D2.1 – DIGITISE End-User Requirements and Socio-Economic Analysis

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Preface

Funded by the European Commission under Grant Agreement number 101160671, DIGITISE is a project focused on enhancing the digital literacy and empowerment of consumers and prosumers in the energy sector. By integrating advanced technologies and fostering active engagement in digital energy activities and markets, DIGITISE aims to play a crucial role in the global energy transition.

Executive Summary

The DIGITISE project is an EU-funded initiative aimed at driving digital innovation to empower consumers in the energy transition. This deliverable, D2.1: DIGITISE End-User Requirements and Socio-Economic Analysis, provides a comprehensive framework for defining business scenarios, use cases, and user engagement strategies, serving as the foundation for the project's digital tools and services.

The document follows a structured approach, beginning with an analysis of business scenarios, categorized into data-driven and service-driven models. Data-driven scenarios focus on efficient data governance, interoperability, and AI-powered analytics to enhance energy optimization. Service-driven scenarios target energy flexibility, prosumer engagement, and smart home solutions, integrating automation, digital twins, and AI-driven decision-making to improve user participation in energy markets.

A critical component of this deliverable is the extraction of end-user requirements, obtained through stakeholder engagement activities, including structured questionnaires and energy dialogues across multiple demonstration sites. Anonymous surveys were distributed among DIGITISE actors to gather valuable feedback on platform design. Feedback from prosumers, consumers, and business actors was instrumental in deriving a comprehensive list of business and user requirements, forming the basis for technical framework specifications in the project.

These engagement activities revealed key insights into user priorities, challenges in digital energy adoption, and socio-economic factors influencing participation. Critical barriers such as behavioural constraints, interoperability issues, financial concerns, and energy literacy gaps were identified, underscoring the need for tailored digital solutions aligned with market expectations and consumer needs.

Furthermore, the document includes a regulatory analysis, mapping the legal and policy frameworks in the project's demonstration countries (Greece, Spain, Ireland, and Croatia). This ensures the DIGITISE framework remains compliant, secure, and adaptable, supporting data privacy, equitable energy access, and transparent energy transactions.

The outcome of this work is a detailed set of business scenarios, use cases, and end-user requirements that will inform the DIGITISE platform's technical development in upcoming work packages, ensuring a consumer-centric, innovative, and sustainable approach to digital energy services.

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Abbreviations

Abbreviation	Full Name
AI	Artificial Intelligence
API	Application Programming Interface
BSC	Business Scenario Component
BS	Business Scenario
CEC	Citizen Energy Communities
CSV	Comma-Separated Values
DER	Distributed Energy Resources
DHW	Domestic Hot Water
DLT	Distributed Ledger Technology
DSO	Distributed System Operator
DR	Demand Response
EV	Electric Vehicle
ESCO	Energy Service Company
GA	Grant Agreement
GDPR	General Data Protection Regulation
HVAC	Heating, Ventilation, and Air Conditioning
ICT	Information and Communication Technology
IEMD	Internal Electricity Market Directive
IoT	Internet of Things
IPR	Intellectual Property Rights
JSON	JavaScript Object Notation
LEC	Local Energy Community
ML	Machine Learning
P2P	Peer-to-Peer
PubSub	Publish-Subscribe Mechanism
UC	Use Case
UI	User Interface
VPP	Virtual Power Plant

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1 Introduction

1.1 Scope of the Document

The scope of this document is to define the business, end-user, and regulatory priorities of the DIGITISE project, which will guide the development of its technical framework and cross-sector digital solutions.

Initially, a business analysis is conducted to map the current interests and focus of the project and to identify core features and functionalities aligned with the needs of the business actors involved in the project. This action focuses on extracting the business scenarios and relevant workflows, setting the project's approach to designing innovative, consumer-centric solutions. Following the definition of business scenarios, the extraction of use cases provides insights into the technical implementation of the various business objectives to be considered in the project. The extraction of use cases also considers consultations with the business actors involved.

This document integrates insights from business stakeholders and end-users, gathered through structured engagement activities aimed at extracting specific business needs. Feedback from these stakeholders forms the basis for defining DIGITISE's requirements, which will drive the project's design and implementation. The extracted requirements reflect the diverse perspectives of the actors involved and ensure that the solutions align with real-world needs and constraints.

Additionally, this document addresses the regulatory landscape, ensuring that the DIGITISE solutions comply with relevant EU and national guidelines. The output of this work is a comprehensive list of business scenarios, use cases, and requirements that will shape the project's innovative framework.

1.2 Relevance to other Deliverables

This document serves as a foundational input for the DIGITISE project, focusing on defining its functional and business objectives. The insights and requirements outlined here are instrumental in shaping the project's technological framework and guiding the development of innovative solutions. These contributions will directly support tasks related to the design, implementation, and validation of digital tools and cross-sector services.

The business scenarios and use cases described in this document will provide critical guidance for subsequent phases of the project, including the integration of consumer-centric technologies and the development of interoperable solutions and tools. Additionally, the document ensures alignment with regulatory frameworks, fostering compliance and setting a strong foundation for the realization of DIGITISE's objectives in creating transformative, consumer-focused energy solutions. Moreover, the list of requirements as derived from this work will drive the technical decisions to be performed in the project, more specifically the definition of DIGITISE architecture as part of the work in T2.5 and further the implementation activities for the different tools in WP3, WP4 and WP5.

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1.3 Structure of the Document

This document provides a structured overview of the DIGITISE project, outlining its objectives, methodology, and key findings. It begins with Chapter 1, which introduces the scope, relevance, and structure of the document. Chapter 2 explains the methodology used to engage stakeholders and extract essential requirements. Chapter 3 presents the process for defining the DIGITISE Business Scenarios and the extracted Use Cases definition. Chapter 4 shares stakeholder engagement outcomes, offering insights gathered from questionnaires and discussions towards the analysis of feedback from the different use cases examined in the project. In chapter 5 and 6, the focus is again on the consumers side and the feedback on the issues related to their engagement in different energy services, further complemented by a review of the regulation, summarizing relevant EU and national regulations that influence the project's design and implementation. Building on these foundations, Chapter 7 outlines the project's requirements and solution framework, detailing how they align with DIGITISE's objectives. The document concludes with a summary of key takeaways, providing a roadmap for the next steps in the DIGITISE project.

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2 Methodology Framework

The DIGITISE project employs a comprehensive, step-by-step methodological framework designed to align technical developments with key energy business objectives, end user needs and regulatory aspects. This methodology integrates business scenarios, stakeholder engagement, technical analysis, and innovative digitization strategies, ensuring a consumer-centric approach to achieving the energy transition. The methodology is structured around five key phases (as shown in Figure 1) and described in detail below:

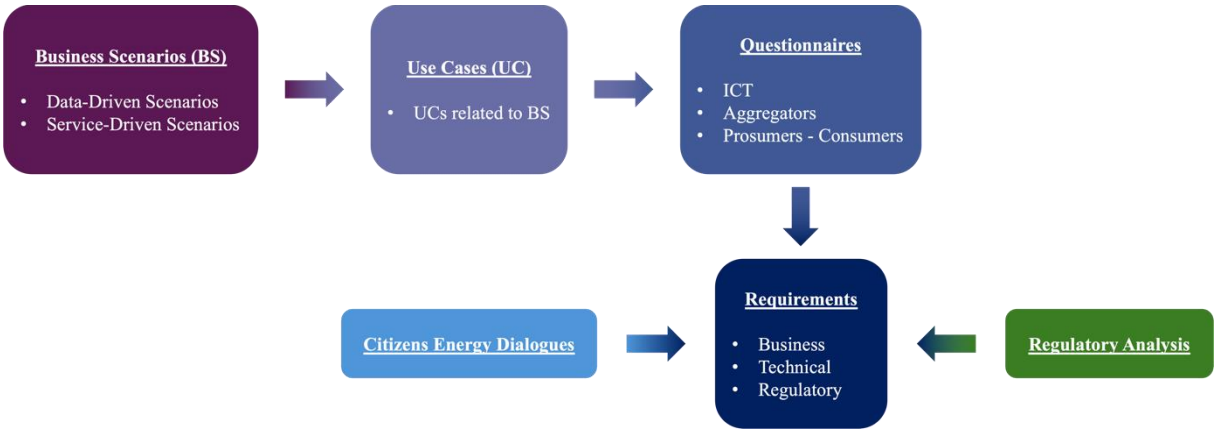

Figure 1: Methodology Framework of DIGITISE project.

The starting point for the work is the GA, and the specification of the main business principles. DIGITISE begins by identifying seven distinct business scenarios, considering the business priorities of the project, categorized as either data-driven or service-driven:

- Data-Driven Scenarios: These scenarios leverage advanced analytics, machine learning, and consumer data to enable proactive and automated participation in energy activities.
- Service-Driven Scenarios: These focus on creating cross-sector services that optimize energy efficiency, flexibility, and overall consumer satisfaction.

These scenarios are further described and elaborated through an analysis of current market challenges at EC level, regulatory trends, and technological innovations, ensuring relevance and adaptability. The elicitation of these business scenarios is considering also the list of business objectives at EC initiative (BRIDGE) to drive the business innovations of the project in line with the core objectives at EC level.

Following the methodological approach and to operationalize the business scenarios, the project defines comprehensive use cases, reflecting real-world applications and stakeholder interactions. These use cases aim to tackle the different business objectives defining the core technical principles towards:

- Ensuring interoperability between smart home devices, distributed energy resources (DERs), and flexibility markets.

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- Addressing the roles of prosumers, aggregators, and ICT providers in the energy ecosystem.
- Highlighting actionable steps for consumers to engage in data-driven and service-driven energy transitions.

as the three core priorities stated also in the GA.

Following the business scenarios and use cases definition, a fundamental aspect of the DIGITISE methodology and its user-centric design approach, is realized through an extensive stakeholder engagement process towards eliciting priorities over the different business objectives. The project has early identified the key energy/business stakeholders enrolled in project activities, namely:

- Residential and Commercial Building Occupants function as both consumers and prosumers within the energy network. Their energy consumption patterns, and demand response behaviours are critical for validating DIGITISE technologies.
- Energy Retailers/Energy communities acting also as Aggregators, leveraging DIGITISE to enhance service delivery through smart energy management and demand-response frameworks, enabling more dynamic, value-added services while strengthening customer engagement and market competitiveness.

In addition, considering the focus of the DIGITISE project on enrolling consumers in the data economy, relevant roles are considered, namely data providers—who supply, share, or generate data—and data consumers—who access, analyse, or utilize data for various applications and services.

To capture diverse perspectives, structured questionnaires are distributed to building occupants in both residential and commercial sectors, gathering insights into their preferences, perceived barriers, and expectations regarding participation in energy-related activities. Additionally, targeted focus groups are conducted with key business stakeholders, including energy retailers and aggregators to refine use case definitions and identify viable business opportunities. Also, considering the technical implementation of the project, a structured questionnaire for ICT services is conducted to get insights into the technical implementation of the project considering the experience in the field from business experts.

Beyond technical and business feasibility, the DIGITISE methodology integrates social and regulatory aspects into its design. Understanding behavioral drivers and societal acceptance is crucial for fostering user engagement and ensuring equitable access to energy-related initiatives. Similarly, regulatory frameworks play a significant role in shaping viable business models and ensuring compliance with policies governing energy markets, data privacy, and consumer protection. Therefore, and beyond the business orientation of the analysis, the engagement process includes consultations with the end users to define social aspects and principles that should be further considered as part of the project foundations. Moreover, regulatory aspects are reviewed to consider the development of the DIGITISE project in compliance with the very recent EC regulation.

The iterative feedback loop established through these activities (questionnaires, surveys and regulatory review) ensures that the DIGITISE framework effectively addresses the distinct needs of all stakeholders while maintaining a balance between technological feasibility, business viability, social acceptance, and regulatory compliance. The insights derived from this analysis are systematically translated into a structured set of requirements that form the foundation for the system architecture and implementation strategy. These requirements are categorized into three primary areas: business, technical and social, considering also regulatory aspects. Business requirements emphasize the business priorities of the energy actors but also consumers/prosumers enrolled in energy services. Regulatory requirements ensure compliance with EU energy directives, data governance policies such as GDPR, and national regulations governing energy markets. Social requirements target mainly consumer empowerment, accessibility, and the seamless adoption of digital energy solutions.

The final phase of the process will involve digitizing these requirements into actionable solutions that empower consumers and stakeholders to actively participate in the energy transition. This includes Interoperable Data Spaces ensure secure, GDPR-compliant data sharing for cross-sector integration and real-time analytics, Digital Twin Development, which simulates household-level energy systems to predict demand, optimize flexibility, and enable self-consumption strategies. AI-Driven Business applications leveraging algorithms to provide recommendations for energy savings, flexibility management, and green technology investments. The details of these structural elements will be presented as part of the architecture definition of the DIGITISE project in D2.2 as part of the work in T2.5.

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3 DIGITISE Business Scenarios and Use Cases Definition

This chapter presents the business perspective of the project as defined by its key stakeholders, establishing a structured foundation for the DIGITISE business framework. The discussion begins with a high-level definition of Business Scenarios (BS), which serves as the conceptual basis for designing and validating the project's business-driven approach. Following this, a detailed analysis of the DIGITISE use cases is conducted, with a focus on the essential system functionalities required for the final implementation.

The analysis is structured to ensure alignment with the core objectives outlined in the project's GA. Additionally, input from DIGITISE project partners, who bring expertise in the energy sector and digital transformation, informs the development of business scenarios. These insights are further refined through iterative consultations with demo partners, ensuring that the defined scenarios accurately reflect their business needs and operational feasibility. By integrating project goals with stakeholder-driven insights, this approach ensures a coherent and technically robust framework that supports the scalability and adoption of DIGITISE solutions within the evolving energy landscape.

3.1 DIGITISE Business Scenarios Definition

The DIGITISE project employs a structured framework for identifying and defining business scenarios that serve as the foundation for its technical and functional development. By leveraging insights from stakeholders and analyzing business domain dynamics, DIGITISE aligns its objectives with the needs of consumers, energy retailers, aggregators, and other key market actors. Once initial insights are gathered, the scenario refinement phase is conducted through an iterative process that incorporates focus group discussions. This iterative approach is also considering the business workflows definition to properly define the business interactions of the DIGITISE project.

Overall, the DIGITISE project identifies seven primary business scenarios, categorized into Data-Driven Scenarios and Service-Driven Scenarios to encapsulate real-world applications and business contexts, offering a roadmap for the project's innovative energy solutions.

Data-Driven Scenarios

Business Scenario Title	Energy Data Asset Stakeholders improve data availability by efficiently integrating and managing various distributed data assets in a seamless and interoperable manner
Business Scenario Description	Energy Data Asset Stakeholders are revolutionizing the way data is managed and shared within the energy sector. By efficiently integrating and managing various distributed data assets, they enhance data availability across the entire system. This seamless and interoperable approach ensures

	that data from different sources can be easily accessed and utilized, breaking down traditional silos and fostering a more collaborative environment. This not only improves operational efficiency but also supports better decision-making, driving innovation and growth within the industry. The adoption of such integrated data management practices allows stakeholders to maximize the value of their data assets. By ensuring that data is readily available and easily shared, stakeholders can quickly respond to changing market conditions, optimize resource allocation, and improve overall system performance. This streamlined approach to data management is critical for enabling advanced data driven insights, which can unlock new opportunities and drive the energy sector towards a more sustainable and efficient future.
Related Actors	All data asset owners/data providers

Table 1: DIGITISE Business Scenario 01

The high-level business scenario definition is further elaborated with the description of the different business details towards effective data handling and management within the DIGITISE project. This is achieved by configuring data gathering methods that manage the flow of data through a series of sequential steps, each addressing various aspects of data ingestion, mapping, curation, anonymization, access policies, storage, and cataloguing. These methods ensure that data is efficiently processed and prepared for integration into the DIGITISE data platform, maintaining high standards of data quality. As illustrated in the workflow, a data gathering process should include the following steps as listed above:

- Data Collection: The provider defines the data collection method, which can range from manual (e.g., file uploads) to automated methods (e.g., APIs, PubSub mechanisms). Configuration settings are required based on the chosen method to ensure proper storage and pipeline execution.
- Data Mapping: The system defines how dataset fields map to the DIGITISE common information model fields. The data provider can manually adjust mappings, add missing fields, and enrich the data.
- Data Curation: Data providers can define rules to address issues like missing or duplicate values, using techniques such as imputation. More advanced methods, like machine learning-based outlier detection, can also be considered.
- Data Anonymization: An optional step where the data provider selects anonymization techniques (e.g., k-anonymity, l-diversity, t-closeness).
- Data Policy: Data providers define access policies for dataset use and visibility during the configuration phase, with enforcement during execution to control who can access and use the data.
- Data Indexing: Metadata is provided for dataset profiling and searching, which includes static metadata (manually input by the provider) and dynamic metadata (calculated or requested for automated calculation).
- Data Storage: This definition influence pipeline execution and further the storage of the data.

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All in all, the data interoperability and governance require the execution of different steps to ensure a robust way for managing data, ensuring the integrity and usability of them within the DIGITISE platform. The visual representation of the overall journey is presented below.

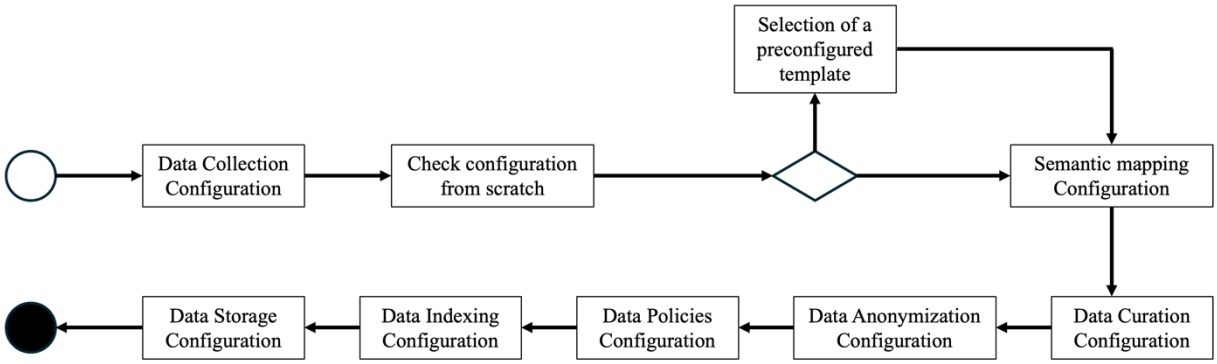

Figure 2: DATA INTEGRATION AND GOVERNANCE IN DIGITISE

Business Scenario Title	Energy Data Asset Stakeholders create new revenue opportunities by sharing and trading their data assets in a transparent, trustworthy, and legally binding way
Business Scenario Description	Energy Data Asset Stakeholders are pioneering new ways for revenue generation by sharing and trading their data assets with a focus on transparency, trust, and legal compliance. This approach ensures that all transactions are conducted in a clear and reliable manner, fostering confidence among participants and encouraging wider data exchange. By establishing a framework that guarantees legal integrity and mutual trust, stakeholders can effectively monetize their data, turning previously untapped information into valuable assets. This not only provides an additional revenue stream but also enhances the overall efficiency and competitiveness of the energy sector. The transparent and legally binding exchange of data assets opens a wealth of opportunities for innovation and collaboration. Stakeholders can leverage shared data to gain deeper insights, optimize operations, and develop new products and services. This data-driven approach enables more informed decision-making and strategic planning, helping companies stay ahead in a rapidly evolving market. By creating a trusted marketplace for data assets, Energy Data Asset Stakeholders are driving the sector towards greater integration, resilience, and profitability.
Related Actors	All data asset owners and recipients

Table 2: DIGITISE Business Scenario 02

The high-level business scenario definition is further elaborated with the description of the different business details towards effective data sharing and exploration within the DIGITISE project.

Starting with data sharing, in DIGITISE is facilitated through a Data Marketplace, which employs advanced search features to enable the visual exploration of data assets available across federated data spaces. Once data assets are discovered, a smart contract management process is initiated. The data recipient submits a request to the data provider, specifying the intended purpose and duration of data usage. Upon receiving the request, the data provider assesses it and, if they agree to share the data, prepares a draft contract (including predefined terms, along with optional custom conditions and details regarding reimbursement). If the provider declines to share the data, the request is rejected. The data recipient then reviews the draft contract. They can accept the terms, negotiate specific elements (such as payment or other conditions), or reject the contract. Once both parties agree to the terms, the data recipient fulfils the reimbursement terms, and the contract becomes active.

Next, the Data Exploration process is initiated to provide the selected data in the preferred format. Users select the dataset they wish to retrieve from the available datasets and configure specific fields as query parameters. The visual representation of the different steps of the respective business workflow is provided below. This workflow ensures that data sharing and retrieval within the DIGITISE platform are efficient, transparent, and compliant with the agreed-upon terms, with mechanisms in place for contract enforcement and revisions.

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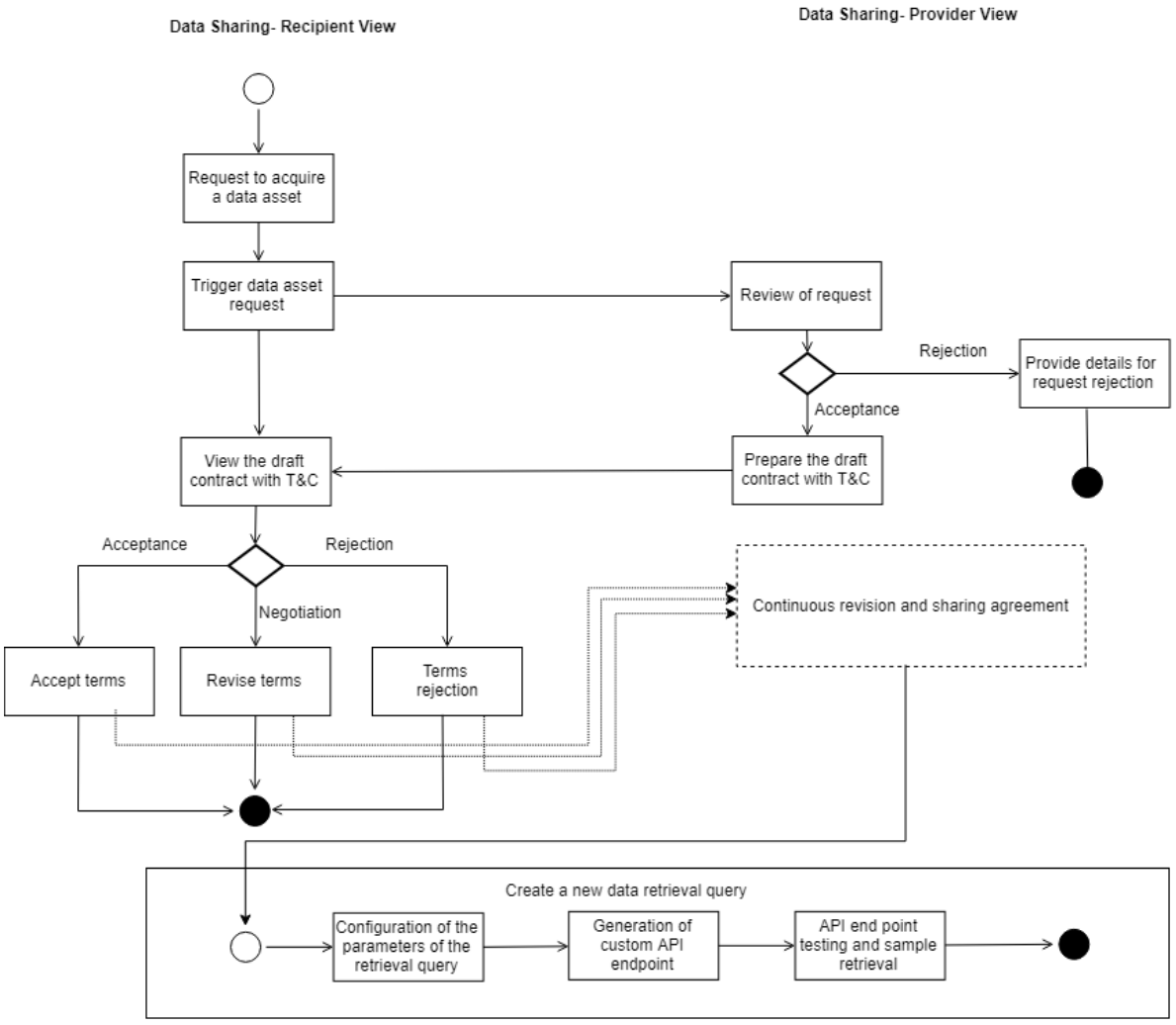

Figure 3: DATA SHARING AND EXPLORATION IN DIGITISE

Business Scenario Title	Energy Data Asset Stakeholders leverage AI-driven insights and knowledge unlocking the hidden value within their data
Business Scenario Description	Energy Data Asset Stakeholders are harnessing AI-driven insights and knowledge to unlock the hidden value within their data. By utilizing advanced AI technologies, they can analyse vast amounts of data more efficiently and accurately than ever before. This allows them to uncover patterns, trends, and opportunities that were previously inaccessible, transforming raw data into actionable intelligence. As a result, stakeholders can make more informed decisions, optimize operations, and enhance overall performance in the energy sector. The ability to extract deep insights from data through AI not only improves operational efficiency but also drives innovation. Stakeholders can develop new strategies, products, and services based on the newfound knowledge,

	gaining a competitive edge in the market. This AI-driven approach to data management and analysis enables Energy Data Asset Stakeholders to fully realize the potential of their data, creating significant value and fostering a culture of continuous improvement and growth within the industry.
Related Actors	All data asset owners and recipients

Table 3: DIGITISE Business Scenario 03

The high-level business scenario definition is further elaborated with the description of the different ways data recipients are enabled to produce valuable insights with the exploitation of data and AI analytics offered as part of the DIGITISE solution. As a first step after a successful data acquisition, a data asset can be loaded in an AI analytics pipeline. At this stage it is possible to add any steps for preprocessing the loaded data, like extracting time-related features, data resampling, aggregations, and more. After this step and the data preparation, a new AI model can be configured and trained and validated on selected data. The model can be then evaluated according to a set of defined metrics.

At a second step, when the user is satisfied with the model's performance, the trained model can be stored to be reused with actual data during the testing/ demonstration phase. After the application of the model on the data, the results can be stored for later use, retrieval or visualization. The details of the different business processes considered for the AI insights extraction are presented below.

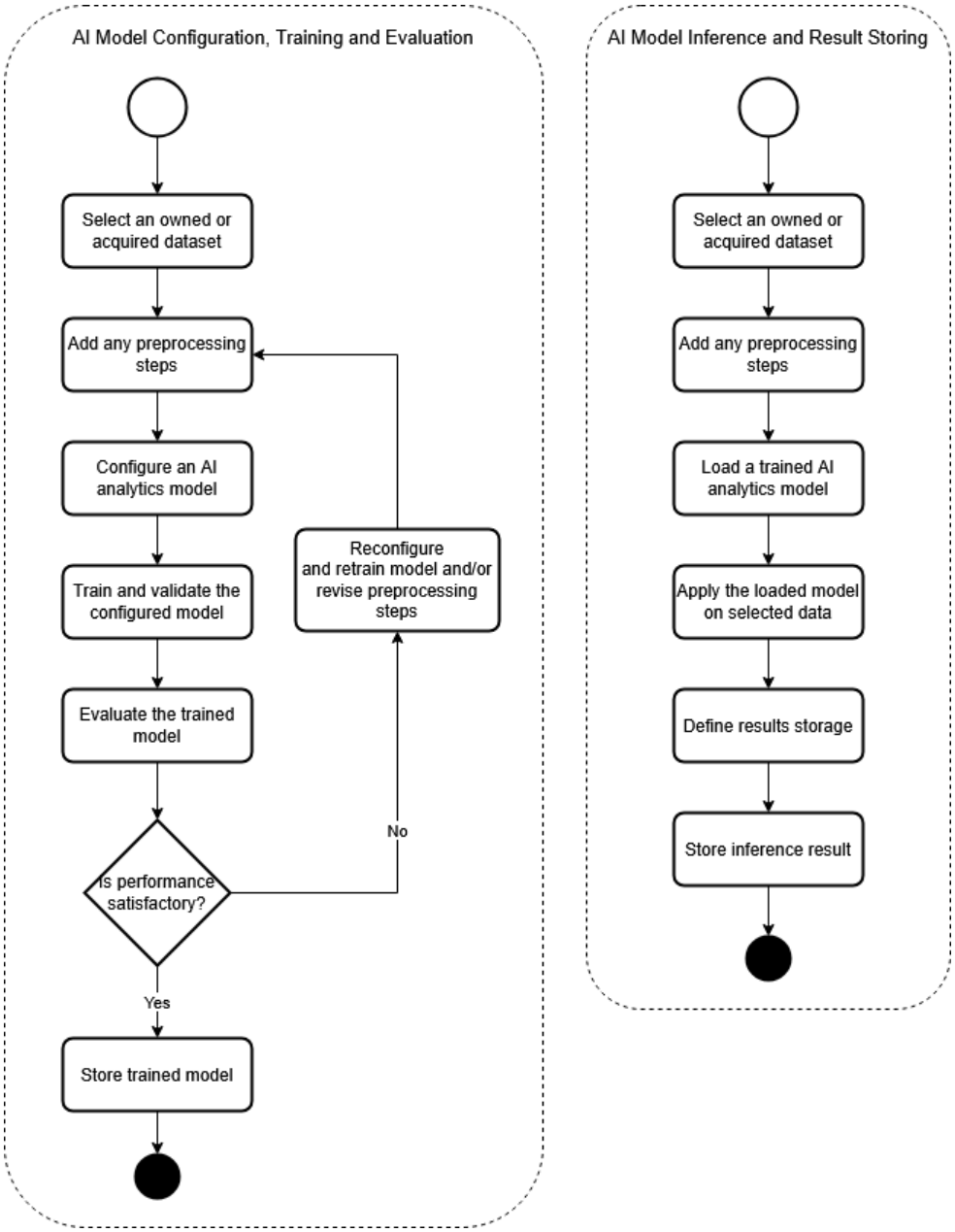

Figure 4: AI Insight extraction Process for Different Business Scenarios

We presented above the business objectives of the DIGITISE project, targeting mainly on the way data and derivative data are to be handled in the project. As stated above, the analysis of the different steps as part of the workflow's definition was performed after consultation with the technical and business partners of the project to detail from the very beginning the different processes to be considered in the project. The same analysis is performed towards the definition of the business objectives for the energy services offered to the business actors of the project below.

Service-Driven Business Scenarios

Business Scenario Title	Energy stakeholders improve their market position by adopting aggregator roles and generating new revenue streams through the implementation of Virtual Power Plant (VPP) strategies and flexibility solutions, utilizing smart contract-based flexibility transactions
Business Scenario Description	Retailers and Local Energy Communities (LECs) (i.e. Energy stakeholder actors) have obtained a new role in energy markets under the Aggregator model. They play a pivotal role in advancing consumer-centric energy transition and flexibility market design by facilitating active prosumer participation in energy activities and enabling better-decision making and the realization of significant benefits for them. To do so, energy stakeholders implement the Virtual Power Plant (VPP) approach to optimize strategies on demand, generation, storage, and Electric Vehicles (EVs). This approach supports ancillary and balancing services and builds on existing flexibility analytics to develop a module for managing flexibility profiles. The overall management of flexibility should be handled in structured and transparent way, facilitating the adoption of market-based principles among prosumers (As flexible asset owners) and aggregators.
Related Actors	Prosumers, Consumers and aggregators

Table 4: DIGITISE Business Scenario 04

The details of this business objective (energy retailers/community operators to enhance their market position by adopting the role of aggregators) are presented below.

As a starting point, aggregators require access to a wide pool of flexible resources (registered by prosumers) in a standardized manner. This necessitates the development of a marketplace environment where flexible asset negotiations can occur, following formalized rules, processes, and contractual parameters (such as bidding time intervals and market clearing models), along with the implementation of smart contracts. These contracts should address the needs of aggregators, and prosumers, covering aspects like contract duration, the number of DER activations, dispatch frequency, flexibility contributions, and compensation for participation in DR initiatives.

Once contracts are established and flexible assets are available within the aggregator's portfolio, aggregators must maintain a comprehensive understanding of their portfolio's performance to supply the necessary flexibility to upwards markets (mainly DSOs through provision of ancillary services). Providing these services without risking penalties depends on selecting operationally and contractually suitable flexibility sources to reliably meet upstream requests. However, challenges arise when control signals for certain loads are overridden, disrupting the balance of flexibility sources. Aggregators must adjust clusters in real-time to maintain the integrity of their VPPs. Advanced VPP tools in the DIGITISE project must enable continuous monitoring of assets performance to address unexpected

withdrawals during flexibility provision. The different business steps of the overall flexibility management at aggregator portfolio level are defined in the figure below.

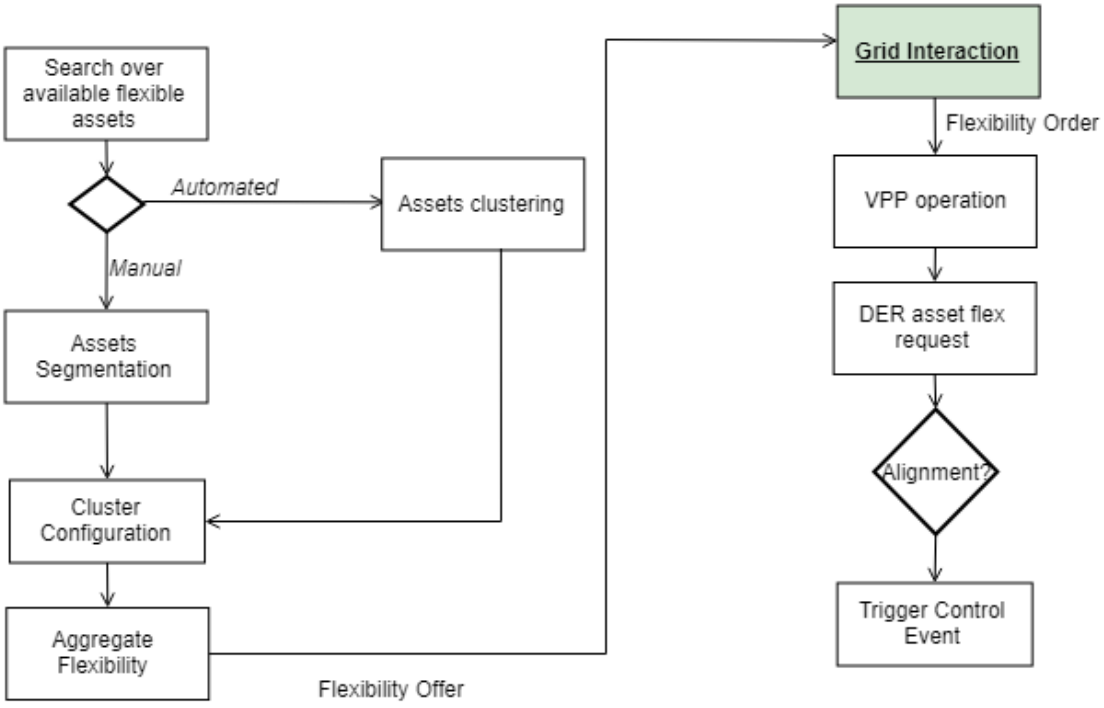

Figure 5: VPP approach to optimize strategies

After demand response campaigns are triggered and flexibility is delivered, it is crucial to verify the execution of smart contracts and ensure prosumers are compensated for their contributions. Flexibility events, such as activation or availability, offer prosumers the opportunity to monetize their flexibility services. Smart contracts automatically enforce the agreed-upon terms between prosumers and aggregators, ensuring compensation and maintaining trust in the settlement and remuneration process. These contracts empower both parties to monitor adherence to the contractual terms, increasing transparency and accountability. The overall business workflow covering the contract negotiation process (as described above) but also considering the settlement and negotiation is provided in the following figure.

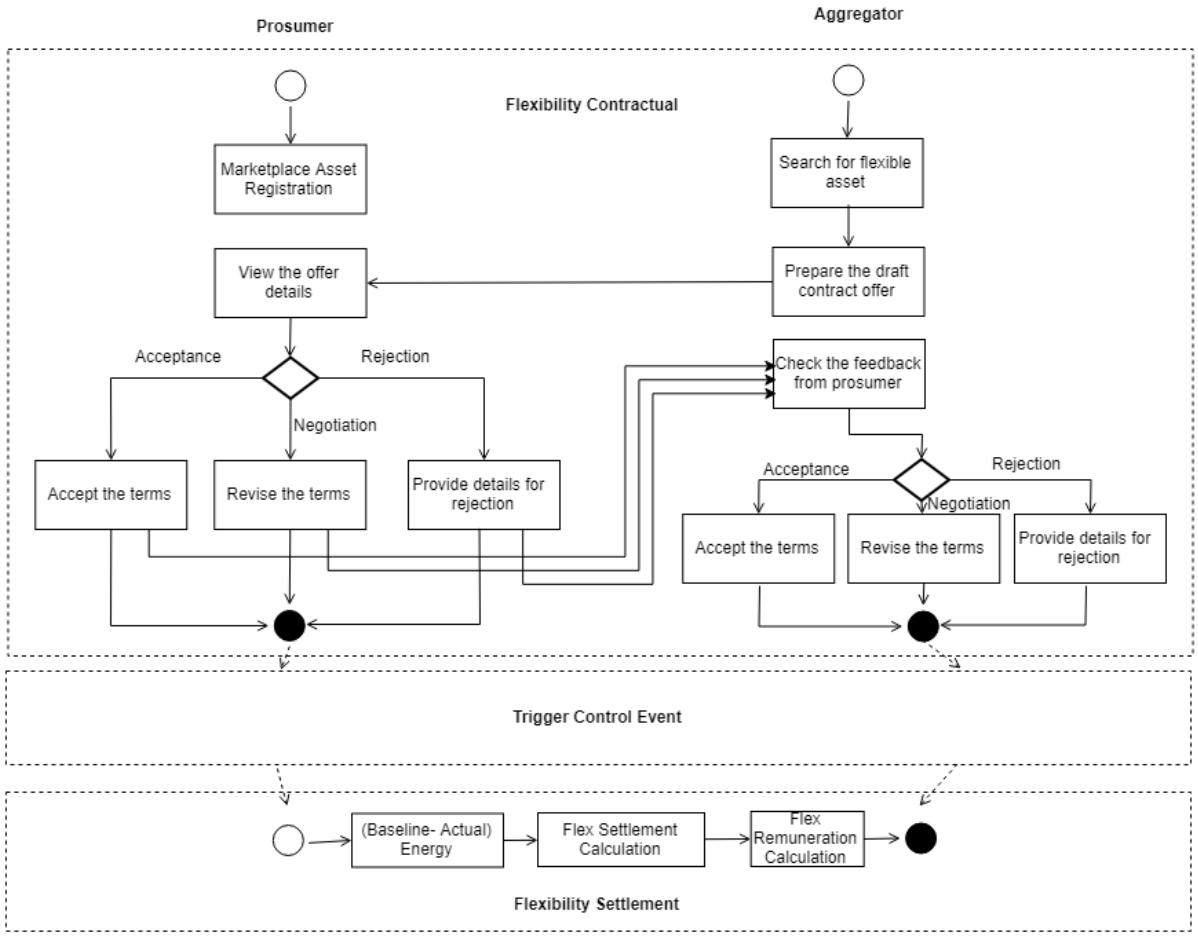

Figure 6: Business Workflow of the Flex Asset Contractual Process

Along with participating in demand response (DR) strategies as stated above, prosumers can achieve substantial energy cost savings and increased self-sufficiency by integrating secure, advanced energy management systems with smart home technologies. By leveraging artificial intelligence and machine learning, energy management systems can be configured to address different prosumers business objectives as listed below, relevant to the DIGITISE project activities.

Business Scenario Title	Prosumers achieve substantial energy cost savings and increased self-sufficiency
Business Scenario Description	Prosumers, or proactive consumers can realize substantial energy and cost savings while achieving self-consumption optimization by utilizing AI-driven strategies to optimize energy consumption patterns throughout their properties. These AI-driven strategies enable smarter energy management systems for prosumers by optimizing energy use across their assets through real-time data monitoring (e.g. metering systems, IoT devices, electric vehicles), considering not only streamlining energy utilization and enhancing self-sufficiency of prosumers, but also providing a user-friendly,

	non-intrusive service, fostering greater social acceptance of citizens. Overall, these innovations enable prosumers to achieve notable savings on their energy bills, contributing to a more sustainable and resilient energy system through self-consumption maximization.
Related Actors	Prosumers

Table 5: DIGITISE Business Scenario 05

Business Scenario Title	Prosumers make well-informed, data-driven investment decisions in green technology
Business Scenario Description	Utilization of green technology at the household level, including renovation, RES, storage, EVs and other flexible energy assets empower prosumers in making data-driven and cost-effective investment decisions. Investment on green technology along with long-term strategies covers not only guidance on financial investment optimization, but also data integration from various sources to assess the financial performance and enhance the attractiveness and financial viability of green investments for consumers and prosumers. Integration of cutting-edge technologies not only supports the transition towards a more sustainable energy system but also ensures that prosumers are at the forefront of this evolution, benefiting from increased transparency, efficiency, and participation in the energy market.
Related Actors	Prosumers

Table 6: DIGITISE Business Scenario 06

Business Scenario Title	Prosumers enjoy an enhanced home management experience through personalized non-energy services, further utilizing data to extract valuable behavioural insights
Business Scenario Description	Prosumers, or proactive consumers, experience a significantly enhanced home management environment through the integration of smart home automation technologies. These advanced systems enable personalized non-energy services, such as automated security, climate control, and comfort-based systems that respond to the preferences and routines of the household. By tailoring these services to individual needs, prosumers not only enjoy increased convenience and comfort but also benefit from more efficient and seamless home operations. Moreover, the data generated by smart home devices offers prosumers valuable insights into their daily behaviours and habits. This information can be analysed to optimize various aspects of home management and beyond. By leveraging these insights, prosumers can make more informed decisions,

	leading to a more efficient and cost-effective home environment. This dynamic use of data not only enhances the overall living experience but also contributes to the development of smarter, beyond energy services for prosumers.
Related Actors	Prosumers

Table 7: DIGITISE Business Scenario 07

As stated above on the description of the business scenarios targeting prosumers, prosumers can increase the level of self-consumption (reducing energy costs) (BSC_05) and make well-informed, data-driven investment decisions in green technology (BSC_06), optimizing the deployment and operation of renewable energy, storage, and EV assets. By analysing real-time and historical energy usage data, they can strategically allocate resources to maximize economic benefits while simultaneously enhancing their environmental impact and energy independence.

Beyond energy management, prosumers enjoy an enhanced home management experience by leveraging smart home automation for personalized non-energy services (BSC_07). By utilizing advanced data analytics, they can extract valuable behavioural insights, allowing for the customization of home environments based on individual preferences and habits. This extends beyond energy efficiency to improve overall quality of life, incorporating automation for security, comfort, and convenience. A visual overview of the prosumer business perspective is presented below.

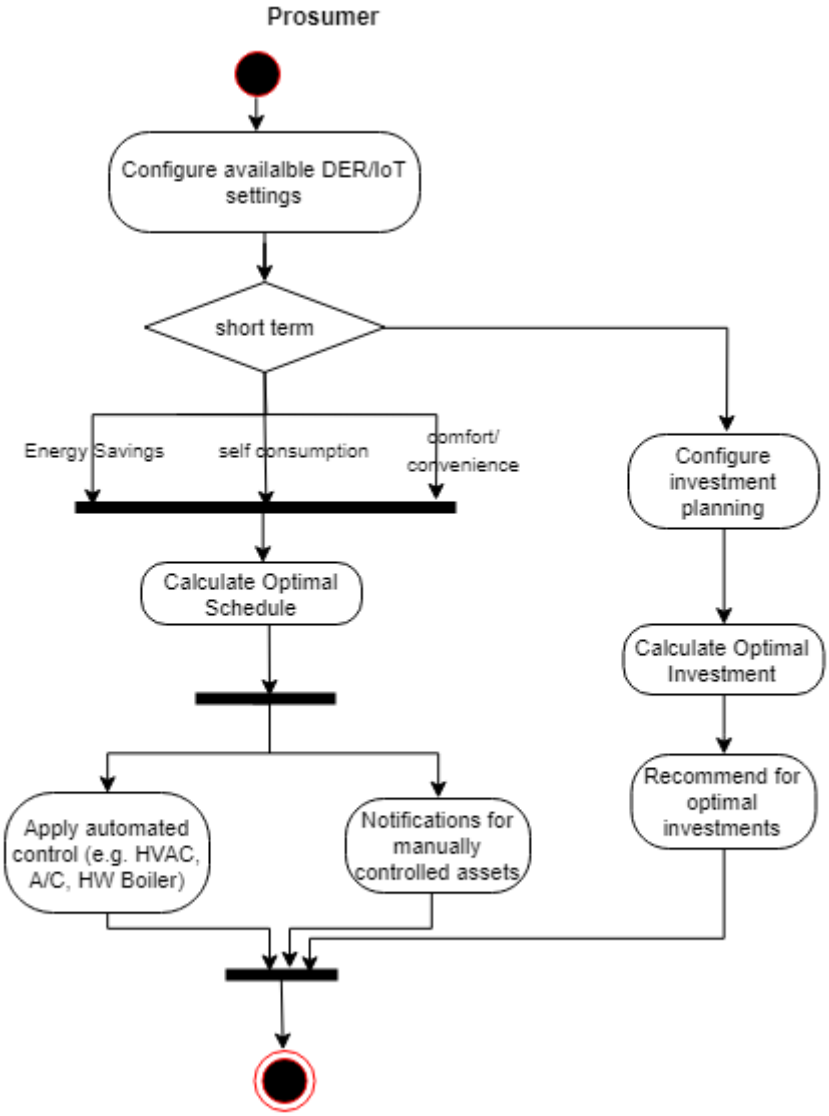

Figure 7: Consumer oriented Business Orientation (short term vs long term decision making)

We presented above the details of the business orientation of DIGITISE project. Following refinement, the business scenarios are systematically integrated with the project's use cases. This step involves translating high-level conceptual scenarios into specific, actionable use cases that serve as technical blueprints for system design and implementation in the next section.

3.2 DIGITISE Use Cases Definition

Following the establishment of business objectives and workflow structures within the DIGITISE project, the corresponding use cases have been identified to define the functional and operational requirements necessary to achieve these goals. These use cases encompass a range of engineering-driven implementations designed to enhance the efficiency, security, and scalability of digital energy systems.

- Robust data governance frameworks are integrated to support secure, data-driven services, empowering prosumers with data sovereignty while maintaining compliance with regulatory standards. Cross-domain interoperability is engineered to bridge energy and non-energy systems through standardized communication protocols and modular system architectures, enabling seamless integration across various digital platforms.
- Advanced AI analytics and human-centric automation are leveraged to enhance consumer participation, utilizing machine learning models for demand forecasting and decision support in energy consumption patterns.
- A key aspect of the methodology involves the integration of digital twin technology for household-level energy optimization, enabling real-time simulation and predictive control strategies to improve energy efficiency and load management. Finally, scalable digital tools are developed to consumer engagement in energy efficiency, self-consumption strategies, informed investment and facilitate access to flexibility markets.

The subsequent sections provide a detailed representation of these use cases, adhering to a standardized framework to maintain clarity, consistency, and technical precision in their documentation and implementation. A clear mapping to the project business objectives and scenarios is also provided.

3.2.1 Enhanced Data Governance and Handling Practices

Use Case Title	Enhanced Data Governance and Handling Practices
Use Case Description	This use case focuses on improving data governance and handling across the energy value chain. For data providers, it is crucial to have diverse and highly customizable methods that enable the integration of various data sources and the collection of data in different states. During the design phase, data providers should have access to a comprehensive range of data ingestion and harvesting methods to efficiently manage and collect data, whether it's through batch uploads, data gathered via third-party APIs, or streaming data through PubSub mechanisms. To simplify the overall ingestion process, providers should also have access to predefined ingestion and governance templates, including the harvesting of real-time data exposed via open-standard connectors. Moreover, data curation techniques as well as data characterization methods are considered to enhance the overall data governance and handling process.
Triggering Event	The increasing volume of energy (And beyond) data generated from smart meters, and distributed energy resources as well as external data sources to be utilized in the project
Preconditions	Data assets available from heterogeneous data sources

Postconditions	Data assets are adequately provisioned and ready for further processing according to the requirements/needs
Actors Involved	All data asset owners
Relevant Business Scenario	BSO1

Table 8: DIGITISE UC01 Description

3.2.2 Seamless Semantic Data Mapping and Harmonization

Use Case Title	Seamless Semantic Data Mapping and Harmonization
Use Case Description	The primary goal of this use case is to enable the seamless semantic mapping and harmonization of heterogeneous energy data sources into a common information model (CIM). This ensures interoperability, consistency, and enhanced data usability across different energy systems, platforms, and stakeholders. Towards this direction, the definition of the DIGITISE information model that considers different energy related data models, schemas, and ontologies concepts to enhance overall semantic interoperability in the project is a major step for seamless mapping and data harmonization.
Triggering Event	Physical asset available and initiation of the data ingestion process
Preconditions	Physical asset availability and connectivity
Postconditions	Data assets are adequately provisioned and ready for further processing according to the requirements/needs
Actors Involved	All data asset owners
Relevant Business Scenario	BSO1

Table 9: DIGITISE UC02 Description

3.2.3 Peer-to-peer data assets sharing and trading through a smart data contract management environment

Use Case Title	Peer-to-peer data assets sharing and trading through a smart data contract management environment
Use Case Description	This use case focuses on enabling a decentralized framework for data sharing and trading in the energy sector using smart data contracts. The smart contract management environment will allow data asset owners, such as energy producers, consumers, and third-party providers, to securely share, trade, and manage DIGITISE-related data in a transparent and automated manner. Smart contracts will govern data access and exchanges based on predefined conditions, enhancing trust, efficiency, and security in data transactions.

Triggering Event	The need for secure and transparent data sharing, driven by the growing interest of data economy through data exchanges, necessitates the implementation of a smart contract-based management environment
Preconditions	• Data made available in the data management environment and available for sharing/exchange • Smart data contract templates defined
Postconditions	• A fully operational data trading system where smart contracts autonomously govern transactions. • Enhanced transparency, security, and efficiency in data exchange processes. • Increased trust among data owners and recipients
Actors Involved	All data asset owners and recipients
Relevant Business Scenario	BSO2

Table 10: DIGITISE UC03 Description

3.2.4 End-to-end data security safeguarding and privacy preservation

Use Case Title	End-to-end data security safeguarding and privacy preservation
Use Case Description	This use case focuses on implementing comprehensive security measures to protect data throughout its lifecycle, from collection and transmission to storage and processing. The goal is to ensure that all data processes are secure, preventing unauthorized access or breaches. Privacy preservation mechanisms will also be integrated to safeguard sensitive information, ensuring compliance with GDPR and other relevant regulations. This use case will develop protocols for authentication, and data anonymization, ensuring that data is both protected and accessible only to authorized entities, supporting secure digital transformation within the energy sector.
Triggering Event	The growing digitalization of the energy sector, combined with increasing cybersecurity threats and strict data protection
Preconditions	Data assets made available in the DIGITISE data management environment
Postconditions	Secure, end-to-end data flows with privacy and access control mechanisms implemented.
Actors Involved	All data asset owners
Relevant Business Scenario	BSO2

Table 11: DIGITISE UC04 Description

3.2.5 Tailored AI-driven insights and analytics that provide individuals with personalized insights

Use Case Title	Tailored AI-driven insights and analytics that provide individuals with personalized insights
Use Case Description	As energy consumers increasingly seek more control and understanding of their energy consumption, personalized insights become essential for informed decision-making. This use case delivers highly customized insights into individual energy behaviors through Tailored AI-driven analytics. By harnessing real-time energy data from smart meters, IoT devices, and non-energy data (such as occupancy parameters, ambient conditions, control actions performed overheating and colling loads) that are used for the AI models and algorithms training, personal insights are provided to help individuals better comprehend their energy usage patterns and broader lifestyle impacts. These AI models will be tailored to address aspects related to energy behavior, personal comfort preferences, and analyze occupancy profiling patterns to generate personalized reports, that will empower users to make better decisions regarding energy consumption, optimize their comfort settings, and receive recommendations for health and security improvements based on household data (non-energy sectors). The results will be provided to all the relevant digital services and applications.
Triggering Event	The demand for personalized AI-driven insights that help consumers understand their energy usage patterns, and provision of non-energy added value services
Preconditions	• Availability of household data from IoT sensors, smart meters, and consumer devices • Secure and efficient data sharing and processing • AI tools configured to analyze energy behavior, occupancy, and comfort profiles across time and contexts
Postconditions	• Consumers receive tailored recommendations to optimize energy usage and enhance comfort and well-being • The results of AI personal analytics are made available as inputs to the different DIGITISE components (e.g. Digital Twin)
Actors Involved	All data asset owners and recipients
Relevant Business Scenario	BS03

Table 12: DIGITISE UC05 Description

3.2.6 Advanced AI-powered tools and models designed to analyze energy related aspects

Use Case Title	Advanced AI-powered tools and models designed to analyze energy related aspects
Use Case Description	As energy consumption becomes increasingly complex and production volatile, stakeholders require sophisticated analytical tools to navigate this landscape effectively. This use case is focused on Energy AI Analytics, which are designed to process data on energy consumption, generation, and flexibility. The developed AI models will analyze energy data to perform complex tasks such as demand and generation profiling, demand and generation short-term forecasting (hour to day-ahead). Moreover, context-aware flexibility profiling and forecasting will be performed at consumer level devices and DERs, leveraging the results of personalized AI analytics for more concrete and accurate results. These tools will handle the dynamic nature of consumer energy behavior and provide a realistic baseline for energy exchanges and flexibility transactions. Multiple implementations of these AI components will be delivered to ensure adaptability to diverse data types, levels of detail, spatial considerations, timeframes, versatile data assets, and specific business and market requirements. Furthermore, the explainable AI features embedded in the analytics will ensure transparency, increasing the trust between consumers, prosumers, and market participants.
Triggering Event	The need for AI-driven tools to enhance energy forecasting, flexibility profiling, and support transparency in energy markets
Preconditions	• Access to comprehensive energy and environmental data from smart meters, IoT devices, household energy systems and DERs • AI pipelines configured to process and analyze real-time and historical energy data • Availability of AI personal analytics' outcomes
Postconditions	• Improved energy management through demand and generation forecasting • Enhanced prosumer engagement and trust in energy markets due to explainable AI analytics
Actors Involved	All data asset owners and recipients
Relevant Business Scenario	BS03

Table 13: DIGITISE UC06 Description

3.2.7 Aggregator Portfolio Management for enhanced flexibility provision

Use Case Title	Aggregator Portfolio Management for enhanced flexibility provision
Use Case Description	This use case focuses on enabling aggregators to manage their energy portfolios more effectively to enhance the provision of flexibility services to the grid. Aggregators, which pool together various small-scale energy producers, consumers, and prosumers, play a crucial role in providing demand response and balancing services. The use case aims to develop a system that allows aggregators to optimize their portfolio management by forecasting flexibility, scheduling distributed energy resources, and participating in flexibility markets. This enhanced management capability will allow aggregators to respond to grid needs more efficiently, ensure system reliability, and maximize the value of flexibility services provided to grid operators.
Triggering Event	The growing need for flexibility in energy systems, driven by increasing renewable energy penetration and the shift toward decentralized energy production, necessitates improved aggregator portfolio management to maintain grid stability
Preconditions	• Aggregators must have access to real-time data on energy consumption, production with focus on flexible assets • Availability of flexibility services at DSO side to further enable exploitation of the available flexibility at portfolio level
Postconditions	• Aggregators have improved capabilities to manage and optimize their portfolios, providing more efficient flexibility services • Enhanced participation in flexibility markets, with better alignment between supply and demand
Actors Involved	Aggregators
Relevant Business Scenario	BS04

Table 14: DIGITISE UC07 Description

3.2.8 Flexibility Marketplace operation for enhancing prosumers enrolment in energy markets

Use Case Title	Flexibility Marketplace operation for enhancing prosumers enrolment in energy markets
Use Case Description	This use case focuses on the development and operation of the DIGITISE Flexibility Marketplace, designed to facilitate

	prosumer participation in flexibility transactions with aggregators or retailers/communities (LECs-Local Energy Communities) with aggregator role. The marketplace enables prosumers to monetize their flexibility by engaging in market transactions, leveraging the capacity of their flexible assets, such as energy storage systems or electric vehicles (EVs). Smart contracts along with distributed ledger technologies (DLTs) ensure transparent and secure settlement of flexibility transactions, automatically managing the verification of flexibility delivered in response to grid demands. Flexibility assessment will be performed based on the DIGITISE AI analytics. These analytics provide precise baselining of demand, generation, and flexibility, establishing the reference point that determines the remuneration and validation of flexibility transactions, ensuring fair and accurate compensation based on the prosumer's actual contributions. Tailored user interfaces allow both prosumers and aggregators to monitor and assess the performance of flexibility contracts, optimizing engagement and maximizing the benefits of participating in the flexibility marketplace. Through this marketplace, prosumers can gain greater control over their energy usage, enhance energy independence, and realize financial returns on their flexible assets.
Triggering Event	A demand signal from aggregators or retailers requesting flexibility to balance grid loads or provide ancillary services, or a prosumer's decision to offer their flexibility to the market for monetization
Preconditions	• Prosumers have flexible assets (e.g., DERs, storage systems, or EVs) that can be integrated into the marketplace and participate to the transactions • Aggregators/LECs have the necessary systems and infrastructure to manage flexibility portfolios • AI-enabled analytics for baseline and flexibility forecasting are operational to support market transactions.
Postconditions	• Prosumers are compensated for providing flexibility to the grid, through the flexibility marketplace • Aggregators optimize their flexibility portfolios and meet grid balancing requirements • Smart contracts ensure transparent and secure transaction settlement between prosumers and market operators • Increased prosumer engagement in flexibility marketplaces and enhanced participation • Negotiation and customization mechanisms for contract settlement processes.
Actors Involved	Aggregators, LECs, retailers, consumers, prosumers

Funded by the European Union

Relevant Business Scenario	BS04

Table 15: DIGITISE UC08 Description

3.2.9 Innovative approaches and tools aimed at reducing energy consumption

Use Case Title	Innovative approaches and tools aimed at reducing energy consumption
Use Case Description	This use case explores how businesses and individuals can leverage innovative technologies, tools, and methods to reduce energy consumption and promote sustainability. The focus is on solutions such as smart energy management systems, IoT-enabled devices, AI-driven energy optimization, and renewable energy sources integration. By using these tools, organizations and households can monitor, analyse, and optimize their energy usage, leading to cost savings, reduced carbon footprints, and better alignment with environmental regulations. The use case also includes predictive analytics for energy demand and supply, integration of renewable energy, and the ability to adapt energy consumption dynamically based on real-time data.
Triggering Event	Implementation of a sustainability initiative or the adoption of energy efficiency regulations by an organization or government. Additionally, rising energy costs or increasing carbon emissions, which would drive the need for AI-driven energy optimization and predictive analytics to lower operational expenses and meet environmental standards
Preconditions	• Availability of energy consumption data from prosumers • Access to tools or platform capable of managing, analysing and optimizing energy consumption data • Integration of renewable energy sources or potential for it within the system
Postconditions	• Optimized energy usage • Cost savings • Improve energy forecasting
Actors Involved	Prosumers
Relevant Business Scenario	BS05

Table 16: DIGITISE UC09 Description

3.2.10 Optimized Self-Consumption for Enhancing Energy Efficiency

Use Case Title	Optimized Self-Consumption for Enhanced Energy Efficiency
Use Case Description	This use case focuses on leveraging optimization strategies to maximize the utilization of self-generated energy in prosumer households, taking advantage of available assets, i.e., consumption and production profiles, storage/shifting, flexibility profiles, and application of AI energy forecasts. By integrating real-time data from various energy assets such as metering systems, IoT devices, and electric vehicles, the system continuously optimizes energy consumption patterns to prioritize self-consumption. This approach not only minimizes dependency on external energy sources but also lowers energy costs and enhances overall efficiency. Through automated control strategies and continuous performance assessments, the solution ensures that energy is utilized in the most cost-effective and sustainable manner, contributing to a resilient and user-friendly energy management system.
Triggering Event	Triggering events include peaks in energy demand, availability of new real-time data from energy assets, fluctuations in energy prices, changes in user behaviour, and thresholds reached in battery storage levels. Additionally, events such as maintenance alerts, weather forecast updates, excess energy production, and user-defined schedules prompt the system to adjust energy management strategies, ensuring optimal self-consumption and efficiency in response to dynamic conditions
Preconditions	• Favourable Legal framework/market • Monitoring of consumption and energy generation
Postconditions	• Optimized costs of energy • Reduced external dependencies of energy supply • Decarbonization of thermal demand through electrification
Actors Involved	Prosumers
Relevant Business Scenario	BS05

Table 17: DIGITISE UC10 Description

3.2.11 Enhanced Energy Management through Household Digital Twin

Use Case Title	Enhanced Energy Management through Household Digital Twin
Use Case Description	This use case focuses on the creation of a comprehensive digital representation of household energy systems, enabling

	real-time monitoring, optimization, and management of energy consumption, generation, and storage assets. The Household Digital Twin, an open-source implementation, will be key to optimizing data-driven services and improving consumer energy literacy. By integrating real-time data from meters, sub-meters, IoT devices, generation systems, and storage assets, the Digital Twin will offer detailed insights into the performance of household assets, allowing for human-centric control and decision-making strategies. The Digital Twin will facilitate several essential functions, including (i) real-time monitoring and assessment of energy assets and building systems, (ii) the definition of optimal human-centric context-aware control strategies for energy consumption and generation, and (iii) continuous evaluation and re-optimization of household energy performance to maximize self-consumption and reduce energy costs. AI-driven baseline analytics will be used to ensure that management strategies align with the business objectives and preferences of consumers, further empowering them to make data-driven, informed decisions.
Triggering Event	The need for prosumers to optimize energy management at the household level, maximizing self-consumption and reducing energy costs through real-time asset monitoring and intelligent control strategies.
Preconditions	• Access to real-time data from household energy assets (metering, sub-metering, IoT devices, renewable energy systems, energy storage and EV charging information) • AI-driven analytics for household energy baselining and performance assessment.
Postconditions	• Real-time performance monitoring of household assets enables consumers to make informed decisions about energy usage • Consumers experience optimized energy consumption, increased self-consumption of renewable energy, and reduced energy costs • Up-to-date Digital Twin simulations based on real-time data and AI-driven analytics, assessing the effectiveness of applied household energy management strategies • Enhanced energy literacy among consumers, promoting more active involvement in managing energy resources.
Actors Involved	• Prosumers/ aggregators • Data recipients
Relevant Business Scenario	BS05, BS06, BS07

Table 18: DIGITISE UC11 Description

3.2.12 Tailored solutions designed to accurately assess and recommend optimal asset size for consumers

Use Case Title	Tailored solutions designed to accurately assess and recommend optimal asset sizes for consumers
Use Case Description	This use case aims to guide consumers in enhancing their involvement in energy activities and their role in the energy transition, through the formulation of future scenarios that involve investments in Renewable Energy Sources (RES), renovation, storage and EV assets. Also, part of this use case is a direct link to retail stores where prices for home appliances can be retrieved to calculate the appropriate economic ROI and recommend the best energy efficient solutions for consumers.
Triggering Event	Possible improvement in energy management at the household level, by purchasing RES assets.
Preconditions	• Monitoring of possible RES assets, which could be applied to the household • Analysis of the status of each household • Availability of financial parameters for ROI estimation of such assets
Postconditions	• Technical assessment of RES and other assets to improve the energy management of the household • Analyze different vendors to maximize ROI for household
Actors Involved	• Prosumers
Relevant Business Scenario	BS06

Table 19: DIGITISE UC12 Description

3.2.13 Integrated Health and Security Monitoring Solution

Use Case Title	Integrated Health and Security Monitoring Solution
Use Case Description	This use case explores the utility prosumers gain from incorporating smart automation technologies into their household. The focus is on designing and implementing a framework that supports personalized predictions regarding the health and security of prosumers via analysing data from both energy and non-energy services. This way, prosumers can make informed decisions that will enhance the health and security of their household individually. Apart from the decision, informed insights to be provided to enhance consumers understanding about non energy aspects in a smart home environment.

Triggering Event	Consumers interest about enhancement of security and establishment of a healthy, comfort and convenient environment
Preconditions	• Availability of data from IoT devices in the building context • Availability of health conditions standards and personalized preferences • Availability of quantifiable security aspects of prosumers
Postconditions	• Extract insights about non-energy conditions (comfort etc.) • Assurance of comfortable and healthy environments • Enhancing security aspects
Actors Involved	Consumers, prosumers
Relevant Business Scenario	BS07

Table 20: DIGITISE UC13 Description

3.2.14 Providing actionable insights for personalized experiences, targeted interventions, and improved user engagement

Use Case Title	Providing actionable insights for personalized experiences, targeted interventions, and improved user engagement
Use Case Description	This use case offers prosumers recommendations regarding the bettering of their behaviour profiles. It focuses on designing and implementing automated tools that are based on the current profile of the prosumer and the potential actions she can take to improve not only her energy literacy and awareness, but also her overall living conditions. This recommendation system is made available through an application UI that is easy-to-use and provides the prosumer with analytics regarding the data collected via the household's smart appliances.
Triggering Event	Consumers interest about insights from behavioural and operational patterns as well as the performance of the different services
Preconditions	• Available AI-driven (and personalized) insights and analytics for prosumers • Available accurate assessments and recommendations for household energy and non-energy services
Postconditions	• Providing a user-friendly interface for prosumers to interact with their household smart applications • Implementing a recommender system for prosumers targeting energy and non-energy services as well as investment decisions • Instantiating a unified view of prosumer profiles across devices

Actors Involved	Prosumers
Relevant Business Scenario	BS07

Table 21: DIGITISE UC14 Description

We provided above the list of use cases of the DIGITISE project, providing (in a structured manner and following the template adopted in BRIDGE DM WG – use cases subgroup) a technical perspective of the different business objectives as defined in DIGITISE. As a next step and considering the principles defined through the use cases documentation, the questionnaires and group discussions were organized to delve into the details of the design principles to be considered in the project. The details of the next steps of the methodology are presented in the following sections.

4 DIGITISE End Users Feedback

4.1 Methodological Framework and Questionnaires

The DIGITISE project employed questionnaires as key tools to gather valuable insights from stakeholders, ensuring that the developed solutions (in line with the definition of the use cases as presented above) aligned closely with their needs, expectations, and challenges. The primary objective of this methodology was to involve diverse stakeholder groups—such as residential and commercial consumers, aggregators, and ICT professionals—to inform the project's design towards the adaptation of the use cases to the different technical solutions to be considered in the DIGITISE project.

The data collection process involved three questionnaires targeting Prosumers-Consumers, Aggregators, and ICT partners (as presented in Annex I). These questionnaires were designed to capture both quantitative and qualitative data. A combination of Likert scales and open-ended questions allowed for the collection of measurable responses while providing participants with the opportunity to elaborate on their views.

The surveys were distributed digitally, maximizing outreach and ensuring a broad response base. The EU Survey tool was used to create and distribute questionnaires to the DIGITISE partners. In total, we received 27 responses from ICT partners, 20 from Aggregators, and 109 from Prosumers-Consumers; the enrolment of citizens and business stakeholders was performed in full compliance with the engagement methodology as defined in WP7/T7.1.

The methodology involved two rounds of questionnaire circulation to better assess the enrollment and commitment of DIGITISE partners. Once collected, the data underwent analysis, as presented in section 4.2. The quantitative responses were examined to identify the necessary requirements for defining the use cases within the DIGITISE project.

In summary, the use of questionnaires provided the DIGITISE project with a robust foundation for designing solutions that resonate with stakeholders' needs. This methodology not only enhanced the project's understanding of business requirements but also ensured that the developed solutions would support a more inclusive and effective energy transition.

4.2 Questionnaires Reports

4.2.1 ICT Questionnaire Report

This analysis presents insights from the ICT questionnaire, focusing on organizational priorities, challenges, and strategies as reflected in the responses. It highlights the importance of structured data collection, effective governance mechanisms, interoperability, and the applications of Digital Twin technologies in defining the needs and requirements of the DIGITISE project.

The key findings of the survey are outlined below.

- Regarding Data Collection and Standards, structured data collection emerged as a critical priority, with half of the respondents considering it of utmost importance, while 29.63% rated it as important. Sensor data was the most frequently collected type at 87.5%, followed by usage metrics at 50% and location data at 25%. Proprietary standards were used by 29.17% of organizations, while 45.83% relied on Modbus for PV-related data, 33.33% on OData, and a notable 54.17% utilized other standards. These findings emphasize the need for comprehensive and diverse data acquisition strategies.
- In the field of Governance and Integration, respondents highlighted the importance of governance mechanisms, challenges in data collection, and the need for flexible data management methods. Governance mechanisms for handling diverse data sources were deemed important by 62.5% of respondents. Key challenges included interoperability, identified by 66.67%, followed by data integration across sources at 45.83% and real-time processing at 37.5%. Additionally, 79.17% of respondents emphasized the importance of supporting both batch uploads and real-time streaming to accommodate various operational demands.
- Regarding Data Marketplaces and Data Sharing, enhancing industry collaboration was identified as the primary objective by 62.5% of participants, followed by accessing external datasets at 45.83%. Monetizing data assets was a lesser priority at 25%, while 70.83% of respondents valued easy-to-use data search and exploration tools. Barriers to marketplace participation included the complexity of data integration (54.17%) and security concerns (50%), highlighting the need for streamlined and secure data-sharing frameworks. Governance priorities, particularly effective access control measures to protect privacy, were rated as highly important by 91.67% of respondents.
- Digital Twin Applications were primarily focused on real-time energy consumption data, prioritized by 79.17%, followed by energy generation data at 58.33%. Data interoperability was a key challenge for 58.33% of respondents, alongside high implementation costs noted by 54.17%. The primary goals of Digital Twin applications included reducing energy costs (66.67%), enhancing comfort and convenience (37.5%), and maximizing renewable self-consumption (33.33%). These findings highlight the potential of Digital Twin technology in optimizing energy management.

The results of the questionnaire reflect a strong commitment to advancing energy management and data governance through structured practices and technological integration. Key challenges such as interoperability, data quality, and security concerns indicate areas that require targeted solutions. The findings emphasize the need for collaborative efforts, standardized approaches, and transparent practices to overcome barriers and drive innovation in energy and data systems. The corresponding technical requirements derived from this analysis are presented in the following sections of the document.

4.2.2 Aggregators Questionnaire Report

The Aggregators Questionnaire provides a comprehensive understanding of the priorities, challenges, and strategies of energy aggregators participating in the DIGITISE project. The

responses emphasize the critical role of aggregators in facilitating energy flexibility and engaging customers in energy management programs. The findings highlight significant opportunities for innovation, such as real-time DR and flexibility marketplaces, while also identifying key barriers, including regulatory and technical constraints.

The key findings of the survey are outlined below.

- Aggregators involved in the DIGITISE project operate across diverse roles, with 68.42% of respondents engaged in technical responsibilities and 36.84% contributing to business and research activities. Their operations span multiple sectors, with 42.11% serving residential and commercial customers each, while 36.84% cater to industrial clients. Additionally, 47.37% of aggregators manage mixed portfolios, demonstrating their adaptability to different customer needs. The range of portfolio sizes is evenly distributed, with 21.05% managing fewer than 500 customers and 21.05% serving more than 10,000 customers, reflecting the varying scales of aggregation services.
- Energy usage monitoring is the most widely provided service, offered by 94.74% of respondents, underscoring the emphasis on delivering actionable insights to customers. Other key priorities include demand forecasting (89.47%), flexibility forecasting (68.42%), load prediction (63.16%), and consumption pattern analysis (57.89%), demonstrating the increasing reliance on data analytics for improving energy management. However, despite these advancements, only 31.58% of aggregators currently have automated systems for monitoring flexibility contributions, indicating a need for further development in this area.
- Demand-side management is the most significant source of energy flexibility, cited by 84.21% of respondents, with generation and storage assets each contributing 31.58%. Aggregators primarily classify flexibility profiles based on customer type (73.68%), while 52.63% prioritize customers by energy usage intensity. These classifications help aggregators efficiently allocate resources and meet specific flexibility needs across their portfolios.
- Despite the potential benefits of flexibility programs, regulatory barriers remain a significant challenge, with 78.95% of respondents identifying them as a primary obstacle. Additionally, 73.68% cited technical challenges, including interoperability and data management, as major concerns. Other hurdles include financial constraints (42.11%) and limited customer engagement (31.58%), which further complicate the widespread adoption of flexibility solutions. Nevertheless, aggregators remain optimistic, with 52.63% expressing strong interest in participating in a real-time flexibility marketplace for energy transactions.
- Data security and privacy are also critical concerns, with 73.69% of respondents expressing some level of apprehension regarding data sharing in contract negotiations. One potential solution is the implementation of standardized smart contracts, which 57.89% of participants believe would significantly simplify energy flexibility transactions. These findings underscore the need for strong data governance and security frameworks to build trust and encourage broader participation in energy flexibility markets.
- Customer engagement remains a key focus area, with 73.68% of aggregators providing personalized recommendations based on customer energy usage patterns. Furthermore, 84.21% of respondents are keen on offering insights that

compare customers' energy performance against peers or historical consumption trends. Real-time feedback on energy consumption, along with actionable recommendations, is highly valued, with 84.21% of aggregators seeing it to improve customer satisfaction and encourage greater participation in energy programs.

The results of the Aggregators Questionnaire highlight the essential role that aggregators play in advancing the energy transition. While structured data analytics and customer engagement initiatives offer significant opportunities, challenges such as regulatory constraints, interoperability issues, and data security concerns must be addressed. The DIGITISE project can support innovation in this space by enabling real-time marketplaces, standardized smart contracts, and enhanced data governance frameworks. By tackling these challenges, the project can empower aggregators to optimize energy flexibility, improve customer experiences, and drive the broader adoption of sustainable energy solutions.

4.2.3 Prosumers - Consumers Questionnaire Report

The Prosumers-Consumers Questionnaire examines the priorities, behaviours, and technical challenges faced by individuals adopting smart energy technologies within the DIGITISE project. The findings highlight significant interest in optimizing energy consumption, increasing system efficiency, and integrating advanced control mechanisms to enhance energy management. While economic benefits and environmental sustainability are key drivers, technical challenges such as data security, system interoperability, and operational complexity indicate the need for robust, transparent, and user-friendly infrastructures.

The key findings of the survey are outlined below.

- Consumers demonstrate varying levels of familiarity with smart energy systems, with 36.7% being well-acquainted and 41.28% having moderate familiarity. The most widely adopted devices include smart meters (46.3%) and smart thermostats (29.63%), which play a critical role in energy monitoring and demand-side management. However, a notable 20.37% of respondents have not yet implemented such technologies, signalling the potential for further market penetration and user engagement.
- The primary motivators for adopting smart energy solutions include energy efficiency and cost reduction, cited by 77.78% of respondents. Comfort and automation follow at 43.52%, while environmental considerations are a priority for 22.22%. These results indicate that the financial and operational performance of energy systems remains the dominant factor driving consumer adoption. Additionally, 65.74% of participants expressed interest in installing additional smart home equipment to improve energy utilization, demonstrating a willingness to invest in technical upgrades that enhance energy performance.
- Consumers show strong demand for real-time energy monitoring and control mechanisms. 47.22% value instant notifications regarding consumption levels, while 49.07% prefer alerts related to cost-saving opportunities. Additionally, 62.96% support automated load optimization based on dynamic pricing structures,

emphasizing the necessity for adaptive control algorithms capable of managing peak loads and reducing consumption during high-tariff periods.

- Energy flexibility is another area of interest, with 50% of respondents willing to participate in demand-response programs that adjust consumption based on electricity price fluctuations. However, only 37.04% have prior knowledge of flexibility services, indicating a need for educational initiatives to bridge the gap. Meanwhile, 40.74% of consumers express interest in participating in energy trading platforms, where they could sell excess energy or adjust consumption patterns for financial benefits. Given these findings, data security and transparency are critical, with 57.41% of respondents rating clear data usage policies as highly important.
- Regarding investment in energy infrastructure, 50% of respondents are interested in tools that assess future energy consumption trends, while 63.89% seek solutions that evaluate feasibility for solar panels and energy storage. Among potential investments, renewable energy systems (54.63%) and battery storage (48.15%) are the most favoured options. Furthermore, 76.85% of respondents see value in simulation-based models, such as a Household Digital Twin, that analyse energy flows and financial outcomes under different operational scenarios.
- Personalization of energy management strategies is also a key demand. 53.7% of respondents find customized recommendations based on usage patterns beneficial for improving efficiency. Similarly, 56.48% favour tools that allow historical data comparisons to track long-term performance trends. Additionally, 77.78% of participants express interest in setting and monitoring energy efficiency targets, demonstrating the need for user-driven control systems that provide actionable feedback.
- Key barriers to wider adoption of smart energy technologies include cost constraints (53.7%) and privacy concerns (25.93%). Usability is another critical factor, with 50.93% of consumers preferring some level of manual control over automated energy adjustments, while 44.44% seek a hybrid control architecture that allows both centralized and device-specific management. These findings underscore the importance of ergonomic, intuitive interfaces that accommodate different levels of user expertise and seamless integration across energy management platforms.

The results of the Prosumers-Consumers Questionnaire emphasize the growing interest in smart energy infrastructure, demand-side flexibility, and enhanced control systems. However, technical challenges such as data security, system complexity, and cost feasibility must be addressed to enable large-scale adoption. Dynamic load management, real-time feedback, and investment assessment tools will be critical in ensuring sustainable energy use.

We presented above the details of the business orientation of the project following business scenarios and use cases definition and the questionnaires circulation to retrieve feedback about the technical principles to be considered in the project. As stated in the GA, special emphasis is delivered also on adopting social and user behavioural aspects as part of the overall design framework, further considering the regulation principles. Therefore, the following sections (Section 5 and 6) complement the business-oriented

analysis that was provided above, towards ensuring the provision of a holistic approach on the design of the DIGITISE solution and results.

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5 DIGITISE social, economic and behavioural barriers to transition

As stated in the GA, DIGITISE should show particular focus to the social, behavioural, and ethical aspects (specific to each demonstration area), including consumer engagement, motivations, expectations, and attitudes toward factors such as comfort, security, data privacy, and trust. This analysis would help identify barriers that may discourage consumer participation in digital energy services and flexibility transactions, such as concerns over transparency in processes and trust in the energy market. Furthermore, challenges related to accessing and using consumer-generated personal data, addressing issues like anonymization requirements, data sovereignty, and security considerations should be examined. Once these barriers and limitations have been identified and contextualized, will further drive the incorporation of social driven aspects in the development and refinement of the technical solutions of the project.

5.1 DIGITISE Social and Behavioural Analysis

To address these social and behavioural aspects, a series of surveys/dialogues and engagement activities involving consumers, citizens, and local stakeholders were planned to be conducted to collaboratively uncover key business, and end-user challenges that could affect the demonstration and validation of DIGITISE envisioned solutions or hinder their commercial adoption. These dialogues complement the results obtained through the questionnaires by offering additional qualitative, concrete and localized insights.

The first dialogue was held in January-February 2025, in fully compliance with the milestones for the engagement strategy developed in WP7 of the project. In more details the dialogue was performed together with the 1st action towards the active engagement of the consumers and stakeholders (direct participants) in DIGITISE project. More details about this 1st engagement actions:

- The workshop in Greece took place on 30 January, in Spain on 7 February, in Croatia on 8 February, and in Ireland on 12 February.
- The participants expressed satisfaction with the format and the discussions.
- All in all, focus groups were organized to delve deeper into specific areas such as energy literacy, adoption of digital tools, and the role of consumer participation in energy transition moderated by experienced facilitators and included participants from varied backgrounds to ensure balanced representation and therefore valuable feedback.
- The energy dialogues attracted a diverse range of stakeholders, including consumers as primary focus group but also energy business actors, service maintenance managers, engineers, marketers and others.
- The first edition of the energy dialogues was held at four different locations, with over 130 participants in total.
- Some groups (mainly externals and business experts) were underrepresented in certain countries, potentially leading to a lack of diversity in the group composition.

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This aspect will be given greater attention in future energy dialogues to ensure that the solutions proposed by DIGITISE are suitable for all audiences.
- The citizens displayed an average level of understanding of the energy topic, but they were highly interested in it and were looking for concrete solutions.

The template of the structure of the 1st focus group on all demo sites and some extra details about the organization and the management of the work is provided in Annex II. In the next section, the analysis of the results is provided, further triggering the incorporation of social and citizens behavioural aspects in the DIGITISE framework.

5.2 Main take aways from the energy dialogues

The following elements show the first trends that emerged from the first energy dialogue, based on the reporting made by the demo's partners, giving a first snapshot of how the selected community may welcome new digital tools, showing the similarities between the different countries as well as some specificities of each of them. These results will provide an initial overview and serve as a foundation for the further development of the DIGITISE tools. The elements and the learnings on the methodology of the process will also help us to build the engagement strategy to keep the participants and the community active throughout the process.

5.2.1 Socio-economical aspects

The following elements outline key trends in the four communities regarding the socio-economic aspects of the energy transition.

- Protecting vulnerable people. It is vital to protect vulnerable people, as participants in the dialogues recognized. Some groups may be more affected by a potential energy shift, including the elderly, under-educated people, people with limited resources or time, small consumers, renters, people living in apartments, and people living in rural areas. These groups are more likely to be overwhelmed by new technology and big cultural changes, creating a risk of digital discrimination. This point is also important for stakeholders, for whom it is not easy to know what group of people can access the funding supports and grants for renovation (Ireland).
- The high costs of the energy transition. The energy transition is expected to require substantial investments in infrastructure and new technologies by both the state and the population. Participants have expressed concerns about potential limitations in access to these technologies and the possibility of increased electricity costs. A group in Croatia has highlighted the potential for economic pressure arising from the transition, while the majority of participants view it as an economic burden that could hinder progress.
- Heating and cooling as major sources of energy consumption. Heating and cooling are identified as the primary sources of energy consumption, with participants considering them to be the areas where they can most effectively reduce energy usage. Transportation is also highlighted as a significant concern; however, this varies depending on the participant's location. For instance, in Ireland, most participants were renters residing in older properties in urban centres, while in Croatia, the discussion took place in a more rural setting. Energy reduction

strategies did not prioritize cooking, as it is not a significant consumption area. IT tools were not identified as a potential avenue for energy conservation.

- A collective process. It is vital that all relevant parties participate in this transition, however it will require significant involvement, accessible information and trained support teams to ensure its success. Local authorities and companies are expected to provide tailored support to individuals based on their personal circumstances. The issue of these entities' ability to develop projects and advance initiatives was raised in the discussions. As observed in Ireland and Spain, this may lead to a sense of empowerment among citizens, encouraging them to devise their own solutions.

Some specific situations:

- In Ireland, the issue of the nation's housing situation dominated proceedings. The issue includes the presence of older buildings that are challenging to renovate or upgrade using modern technologies, as well as an imbalance between renters and homeowners. This has the potential to increase the costs of the transition for both citizens and the public authority.
- In the Greek and Spanish demonstrations site, the impact of the transition on the private sector was a topic of discussion, with particular reference to the loss of employment. Participants recognized that while the transition could create new jobs, it could also result in the loss of some existing jobs, particularly those held by less educated people, as the energy system becomes automated.
- The group in Croatia has taken a more advanced approach in its deliberations compared to other countries, proposing a universal system of penalties and incentives to drive the global transition towards green energy.
- There is a divergence of opinion when it comes to energy consumption. In certain countries (notably Greece and Ireland), there has been a reported decrease in energy usage. These countries have cited cost as the primary motivator for behavioural change. Additionally, many participants have noted that their energy consumption has increased due to the proliferation of devices. Notwithstanding these variations, a pervasive awareness regarding the role of energy in the environmental transition and the imperative to reduce its consumption is evident across all pilot sites.

5.2.2 Behavioural aspects

The following elements outline key trends in the four communities regarding the behavioural aspects of the energy transition.

- Energy literacy to face new consumption model. Information and support should be made available to consumers, as well as to other relevant parties such as companies and local authorities, to ensure the success of this transition. Simpler incentives and demonstrations of what is realistic and feasible are also required. The creation of dedicated educators on energy matters has been proposed by several groups.
- A personalized support. In the final stage of the process, participants explicitly stated their desire for personalised energy management support, tailored to their individual needs and requests. They expressed no objection to the utilisation of automated tools or AI to facilitate this. They acknowledged that a universal solution

is not feasible, as individuals have distinct energy consumption patterns and requirements. Accordingly, participants are less willing to play an active role in adding or managing themselves information to feed the developed tool and prefer an intermediary to do it.

- Cultural change as the biggest obstacle to overcome. In anticipating the evolution of their community in 2030, individuals expressed a sense of caution, bordering on scepticism, regarding the potential implications of a transition to a renewable energy system on their daily lives. They advocated for a gradual and phased approach, emphasizing the importance of comprehensive training, particularly for vulnerable groups. They do not foresee a sudden shift soon but rather anticipate it to occur over an extended timeframe. While they recognize the added value of new energy solutions, they believe that society and individuals alike may find it challenging to adapt to these changes, which could lead to significant inconvenience.
- Fear of dependence to the new energy system management. Participants have expressed concerns that the integration of new energy solutions into our daily activities may lead to dependency and the management of our lives around energy accessibility. They view this new relationship with energy as a lifestyle that is more demanding, particularly due to its dependence on weather conditions and current energy costs, which necessitates more planning, anticipation and adjustments to daily routines. Furthermore, the necessity for constant monitoring may give rise to safety concerns, as highlighted by a group from Croatia. Furthermore, this new approach may not be universally applicable, for instance to those who work remotely or with unusual schedules.
- Need of concrete outputs. The proposed solutions are not yet considered to be feasible or affordable, and the stakeholders have yet to demonstrate their capacity to propose creative solutions that will benefit them. Currently, there is an absence of evidence to support the existence of good practice, and there are no examples of successfully completed projects or business models. If such examples exist, they require greater visibility and replication. It is essential that the benefits are clearly defined in the long term, for the benefit of future generations, as well as in the short term, for the benefit of the various actors involved.
- With awareness comes the change. Stakeholders in Greece, Ireland and Spain have indicated an increased awareness of energy management throughout the day, with a subsequent adaptation of behaviour. In Croatia, stakeholders have focused on shifting traditional fuels, such as heating oil, coal and wood, towards more sustainable alternatives.
- Rise of individualism. The energy transition may be perceived as a potential disruptor to societal cohesion. As energy becomes a more individualized concern, there are concerns that it may lead to social conflict and the rise of individualism, potentially creating division between older and younger demographics, rural and urban populations. This sentiment is particularly prevalent in Croatia, where the group perceives the society to be quite conservative and resistant to change. Also in this country, the question of the generation gap and the ability of the elderly people to adapt to adapt to the energy shift and the new energy usage is pointed out.

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5.2.3 Additional citizen-focused barriers/limitations

The following elements outline key trends in the four communities regarding the other aspects of the energy transition.

- Energy infrastructure is not ready yet. All participants in each demonstration site noted that the energy infrastructure, ranging from local to national levels, has yet to reach a point that would enable a successful transition. However, stakeholders across the country recognize that new regulations and technological advancements are facilitating progress. These factors have led to enhanced energy efficiency, although this is not universally accessible.
- A strong legislation. Stakeholders acknowledged the European Union's effective role in guiding the transition towards renewable energy and decarbonization, through the promotion of policies aimed at accelerating the shift towards a low-carbon economy, while also ensuring the involvement of all relevant stakeholders. However, it is crucial to recognize the necessity for these changes to be implemented at both the local and national levels. National governments must be empowered to target vulnerable populations, modify their internal legislation, and enhance market control and transparency. Ireland due to its isolated geographical location, has recognized the necessity to avoid reliance on a single source of energy. This is to mitigate the risks associated with a lack of flexibility, which could lead to high prices for consumers.
- Improve the administrative process. The administration is currently unable to support the efforts of companies and participants, as it is overwhelmed by bureaucracy, excessive procedures and a complex tax system. The system must be streamlined and flexible and serve as an ally in the energy transition. Participants are not reluctant to see the administration and public authority playing a more central role in energy management, as evidenced by the results of the last stage of the process.

Some specific situations:

- Croatian stakeholders have identified corruption and the role of the lobby as obstacles to a shift in energy policy, compounded by a lack of political will. There is a lack of a clear strategy for addressing these issues, which has resulted in a lack of awareness or willingness to create new solutions among the population.
- Croatian groups have expressed a desire for greater appeal in the energy sector, whether in the private or public sector. It is vital that this sector generates more interest and more recognition, both locally and further afield.
- Privacy and data ownership is something the participants consider, but they don't agree on who can manage the data. If it is by private actors, they request additional guarantee but as it may give them a more personalized experience and relation with the private actor, they may accept the trade (as heard in the Greek, Irish and Croatian dialogues). They like the idea of data managed by a neutral institution as the state, but then they see the relation as less individualized and personalized (expressed in discussions Spain and Croatia).

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5.3 Learnings and the next steps of the process

The results of the first edition of the energy dialogues in the four communities show some common trends, which raise interesting questions about the role citizens want to play in this transition. While they all see it as a significant change in our relationship with the energy system, they appear to be very cautious about how they can actively contribute to it. They are more likely to contribute or adopt a beneficial position rather than act as an independent actor with its own tools and solutions. The system should adapt to them, but they do not wish to adapt it themselves.

An energy shift could potentially disrupt the community's perception of itself as a functioning entity, given that its overall functioning may be impacted by emerging energy habits. The transition is likely to necessitate substantial structural changes from both public and private entities. There is a call from the participants for enhanced connections between the various stakeholders.

The socio-economic consequences of the transition are acknowledged, though not yet fully delineated, as the transition appears to be a long-term prospect for the participants. It is also interesting to notice the differences between the more urban communities and the more rural communities, with differences in challenges to face, regarding housing, energy autonomy and community feeling.

Further analysis and evaluation of these results is required. In addition, a comparison with the quantitative questionnaires presented above would be beneficial. They provide general and community-specific indications on how people perceive the energy transition. Based on these elements, we can deepen our understanding of the barriers and incentives of participants in the development of new energy tools.

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6 DIGITISE Regulatory Framework Analysis and Barriers Extraction

6.1 Regulatory Framework Analysis Overview

As stated in the GA and more specifically in T2.2, one of the objectives of the project is to define (apart from social and ethical barriers) regulatory barriers involved in the application and demonstration of the DIGITISE concept and results in the project.

Towards this direction, at first a review of the relevant regulation at EC and national level is performed to check the status of implementation at the demo countries. Then, taking into consideration the status of regulation adoption and building on the large insights the consortium from previous projects and through participation in EC initiatives, the identification of key regulation barriers and limitations are defined.

As stated in the GA the focus on the analysis should be twofold: (i) on the regulation related to consumer engagement and motivation towards aspects linked with digital energy services and flexibility transactions (e.g. transparency of processes, trust in energy market) (ii) on the regulation related to consumer trust about data privacy and security (access to personal data generated by consumers, anonymization needs, data sovereignty etc.). Starting with the review of the EC regulation, there are numerous initiatives promoting consumer engagement and energy democratization (enhancing market-based participation). Targeting the most recent regulation, the European Union's REPowerEU plan,[1] introduced in May 2022, aims accelerate the green transition. While its primary focus is on energy diversification and sustainability, REPowerEU also emphasizes consumer empowerment in the energy sector through energy communities and further aggregation for provision of added value services, while further promoting investments in local RES.[2] Also, the regulation encourages consumers to adopt energy-saving measures, contributing to an 18% reduction in gas consumption across the EU over the past two years.

The Social Climate Fund,[3] created in May 2023 under Regulation EU/2023/955, provides financial support to EU countries for assisting vulnerable households, including those experiencing energy poverty. This funding supports investments in energy efficiency, with EU countries required to submit their Social Climate Plans by June 2025 to access it. The revised Energy Efficiency Directive (EU/2023/1791),[4] adopted in September 2023, strengthens efforts to alleviate energy poverty and empower consumers through a range of comprehensive measures.

The revised Energy Performance of Buildings Directive (EU/2024/1275),[5] effective from May 2024, includes specific provisions for energy-poor and vulnerable households, as well as individuals living in social housing. Among other measures, it also promotes investments in the building environment to increase building performance.

The Electricity Market Reform (Directive (EU) 2024/1711[6] and Regulation (EU) 2024/1747),[7] introduced in June 2024, reinforce consumer rights and protections, further promoted at

EC level by the relevant initiatives[8]. These reforms ensure clearer information and stronger safeguards. Furthermore, in the case of a natural gas price crisis, EU countries are required to guarantee access to affordable energy and essential social services for these consumers, including through price interventions to protect them from excessively high costs.

While EC regulation is paving the way for the enhancement of consumers in energy transition, National Energy and Climate Plans (NECPs)[9] are the key framework through which EU Member States outline the aforementioned strategies (REPowerEU and EC directives) to meet the Union's 2030 energy and climate targets By **30 June 2024**, Member States have to submit their final versions, integrating the Commission's feedback and therefore this is the current ongoing status of the member states to be considered in the analysis below.

Note: We must point out that the review of the regulation in the field of energy markets operation is out of the scope of this document. The detailed market review is performed as part of the work in T2.4 to be reported in D2.2.

As stated above, apart from the review of the energy related regulation and towards energy sector digitalization, data protection is of utmost importance in EC and in DIGITISE. As a focal point is the European Data Protection Regulation (GDPR), applicable as of 25 May 2018 in all Member States, has heralded a major reform of the EU data protection framework. Designed to harmonise data privacy laws throughout Europe, to protect and empower EU citizens' data privacy, the new set of rules have posed considerable moves towards compliance across the energy sector. The GDPR has been applied also to the national legislation of each EC country and thus special remark will follow in the next section.

The General Data Protection Regulation (GDPR)[10] foresees the DPIA as a key instrument to enhance data controllers' (an entity that determines the purposes and means of the processing of personal data) accountability as it helps them build and demonstrate compliance. Towards this direction, and with high applicability in the energy sector, the **DPIA (Data Protection Impact Assessment)** [11] template was proposed as a tool designed to help ensure that consumer data, such as household energy consumption, is protected in line with GDPR standards. By using this template, operators can embed **privacy by design** and ensure that consumers' personal data is handled responsibly and securely, giving them more control over how their data is used.

In the field of data security and protection, special remark about the EC digital strategy [12] and the specifications of:

- The Data Governance Act (DGA) as a comprehensive tool designed to oversee the reuse of publicly or protected data across various sectors. The inclusion of built-in safeguards, in addition to GDPR, is intended to enhance trust in the sharing and reuse of data. This trust-building is crucial for increasing the availability of data in the market.
- The Data Act entered into force on 11 January 2024. It is a pillar of the European strategy for data. Its main objective is to make Europe a leader in the data economy

by harnessing the potential of the ever-increasing amount of industrial data, to benefit the European economy and society.

The review of the aforementioned strategies is thoroughly considered as high relevant in the context of the DIGITISE project. The way these regulations are applied at national level is presented below, covering also the particularities of each demo site.

6.2 Greek Demonstrator

6.2.1 Data protection

In accordance with Regulation (EU) 2016/679 (GDPR), the Greek Data Protection Law (Law 4624/2019) [13], the EU Data Act (Regulation (EU) 2023/2854), and the Data Governance Act (Regulation (EU) 2022/868), the client agrees to the processing of their personal data by the electricity marketer upon signing the electricity supply contract. The processing of this data is essential for the execution, management, and monitoring of the contractual terms. The processed data includes both the details provided by the client and any data generated during the duration of the contract, handled with strict confidentiality and full regulatory compliance.

For the purposes of fulfilling the contract, the client's personal data may be shared with other entities in the electricity sector, credit and solvency institutions, and relevant regulatory bodies, especially in cases of non-payment or for debt recovery. In compliance with the Data Act, the client has the right to access, transfer, and share their data with third-party services in a structured, commonly used, and machine-readable format. If the client wishes to grant a third-party entity access to their energy consumption data, this will be facilitated under fair, transparent, and non-discriminatory conditions, as required by the Data Governance Act. Furthermore, any data-sharing between organizations within the energy sector will adhere to principles of interoperability and fair use, ensuring that no competitive disadvantages arise from such processing. Provisions related to the Data Act will be fully implemented in accordance with its applicability date, which is set for September 12, 2025.

It is evident that the GDPR regulation is fully adopted in the Greek regulation while the most recent actions about data act are also considered promoting the transition to the data era and data economy.

6.2.2 Consumers enrolment in energy business schemas

In the Greek electricity market, consumers have several ways to participate and save money. Since 2007, they can choose between government-regulated tariffs and competitive rates from private suppliers. A key part of this change is the Hellenic Energy Exchange (HEnEx), established by Laws 4425/2016[14] and 4512/2018[15]. This exchange creates a marketplace for electricity trading, helping consumers find better options. However, challenges like price changes and regional differences still exist. To tackle these issues, the Greek government is working with neighboring countries to manage rising power prices and improve energy cooperation.

Consumers can also take part in self-consumption and renewable energy generation. Law 4414/2016[16] supports the installation of renewable energy systems, such as solar panels, allowing people to produce their own electricity and sell any excess back to the grid. Law

4643/2019[17], aligning with Regulation (EU) 2019/943[18], further adjusted eligibility criteria for FiP contracts. Following the 2022 energy price surge, Law 5037/2023[19] allowed RES producers with operating aid contracts to temporarily opt out and trade freely in the market. The self-consumption framework has also undergone substantial changes. Law 5037/2023 introduced net-billing and collective self-consumption mechanisms. Law 5106/2024[20] further refined these rules, with implementation finalized by a Ministerial Decision in September 2024.
Law 4710/2020[21] established the first comprehensive legal framework for e-mobility, enabling the deployment of public EV charging infrastructure and providing incentives such as tax reductions and traffic privileges for EV users.
Demand response programs are becoming more popular, encouraging consumers to lower their energy use during peak times, which can lead to savings and help stabilize the grid. The NECP[22] emphasizes the importance of empowering consumers by promoting energy efficiency measures, which can help households and businesses reduce their energy costs. This includes incentives for upgrading appliances and improving insulation in homes, making it easier for consumers to lower their energy consumption. Additionally, the NECP encourages the formation of energy communities, allowing groups of consumers to invest together in renewable energy projects. This not only provides financial benefits but also fosters community engagement in energy production. Energy communities were originally established under Law 4513/2018[23], granting incentives to cooperative energy projects. However, Law 5037/2023 redefined the framework, replacing traditional energy communities with Renewable Energy Communities and Citizen Energy Communities, ensuring a focus on local benefit and sustainability.
Investing in smart technologies, like smart meters, helps consumers monitor and optimize their energy usage. Law 4572/2018 requires the installation of smart meters, which provide real-time data on energy consumption. This law is part of the effort to enhance grid management and energy efficiency, giving consumers better control over their energy use. Greece's laws ensure consumer rights and protections, promoting transparency and fair pricing. The government continues to support consumers through initiatives like power bill subsidies, especially during times of high energy costs.

The government has implemented various programs to support these regulatory objectives as stated above and relevant to DIGITISE project. The most prominent are provided.

Exoikonomo 2025 Program[24]
The Exoikonomo 2025 program is a significant initiative designed to improve energy efficiency in residential buildings across Greece. This program builds on the successes of the previous Exoikonomo 2023 program, which provided financial assistance for energy-saving renovations and upgrades, leading to increased energy efficiency in many homes. The 2023 program helped homeowners reduce energy bills and enhance their living conditions by subsidizing the installation of renewable energy systems and improvements to thermal insulation.
The Exoikonomo 2025 program continues this momentum, offering financial assistance to homeowners for energy-saving renovations and upgrades, including the installation of renewable energy systems and enhancements to thermal insulation. The initiative is part

of Greece's broader sustainability strategy, aiming to reduce energy bills, improve living conditions, and contribute to the green transition.

Energy communities Support and Funding [25]
To support the establishment and operation of energy communities, the Greek government has allocated €42 million. This funding aims to facilitate the adoption of renewable energy at the community level, promoting local energy autonomy and contributing to national sustainability goals.

Renewable Energy Support Measures
The Greek government is committed to promoting the generation and storage of renewable energy as part of its strategy to achieve climate and energy goals. In December 2023, the European Commission approved €1 billion in funding for Greek measures to support projects focused on renewable energy generation and storage [26]. This funding is designed to facilitate the development of solar, wind, and other renewable energy projects, enhancing Greece's capacity to meet its ambitious targets for renewable energy adoption.
Greece has also implemented several measures in 2024 to combat energy poverty and support vulnerable households [27]. In December 2024, Greece announced new power bill subsidies to assist households facing rising electricity costs. This initiative reflects the government's commitment to supporting consumers and promoting energy efficiency.:

- Power Bill Subsidies: The government provides electricity subsidies to help households manage rising costs. In December 2024, a 1.5-cent/kWh subsidy was introduced for consumption up to 500 kWh, benefiting 90% of variable-rate consumers, with a total cost of €20.5 million.
- Tax Reductions: The government has reduced taxes on electricity and gas to alleviate the financial burden on families, especially during periods of high energy prices.

6.3 Spanish Demonstrator

6.3.1 Data protection

In general, in accordance with Regulation EU2016/679 (GDPR) and the current Spanish regulations (GDPR and LOPD), the client consents to their data being processed by the marketer through the signing of the electricity contract. The marketer uses the client's data for the execution, maintenance, and control of what is agreed in the contract. The data processed includes both those provided by the user and those generated during the term of the contract. The data is kept and processed with the utmost confidentiality during the term of the contract and in accordance with current regulations.
Specifically, for the fulfilment of the contract, the data may be communicated to other operators in the electricity sector and to companies providing information on asset solvency and credit in situations of non-payment and recovery of the user for the interest of the marketer. The user always, can exercise the rights of access, rectification, deletion, opposition, limitation of processing, and portability with respect to their personal data. In addition, the user has the right to make any type of claim regarding personal data

protection before the supervisory authority, which in Spain is the Spanish Data Protection Agency.

6.3.2 Consumers enrolment in energy business schemas

The Integrated National Energy and Climate Plan (NECP) of Spain outlines the country's strategy for transitioning to a sustainable energy system while meeting EU climate targets. The latest update, approved in September 2024, reflects European climate legislation, including the Fit for 55 package and REPowerEU. A central focus of the updated NECP is the expansion of renewable energy, with a target of 81% of electricity generation coming from renewable sources by 2030. Additionally, investments in energy storage and grid modernization, promotion of self-consumption and energy communities will enhance steady supply of electricity.

In the Spanish electricity market, consumers can participate in several ways, allowing them to play a more active role and gain economic benefits. Consumers can choose between the regulated market, with government-set tariffs (Voluntary Price for Small Consumers, PVPC), and the free market, where tariffs are set by the suppliers [28] . The regulated market is controlled and supervised by the State, specifically by the Ministry of Industry, Energy, and Tourism. Due to its regulations, the number of companies that can commercialize energy in this type is limited. Additionally, they can only sell energy with the PVPC tariff, without any extra services. In the free market, consumers have greater freedom of choice in both provider and tariff. Energy providers compete by offering prices and additional services. Consumers can access discounts and additional services, and there is the option to contract green energy. In recent years, there has been a significant increase in the number of consumers moving from the regulated market to the free market.
The net-billing mechanism, introduced in 2024, enables self-consumers to sell surplus electricity on the wholesale market or through [29]Power Purchase Agreements (PPAs). At the same time, collective self-consumption policies allow communities and apartment buildings to share locally produced solar energy, making renewable energy more accessible and affordable for all. Consumers can participate in demand response programs, where they are incentivized to reduce their consumption during peak demand periods in exchange for economic compensation [30]. Recognizing the importance of protecting vulnerable consumers, the NECP strengthens the social electricity tariff, ensuring that low-income households receive financial support for their energy needs. Additionally, targeted measures to combat energy poverty aid with heating and cooling costs, guaranteeing that all citizens can afford essential energy services.

The adoption of smart meters and energy management systems allows consumers to monitor and optimize their consumption in real-time, which can lead to significant savings.

In line with the regulation above, there are several grants and subsidies available to improve energy efficiency and support energy communities in 2024. Here is a summary of the main ones.

- Recovery, Transformation, and Resilience Plan (PERTE):[31]
    - Objective: Subsidize energy efficiency projects in the residential sector.

    - Coverage: Renovation of heating systems, installation of renewable energy sources, and improvements in thermal insulation.
    - Regulation: it is created within the framework of the Recovery, Transformation, and Resilience Plan, which is part of the NextGenerationEU Recovery Plan for Europe.
- Aid Program for Energy Efficiency Improvement Actions in Housing:[32]
    - Objective: Finance actions that achieve a significant reduction in energy demand.
    - Coverage: At least a 7% reduction in heating and cooling energy demand, and a 30% reduction in non-renewable primary energy consumption.
    - Regulation: it is created within the framework of the Recovery, Transformation, and Resilience Plan, which is part of the NextGenerationEU Recovery Plan for Europe
- Energy Communities allow citizens and companies to directly engage in the production and consumption of renewable energy, promoting sustainability and active participation in the energy system. Currently, Spain has 353 active energy communities. Since 2018, the installed capacity for self-consumption has multiplied by 20, reaching over 5 GW. [33]
- Towards targeting energy poverty, there are different measures to aim to reduce it:[34]
    - The Social Bonus is a significant discount on the electricity bill. It is regulated by the Government and aims to protect households considered vulnerable or severely vulnerable due to their socioeconomic conditions. Additionally, being a beneficiary of the Social Bonus also means receiving the Thermal Social Bonus defined by the Government. To benefit from the Social Bonus, it is essential that you have contracted the PVPC electricity tariff and a power equal to or less than 10 kilowatts in your primary residence. To apply for the Social Bonus, you must meet certain requirements that certify your status as a vulnerable customer, severely vulnerable customer, or severely vulnerable customer at risk of social exclusion, as detailed below.
    - Thermal Social Bonus, an aid designed and regulated by the Government to cover the costs of heating, hot water, and cooking for families considered vulnerable.
    - The Spanish Government has also prohibited the cutting off essential supplies until 2025. The aim of this measure is to ensure that no one loses their right to access basic energy sources, even if they are unable to pay their energy bills.
    - Tax reduction on electricity and gas have been implemented to alleviate the economic burden on families when the market has been tense.

6.4 Irish Demonstrator

6.4.1 Data Protection

Suppliers in Ireland must comply with the General Data Protection Regulation (GDPR) and the Data Protection Act 2018[35] ,which implements and supplements the EU GDPR

(Regulation (EU) 2016/679) regarding the collection, processing, and storage of personal data. The Irish GDPR framework enforces several core principles, including lawfulness, fairness, and transparency, which require organizations to process personal data in a clear and justifiable manner. Further consent will be required to gain permission to monitor/control users' assets. Electricity Suppliers require robust data security measures and clear policies for handling customer information.

6.4.2 Consumers enrolment in energy business schemas

The National Energy and Climate Plan (NECP) of Ireland outlines the country's strategy to achieve its energy and climate goals while emphasizing the role of consumers in the energy transition.

The NECP aims to empower consumers by promoting self-Generation/Self-Consumption. Consumers can generate renewable energy, like solar, and sell their excess generated Electricity. Government schemes, such as the Microgeneration Support Scheme (MSS) (50 kW or less), are in place. It encourages small-scale renewable energy production by individuals, businesses, and communities, contributing to a more decentralized energy system. For more significant users, it is easier to get a connection agreement if a site ensures its MEC=0; [36] this ensures that many large-generation sites are self-consuming. Furthermore, self-consuming generated energy at both residential and commercial scales makes more financial sense, as the unit price of imported electricity far exceeds the export electricity subsidized rate.

Energy communities are also seen to be essential stakeholder in helping Ireland meet its carbon reduction targets. The Irish Energy government body, the Sustainable Energy Authority of Ireland (SEAI), has established a framework for Energy Communities through the development of SEC (Sustainability Energy Communities). There are now a few hundred Sustainable Energy Communities throughout Ireland. A key activity of the program is for communities to utilize Energy Master Plans [37] developed by Energy Consultants. This plan outlines the community's energy usage and highlight options for improvement. You can then apply for individual or community grants to support the implementation of these improvements. Most Notable are the Community Climate Action Program, Leader Rural Development Programme and SEAI Community Energy Grant Programme.[38]

In the field of Local Demand Response Programs, the Irish DSO is trialling demand response programs for individuals and SMEs (Small and Medium Enterprises), encouraging consumers to reduce usage during peak times. Participation in the Frequency Reserve Market is generally limited to large generation assets or significant energy users, typically with flexible capacities exceeding 100 kW. Energy communities are also seen as potential enablers in providing grid flexibility and supporting renewable energy integration. A key activity for energy communities is to provide flexibility through group aggregation, which is the combining of flexible assets such as battery storage, electrical heating, and demand-response capabilities from homes and businesses [39] . However, to date, Irish authorities are focusing on local flexibility trials, which target the participation of individual SMEs and individual consumers; it is uncertain whether the Irish authorities will develop a regulatory framework for activities aggregated demand response.

The NECP includes various initiatives to improve energy efficiency in residential and commercial buildings. This includes financial support for retrofitting homes and businesses, which can lead to reduced energy bills for consumers.[40]
The NECP emphasizes increasing access to renewable energy options for consumers, Ireland's Renewable Electricity Support Scheme (RESS) and upcoming Small-Scale Renewable Energy Scheme (SSRESS) [41] encourage community-led renewable projects:

- RESS (5 MW or more significant) Supports the integration of utility- scalable renewable energy plants, predominantly in rural areas.
- SSRESS (50 kW to 5 MW) This scheme, to be launched in late 2025, focuses on small-scale solar projects. To encourage community participation, Renewable Energy Communities (RECs) will receive higher payment rates.
- Microgeneration Support Scheme (MSS) (50 kW or less) It encourages small-scale renewable energy production by individuals, businesses, and communities, contributing to a more decentralized energy system.

The implementation of smart meters is a key focus, providing consumers with real-time data on their energy usage. This technology empowers consumers to make informed decisions about their energy consumption and to shift usage to times when energy is cheaper or more abundant.
The NECP recognizes the need to protect vulnerable consumers during the transition to a low-carbon economy. Measures are included to ensure that all consumers, particularly those in energy poverty, have access to affordable energy and the necessary support to transition to more sustainable energy solutions.[42] [43]

6.5 Croatian Demonstrator

6.5.1 Data protection

As any other entity on the marker, ZEZ follows the rules set by the General Data Protection Regulation (GDPR) act, which governs the collection, storage, and processing of personal data. The Croatian data protection framework is primarily governed by the Personal Data Protection Act (Zakon o zaštiti osobnih podataka) [44], which aligns with the General Data Protection Regulation (GDPR) of the European Union. This act was adopted in 2018 and serves to implement the GDPR at the national level while addressing specific provisions relevant to Croatia.
The Energy Market Act [45] specifically includes provisions for secure handling of customer energy consumption data, where energy companies are required to obtain explicit consent for processing personal data. 20 household prosumers that will take active part in the DIGITISE Croatian DEMO, will need to sign special consent giving permission for monitoring (and managing) their data and/or assets within the project.
A lack of standardized systems for data exchange between different stakeholders in the market (e.g. energy cooperative and suppliers) might possibly hinder development of innovative services such as demand response, real-time energy usage apps, and personalized tariffs. Regarding the DSO infrastructure limitations, there is a significant lack of advanced metering infrastructure to enable real-time energy management.

6.5.2 Consumers enrolment in energy business schemas

The National Energy and Climate Plan (NECP) of Croatia outlines the country's strategy to achieve its energy and climate goals while highlighting the benefits for consumers. The NECP aims to empower consumers by providing them with the tools and information needed to make informed energy choices. This includes promoting energy efficiency measures and facilitating access to renewable energy sources.

The NECP promotes the use of renewable energy sources, by encouraging consumers to invest in their own renewable energy systems. **Renewable Energy Sources and High-Efficiency Cogeneration Act** [46] establishes a framework for promoting the sustainable use of renewable energy, including the planning and encouragement of production and consumption of electricity generated from renewable sources.

- Net metering in a key support mechanism for solar PV for households in Croatia. It enables households with installed PV systems to offset their electricity consumption by feeding excess electricity into the grid and receiving credit for it (monthly billing).
- The Environmental Protection and Energy Efficiency Fund announces public calls offering subsidy for the installation of solar PV for households. Call usually opens once a year, and these subsidies cover up to 50% of the total investment cost. Local Governments (Cities, Municipalities) often offer additional financial support.
- The government introduced a 0% value-added tax rate for the installation (and equipment) of solar PV power for self-consumption in households and public buildings.
- Also, regulatory changes continue simplifying administrative procedures. Obtaining necessary permits is less complicated compared to 5 years ago, and incentives are widely accessible. The national DSO (regulated activity) is split into local divisions, and the permit issuing process often varies locally in terms of processing time and access to information.

Special reference to the establishment of energy communities for the promotion of RES investments. In the **associations Act** energy communities are defined as non-profit legal entities and can be established as associations. This Act outlines the procedure for founding an association. There are currently no support schemes available for development of energy communities in Croatia.

The NECP plan emphasizes energy efficiency to reduce energy consumption and costs for consumers. Initiatives include financial incentives for home renovations, energy-efficient appliances, and the implementation of energy management systems in businesses. The implementation of smart metering technologies is also a key aspect in the regulation to promote smart grid transition.

Support for vulnerable consumers is essential and thus the NECP recognizes the importance of protecting vulnerable consumers, ensuring they have access to affordable energy. Measures are included to assist low-income households and those in energy poverty through targeted support programs. In response to escalating energy prices in

2022, the Croatian government implemented a subsidy program. This initiative, valued at 2.8 billion EUR, aimed to mitigate the impact of rising energy and food costs. Under this scheme, from October 2022 to March 31, 2023, the electricity tariffs for households were locked at 59 EUR/MWh for consumption up to 2,500 kWh in 6-month period, and 88 EUR/MWh for consumption exceeding that threshold. In September 2024, the government announced a reduction in the energy subsidies, leading to a 10% increase in electricity and gas prices at the beginning of 2025.

Overall, while Croatia has formally transposed the relevant directives, continuous efforts are needed to address practical implementation challenges and fully realize the benefits envisioned by these directives.

6.6 Regulatory Barriers Overview

In this section and following the presentation of the regulation as provided above, the key barriers that hinder the active participation of energy consumers in the energy transition are provided. As stated above, the different barriers are derived from the knowledge of the consortium members as well as discussion with business experts to clearly highlight missing regulatory aspects that hinder the adoption of solutions as examined in DIGITISE project.

6.6.1 Greece

In Greece, various regulatory and operational hurdles impede consumers' active participation in the energy transition. A primary concern is the lack of real dynamic pricing mechanisms. The absence of such pricing means that consumers miss out on the opportunity to adjust their energy use in response to market price changes, which limits their ability to engage in demand response initiatives and take advantage of lower costs during off-peak hours.

Another significant issue is the unclear regulations surrounding self-consumption with battery storage systems. Consumers who choose to invest in renewable energy solutions should have the ability to store surplus energy for future use, but the current regulatory uncertainties hinder their capacity to implement these systems effectively. The current regulatory framework also lacks provisions for flexible demand. Allowing consumers to modify their energy consumption based on price signals or the needs of the grid could enhance overall energy efficiency and alleviate pressure on the system during peak demand periods. Additionally, the absence of guidelines for aggregation and flexibility through aggregators restricts consumers' ability to combine their resources and engage collectively in energy markets. Such aggregation would provide consumers with increased bargaining power and improved access to energy services.
Financial limitations pose another significant barrier to consumer involvement. There is a pressing need for greater investments in solutions tailored to consumers, as the perceived risks associated with innovative energy projects deter potential funding. Lastly, the existing regulatory environment does not adequately support a data economy. For consumers to make informed choices regarding their energy consumption and

investments in efficiency technologies, they need access to their energy usage data in a transparent way.

To empower consumers in Greece, it is essential to address these regulatory gaps. Implementing real dynamic pricing, facilitating self-consumption with battery storage, enabling flexible demand, allowing for aggregation, promoting investments, and fostering a data-driven economy will all contribute to a more inclusive and sustainable energy future.

6.6.2 Spain

While there is significant progress the recent years, there are still several regulatory barriers for the active enrolment of prosumers and further promotion of energy services. The legislation in Spain related to dynamic pricing for consumers does not have legal loopholes. The market is regulated, being favourable to the interests of consumers because there is greater flexibility to adjust prices, quick responsiveness, and more competitive prices. Nevertheless, current energy tariffs may not sufficiently to address users' profiles and needs.

The regulation of energy storage in Spain involves addressing two distinct fronts: the access and connection of energy for generation and for demand. This is because a battery sometimes behaves like a generator, exporting energy to the grid, and at other times like a consumer, importing energy from the grid. In both cases, there is a regulatory framework, although detailed specifications are still awaited to enable its effective application.

The main lack of regulation though (to be provided in more details as part of the work in T2.4) has to do with consumers enrolment in flexibility services. At this moment, there is a Draft Royal Decree that approves the General Supply and Contracting Regulation and establishes the conditions for the commercialization, aggregation, and protection of electricity consumers. This royal decree defines the general principles of aggregation activity, detailing the rights, obligations, and requirements of independent aggregators, thus facilitating the integration of consumers into the electrical system. This new regulation includes and regulates the role of independent aggregators, allowing consumers to participate more actively in the energy market. This project is expected to become a reality throughout 2025. The proposed capacity mechanism envisions a market in which generation and storage facilities, as well as demand, that is, consumers and aggregators, participate.

In the field of RES and other installations, although there are financial incentives available, the initial investment required for energy efficiency improvements or renewable energy installations can still be significant. Also access to financing options for energy efficiency and RES projects can be a barrier for many consumers as not clear to all users. Moreover, frequent changes in energy policies and regulations can create uncertainty for consumers considering investments in energy efficiency and RES.

Addressing these barriers is crucial for fostering the growth and success of energy services targeting consumers in Spain.

6.6.3 Ireland

Ireland has yet to transpose many articles of the Electricity Market Directive (EU/2019/944), limiting the impact of Energy Communities in the smart grid realm. There is no regulatory framework that supports citizen energy communities, meaning energy sharing and peer-to-peer (P2P) trading remain unsupported. Additionally, there are regulative barriers to the energy community's role within local flexibility markets.

The absence of a regulative framework for aggregated demand response hinders the coordinated management of flexible residential assets. Similarly, no long-term local flexible products exist for assets below .5 MW flexibility Capacity. Although the Distribution System Operator (DSO) has suggested the potential for introducing lower capacity products, nothing has been implemented.

Regarding grid standards for controlling residential Distributed Energy Resources (DERs), Ireland falls behind regions like California, which have adopted standards such as IEEE 2030.5. Without a comparable standard, the integration and control of residential DERs remain underdeveloped in the Irish energy market.

Ireland faces significant challenges in meeting energy efficiency targets, particularly for existing buildings, with investment being the biggest barrier. This challenge is further worsened by the ongoing cost-of-living crisis, driven recently by years of inflation, leaving many unable to afford energy upgrades. Furthermore, a key issue pertains to building ownership, there is a reluctance of landlords to invest in improving the energy efficiency of their properties. Furthermore, The Energy Master Plan Guides Energy Communities in aligning with the targets set by Ireland's Climate Action Plan. A key target in the Climate Action Plan related to heat pumps is the installation of 680,000 units in new and existing buildings by 2030. There is a regulative barrier; the current policy requires existing buildings to upgrade to a B rating, which in many cases costs tens of thousands of euros.

6.6.4 Croatia

Croatia has transposed the Internal Electricity Market Directive (IEMD) into national law, facilitating the formation and functioning of (citizen) energy communities. However, certain challenges persist in the practical implementation of the directive. For example, four energy communities are currently registered in Croatia, but there is no clear framework within which they can operate in the market. One key mission of ZEZ and the initiatives participating in the Community Forum is to: *"Enable citizens to have direct ownership and decision-making rights over their own energy production, as well as active participation in the energy market through energy communities, thereby facilitating the realization of new renewable energy installations with a total capacity of at least 1 GW by 2030."*
To achieve this mission for energy communities in Croatia, key goals include addressing current regulatory barriers by:

- Introducing a **simple and affordable (administrative) process** for establishing and registering energy communities for citizens who are not (energy) experts.

- Developing accessible **technical and financial support mechanisms** aimed at reducing the risks of energy community projects and encouraging their establishment, development, and stable growth.
- Enhancing a **favourable (market) environment** for the operation of energy communities, ensuring their economic and financial sustainability, with a focus on solutions such as equal market participation, direct energy sharing with members, and the ability to enter into energy purchase agreements directly with other market actors.
- Encouraging an **active role of cities and municipalities** in the development of energy communities and citizen energy projects on public spaces and rooftops.

A new Renewable Energy Sources and High-Efficiency Cogeneration Act is currently in preparation and is expected to be open for public consultation in the first half of 2025. The new legislation (hopefully) will improve the regulatory framework for renewable energy development, enhance market integration, and support the growth of energy communities in Croatia. It is very likely that the new law will introduce changes to the net metering scheme, which could result in a longer payback period for solar PV for self-consumption in households.

To maintain momentum in citizen investments in solar, it is crucial to introduce new (market) mechanisms that will continue to drive these investments and ensure a favourable environment for active citizen participation. This is also where the relevance of the DIGITISE project for the Croatian DEMO lies. By developing tools to support energy sharing and local flexibility, developing optimization algorithms and digital twins, will help reduce reliance on traditional support schemes like net metering and foster consumer-driven energy market.

Following the identification and instantiation of regulatory barriers and limitations across the project's demonstration sites, we proceed with the elicitation of the key principles to drive the elaboration of technical and managerial solutions that need to be applied for effectively addressing or even mitigating them. Therefore, regulatory related requirements are defined to ensure that the local principles are incorporated in the final DIGITISE solution.

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7 DIGITISE Requirements Extraction

As stated above, the DIGITISE project employs a structured methodology for extracting requirements that are fundamental to the design, development, and implementation of digital solutions. This process involves multiple steps, including stakeholder engagement, citizens enrolment, business analysis, regulatory compliance assessment etc.

- In more details, stakeholder feedback has been a key input, with insights collected from prosumers, consumers, aggregators, and ICT partners through structured questionnaires, workshops and direct engagement activities.
- Additionally, use case analysis has played a crucial role in defining key scenarios that address business needs and technological advancements, ensuring relevance and scalability. Business-driven priorities have been considered, emphasizing consumer empowerment, flexibility markets, and interoperability between smart devices and distributed energy resources (DERs).
- Finally, the regulatory landscape has also been carefully reviewed to ensure compliance with EU and national energy policies, GDPR regulations, and data governance standards, thereby guaranteeing legal and ethical implementation.

By considering the detailed steps and the analysis performed, the initial list of DIGITISE requirements, categorized into ICT, aggregators and prosumers and consumers, and non-functional requirements, has been considered to ensure a comprehensive and well-informed approach for the DIGITISE solutions, detailed in the following section.

7.1 DIGITISE Functional Requirements extraction

The table below presents the consolidated functional and technical requirements extracted for the DIGITISE project, categorized based on their respective focus areas. The starting point of this work is the business orientation of the project, with emphasis on the definition of use cases (targeting the different business objectives) and further the contribution through the questionnaire analysis. In more details, the questionnaires (reflecting the business objectives set from the use cases definition) were analysed to properly derive functional needs as defined through the analysis.

The functional requirements presentation is following the technical segmentation defined in the project, thus presenting the pool of requirements linked to the data and AI analytics part (ICT related analysis and the associated questionnaire) and further the requirements linked to the different business functionalities/features (reflecting the feedback gathered through the business actors/consumers/prosumers questionnaires). The linkage to the different UCs is also provided to showcase the connection to the business orientation of each functional requirement.

Req ID	Description	Rationale	Related UC
ICT-01	Allow users to upload batch data files in various formats (e.g., CSV, JSON, etc.).	Supporting multiple formats enhances flexibility in data ingestion.	UC1
ICT-02	Facilitate the retrieval of data assets from external APIs following the principles of open API standardization.	API-based retrieval ensures seamless and automated data ingestion from various sources.	UC1

ICT-03	Facilitate the retrieval of data assets from external APIs according to the scheduled configuration.	API-based retrieval based on schedules to support continuous data retrieval	UC1
ICT-04	Enable the ingestion of near real-time and real-time data assets through streaming (PubSub mechanisms).	Real-time ingestion supports timely decision-making and monitoring.	UC1
ICT-05	Support the ingestion of real-time data assets by subscribing to an existing PubSub mechanism provided by an external entity.	Real-time ingestion through external data brokers that are massively used in the domain.	UC1
ICT-06	Support the retrieval of data assets from open-standards-based connectors (e.g., MODBUS) based on the defined configuration.	Supporting open standards ensures compatibility with industry protocols.	UC1
ICT-07	Enable users to modify the details of a data collection job, including its name, description, and configuration.	Editable job configurations enhance flexibility and customisation.	UC1
ICT-09	Enable users to configure curation rules for handling incorrect, incomplete, inaccurate, irrelevant, or missing data.	Configurable curation rules improve data quality and reliability.	UC1
ICT-10	Assist users in automating the curation of incorrect, incomplete, inaccurate, irrelevant, or missing data through appropriate machine learning techniques.	Automated curation reduces manual effort and enhances accuracy.	UC1
ICT-11	Ensure the enforcement of manual or automated rules for handling incorrect, incomplete, inaccurate, irrelevant, or missing data during the execution of a data collection process.	Enforcing rules ensures consistent application of data quality measures.	UC1
ICT-12	Provide an energy-oriented Data Model to enhance interoperability.	Ensures seamless integration and interoperability between different energy-related systems and datasets.	UC2
ICT-13	Effectively handle the relationships between the different concepts of the Data Model.	Improves data consistency and enables a more structured and meaningful data representation.	UC2
ICT-14	Implement the necessary lifecycle management methods for the Data Model, including the addition, modification, and removal of concepts or fields.	Ensures that the data model remains flexible, adaptable, and up to date with evolving data requirements.	UC2
ICT-15	Ensure the propagation of any updates across the related concepts of the Data Model.	Maintains consistency and accuracy throughout the data model by propagating updates across related concepts.	UC2
ICT-16	Support the exploration of the Common Data Model.	Helps users better understand the data model structure and effectively leverage its components.	UC2
ICT-17	Allow the user to choose the appropriate data concept for the data asset to be ingested.	Ensures accurate alignment with the data model, improving data usability.	UC2
ICT-19	Allow the user to execute the mapping configuration on sample data to assess how the data are transformed to comply with the selected concept.	Helps validate configurations before full-scale data ingestion, reducing errors.	UC2

ICT-20	Enable the user to define data harmonization and transformation rules to be applied to each field of a data asset in alignment with its mapping to the selected data concept.	Ensures consistency, standardisation, and compatibility with the chosen data model.	UC2
ICT-21	Enable users to configure anonymization rules for handling personal data.	Ensuring user-defined anonymization rules enhances privacy and compliance with data protection regulations.	UC3
ICT-22	Assist users in automating the anonymization process through appropriate standardized techniques.	Automation improves efficiency and consistency in applying anonymization techniques to data assets.	UC3
ICT-23	Ensure the enforcement of manual or automated rules for handling anonymization of data during the execution of a data collection process.	Enforcing anonymization rules ensures data privacy is maintained throughout the data ingestion process.	UC3
ICT-24	Ensure the provision of a secure data storage environment for the project data storage.	Secure storage safeguards sensitive data and protects against unauthorized access or breaches.	UC3
ICT-25	Allow data providers and owners to establish comprehensive access policies for their data assets as part of licensing agreements, ensuring consistent enforcement.	Well-defined access policies ensure that data-sharing terms are upheld and consistently applied.	UC3
ICT-26	Provide data providers and owners with the ability to define granular access policies for their data assets, subject to the consent of the original data provider or owner for reuse.	Granular access control ensures data providers maintain authority over data reuse while enhancing flexibility.	UC3
ICT-27	Support the definition of access control policies based on multiple criteria, such as organization type, user type, and geographical region.	Defining access policies based on diverse criteria allows for more refined and secure data-sharing practices.	UC3
ICT-28	Ensure the enforcement of access policies for data assets throughout the execution phase, adhering to the initial configuration settings.	Enforcing access policies at execution ensures that data governance rules remain intact during data usage.	UC3
ICT-29	Provide tools for data consumers to explore and inquire about available data assets.	Enables data consumers to understand available data, ensuring informed decision-making and enhancing transparency.	UC4
ICT-30	Support data owners, providers, and consumers in negotiating data-sharing agreements after an inquiry is accepted.	Facilitates structured negotiations between parties, ensuring clear communication and agreement on data sharing terms.	UC4
ICT-31	Allow data owners and providers to define conditions and terms for data-sharing agreements before negotiations begin.	Allows data owners and providers to set initial terms, streamlining the negotiation process and improving focus.	UC4
ICT-32	Enable data consumers to review and respond to the predefined terms and conditions set by data owners and providers during negotiations.	Gives data consumers the ability to agree, reject, or modify terms, allowing for active participation in the negotiation.	UC4
ICT-33	Support data consumers in proposing alternative terms during the negotiation process.	Enables data consumers to propose changes, fostering flexibility and mutual agreement in negotiations.	UC4

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ICT-34	Grant data owners and providers full control over whether any processed data assets derived from their datasets can be shared with consumers.	Protects data owners/providers by allowing them to control the sharing of derived datasets.	UC4
ICT-35	Allow users to create data-sharing contracts that include appropriate compensation structures.	Ensures fair and transparent agreements, addressing compensation for data providers.	UC4
ICT-36	Ensure the secure and reliable exchange of data assets by managing contractual agreements.	Guarantees data exchange under secure, legally binding agreements, minimizing misuse and unauthorized access.	UC4
ICT-37	Facilitate the integration of relevant intellectual property rights (IPR) policies into data-sharing contracts.	Protects intellectual property by ensuring IPR policies are clearly outlined in data-sharing contracts.	UC4
ICT-38	Allow users to create or upload standardized data contract templates for streamlined contract creation.	Increases efficiency by allowing users to use or upload standardized templates for contract creation.	UC4
ICT-39	Enable data sharing strictly in accordance with the established contractual agreements.	Ensures data sharing occurs strictly in line with contractual terms, safeguarding integrity and trust.	UC4
ICT-40	Support data sharing through API-based data retrieval mechanisms.	Enables seamless, automated data sharing through APIs, improving scalability and efficiency.	UC4
ICT-41	Allow users to configure dynamic data retrieval requests by applying filters to acquired datasets.	Provides flexibility in retrieving specific data by applying customizable filters.	UC4
ICT-42	Enhance data exploration and retrieval through robust search functionality.	Improves data discovery by offering a robust search function, making it easier to locate relevant datasets.	UC4
ICT-43	Extract comfort levels by applying ML techniques correlating energy behaviour with indoor environmental conditions.	Machine learning (ML) techniques analyse energy usage patterns alongside indoor environmental data to determine comfort levels	UC5
ICT-44	Extract short-term (hours ahead) energy behavioural profiling based on the available data granularity.	Short-term profiling helps, allowing for better demand-side management, load forecasting, and personalized energy recommendations.	UC5
ICT-45	Extract demand forecasting at various levels (device and building) considering the available data.	Forecasting demand at different scales (individual devices and entire buildings) enables precise load management, energy efficiency improvements, and demand response strategies.	UC6
ICT-46	Extract generation forecasting at DER level considering the available historical data and weather conditions.	Historical data and weather forecasts improve generation predictions	UC6
ICT-47	Provide demand and generation forecasts across multiple time scales (from 15 minutes to days, months).	Multi-scale forecasting ensures adaptability for both short-term operations (DR/energy efficiency) and long-term energy planning	UC6
ICT-48	Leverage energy behaviour analytics, comfort profiling analytics, and demand forecasts to extract context-aware demand flexibility analytics and forecasts.	Combining behavioural, comfort, and demand data provides deeper insights into energy flexibility potential	UC6
ICT-49	Enable flexibility analytics and forecasts for HVAC, domestic hot water (DHW) systems, and other controllable loads within the building environment.	HVAC and DHW systems represent major energy-consuming loads and flexible assets	UC6

ICT-50	Enable flexibility analytics and forecasts for EV charging points taking into consideration information about EV profiles.	Electric vehicle (EV) charging has a significant impact on energy demand.	UC6
ICT-51	Enable flexibility analytics and forecasts for battery storage systems.	Forecasting storage flexibility helps maximize self-consumption, peak shaving, and flex provision	UC6
ICT-52	Ensure flexibility extraction is aligned with the temporal granularity of available energy data, including minute-level resolutions for high accuracy.	Granular data ensures precise flexibility assessments, enabling real-time energy optimization	UC6
ICT-53	Enable short-term flexibility profiling (hours ahead) and forecasts based on real-time and historical energy data.	Short-term flexibility insights based on actual data	UC6

Table 22: ICT Requirements Related to the DIGITISE Use Case

Moving beyond the core data and analytics related functional requirements, the requirements towards the delivery of the business applications of the project are derived. As stated above, there are two key business actors (aggregators but mainly consumers) and therefore the requirements are derived from the relevant questionnaires, always considering the business objectives of the project (as listed in the use cases description following the detailed business scenarios definition).

The analysis starts with the feedback gathered from energy aggregators, offered with services to facilitate the management/enrolment of flexible assets. The non exhaustive list is presented below.

ID	Description	Rationale	Related UC
AGG-01	Support flexible asset classification based on contracted parameters (i.e., activation duration, number of activations, capacity potential, etc.).	Ensuring classification based on contracted parameters allows aggregators to align assets with predefined contractual obligations, ensuring compliance and maximizing efficiency in resource allocation.	UC7
AGG-02	Facilitate flexibility classification based on asset actual parameters (i.e., actual flexibility capacity, type, etc.).	Classifying assets based on their real-time characteristics enables accurate matching of flexibility supply to demand, improving system reliability and performance.	UC7
AGG-03	Enable segmentation of flexibility sources spatially (district and regional levels) and temporally (day, hour, minute, and month).	Spatial and temporal segmentation ensures precise planning and operation of flexibility resources, optimizing their use to address localized and time-specific grid needs.	UC7
AGG-04	Allow filtering of flexibility based on specific time periods, type, capacity, and activation parameters.	Filtering flexibility assets provides aggregators with the ability to quickly identify and deploy the most suitable resources for specific requirements, reducing response time and improving operational agility.	UC7
AGG-05	Provide a user interface for aggregator stakeholders to classify flexibility assets and perform segmentation analysis.	A dedicated user interface empowers stakeholders to make informed decisions by providing intuitive tools for asset classification and segmentation, enhancing usability and operational control.	UC7

AGG-06	Enable the definition of virtual power plants (VPPs) based on flexible asset characteristics (i.e., type, capacity, availability, location, contribution to ancillary services, etc.).	Defining VPPs based on asset characteristics ensures the creation of highly tailored and efficient virtual plants, optimizing their ability to meet specific grid service requirements.	UC7
AGG-07	Support the configuration of VPPs considering economic terms (e.g., contract parameters and availability).	Incorporating economic terms into VPP configuration ensures that the aggregation strategy maximizes profitability while meeting contractual obligations.	UC7
AGG-08	Enable the definition of virtual power plants (VPPs) based on operational timeframes (e.g., schedules and horizons) for the different ancillary services.	Defining VPPs with operational timeframes ensures proper alignment with grid service schedules, improving reliability and coordination with ancillary service markets.	UC7
AGG-09	Allow manual reconfiguration of VPPs by aggregator stakeholders through a dedicated user interface.	Manual reconfiguration enables flexibility to respond to changing conditions or unexpected grid demands, allowing aggregators to maintain adaptability in dynamic environments.	UC7
AGG-10	Allow monitoring through the UI of the performance of each specific VPP campaign.	Monitoring VPP campaign performance provides aggregators with insights to evaluate operational effectiveness, identify issues, and optimize future campaigns.	UC7
AGG-11	Provide a flexibility marketplace environment to allow prosumers to configure their flexible assets' characteristics, i.e. the offered capacity	The definition of such flexibility-related details per asset enables prosumers to start engaging in the flexibility market	UC8
AGG-12	Provide aggregator with the ability to get a full list of flexible assets or search/filter them based on provided criteria, i.e. the type of the flexible asset	Search/filtering of assets allows users (mainly aggregators) to explore and gain more insights on the flexibility potential of the available assets based on various characteristics	UC8
AGG-13	Equip an aggregator with the ability to introduce a new flexibility contract, where all the necessary contract details are defined in a standardized way	Flexibility contracts can be initiated by an aggregator ensuring that the proposed terms are defined in a standardized way for all bilateral agreements	UC8
AGG-14	Prosumers are allowed to negotiate contract terms introduced by an aggregator by providing an altered version of the flexibility contract with edited details	Prosumers should be able to propose counter terms to the ones proposed by the aggregator if they don't agree totally with the initial proposal, as part of a negotiation process	UC8
AGG-15	Provide aggregators the possibility to publish and sign a smart flexibility contract on the Blockchain after both partners have agreed on terms	An established bilateral agreement on the marketplace between an aggregator and a prosumer is made available on the blockchain for ensuring immutability and transparency in the process	UC8
AGG-16	Allow prosumers to sign a smart contract through the flexibility marketplace environment	An established bilateral agreement on the marketplace between an aggregator and a prosumer needs to be sealed by being signed on the blockchain from the prosumer	UC8
AGG-17	Support the flexibility market with automated mechanisms for monitoring and calculating remuneration amounts, exploiting also relevant AI analytics for baselining	Allows the continuous validation and verification of prosumers' response to flexibility requests, facilitating the calculation of the respective remuneration amounts (revenues or penalties)	UC8

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AGG-18	Provide aggregators with a UI to monitor their contracts' performance and relevant analytics at LEC level, in the form of event based as well as weekly and monthly reports	Aggregators' activities in the flexibility market are supported by useful visualizations for gaining better insights of their portfolio's performance	UC8
AGG-19	Allow prosumers, through an intuitive UI, to monitor their individual contracts' performance along insightful analytics in the form of event based as well as monthly reports	Enabling prosumers to receive detailed information and aggregated reports on their financial gains and level of flexibility requests fulfilment	UC8
AGG-20	Allow prosumers to be prioritized in the flexibility contract introduction process based on their assets' flexible capacity	Facilitates the way prosumers are proposed/presented as candidates for flexibility contract participants based on their assets' capacity	UC8

Table 23: Aggregators Requirements Related to the DIGITISE Use Case

Note: Some of the requirements presented above (AGG—11, AGG—14, AGG—16, AGG—19) are more related to the role of consumers/prosumers though presented above as reflect the functionality linked with aggregation of flexibility and enrolment in flexibility services

The last part of the analysis considers feedback gathered from consumers questionnaires, towards the elicitation of the functional aspects/parameters to be considered at the design of the DIGITISE digital solutions (always considering the definition of the use cases and thus reflecting the specific business objectives). The non exhaustive list of requirements is presented below.

ID	Description	Rationale	Related UC
PRO-01	Incorporate real-time/historical data from IoT devices, metering systems, and electric vehicles towards energy optimization	Enables accurate forecasting, monitoring, and optimization of energy consumption.	UC9, UC10
PRO-02	Incorporate short term AI-driven forecasts for energy demand, production, weather conditions, and market prices towards energy optimization	Helps in proactive energy management by anticipating future requirements and market trends.	UC9, UC10
PRO-03	Ensure integration with weather and market price data	Provides critical external inputs for energy planning and cost efficiency.	UC9, UC10
PRO-04	Facilitate the use of AI-driven analytics for forecasting energy demands and baselines	To optimize resource allocation and reduce energy waste.	UC9
PRO-05	Compare energy generation with demand to identify inefficiencies or surpluses.	Identifies areas for improvement to balance supply and demand efficiently.	UC10
PRO-06	Develop optimization strategies for energy self-consumption.	Maximizes the use of self-generated energy, reducing reliance on external sources.	UC10
PRO-07	Facilitate implementation of real-time monitoring and performance assessment for ongoing optimization.	Ensures continuous feedback for system adjustments and sustained performance improvements.	UC10

PRO-08	Offer AI-driven recommendations for energy savings and self-consumption optimization.	To help consumers reduce energy costs and improve energy efficiency.	UC9, UC10
PRO-09	Provide insights and recommendations for cost savings and energy efficiency.	Helps users' lower energy bills and improve the system's cost-effectiveness.	UC9, UC10
PRO-10	Provide insights to improve overall system efficiency, autonomy, and flexibility.	Drives the system towards self-sufficiency and robust performance under diverse conditions.	UC9, UC10
PRO-11	Ensure seamless communication with energy storage systems and flexibility assets to trigger control actions	Facilitates effective integration of energy systems for smooth operation and data exchange.	UC9, UC10, UC13, UC14
PRO-12	Ensure integration of real-time and historic measurements from various household data sources (i.e. appliance consumption, DERs, IoT sensors, etc)	Making sure that a variety of data measurements can be considered for household modelling	UC11
PRO-13	Support the integration of AI baseline analytics for incorporating any user- and energy-related aspects in the household digital twins, i.e. DER generation forecasts or occupancy profiling analytics	Allows the enhancement of system's knowledge with AI analytics insights for providing more realistic/optimized results	UC11
PRO-14	Consider physical aspects of household assets in energy demand(/household) simulations	Exploiting the physical characteristics of the household and its assets ensures a better representation of a household in the digital world	UC11
PRO-15	Allow the configuration of the digital twins with several parameters, i.e. social, energy or economics	Providing flexibility in the different scenarios to be simulated	UC11
PRO-16	Provide an easily accessible interface for interaction with the Digital Twin (request and retrieval of digital twin simulation results) for updating or reviewing the simulated scenarios at any time	Allows Digital Twin users to exploit an interface for easily requesting and retrieving modelling results	UC11
PRO-17	Exploit and extend open-source solutions for the implementation of the Digital Twins	Providing easily customizable Household Digital Twins and effectively combining physical and AI models	UC11
PRO-18	Facilitate the implementation and evaluation of the DIGITISE services and tools	Providing simulation results from the Household Digital Twin allows energy-related services to receive valuable input and evaluate their outcomes, i.e. energy optimization strategies	UC11
PRO-19	Leverage the household digital twin for long term simulations	In order to be able to understand the current status of the household/information related to all existing household assets data	UC12
PRO-20	Integrate forecasts about long term energy consumption	In order to be able to understand the long-term demand of the building environment	UC12
PRO-21	Consider details of nominal characteristics of RES	We need to identify the technical and economic details of potential RES to get installed	UC12
PRO-22	Incorporate information related to installable new assets (e.g. size of the roof available to install solar panels, etc)	In order to recommend the investment tin news assets, we need to understand if these new assets can be installed or not	UC12

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PRO-23	Integrate forecasts about long term energy generation	In order to be able to understand the long-term generation impact from installed RES	UC12
PRO-24	Calculate the ROI of applying specific RES	We need to be able to calculate the ROI of purchasing specific RES assets, comparing the energy consumption costs before and the prediction after the purchase and installation of new RES	UC12
PRO-25	Track most recent details about technical and economic renovation actions	We need to identify the technical and economic details of renovation actions in the building environment	UC12
PRO-26	Calculate the ROI of applying renovation actions	We need to be able to calculate the ROI of performing renovation actions	UC12
PRO-27	Consider details about demand side assets' installation	We need to identify the technical and economic details of installations of new demand assets in the building environment	UC12
PRO-28	Calculate the ROI of applying new demand side assets	We need to be able to calculate the ROI of installing new assets (i.e. HVAC systems)	UC12
PRO-29	Provide the ability to create "virtual assets" as part of the building environment in order to apply the optimization algorithm for multiple scenarios	This will allow us to create multiple assets as part of the household in order to do multiple optimizations, taking into consideration different configurations and different RES assets	UC12
PRO-30	Integrate non-energy, comfort-related sensor data from the household (temperature, humidity etc)	Essential for assessing indoor environmental conditions that impact user comfort.	UC13
PRO-31	Integrate non-energy, health-related sensor data from the household (CO2, PPM etc)	Critical for monitoring air quality and detecting potential health hazards.	UC13
PRO-32	Incorporate information about operational status of specific devices (HVAC, luminance, ventilation)	Necessary for optimizing energy consumption while maintaining comfort and health.	UC13
PRO-33	Consider user preferences regarding the desirable levels of comfort from AI analytics services	Allows personalized adaptation of environmental conditions to user needs.	UC13
PRO-34	Consider user preferences regarding the desirable levels of health standards	Supports data-driven decision-making for long-term health improvements.	UC13
PRO-35	Consider user preferences regarding the desirable levels of security standards	Ensures a balance between security and convenience for occupants.	UC13
PRO-36	Develop optimization strategies for comfort preservation in the building environment	Helps maintain stable indoor conditions despite external climate variations.	UC13
PRO-37	Develop optimization strategies for health preservation in the building environment	Enhances indoor air quality to promote occupant well-being.	UC13
PRO-38	Develop optimization strategies for security enhancement in the building environment	Enhances threat detection through AI-powered monitoring and analytics.	UC13
PRO-39	Facilitate implementation of real-time monitoring and performance assessment for ongoing optimization.	Enables continuous improvement of comfort, health, and security conditions.	UC13
PRO-40	Offer AI-driven recommendations for comfort optimization.	Enhances user experience by learning and adapting to preferences.	UC13

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PRO-41	Provide insights and recommendations for health and security	Helps in identifying patterns and making proactive adjustments.	UC13
PRO-42	Provide insights to improve overall comfort and health conditions in premises	Combines comfort and health metrics for holistic indoor environment management.	UC13
PRO-43	Develop user-friendly interfaces for managing and analysing energy and non-energy data.	Ensures accessibility and ease of use for end-users, allowing them to understand and act on energy-related insights.	UC14
PRO-44	Implement real-time monitoring and reporting for energy consumption and generation	Provides up-to-date information to optimize energy usage and improve efficiency.	UC14
PRO-45	Provide inputs to a user-friendly dashboard for monitoring and control of devices	Enables intuitive interaction with smart energy systems, improving usability and decision-making.	UC14
PRO-46	Provide inputs to a user-friendly dashboard for monitoring sensing conditions	Helps users track environmental and operational parameters that affect energy performance.	UC14
PRO-47	Implement historical data monitoring and reporting for energy consumption.	Supports long-term analysis and trend identification, facilitating better energy planning.	UC14
PRO-48	Consider user input of preferences and schedules for customized energy management.	Allows personalization of energy consumption patterns to enhance efficiency and cost savings.	UC14
PRO-49	Provide information on the status of the storage devices	Ensures awareness of available energy reserves and their optimal utilization.	UC14
PRO-50	Provide information on the status of the EV charging points	Supports efficient EV charging management, improving availability and reducing wait times.	UC14
PRO-51	Implement real-time monitoring of energy performance and self-consumption indicators	Helps users assess the overall energy performance	UC14
PRO-52	Implement monitoring of comfort and healthy indicators	Enhances user well-being by ensuring that energy management strategies do not compromise indoor comfort and air quality.	UC14
PRO-53	Implement monitoring of technoeconomic analysis of potential investments on DERs and renovation actions	Aids in making informed financial decisions regarding energy infrastructure upgrades.	UC14
PRO-54	Implement visualization of intuitive recommendations for the different actions of the project	Simplifies decision-making by providing actionable insights for the different services	UC14
PRO-55	Leverage info on frequent activities in the households and their flexibility at an individual level	Encourages demand-side flexibility by analysing and optimizing household energy habits.	UC14
PRO-56	Provide a comparative view with neighbours' performance	Motivates energy-efficient behaviour by providing benchmarks and insights from peer performance.	UC14

Table 24: Prosumers – Consumers Requirements Related to the DIGITISE Use Case

7.2 DIGITISE Nonfunctional requirements

In this section, the list of non-functional requirements is defined considering technical requirements about the development/deployment analysis as well as social driven, ethical, behavioural and regulatory requirements as derived from discussions and consultation

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with demo citizens (energy dialogues) and the business stakeholders. A non-exhaustive list is presented below, while the elaboration of this list will be continuously performed considering the continuous discussions with the users that are part of the engagement groups and the technical partners during the development phase of the project.

ID	Description	Rationale	Type
NF-01	Ensure accessibility for vulnerable groups	Prevent digital discrimination and provide clear guidelines on funding and support access	Social
NF-02	Enhance digital inclusion	Provide user-friendly digital tools and training to ensure all population groups can effectively engage with new energy technologies	Social
NF-03	Ensure inclusivity in smart energy solutions	Design interfaces that accommodate diverse user needs, including elderly individuals and those with disabilities	Social
NF-04	Mitigate risks of energy poverty	Implement targeted assistance programs to ensure low-income households are not disproportionately affected	Economic
NF-05	Minimize financial burden of energy transition	Implement cost-effective strategies and financial support mechanisms to ensure affordability for all users	Economic
NF-06	Provide transparent cost-benefit analyses	Clearly communicate the financial impact of energy investments to motivate participation	Economic
NF-07	Facilitate energy-sharing models	Encourage community-based peer-to-peer energy exchange systems to optimize local resources	Economic
NF-08	Prioritize heating and cooling efficiency	Focus on solutions that optimize energy use in heating and cooling, which are major consumption areas	Economic
NF-09	Develop AI-driven or intermediary-supported personalized energy management support	Cater to individual energy needs and preferences	Behavioural
NF-10	Adapt energy policies to diverse consumption patterns	Consider variations in energy use due to economic, cultural, and technological differences	Economic
NF-11	Balance energy efficiency with user comfort	Implement solutions that optimize energy savings without compromising indoor living conditions	Behavioural
NF-12	Encourage collective participation in the energy transition	Facilitate collaboration among individuals, local authorities, and private companies with clear roles and responsibilities	Social
NF-13	Foster trust in energy solutions	Improve transparency in decision-making processes to increase public confidence in energy transition initiatives	Social
NF-14	Reduce fear of automation in energy systems	Ensure human oversight in automated energy management to maintain user control and comfort	Social
NF-15	Address psychological barriers to change	Implement behavioural interventions that reduce resistance to adopting sustainable practices	Behavioural
NF-16	Promote energy-conscious consumer behaviour	Encourage responsible energy use through nudging techniques and gamification strategies	Behavioural

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NF-17	Foster behavioural shifts through awareness	Promote best practices and emphasize the environmental impact of energy choices	Behavioural
NF-18	Support gradual cultural adaptation to new energy models	Implement phased transition strategies with proper training to reduce resistance and adaptation challenges	Behavioural
NF-19	Support flexible energy lifestyles	Design energy management systems that accommodate varying work schedules	Behavioural
NF-20	Implement incentive-based mechanisms	Introduce penalties and rewards to drive sustainable energy behaviour	Economic
NF-21	Develop training programs for intermediaries	Equip energy advisors, local authorities, and NGOs with the skills needed to guide consumers effectively	Social
NF-22	Increase visibility of successful behaviour projects	Highlight real-world examples of sustainable energy initiatives to inspire replication	Social
NF-23	Deliver tangible benefits of energy transition	Showcase successful impact and business cases to increase trust and engagement	Economic
NF-24	Prevent social fragmentation	Develop energy transition strategies that maintain societal cohesion and avoid widening demographic divisions	Social
NF-25	Strengthen legal frameworks for energy transition	Implement policies that balance EU directives with localized governance	Regulatory
NF-26	Simplify administrative processes	Reduce bureaucratic barriers and streamline citizen involvement in energy initiatives	Regulatory
NF-27	Address transparency and governance issues	Implement anti-corruption measures and improve public engagement in energy decision-making	Regulatory
NF-28	Clarify data ownership and privacy concerns	Establish clear guidelines on data management, balancing personalized services with user control and security	Regulatory
NF-29	Clarify data security concerns	Establish clear security measures on data management	Regulatory
NF-30	Ensure transparency on data sharing	Establish clear market-based data-sharing mechanisms to enhance trust and transparency	Regulatory
NF-31	Consider AI explainability features on AI analytics	Ensure AI-driven decision-making is interpretable and trustworthy for users	Regulatory
NF-32	Ensure the adaptation of GDPR principles as adopted per country	Align data protection policies with national GDPR implementations	Regulatory
NF-33	Support an authentication mechanism to ensure classified RBAC access	Strengthen security by enforcing Role-Based Access Control (RBAC)	Regulatory
NF-34	Consider the national regulation for energy performance on the customization of different business applications	Ensure energy solutions comply with national energy performance standards	Regulatory
NF-35	Consider the national regulation for self-consumption on the customization of different business applications	Align self-consumption strategies with national policies	Regulatory

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NF-36	Consider the national regulation for energy markets operation on the customization of different business applications	Ensure compliance with national energy market regulations	Regulatory
NF-37	Consider the national regulation and ongoing programs to promote investments and interventions	Leverage national policies to support energy transition investments	Regulatory
NF-38	Consider the national mechanisms towards addressing energy poverty on the customization of different business applications	Align business models with national programs to mitigate energy poverty	Regulatory
NF-39	Consider the national regulation for the provision of non-energy services in the DIGITISE project	Ensure non-energy service offerings comply with national legal frameworks	Regulatory
NF-40	The overall development and deployment of solutions must prioritize scalability and expandability	Scalability ensures the system can grow and adapt to increasing demands without major overhauls	Technical
NF-41	Reliable applications must be provided to meet the needs of citizens	Reliability builds trust and enhances user satisfaction and engagement	Technical
NF-42	Creating user-friendly applications (UX) is essential for satisfying citizens' requirements	A positive UX increases satisfaction and encourages effective use of applications	Technical
NF-43	The aesthetic design and user interface (UI) of the applications are crucial for citizens, and therefore, the applications should be visually appealing	Attractive designs enhance user engagement and contribute to a more enjoyable and intuitive experience	Technical
NF-44	Citizens should have access to various applications through multiple channels, such as mobile devices and the web	Multi-channel access increases inclusivity and convenience for users	Technical
NF-45	The applications should support localization to cater to the diverse needs of citizens	Localization makes applications relevant and accessible for users from different backgrounds	Technical
NF-46	A comprehensive logging and monitoring system should be in place to track user activity and system performance	Monitoring helps identify issues and improves user experience, aiding in compliance and security	Technical
NF-47	The application should support automated updates to ensure users have access to the latest features and security enhancements	Automated updates enhance security and functionality, reducing vulnerabilities from outdated software	Technical
NF-48	The system should include comprehensive documentation and user guides to assist citizens and administrators	Documentation supports user training and helps resolve issues independently	Technical
NF-49	The system must ensure high availability to minimize downtime	High availability maintains user trust and ensures access to services when needed	Technical
NF-50	The applications should be designed for cross-platform compatibility, ensuring a consistent experience on different devices and operating systems	Cross-platform compatibility ensures all users have a seamless experience, promoting broader adoption	Technical

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NF-51	DIGITISE should provide analytics dashboards for administrators to monitor system usage and performance metrics	Dashboards enable informed decision-making based on real-time data, improving management and resource allocation	Technical
NF-52	DIGITISE shall support open standards to ensure compatibility with a wide range of third-party systems and devices	Open standards enhance interoperability and facilitate integration with existing systems	Technical
NF-53	Applications developed within DIGITISE shall be designed for optimal performance, minimizing latency and ensuring quick response times for users	Optimal performance is crucial for user satisfaction, as slow response times can lead to frustration	Technical
NF-54	DIGITISE shall adopt a modular architecture that allows for independent development, testing, and deployment of components	A modular approach supports flexibility, allowing simultaneous work on components and simplifying updates	Technical
NF-55	DIGITISE shall implement mechanisms to ensure data integrity throughout its lifecycle, including validation checks and redundancy measures to prevent data loss or corruption	Data integrity maintains trust and accuracy, preventing loss and errors critical for operational efficiency	Technical

Table 25: Non-Functional DIGITISE Requirements

In conclusion, the extraction of functional and non-functional requirements for DIGITISE emphasizes the importance of user-centric design and system reliability. By prioritizing end users' engagement in the overall co creation process, the project aims to deliver effective solutions that meet the diverse needs of citizens. Additionally, the focus on open standards and modular architecture ensures adaptability and integration with existing systems. Overall, these requirements lay a strong foundation for creating robust applications that enhance citizen engagement and satisfaction.

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8 Summary and Conclusions

The DIGITISE project has undertaken a rigorous and systematic approach to defining end-user requirements, addressing socio-economic barriers, and formulating a robust framework for digital energy services. The findings of this deliverable, D2.1, have been derived from extensive stakeholder engagement, and regulatory assessments, all of which serve as a foundation for the technical implementation of the project.

A structured methodology was adopted to define the business scenarios and corresponding use cases, ensuring that the proposed solutions align with real-world energy system operations. Seven distinct business scenarios were formulated, classified into data-driven and service-driven approaches. These scenarios address data governance aspects, AI-driven energy insights, digital twin applications, and enhanced energy applications features.

A set of 14 use cases was developed, providing detailed functional descriptions that will guide the subsequent system design and implementation. The use cases emphasize the importance of secure data exchange, AI-enabled forecasting for energy demand and flexibility, smart contract-based energy trading, and optimized self-consumption strategies among others.

Then, on the basis of business objectives as defined through the business scenarios and use cases definition, the analysis of end user needs is performed. The study has identified key insights through an extensive consultation process involving multiple energy actors, including prosumers, consumer, aggregators, and ICT partners. Structured questionnaires were provided, and feedback was gathered and analysed to extract the functional and technical priorities and needs to be considered towards the implementation of the DIGITISE solution.

As a parallel action and considering also the need for active enrolment of citizens in project activities, social and behavioural aspects should be considered in the overall design of DIGITISE solution. Towards this direction, and in full compliance with the engagement methodology as defined in WP7/T7.1, discussions with citizens, consumers and prosumers, took place to identify key social and behavioural priorities and barriers that affect the applicability and mass penetration of digital solutions and services as examined in the project.

Also, the regulatory analysis conducted within the project has highlighted the necessity of ensuring compliance with EU energy policies, GDPR, and national energy market regulations. Various country-specific regulatory barriers have been identified, particularly those related to data protection, consumer rights, and the integration of distributed energy resources into flexibility markets. Addressing these regulatory constraints is crucial for ensuring the scalability and interoperability of the DIGITISE framework across different energy markets.

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Following the extensive study of business, social and regulatory aspects, the requirements extraction process has resulted in a structured set of business, technical, and regulatory requirements that define the system's architecture. The project emphasizes the integration of interoperable data management frameworks, AI-driven analytics, digital twins and social driven energy applications to create a holistic and intelligent energy management ecosystem. The design of the DIGITISE platform must prioritize modularity and scalability to accommodate varying levels of technological maturity and regulatory structures across European markets.

The conclusions drawn from this study underscore the importance of a multidisciplinary approach that combines engineering, regulatory, and socio-economic expertise. Moving forward, the project will focus on translating these requirements into functional prototypes that will be reflected in the architecture definition in T2.5 and further to the DIGITISE solutions implementation in WP3/WP4/WP5.

Note: As the project evolves, updates on the list of requirements and priorities may be considered. Any updates will be reported in the 2nd version of the work in T2.1/T2.2 to be provided in D2.3.

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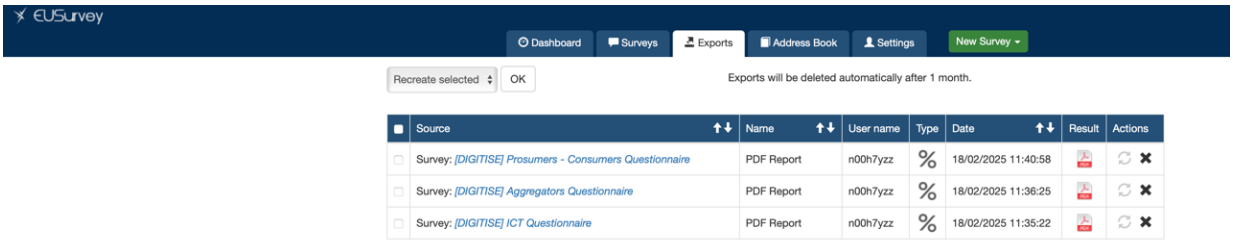
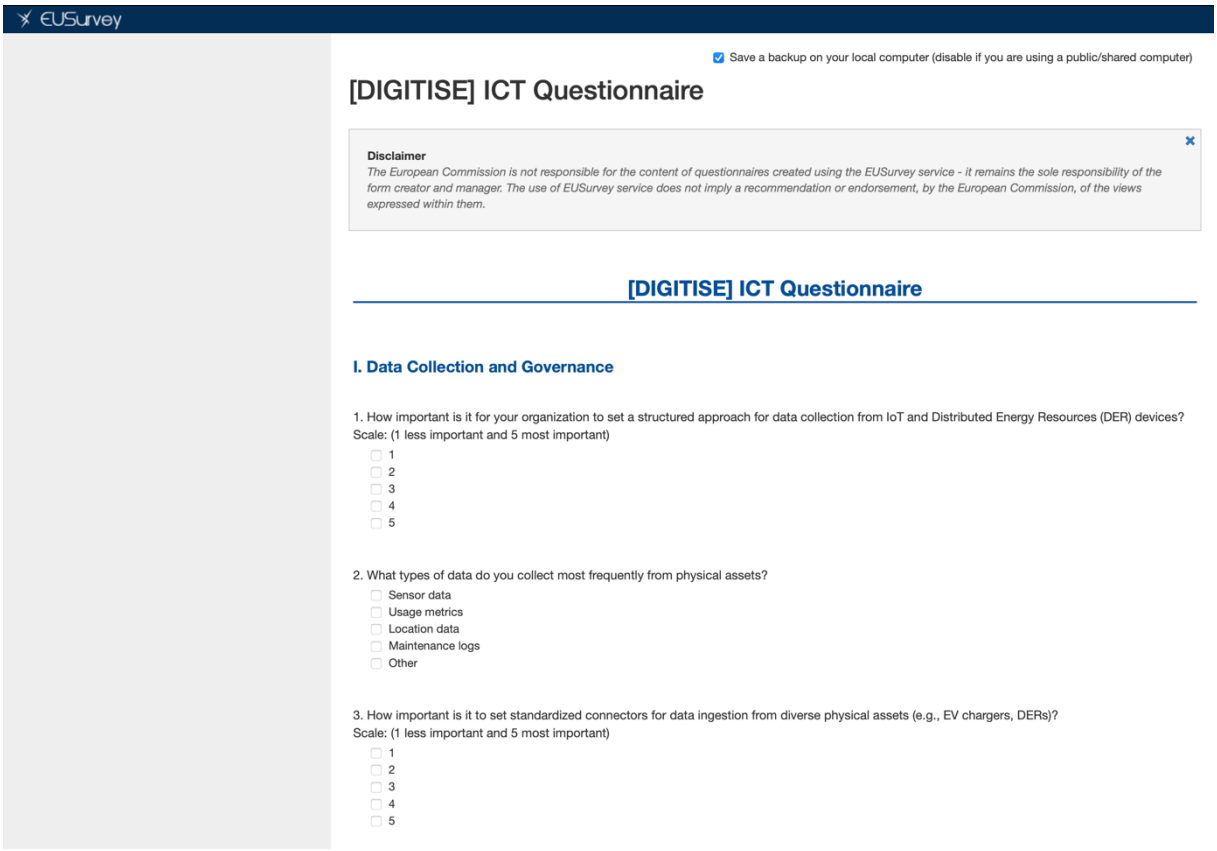
10 Annex I – Questionnaires Template and Results Overview

The data collection process used three targeted questionnaires for Prosumers-Consumers, Aggregators, and ICT partners. Distributed digitally via the EU Survey tool, the questionnaires reached DIGITISE partners.



Tangible evidence is presented below as screenshots of the first page of the questionnaires and the results, as well. The whole reports for the questionnaires are available at the project's repository.

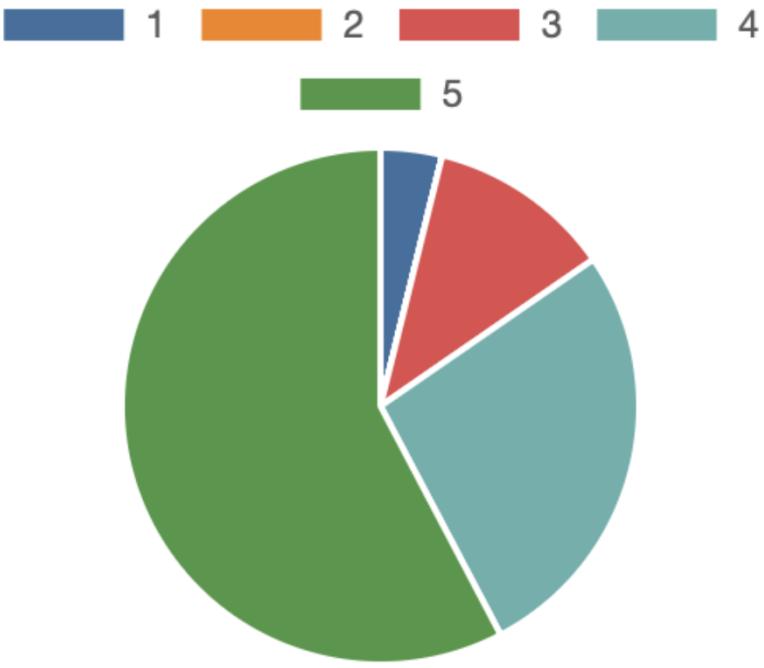
ICT Questionnaire and Results



Statistics: [DIGITISE] ICT Questionnaire

1. How important is it for your organization to set a structured approach for data collection from IoT and Distributed Energy Resources (DER) devices? Scale: (1 less important and 5 most important)

		Answers	Ratio
1		1	3.7 %
2		0	0 %
3		3	11.11 %
4		7	25.93 %
5		15	55.56 %
No Answer		1	3.7 %



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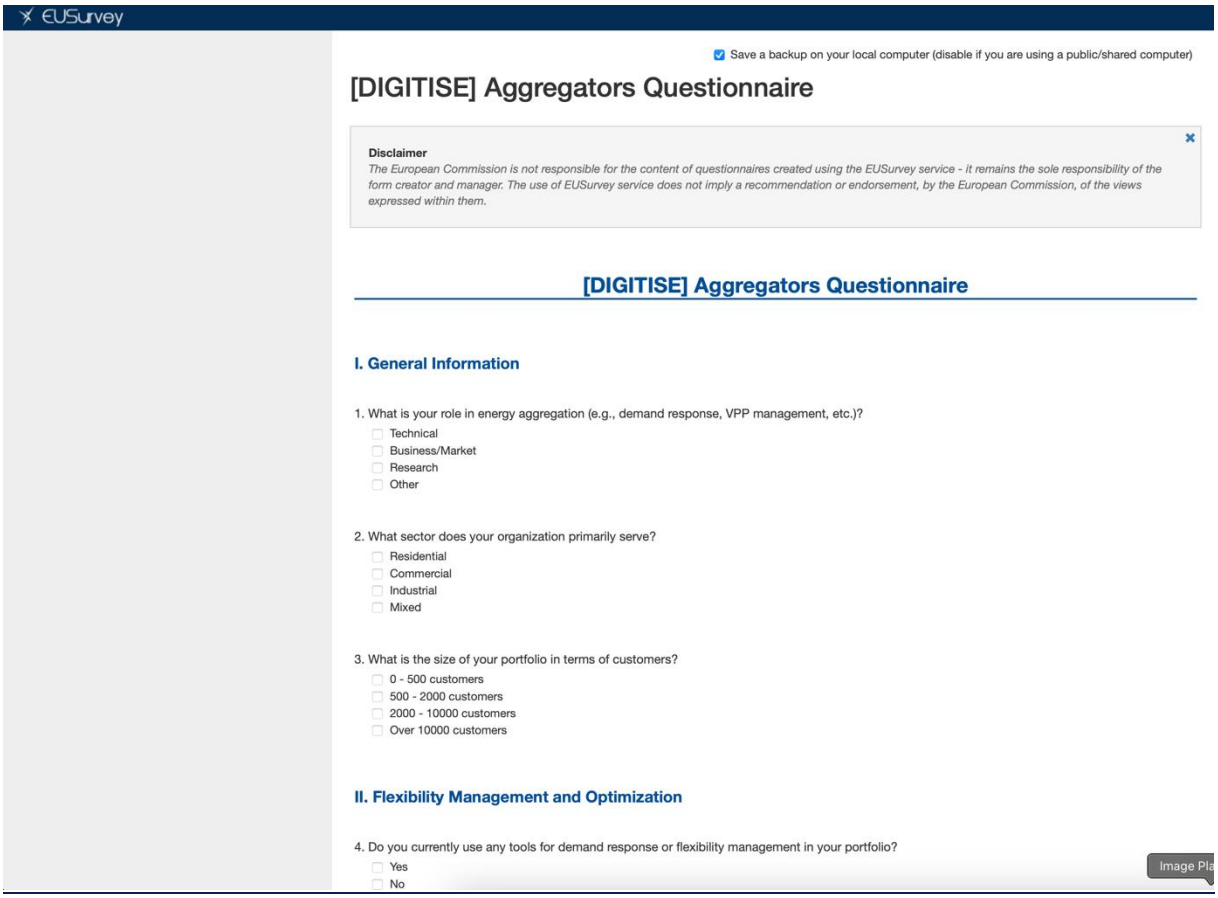
Aggregators Questionnaire and Results


EUSurvey

Save a backup on your local computer (disable if you are using a public/shared computer)

[DIGITISE] Aggregators Questionnaire

Disclaimer

The European Commission is not responsible for the content of questionnaires created using the EUSurvey service - it remains the sole responsibility of the form creator and manager. The use of EUSurvey service does not imply a recommendation or endorsement, by the European Commission, of the views expressed within them.

[DIGITISE] Aggregators Questionnaire

I. General Information

1. What is your role in energy aggregation (e.g., demand response, VPP management, etc.)?
- Technical
- Business/Market
- Research
- Other

2. What sector does your organization primarily serve?
- Residential
- Commercial
- Industrial
- Mixed

3. What is the size of your portfolio in terms of customers?
- 0 - 500 customers
- 500 - 2000 customers
- 2000 - 10000 customers
- Over 10000 customers

II. Flexibility Management and Optimization

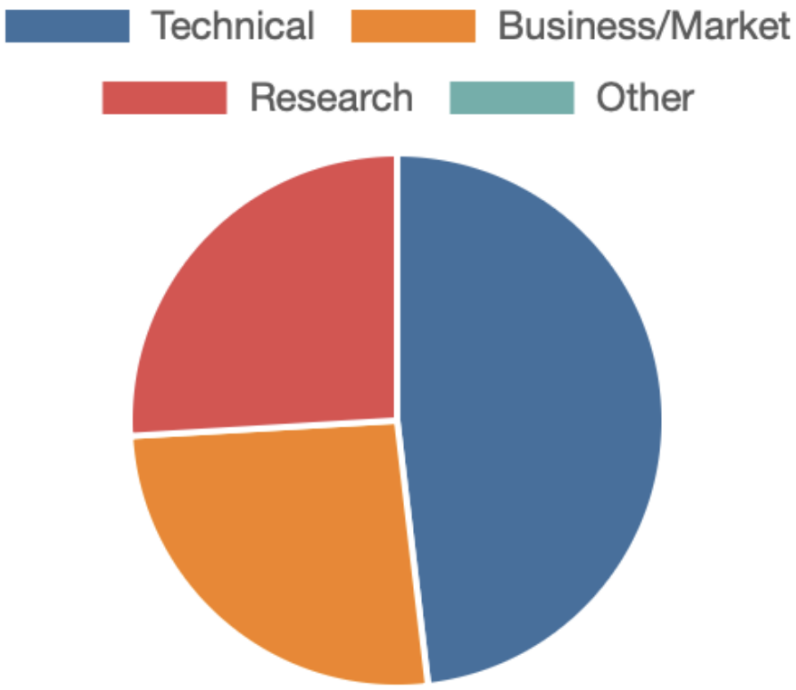
4. Do you currently use any tools for demand response or flexibility management in your portfolio?
- Yes
- No

Image Pla

Statistics: [DIGITISE] Aggregators Questionnaire

1. What is your role in energy aggregation (e.g., demand response, VPP management, etc.)?

		Answers	Ratio
Technical		13	68.42 %
Business/Market		7	36.84 %
Research		7	36.84 %
Other		0	0 %
No Answer		0	0 %



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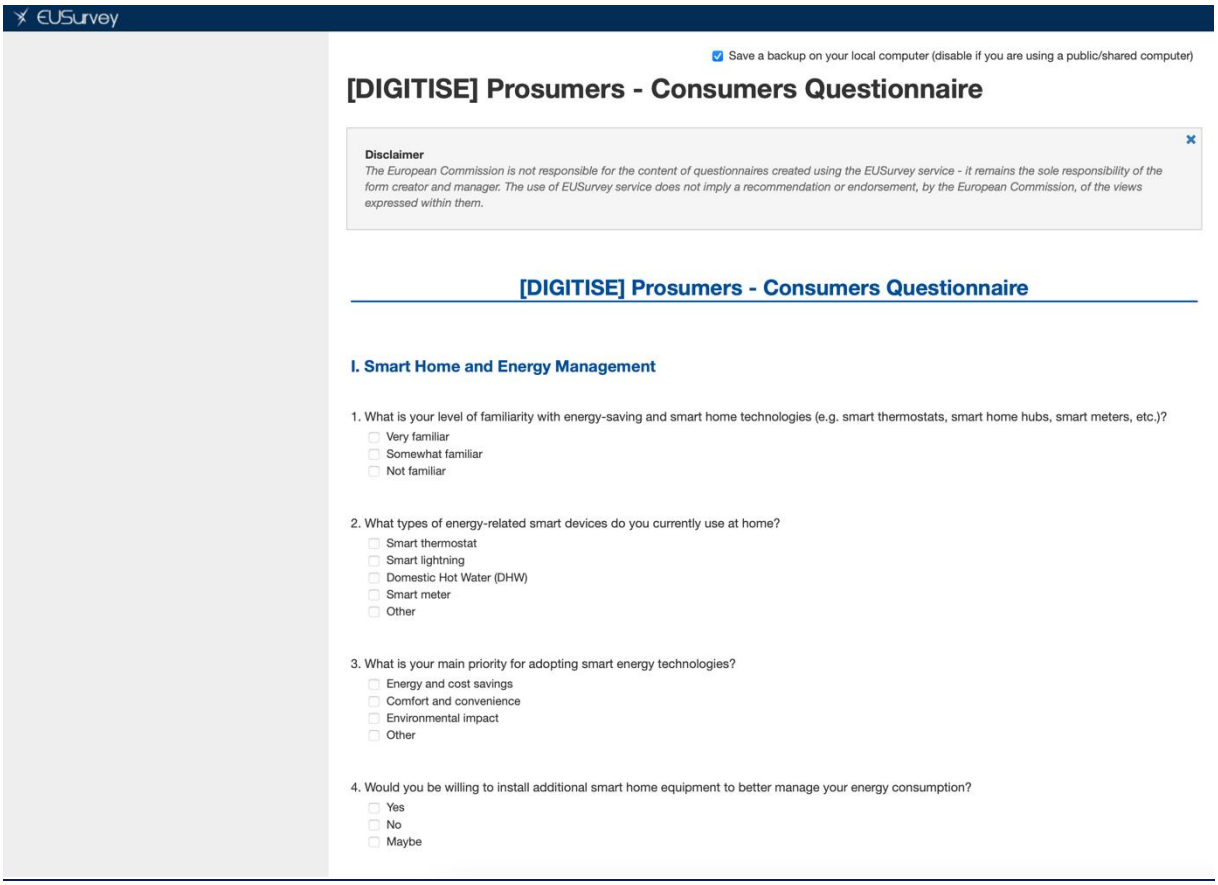
Prosumers – Consumers Questionnaire and Results



EUSurvey

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[DIGITISE] Prosumers - Consumers Questionnaire

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[DIGITISE] Prosumers - Consumers Questionnaire

I. Smart Home and Energy Management

1. What is your level of familiarity with energy-saving and smart home technologies (e.g. smart thermostats, smart home hubs, smart meters, etc.)?
   - Very familiar
   - Somewhat familiar
   - Not familiar

2. What types of energy-related smart devices do you currently use at home?
   - Smart thermostat
   - Smart lightning
   - Domestic Hot Water (DHW)
   - Smart meter
   - Other

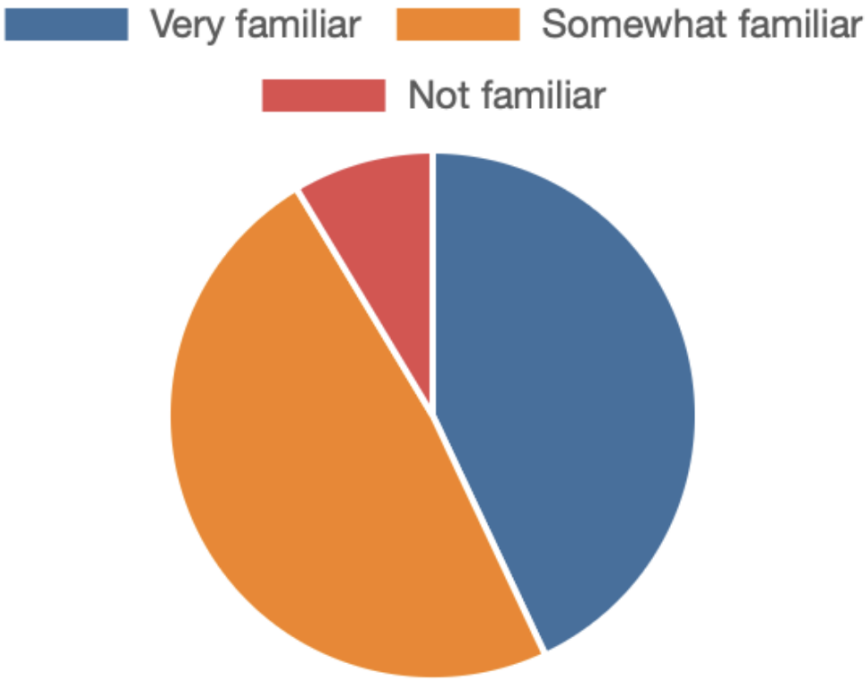
3. What is your main priority for adopting smart energy technologies?
   - Energy and cost savings
   - Comfort and convenience
   - Environmental impact
   - Other

4. Would you be willing to install additional smart home equipment to better manage your energy consumption?
   - Yes
   - No
   - Maybe

Statistics: [DIGITISE] Prosumers - Consumers Questionnaire

1. What is your level of familiarity with energy-saving and smart home technologies (e.g. smart thermostats, smart home hubs, smart meters, etc.)?

		Answers	Ratio
Very familiar		40	36.7 %
Somewhat familiar		45	41.28 %
Not familiar		8	7.34 %
No Answer		16	14.68 %



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11 Annex II- Energy dialogues with Focus groups

The dialogues are based on the principles of citizens' deliberation, meaning they go beyond mere discussion and aim to achieve a defined output from the discussion, based on clear arguments, thanks to the support of trained discussion facilitators. Each dialogue gathers twenty citizens and ten stakeholders, with a diversity of life experience and relation to the energy sector. Particular attention was paid to ensuring the participation of different publics, who are not often heard in the public debate or who don't have the opportunity to talk to each other.

The program for the first dialogue is based on four blocks of discussion in an iterative way: participants start talking broadly about the topic of energy and then go deeper into how the energy transition can be successful within their community. The dialogue ends by opening the reflection on what tools are needed to support the energy transition, which opens the way for the next steps of the DIGITISE project.

During the dialogue, there are dedicated moments for stakeholders and citizens on each side, as well as moments where they are brought together to share experiences and exchange views. The program of the first Energy Dialogue is as follows:

<table>
<tr><th>Sequence</th><th colspan="2">Details</th></tr>
<tr><td>Welcome
(Citizens and stakeholders together)</td><td colspan="2">Objective: Ensuring everyone feels at ease in the process
Expected output: Participants are ready to actively participate</td></tr>
<tr><td>Introduction to the day
(Citizens and stakeholders together)</td><td colspan="2">Objective: Frame the context of this workshop
• Presentation of the DIGTISE project and team
• Overall timeline of the project and why we do deliberation groups
• Objective of the day
• How to deliberate together
• Logistical aspects
Expected output: Participants understand why they are being asked to participate and in what context.</td></tr>
<tr><td rowspan="2">Energy Story
(Citizens and stakeholders separated)</td><td colspan="2">Objective: Understand how people/stakeholders use and perceived energy</td></tr>
<tr><td>For citizens:
• What are the ways you use energy in your life?
• Do you understand how energy system works?</td><td>For stakeholders:
• How do you work on energy?
• What are the priorities for the energy sector and at</td></tr>
</table>

<table>
<tr><td></td><td colspan="2">How has the way you use energy changed?</td><td>what level should they be tackled?
What are the things you can do now to improve the energy system that you couldn't do 10 years ago (= innovations)?
What are the things you used to do that you have stopped doing to better support the energy transition (=relics)? In both cases how hard was it to change?</td></tr>
<tr><td></td><td colspan="3">Expected outputs: People understand that
Everyone has a different position or view on energy
It is a complex issue with many people involved.
It has become a new hot topic, but things have been changing for a number of years.</td></tr>
<tr><td>Energy diary
(Citizens and stakeholders together)</td><td colspan="3">Objective: Get a projection on how our community will change in the coming years based on a scenario of a successful energy transition

Participants read relatable and detailed descriptions of the ways energy use will be changing by 2030 in their community
How you react to this scenario?
What might be the consequences of such a change for you? Do you think other people may be impacted differently?
Is there anything about this community that means those changes would make life difficult?
Expected output: Participants get an idea of what their community looks like and how it could affect their daily lives, the relationships between citizens, the drivers of the community, their interaction with other stakeholders.</td></tr>
<tr><td colspan="4">Break</td></tr>
<tr><td rowspan="2">Energy obstacles and enablers
(Citizens and stakeholders separated)</td><td colspan="3">Objective: -based on the Energy diary - Understand the obstacles and enablers that could help the building of a new energy system in the energy and who should do what in order to make it a success</td></tr>
<tr><td colspan="2">Obstacles of citizens' implications
Fear/ Misunderstanding
Financial and economic
Unfairness
Lack of skills/technical</td><td>Obstacles of stakeholder's implication
Political and legal
Financial and economic
Commercial</td></tr>
</table>

	Which public should we give particular attention to and why? *What do you expect from the stakeholders (public authorities, private companies, national state…)?* *What will give us a push to move forward?*	*Which public should we give particular attention to and why?* *What do you expect from the other stakeholders (upper authorities, citizens, association…)?* *What will give us a push to move forward?*
	Expected output: Participants have identified what the barriers are and who should do what to overcome them, taking into account all the different publics within the community. They see that some things depend on them, but others don't.	
Energy shift *(Citizens and stakeholders together)*	**Objective:** -based on the obstacles and enablers identified in the previous section – face three scenarios of potential new energy tool in your community and look what you like/don't like in it • *Which scenario do you prefer? Is there one that they don't particularly like?* • *Do you see yourself in this scenario, how they would be active in it?* ***Expected output:*** Participants understand how it can be concretized and implemented in their community and what are the pro and cons of each solution	
Conclusion	**Objective: Remind of the purpose of the project and the next steps** *Expected output: people are happy with the day and want to get more involved in energy management in their community/home.*	

Some pictures of the energy dialogues in the different countries:

Some of the materials used for the discussions of the first Energy dialogue: