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DE-RISK Project

D4.4: Implementation and operation for DE-RISK Case Studies

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DE-RISK

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Deliverable	**Number**	D4.4	**Title**	Implementation and operation for DE-RISK Case Studies
Work Package	**Number**	WP4	**Title**	Case study preparation, implementation and validation

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ABBREVIATIONS

AC	Air Conditioning
BMS	Building management system
BIML	Building Information Management Layer
BRP	Balance Responsible Party
D	Deliverable
DHW	Domestic Hot Water
DoA	Description of Action
DR	Demand Response
DSO	Distribution System Operator
ESCO	Energy service company
FRP	Flexibility Requesting Party
GDPR	General Data Protection Regulation
HVAC	Heating Ventilation and Air Conditioning
IEC	International Electrotechnical Commission
IoT	Internet of Things
KPI	Key Performance Indicator
kWh	Kilowatt-hour
kWp	Kilowatt-peak
LFM	Local Flexibility Market
LFA	Local Flexibility aggregator
M	Month
MWh	Megawatt-hour
PV	Photovoltaic Panel
RES	Renewable Energy Sources
Sc.	Scenario
St.	Step
T	Task
TSO	Transmission system operator
UC	Use case
WMAs	Wholesale Market Aggregators

EXECUTIVE SUMMARY

This deliverable outlines the implementation and operational plans for DE-RISK's four pilot case studies. Five use cases have been identified to demonstrate how these pilot studies will function in the local flexibility market, focusing on assessing, unlocking, and validating their flexibility potential.

The identified use cases are:

1. Participation in explicit Demand Response.
2. Participation in implicit Demand Response.
3. Dashboard monitoring.
4. Optimization of renewable electricity utilization.
5. Minimization of electricity bills.

These use cases have been devised according to the IEC 62559-2 standard, ensuring high quality and consistency.

1 INTRODUCTION

1.1 Scope of the deliverable

Local Flexibility Markets (LFMs) are crucial for the successful integration of renewable energy systems into the grid. DE-RISK aims to support the market uptake of these systems by fostering the adoption of LFMs and unlocking up to 100 GW of flexibility by 2030. This will facilitate the safe and reliable integration of renewable energy sources (RES) into the grid, minimizing investment and implementation risks. DE-RISK aims to address this through an innovative approach that encourages customer behaviour change, increasing end users' trust and willingness to participate in flexibility markets.

By integrating digital twins into its flexibility platform, DE-RISK aims to bridge the gap between simulation and real-world implementation, mitigating potential technical risks during deployment and operation.

This deliverable builds upon the simulation results and the analysis of the local setting conducted in previous Tasks, T4.1 and T4.2 respectively, to outline the implementation and operation plans. It focuses on the use cases based on which the low-cost DE-RISK digital twin platform will be deployed to assess, validate, and unlock flexibility potential in DE-RISK's Pilot case studies. These use case studies are located in Çanakkale, Türkiye; Murcia and Barcelona, Spain; and Galway, Ireland.

1.2 Structure of the deliverable

This deliverable is organized into four main chapters. Besides chapter 1, which introduces this deliverable, the following chapters are included:

Chapter 2: Describes the four pilot case studies located in Çanakkale, Türkiye; Murcia and Barcelona, Spain; and Galway, Ireland.
Chapter 3 explains the methodology used to develop the use cases, based on the IEC 62559-2 standard.
Chapter 4 presents the five use cases that outline the implementation and operation plans for the DE-RISK platform. Each use case includes detailed descriptions of the processes, interactions between components and stakeholders/ actors.

1.3 Relation to other tasks and deliverables

D4.4 “Implementation and Operation for DE-RISK Case Studies,” builds on the groundwork laid in the previous tasks of WP4, T4.1 “Preparation and Set-Up of DE-RISK Data Collection” and T4.2 “Building Case Studies Digital Twins and Simulation Scenarios”. Additionally, T4.5 “Benchmarking DE-RISK case studies and monitoring the multi criteria performance of DE-RISK” relies heavily on the outcomes and data gathered from T4.4.

Beyond WP4, this task will support the advancement of user engagement initiatives in WP2 and regulatory advocacy in WP3. The use cases presented in this deliverable will also contribute to developing innovative financing and contracting models in WP5.

2 PILOT CASE STUDIES

This section comprises a brief description of the Pilot case studies and their corresponding infrastructure within DE-RISK project. It also includes the presentation of simulation results that will be validated in the Pilot case studies over the next few months.

2.1 Joven Futura (Murcia, Spain)

The pilot case study is based in the residential neighbourhood of Joven Futura in Murcia, Spain. Comprising multi-family apartment buildings constructed between 2006 and 2010, the neighbourhood features 15 apartments participating in the DE-RISK project producing their own energy with a solar PV installation. With a Mediterranean climate characterized by mild winters and hot summers, Murcia is the 7th largest city in Spain. The apartments primarily rely on electricity for energy consumption, with an average yearly consumption of 3.5 MWh per apartment, costing approximately €700 annually. Additionally, there are tariffs with different prices depending on the period of use and also dynamic tariffs with prices related to the wholesale market hourly electricity prices.

DE-RISK aims to pave the way creating a flexible environment where prosumers can offer their available flexibility to a local flexibility aggregator. This role can be filled by MIW for the demonstration activities, pilot case study leader and the electricity utility providing energy to the apartments. This way prosumers can participate in Demand response events, reducing the cost of their electricity bill. Moreover, prosumers will have the opportunity to maximize their self-consumption, thereby reducing reliance on grid electricity and optimizing the use of renewable energy resources.

2.2 La Balma (Barcelona, Spain)

The La Balma Pilot case study located in Barcelona, Spain, is a multi-apartment cooperative building aimed at achieving affordable housing and sustainable practices. Comprising of 20 dwellings with a collective self-consumption PV system and various communal spaces, La Balma fosters community life and strengthens ties with the neighbourhood. The building, constructed with a compact design and an A energy rating, utilizes active and passive strategies for energy reduction and collective management of energy production. The installations are fully centralized, featuring a geothermal system for hot water and heating, contributing to exceptionally low yearly electrical consumption compared to the Spanish average. The building also integrates PV installations connected to a battery for communal spaces. Despite the low individual consumption, communal areas and heat pumps indirectly increase total electrical loads, distributed among residents based on proportional coefficients. The PV generation in La Balma, totalling 17.36 kWp, is divided between household consumption (7.84 kWp) and communal areas (9.52 kWp), enabling residents to maximize self-consumption and optimize renewable energy usage. The pilot case study aims to create a flexible environment where prosumers can offer their available flexibility, participate in demand response events, and reduce electricity bills.

2.3 Kepez (Çanakkale, Türkiye)

The Turkish pilot case study is centered in the small town of Kepez in Çanakkale, Türkiye and aims to enhance energy efficiency and demand response capabilities in residential buildings. Çanakkale experiences a Mediterranean climate, characterized by warm, humid summers and long, cold, wet winters with occasional winds and partly cloudy skies. Initially lacking IoT infrastructure, 18 households were identified suitable to participate in the DE-RISK project, equipped with air conditioning split units for heating and cooling, and hot water systems, the Pilot case study leaders, TRO and UE collaborated with QUE to implement QUE's end-to-end IoT solution.

The pilot aims to enhance energy management, particularly for heating and cooling, in line with the region's climatic conditions. The implementation of semi-automated control systems, offering a blend of automated and manual control functionalities, will allow residents to participate in Demand Response schemes ensuring GDPR compliance.

2.4 National University of Ireland Galway (Galway, Ireland)

The Aras DeBrún building, situated at the core of the University of Galway Campus, is the primary focus of the Irish Pilot case study within the DE-RISK project. Originally erected in the 1960s, it serves as the home to the School of Mathematics, Mathematical Physics, and Statistics at the University of Galway. Named in honour of the former university president, Pádraig DeBrún, the building stands as a testament to his multifaceted contributions as an Irish clergyman, mathematician, poet, and classical scholar. The building's orientation aligns with a North/South axis, accommodating classrooms, research laboratories, PC suites, and offices under a single, flat felted roof. The climate of Galway is oceanic, with quite mild, rainy winters and mild, relatively rainy summers.

Galway pilot faces several challenges and obstacles in DE-RISK. One significant difficulty revolves around the cybersecurity constraints that hinder communication between the building management system (BMS) database at Aras DeBrún and QUE's cloud-based platform utilized for the project monitoring and data management.

As for the time being, Galway will focus to inform the occupants, students, and teachers of the building with the use of the internal, accessible, BMS metered data associated with its energy systems, facilitating informed decision-making and rationalization of energy usage.

3 USE CASE METHODOLOGY

3.1 Introduction

The findings from Task 4.2 have led to the identification of appropriate simulation scenarios, each tailored to optimize control strategies effectively. These simulations offer valuable insights into the practical implementation of each scenario within DE-RISK case studies. To execute these simulations, along with Demand Response scenarios, a series of use cases have been developed, outlining precise steps to guide the process. These use cases have been devised based on the Use-Case Methodology defined in the standard IEC 62559-2:2015. The following chapter describes this use case methodology in detail.

3.2 Use Case Methodology

The implementation and operation plans for the DE-RISK case studies will be outlined using use cases which facilitate the identification of involved domains and both human/non-human actors as well as the description and organisation of technical requirements. DE-RISK use cases are based on the IEC 62559-2:2015 standard, a methodology proposed by the International Electrotechnical Commission (IEC) [6]. To ensure better replicability and scalability, they will be kept generic.

Use cases are a powerful tool in system development and project planning. They provide a clear framework for defining how different components interact within a system. By employing this methodology, we ensure that all aspects of the project are meticulously documented and understood by all stakeholders. This approach not only streamlines the development process but also improves communication and coordination among team members.

In addition, the generic nature of the use cases ensures that they can be adapted to different contexts and projects, making them versatile and scalable. This flexibility is crucial for the DE-RISK project, as it involves diverse scenarios and requirements. By adhering to the IEC 59-2:2015 standard, the defined methodology is aligned with internationally recognized best practices, ensuring high quality and consistency in our use cases.

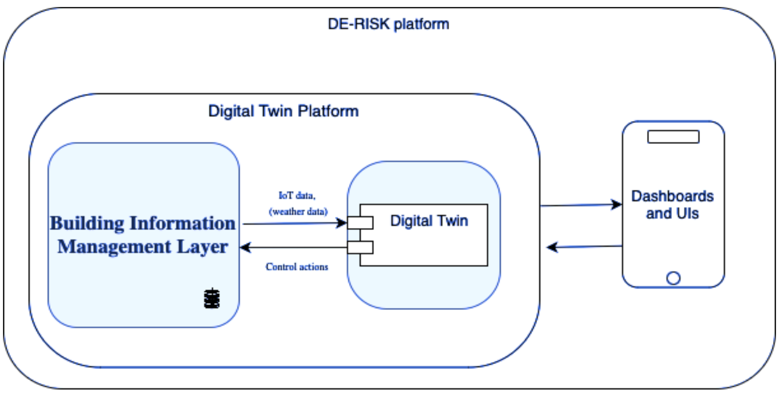
To enhance understanding of the following use cases, definitions of key components, platforms, and stakeholders within DE-RISK are provided below.

DE-RISK platform: The project's flexibility platform, DE-RISK platform aims to bridge the gap between simulation and real-world implementation, thereby reducing potential technical risks during deployment and operation. This component consists of the Digital Twin platform and a form of embedded dashboard.

- **Digital twin platform:** Facilitates information exchange between the Building Information Management Layer (BIML) and the Digital Twin component. It manages internal functionalities within these subcomponents and communicates with external systems.
    - **Building Information Management Layer (BIML) component:** A subcomponent of the Digital Twin platform, responsible for collecting real-time, near real-time and historical data from IoT devices and other building assets (e.g., photovoltaic systems) identified in the various DE-RISK Pilot case studies. These devices, assets, and the BIML component have been described in D4.1 [4].
    - **Digital Twin component:** This subcomponent of the Digital Twin platform includes state-of-the-art embedded algorithms to accurately forecast building occupants' consumption behaviour and comfort profiles, also it assesses and validates potential flexibility, based on QUE’s technology stack. Details of the Digital Twin component is provided in D4.2 [5].

Below a graphical representation of the DE-RISK platform and its subcomponents:

***Figure 1:** DE-RISK flexibility platform*



Local flexibility aggregator (LFA): The Local Flexibility Aggregator (LFA) is a key player in DE-RISK's Local Flexibility Market Model, aimed at transforming the current flexibility market. The LFA aggregates flexibility resources from prosumers and coordinates their participation in the market. It acts as a bridge between these local entities and larger market players like Wholesale Market Aggregators (WMAs) and Distribution Service Operators (DSOs). [2]

The tables below show the DE-RISK's use cases and the association per pilot case study.

Table 1: *DE-RISK use cases*

Use case ID	Use case name
UC1	Participate in explicit Demand response
UC2	Participate in implicit Demand response
UC3	Dashboard monitoring
UC4	Optimize the utilization of renewable electricity
UC5	Minimize the electricity bill

Table 2: *DE-RISK use cases and Pilot case studies association*

Use Case	Joven Futura, Murcia, Spain	LaBalma, Barcelona, Spain	Kepez, Çanakkale, Türkiye	National University of Ireland Galway, Ireland
UC1	X		X	
UC2	X	X	X	X
UC3	-	-	-	-
UC4	X	X		X
UC5	X	X	X	

3.3 Use Case Template

The structure of the use cases can be divided in the following main sections:

- **Use case description:** This section provides information about the scope, objectives, narrative, and other generic information about the use case.
- **Diagrams:** This section depicts the relationships between different components and stakeholders, illustrating how they operate within the context of the use case.
- **Actors and scenarios:** The first part of this section details the various stakeholders participating in the use case. The second part outlines the scenarios, providing brief descriptions and specific steps.

- **Information exchange:** This fourth and final section describes the data that must be exchanged between actors or other use cases throughout the execution of a given use case.

3.4 UC1 Participate in explicit Demand response

3.4.1 Use case Description

3.4.1.1 Name of the Use Case

Use case identification		
ID	**Area/Domain/Zone(s)**	**Name of the use case**
UC1	Areas: Energy system, Smart Home/Building Domains: Transmission, Distribution, Customer Premises Zones: Operation and Market	Participate in explicit Demand response

3.4.1.2 Version Management

Version management				
Version No.	**Date**	**Name of Authors**	**Changes**	**Approval status**
0.0	15/04/2024	Konstantinos Mamis	First Version	
0.1	28/04/2024	Thanos Kalamaris	Second draft	
0.2	25/05/2024	Konstantinos Mamis	Final draft	

3.4.1.3 Scope and objectives of the Use Case

Scope and objective of the use case	
Scope	Participation in explicit Demand Response
Objective(s)	a) Offer flexibility to market actors b) Align the consumption with remote control commands based on the flexibility available

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3.4.1.4 Narrative of the Use Case

Narrative of use case
Short description
This use case describes how the flexibility from DE-RISK prosumers will be extracted and be proposed explicitly to the Local Flexibility Market via a local flexibility aggregator, who will act as the "match maker" between two different stakeholders.
Complete description
In the context of unlocking the potential of the local flexibility markets in the distribution grid there are many challenges, coordination among the stakeholders and the need for data exchange. Occupants of a smart home/ building (prosumers) can offer their flexibility to the market, via an aggregator, participating in explicit Demand Response. Demand Response (DR) refers to a reduction or a shift of the electricity usage of a consumer in response to supply constraints. This Use Case describes: • The involvement of households/buildings in DE-RISK's case studies in explicit Demand Response. This involvement occurs through providing flexibility via Heating Ventilating Air-conditioning (HVAC) systems and Domestic Hot Water (DHW) to a Local Flexibility Aggregator (an aggregator, energy retailer, ESCO). Subsequently, these stakeholders collect this flexibility and offer diverse services to actors who need this energy for efficiency, such as grid operators (DSO, TSO) or to decrease sourcing costs (purchase of electricity), such as market actors (BRP, FRP). These services may include grid capacity management, congestion management, voltage control, adequacy services, balancing services, etc. [2] • How the explicit Demand Response signals will be executed to the households/buildings assets to adjust the consumption, shifting available loads in response to flexibility demands. This Use Case is composed of the following functions: • Evaluate the flexibility from HVAC or DHW water systems. • Send the potential flexibility to a local flexibility aggregator. • At the start of the flexibility period, Define and carry out the proper remote controls. • At the end of the flexibility period, Define and carry out corrective controls for the loads. • Opt-out; give the option to not participate or override the automated actions to the occupant.

3.4.1.5 Use case conditions

Use case conditions
Assumptions
• The consumer has a contract with an aggregator to provide their flexibility. • The local flexibility aggregator requests an amount of flexibility and creates a DR signal. • Aggregators have the capability to process and act on flexibility data received from consumers.
Prerequisites
• The smart home/building is equipped with an IoT solution compatible with QUE's solution. • The consumer has at least one controllable load. • DE-RISK solution is up and running. (i.e., seamless information flow among interacting components and valid and adequate data acquisition). • Regulatory and market frameworks support explicit demand response programs.

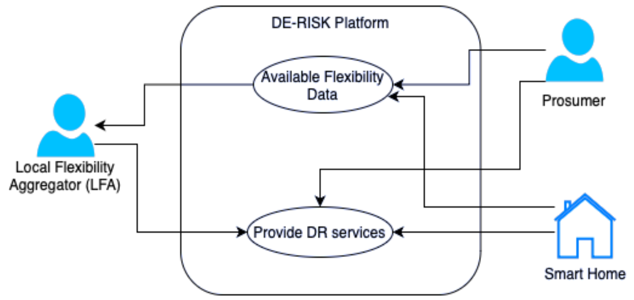
Further information to the use case for classification/mapping:

Classification Information
Relation to the other use cases
Possible conflict with UC4 and UC5 may occur. The priority of use cases will be further investigated.
Level of depth
Medium
Generic, regional or national relation
Generic
Nature of the use case
Technical
Further keywords for classification
Explicit demand Response, Local flexibility Aggregator, Flexibility, Smart Home, Potential flexibility, Grid Stability, Smart Grid

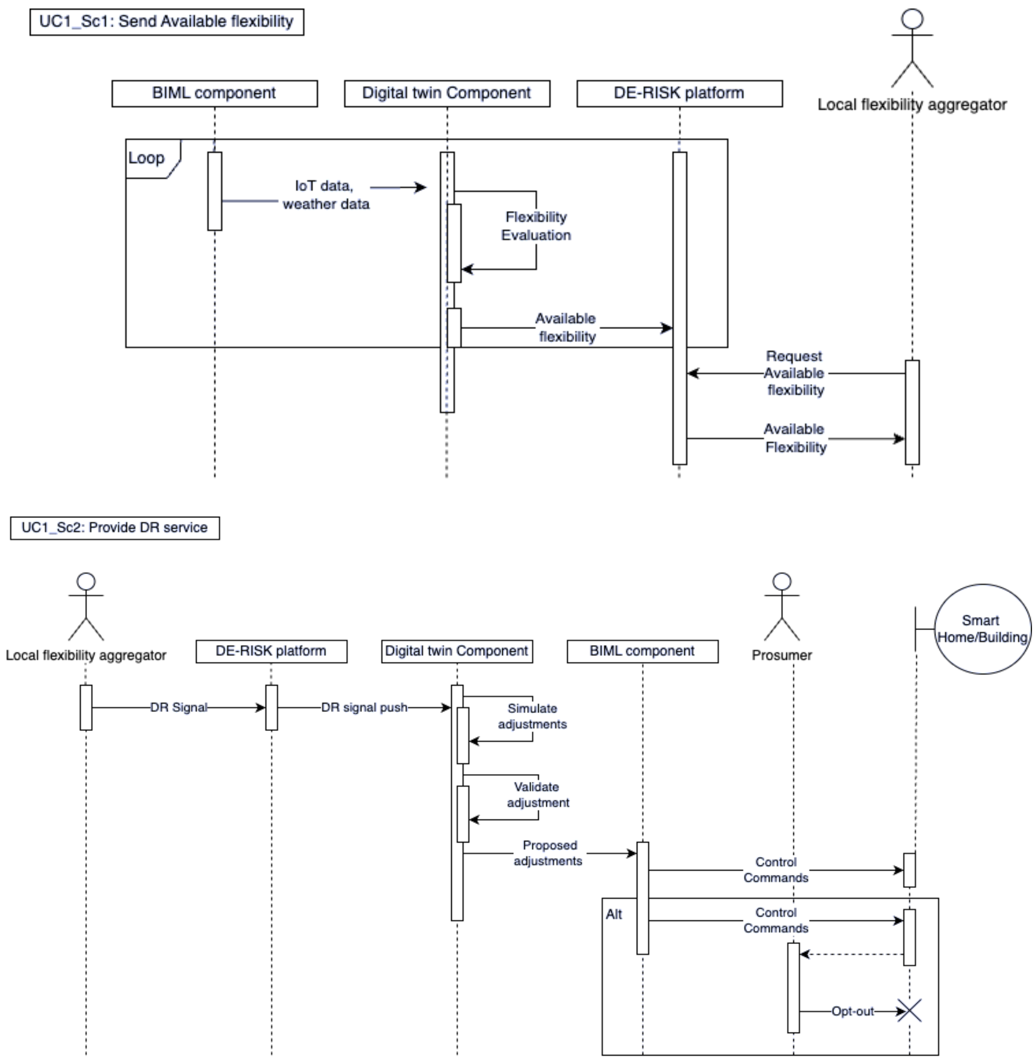
3.4.2 Diagrams of use case

Diagram(s) of the use case

[Use case diagram.]



[Sequence diagram.]



3.4.3 Actors and Scenarios

3.4.3.1 Actors

Actors			
Grouping	**Group description**		
Business Actor	Business actor is a stakeholder that possesses and pursues its own interests. Business actors may exist as either legal or physical entities.		
Logical Actor	A physical component that plays a role in the execution of a use case.		
Actor name	**Actor type**	**Actor description**	**Further information specific to this use case**
Prosumers/ consumer	Business actor	End user that consumes and/ or generates electricity.	
Smart home/ building	Logical actor	Home or building equipped with an IoT solution with the capability to participate in DR.	
Domestic Hot Water (DHW) systems.	Logical actor	Uses electricity to heat water in a preferable higher temperature.	
Heating Ventilation Air-Conditioning systems (HVAC)	Logical actor	HVAC systems increase the thermal comfort of occupants in a house or building.	
Local Flexibility Aggregator (Aggregator, ESCO, energy retailer)	Business actor	An entity that consolidates flexibilities on behalf of its customer.	
DSO, TSO	Business actor	An entity that requests flexibility	

3.4.3.2 Overview of scenarios

3.4.3.2.1 Scenarios of the use case

Scenario conditions					
No.	**Scenario name**	**Primary Actor**	**Triggering event**	**Pre-condition**	**Post-condition**
Sc.1	Send Available Flexibility Data	DE-RISK Platform	Local flexibility market aggregator initiates a request for available flexibility.	DE-RISK platform up and running.	Flexibility data received by the local flexibility aggregator.

Scenario conditions					
No.	**Scenario name**	**Primary Actor**	**Triggering event**	**Pre-condition**	**Post-condition**
Sc.2	Provide DR services	DE-RISK Platform	Receipt of DR signal from the Local flexibility market aggregator.	Flexibility data has been evaluated, sent to the aggregator (Sc.1) and a DR event has been created.	Adjustments are validated, and the systems are prepared to implement them safely.

3.4.3.2.2 Steps per scenario

The following tables present the steps of each of the scenarios associated with this use case as well as the respective requirements:

Scenario name		Sc.1 Send Available Flexibility					
Step No.	**Event**	**Name of the process**	**Description of the process**	**Service**	**Information producer (actor)**	**information receiver (actor)**	**Information exchanged (IDs)**
St.01	Flexibility Evaluation	Assess Energy Usage	Assess energy usage patterns of HVAC and DHW systems. This is an internal function regularly performed	Energy Monitoring	BIML component	Digital Twin component	Energy usage data
St.02	Calculation of Flexibility	Calculate Available Flexibility	Calculation of available flexibility, ensuring no negative impact on occupant comfort.	Flexibility Calculation	Digital Twin platform	Digital Twin platform	Available flexibility data
St.03	Request available flexibility	Available flexibility request	Local flexibility aggregator requests the available flexibility	Flexibility Request	Local flexibility aggregator	DE-RISK platform	Available flexibility data
St.04	Send Available Flexibility Data	Send Available Flexibility Data	Available Flexibility data is sent from the DE-RISK flexibility Platform to the Local flexibility aggregator.	Data Transmission	DE-RISK platform	Local flexibility aggregator	Available flexibility data

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Scenario name	Sc.2 Provide DR services						
Step No.	**Event**	**Name of the process**	**Description of the process**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information exchanged (IDs)**
St.01	Receive DR Signal	Receive DR Signal	Receive DR signal from the Local Flexibility aggregator.	Request	Local flexibility aggregator	DE-RISK platform	DR signal
St.02	Simulate Adjustments	Adjust HVAC and DHW Consumption	Digital Twin simulates adjustments to HVAC and DHW consumption to reduce or shift energy consumption.	Flexibility simulation	Digital Twin component	Digital Twin component	Simulation Data
St.03	Validate Adjustments	Validate Simulation Results	The Digital twin platform validates that simulated adjustments meet DR requirements without negatively affecting system performance.	Validation	Digital Twin component	Digital Twin component	Validation data
St.04	Implement Adjustments	Implementation	Upon successful validation, the Digital Twin Platform sends the proposed adjustment to the BIML component.	Control commands	Digital Twin component	BIML component	Control commands
St.05	Opt-out Option	Occupant Overrides	Occupants can opt-out or override automated actions if necessary.	Prosumer Control	Prosumer	HVAC/ DHW systems	Override commands

3.4.4 Information exchange

Information exchange		
Information exchanged (ID)	**Name of information**	**Description of Information Exchanged**
ID1	Energy Usage Data	Data on energy consumption of HVAC and DHW systems from the BIML component
ID2	Available flexibility Data	Data indicating the potential flexibility from a prosumer
ID3	DR Signal	Demand Response signal indicating the need to adjust energy consumption
ID4	Simulation Data	Data from the simulation of adjustments to HVAC and DHW settings
ID5	Validation Data	Results of the validation process ensuring adjustments are viable

Information exchange		
Information exchanged (ID)	Name of information	Description of Information Exchanged
ID6	Control commands	Commands to adjust HVAC and DHW settings based on validated simulation
ID7	Override Commands	Commands from occupants to override automated DR actions

3.5 UC2 Participate in implicit Demand response.

3.5.1 Use case Description

3.5.1.1 Name of the Use Case

Use case identification		
ID	**Area/Domain/Zone(s)**	**Name of the use case**
UC2	Areas: Energy system, Wholesale market, Smart Home/Building Domains: Transmission, Distribution, Customer Premises Zones: Operation and Market	Participate in Implicit Demand Response

3.5.1.2 Version Management

Version management				
Version No.	**Date**	**Name of Authors**	**Changes**	**Approval status**
0.0	15/04/2024	Konstantinos Mamis	First Version	
0.1	28/04/2024	Thanos Kalamaris	Second draft	
0.2	25/05/2024	Konstantinos Mamis	Final draft	

3.5.1.3 Scope and objectives of the Use Case

Scope and objective of the use case	
Scope	Participation in Implicit Demand Response
Objective(s)	a) Offer flexibility to market actors through flexibility forecasts. b) Suggest the optimal load usage at specific periods based on the flexibility available.

3.5.1.4 Narrative of the Use Case

Narrative of use case
Short description
This use case describes how the flexibility from DE-RISK consumers/ prosumers will be extracted and be proposed implicitly to an ESCo.
Complete description
In infrastructures where direct exposure to markets explicitly is not feasible, occupants of smart homes/buildings can contribute their flexibility to the market, participating in Demand Response schemes implicitly. Data streams from HVAC and/or DHW loads can forecast their potential flexibility. Owners of these assets receive appropriate Demand Response (DR) event notifications, indicating upcoming demand/generation requests and suggesting actions for their assets. These notifications could be facilitated through smart contracts, detailing the requested action, timing, rewards, and penalties for (non-)compliance. The end user then informs the ESCo of their acceptance or rejection of the request. Upon the agreed period's conclusion, a clearance process distributes rewards or penalties to DR participants accordingly. [2]

3.5.1.5 Use case conditions

Use case conditions
Assumptions
• The consumer has a contract with an aggregator to provide their flexibility.
Prerequisites
• The smart home/building is equipped with an IoT solution, a bespoke database connected with the BIML component. • The local flexibility aggregator requests an amount of flexibility. • The local flexibility aggregator creates a DR event.

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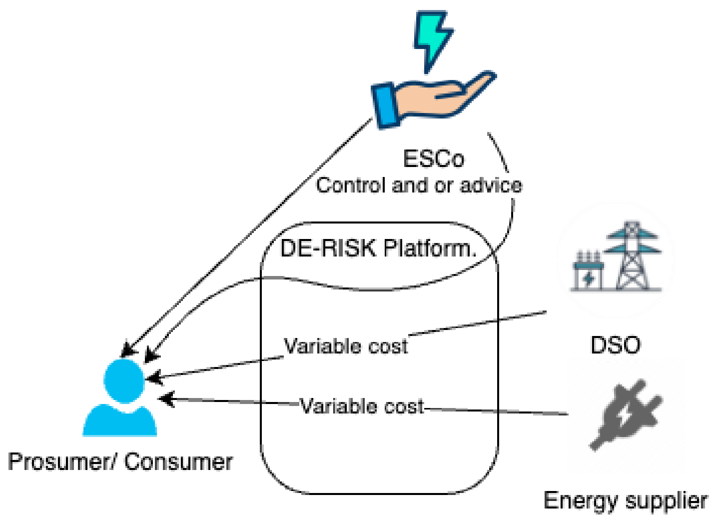
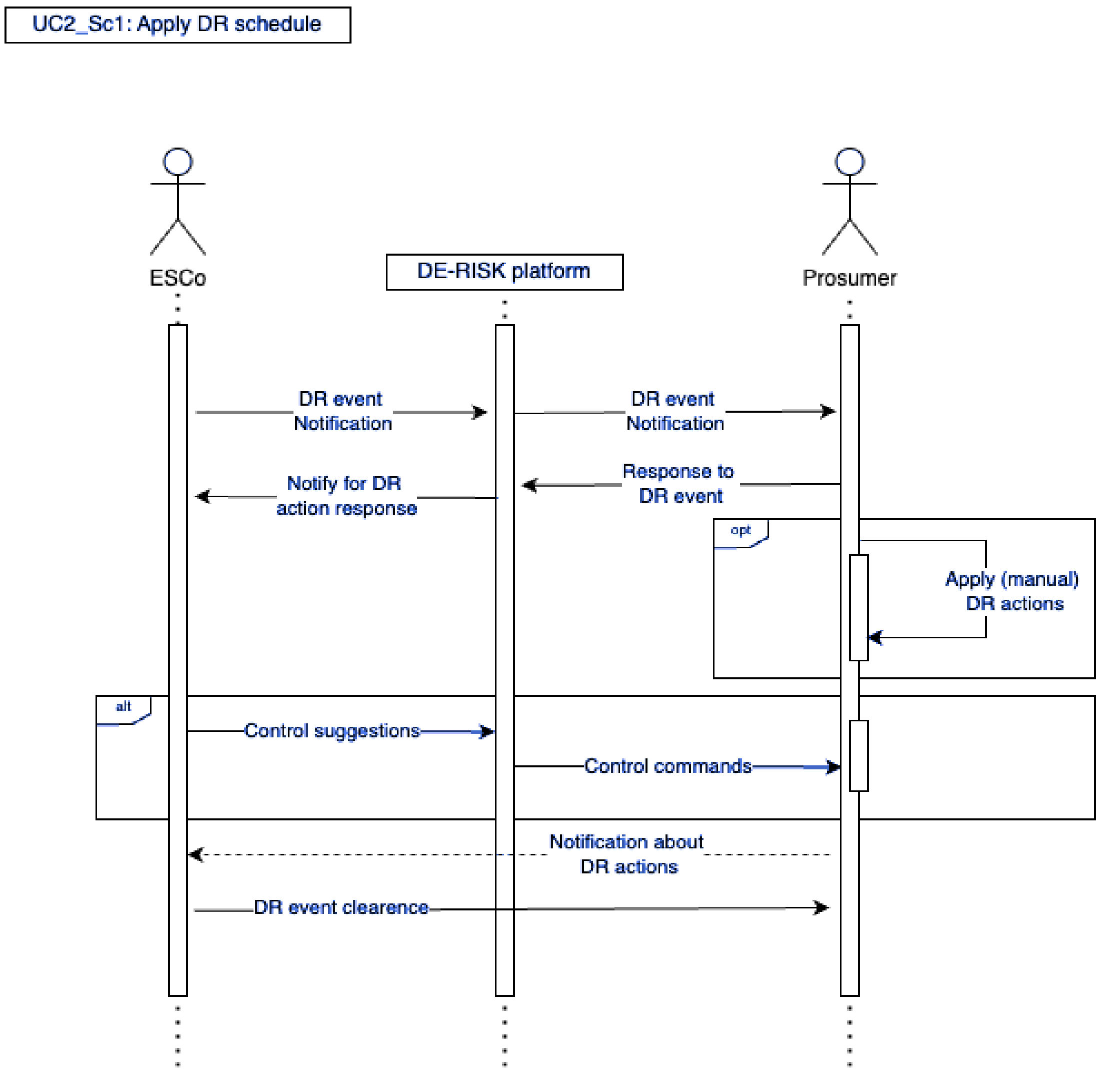
3.5.1.6 Further information to the use case for classification/mapping

Classification Information
Relation to the other use cases
UC4 and UC5 describe how each implicit flexibility service will be materialized. [2]
Level of depth
Medium
Generic, regional or national relation
Generic
Nature of the use case
Technical
Further keywords for classification
Implicit demand Response, Local flexibility Aggregator, Flexibility, Flexibility forecast, Smart Home, Potential flexibility, IoT

3.5.2 Diagrams of use case

Diagram(s) of the use case
[Use case diagram.] 

[Sequence diagram.]



3.5.3 Actors and Scenarios

3.5.3.1 Actors

Actors			
Grouping	**Group description**		
Business Actor	Business actor is a stakeholder that possesses and pursues its own interests. Business actors may exist as either legal or physical entities.		
Logical Actor	A physical component that plays a role in the execution of a use case.		
Actor name	**Actor type**	**Actor description**	**Further information specific to this use case**
Prosumers and consumers	Business actor	End user that consumes and/ or generates electricity	
Smart home/ building	Logical actor	Home or building equipped with an IoT solution with the capability to participate in DR	
Domestic Hot Water (DHW) systems.	Logical actor	Uses electricity to heat water in a preferable higher temperature	
Heating Ventilation Air-Conditioning systems (HVAC)	Logical actor	HVAC systems increase the thermal comfort of occupants in a house or building	
ESCo	Business actor	An entity that consolidates flexibilities on behalf of its customer	
DSO, TSO	Business actor	An entity that requests flexibility	

3.5.3.2 Overview of scenarios

Scenario conditions					
No.	**Scenario name**	**Primary Actor**	**Triggering event**	**Pre-condition**	**Post-condition**
Sc.1	Apply DR schedule	DE-RISK platform	Prosumer/ consumer receives DR event notification advice from the ESCo.	A timeframe of financial incentive from the DSO or the energy supplier is available	Prosumers are notified and can accept or reject the DR event request.

3.5.3.3 Steps per scenario

The following tables present the steps of each of the scenarios associated with this use case as well as the respective requirements:

Scenario name	Sc.1 Apply DR schedule						
Step No.	**Event**	**Name of the process**	**Description of the process**	**Service**	**Information producer (actor)**	**information receiver (actor)**	**Information exchanged (IDs)**
St.01	Receive DR Event Notification Request	DR Event Notification Request	DE-RISK platform receives a request from the ESCo to notify users of a DR event.	Notification Request Reception	ESCo	DE-RISK platform	DR Event Notification Request
St.02	Send DR Event Notification	Notify prosumers	DE-RISK Platform sends notifications to prosumers, suggesting actions to adjust energy consumption.	Prosumer Notification	DE-RISK platform	Prosumer	DR Event Notification
St.03	Prosumer Response to DR Event	Prosumer Response	Prosumers accept or reject the DR event request and inform the local flexibility aggregator of their decision.	Response Collection	Prosumer	ESCo	Prosumer Response
St.04	Apply DR schedule	DR Event Execution	Prosumers manually adjust their energy consumption as per the DR event notification.	Manual Load Adjustment	Prosumer	Prosumer	Comply with proposed DR actions.
St.05	DR Event Clearance	Distribute Rewards/ Penalties	At the end of the DR period, the system processes and distributes rewards or penalties based on prosumer compliance.	Reward/ Penalty Distribution	Local flexibility aggregator	Prosumer	Rewards/ Penalties Information

3.5.4 Information exchange

Information exchange		
Information exchanged (ID)	**Name of information**	**Description of Information Exchanged**
ID1	Energy Usage Data	Data on energy consumption of HVAC and DHW systems from the BIML component.
ID2	Flexibility Forecast Data	Data indicating the potential flexibility forecast from a prosumer.
ID3	DR Event Notification Request	Request from the local flexibility aggregator to notify users about upcoming DR events.
ID4	DR Event Notification	Notification to users about DR events, including suggested actions, timing, rewards, and penalties.
ID5	User Response	Manual adjustments made by prosumers as a response to DR events.
ID6	Adjustment Actions	Commands to adjust HVAC and DHW settings based on validated simulation.
ID7	Rewards/ Penalties Information	Information on rewards or penalties distributed to users based on their participation.

3.6 UC3 Monitoring and dashboards

3.6.1 Use case Description

3.6.1.1 Name of the Use Case

Use case identification		
ID	**Area/Domain/Zone(s)**	**Name of the use case**
UC2	Areas: IoT, Smart Home/Building Domains: Customer Premises Zones: Operation	Dashboard monitoring

3.6.1.2 Version Management

Version management				
Version No.	**Date**	**Name of Authors**	**Changes**	**Approval status**
0.0	15/04/2024	Konstantinos Mamis	First Version	
0.1	28/04/2024	Thanos Kalamaris	Second draft	
0.2	25/05/2024	Konstantinos Mamis	Final draft	

3.6.1.3 Scope and objectives of the Use Case

Scope and objective of the use case	
Scope	Remote monitoring devices through dashboards, support decision making.
Objective(s)	Allow consumers, prosumers to monitor their devices, receive notifications and support them in their decision making. The functionalities of these dashboards have not been defined yet among the consortium.

3.6.1.4 Narrative of the Use Case

Narrative of use case
Short description
This use case describes how end users can monitor their devices through dashboards.
Complete description
This Use case will enable consumers and prosumers to monitor their devices managing their energy and participate in manual optimization and implicit Demand Response. These dashboards need further discussions between partners and users to outline the exact functionalities of the web application to be developed.

3.7 UC4 Optimize the utilization of renewable electricity

3.7.1 Use case Description

3.7.1.1 Name of the Use Case

Use case identification		
ID	**Area/Domain/Zone(s)**	**Name of the use case**
UC1	Areas: Energy system, Smart Home/Building Domains: DER, Customer Premises Zones: Operation	Optimize the utilization of renewable electricity

3.7.1.2 Version Management

Version management				
Version No.	**Date**	**Name of Authors**	**Changes**	**Approval status**
0.0	15/04/2024	Konstantinos Mamis	First Version	
0.1	28/04/2024	Thanos Kalamaris	Second draft	
0.2	25/05/2024	Konstantinos Mamis	Final draft	

3.7.1.3 Scope and objectives of the Use Case

Scope and objective of the use case	
Scope	Maximise self-consumption.
Objective(s)	Optimize the utilization of locally generated renewable energy by aligning the operation of household devices with periods of local renewable energy generation.

3.7.1.4 Narrative of the Use Case

Narrative of use case
Short description
This use case describes how the flexibility from DE-RISK consumers/ prosumers will be extracted and optimize the utilization of self generated energy.
Complete description
This Use case concerns the end users, prosumers, that have a PV panel installation (the same principle could apply to prosumers equipped with other renewable energy sources, such as windmills, small hydro, batteries, etc). Prosumers who wish to maximize the utilisation of their local PV generation can either automatically or manually synchronize their consumption to match their electricity generation. **Automatic optimization:** The DHW and HVAC loads will be synchronized to consume on periods of PV generation, taking into account user thermal comfort and personal preferences. **Manual optimization: I**n this scenario end users will receive indicative periods where they should consume the forecasted energy. Moreover, by constantly monitoring the generated energy through DE-RISK's dashboards these actions could significantly impact the consumption of the generated electricity. This Use Case is composed of the following functions: • Forecast of the PV generation available. • Learning the building's hot water usage patterns. • Learning the building's thermal comfort profile in spaces where an HVAC operates. • Forecast and optimize the water heating to consume when the PV system generates electricity. • Forecast and optimize the HVAC to consume when the PV system generates electricity. • Opt-out; give the option to not participate or override the automated actions to the occupant.

3.7.1.5 Use case conditions

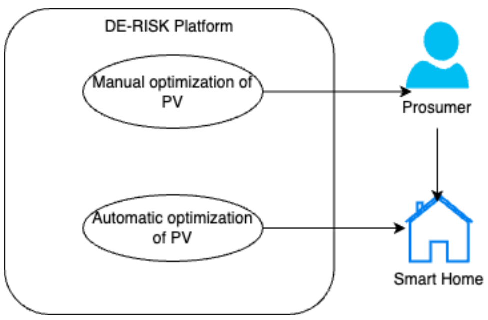
Use case conditions
Assumptions
• It is assumed that the prosumer has a renewable energy source (e.g., PV panels), which is functional and capable of generating electricity as expected.
Prerequisites
• The smart home/building is equipped with an IoT solution, a bespoke database connected to BIML. • The prosumer has a renewable energy source.

3.7.1.6 Further information to the use case for classification/mapping

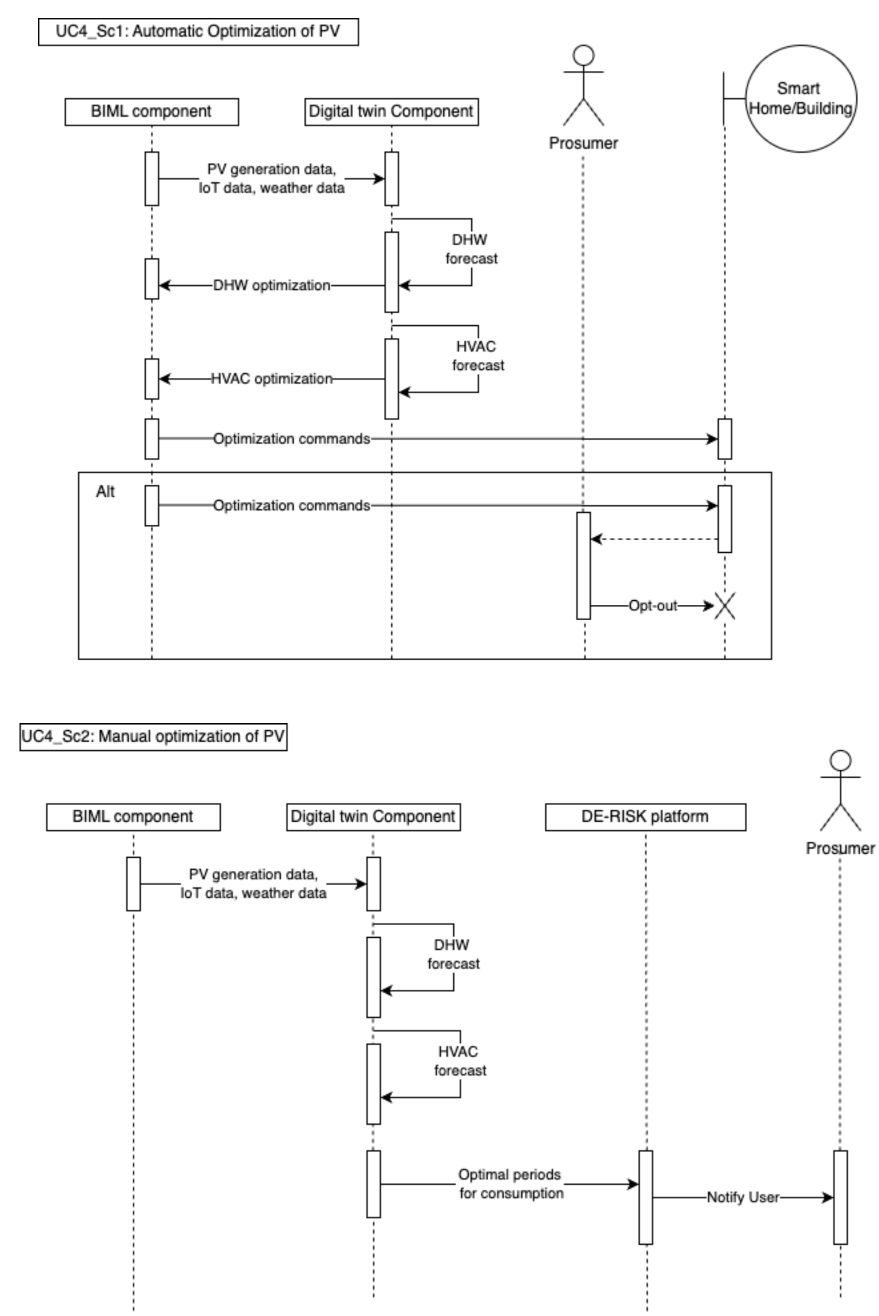
Classification Information
Relation to the other use cases
Possible conflict with UC1. The priority of use cases needs to be further investigated. This use case is a category of implicit distributed flexibility service, described in UC2.
Level of depth
Medium
Generic, regional or national relation
Generic
Nature of the use case
Technical
Further keywords for classification
PV forecast, Self-consumption, Flexibility, Smart Home, Potential flexibility, Load Shifting

3.7.2 Diagrams of use case

Diagram(s) of the use case
[Use case diagram.]



[Sequence diagram.]



3.7.3 Actors and Scenarios

3.7.3.1 Actors

Actors			
Grouping	**Group description**		
Business Actor	Business actor is a stakeholder that possesses and pursues its own interests. Business actors may exist as either legal or physical entities.		
Logical Actor	A physical or software component that plays a role in the execution of a use case.		
Actor name	**Actor type**	**Actor description**	**Further information specific to this use case**
Prosumers	Business actor	End user that consumes and/ or generates electricity.	
Smart home/ building	Logical actor	Home or building equipped with an IoT solution with the capability to participate in DR.	
Domestic Hot Water (DHW) systems.	Logical actor	Uses electricity to heat water in a preferable higher temperature	
Heating Ventilation Air-Conditioning systems (HVAC)	Logical actor	HVAC systems increase the thermal comfort of occupants in a house or building.	
ESCO/ energy retailer	Business actor	An entity that consolidates flexibilities on behalf of its customer.	
DSO, TSO	Business actor	An entity that requests flexibility	

3.7.3.2 Overview of scenarios

Scenario conditions					
No.	**Scenario name**	**Primary Actor**	**Triggering event**	**Pre-condition**	**Post-condition**
Sc.1	Automatic Optimization of Renewable Energy	DE-RISK platform	Prosumer or ESCo triggers to initiate self-consumption optimization	DE-RISK platform up and running.	DHW and HVAC loads are load shifted automatically to optimize PV energy utilization.

Sc.2	Manual Optimization of Renewable Energy	DE-RISK platform	Prosumer or ESCo triggers to get a suggestion.	DE-RISK platform up and running.	Prosumers manually adjust their consumption based on the notifications and monitoring dashboards.

3.7.3.3 Steps per scenario

The following tables present the steps of each of the scenarios associated with this use case as well as the respective requirements:

Scenario name	**Sc. 1 Automatic Optimization of Renewable Energy**						
Step No.	**Event**	**Name of the process**	**Description of the process**	**Service**	**Information producer (actor)**	**information receiver (actor)**	**Information exchanged (IDs)**
St.01	PV Generation Forecast	Monitor PV Generation	BIML component sends the data to the Digital twin platform	PV Forecasting	BIML component	Digital Twin component	PV Generation Data
St.02	Evaluate Energy Consumption Patterns	Learn Usage Patterns	Digital Twin Platform Usage Pattern Learning	Usage Pattern Learning	BIML component	Digital Twin component	Data on energy consumption and ambience
St.03	Optimize DHW Consumption	Forecast and Optimize DHW	The system forecasts and optimizes DHW heating to consume during periods of PV generation	DHW Optimization	Digital Twin component	BIML component	Optimization Commands
St.04	Optimize HVAC Consumption	Forecast and Optimize HVAC	The system forecasts and optimizes HVAC operation to consume during periods of PV generation	HVAC Optimization	Digital Twin component	BIML component	Optimization Commands
St.05	Opt-out or Override	Prosumer Control	Prosumers can override the automated actions if desired	Prosumer Control	Prosumer	HVAC/ DHW systems	Override Commands

DE-RISK

Scenario name	Sc.2 Manual Optimization of Renewable Energy						
Step No.	**Event**	**Name of the process**	**Description of the process**	**Service**	**Information producer (actor)**	**information receiver (actor)**	**Information exchanged (IDs)**
St.01	PV Generation Forecast	Monitor PV Generation	BIML component sends the data to the Digital twin platform	PV Forecasting	BIML component	Digital Twin component	PV Generation Data
St.02	Notify Users	Send Generation Period Notifications	DE-RISK platform sends notifications to users indicating optimal periods for energy consumption	Prosumer Notification	DE-RISK platform	Prosumer	Generation Period Notifications
St.03	Monitor Energy Generation	Dashboards Real-Time PV Data	Prosumers monitor real-time PV generation data through dashboards	Monitoring	DE-RISK platform	prosumer	Real-Time PV Data

3.7.4 Information exchange

Information exchange		
Information exchange (ID)	**Name of information**	**Description of Information Exchanged**
ID1	PV Generation Data	Forecasted data on PV energy generation.
ID2	Usage Patterns Data	Data on hot water and HVAC usage patterns.
ID3	Optimization Commands	Load shifting optimization commands to adjust HVAC and/ or DHW heating schedules.
ID4	Override Commands	Commands from occupants to override automated DR actions.
ID5	Suggested consumption period notifications	Notifications about optimal periods for energy consumption.

3.8 UC5 Minimize the electricity bill

3.8.1 Use case Description

3.8.1.1 Name of the Use Case

Use case identification		
ID	**Area/Domain/Zone(s)**	**Name of the use case**
UC1	Areas: Energy system, Wholesale market, Smart Home/Building Domains: Customer Premises Zones: Operation	Minimize the electricity Bill

3.8.1.2 Version Management

Version management				
Version No.	**Date**	**Name of Authors**	**Changes**	**Approval status**
0.0	15/04/2024	Konstantinos Mamis	First Version	
0.1	28/04/2024	Thanos Kalamaris	Second draft	
0.2	25/05/2024	Konstantinos Mamis	Final draft	

3.8.1.3 Scope and objectives of the Use Case

Scope and objective of the use case	
Scope	Minimize the cost of electricity
Objective(s)	Align the energy consumption in periods when the cost of electricity is lower

3.8.1.4 Narrative of the Use Case

Narrative of use case
Short description
The objective of this Use Case is to decrease the consumer's electricity expenses by aligning the usage of customer's appliances with periods of lower pricing from the energy supplier and/or distribution system operator.
Complete description
Consumers that have the option to participate in dynamic tariff schemes may want to reduce their electricity bill by consuming electricity in periods of lower pricing from the energy supplier and/or

distribution system operator. Consumers can synchronize their electricity consumption automatically or manually. **Automatic optimization:** DE-RISK solution will receive day ahead prices, in which case the DHW and HVAC loads will be used mainly in instances of low energy price and will limit their usage in periods of expensive energy. In order for the aforementioned devices to operate within consumers boundaries and habits the optimization will store energy during the "cheap" period in order to be used during the "expensive". For example, HVAC will pre-cool the building utilizing low priced period. **Manual optimization:** Consumers, in this scenario will receive a suggestion on when to consume based on the price forecast. This Use Case is composed of the following functions: • Receive day ahead price signal. • Learning the building's hot water usage patterns. • Learning the building's thermal comfort profile in spaces where an HVAC operates. • Forecast and optimize the water heating to consume in periods of best price. • Forecast and optimize the HVAC to consume in periods of best price. • Opt-out; give the option to not participate or override the automated actions to the occupant.

3.8.1.5 Use case conditions

Use case conditions
Assumptions
• The consumer has a dynamic tariff contract.
Prerequisites
• The smart home/building is equipped with an IoT solution compatible with QUE's solution. • The consumer has at least one controllable load. • The consumer has an up and running DE-RISK solution.

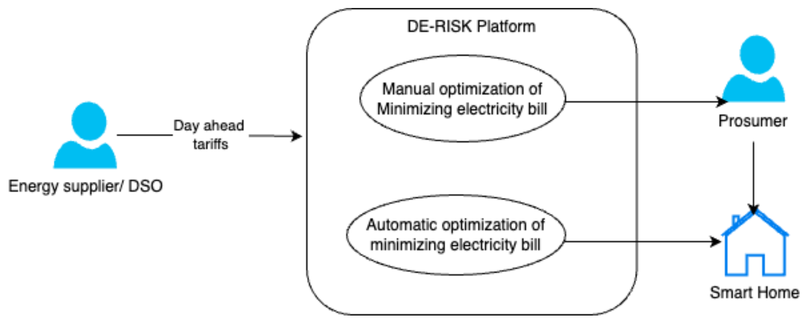
3.8.1.6 Further information to the use case for classification/mapping

Classification Information
Relation to the other use cases
Possible conflict with UC1. The priority of use cases needs to be further investigated. This use case is a category of implicit distributed flexibility service, described in UC2.

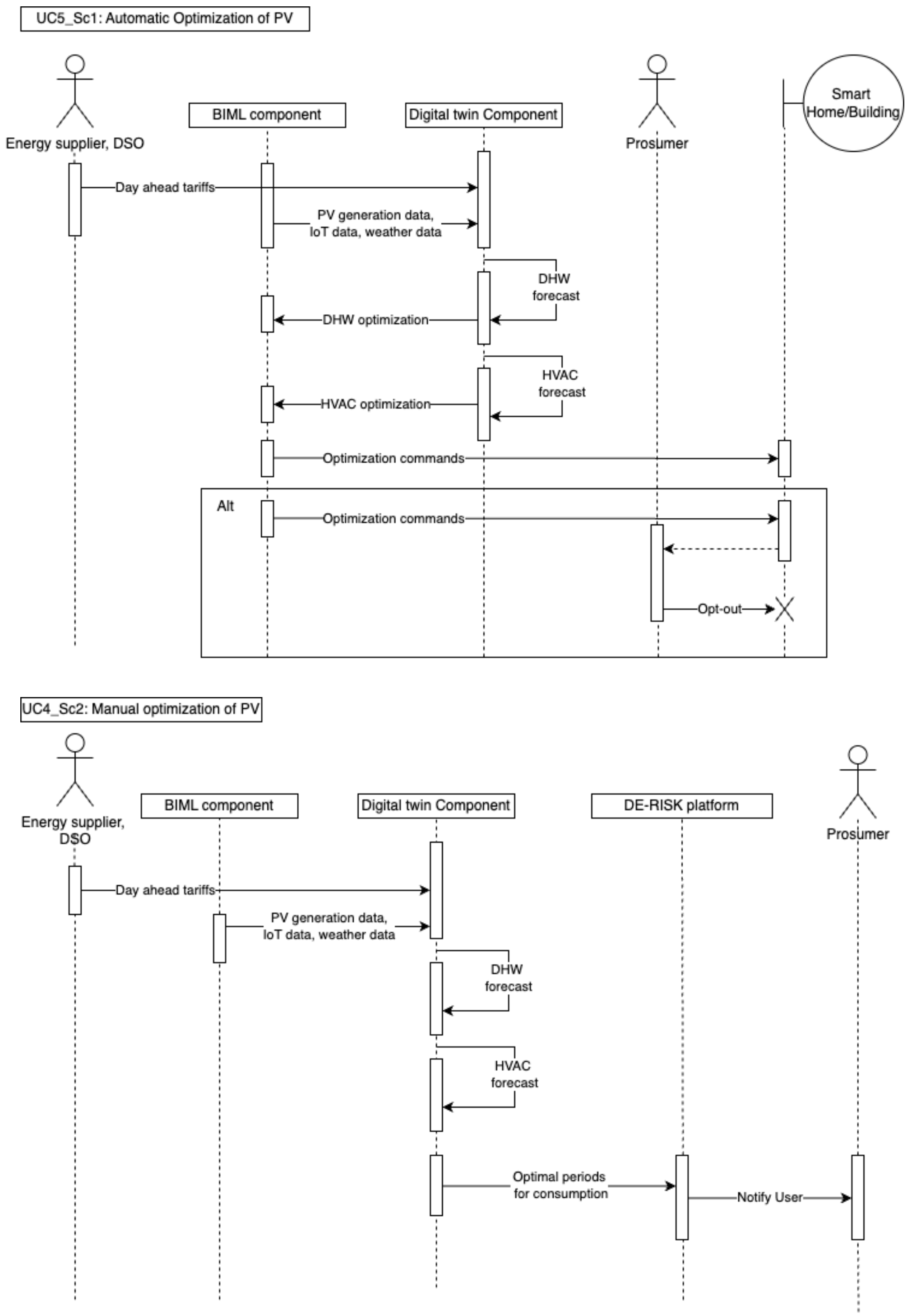
Level of depth
Medium
Generic, regional or national relation
Generic
Nature of the use case
Technical
Further keywords for classification
PV forecast, Self-consumption, Flexibility, Smart Home, Potential flexibility

3.8.2 Diagrams of use case

Diagram(s) of the use case
[Use case diagram.]



[Sequence diagram.]



3.8.3 Actors and Scenarios

3.8.3.1 Actors

Actors			
Grouping	**Group description**		
Business Actor	A business actor is a stakeholder that possesses and pursues its own interests. Business actors may exist as either legal or physical entities.		
Logical Actor	A physical or software component that plays a role in the execution of a use case.		
Actor name	**Actor type**	**Actor description**	**Further information specific to this use case**
Prosumers	Business actor	End user that consumes and/ or generates electricity.	
Smart home/ building	Logical actor	Home or building equipped with an IoT solution with the capability to participate in DR.	
Domestic Hot Water (DHW) systems.	Logical actor	Uses electricity to heat water in a preferable higher temperature	
Heating Ventilation Air-Conditioning systems (HVAC)	Logical actor	HVAC systems increase the thermal comfort of occupants in a house or building.	
ESCO/ energy retailer	Business actor	An entity that consolidates flexibilities on behalf of its customer.	
DSO, TSO	Business actor	An entity that requests flexibility	

3.8.3.2 Overview of scenarios

Scenario conditions					
No.	**Scenario name**	**Primary Actor**	**Triggering event**	**Pre-condition**	**Post-condition**
Sc.1	Automatic Optimization for Minimizing Electricity Bill	DE-RISK platform	Receipt of day-ahead price forecast.	DE-RISK platform operational and integrated with price forecast data. -BIML database available -Digital twin component up and running.	DHW and HVAC loads are load shifted automatically to optimize electricity usage based on price forecasts.
Sc.2	Manual Optimization for Minimizing Electricity Bill	DE-RISK platform	Receipt of day-ahead price forecast.	DE-RISK platform operational and integrated with price forecast data. -BIML database available -Digital twin component up and running.	Prosumers manually adjust their consumption based on the notifications and monitoring dashboards.

3.8.3.3 Steps per scenario

The following tables present the steps of each of the scenarios associated with this use case as well as the respective requirements:

Scenario name	Sc. 1 Automatic Optimization for Minimizing Electricity Bill						
Step No.	**Event**	**Name of the process**	**Description of the process**	**Service**	**Information producer (actor)**	**information receiver (actor)**	**Information exchanged (IDs)**
St.01	Receive Day-Ahead Price Forecast	Receive Price Forecast	The system receives day-ahead electricity price forecasts from the energy supplier or DSO.	Price Forecasting	Energy Supplier/DSO	Digital Twin Platform	Price Forecast Data
St.02	Evaluate Energy Consumption Patterns	Learn Usage Patterns	Digital Twin Platform Usage Pattern Learning	Usage Pattern Learning	BIML component	Digital Twin component	Data on energy consumption and ambience
St.03	Optimize DHW Consumption	Forecast and Optimize DHW	The system forecasts and optimizes DHW heating to consume during periods of PV generation.	DHW Optimization	Digital Twin component	BIML component	Optimization Commands
St.04	Optimize HVAC Consumption	Forecast and Optimize HVAC	The system forecasts and optimizes HVAC operation to consume during periods of PV generation.	HVAC Optimization	Digital Twin component	BIML component	Optimization Commands
St.05	Opt-out or Override	Prosumer Control	Prosumers can override the automated actions if desired.	Prosumer Control	Prosumer	HVAC/ DHW systems	Override Commands

Scenario name	Sc.2 Manual Optimization for Minimizing Electricity Bill						
Step No.	**Event**	**Name of the process**	**Description of the process**	**Service**	**Information producer (actor)**	**information receiver (actor)**	**Information exchanged (IDs)**
St.01	Receive Day-Ahead Price Forecast	Receive Price Forecast	BIML component sends the data to the Digital twin component	Price Forecasting	Energy Supplier/DSO	Digital Twin Platform	Price Forecast Data
St.02	Notify Users	Send Consumption Period Notifications	DE-RISK platform sends notifications to prosumers indicating optimal periods for energy consumption based on price forecasts.	Prosumer Notification	DE-RISK platform	Prosumer	Low-cost Consumption Period Notifications
St.03	Prosumer Adjustment	Adjust Energy Consumption	Prosumers manually adjust their energy consumption based on the received suggestions	Notification	DE-RISK platform	prosumer	Load shifting actions

3.8.4 Information exchange

Information exchange		
Information exchange (ID)	**Name of information**	**Description of Information Exchanged**
ID1	Price Forecast data	Day-ahead electricity prices.
ID2	Usage Patterns Data	Data on hot water and HVAC usage patterns.
ID3	Optimization Commands	Load shifting optimization commands to adjust HVAC and/ or DHW heating schedules.
ID4	Override Commands	Commands from occupants to override automated DR actions.
ID5	Low-cost Consumption Period Notifications	Notifications about load shifting on low-cost periods

4 NEXT STEPS AND CHALLENGES

This Deliverable, D4.4, presents the implementation and operation plans for DE-RISK case studies based on the current information available regarding the pilot status of DE-RISK and the maturity of the project's tools and services as of month 20 (M20). The use cases defined will be reviewed and adjusted as necessary to address any changes identified during the work conducted under T4.4.

In the coming months, the DE-RISK platform will support the establishment of a local integrated flex marketplace. This will begin with the application of the use cases outlined in D4.4 at DE-RISK's pilot sites. The web application for user dashboards and its functionalities will be further explored among partners. With combined input from D2.3 ``Strategies and Recommendation Plan for Consumer Engagement" and the actual implementation of the use cases in pilot buildings, additional requirements will be considered, assessed, and integrated if relevant to DE-RISK's scope.

The main challenges to be addressed in the upcoming period, primarily involve the communication between the DE-RISK platform and the project's pilot sites. Specifically, for the pilot case study at the National University of Ireland Galway, cybersecurity-related constraints are currently affecting data exchange due to Ireland's security framework.

These constraints impede the interfacing between the BIML component and NUIG's database. However, if necessary, the consortium will conduct simulations with offline data extracted from NUIG's database to test the DE-RISK use cases.

5 REFERENCES

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[6] IEC 62559 use case methodology. https://www.sis.se/api/document/preview/8013841/

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