D8.7: Business use cases for flexibility provision by industrial processes

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Technical references

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Table of contents

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List of Tables

List of Figures

List of acronyms

Acronym	Description
BA	Bidding Application
BIML	Business Intelligence Markup Language
BRP	Balance Responsible Party
BSP	Balance Service Provider
CIM	Common Information Model
CMSP	Constraint management services
DER	Distributed Energy Resources
DHN	District Heating Network
DLMP	Distributed Locational Marginal Prices
DR	Demand Response
DSEF	Demand-Side Energy Flexibility

DSO	Distribution System Operator
DS-SCADA	Supervisory Control and Data Acquisition system for Distribution System
EFM	Energy Flexibility Measure
EFP	Energy Flexibility Potential
ESCO	Energy Service Company
GHG	Greenhouse gas
HLUC	High-level Use Case
IEC	International Electrotechnical Commission
IEF	Industrial Energy Flexibility
NDC	Nationally Determined Contributions
NDPA	Network Data Processing Application
NDPA	Network Data Processing Application
PUC	Primary Use Case
RTBMM	Real-Time Balancing Market Mechanism
SSEF	Supply-Side Energy Flexibility
TSO	Transmission System Operator
UC	Use Cases
VRE	Variable Renewable Energy

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1. Introduction

The purpose of this deliverable is to define suitable business cases to demonstrate the most promising flexibility services and to support the commercialization phase of FLEXIndustries solutions. It also establishes the FLEXIndustries Use Cases that will be deployed and validated in the seven Demo Sites, as well as examines the state-of-the-art of flexibility services.

The Use Cases will drive the development of the tools and the demonstration activities. They will also act as a foundation for defining the FLEXIndustries system architecture, during an iterative process. After that, the Use Cases will be categorized into various business scenarios and thoroughly examined in D8.8. To make it simple for communities, prosumers, and other market participants to understand the purpose, functionality, and application of the project outcomes, business scenarios, and use cases will guide the requirement definition process for the FLEXIndustries framework.

All of the activities have been performed considering the Business Use Case Methodology defined in the Standard IEC-62599.[1]

Within this Deliverable the following sections are included:

- **Chapter 2** analyses the current state of the art of flexibility services that will serve as the starting point to evaluate the business scenarios and their applicability to the Demo Sites;
- **Chapter 3** analyses Standard IEC-62599 in each of its components, serving as basis for the following two chapters;
- **Chapter 4** defines the UCs methodology followed for the definition and description of FLEXIndustries UCs;
- **Chapter 5** presents the preliminary business cases identified within FLEXIndustries. A description of each of them will be reported.

As they seek to build the system architecture and specifications as a roadmap for project tool development, based on user needs, the activities included in this deliverable form the basis of the FLEXIndustries project. The tasks detailed in this deliverable have been carried out in close cooperation with WP6 in regard to the field demonstrations, and they are based

[1] https://webstore.iec.ch/publication/22349

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on the findings of T2.1 regarding the market structure of flexibility services. The development of FLEXIndustries' tools and solutions will be guided by the outcomes. More in detail:

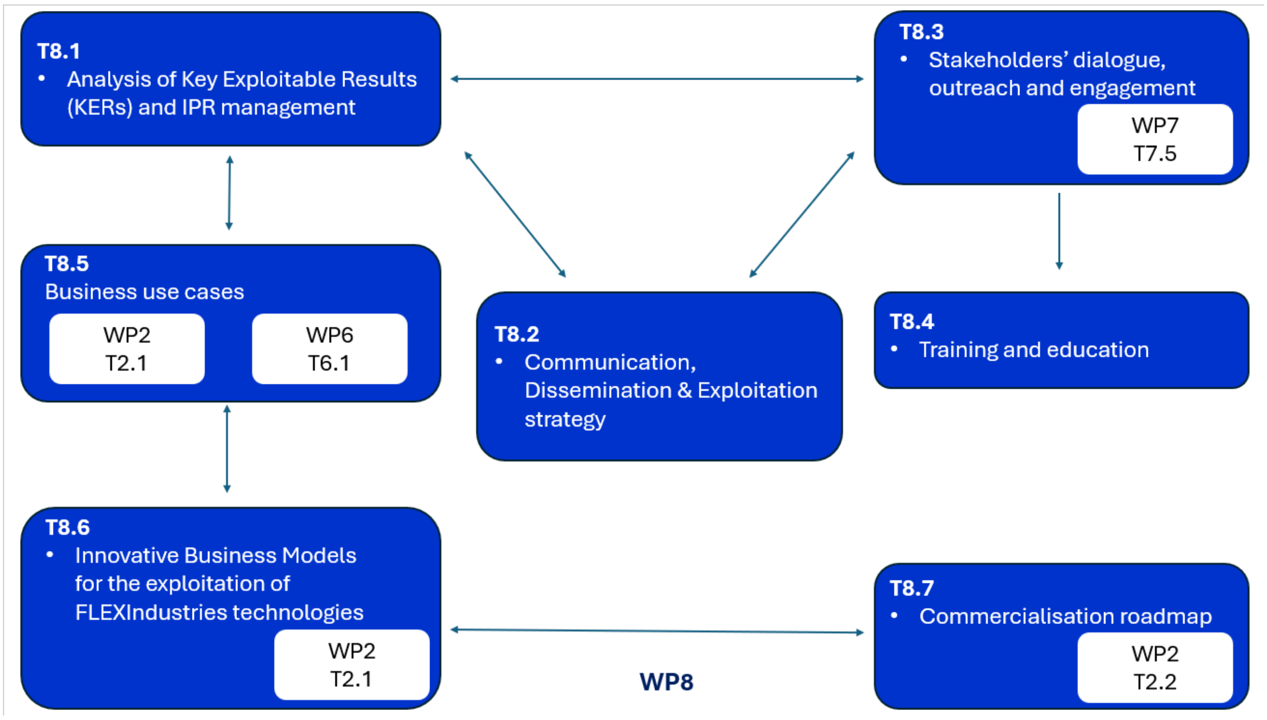

Figure 1: Business Use cases relation with other activities

Figure 1 shows the relation of the Business use cases with other Work packages and activities. WP6: "Multi-sectorial pilot demonstration and validation" & WP2: "Flexibility assessment and project framework definition" serving as the main inputs. These inputs are in the form of "Pilots' preparation including platform deployment in the demo-sites" from WP6 and "Market analysis of flexibility potential" from WP2.
Within the WP8, Business use cases have interdependency with analysis of KERs and Innovative Business Models.

2. Business Use Cases for Flexibility Services

2.1 State of the Art of Flexibility Services

Global energy systems are drastically switching to low-carbon energy sources. In accordance with the 2015 Paris Agreement, this shift is required for nations to fulfil their nationally determined contributions (NDCs). According to the International Renewable Energy Association's (IRENA) REmap global plan for energy transformation, countries must have two-thirds of the world's primary energy supply come from renewable sources by 2050 in order to meet their NDCs.

A large-scale electrification of the energy demand is also recommended by REmap. As per the strategy, by 2050, electricity should make up 49% of the total energy consumption globally, compared to its current 20% share. Consequently, in order to achieve the targeted NDCs, there should be a simultaneous global increase in the installed capacity of renewable electricity sources by three times and a significant electrification of the final energy consumption. Furthermore, variable renewable energy sources (VRE), especially wind and solar energy, are predicted to be the producers of 61% of the world's electricity due to their increased availability and steadily declining costs. [1]

In this scenario, the world's electrical systems will face tremendous strain on two fronts: a dizzying increase in demand while fundamental energy sources are replaced by highly volatile alternatives. Thus, for the energy transition to succeed, grid operators need to have access to new opportunities for grid management. These operators have up to now depended on a mix of peak and base load power plants that modify their output to match variations in demand. Nevertheless, new types of grid flexibility are crucial in an electrical grid that depends heavily on VREs. Grid stability is ensured by grid flexibility, which permits supply and demand on both ends of the electrical system to be balanced. Supply-side energy flexibility (SSEF), demand-side energy flexibility (DSEF), grid extension, and storage at the grid level are examples of grid flexibility alternatives in a VRE-centered electrical grid.

By diversifying primary energy sources and raising the proportion of dispatchable sources - which can modify their electrical output to counteract any unanticipated deviation in VRE output - SSEF is achieved. The only objective of energy storage facilities, which are directly connected to the grid, is to store various sources of energy that serve as a buffer between the supply and demand of electricity. Alongside energy storage, grid expansion entails building more high-performance electrical networks that can aggregate VREs with various generation profiles and transport and distribute electricity over large geographic areas. All of these choices entail a significant increase in infrastructure spending, which raises the price of electricity and, in certain situations, may even necessitate the use of non-renewable energy sources.

The last option, known as DSEF, refers to the ability of the demand sectors in the electrical grid to adjust (render, raise, or lower) their energy use over a given period in order to counteract fluctuations in the energy supply.

The industrial sector's DSEF, or Industrial Energy Flexibility (IEF), is one of the sectors that makes up the electrical demand that is of special interest. From the standpoint of the grid operators, the industrial sector is a great option to add flexibility to the electrical grid due to its sizeable proportion of the electrical demand, which in the EU-28 represented 37.4% of the total electrical consumption in 2017 and is predicted to expand. From the standpoint of the companies, IEF presents an alluring optimization opportunity because to the elevated relative prices of electricity in comparison to alternative energy carriers, such as natural gas, and the heightened control over their energy consumption. Unlike SSEF, grid-level storage, and system extension, DSEF and IEF specifically enable the techno-economic optimization of energy use, potentially lowering rather than raising the total energy costs for the industrial sector (which are mostly related to electricity).

Notwithstanding the aforementioned advantages, the industrial sector still contributes very little to the existing and projected potential of demand response (DR), according to the International Energy Agency's (IEA) tracking report on the subject of DSEF applications. This may be partly because businesses are unaware of the energy flexibility potential of their production sites and the potential advantages that come with taking advantage of these capabilities. In order to help the industrial sector systematically identify and measure the energy flexibility capabilities of their facilities and estimate the accompanying advantages of utilizing such capabilities, third-party industrial energy audits are therefore necessary.

2.1.1 DSEF and IEF

IEF is defined as an industrial system's capacity to adjust quickly and economically to shifts in the energy markets. Typically, the terms demand response (DR) and DSEF, and consequently IEF, are used interchangeably. However, DR is defined by the US Federal Energy Regulatory Commission as deviations from end-user customers' typical consumption patterns in response to variations in the price of electricity over time, or as incentive payments intended to encourage reduced electricity use during periods of high wholesale market prices or when system reliability is threatened.

Conversely, the European Commission defines distributed reserves as "A range of grid-sponsored initiatives, the most prevalent of which compensates businesses (commercial DR) or end users (residential DR) for being available to cut back on electricity use when the grid is overloaded." From the definitions, it is clear that DR refers to the act of modifying electricity use in order to take advantage of financial incentives provided by grid operators. Conversely, DSEF delineates the ability of an energy-consuming system - an industrial system in the context of IEF - to respond to a triggering event by altering its energy consumption. The energy-consuming system can now participate in DR plans and initiatives thanks to this capacity, but DSEF's potential uses are still far-reaching.

Regarding IEF, possible results or goals for implementation consist of:

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- As previously noted, IEF may optimize the factory's energy costs. In its most basic form, this means lowering energy costs through the reactive adjustment of consumption to price fluctuations in the electrical markets. This is an intelligent response to the volatility of energy prices.
- Proactively marketing the energy flexibility potentials in the grid service markets: by combining production planning and IEF, it is possible to provide energy flexibility in the electrical grid's ancillary service markets and so get financial support from the grid operators.
- Make the most of local energy sources and the portfolio of renewable energy sources: an industrial system's energy consumption can be adjusted through IEF to align with the output profiles of neighbouring or local electricity generating plants (within the factory's limits). attaining in the production facility balanced or true energy self-sufficiency. When using renewable energy sources, IEF can lessen the factory's carbon footprint and hence lower possible expenses associated with greenhouse gas emissions.
- Peak shaving and load management are two advantages of the IEF. Peak shaving and load management reduce time-of-use related expenses and strain on the energy distribution infrastructure by doing away with the requirement for over-capacity to meet the peaks of highly variable loads.
- Increasing the proprietary energy infrastructure's resilience: IEF can help the infrastructure bounce back fast from interruptions in the energy supply or enable self-sufficient operation. Preventing the high costs associated with a stoppage in production. By adjusting the consumption patterns of various industrial systems to the capacity of the current infrastructure, IEF can also help prevent or postpone the need for energy infrastructure expansions and the associated investment costs.

2.1.2 Energy Flexibility Measures

IEF is given a practical form by being expressed as an Energy Flexibility Measure (EFM). An intentional, measurable action to implement a specified modification of an operational state in an industrial system is known as an EFM. According to this definition, an industrial system's energy demand rate at a given moment is referred to as its "operative state." As a result, the variation of this rate of energy demand over a specific duration is referred to as a change of operative state. The measurement of the operational state change that the EFM will bring about in the industrial system is called the Energy Flexibility Potential, or EFP. As a result, the EFP may be mathematically defined as having two components: the flexible power and the active duration. The industrial system's properties and the contextual elements that go into its computation determine how the EFP is quantified. To quantify the EFP, a reference framework must be constructed.

This reference framework can be gradually expanded to include more context or system features, increasing the complexity of its quantification while achieving a more precise EFP value. The EFP will be theoretical if it is exclusively computed using the industrial system's physical properties as a foundation for comparison. Typically, the industrial system's power rating and operating time are the sole factors taken into account by the theoretical EFP. On the other side, the system's operational characteristics are added to the reference framework to calculate the technical EFP. The traits that pertain to the patterns of operation that the industrial system adheres to in order to efficiently accomplish its tasks are known as its operational characteristics. The applicable features of the production facility, of which the system is a component, are also included in the practical EFP. These pertinent traits have to do with the factory's current production planning techniques.

The portion of the practical EFP that is economically feasible—that is, when the profits from using the EFM exceed its expenses—is known as the economical EFP. These profits are a result of pursuing the implementation goals outlined in the previous section.

Last but not least, the viable EFP is the portion of the economical EFP that beats other pertinent investments, such energy efficiency measures, and also fits in with the company's investment approach, i.e., payback periods and risk policies.

2.1.3 Energy Flexibility Measures Categorization

EFMs can be categorized as technical or organizational depending on their nature. Organizational EFMs entail taking steps to alter the industrial systems' operational condition by utilizing the factory's production plan. Organizational EFMs typically have no effect on the total energy usage of the associated industrial system. If so, organizational EFMs won't have an impact on the industrial system's energy efficiency.

Conversely, technical EFMs modify the industrial system's operating pattern, which in turn affects the particular load profile of the system. They often do affect total energy usage, so after characterizing the EFM, their impact needs to be carefully assessed.

2.1.4 Business Use Cases

A use case is a way for organizing, defining, and identifying system needs in system analysis. A use case is a collection of potential interactions between people and systems in a certain setting that are all aimed at achieving a specific objective. The process generates a document that lists every action a user takes to finish a task.

Business analysts are engaged in several stages of software development, including establishing system requirements, validating design, testing software, and generating an overview for online help and user guides. They are generally in charge of writing use cases. The development team may find and comprehend potential error locations during a transaction with the use of a use case document, allowing for issue resolution.

Three components are present in every use case:

- The system user, who may be an individual or a group interacting with the process, is the actor.
- The objective is to bring the process to a successful conclusion.
- The system: The actions taken to accomplish the final result, along with the functional requirements that must be met and the expected behaviours of those requirements.

Use cases create an easy-to-follow, goal-focused sequence of actions for users and developers by describing the functional requirements of a system from the viewpoint of the end user. A full use case will comprise multiple alternative flows in addition to the primary or basic flow. The alternate flow, sometimes referred to as an extending use case, outlines both common and uncommon deviations from the basic flow.

A use case should:

- Arrange the functional specifications.
- Assume the objectives of the system/actor interactions.
- Record routes, sometimes known as scenarios, from trigger events to objectives.
- Describe a primary flow of events as well as several secondary flows.
- Be multilayer so that the functionality of one-use case can be applied to another.

Use cases come in two varieties: system use cases and business use cases.

A business use case, which solely refers to the business process under description and the actors involved in the activity, is a more abstract explanation that is stated in a technology-agnostic manner. A business use case outlines the steps that must be taken by the company in order to give the end user a useful, observable result.

A system use case, on the other hand, is stated in greater depth than a business use case and describes the precise steps that need to be taken in different system components in order to achieve the end user goal. Functional specifications, including dependencies, required internal supporting features, and optional internal features, are detailed in a system use case diagram.

To identify all components that fall inside and outside of the processes, the writer of a use case should take the design scope into account. Anything that is outside the scope of the use case but is crucial should be stated by another use case or a supporting actor. A single system, a subsystem, or the complete business can be included in the design scope. Use cases belonging to the enterprise scope are usually those that explain business processes.

As previously stated, a use case consists of three fundamental components: actors, the system, and the purpose. When drafting a use case, keep the following extra factors in mind:

- Anybody with a stake in the system's performance is considered a stakeholder.
- Preconditions are the requirements that need to be met in order for a use case to proceed.
- triggers, or the things that set off the use case.
- Post-conditions: the tasks that the system ought to have finished by the time the steps ended.

Use cases are narrative descriptions of a system's functional requirements written by developers from the viewpoint of the end user. Additionally, they can use a unified modelling language to create a use case diagram in which each actor is represented by a stick figure with their name written below, each step is represented by its name in an oval, each action is indicated by a line between the actor and step, and the system boundaries are indicated by a rectangle surrounding the use case.

Developers can gain from a single use case by seeing how a system should operate and being able to spot any mistakes early on.

Further advantages of developing use cases are as follows:

- The system's cost and complexity can be determined using the list of objectives developed throughout the use case authoring process.
- It is possible to identify true system demands early in the design process by concentrating on both the user and the system.
- Use cases are easily understood by stakeholders, not just developers and testers, but also consumers, users, and executives because they are primarily written in a narrative style.
- Developers can save time by defining delicate system requirements more easily through the construction of extended use cases and the identification of exceptions to successful use case situations.
- Developers can prevent scope creep by defining boundaries for the system within the use case design scope.
- By concentrating on the intended functionality of the system rather than its implementation, premature design can be prevented.

Furthermore, by mapping the common course and alternative courses and collecting test data for each scenario, use cases may be readily converted into test cases. The development team will be able to make sure that the test plan includes every functional need of the system with the aid of these functional test cases.

Use cases can also be applied to test case definitions, user documentation, project planning, and many other aspects of software development. Utilizing use cases as a planning tool for iterative development is another option.

2.1.5 Example 1: FEVER Project's Business Use Case

One high-level use case from the FEVER business use cases [2] is provided in this section as an illustration. The Distribution System Operator (DSO), Market Operator, and Flexibility Service Provider domains are the overall targeted domains identified in relation to the project scope.

HLUC 11: Real-time market mechanism incentivizing energy & capacity flexibility trading from Balance Service Provider (BSP)s, to address balancing and T&D congestion management, integrating wholesale and retail markets.

Scope

This UC's goal is to encourage the real-time trading of flexible reserve capacity and energy balance on the transmission and distribution grids. The primary actor in the balance service provider market is the prosumer, who trades balancing energy to offset imbalances in non-dispatchable resources and sells reserve capacity that the Transmission System Operator (TSO) /DSO must purchase. The transmission and distribution constraints are incorporated into the market modelling to improve cooperation. In this manner, it will be possible to carry out the dispatch instructions and minimize instructed deviations. The locational marginal prices at T/D nodes/areas are produced by the market model in order to support variable retail pricing systems.

Objectives

This use case's objective is to create a common TSO/DSO market where a clearinghouse will support the integration of energy flexibilities on the distribution and transmission grids to balance the electricity market while simultaneously taking distribution network and transmission constraints into account.

Actors

Real-Time Balancing Market Mechanism (RTBMM), Bidding Application (BA), Supervisory Control and Data Acquisition system for Distribution System (DS-SCADA and Transmission System (TS-SCADA), Network Data Processing Application (NDPA).

Complete Narrative

This use case's real-time balancing market is a balancing and congestion management platform that calculates Distributed Locational Marginal Prices (DLMP) for retail markets as well as real-time balancing actions. It is a part of the common TSO/DSO flexibility market mechanisms.

Congestion control and balancing are intended to be integrated across the transmission and distribution system by the real-time market platform. The resulting pricing signals offer signals for network reinforcement wherever needed, as well as locational investment signals that entice investment in necessary technologies. By matching orders that profit from trade and coordinating the balancing and congestion management processes, the platform fosters economic efficiency. Because the generated DLMPs expose agents to a locally uniform price signal and circumvent the well-known manipulation opportunities that arise from zonal pricing, they inhibit market manipulation through increase-decrease (INC-DEC) gaming.

Real-time balancing participants must abide by certain market regulations. The Bidding Application (BA) creates the proper order, which includes at least a real power amount and a price and submits it to the real-time balancing market. This allows Balance Responsible Party (BRPs) and BSPs to define their bidding strategies.

To guarantee that available flexibility capacity/energy is utilized, regardless of the grid level at which it is located, and to prevent any operational issues with the network, the balancing market mechanism should incorporate the operational limitations and technical specifications for both the distribution and transmission grids. The TS-SCADA and DS-SCADA systems of TSO and DSO supply the network technical specifications (i.e. topologies, thermal limitations, voltage boundaries, etc.). This data may be offered in another data type or in a standardized manner using the Common Information Model (CIM). The Network Data Processing Application (NDPA) may need to preprocess the source data in order to integrate such data into the real-time balancing market in a uniform manner.

The creation of the balancing/congestion market mechanism is the main objective of this use case. Thus, this use case does not include the methods for obtaining flexibility from Distributed Energy Resources (DERs).

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Use case diagram

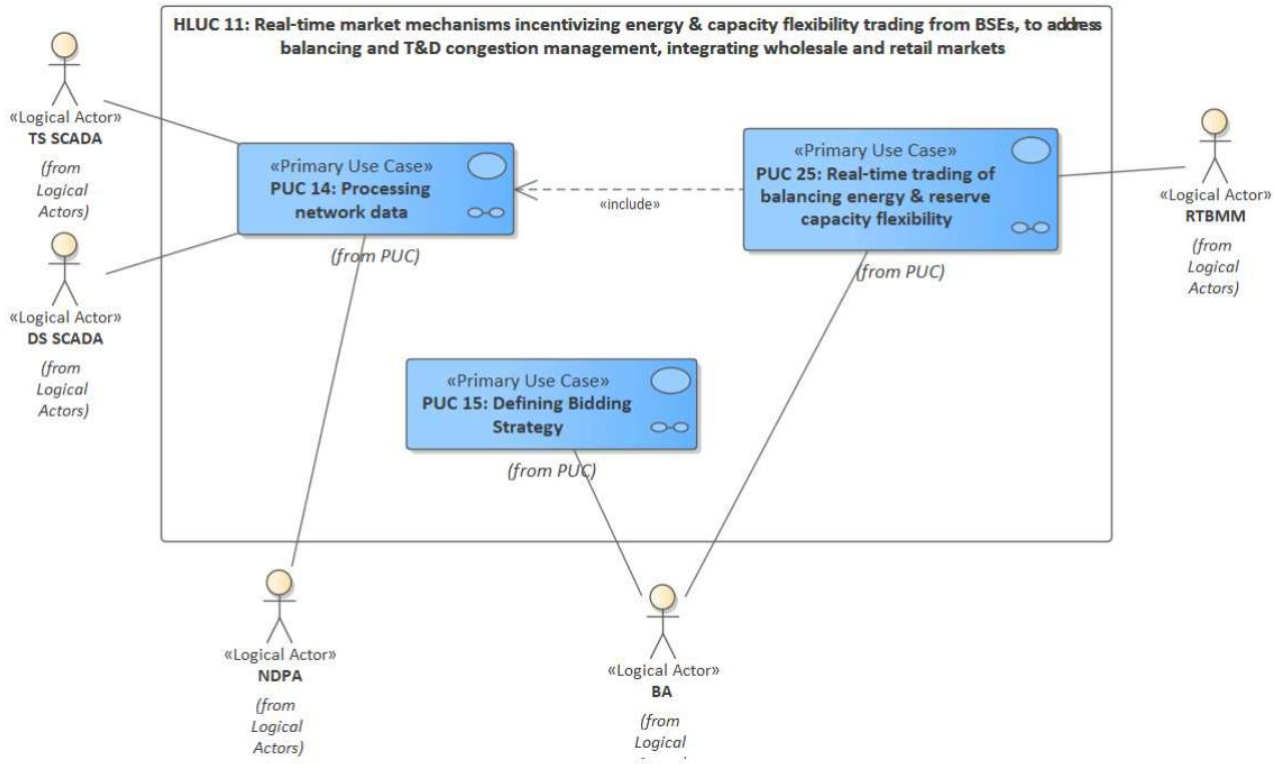

Figure 2: Use Case Diagram example from FEVER project.

2.1.6 Example 2: ACCEPT Project Business Use Case

This section uses a use case as an example from the business use cases for the ACCEPT project [3].

UC3 Consumer demand-side flexibility forecasting and optimization taking into account comfort boundaries, activity patterns and possible requirements.

Scope

Establishing the pipeline from building asset monitoring and metering to occupant and device modelling, flexibility forecasting, and ultimately the application of control actions to the flexible resources is the aim of this User Conference. Building Digital Twins, Building Citizen Twins, and On-Demand Flexibility Management (including Business Intelligence Markup Language (BIML), citizen apps, and community portfolio management) are pertinent ACCEPT system components).

Objectives

- Based on the energy resources installed on the property, provide intraday and day-ahead projections of flexibility (possibility of higher or downward regulation of a building/asset consumption).

- Convert requests for flexibility to the building's schedule of operations for the building's, apartments', and thermal zones' power resources.

Complete Narrative

It is expected that aggregators and energy communities would play a major role in opening up the energy markets to demand flexibility in the upcoming years. The method for accomplishing this is by combining the flexibility of individual customers with district-wide resources. This UC focused primarily on the first section and seeks to facilitate building-level customer engagement in these kinds of marketplaces.

To put this business scenario into practice, one of the first and most important stages is to anticipate each asset's potential for demand flexibility. Individual customer data, including occupancy, device operating statuses, environmental factors, metering and pricing information, and occupant comfort preferences, must be tracked in order to do this. After creating this information management layer, the data is processed by the algorithms in the citizen twin module to determine the occupants' preferred levels of comfort and activity. The building's thermal properties and electrical resources must be modelled simultaneously by the digital twin module. The flexibility demand management component receives these models and uses them to anticipate the future energy requirements and flexibility of each device, apartment, and building. It also receives environmental projections as input.

In order to really participate in the energy market, the computed flexibility forecasts can subsequently be provided to the community flexibility management layer.

Use Case Diagram

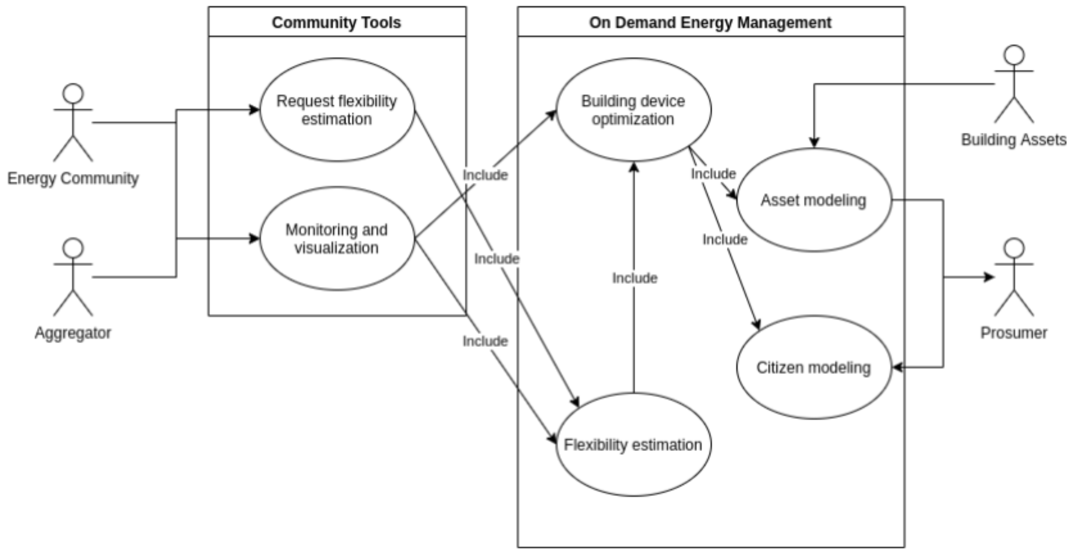

Figure 3: Use Case Diagram example from ACCEPT project.

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3. Analysis of Standard IEC-62599

3.1 Description of the Standard IEC-62599

The Use Case methodology - Definition of the templates for use cases, actor list, and requirements list is an international standard methodology that the International Electrotechnical Commission (IEC) proposed in its IEC 62559-2 norm to define and describe use cases. International cooperation in the area of electrical and electronic standards is encouraged by the IEC.

The IEC 62559-2 standard also defines the following: a serialization mechanism for the defining of UCs; the fundamental structure for a UC, which provides a thorough template; and the important concepts and language connected with the UC creation (which establishes the foundation for a shared repository of UCs).

FLEXIndustries will make use of the template provided by the IEC standard to define the set of (inter)actions that will be developed and implemented throughout the project. This will help to define high-level requirements and specifications for the early stage of FLEXIndustries development and contribute to the foundation of the work being developed in the remaining work packages (WPs). This is because the IEC standard on Use Case Methodology (IEC 62559-2) was created with the project in electrical and electronics fields in mind, and the development of the FLEXIndustries project will require the interaction of different areas of knowledge.

The form of a use case template, template lists for actors and requirements, and their relationships are all defined by the IEC 62559 "Use case methodology." A standardized format for use case descriptions is described in the document for a number of uses, including standardization organizations for the production of standards and development projects for the development of systems.

The IEC 62559 standard was created with a wide range of systems and domains in mind. As one of the initial use cases for this use case template, the energy system/smart grid is used as an example in this document; however, this general template can also be applied to other use cases that are not related to energy systems (e.g. smart house or electro-mobility).

IEC 62559-1 describes the rationale, the history of use cases, best practices for managing use cases, and the procedures for describing use cases within standardization and in connection with a central use case repository.

In line with the definitions provided in the IEC standard in the section "Terms, definitions, and abbreviations," any pertinent terminology pertaining to the UCs used throughout this work will be specified in this part. It is important to possess a set of precise definitions for the primary concepts in order to finish and comprehend the UC template. We have chosen the most significant definitions from the IEC standard, which include Actor, Domain, Scenario, High-level Use Case (HLUC), and Primary Use Case (PUC).

- Any entity that interacts and communicates with the different FLEXIndustries modules and services is referred to as an **actor**. Humans, software programs, databases, systems, and even the power system itself (such as aggregators, distributor system operators, or transmission system operators, or TSOs) are examples of these actors.
- A **domain** is a body of knowledge or activity that employs vocabulary and concepts that are widely known among those who work in that field. Regarding FLEXIndustries, the domains will be established based on the many phases required to implement various intelligent solutions.
- A **scenario** is a potential series of events that are methodically explained, with the pertinent data exchange appropriately established.
- A **Use Case (UC)** that characterizes a basic demand, notion, or concept apart from a particular technical implementation, such as an architectural solution, is called a **High-Level Use Case (HLUC**). Typically generic in nature, HLUCs form the foundation for the creation of Primary Use Cases.
- Unlike the generic HLUCs, a **Primary Use Case (PUC)** provides a detailed description of certain features, functionalities, or solutions that may be unique to certain pilots or nations. PUCs are typically associated with an HLUC's objective or system requirement, and they might not be used in every pilot that the corresponding HLUC is targeting. Since PUCs are developed from HLUC, they offer more particular and in-depth data than HLUC. It is not necessary to define PUCs in order to implement HLUCs, but the contrary is not true.

The IEC 62559 Standard is structured in order to give:

- Definition of a use case template.
- Use case template.
- Explanation of fields of the use case template.
- Definition of an actor list.
- Definition of a list for requirements.
- Examples in the form of annexes.

The use case template illustrated in IEC 62559 is reported in the following section:

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Use Case Title

1 Description of the Use Case

1.1 Name of Use Case

Use Case Identification		
ID	Area / Domain(s)/ Zone(s)	Name of Use Case

1.2 Version management

Version Management				
Version No.	Date	Name of Author(s)	Changes	Approval Status

1.3 Scope and Objectives of Use Case

Scope and Objectives of Use Case	
Scope	
Objective(s)	
Related business case(s)	

1.4 Narrative of Use Case

Narrative of Use Case
Short description
Complete description

1.5 General Remarks

General Remarks
Is used for further comments which are not considered elsewhere.

1.6 Further Information to the Use Case for Classification / Mapping

The following table presents further Information for the classification of this use case:

Classification Information
Relation to Other Use Cases
Level of Depth
Prioritization
Generic, Regional or National Relation
Viewpoint
Further Keywords for Classification

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2 Diagrams of Use Case

The diagram aims to illustrate the structure of the use case.

For clarification, it is recommended to provide drawing(s) by hand, by a graphic or as UML graphics. The drawing should show interactions which identify the steps where possible.

Diagram(s) of Use Case
[Use Case Diagram] [Sequence Diagram]

3 Technical Details

3.1 Actors

In this section 3.1, actors which are involved in the use case are listed and described. These can for instance include people, systems, applications, databases, devices, etc.

The following table presents the actors involved in this use case:

Actors			
Actor Name	**Actor Type**	**Actor Description**	**Further information specific to this Use Case**

3.2 Triggering Event, Preconditions, Assumptions

The following table presents the triggering events, pre-conditions and assumptions of this use case:

Use Case Conditions			
Actor/System/Information/ Contract	**Triggering Event**	**Pre-conditions**	**Assumption**

4 Step by Step Analysis of Use Case

Template section 4 focuses on describing scenarios of the use case with a step-step analysis (sequence description). There should be a clear correlation between the narrative and these scenarios and steps.

4.1 Overview of Scenarios

The table provides an overview of the different scenarios of the use case like normal and alternative scenarios which are described in section 4.2 of the template.

In general, the writer of the use case starts with the normal sequence (success). In case precondition or post-condition does not provide the expected output (e.g. no success = failure), alternative scenarios have to be defined.

The following table presents the scenarios associated with this use case

Scenario Conditions					
No.	**Scenario Name**	**Primary Actor**	**Triggering Event**	**Pre-Condition**	**Post-Condition**

S01					
S02					
S03					
S04					

4.2 Steps per scenario

For this scenario, all the steps performed shall be described going from start to end using simple verbs like – get, put, cancel, subscribe etc. Steps shall be numbered sequentially – 1, 2, 3 and so on. Further steps can be added to the table, if needed (number of steps are not limited).

Should the scenario require detailed descriptions of steps that are also used by other use cases, it should be considered creating a new “sub” use case, then referring to that “subroutine” in this 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:	**S01 – “Title of Scenario”**							
Step No.	**Event**	**Name of Process/ Activity**	**Description of Process/ Activity**	**Service**	**Information Producer (Actor)**	**Information Receiver (Actor)**	**Information Exchanged**	**Requirements, R-ID**
St01								
St02								
St03								

Scenario Name:	**S02 – “Title of Scenario”**							
Step No.	**Event**	**Name of Process/ Activity**	**Description of Process/ Activity**	**Service**	**Information Producer (Actor)**	**Information Receiver (Actor)**	**Information Exchanged**	**Requirements, R-ID**
St01								
St02								
St03								

Scenario Name:	**S03 – “Title of Scenario”**							
Step No.	***Event***	***Name of Process/ Activity***	***Description of Process/ Activity***	***Service***	***Information Producer (Actor)***	***Information Receiver (Actor)***	***Information Exchanged***	***Requirements, R-ID***
St01								
St02								
St03								

5 Information Exchanged

The following table presents the information exchanged in the context of this use case:

These information objects are corresponding to the “Name of Information” of the “Information Exchanged” column referenced in the scenario steps in template section 4 “Step by Step Analysis”. If appropriate, further requirements to the information objects can be added.

Information Exchanged			
Information exchanged (ID)	**Name of information**	**Description of Information Exchanged**	**Requirements to information data**
Refers to an identifier used in the field “Information Exchanged” of Table 4.2.	Is a unique ID which identifies the selected information in the context of the use case.	Brief description, in case a reference to existing data models/information classes should be added. Using existing canonical data models is recommended.	Can be used to define requirements referring to the information and not to the step as in the step by step analysis (see template section 6 below): EXAMPLE: Data protection class corresponding to this information object.

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6 Common Terms and Definitions

Should be defined in a common glossary for all use cases. Here relevant terms belonging to this use case are listed. Using a database repository for the glossary, the definitions might be filled automatically based on existing information.

Common Terms and Definitions	
Term	**Definition**

7 Additional information

This concluding section is available to report and describe relevant custom information without any kind of format requirements which can add value and completeness to the use case definition. A practical example can be the development of a diagram to better show the correlation of the Use Case previously developed with all the others or tables reporting information with increasing level of detail.

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4. FLEXIndustries Use Cases

4.1 Methodology for UC identification

4.1.1 Methodology for UC identification (HDSS meetings with DEMOs)

To properly address the subjects proposed in FLEXIndustries, a set of use cases has been identified and developed to demonstrate a possible future business case of the platform, as well as to disseminate results and engage relevant stakeholders. Below, the methodology adopted to develop the use cases initially identified is reported.

METHODOLOGY ADOPTED FOR THE IDENTIFICATION OF THE USE CASES:

This chapter provides an overview of the methodology employed for the definition of possible use cases in line with the goals of "FLEXIndustries" project.

The FLEXIndustries project promotes, within the industrial context, energy flexibility and energy efficiency services. These pillars are aimed at ensuring an ever-increasing communication between industrial sites and energy service providers as well as a continuous improvement in the energy performance and overall efficiencies of the industrial sector.

The process for the definition of use cases was structured through a series of online meetings with representatives of the project's involved Demo Sites and partners of the consortium.

For each Demosite, a presentation was requested to provide a general overview of the objectives set by the implementation of the platform. The presentation was intended to report:

- Detailed information about Targeted Process, i.e. energy vectors and variables, energy consumption, control devices, measuring devices already implemented in the production process, etc.;
- Detailed investigation of each Demonstration Actions planned by demos with the scope of increase flexibility in the industrial production processes, i.e. installation of PV Plants and BESS, Organic Ranking Cycle and Thermoelectric Generators for waste energy conversion, implementation of real-time monitoring systems, etc.;
- The objectives and goals that each Demosite expects from the implementation of the FLEXIndustries platform, such as the reduction of natural gas and electricity consumption, increased energy efficiency, more efficient monitoring infrastructure, etc.;
- The type of output each demo wants to receive from the platform, including real-time notifications about energy and processes parameters, control system set points for predictive maintenance, high-level automation, etc.;

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All the information previously mentioned are necessary for a complete elaboration of the use cases according to the structure provided by the Standard IEC-62599.

Finally, the results of these activities were synthesized, elaborated, and crossed together to identify possible common use cases among the various Demo Sites involved in the project. This phase of synthesis represented the crucial moment in the use cases definition process, allowing for the delineation of realistic scenarios for the implementation of the "FLEXIndustries" platform.

The results of this process were presented to the consortium during the General Assembly held in Turin in January 2024, where the involved partners had the opportunity to examine and discuss the proposed developments.

LIST OF USE CASES:

The list reporting the first version of developed use cases is proposed in Table 1.
The use cases were developed according to the methodology previously proposed.

Table 1: Use Cases

UC 1	**Process Load Optimization through Energy Price Forecasting**
UC 2	Optimized Process Predictive Maintenance
UC 3	Advance Process Management
UC 4	Augmented Waste Heat Recovery Management for Power Generation
UC 5	Augmented Waste Heat Recovery for Emission Savings
UC 6	Participation in Flexibility Markets

The proposed use cases show the potential applications and possible benefits of implementing the "FLEXIndustries" platform within the industry.
As shown in the above table, use cases such as process optimization through energy price forecasting, predictive maintenance, and recovery of waste energy resources define a clear input towards a continuous improvement process which certainly generates multiple benefits.

Finally, the possibility that industries can actively participate in the energy markets, adapting loads according to the energy supply, market prices, up to inject energy into the network contributing to the optimization of network balancing was analysed.

Below, the association of each Demo Site with the relevant use case is provided.

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Table 2: FLEXIndustries Use Cases and Demo Sites association.

	Sector	Expected result from the platform	UC1	UC2	UC3	UC4	UC5	UC6
SUANFARMA	Pharmaceutical industry	• Optimization of the process load through Prediction/estimation of energy consumption, energy prices, and energy production. • Monitoring of most influential energy variables.	☑		☑			☑
K-FLEX	Polymer processing	• Predictive maintenance tool • Remote control of the whole system. • Possibility to set setpoint related to process parameters from the platform.		☑	☑	☑	☑	☑
MIL OIL	Biofuels	• Monitoring of ORC electricity production ORC Equipment energy consumption. • Waste heat recovery. • Monitoring of hot water outlet temperature. • Recommendation about maintenance & predictive maintenance using machine learning method.		☑		☑		
FORD OTOSAN	Automotive (Commercial vehicles)	• Maximize the efficiency of economizer (through decision-maker system working on economizer valves). • Maximize the efficiency of heat exchanger (through the monitoring of inlet/outlet flow). • HDSS must provide high level of notification. • Reduction in NG consumption. • Predictive maintenance. • Monitoring of PV plant Electric Energy generation and Electric Energy stored in BESS.		☑			☑	☑
STOMANA	Steel-making industry	• Implementation of modern monitoring infrastructure. • Implementation of FLEXIndustries DSS dedicated load and price forecasting module.	☑		☑			☑
TITAN	Cement Industry	• Implementation of TEG elements on kiln for heat capture and electrical power generation using AI management platform.			☑	☑		

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Each use case (UC) reflects on at least two possible Demo Sites, ensuring that each case can be representative of companies characterized by diverse activities and products.

In the previously presented table, it should be noted that the Fertinagro Demo Site is not listed as it has replaced the Progroup Power 1 GmbH- Pulp & Paper during the ongoing operations. The business cases for Fertinagro will be analysed subsequently.

4.1.2 Use Case Definition

A UC definition template has been developed by RINA-C following the standardized IEC 62559 methodology and includes the following sections: a) general description, scope and objectives, b) use case diagram and sequence diagram, c) technical details (actors, triggering events, preconditions, and assumptions), d) scenarios and steps, e) exchanged information, f) interconnection with other Use Case [3].

Being D8.7 a first version of the deliverable and since, during its drafting, the platform architecture was still in the process of being defined, it was developed exclusively for the introductory chapter of each individual Use case.

All missing information will be reported in the second version of the report due at M48, once all necessary inputs will be available.

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UC1: Process Load Optimization through Energy Price Forecasting

1. Introduction

1.1 Name of Use Case

Use Case Identification		
ID	**Area / Domain(s)/ Zone(s)**	**Name of Use Case**
1	Area: Energy related process data forecasting/energy price forecasting/energy consumption and flexibility forecasting Domain: Energy management Zone: Industry/Demo Site	Process Load Optimization through Energy Price Forecasting

1.2 Version management

Version Management				
Version No.	**Date**	**Name of Author(s)**	**Changes**	**Approval Status**
01	25.01.2024	RINA-C	First proposal of use case	Draft

1.3 Scope and Objectives of Use Case

Scope and Objectives of Use Case	
Scope	The scope of the current use case is the optimization of process load in real-time, based on accurate energy price forecasts to minimize operational costs while maintaining production efficiency.
Objective(s)	• Increase of energy efficiency; • Reduction of operational costs; • Optimisation of industrial activity planning.
Related business case(s)	BC 1 - ESCO Support for Energy Management Services

1.4 Narrative of Use Case

Narrative of Use Case
Short description
The optimization of the process load in the function of energy price forecasts represents the first fundamental step towards the implementation of the flexibility approach inside the business decision-making processes. For this purpose, it will be necessary to receive accurate forecasts on the future trend of market prices and compare them with the planned production activities to identify a strategy that allows minimizing operating costs and improve energy efficiency.
Complete description

The use case "Process Load Optimization through Energy Price Forecasting" involves all those production sites, which are interested in developing a model/strategy that allows them to plan the production activities and the workload according to the forecast of the energy price. For this purpose, it is necessary to implement a system of monitoring and acquisition of energy consumption through which to create an energy model to correlate to the production strategy. This strategy will be implemented with the prediction of future energy costs. The variety of scenarios and the specific needs require a modular and adaptable solution to the various production contexts [3]. Therefore, the infrastructure for data management and decision making will consist of certified hardware and sensors, actuators, and meters, which will communicate through an internal infrastructure. Finally, the result of the analysis will be transmitted and made available to the end user through the creation of a digital twin model.

1.5 General Remarks

General Remarks
The load Optimization through Energy Price Forecasting requires: • Identification of production processes and energy consumption; • Identification of load and actual/future production rate; • Clear and accurate energy price forecasting model. Of course, to obtain the information, an optimized and robust monitoring system is necessary. Specific remarks for SUANFARMA • Monitoring of electricity production from PV plants • Monitoring of the level of energy storage in Battery Energy Storage Systems (BESS) • Development and optimization of Energy Management Systems (EMS) Specific remarks for STOMANA • Implementation of modern monitoring infrastructure. • Implementation of a dedicated load and price forecasting module within the Decision Support System (DSS).

1.6 Further Information to the Use Case for Classification / Mapping

The following table presents further Information for the classification of this use case:

Classification Information
Relation to Other Use Cases
BC 1 - ESCO Support for Energy Management Services
Level of Depth
Medium
Prioritization
High
Generic, Regional or National Relation
National relation
Viewpoint
Technical
Further Keywords for Classification
Price and energy forecasting, load optimization, DSS, EMS

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UC2: Optimized Process Predictive Maintenance

1. Introduction

1.1 Name of Use Case

Use Case Identification		
ID	**Area / Domain(s)/ Zone(s)**	**Name of Use Case**
1	Area: Real-time process optimization Domain: Predictive Maintenance Zone: Industry/Demo Site	Optimized Process Predictive Maintenance

1.2 Version management

Version Management				
Version No.	**Date**	**Name of Author(s)**	**Changes**	**Approval Status**
01	25.01.2024	RINA-C	First proposal of use case	Draft

1.3 Scope and Objectives of Use Case

Scope and Objectives of Use Case	
Scope	The scope of Optimized Process Predictive Maintenance consists of the implementation of predictive maintenance strategies to maximize equipment reliability and minimize downtime, optimizing the overall process.
Objective(s)	• Reduction of unplanned downtime; • increase in the reliability of the equipment; • Improvement of overall efficiency and productivity; • Minimization of maintenance costs; • Implementation of a continuous improvement culture.
Related business case(s)	BC 1 - ESCO Support for Energy Management Services

1.4 Narrative of Use Case

Narrative of Use Case
Short description
The Use Case (UC) aims to analyse the optimization of predictive maintenance, which is today a field of extreme interest for all those industries whose processes are carried out by complex and sophisticated machinery. Despite advances in predictive maintenance technologies, time-based and hands-on equipment maintenance is still the norm in many industrial processes. Today, almost 30% of industrial equipment does not benefit from predictive maintenance technologies. [4] Predictive maintenance and its optimization require the implementation of advanced systems for monitoring and processing the performance of equipment, coupled with machine learning platforms. However, the benefits of adoption and optimization are countless, including anticipating equipment failures, reducing downtime, and improving operational efficiency.

Complete description
The use case "Optimized Process Predictive Maintenance" involves all the Demo Sites interested in the implementation of optimized predictive maintenance solutions. The first step consists of the assessment/ choice of all machinery for which predictive maintenance can be reasonably applied. The choice can be based on several factors such as, for example, the availability of operational parameters already monitored, or the frequency and type of failure that occurred in the past. The installation of an advanced real-time monitoring, acquisition, and data processing system will be necessary. These data will be subsequently checked and normalized with respect to the standard working conditions, to identify any discrepancies that may lead to non-optimal operation or even a plant downtime. Subsequently, through the implementation of infrastructures for communication and data processing, it will be possible to develop a twin digital model that will allow the supervision of all the necessary parameters to prepare and optimize the predictive maintenance process.

1.5 General Remarks

General Remarks
The Optimized Process Predictive Maintenance requires: • Access to historical data on equipment performance or technical datasheet reporting the standard working condition of equipment under investigation; • Implementation of monitoring systems for real-time data collection and elaboration; • Development of a digital model for predictive analytics to analyse collected data and avoid potential failures; • real-time alert systems to notify personnel of un-optimal working conditions. Specific remarks for K-FLEX/MIL OIL/FORD OTOSAN • Implementation of all the requirements previously reported

1.6 Further Information to the Use Case for Classification / Mapping

The following table presents further Information for the classification of this use case:

Classification Information
Relation to Other Use Cases
-
Level of Depth
Medium
Prioritization
High
Generic, Regional or National Relation
Generic
Viewpoint
Technical
Further Keywords for Classification
Predictive maintenance, machine learning, digital twin model.

UC3: Advance Process Management

1 Introduction

1.1 Name of Use Case

Use Case Identification		
ID	**Area / Domain(s)/ Zone(s)**	**Name of Use Case**
1	Area: Process planning/ Real-time process optimization Domain: Energy efficiency Zone: Industry/Demo Site	Advance Process Management

1.2 Version management

Version Management				
Version No.	**Date**	**Name of Author(s)**	**Changes**	**Approval Status**
01	25.01.2024	RINA-C	First proposal of use case	Draft

1.3 Scope and Objectives of Use Case

Scope and Objectives of Use Case	
Scope	The scope of advanced process management consists in enhancing overall process management through advanced control systems, ensuring optimal resource allocation and production quality. Advanced process management involves the integration of technological solutions, real-time data monitoring, and continuous improvement culture.
Objective(s)	• Enhance overall process management efficiency; • Identify opportunities for cost savings; • Integration of innovative technologies for continuous improvement.
Related business case(s)	TBD

1.4 Narrative of Use Case

Narrative of Use Case
Short description
The Use Case refers to the implementation of advanced process control systems for continuous improvement and identification of process inefficiencies. It focuses on real-time monitoring and feedback mechanisms and the implementation of innovative technologies. Using data and the promotion of a culture of continuous improvement, promotes efficiency, cost-effectiveness, and quality of products.
Complete description

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The use case of Advanced Process Management involves all Demo Sites willing to develop an efficient and highly optimized process management system. The crucial steps are the implementation of a real-time monitoring and data acquisition system to identify inefficiencies within the production process. This allows for the identification of critical points and areas for improvement. At the same time, research is being conducted to identify innovative technologies and raw materials that can further optimize the operations and overall quality. A key element is the creation of a management layer and the development of a dedicated model for monitoring the benefits derived from process management. Finally, the activity is implemented in the Twin Digital Model, to simulate and test different optimization strategies without directly affecting production. Through the digital twin frontend, the user will be able to monitor all progress.

1.5 General Remarks

General Remarks
The Advance process management requires: • Deep analysis of existing working conditions and identification of inefficiencies; • Adoption of new production techniques and Integration of advanced technologies; • Implementation of real-time monitoring and elaboration systems to evaluate progresse. Specific remarks for SUANFARMA: • Development and deployment of a new EMS (Energy Monitoring System) to optimally forecast & control internal energy fluxes. Specific remarks for K-FLEX: • Development and deployment of a new EMS (Energy Monitoring System) for a remote control of the whole production plant; • Possibility to set setpoints. Specific remarks for STOMANA: • Implementation of modern EMS (Energy Monitoring System). Specific remarks for TITAN: • Improvement of the existing EMS (Energy Monitoring System).

1.6 Further Information to the Use Case for Classification / Mapping

The following table presents further Information for the classification of this use case:

Classification Information
Relation to Other Use Cases
UC1 - Process Load Optimization through Energy Price Forecasting, UC2 - Optimized Process Predictive Maintenance
Level of Depth
Medium
Prioritization
High
Generic, Regional or National Relation
Generic
Viewpoint
Technical
Further Keywords for Classification
Process management, efficiency, continuous improvement, real-time monitoring system

UC4: Augmented Waste Heat Recovery Management for Power Generation

1 Introduction

1.1 Name of Use Case

Use Case Identification		
ID	**Area / Domain(s)/ Zone(s)**	**Name of Use Case**
1	Area: Energy consumption and flexibility consumption/Process planning/Energy and flexibility market Domain: Energy efficiency Zone: Industry/Demo Site	Augmented Waste Heat Recovery Management for Power Generation

1.2 Version management

Version Management				
Version No.	**Date**	**Name of Author(s)**	**Changes**	**Approval Status**
01	25.01.2024	RINA-C	First proposal of use case	Draft

1.3 Scope and Objectives of Use Case

Scope and Objectives of Use Case	
Scope	The purpose of this use case consists in the management and use of the residual waste heat from production processes to generate electric energy for self-consumption and increase the overall efficiency of the plant.
Objective(s)	• Maximize the utilization of waste heat from industrial processes or energy production plants for electricity generation; • Adoption of innovative technologies for waste heat recovery; • Improve the overall efficiency and sustainability of power generation operations through the integration of waste heat recovery solutions.
Related business case(s)	BC1 - ESCO Support for Energy Management Services BC2 - Flexibility Aggregator for Balancing Services

1.4 Narrative of Use Case

Narrative of Use Case
Short description
This use case focuses on the implementation of innovative technologies for the management of waste heat recovery in order to generate additional electricity without the consumption of other energy carriers. The case study is particularly interesting, especially in terms of energy flexibility and sustainability, and is highly relevant in today's context.
Complete description

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The use case "Augmented Waste Heat Recovery Management for Power Generation" directly involves Demo Sites and their industrial processes, as well as thermal and electrical energy generation plants installed within their perimeter.

The main objective of the UC is the implementation of innovative technologies for the recovery of residual heat, subsequently used as input for electricity generation.

To achieve this goal, a monitoring and data acquisition system must be implemented to analyse the amount of waste heat produced by industrial processes or cogeneration plants. This system will enable the assessment of the equivalent amount of electrical energy that could be produced through recovery systems.

A key element for the development of the use case is the creation of management layer and the development of an algorithm for the conversion of thermal energy into electricity, according to the technology adopted.

Once the amount of thermal energy has been quantified, the most suitable technology for the recovery of waste heat and electricity conversion can be proposed. Examples of these technologies are Rankine Organic Cycle Generators (ORC) and Thermoelectric Generators (TEG).

Finally, the activity is implemented in the Twin Digital Model, to simulate and test different optimization strategies without directly affecting production.

1.5 General Remarks

General Remarks
The Augmented Waste Heat Recovery Management for Power Generation requires: • Integration of monitoring and data acquisition systems to analyse waste heat production. • Development of a management layer with an algorithm for the conversion of waste heat into electric energy. Specific remarks for MIL OIL • Monitoring of waste heat used as input for ORC Power Plant Specific remarks for K-FLEX • Monitoring of waste heat used as input for ORC Power Plant Specific remarks for TITAN • Monitoring of heat captured by TEG Elements

1.6 Further Information to the Use Case for Classification / Mapping

The following table presents further Information for the classification of this use case:

Classification Information
Relation to Other Use Cases
UC1: Process Load Optimization through Energy Price Forecasting UC5: Augmented Waste Heat Recovery for Emission Savings
Level of Depth
Medium
Prioritization
High
Generic, Regional or National Relation
Generic
Viewpoint
Technical
Further Keywords for Classification
Waste heat, electric energy generation, ORC, TEG Elements, real-time monitoring systems

UC5: Augmented Waste Heat Recovery for Emission Savings

1 Introduction

1.1 Name of Use Case

Use Case Identification		
ID	**Area / Domain(s)/ Zone(s)**	**Name of Use Case**
1	Area: Real-time process optimization Domain: Energy and sustainability Zone: Industry/Demo Site	Augmented Waste Heat Recovery for Emission Savings

1.2 Version management

Version Management				
Version No.	**Date**	**Name of Author(s)**	**Changes**	**Approval Status**
01	25.01.2024	RINA-C	First proposal of use case	Draft

1.3 Scope and Objectives of Use Case

Scope and Objectives of Use Case	
Scope	The purpose of the use case is the recovery of the energy contained in the waste heat generated during industrial processes not only to generate power but also to achieve a significant reduction in greenhouse gas emissions, contributing to environmental sustainability.
Objective(s)	• Minimize greenhouse gas emissions by recovering waste heat; • Improve the sustainability of industrial processes; • Reduce energy consumption and costs associated; • Active contribution to Climate change mitigation through the implementation of innovative and efficient waste heat recovery technologies.
Related business case(s)	BC 4 - FLEXIndustries as a Company acting in the Emission Trading Scheme

1.4 Narrative of Use Case

Narrative of Use Case
Short description
The use case involves the implementation of innovative technologies to convert waste heat generated by industrial processes into reusable energy. This implies a clear reduction of greenhouse gas emissions, a reduction in energy expenditure, and an improvement in the overall efficiency.
Complete description

The use case " Augmented Waste Heat Recovery for Emission Savings " directly involves Demo Sites and their industrial processes, as well as thermal and electric power plants installed within their perimeter. The main objective of the UC is the implementation of innovative technologies for the recovery of residual heat, subsequently used as input for other production processes. The implementation of a data monitoring and acquisition system will play a fundamental role in detecting and recording the quantity of waste heat produced by industrial processes. This system will allow real-time data collection regarding thermal flow and other relevant variables, ensuring an accurate assessment of the potential for heat recovery. The identified waste heat can be recovered through the implementation of economizers and heat exchanger and used as input for other processes. This practice will not only optimize overall energy efficiency but also reduce the environmental impact by decreasing the need for conventional fossil fuels, such as natural gas. A key element of the development of the use case is the establishment of a management layer and a Digital twin model for quantifying, through algorithms, the CO_2 emission savings resulting from the implementation of waste heat recovery technologies.

1.5 General Remarks

General Remarks
Augmented Waste Heat Recovery for Emission Savings requires: • Real-time monitoring of waste heat generation and recovery; • Implementation of suitable heat recovery technologies; • Tool for Counting Avoided CO2 Emissions Specific remarks for K-FLEX • Real-time monitoring of waste heat generation and monitoring of recovered heat through advance technologies; • Tool for Counting Avoided CO2 Emissions Specific remarks for FORD OTOSAN • Implementation of monitoring system for heat recovery optimization and heat loss reduction. • Tool for Counting Avoided CO2 Emissions For the K-FLEX the installation of an DHR (Direct Heat Recovery) plant is investigating for recovering waste heat from the main production processes. Regarding the FORD OTOSAN demo, heat recovery systems are already installed. The goal is to ensure proper monitoring of operating conditions to optimize the process, reducing heat loss and fossil fuel consumption

1.6 Further Information to the Use Case for Classification / Mapping

The following table presents further Information for the classification of this use case:

Classification Information
Relation to Other Use Cases
UC4 - Augmented Waste Heat Recovery Management for Power Generation
Level of Depth
Medium
Prioritization
High
Generic, Regional or National Relation
Generic

Funded by the European Union

Viewpoint
Technical
Further Keywords for Classification
CO_2 emission reduction, waste heat recovery, environmental sustainability

Funded by the European Union

UC6: Participation in Flexibility Markets

1 Introduction

1.1 Name of Use Case

Use Case Identification		
ID	**Area / Domain(s)/ Zone(s)**	**Name of Use Case**
1	Area: Energy consumption and flexibility forecasting/Energy and flexibility markets Domain: Energy efficiency/Energy management Zone: Industry/Demo Site	Participation in Flexibility Markets

1.2 Version management

Version Management				
Version No.	**Date**	**Name of Author(s)**	**Changes**	**Approval Status**
01	25.01.2024	RINA-C	First proposal of use case	Draft

1.3 Scope and Objectives of Use Case

Scope and Objectives of Use Case	
Scope	The purpose of the use case is to enable the production plant to actively participate in flexibility markets, leveraging demand response strategies to gain economic benefits.
Objective(s)	• Balancing the electricity grid; • Remuneration for electricity fed into the grid; • CO_2 emission reduction.
Related business case(s)	BC1: ESCO Support for Energy Management Services BC2: Flexibility Aggregator for Balancing Services BC4: FLEXIndustries as a Company acting in the Emission Trading Scheme

1.4 Narrative of Use Case

Narrative of Use Case
Short description
The use case involves the interaction with energy service distributors to actively contribute to the demand-response and balancing mechanism of the network when the energy production systems installed on-site (such as congenators and photovoltaic systems) generate an energy surplus.
Complete description

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The growing share of volatile renewable generation increases the demand for flexibility in the electricity grid. Flexible capacity can be offered by industrial energy systems through participation in continuous intraday, day-ahead, or balancing markets. [5]

The use case entitled "Participation in Flexibility Markets" directly involves Demo Sites that have or have planned the installation of technologies for the on-site production of electricity and are interested in developing contractual agreements for participation in the energy market.

The main objective of the UC is to introduce and familiarize the current but innovative concepts relating to the balancing and demand response mechanism in the energy flexibility market, showing all the possible benefits.

The first step consists in installing, within the Demo Site, renewable/sustainable energy production technologies which, during peak production periods, have the capacity to feed any surplus energy into the electricity grid to balance demand and draw from its monetary compensation. Obviously, this quantity of energy must comply with the contractual agreements with the energy service distributor.

The key steps for the excellent success of the use case, in addition to the definition of the previously mentioned contractual agreement, are many. In the foreground, the site must be registered in the flexibility market platform, which offers integrated solutions for the purchase and sale of energy. To do this, the demo requires a sophisticated system for monitoring and processing on-site energy production data to which self-consumption must be associated, to be able to accurately identify the share of energy available for injection into the grid.

In addition, a system that meets the needs of the energy market must be implemented. The systems must provide predefined market signals.

A following element of the use case development is the creation of a management layer and a digital twin model for real-time evaluation of balancing opportunities and possible rewards.

1.5 General Remarks

General Remarks
The Participation in Flexibility Markets requires: • On-site technologies for electricity production; • Integration with flexibility market platforms; • Contractual agreements for market participation; • Implementation of real-time monitoring and elaboration systems to energy production evaluation. • Bidirectional energy exchange with energy network. Specific remarks for SUANFARMA • Trigeneration 3 and Biogas CHP performance monitoring; • Development/Update contract agreement for electrical and thermal market participation according with the new technologies installed. It is relevant to mentioned according to the GA,demosites FORD , STN and KFX will be studied possible connections to grid platforms to enable novel, sustainable market operations and business models. The analyses will be developed through case studies emulated thanks to data provided by national TSOs.

1.6 Further Information to the Use Case for Classification / Mapping

The following table presents further Information for the classification of this use case:

Classification Information
Relation to Other Use Cases
UC1: Process Load Optimization through Energy Price Forecasting
Level of Depth
Medium
Prioritization
High

Generic, Regional or National Relation
Regional or National Relation
Viewpoint
Technical
Further Keywords for Classification
Market flexibility platform, contractual agreements, renewable energy, grid balancing

5. Preliminary Business Cases for FLEXIndustries

5.1 Business Use Cases

5.1.1 Business Cases Table

One of the objectives of the FLEXIndustries Project is to test and validate several business cases and models. Considering the FLEXIndustries Use Cases (UCs) discussed in the previous chapter, in this section Business Cases (BCs) will be analysed to define possible business scenarios that, along with use cases, drive the user requirement definition process. [3]

Business scenarios aim to derive an understanding of the significant business needs, which can then be used to determine the important requirements and ensure solutions that meet the overall business needs. Business cases are intended as all the operations that the FLEXIndustries Demo Sites intend and need to undertake to successfully reach their goals through the implementation of specific UCs. [3]

The BCs that have been identified are summarized in Table 3.

Table 3: Short description of FLEXIndustries Business Cases.

BC #	BUSINESS CASE	SHORT DESCRIPTION
BC 1	ESCO Support for Energy Management Services	FLEXIndustries acts as an Energy Service Company (ESCO), providing support to Demo Sites for optimizing their energy consumption. The platform helps in determining the most efficient generation-storage strategy. It enables the Battery Energy Storage System to charge during high energy production or low electricity prices and facilitates self-consumption during peak pricing or selling stored electricity when profitable.
BC 2	Flexibility Aggregator for Balancing Services	FLEXIndustries serves as a flexibility aggregator, aiding Transmission System Operators (TSO), Distribution System Operators (DSO), and other parties in congestion management and balancing services. It leverages flexible actions and technologies to participate in energy markets, modulating loads based on market prices.

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BC 3	ESCO Support for Demo Sites Thermal Power Generation	FLEXIndustries acts as an ESCO, providing support to Demo Sites in understanding co-generation strategies for thermal power generation. The platform considers District Heating Network (DHN) prices and available heating capacity, optimizing thermal power generation.
BC 4	FLEXIndustries as a Company acting in Emission Trading Scheme	FLEXIndustries serves as a facilitator platform, enabling companies to enter emission trading markets. It maximizes waste heat recovery, implements heat exchanger systems, and integrates TEG elements to achieve greenhouse gas (GHG) emission reduction results.

Each Demo Site will have the opportunity to assess and implement the business cases that align most with their specific goals and operational requirements. The business case testing and validation will be performed according to the flexibility demonstration activities at each Demo Site.

Below, the association between business cases and Demo Sites is proposed.

Table 4: FLEXIndustries Business Cases and Demo Sites association.

	Sector	Expected result from the platform	BC1	BC2	BC3	BC4
SUANFARMA	Pharmaceutical industry	• Optimization of the process load trough Prediction/estimation of energy consumption, energy prices and energy production. • Monitoring of most influential energy variables.	☑	☑	☑	
K-FLEX	Polymer processing	• Predictive maintenance tool • Remote control of the whole system. • Possibility to set setpoint related to process parameters from the platform.	☑			
MIL OIL	Biofuels	• Monitoring of ORC electricity production ORC Equipment energy consumption. • Waste heat recovery. • Monitoring of hot water outlet temperature. • Recommendation about maintenance & predictive maintenance using machine learning method.		☑		☑
FORD OTOSAN	Automotive (Commercial vehicles)	• Maximize the efficiency of economizer (through decision-maker system working on economizer valves).	☑			☑

		• Maximize the efficiency of heat exchanger (through the monitoring of inlet/outlet flow). • HDSS must provide high level of notification. • Reduction in NG consumption. • Predictive maintenance. • Monitoring of PV plant Electric Energy generation and Electric Energy stored in BESS.				
STOMANA	Steel-making industry	• Implementation of modern monitoring infrastructure. • Implementation of FLEXIndustries DSS dedicated load and price forecasting module.				
TITAN	Cement Industry	• Implementation of TEG elements on kiln for heat capture and electrical power generation using AI management platform.				☑

In the previously presented table, it should be noted that the Fertinagro Demo Site is not listed as it has replaced the Progroup Power 1 GmbH- Pulp & Paper during the ongoing operations. The business cases for Fertinagro will be analysed subsequently.

For each business case, additional information and details are provided in the chapter below.

5.1.2 Business Cases description

In this section of the report, a first version of the identified business cases is outlined.
Each business case is briefly described, presenting the flexibility service, stakeholders involved, and the implemented technologies.
Finally, the benefits and the potential applications of these business cases are proposed.

Business Case 1: ESCO Support for Energy Management Services

The business case under investigation focuses on the potential for the FLEXIndustries platform to operate as an Energy Service Company (ESCO) to provide energy management services, with particular attention to energy production-storage strategy.

All the Demo Sites involved in BC1 have planned the installation of technologies dedicated to energy production, electrical or thermal, coupled with storage systems. It is therefore crucial to develop strategies for the optimal utilization of these resources, considering the energy needs for production processes and market energy costs.

It is in this context that the FLEXIndustries platform can act as an ESCO and support the decision-making processes of the involved entities.

In addition, ESCo offers a wide range of auxiliary energy-related services, including energy optimization [6], energy efficiency consulting, and the implementation of procedures to reduce energy consumption and costs.

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In Table 5, the details of Business Case 1 are reported.

Table 5: BC1: ESCO Support for Energy Management Services.

Business Case 1: ESCO Support for Energy Management Services

Stakeholders:	• Demo Sites. • ESCos
Demo Sites involved	• FORD OTOSAN • SUANFARMA • K-FLEX
Flexibility actions and technology	• FORD OTOSAN: Photovoltaic Plant coupled with Battery Energy Storage System • SUANFARMA: Photovoltaic Plant, CCHP and Battery Energy Storage System • K-FLEX: Heat exchanger and Solar Thermal Plant
Flexibility service description	FLEXIndustries acts as an Energy Service Company (ESCO), providing support to Demo Sites for optimizing their energy consumption. The platform helps in determining the most efficient generation-storage strategy. It enables the Battery Energy Storage System to charge during high energy production or low electricity prices and facilitates self-consumption during peak pricing or selling stored electricity when profitable.
Associated Use Cases	• UC1 (Process Load Optimization), • UC2 (Optimized Process Predictive Maintenance), • UC4 (Waste Heat Recovery for Power Generation)

The Business Case will be further investigated in the final version of the report.

In Figure 4, an illustrative diagram depicting the interconnectivity between the Demo Site, represented as a Prosumer, and the ESCo is proposed. The flexibility previously described can be mainly summarized in the following services:

- ToU (Time of Use) optimization involves shifting loads from high-price intervals to low-price intervals (or vice versa for generation) and potentially implementing complete load shedding during periods with high prices [6];
- Self-Balancing refers to a procedure aimed at balancing the energy consumption and generation of customers who both produce electricity and possess flexible demands. This approach generates value through the disparity in prices between

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purchasing energy from the grid and feeding excess energy back into the grid, considering taxation. [6]

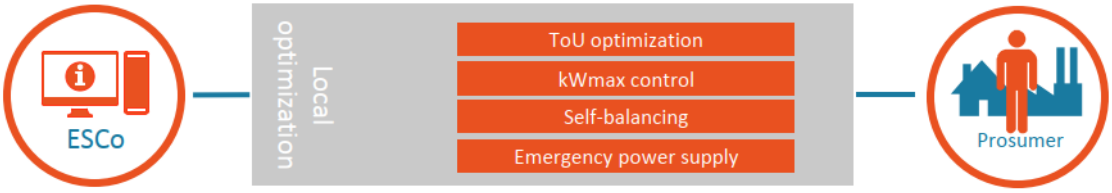

Figure 4: Business Case block diagram ESCO – PROSUMER [6].

Other flexibility services as the control of maximum load (kW$_{max}$ control) and Emergency power supply can also be performed by the FLEXIndustries ESCO service.

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Business Case 2: Flexibility Aggregator for Balancing Services

The second business case examined is titled "Flexibility Aggregator for Balancing Services".

The business case examines the potential service provided by the FLEXIndustries platform, which could operate as an "aggregator" to ensure interaction between Transmission System Operators (TSO), Distribution System Operators (DSO), Demo Sites, and other interested parties in congestion management and balancing services, utilizing flexible actions and technologies for market participation.

All the Demo Sites involved in BC2 have already installed or are planning to install Cogeneration and Trigeneration Plants for energy generation (both electric and thermal). The electric energy generated can be used internally for self-consumption, or if requirements are met, it can be injected into the grid, participating positively in the balancing market.
It is therefore crucial to develop strategies for the optimal utilization of the electric energy generated, considering the energy needs for production processes and market energy costs.

It is in this context that the FLEXIndustries platform can act as an Aggregator and support the decision-making processes of the involved demo.

The Aggregator essentially functions as a flexibility retailer, positioned centrally between the prosumer and all the parties requesting flexibility, i.e. BRP, DSO, and TSO. [6]
The Aggregator is responsible for acquiring flexibility from prosumer, aggregating it into a portfolio, creating services that leverage it, and offering these services to different markets. The value received by the Aggregator in return is shared with Active Customers as an incentive for them to shift, reduce, or enhance their load or generation. [6]
Please note that the Aggregator and the ESCO can be the same entity, as is the case here, with both roles being represented by the FLEXIndustries platform. [6]

In Table 6, the details of Business Case 2 are reported.

Table 6: Flexibility Aggregator for Balancing Services

Business Case 2: Flexibility Aggregator for Balancing Services

Stakeholders:	• Demo Sites • Aggregator • Transmission System Operators (TSO) • Distribution System Operators (DSO) • Balance responsible party (BRP)
Demo Sites involved	• MIL OIL • SUANFARMA
Flexibility actions and technology	• MIL OIL: ORC/CHP plant for electricity production from waste thermal energy • SUANFARMA: CHP with variable load to accommodate market signals and Trigeneration 3 to sell electricity to the grid
Flexibility service description	FLEXIndustries serves as a flexibility aggregator, aiding Transmission System Operators (TSO), Distribution System Operators (DSO), and other parties in congestion management and balancing services. It leverages flexible actions and technologies to participate in energy markets, modulating loads based on market prices.
Associated Use Cases	• UC5 (Waste Heat Recovery for Emission Savings) • UC6 (Participation in Flexibility Markets)

The Business Case will be further investigated in the final version of the report.

In Figure 5, an illustrative diagram representing the interconnectivity between the Demo Sites, represented as a Prosumer, the Aggregator, and the stakeholder involved is reported.

The flexibility previously described can be mainly summarized in the following services:

- Constraint management services (CMSP) assist TSOs and DSOs in optimizing grid operations by addressing physical constraints and their impact on markets. [6]
- Adequacy services aim to enhance the security of the power supply by ensuring sufficient long-term generation capacity for both peak and off-peak periods. [6] These services can be provided to either the TSO or the BRP, depending on market design. [6]
- Wholesale services aid BRPs in reducing electricity procurement costs and expenses associated with sourcing through balancing mechanisms. [6]
- Balancing services encompass all services mandated by the TSO for frequency regulation. [6]

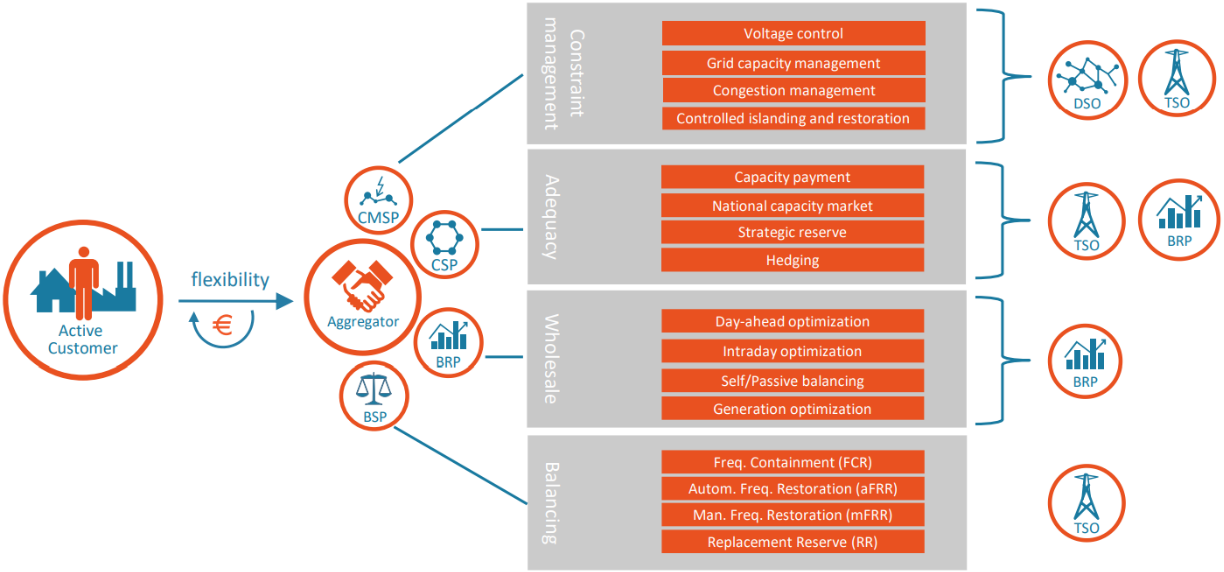

Figure 5: Business Case block diagram AGGREGATOR – PROSUMER [6].

Business Case 3: ESCO Support for Demo Sites in Thermal Power Generation

The business case titled "ESCo Support for Demo Sites in Thermal Power Generation" suggests the participation of the FLEXIndustries Platform as an Energy Service Company (ESCo) to provide support in thermal power generation planning.

The possible role of the ESCo is to support industrial sites in modulating/optimizing the thermal energy generated by thermal/cogeneration power plants operating within the industrial perimeter also based on the possible connection to the local district heating network, its thermal demand and to the relative remuneration for the heat released.

The Demo Site involved in BC3 is SUANFARMA, which has already installed a trigeneration power plant characterized by modular capacity and already interconnected with the local District Heating System. Additionally, the Demo Site is planning to install an additional 1 MW_{th} heat pump plant to produce cooling and heating for processes.

The idea is for the heat pump to operate primarily based on the thermal needs of the production processes, but also according to the requirements of the network, following a predefined technical and economic scheme.

Of course, the temperature setpoint and working conditions must be defined in agreement with the entity responsible of the service, to grant the correct operation of the district heating system.

In Table 7, the details of Business Case 3 are reported.

Table 7: Business Case 3: ESCO Support for Demo Sites Thermal Power Generation.

Business Case 3: ESCO Support for Demo Sites Thermal Power Generation

Stakeholders:	• Demo Sites. • ESCo • District Heating network Operator
Demo Sites involved	• SUANFARMA
Flexibility actions and technology	• SUANFARMA: Trigeneration 3 and heat pump plant for thermal power production and exchange with district heating network
Flexibility service description	FLEXIndustries acts as ESCo, providing support to Demo Site in understanding co-generation strategies for thermal power generation. The platform considers district heating network (DHN) prices and available heating capacity, optimizing thermal power generation.
Associated Use Cases	• UC6 (Participation in Flexibility Markets)

The Business Case will be further investigated in the final version of the report.

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In Figure 6, an illustrative diagram depicting the interconnectivity between the Demo Site, represented as a Prosumer, the ESCo, and the stakeholder involved is reported.

The ESCo can interact with the district heating network operator when it requires support to meet the thermal energy demand. The thermal request provided by the Demo Site is defined to balance the demand, along with determining the remuneration for the produced heat.

ESCo can collaborates with the Demo Site to assess whether it is necessary to adjust the load of cogenerators in response to the demand for heat. The Demo Site can increase the load if the remuneration for the heat fed into the network is advantageous.

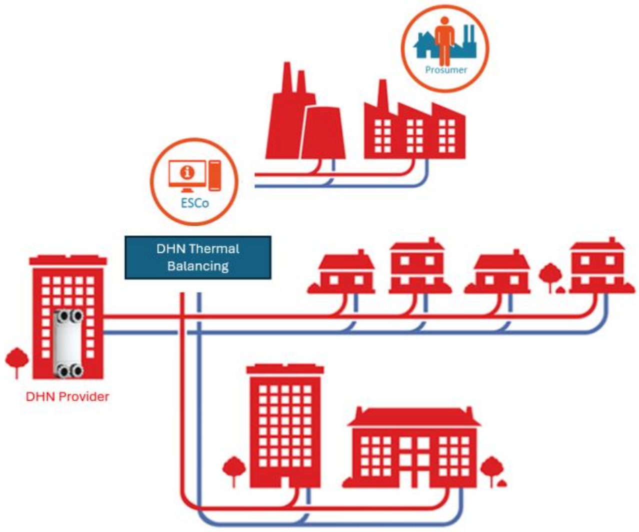

Figure 6: Business Case block diagram ESCO – PROSUMER. [2]

[2] https://www.swep.net/campaigns/district-energy/

Business Case 4: FLEXIndustries as a Company acting in Emission Trading Scheme

The business case entitled "FLEXIndustries as a Company acting in Emission Trading Scheme" focuses on the participation of the FLEXIndustries platform, depicted as ESCo, in an emission trading scheme.

In this context, the primary role of the platform would be to act as an intermediary or active participant in the emissions market, buying and selling emission credits to manage and reduce the environmental impact of the industrial sector.

The involved industry could benefit from the partnership with FLEXIndustries by gaining access to emission offset mechanisms, improving its environmental sustainability, and gaining competitive advantages in compliance with environmental regulations.

The business case presents itself as a natural consequence of the previously developed use cases, as any activity that implies a more rational use of energy resources combined with energy efficiency related activities and waste reduction, implies benefits in terms of environmental impact and reduction of carbon emission.

Through the proposed service, the platform also acts as a spokesperson for new ideas such as environmental sustainability and climate change.

In Table 8, the details of Business Case 3 are reported.

Table 8: FLEXIndustries as a Company acting in Emission Trading Scheme.

Business Case 4: FLEXIndustries as a Company acting in Emission Trading Scheme	
Stakeholders:	• Demo Sites • ESCo • Local parties responsible of emission trading schemes
Demo Sites involved	• MIL OIL • FORD OTOSAN • TITAN
Flexibility actions and technology	• MIL OIL: Recovery of Waste Heat • FORD OTOSAN: Maximization of Heat Exchanger and economizer System • TITAN: Implementation of Thermoelectric Generator (TEG) Elements for electric energy production
Flexibility service description	FLEXIndustries serves as a facilitator platform, enabling companies to enter emission trading markets. It maximizes waste heat recovery, minimizing natural gas consumption, driving involved actors to achieve greenhouse gas (GHG) emission reduction results.
Associated Use Cases	• UC5 (Waste Heat Recovery for Emission Savings)

The Business Case will be further investigated in the final version of the report.

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In Figure 7, an illustrative diagram depicting the interconnectivity between the Demo Site, represented as a Prosumer, the ESCo, and the stakeholder involved is reported. The flexibility previously described can be mainly summarized in the following services:

- Conduct analysis and provide support on emission reduction strategy;
- Participation in carbon emission trading schemes;
- Act as an intermediary figure in the emission credit market;
- Ensure compliance with current national and international regulations.

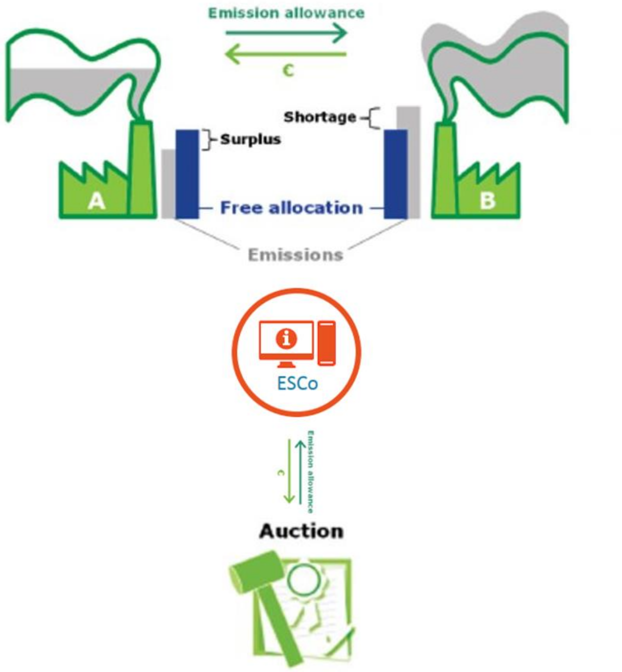

Figure 7: Business Case block diagram ESCO – PROSUMER.

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6. Conclusions

As the outcomes of this deliverable will direct FLEXIndustries tool development and demonstration activities, the activities of all other WPs and tasks as well as the planning and creation of consolidated Business Use Cases are made possible by the results of the activities compiled and reported below.

FLEXIndustries framework will undergo further definition and analysis of business and citizen/user requirements, guided by business scenarios and use-cases. This will make it easier for communities, prosumers, and other market participants to understand the purpose, functionality, and application of the project's outcomes.

FLEXIndustries Use Cases

Six FLEXIndustries Use Cases have been selected and are in the first stages of formulation to properly address the FLEXIndustries goal.

The following sections are included in each Use Case, which has been defined using a specific template and the standardized IEC 62559 methodology: The overall description, goals, and scope are listed in items a) and b), along with the use case and sequence diagram, technical details (actors, triggering events, preconditions, and assumptions), processes and scenarios, e) information exchanged, and f) connections with other use cases.

The first draft of the Use Case definitions will serve as a basis for the development of all future FLEXIndustries products and will also direct demonstration efforts. Additionally, technical partners and the responsible parties of each pilot site have agreed to establish a relationship between Use Cases and Demo Sites where the UC will be deployed, tested, and validated. This relationship will allow for the evaluation of particular aspects that are specific to each pilot site.

FLEXIndustries Business Cases

Four distinct business cases have been examined in light of the FLEXIndustries use cases in order to provide a preliminary characterization of potential business scenarios that, in conjunction with use cases, guide the process of determining user requirements. Every Business Case has been linked to a Demo Site where it will be tested, and a relationship has been established between every BC and the UCs. With the help of the pilot in charge, each business case's potential services, key players and their roles, primary goals for each service, resources required to meet the BC goal, and anticipated benefits have been determined.

A good basis for the project's further actions is provided by the outcomes of this type of deliverable. More importantly, they will make it possible to define the FLEXIndustries system architecture, implement the Performance Measurement and Verification Methodology and associated KPIs, develop FLEXIndustries ICT solutions, carry out the actual implementation

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of FLEXIndustries technical solutions and organizational tasks, and define and assess FLEXIndustries business models.

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