiGREEN is a business REC composed of industries, enterprises, hospitals and public authorities in Picardy Wallonia. Its goal is to share and self-consume renewable energy as a community of businesses (industries, enterprises, hospital and public authorities), as from 2024-2025. Around 35 consumption sites are currently being studied. The project will grow progressively in size, with the gradual addition of members and production resources. The energy source will be local solar and wind power. The photovoltaic production for the community will involve producers and prosumers with direct injection on the grid or surplus that is not directly self-consumed. Any supply or consumption of electricity will take place via the distribution network.
Sectors	Electricity: Wind and solar renewable energy connected, via the Grid, to a local REC of consumers.
End-uses	Industries, enterprises, hospitals and public authorities
Energy assets	Under development depending on the future members of the REC
Energy networks	Electrical energy Network - local grid (ORES) and transport grid (ELIA)
Sector coupling	Electricity production from wind turbine and solar PV connected on the national grid and shared for consumption with members of the REC.
Flexibility	92% of the production was collectively self-consumed by the REC HospiGREEN. There was no EMS or controllable assets. No batteries either. WapiGREEN is aiming for similar levels of self-consumption.
Does this test case build on the work of previous projects?	This test case followed a previous test case called “e-Cloud” which performed energy sharing (via the Grid) between some enterprises of the business park in Tournai. IDETA (Energy and renewable solutions division) studies for several years the interest of energy sharing and RECs. From 2019 on, IDETA ran 3 pilot cases under specific authorisations (legal framework): - E-Cloud project (2019 - CD-19c21-CWaPE-0303)

	- HospiGREEN project (2020-2022 CD-20j15-CWaPE-0451) - ACRUS project (2022-2025 CD-22c24-CWaPE-0639 - still running energy sharing in a same building). IDETA is also involved in several study cases to develop and run RECs in 2024-2026.

A.10 Responses: Test Case 7

Test case:	7
Title:	Integrated Energy Systems for Gas and Electricity
Test case owner	Fluxys Belgium
Location	Whole of Belgium
Status	Extension of functionalities for pilot developed under the framework of ETF project “Integration”.
Test case description	The INTEGRATION model aims to identify the optimal, carbon-neutral multi-energy system for North-West Europe. The initial version of the model has been built for Belgium only by ULiège & Fluxys during an ETF project financed by SPF Economie and was further developed by Fluxys to cover North-West Europe. The model is used to simulate the interactions between electricity, CH4, H2 and CO2 for the energy systems of countries bordering the North Sea. A specific ‘North Sea Cluster’ is being developed to better understand the optimal way of transporting the available offshore wind energy to the continent. This can be done for different scenarios and price sensitivities. Additionally, the Integration model can be used to complement and/or challenge certain results of the scenario testing that will be done in WP 2.1.
Sectors	- Electricity - Natural gas / Biomethane / Synthetic methane - Hydrogen - Biomass - (CO2)
End-uses	- Individual consumers modelled as one end-user group - Residential, commercial, industrial, transport (including international shipping) sectors
Energy assets	- End-use - Generation (wind, PV, gas, hydrogen, nuclear) - Transport - Distribution - Storage - Electrolysis - SMR - CC(U)S (capture, transport, sequestration and/or usage of CO2
Energy networks	Interconnected multi-energy system coupled with a carbon system: - Methane - Hydrogen - Electricity
Sector coupling	- CH4 CCGT / OCGT / CHP - H2 CCGT / Fuel cells - Electrolysis - SMR (CH4 => H2) - Methanation (H2 => CH4)

Flexibility	- Batteries - DSR - Pumped hydro - CH4 storage - H2 storage (caverns/tanks) - CO2 tanks - Line pack for molecules
Does this test case build on the work of previous projects?	The initial version of the model has been built for Belgium only by ULiège & Fluxys during an ETF project financed by SPF Economie.

Annex B Business Use Case Template

1. Description of the Use Case

1.1 General Information

Test Case ID	Name of Test Case
Maturity of Test Case – in business operation, realized in demonstration project, realised in R&D, in preparation, visionary	
Classifications According to ReInvent Cross-Sectoral Categories	
Energy Sectors: ☐ Electricity ☐ Gas ☐ Fuels ☐ Heating/Cooling ☐ Bioenergy ☐ Other:	**End-Use Sectors:** ☐ Industry ☐ Residential ☐ Commercial ☐ Transport & Mobility ☐ Agriculture ☐ Other:

1.2 Name of Use Case

ID	Name of Use Case

1.3 Version Management

Version	Date	Name – Author(s) or Committee

1.4 Scope and Objectives of Use Case

Research Question(s)	Test Case
Scope	
Objectives	
•	
View - Technical / Business	

1.5 Narrative of Use Case

Short description – max 3 sentences (focus on key points of the use case)
Complete description – detail all steps and components of use case

1.6 Use Case Conditions

Assumptions
Prerequisites

1.7 General Remarks

General Remarks

2. Structure

2.1 Actors and Roles

Roles – *refer to the bottom of the document for descriptions of each actor*	
☐ Consumer	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ Producer	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ Prosumer	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ Storage Provider	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ Multi-Energy System (MES) Operator	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ DSO/DNO	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ Network/Grid user	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ TSO	☐ Electricity ☐ Gas
☐ H/C Network Owner	
☐ Market Operator	
☐ Balance Responsible Party (BRP)	
☐ Supplier/Retailer	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ Aggregator	
☐ Regulator	
☐ Flexibility Service Provider (FSP)	☐ Green Molecules ☐ Electricity ☐ Heating/Cooling ☐ Gas
☐ Data Provider	
☐ Meter Operator	
☐ Meter Data Administrator	
☐ Meter Data Aggregator	
☐ Meter Data Collector	
☐ Metered Data Responsible	
☐ Metering Point Administrator	
☐ Other: ____________________________	
☐ Other: ____________________________	
☐ Other: ____________________________	
☐ Other: ____________________________	

Actor Name	Actor Description	Role(s)	Test Case

2.2 Drawing or Diagram of Use Case

Drawing or Diagram of Use Case – *recommended "context diagram" and "sequence diagram" in UML*

3. Key Performance Indicators

Name	*Description*	*Domain*