



D5.2: DEDALUS Pilots' execution documentation and consumers' engagement pre-pilot phase

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WP 5, T 5.2 – T 5.8



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List of Acronyms

A/C	Air Condition
API	Application Programming Interface
BEMS	Building Energy Management System
DHW	Domestic Hot Water
DLT	Distributed Ledger Technology
DR	Demand Response
DSO	Distribution System Operator
EC	European Commission
EFI	Energy Flexibility Indicator
EV	Electric Vehicle
GDPR	General Data Protection Regulation
GUI	Graphical User Interface
HVAC	Heating, Ventilation, and Air Conditioning
IAQ	Indoor Air Quality
KPI	Key Performance Indicator
LSTM	Long Short-Term Memory
MAE	Mean Absolute Error
MQTT	Message Queuing Telemetry Transport
MSE	Mean Squared Error
P2P	Peer-to-Peer
PCA	Principal Component Analysis
PV	Photovoltaic
RES	Renewable Energy Sources
RTU	Remote Terminal Unit
SAB	Social Acceptance Booster
TAM	Technology Acceptance Model
TE	Technology Enabler
TSO	Transmission System Operator



USG	Universal Secure Gateway
WP	Work Package



Executive summary

The "DEDALUS Pilots' execution documentation and consumers' engagement pre-pilot phase" report provides a detailed reporting of the preliminary demonstration activities executed in the pre-pilot phase (M14-M16), including updates on pilot infrastructure, early asset and technology assessment. In addition, it encapsulates the planned engagement and social acceptance strategies, outlining the framework for forthcoming technical workshops and residential user engagement strategies.

In the pre-pilot phase, the more mature technology enablers (TEs) developed under WP3, WP4, and reported in D3.1 – “DEDALUS technological enablers for multi-value and energy carrier-agnostic residential DR (1st technology release)” and D4.1 – “‘First wave’ of DEDALUS Digital Twins and data-driven services for residential DR”, were tested in a select group of front runner pilot sites equipped with sufficient data and infrastructure readiness. An impact analysis of the demonstrated activities and technologies was conducted indicated by the progress of the Key Performance Indicators (KPIs) that were established and elaborated for each pilot site in the previous deliverable of WP5 (D5.1 – “DEDALUS evaluation methodology, baseline assessment and pilot implementation plan”) assessing the technological feasibility, user engagements, economic viability and environmental benefits of the DEDALUS services. Given the nascent phase of the TEs, advancements in the KPIs were modest. Nevertheless, based on the applied evaluation framework, valuable insights into each technology's application were derived, including its inputs and outputs, and suggested improvements to meet the specific needs and goals of the pilot. Further, the pilot-specific implementation plan was updated to reflect a structured timeline up to the next pilot cycle, encapsulating technology enabler implementation, user engagement, and evaluation periods. This structured approach ensures all stakeholders are well-informed of progress and expectations across each demonstration site, aligning with the project's overarching goal to enhance technological capabilities and conduct effective pilots.

As the DEDALUS project progresses through its subsequent phases—Product Integration & Fine Tuning (M17-M25) and Product Assessment & Market Uptake (M26-M36)—it will continue to refine its components and system-level technologies based on pilot feedback, ultimately leading to scalable, market-ready solutions.



1. Introduction

1.1. Purpose and audience of the document

This document constitutes the initial report outlining the progress of the DEDALUS project's demonstration activities during the pre-pilot cycle at various pilot sites, as framed by the existing evaluation framework. It informs all involved energy stakeholders of the advancements achieved in relation to the KPIs and the deployment of services. Additionally, this report acts as a roadmap for forthcoming engagement and social acceptance initiatives across each pilot site and outlines the implementation schedule for TEs for the latter half of the project.

The primary aim of this document is to evaluate the impacts of the deployed technologies within the pilot sites, ensuring that all stakeholders, including technology providers and pilot site managers, are fully informed of the outcomes. This enables a clear understanding of how these technologies perform in real-world settings and guides the continuous refinement and optimization of the project's tools and services. As such, this report is a critical tool for guiding the execution and ongoing assessment of activities, aligning with the DEDALUS project's goals of advancing energy efficiency and enhancing user engagement in DR programmes.

1.2. Relation to other activities

This document builds upon the framework outlined in D5.1 – “DEDALUS evaluation methodology, baseline assessment and pilot implementation plan” and integrates insights from the pilot site leaders, technology providers, and experts in social sciences and humanities. It connects with several aspects of the project's activities as follows:

- It discusses the current state of pilot infrastructure and the on-going updates, demonstrates the application of the evaluation framework, and updates the pilot-specific implementation plans under Task 5.1.
- The document captures lessons from initial engagement activities with the residential end-users, including the distribution of questionnaires (Task 2.3) and insights from co-creation workshops (Task 2.4). The feedback from these interactions has led to the development of a preliminary technical workshop approach and strategies for enhancing user engagement.
- It outlines the assessment of the first version of technologies developed under WP3 and WP4 deployed along a subset of pilot sites, providing actionable insights for both technology providers and pilot site leaders to refine their services.

Importantly, this document sets the stage for future reporting and development within the project. It will directly contribute to the forthcoming deliverables of WP5, which will encompass detailed reports on the demonstration activities for the second pilot cycle (full pilot operation phase) and third pilot cycle (large scale pilot operation phase).

1.3. Structure of the document

The document is structured as follows:



- Section 2 delves into the engagement and social acceptance actions initiated during the pre-pilot cycle. This includes a comprehensive analysis of the outcomes from both the questionnaire survey and the co-creation workshops, which were instrumental in shaping the initial designs of the technical workshops and crafting strategies for ongoing engagement with residential end-users in DR programmes.
- Sections 3-9 are dedicated to monitoring the progress of the pilot sites, with detailed updates on both the physical and digital infrastructure enhancements made during the pre-pilot phase. The impact analysis is thoroughly presented, assessing the effectiveness of the deployed TEs and the progress of KPIs. Each TE's performance is evaluated based on its functionality, integration capabilities, and user acceptance, as per the structured matrix filled out by technology providers for each pilot cycle that was included in D5.1 – “DEDALUS evaluation methodology, baseline assessment and pilot implementation plan”. The matrix includes critical assessments such as the TE's demonstration strategy, key metrics for successful implementation, inputs used, outputs generated, the primary end-user demographic, and suggested improvements based on iterative feedback and usage patterns. Through this framework it is ensured that each technology's direct impact on the pilot's objectives is clearly understood and effectively measured, guiding subsequent optimizations and integrations within the project lifecycle. These sections also include the revised pilot-specific implementation plans extending up to month 25, featuring updated Gantt Charts and outlining the TEs scheduled for evaluation in subsequent pilot cycles.
- Section 10 presents the conclusions of this deliverable.



2. Engagement and social acceptance actions

2.1. Lessons learned from the questionnaire survey

The questionnaire survey circulation held in M3 to M9 aimed to collect socio-economic information about participants, combined with their perspectives and awareness regarding energy issues and demand response, successfully engaging. Through the analysis of their responses a profile persona was produced, and each pilot was split into different distinct personas. This segmentation process led to participant groups of distinct character. The number of segments per pilot depends on the number of participants – the larger the pilot population, the more abilities we have to segment producing an analysable segment population. In addition, it depends on the level of distinction among the different segments once we use the key segmentation factors to form them. The awareness on the specificities of each pilot and thereupon of each pilot segment shall lead to a better understanding of the targeted users. As a result, it shall assist designing a customized and more efficient strategy to approach them, cover their needs and render DR programmes appealing for them. Further information on the analysis is available in the ensuing sections dedicated to each pilot - see the respective presentation of TE-1 per pilot.

The principal persona dimensions that led to the residential users segmentation and were their willingness to participate in DR programmes and also their level of familiarity with the concept of DR. The dominant features per pilot were presented and juxtaposed against the dominant features per pilot segment. The synthesis of those pieces of information was used to grade the prospects of applying DR for each segment. The final outcome is presented in the table below, Table 1.

Table 1: Assessment of DR prospects per pilot segment

	*	DR Prospects
Denmark	Segment A: Willing	High
	Segment B: Unwilling	Medium
Italy	Segment A: Willing	High
	Segment B: Unwilling	Low
Greece	Segment A: Willing & Familiar	High
	Segment B: Willing & Unfamiliar	High
	Segment C: Unwilling & Familiar	High



	*	DR Prospects
	Segment D: Unwilling & Unfamiliar	Medium
Spain	Segment A: Familiar	High
	Segment B: Unfamiliar	Low
Austria	Segment A: Willing & Familiar	High
	Segment B: Willing & Unfamiliar	Medium
	Segment C: Unwilling	Low
Romania	Segment A: Willing & Familiar	High
	Segment B: Willing & Unfamiliar	Medium
	Segment C: Unwilling & Familiar	Medium
	Segment D: Unwilling & Unfamiliar	Medium

2.2. Insights from the co-creation workshop

The co-creation workshops held in M12 to M14 have successfully engaged a diverse group of participants across multiple pilot sites. These participants include 52 residents, building managers, and other stakeholders from various demographic backgrounds.

The co-creation workshops employed a structured approach to gather insights and feedback from participants. The methodology was designed to be modular, allowing pilot partners to select and adapt activities based on their specific needs and goals. The primary activities included:

- **Barriers and Drivers Activity:** This activity utilised the Q-sort methodology to identify the barriers and drivers associated with comfort-based flexibility models in energy demand response (DR) services. Participants ranked a set of statements along a continuum based on their level of agreement or disagreement. The results were then analysed using principal component analysis (PCA) to identify distinct user groups and consensus statements.
- **Incentive Activity:** This activity involved ranking a set of incentive statements and participating in structured focus group discussions. Participants explored various incentives, including recognition and rewards, community contributions, environmental impact, and gamification. The goal was to identify the most appealing incentives and gather qualitative feedback to inform the development of effective DR strategies.



- **Nudging Activity:** This activity employed a Design Thinking user testing methodology, where participants evaluated nudge mock-ups related to energy consumption. The feedback focused on aspects such as clarity, understanding, targeted improvements, and language framing preferences. In some workshops, a Make Exercise methodology was also used to engage participants in creating their ideal nudge messages.

The following table summarizes which co-creation activities have been carried out by each pilot. Due to other delays with the Irish pilot, the co-creation workshop has not yet been organized for that location, however, when possible, a similar session will be organized using the same methodologies.

Table 2: Co-creation workshop activities completed in each pilot

	Nudging activity	Barriers & Drivers activity	Incentives activity
Danish workshop	X	X	
Italian workshop		X	X
Greek workshop 1 ¹	X	X	
Greek workshop 2	X	X	
Spanish workshop	X	X	
Austrian workshop	X		X
Romanian workshop	X		X
Irish pilot	TBD	TBD	TBD

For further details on regarding the co-creation methodology, and how this links to the DEDALUS Social Science Framework and other WP2 tasks, refer to D2.4 – “Enabling conditions for DR in energy-efficient residential buildings”.

General Insights Gained

The co-creation workshops have provided several key insights that will inform the development and implementation of DR solutions within the DEDALUS project:

- **Information and Understanding:** A significant barrier identified across workshops was the lack of information. Participants expressed a need for clear and accessible information to make informed decisions about participating in DR programs. Effective education and communication strategies are essential to drive participation.

¹ In the case of Greece, the pilot has been subdivided into two groups: Greek pilot 1 and Greek pilot 2. Greek pilot 1 refers to the demonstration led by DOM-X, which has a gas vector focus. Greek pilot 2 refers to the demonstration led by HERON which has an electricity vector focus. These pilots each have a different set of end-users, and therefore, their co-creation workshops have been designed independently of one another.



- **Customization and Technology:** The ability to customize energy preferences and settings was a crucial driver for participation. Participants valued technology that allowed personalization and ensured comfort while saving energy. Simplifying technology and providing necessary training can help overcome discomfort with smart devices and applications.
- **Trust and Data Privacy:** Trust issues regarding the collection, storage, and sharing of personal data were common barriers. Transparent communication about data management and evidence of secure data practices can enhance trust and drive participation.
- **Comfort vs. Energy Saving:** Comfort at home was a critical factor for some users. While some participants were willing to compromise comfort for energy savings, others were not. Effectively communicating the environmental benefits of DR programs can encourage more flexibility from comfort-oriented end users.
- **Community and Social Benefits:** Incentives related to contributing to community goals and enhancing social benefits were consistently ranked highly. This indicates a strong preference for incentives that foster a sense of collective achievement and community well-being.
- **Environmental Impact:** Participants acknowledged the significance of environmental impact and expressed a desire to see tangible positive outcomes from their energy-saving actions. Regular reports on carbon emissions saved and other environmental benefits can motivate participation.
- **Low Interest in Gamification:** Incentives related to gamification, such as energy-saving challenges and competitions, were generally not favoured. Participants preferred personal satisfaction and community contributions over competitive elements.
- **Recognition and Rewards:** There were mixed feelings regarding public recognition and rewards. While some participants appreciated public acknowledgement, others preferred personal satisfaction without the need for public recognition.

These insights will be taken forward to enhance the social acceptance potential of the DEDALUS DR solutions and inform the implementation of the DR services in the demonstrations.

2.3. Design of the technical workshop

The technical workshops will serve as platforms for technology providers to exhibit and demonstrate their advancements of their TEs to energy stakeholders and residential consumers at each pilot site. Given the different user profiles for each TE, two technical workshops will be organised per pilot – one targeting **residential users** and the other targeting **professional users**. The primary objective of the workshops will be to measure the acceptance of the TEs. For example, whether the TE is useful, whether the TE is well understood, how the TE aligns with existing tools, how confident they are in using the TE service. The residential technical workshop will present the TE relevant for each user type; showcasing the benefits and gathering feedback on the DR services and tools. Given these different target audiences and objectives, the professional technical workshop will take a deeper dive into demonstrating and explaining the TEs, while the residential technical workshop will adopt a more high-level focus.

The TE presentations during the workshops will also include Social Acceptance Boosters (SABs). SABs are defined as acceptance catalysts that can be added to workshop content to enhance DR awareness and literacy. These boosters aim to support end users in more confidently



navigating the TEs so that can make informed decisions about their willingness to use and participate in the DEDALUS DR services. A successful SAB will therefore result in a meaningful increase in TE acceptance dimensions such as understanding, confidence, and willingness to use DR services. These boosters have been developed based on the insights collected from the co-creation activities in WP2 and will be further defined in the pilot engagement plans that are currently under development.

Technical workshop structure

The technical workshops will be held between M21-M25 by all pilots. While the residential and professional versions of the technical workshop will adopt slightly different tones – more technical and detailed for the professional audience and simpler and more high-level for the residential audience – both workshops will follow the same structure that incorporate the social acceptance assessment pre- and post-test questionnaires (see Figure 1).



Figure 1: Technical workshop and social acceptance assessment process

TE presentation: After a brief introduction and welcome, pilot and audience specific TEs will be presented. In the residential workshop, the TEs which lead to updates in the local business platforms in each pilot site will be presented to the workshop participants. This demonstration will be kept simple and aim to avoid overly technical or jargony language. The presentation will also aim to highlight aspects most relevant to the residential user, taking into consideration insights from each pilot persona. For example, how will the TE benefit the end user directly? What training or coach will be needed to use the TE? Are there any inconveniences or costs related to the TE end users should be aware of?

For the professional workshop, the TE presentation will be adapted to the profile of the professional users (e.g. building managers, energy retailers, grid operators, energy services providers, etc.), but will generally include the methodology and outputs of the TE, benefits, and where possible, a demo. Given the higher level of DR and energy literacy among the professional users, the TEs will be described with greater technical detail than in the residential technical workshops.

The TE presentation will also incorporate SAB elements based on the learnings of social factors to facilitate interest and participation. For example, if the pilot specific learning from WP2 show that pilot users are motivated by community aspects, the communal benefits of a service can be emphasized.

Social acceptance pre-test: Following the TE presentation, the social acceptance assessment pre-test questionnaire will be administered to participants. This questionnaire will collect



quantitative baseline data related to user's perceptions of the TEs, such as willingness to use the TEs, understanding of the TEs, and usefulness of the TEs. The format of the social acceptance pre-test questionnaires, which was based on the technology acceptance model (TAM) and the proposed questions that were reported in section 2.2.4 of D5.1, are presented below:

Pre-test questionnaire (professional)

Introduce TE-1

Qx. To what extent do you agree or disagree with the following statements?

[GRID QUESTION]

1 Strongly disagree

5 Strongly agree

[RANDOMIZE]

I believe this TE will be useful for my organization [PERCIEVED USEFULNESS]

I expect this TE to be easy to use and understand [EASE OF USE]

I feel very confident using the TE [ATTITUDE TOWARDS USING]

I am likely to continue using this TE in the future [BEHAVIOURAL INTENTION]

I am likely to recommend this TE to colleagues/peers [SOCIAL INFLUENCE]

I am familiar with this kind of TE service [EXPERIENCE]

I trust the reliability and performance of this TE [TRUST]

I would need to learn a lot of things before I could start using this TE [FACILITATING CONDITIONS]

Qx. Any other comments about this TE?

[OPEN ENDED] [OPTIONAL]

Introduce TE2

[REPEAT QUESTIONS ABOVE]

Introduce TE3

[REPEAT QUESTIONS ABOVE]

Etc.

Pre-test questionnaire (residential)

Qx. To what extent do you agree or disagree with the following statements?

[GRID QUESTION]

1 Strongly disagree

5 Strongly agree

[RANDOMIZE]

I believe this TE will be useful in managing my home's energy usage [PERCIEVED USEFULNESS]

I expect this TE to be easy to use and understand [EASE OF USE]

I feel very confident using the TE [ATTITUDE TOWARDS USING]

I am likely to continue using this TE in the future [BEHAVIOURAL INTENTION]



I am likely to recommend this TE to friends/family [SOCIAL INFLUENCE]
I trust the reliability and performance of this TE [TRUST]
I would need to learn a lot of things before I could start using this TE [FACILITATING CONDITIONS]

Qx. Any other comments about this TE?
[OPEN ENDED] [OPTIONAL]

Feedback discussion: Following the post-test questionnaire, users will participate in a feedback discussion, facilitated by pilot partners, about the TEs presented earlier. The aim of this discussion will be to collect feedback on the TEs, including areas of improvement, points of confusion, and required training/support for adoption. The discussion will also allow for participant so to elaborate on *why* they responded as they did in the pre-test survey (e.g. why/why not was the TE useful?)

Social Acceptance post-test: Following the workshops, professional and residential users will have the opportunity to engage directly with the TEs during the piloting period. At the conclusion of piloting, these same workshop participants will be asked to complete the social acceptance assessment post-test questionnaire. This questionnaire will repeat the pre-test questions, allowing for shift in perceptions towards TEs to be measured; giving an indication of how favourable (or not) users experienced the TEs during piloting. The format of the social acceptance post-test questionnaires are presented below:

Post-test questionnaire (professional)

Introduce TE1

Qx. To what extent do you agree or disagree with the following statements?

[GRID QUESTION]

1- Strongly disagree

5- Strongly agree

[RANDOMIZE]

I believe this TE was useful for my organization [PERCIEVED USEFULNESS]

I found this TE easy to use and understand [EASE OF USE]

I felt very confident using the TE [ATTITUDE TOWARDS USING]

I am likely to continue using this TE in the future [BEHAVIOURAL INTENTION]

I am likely to recommend this TE to colleagues/peers [BEHAVIOURAL INTENTION]

Other professionals in my field are using similar services [SOCIAL INFLUENCE]

I am familiar with this kind of TE service [EXPERIENCE]

I trust the reliability and performance of this TE [TRUST]

I needed to learn a lot of things before I could start using this TE [FACILITATING CONDITIONS]

Qx. After having used this TE, my impression of it has:

Improved

Worsened

Stayed the same

Qx. Have you experienced any issues using this TE? Please describe below



[OPEN ENDED]

Qx. Any other comments about this TE?

[OPEN ENDED] [OPTIONAL]

Introduce TE2

[REPEAT QUESTIONS ABOVE]

Introduce TE3

[REPEAT QUESTIONS ABOVE]

Etc.

Post-test questionnaire (residential)

Qx. To what extent do you agree or disagree with the following statements?

[GRID QUESTION]

1 Strongly disagree

5 Strongly agree

[RANDOMIZE]

The TE was useful in managing my home's energy usage [PERCEIVED USEFULNESS]

I found this TE easy to use and understand [EASE OF USE]

I felt very confident using the TE [ATTITUDE TOWARDS USING]

I am likely to continue using this TE in the future [BEHAVIOURAL INTENTION]

I am likely to recommend this TE to friends/family [SOCIAL INFLUENCE]

I trust the reliability and performance of this TE [TRUST]

I needed to learn a lot of things before I could start using this TE [FACILITATING CONDITIONS]

Qx. After having used this TE, my impression of it has:

Improved

Worsened

Stayed the same

Qx. Did you experience any negative impacts related to the following areas when using the TE (e.g. Financial, Daily schedule, Privacy, Learning to use)?

Qx. Any other comments about this TE?

[OPEN ENDED][OPTIONAL]

2.4. Strategy for the engagement of the end users

Outside of the technical and co-creation workshops, it is important to ensure that end users are engaged throughout the DEDALUS project to maintain interest and participation. Therefore, in addition to the technical workshop explained in the previous sub-section, additional engagement activities will be carried out within each pilot. These activities will be tailored for each pilot to ensure they match the specific needs of the end user and the characteristics of the pilot living lab. To devise pilot-specific engagement strategies, engagement planning meeting will take place in M19-M20, before the conducting of the technical workshops. During these meetings,



SIN, NTUA, and pilot leaders will identify potential engagement activities and devise a timeline which fosters interest and participation in the DEDALUS solutions and services amongst pilot end users. Following these calls, a comprehensive engagement plan detailing a timeline of engagement activities will be developed and reported in deliverable D5.3 – “DEDALUS Pilots' execution documentation and consumers' engagement – full pilot operation phase” along with completed engagement activities.

The foundation for creating the engagement strategies will be the SABs introduced in the previous section. For example, if the identified SAB for a pilot relates to community involvement, engagement activities specifically aimed at this need will be prioritized. The SABs are devised from the output from the pilot workshops and segmentation analysis conducted as part of WP2. Table 3 shows the engagement recommendations for SAB for each pilot.

The SABs should be considered a starting point, as opposed to a set of steadfast rules, to be discussed with pilot leaders to ensure an effective and efficient engagement strategy can be developed. Combining the SABs with the contextual knowledge from each pilot leader will produce an engagement strategy that addresses key topics and factors related to each pilot whilst also ensuring activities do not overburden end users or strain existing relationships within the living labs which could negatively impact participation or interest.

Table 3: Engagement recommendations for SAB for each pilot site

Pilot site ²	Social Acceptance Boosters (SABs)
Austria	Incentives should focus equally on financial benefits and positive environmental impact. Contribution to the community is a valuable incentive but should not be considered as important as financial or environmental benefits. Technology is a potential barrier for users, caution should be exercised when offering new devices or APPs and should be accompanied with the right incentives and training. As 60% of users are willing to be part of a DR scheme, to facilitate acceptance, engagement strategies should be informative and focus on inclusivity to maximise uptake.
Denmark	Engagement should aim to encourage women into DR schemes. Focusing on raising awareness and knowledge. Technology and services should be simplified or have a preference-setting option to reduce the sense of intrusion in current day-to-day living.
Greece (DomX)	Many potential users were willing to participate and expressed flexibility regarding their comfort. Increasing the number of engagement activities is advised to preserve this interest and raise education and awareness to reach all potential DR participants.

² In the case of the Spanish and Irish pilot, the engagement recommendations for SABs will be produced when the co-creation workshops have been conducted.



Pilot site ²	Social Acceptance Boosters (SABs)
	The technology being developed is an important avenue to reach potential users, so further feedback gathering through UI/UX testing would be highly beneficial. Despite the majority of users showing interest and flexibility, a significant amount had concerns regarding the impact on their daily lives and also lacked some information regarding financial aspects related to participation. Awareness raising through communication efforts and hosting public events could help to mitigate these barriers and convince some users who are currently sceptical or wary about participating.
Greece (Heron)	As many potential users were knowledgeable about DR and comfortable with technology, providing the right information for them to make an informed decision would promote social acceptance. This should be considered with communication strategies and 'nudges' within the tools and services. Gathering further feedback on the tools would address user concerns over seeing tangible benefits and ensuring they receive the right kind of information that shows how their participation is benefiting them. Users expressed willingness to participate and expressed flexibility regarding their comforts. Therefore, increasing the number of engagement activities would maintain interest and raise education and awareness to reach all potential DR participants.
Italy	Engagement activities should focus on the community. This includes hosting events or activities at the community level and educating users on the benefits to the community associated with DR. Awareness raising regarding safeguarding their comfort should be undertaken to mitigate existing fears. Providing information and options regarding automation could further encourage participation. Training should be provided regarding any technology to increase comfort with tools, particularly with female users. Furthermore, feedback on what preferences and interfaces they prefer should be investigated to ensure it suits user needs.
Romania	Engagement activities should focus on raising awareness and promoting the tangible benefits of DR participation. Tools should offer personal gratification and recognition. Due to the conflicting findings between the incentive investigation and the segmentation analysis (i.e. user perspective on automation). Further engagement activities should continue to try to understand the user and the nuances between user types. In addition, mixed findings suggest that customisation options for tools and services would be important.



3. Pilot 1 – Austria

3.1. Pilot status

3.1.1. Infrastructure and local business platform updates

The current updates on the pilot site are related to enhancing OurPower digital platform capabilities through Application Programming Interface (API) integrations. Specifically:

- The EUDT API is being integrated to streamline data acquisition from metering systems (BMS) installed at the pilot site.
- Integration with Sonnen APIs for the Photovoltaic (PV) and battery systems is underway, which will facilitate better management of solar energy generation and storage, optimizing the use of renewable energy sources at the site.
- APIs from EcoFactor are being integrated to improve the management of the EV charging stations.

At the same time, there are ongoing developments of platforms and tools such as the following:

- The COMS pre-aggregation platform (**TE-6**) is being developed to aggregate and analyse data before it is processed on the main platform, aiming to improve data handling efficiencies and predictive capabilities
- Ongoing enhancements to the OurPower nudging app (**TE-10**) are focused on encouraging energy-efficient behaviour among users through personalized prompts and energy usage insights.
- The OurPower energy community platform is being enhanced to better support the formation and management of energy communities, facilitating peer-to-peer energy trading (**TE-12**).

3.1.2. Available data sources

The following table lists all new data sources made available due to recent updates in both the physical and digital infrastructures at the pilot site, crucial for the development of the relevant services. The previous available data sources for the Austrian pilot site are reported in section 4.1.4. of D5.1.

Table 4: Data sources in the Austrian pilot site

Source 4 (EV charging data)	
Data Source Name:	EV charging data
General Sensor Placement (electrical panel, Heat/Cool Producer, radiator, etc):	Outdoor at EV charging station
Description of Data Source:	Electricity consumption
Data Format (CSV, Excel, JSON, Database, etc.):	CSV, Excel, JSON, Database
Data Frequency (Real-time, Daily, Weekly, Monthly, etc.):	Real-time



Data Volume (Approximate size of current available data - per day):

Data Fields/Columns (Number of features):	Datetime, Power (kW)
Data Quality (Excellent, Good, Fair, Poor):	Good
Data Collection Methodology:	Online portal, API
Data Access Restrictions (or limitations if any):	Credentials, password, token
Data Privacy and Security Measures (GDPR):	Privacy: own data
Data Sharing and Integration Capabilities are possible in DEDALUS:	Yes
Additional Notes/Comments:	Still preliminary information

Source 5 (Battery system data)

Data Source Name:	Battery system data
General Sensor Placement (electrical panel, Heat/Cool Producer, radiator, etc):	Indoor at battery system
Description of Data Source:	Local gateway
Data Format (CSV, Excel, JSON, Database, etc.):	CSV, Excel, JSON, Database
Data Frequency (Real-time, Daily, Weekly, Monthly, etc.):	Real-time
Data Volume (Approximate size of current available data - per day):	
Data Fields/Columns (Number of features):	Datetime, Power (kW), Status, SoC
Data Quality (Excellent, Good, Fair, Poor):	Good
Data Collection Methodology:	Online portal, API
Data Access Restrictions (or limitations if any):	Credentials, password, token
Data Privacy and Security Measures (GDPR):	Privacy: own data
Data Sharing and Integration Capabilities are possible in DEDALUS:	Yes
Additional Notes/Comments:	Still preliminary information

3.2. Impact analysis

3.2.1. Progress on the Key Performance Indicators

The following table presents how each KPI progressed for the Austrian pilot site, along with their respective values at the conclusion of the pre-pilot cycle.



Table 5: Progress and current values of KPIs at the end of the pre-pilot cycle for the Austrian pilot site

	KPI	Name	Baseline	Progress during the pre-pilot cycle	Value at M16
TECHNOLOGICAL	KPI _{TE1}	Increased buildings energy efficiency due to DR programs measured in the pilots	45 %	During the pre-pilot phase, the services (TE-10, TE-12) for the DR programs were still under development. As a result, no DR programs were in place during this phase.	45%
	KPI _{TE2}	Increased share of aggregated flexibility mobilised by piloted assets	0	The development of the necessary infrastructure and services to support aggregated flexibility was still ongoing in the pre-pilot phase. Piloted assets have not yet been activated for flexibility mobilization.	N/A
	KPI _{TE3}	Increased ratio of exploited vs planned aggregated flexibility validated through pilots	0	During the pre-pilot phase, foundational work was carried out to develop the necessary systems and services for aggregated flexibility. Although no flexibility system has been implemented yet, key components and preparatory measures have been established to enable flexibility aggregation in the upcoming phases.	N/A
SOCIAL	KPI _{S01}	Number of consumers engaged in residential DR	0	As of M16, no consumers have been engaged directly in residential DR. However, during the pre-pilot phase, potential future users were engaged through questionnaire, workshop, and direct communication. These efforts have built a base of interested parties for when the DEDALUS services become operational.	41 (29 questionnaire, 6 workshop, 6 direct comm.)
	KPI _{S02}	DR participation rate	0	The DR participation rate remains at 0 as no users are actively engaged in the program yet. With the groundwork laid through user engagement efforts in the pre-pilot phase, the participation rate is expected to increase once the first prototypes of the DEDALUS services are deployed.	N/A



	KPI	Name	Baseline	Progress during the pre-pilot cycle	Value at M16
	KPI _{SO3}	Different types of actors engaged by DEDALUS services	0	During the pre-pilot phase, various types of actors were engaged in preparation for future participation in the services. These actors include building owners, building operators, and inhabitants.	3
BUSINESS	KPI _{BU1}	Energy system cost reduction	0	No energy system cost reduction has been achieved as of M16 due to the absence of the flexibility system. In the pre-pilot phase, the focus has been on the development of the DEDALUS services, specifically the technology enablers TE-10 and TE-12, which will support future cost reductions.	N/A
	KPI _{BU2}	Increased rate of self-consumption of locally generated renewable energy	60%	The current self-consumption rate remains at 60%, based on historical data. During the pre-pilot phase, the focus has been on the development of the TE-10 and TE-12, which are crucial for optimizing local energy self-consumption. The groundwork laid through the ongoing development of these enablers is expected to result in higher self-consumption rates once the flexibility system is operational.	60%

3.2.2. Technology enablers evaluation in the pre-pilot cycle

The following tables present the evaluation of the TEs demonstrated in the pre-pilot cycle.

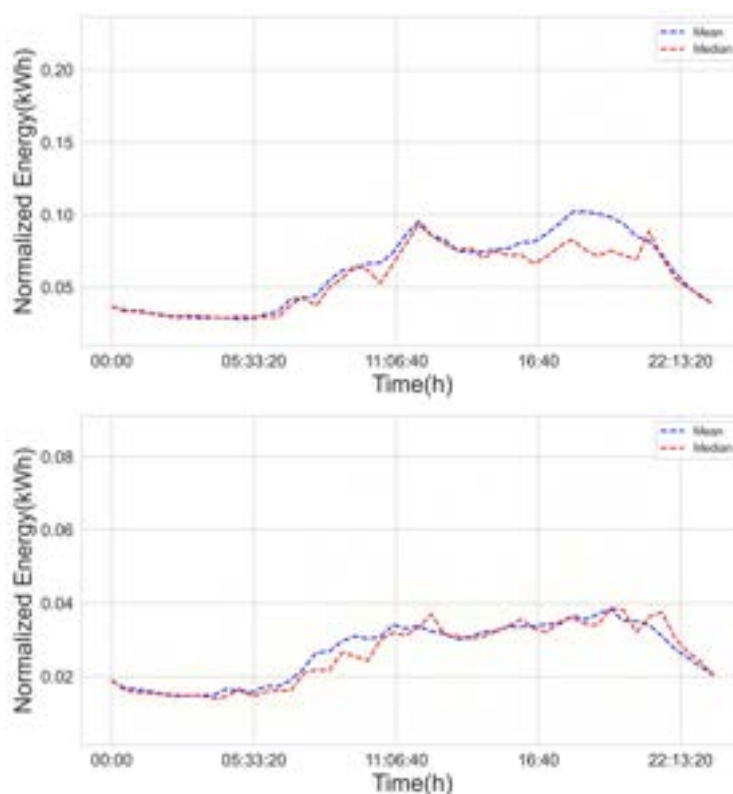
Table 6: TE-1 evaluation in the Austrian pilot site

TE – 1 Consumers clustering and segmentation models	
Demonstration in this pilot cycle	<i>The machine learning based clustering framework that we have developed is applied on 21 households from the Austrian pilot. Furthermore, the results of the questionnaire-based segmentation were conducted as well.</i> <i>A questionnaire was formed covering user features about demographics, energy literacy, energy behaviour, attitude, and DR barriers. Every pilot translated it in the local language and shared it with participants either in</i>



	<i>person or digitally. The questionnaire responses were used to produce a visualisation dashboard, which assisted in gaining insights to delineate a generic pilot persona. Thereafter, a segmentation was performed to split the population into groups of distinctive character. The utter goal is to identify users with similar attributes so as to plan a tailored approach strategy.</i>
Key metrics measuring the successful implementation	<i>The optimal number of clusters for the Austrian pilot, based on our analysis is 2. While the most important features were the peak morning one. Meaning that most of the users differentiated their energy consumption patterns during the morning hours.</i> <i>Regarding the questionnaire, the analysis produced 3 different clusters:</i> <i>1) Willing & familiar: male, advanced education, highest scoring in pilot – very high DR prospects.</i> <i>2) Willing & unfamiliar: female, secondary education, quite high scores, but see barriers – good DR prospects.</i> <i>3) Unwilling: weakest scoring in pilot – very low outreach prospects.</i>
Input	<i>Data from 21 households were provided for the clustering analysis. Data from 28 questionnaire responses were provided for the segmentation analysis.</i>
Output	<i>Data analysis results</i> <i>As mentioned above, the optimal number of clusters for this dataset, according to all indices of our methodology, is 2. The load profiles of each cluster can be seen below:</i>





Questionnaire segmentation results

		Segment A Willing & Familiar	Segment B Willing & Unfamiliar	Segment C Unwilling
Population	Number of Participants	10 [36%]	8 [29%]	10 [36%]
Segmenting Metrics	Overall DR Willingness	2-6	2-6	0-1
	DR Familiarity	4-5	1-3	1-5
Energy Literacy	Average	3.9	3.8	3.3
Demographics	Gender	7 Male (relatively dominant)	5 Female (dominant)	No pattern
	Age	No pattern	No pattern	No pattern
	Education	Higher+	Secondary	No pattern
	Digital Expertise	High	No pattern	No pattern
	Occupation	No pattern	No pattern	Employed
	Adults	No pattern	No pattern	No pattern
	Seniors	No pattern	0	0
	Children	No pattern	No pattern	0
	Income	No pattern	Mid-High	No pattern
Energy Behaviour	Spending Behaviour	Liberal	Conservative	No pattern
		N/A	N/A	N/A
	Attitude			
	Eco	High	High	Mid
	Fin	High	Mid	Low
DR Barriers	Tech	High	High	High
	Social	Mid	Low-Mid	Low
		Tech Challenges /	Tech Challenges	Limited fin rewards /



			Limited financial rewards		Lack of awareness
End user	Building operator, Energy community manager				
Further improvements	Further improvements may include mapping the questionnaire responses to real household consumption data and combining our approaches for the Austrian pilot. Also, more data may be provided for the algorithms to scale on a bigger dataset and find more intricacies between load profiles.				

Table 7: TE-4 evaluation in the Austrian pilot site

TE – 4 Flexibility modelling tool for residential DR	
Demonstration in this pilot cycle	The flexibility prediction methodology that we have developed was incorporated on the flexibility modeling tool and demonstrated on the Austrian pilot. The tool used historical building energy consumption and photovoltaic panel production data to predict the next day's consumption and production flexibility, leveraging Long Short-Term Memory (LSTM) models. These models were trained using building-level data to forecast energy flexibility for each hour, identifying upper and lower flexibility levels.
Key metrics measuring the successful implementation	The following key metrics were used to measure the successful implementation of the TE in the pilot: Energy Forecasting Accuracy: The model's performance was evaluated using metrics like Mean Absolute Error (MAE), Mean Squared Error (MSE), and R^2 for both consumption and production predictions. Electricity consumption prediction achieved an MAE of 1.06, an MSE of 2.23, and an R^2 of 0.74 while electricity production forecast achieved an MAE of 1.21, an MSE of 2.95, and an R^2 of 0.93. Flexibility Calculation: The flexibility baseline, maximum, and minimum levels were computed for both energy consumption and production, providing insights into potential adjustments for each hour of the target day.
Input	The data included energy consumption and production from the pilot site, collected over two years with a one-hour granularity.
Output	The final output of the TE implementation included: Charts: The flexibility prediction was visualized through charts. These charts showcased the flexibility metrics, including the



	baseline, maximum, and minimum flexibility for both energy consumption and production, represented graphically. • Energy Flexibility Indicators: (EFIs) provided quantitative measures of flexibility, enabling a more precise assessment of potential upward or downward adjustments in energy consumption or production for each hour and for specific time intervals of the predicted day. User interfaces with the charts and energy flexibility indicators will be provided to the end users. More information about the tool will be reported in D3.2 – “DEDALUS technological enablers for multi value and energy carrier-agnostic residential DR (2nd technology release)”.
End user	The primary end users of this TE included: • Residents: Direct beneficiaries of improved energy management practices, leading to potential cost savings and more efficient energy use. • Building Managers: Used the flexibility predictions to better manage energy systems in residential buildings.
Further improvements	• Enhancing Forecasting Accuracy: Further refinement of the prediction models could improve prediction accuracy, particularly through the use of advanced machine learning techniques. • Device-level disaggregation will be incorporated to isolate and forecast the energy consumption flexibility of individual devices. This will provide a more granular understanding of how each device contributes to the overall energy flexibility, improving the precision of demand response strategies. • Frontend Development: Further development of the frontend dashboard to make the user interface more intuitive and user-friendly. Enhancements would include improved data visualization techniques, customizable reports, and analytics to offer end users a more interactive experience when viewing and interpreting flexibility data.

Table 8: TE-6 evaluation in the Austrian pilot site

	TE – 6 Universal Secure Gateway
Demonstration in this pilot cycle	Universal Secure Gateway (USG) is currently deployed as a software-only platform acting as a local asset integration component, data collection component, pre-aggregation platform and user interface (UI) for the buildings as energy communities. In the case that some special asset integration equipment will be needed, the software-only platform will be



	extended by integrating the required hardware interface components (e.g. in case where the Modbus RTU interface is needed to integrate assets). In this first stage of TE-6 evaluation in the Austrian pilot the USG was deployed on a server computer. User accounts were created for the building owner, community manager and two commercial users respectively. In the Austrian pilot most of the assets except the smart meters for individual rented apartments are connected to the building management system (BMS) collecting the consumption and production data. The data collection was implemented by interfacing the BMS's API and transforming the input data into the internal USG data model format. All data is stored in internal USG data base to provide unified data interface to the pre-aggregation platform component and to the potential external data processors. In the first demonstration cycle the USG is deployed as a data collection and visualisation platform. Flexibility management and aggregation functionalities will be integrated and implemented in the following pilot demonstration cycles.
Key metrics measuring the successful implementation	Currently, there are no meaningful metrics for measuring the performance of deployed software platform that would explicitly show the quality of deployed TE. The USG platform currently collects and presents consumption and production data to the selected user. In the following demonstration cycles, when additional functionalities will be added, such as forecasting and flexibility aggregation, more meaningful KPIs can be developed. Also, some metrics regarding the system availability and computational resource consumption can be implemented.
Input	Collected data include many data sources from installed assets in the Austrian pilot which contain predominantly smart meters and PV inverters. The community building's consumption is split into 3 branches where the first branch aggregates consumption for the apartments on the 1st floor, the second branch aggregates the energy consumption for the 2nd floor and the third branch aggregates the energy consumption for the commercial entities and EV charging stations. The detailed scheme of data sources for the electrical energy consumption in Austrian pilot and their hierarchical relations are presented in Figure 2.



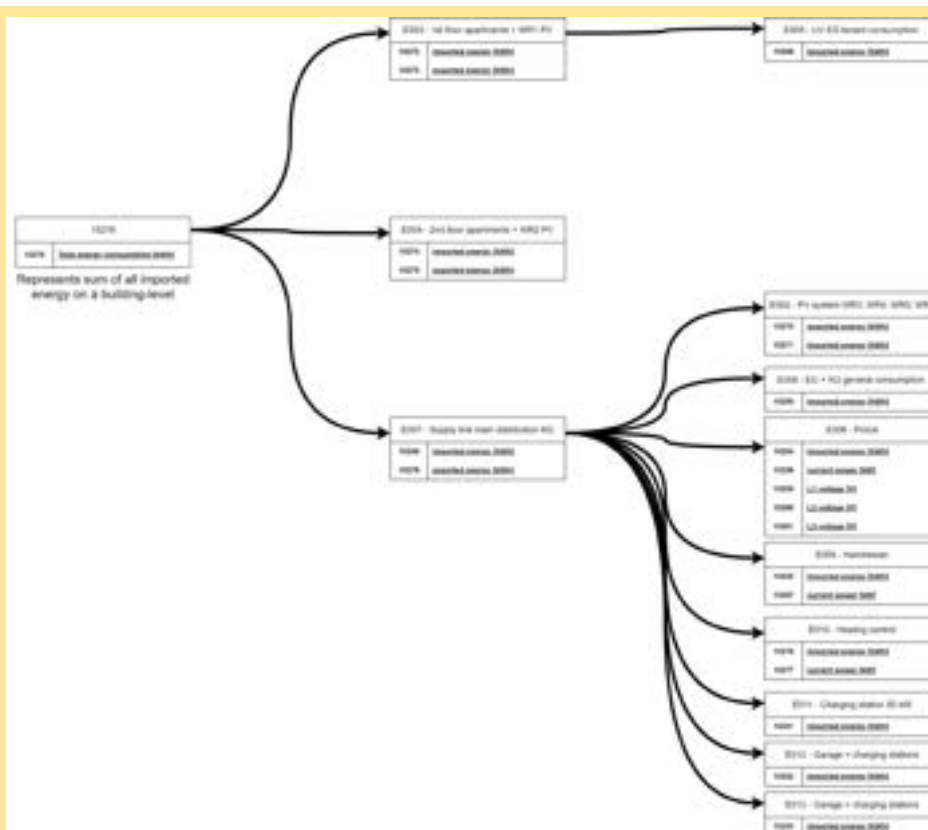


Figure 2: Data sources in Austrian pilot related to the electrical energy consumption

Electrical energy in Austrian pilot is being produced by 6 PV power plants with total peak power capacity of 228 kVA. Data from 5 out of 6 PV inverters is being collected where the production of 6th PV inverter is calculated from the aggregated total PV production and the sum of power of remaining 5 PV inverters. The data sources for electrical energy production and their hierarchical relations are presented in Figure 3.

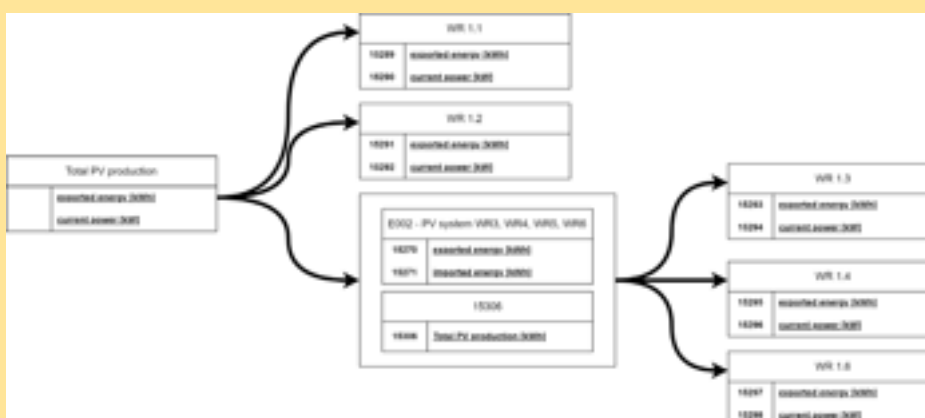


Figure 3: Data sources in Austrian pilot related to the electrical energy production

	Additionally, to the data sources related to the electrical energy the USG platform collects also weather data from one indoor and one outdoor weather station and heating energy provided by two district heating heat exchangers. The heating energy provided by the two district heating heat exchangers is not a subject of optimisation in DEDALUS project.
Output	The outputs of USG platform are several. First, the platform generates an interactive web UI for the user according to his role in energy community and assets he/she owns. Community manager can see the aggregated values for the whole energy community including the individual contributions from the community members while building owner or inhabitant of a rented apartment can see only the data related to the assets, he/she owns. The resulting outputs are both for energy community and individual living unit the same. The main difference between the scope of energy community outputs and individual living unit output is the fact that the output values for the energy community are calculated based on the aggregated presumption (production and consumption combined) power profiles from the whole community and for the individual living unit, the output values are calculated based on the presumption data for the selected living unit. First section of web UI presents basic presumption information for the current day. First column of information presents electrical energy imported from the grid during the current day, electrical energy exported to the grid during the current day and the net amount of energy during the current day, where positive values represent the net export and negative values present the net import during the current day. The second column of daily statistics present the information related to the costs and revenue, where the first information present the cost of imported energy, the second item presents the revenue generated by the exported energy and the third item presents the net revenue, where positive values present the profit generated by the surplus of produced energy and negative values present the loss (costs) generated by the surplus of imported energy over the exported electrical energy. The last column contains information on CO₂ emissions generated by the imported electrical energy, where information on CO₂ generated per kWh is provided by the ENTSO-E's Transparency Platform, where CO₂ emissions are calculated by the energy mix used for the production of electricity at a certain time of day in the selected country or area. The second section of web UI presents the information on self-sufficiency and self-consumption. Self-sufficiency presents the ability of selected household, building or energy community to provide its own needs on the energy consumption in the selected time period (current day in the current version of USG pre-aggregation platform). The percentage information of self-sufficiency presents the ratio between the self-consumed locally produced electrical energy and total amount of consumed energy. The higher the amount of self-sufficiency, the less dependent the household or energy community is on the energy grid.



The self-consumption item presents the percentage on the amount of locally produced electrical energy that was also consumed locally. The higher the percentage of the self-consumption, the lower is the effect of the household on the grid by the means of exported energy.

Next section of web UI on an USG pre-aggregation platform presents a graph with profiles of consumption, production and prosumption for the current day.

In the last part of web UI, the energy community members are presented with their basic prosumption information. The image of web UI with the view of energy community manager is presented in the Figure 4.



Figure 4: USG pre-aggregation platform UI with the view of a community manager.

End user

Building manager, community manager, active customer, end user

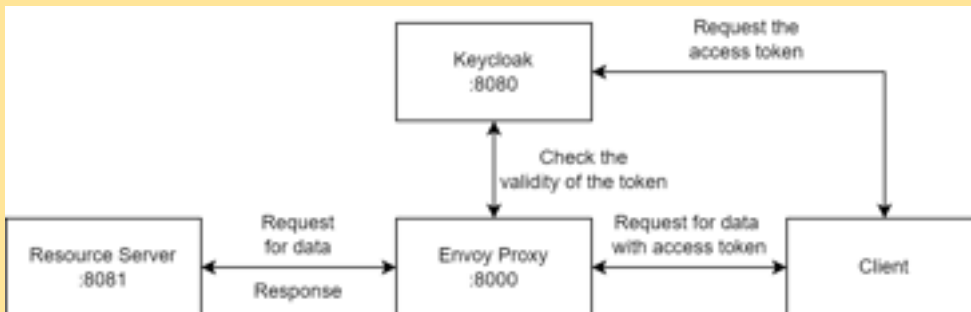


Further improvements	USG platform will be further extended to provide additional functionality in addition to the existing energy community aggregation functions. In addition to the existing integration of smart meters, EV charging stations and battery storage units will be integrated into the USG platform to provide direct control over flexible energy assets. User interface for energy community and user management will be further extended to provide more seamless energy community management providing means to add new community users and integrating their energy assets directly to the existing energy community. Pre-aggregation platform will be integrated with the OurPower P2P marketplace to expose the aggregated flexibility to the OurPower energy and flexibility market.
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Table 9: TE-7 evaluation in the Austrian pilot site

TE – 7 Secure and Privacy/Confidentiality Preserving Data Transactions	
Demonstration in this pilot cycle	TE-7 provides tools and mechanisms for secure and privacy preserving data transactions by implementing mechanisms for data registration, consent exchange, data access and data usage policy definition, comprehensive auditing functionalities, and actor reputation assessment. The core component of TE-7 is Envoy proxy acting as an API gateway integrated together with Keycloak and Privacy Protection Enforcement (PPE) component. Data plane is solely controlled by the Envoy proxy, where PPE and Keycloak are together with privacy protection UI in USG platform integrated into the control plane. Internal services of the USG have direct access to the user data. The user gives the USG platform consent to collect and process his/her data to provide energy management services. In case user doesn't want to participate in the energy community anymore, his/her user accounts get deleted together with all collected data. User data is crucial to the USG platform to provide pre-aggregation and flexibility management services. Data access to outside users and services is controlled by the API gateway integrated into the USG platform. The user's data can be shared only to the external users and services that were given explicit consent by the data owner (user). Other users and services requesting data from the USG platform without the explicit consent are rejected while requesting the data. In the first TE demonstration cycle TE-7 is deployed as a barebone API gateway solution without integration into USG user interface. The consents and permissions for data access are given by the user manually inside the Keycloak user interface. In the next evaluation cycles the API gateway functionality will be seamlessly integrated into the USG platform, where user will have specific parts of UI intended for secure and privacy-preserving data management and exchange.
Key metrics measuring the	The metrics evaluating the success of TE-7 implementation are of a binary nature, where protecting the specific data resource can only be successful or unsuccessful.



successful implementation	The functionality that was evaluated for operational success was protecting user data by rejecting access to the data for users that were not given consent by the data owner.
Input	The API gateway acts as a protector of data resources behind the API gateway owned by the user and managed by the resource server. Each external user and external client that were given the consent to access user data can request an access token from the Keycloak. Access token has to be included in the request for the data. Request for the data is first intercepted by the Envoy proxy inside the API gateway. API gateway checks with the Keycloak for the consent and permission for the user requesting data and in case of existing consent, the request for data is forwarded to the resource server, otherwise it is rejected. The whole process of data protection by the API gateway is presented in Figure 5.  Figure 5: Complete process of requesting the protected resource behind the API gateway.
Output	The output of the API gateway while requesting the data can have two outcomes: • If the external user/client was given consent by the data owner, the external user/client gets the requested data. If the external user/client was not given the consent by the data owner, the external user/client gets a request rejected.
End user	User (data owner), external user/client/service (data requester, data processor)
Further improvements	API gateway functionality will be extended in the following evaluation cycles by the following extensions: • Provide the encryption. • Data access management UI. • Seamless integration with USG platform.



3.3. Pilot-specific implementation plan up to M25

This section includes the Gantt Chart with all the activities demonstrated in the Austrian pilot site, the timelines for the TEs implementation, and the table with the evaluation phase check list for each TE.

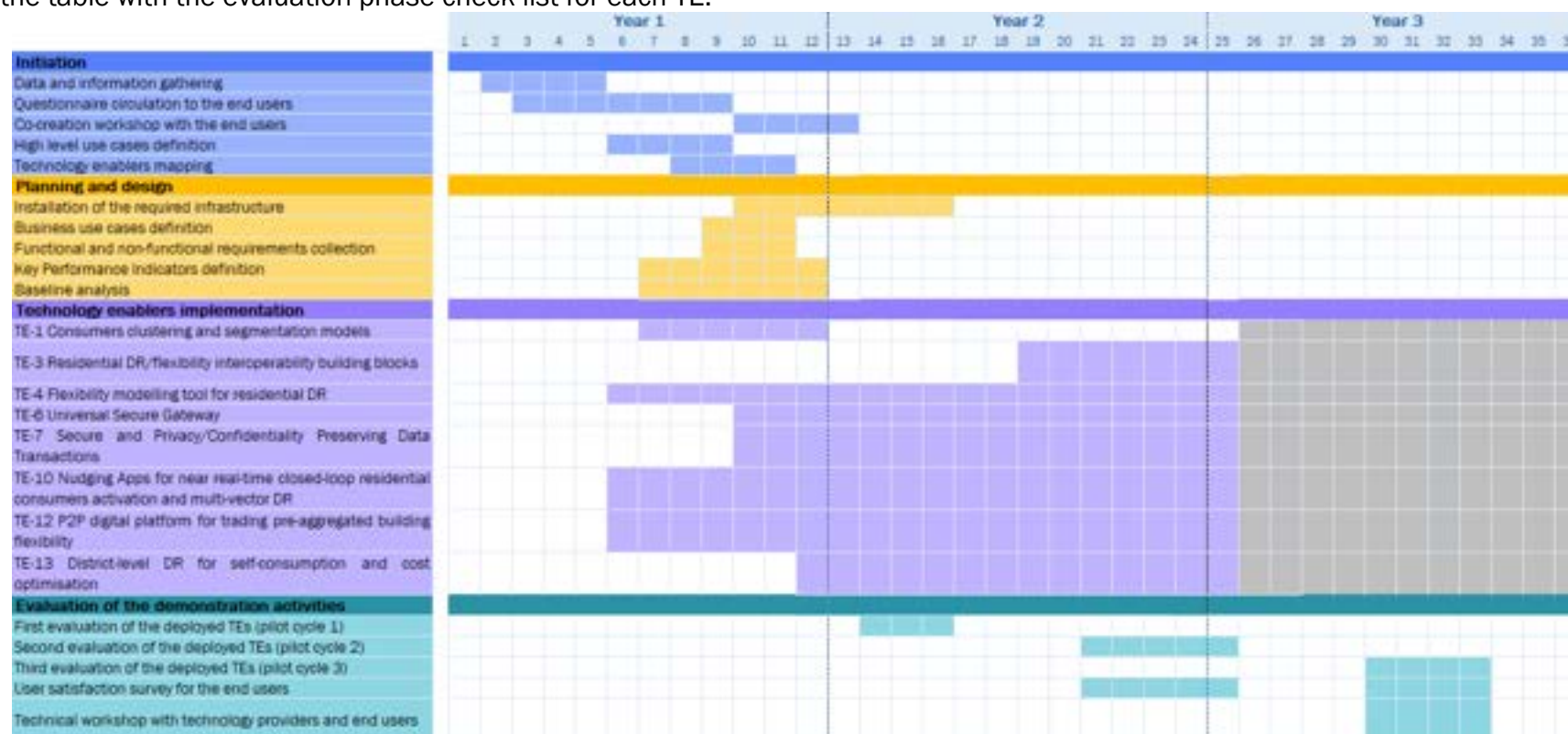


Figure 6: Gantt Chart for the implementation plan in the Austrian Pilot



Table 10: Evaluation phase check list for the TEs in the Austrian pilot

	Evaluated in the pre-pilot cycle (until M16)	Evaluated in the full-pilot cycle (until M25)	Evaluated in the large scale-pilot cycle (until M33)
TE-1 Consumers clustering and segmentation models	Yes	No	TBD
TE-3 Residential DR/flexibility interoperability building blocks	No	Yes	TBD
TE-4 Flexibility modelling tool for residential DR	Yes	Yes	TBD
TE-6 Universal Secure Gateway	Yes	Yes	Yes
TE-7 Secure and Privacy/Confidentiality Preserving Data Transactions	Yes	Yes	Yes
TE-10 Nudging Apps for near real-time closed-loop residential consumers activation and multi-vector DR	No	Yes	Yes
TE-12 P2P digital platform for trading pre-aggregated building flexibility	No	Yes	Yes
TE-13 District-level DR for self-consumption and cost optimisation	No	Yes	Yes



4. Pilot 2 – Denmark

4.1. Pilot status

4.1.1. Infrastructure and local business platform updates

The table below outlines the progress and scheduled updates for the infrastructure at the Danish Pilot site, encompassing two blocks with a total of 56 buildings. It details the implementation phases of various energy management solutions, from completed installations to ongoing and planned developments, aimed at enhancing heating control, indoor climate monitoring, and overall energy efficiency.

Table 11: Timeline of infrastructure updates and technological implementations at the Danish Pilot Site

#	Delivery	Timeline
1	Heating control in homes by smart thermostats on all radiators (MClimate Vicki LaRaWAN)	Q1-Q2 2024 - Done
2	Monitoring of indoor climate parameters in homes with (Elsys ERS CO2 Lite)	Q2 2024 - Done
3	Monitoring of decentralized residential ventilation systems via the manufacturer's cloud solution	Q3 2024 - Ongoing
4	Start-up of predictive central heating control via Danfoss ECL regulator and district heating main meter (NeoGrid)	Q3 2024 - Started
5	Monitoring of bi-meters for cold and hot domestic water and district heating in homes	Q3 2024 - Started
6	Web-app updates for data analysis (Neogrid Preheat App V2)	Q1 2025 - Planned
7	Web-app interface for residents with the possibility of interactive choice of indoor climate comfort and financial savings.	Q1 2025 - Planned

The NEOGRID PreHeat App, as part of the DEDALUS project (**TE-14**), is being developed (version 2) to comprehensively manage sensor hierarchies that stretch from entire buildings down to individual apartments and rooms. Here are the current updates on the platform's development:

- The platform can currently model the hierarchy of sensors across different building levels but lacks the capability to display all sensor data within the application.
- Ongoing design and scoping of graphical user interfaces (GUIs) are in place to enable tenants and building managers to interact with and monitor building conditions actively.
- Integration with the DEDALUS ontology (**TE-3**) to ensure structured data and system interoperability.
- Support the broader projects objectives and the implementation of different services such as the digital twin (**TE-8**) and the comfort flexibility model (**TE-9**) via the present API.

Currently there are two issues that are expected to be addressed within the next weeks:

- Although the ventilation systems are electrically connected, they are not transmitting data, which is an issue currently under investigation. NEOGRID is trying to resolve this issue by gaining access to each apartment. This has been fixed on one of the building blocks and will be addressed in the other building block during the next weeks.



- The energy meters in apartments are installed and encryption keys are available. However, there's difficulty in mapping them accurately because only serial numbers of the communication modules are visible.

In addition, regarding the development of the comfort flexibility model, UNIVPM has developed an initial version of a **user-friendly web interface** where residents can directly express their comfort perceptions. Based on the feedback provided, the interface was designed to be intuitive and accessible, considering the specific needs of the target demographic and marking a significant step towards adaptive, resident-centered energy management and living comfort enhancement in the pilot site.

The notification system involves the integration of a communication app, **Telegram**, which users may already have or can easily install. This bot is designed to streamline user engagement by sending **hourly reminders** to a public **Telegram group** (Figure 7), which is accessible via the link https://t.me/Dedalus_pilots. Each reminder includes a link to an online questionnaire (<https://digibuild-demo.eu/dedalus/pilots/>), encouraging users to provide feedback on their comfort sensation (Figure 8).

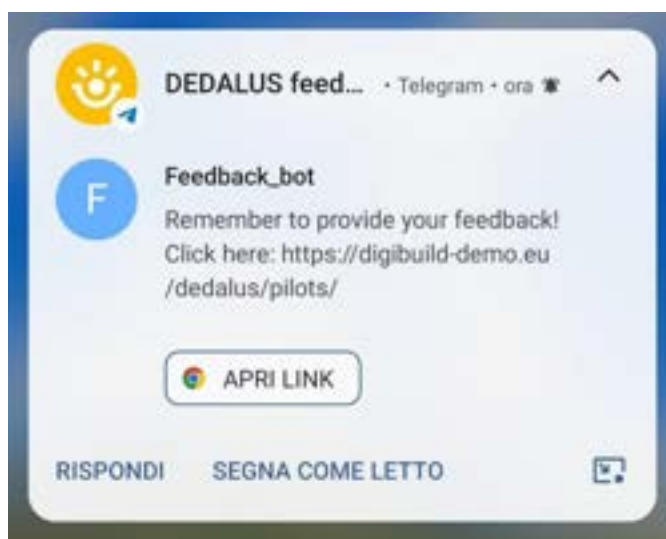


Figure 7: Overview of the Telegram notification on the smartphone

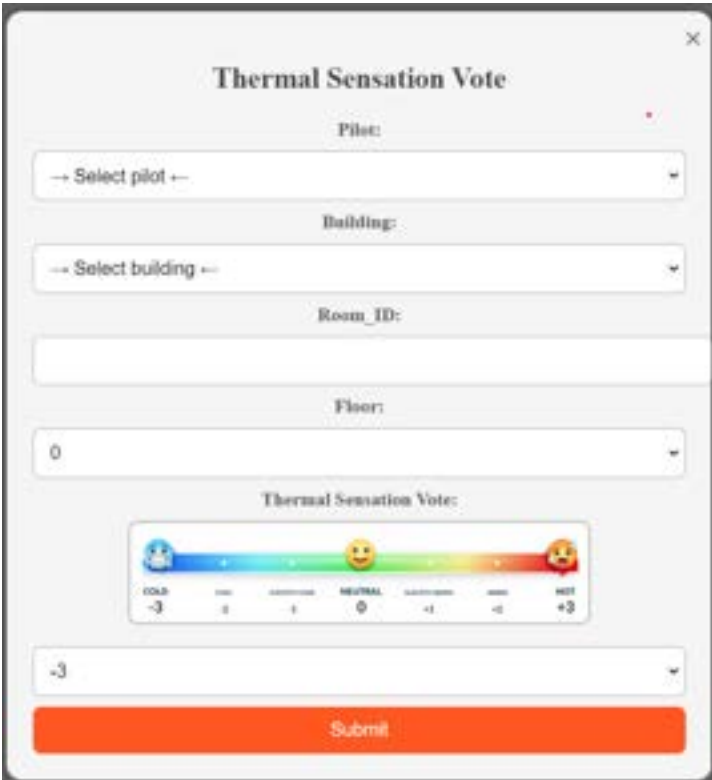


Figure 8: Online questionnaire to collect user feedback

4.1.2. Data sources and availability

The following table lists all new data sources made available due to recent updates in both the physical and digital infrastructures at the pilot site, crucial for the development of the relevant services. The previously available data sources for the Danish pilot site are reported in section 5.1.4. of D5.1.

Table 12: Data sources in the Danish pilot site

Source 9 (Energy Main Meter)	
Data Source Name (ID):	Energy Main Meter
General Sensor Placement (electrical panel, Heat/Cool Producer, radiator, etc):	Basement
Description of Data Source:	wMbus or API
Data Format (CSV, Excel, JSON, Database, etc.):	wMbus or JSON
Data Frequency (Real-time, Daily, Weekly, Monthly, etc.):	5 minutes or less
Data Volume (Approximate size of current available data per day):	



Data Fields/Columns (Number of features):	
Data Quality (Excellent, Good, Fair, Poor):	
Data Collection Methodology:	<i>wireless via gateway or API</i>
Data Access Restrictions (or limitations if any):	<i>None</i>
Data Privacy and Security Measures (GDPR):	<i>Yes</i>
Data Sharing and Integration Capabilities are possible in DEDALUS:	<i>Yes</i>
Additional Notes/Comments:	<i>Part of the main district heating installation</i>
Source 10 (Energy Meter DHW)	
Data Source Name (ID):	<i>Energy Meter DHW</i>
General Sensor Placement (electrical panel, Heat/Cool Producer, radiator, etc):	<i>Basement</i>
Description of Data Source:	<i>wMbus or API</i>
Data Format (CSV, Excel, JSON, Database, etc.):	<i>wMbus or JSON</i>
Data Frequency (Real-time, Daily, Weekly, Monthly, etc.):	<i>5 minutes or less</i>
Data Volume (Approximate size of current available data per day):	
Data Fields/Columns (Number of features):	
Data Quality (Excellent, Good, Fair, Poor):	
Data Collection Methodology:	<i>wireless via gateway or API</i>
Data Access Restrictions (or limitations if any):	<i>None</i>
Data Privacy and Security Measures (GDPR):	<i>Yes</i>
Data Sharing and Integration Capabilities are possible in DEDALUS:	<i>Yes</i>
Additional Notes/Comments:	<i>Part of the main district heating installation</i>
Source 11 (Cold Water Meter DHW)	
Data Source Name (ID):	<i>Cold Water Meter DHW</i>
General Sensor Placement (electrical panel, Heat/Cool Producer, radiator, etc):	<i>Apartment</i>
Description of Data Source:	<i>wMbus or API</i>
Data Format (CSV, Excel, JSON, Database, etc.):	<i>wMbus or JSON</i>



Data Frequency (Real-time, Daily, Weekly, Monthly, etc.): 5 minutes or less

Data Volume (Approximate size of current available data per day):

Data Fields/Columns (Number of features):

Data Quality (Excellent, Good, Fair, Poor):

Data Collection Methodology: wireless via gateway or API

Data Access Restrictions (or limitations if any): None

Data Privacy and Security Measures (GDPR): Yes

Data Sharing and Integration Capabilities are possible in DEDALUS: Yes

Additional Notes/Comments: Part of the main district heating installation

4.2. Impact analysis

4.2.1. Progress on the Key Performance Indicators

The following table presents how each KPI progressed for the Danish pilot site, along with their respective values at the conclusion of the pre-pilot cycle.

Table 13: Progress and current values of KPIs at the end of the pre-pilot cycle for the Danish pilot site

	KPI	Name	Baseline	Progress during the pre-pilot cycle	Value at M16
TECHNOLOGICAL	KPI _{TE1}	Increased buildings energy efficiency due to DR programs measured in the pilots	10%, totally heating savings of 12 kWh/m ² per year, totally 53,760 kWh of 5.53 c€, totally 2,973 €/year	The development of the necessary infrastructure and services to support aggregated flexibility was still ongoing during the pre-pilot phase. Piloted assets have not yet been activated for flexibility mobilization (TE-14)	N/A
	KPI _{TE2}	Increased share of aggregated flexibility mobilised by piloted assets	80% on ventilation systems (Electricity) 80 % on District Heating	The development of the necessary infrastructure and services to support aggregated flexibility was still ongoing during the pre-pilot phase. Piloted assets have not yet been activated for flexibility mobilization (TE-14)	N/A



	KPI	Name	Baseline	Progress during the pre-pilot cycle	Value at M16
SOCIAL	KPI _{S01}	No of consumers engaged in residential DR	0	No direct involvement of residents to DR programmes, as the service is still in development stage. However, consumer have been engaged indirectly (questionnaire, workshop) in residential DR. More consumers will be engaged through the application (nudges).	20
	KPI _{S02}	Reduction of the number of complaints from tenants regarding temperature comfort and indoor climate	Up to 10% of tenants will complain regarding temperature and indoor climate.	UNIVPM provided the pilot with Thermal Sensation Vote questionnaire, which will be used to assess tenants' perceptions of their environment.	N/A
	KPI _{S03}	Different types of actors engaged by DEDALUS services	0	Several actors have been engaged in this pre-pilot phase, including the tenants, the building manager and the housing administration.	3
BUSINESS	KPI _{BU1}	Energy system cost reduction, by providing flexibility services to electrical, gas and district heating grids	10%, totally heating savings of 12 kWh/m ² per year, totally 53,760 kWh of 5.53 c€, totally 2,973 €/year.	The development of the necessary infrastructure and services to support aggregated flexibility was still ongoing during the pre-pilot phase. Piloted assets have not yet been activated for flexibility mobilization. (TE-14)	N/A



	KPI	Name	Baseline	Progress during the pre-pilot cycle	Value at M16
ENVIRONMENTAL	KPI _{EN1}	Carbon emissions reduction (environmental benefit) for the energy grids measured at piloted local community level	19,75 tons/year	The development of the necessary infrastructure and services to support aggregated flexibility was still ongoing during the pre-pilot phase. Piloted assets have not yet been activated for flexibility mobilization. (TE-14)	N/A
	KPI _{EN2}	Thermal comfort assurance	-	Thermal comfort will be ensured by the development of a comfort-based optimization tool that will provide tenants with improvement suggestions for their environment. At the moment, the survey that it will be necessary to develop the comfort-based optimization tool has been given to the pilot.	N/A
	KPI _{EN3}	Thermal discomfort mitigation	-	Specific feedback on how to modify the environmental parameters will be provided by the comfort-based optimization tool developed by UNIVPM. At the moment, the survey that it will be necessary to develop the comfort-based optimization tool has been given to the pilot.	N/A



4.2.2. Technology enablers evaluation in the pre-pilot cycle

The following tables present the evaluation of the TEs demonstrated in the pre-pilot cycle.

Table 14: TE-1 evaluation in the Danish pilot site

TE – 1 Consumers clustering and segmentation models																																																																										
Demonstration in this pilot cycle	A questionnaire was formed covering user features about demographics, energy literacy, energy behaviour, attitude, and DR barriers. Every pilot translated it in the local language and shared it with participants either in person or digitally. The questionnaire responses were used to produce a visualisation dashboard, which assisted in gaining insights to delineate a generic pilot persona. Thereafter, a segmentation was performed to split the population into groups of distinctive character. The utter goal is to identify users with similar attributes to plan a tailored approach strategy.																																																																									
Key metrics measuring the successful implementation	Regarding the questionnaire, the analysis produced 2 different clusters: 1) Willing: male, higher income, highest scoring in pilot – good DR prospects. 2) Unwilling: female, very low income, high scores in selected categories, identified barriers – potentially good DR prospects.																																																																									
Input	Data from 20 questionnaire responses were provided for the segmentation analysis.																																																																									
Output	Questionnaire segmentation results <table> <tr> <th colspan="2"></th><th>Segment A Willing</th><th>Segment B Unwilling</th></tr> <tr> <td>Population</td><td>Number of Participants</td><td>8 [40%]</td><td>12 [60%]</td></tr> <tr> <td rowspan="2">Segmenting Metrics</td><td>Overall DR Willingness average</td><td>3.1</td><td>1.2</td></tr> <tr> <td>DR Familiarity</td><td>3</td><td>3</td></tr> <tr> <td>Energy Literacy</td><td>Average</td><td>3.7</td><td>3.5</td></tr> <tr> <td rowspan="10">Demographics</td><td>Gender</td><td>3 Male (relatively dominant)</td><td>12 Female</td></tr> <tr> <td>Age</td><td>No dominant</td><td>No dominant</td></tr> <tr> <td>Education</td><td>High school</td><td>No pattern</td></tr> <tr> <td>Digital Expertise</td><td>Mid-High</td><td>No pattern</td></tr> <tr> <td>Occupation</td><td>Employed</td><td>No pattern</td></tr> <tr> <td>Adults</td><td>No pattern</td><td>No pattern</td></tr> <tr> <td>Seniors</td><td>0</td><td>0-1</td></tr> <tr> <td>Children</td><td>No dominant</td><td>No dominant</td></tr> <tr> <td>Income</td><td>Low-Mid</td><td>Very low</td></tr> <tr> <td>Spending Behaviour</td><td>No pattern</td><td>Conservative</td></tr> <tr> <td>Energy Behaviour</td><td></td><td>N/A</td><td>N/A</td></tr> <tr> <td rowspan="4">Attitude</td><td>Eco</td><td>High</td><td>High</td></tr> <tr> <td>Fin</td><td>Low-Mid</td><td>Mid</td></tr> <tr> <td>Tech</td><td>High</td><td>Mid-High</td></tr> <tr> <td>Social</td><td>Mid</td><td>Mid</td></tr> <tr> <td>DR Barriers</td><td></td><td>Lack of awareness</td><td>Daily impact</td></tr> </table>					Segment A Willing	Segment B Unwilling	Population	Number of Participants	8 [40%]	12 [60%]	Segmenting Metrics	Overall DR Willingness average	3.1	1.2	DR Familiarity	3	3	Energy Literacy	Average	3.7	3.5	Demographics	Gender	3 Male (relatively dominant)	12 Female	Age	No dominant	No dominant	Education	High school	No pattern	Digital Expertise	Mid-High	No pattern	Occupation	Employed	No pattern	Adults	No pattern	No pattern	Seniors	0	0-1	Children	No dominant	No dominant	Income	Low-Mid	Very low	Spending Behaviour	No pattern	Conservative	Energy Behaviour		N/A	N/A	Attitude	Eco	High	High	Fin	Low-Mid	Mid	Tech	High	Mid-High	Social	Mid	Mid	DR Barriers		Lack of awareness	Daily impact
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DR Barriers		Lack of awareness	Daily impact																																																																							

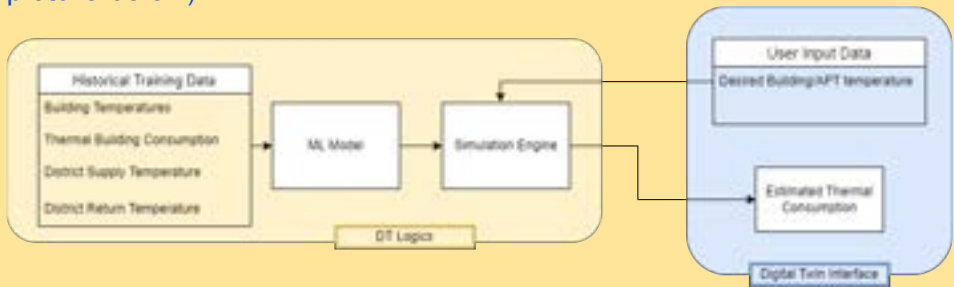


End user	Building manager, service provider
Further improvements	Further improvements may include mapping the questionnaire responses to real household consumption data and combining our approaches for the pilot.

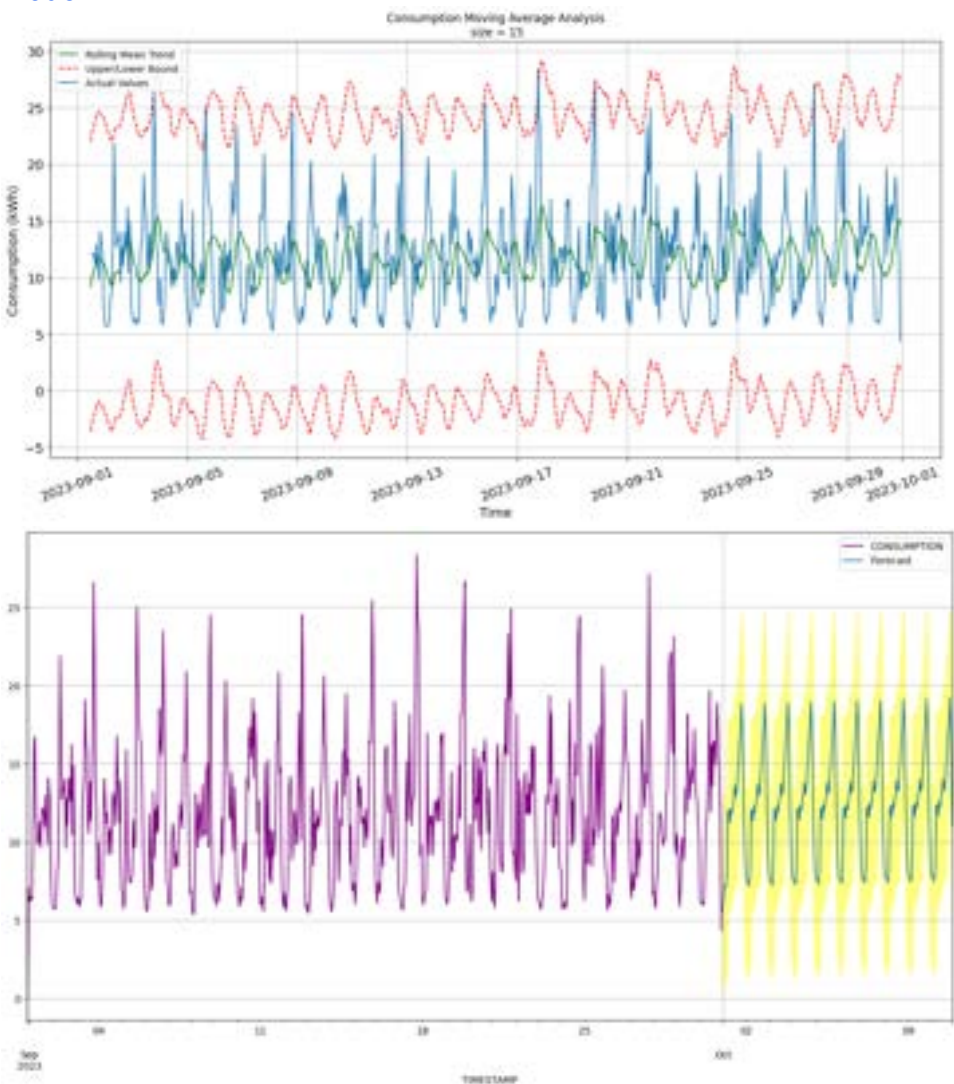
Table 15: TE-3 evaluation in the Danish pilot site

TE – 3 Residential DR/flexibility interoperability building blocks	
Demonstration in this pilot cycle	TE-3 provides the interoperability middleware that is in charge of ensuring the proper communication between the local business platform used by the Danish pilot and the value-added services provided within WP4.
Key metrics measuring the successful implementation	Currently, there are no meaningful metrics for measuring the performance of deployed software platform.
Input	Measurement data from the NEOGRID platform. For the time being we are considering just temperature data; other data from NEOGRID will be managed by TE-3 based on what is managed by the DEDALUS ontology or based on what needed by the service providers.
Output	The output of TE-3, that is context information created starting from input data taking into consideration the vocabulary of the DEDALUS ontology, is made available to any services in WP4.
End user	Service Provider
Further improvements	Adaptation to the NGSI-LD standard.

Table 16: TE-8 evaluation in the Danish pilot site

TE – 8 Digital Twins for consumer-aware optimal flexibility planning	
Demonstration in this pilot cycle	The first round of activities was focused on an extensive data analysis to set up the development of the Simulation Engine. After discussions with the Pilot Leader, a final architecture of this simulation model was agreed (in the picture below). 



Key metrics measuring the successful implementation	No key metrics were calculated during this cycle. Those can be discussed in the coming period with the Pilot Leader.
Input	The input was taken collecting Historical Data from NEOGRID PreHeat Application. Samples of data from a demo building were collected and used to train a first instance of the Simulation Model.
Output	Since the development was focused on the back end of the application, no User Interface has been provided during this period. The following picture shows instead the results of the first analysis of the data, while the second one depicts some initial consumption forecasts given by the simulation model. 



End user	Building Manager
Further improvements	With the aim of providing a complete solution, some components will be developed in the next period: 1. Improve and finalize the Simulation Model 2. Develop UI Development 3. Improve Middleware Layer 4. Integration with DEDALUS Interoperability Layer 5. Integration with TE-9 Comfort Based Flexibility Model



4.3. Pilot-specific implementation plan up to M25

This section includes the Gantt Chart with all the activities demonstrated in the Danish pilot site, the timelines for the TEs implementation, and the table with the evaluation phase check list for each TE.

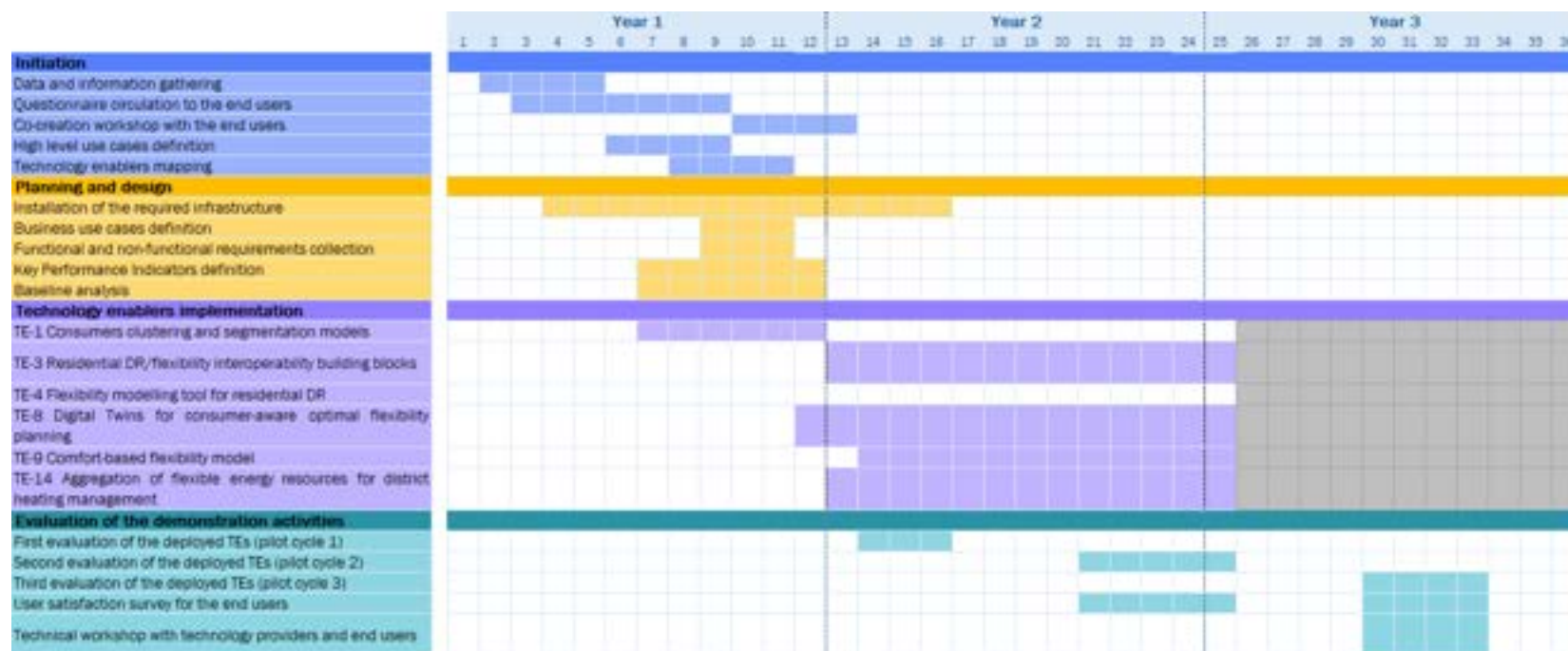


Figure 9: Gantt Chart for the implementation plan in the Danish Pilot

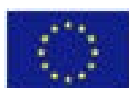


Table 17: Evaluation phase check list for the TEs in the Danish pilot

	Evaluated in the pre-pilot cycle (until M16)	Evaluated in the full-pilot cycle (until M25)	Evaluated in the large scale-pilot cycle (until M33)
TE-1 Consumers clustering and segmentation models	Yes	No	TBD
TE-3 Residential DR/flexibility interoperability building blocks	Yes	Yes	TBD
TE-4 Flexibility modelling tool for residential DR	No	No	TBD
TE-8 Digital Twins for consumer-aware optimal flexibility planning	Yes	Yes	Yes
TE-9 Comfort-based flexibility model	No	Yes	Yes
TE-14 Aggregation of flexible energy resources for district heating management	No	Yes	Yes



5. Pilot 3 – Greece

5.1. Pilot status

5.1.1. Infrastructure and local business platform updates

5.1.1.1. *DOM-X*

DOM-X is making significant progress in integrating advanced control and monitoring technologies into residential heating systems. Currently, the infrastructure includes 35 heating controllers in gas boiler systems and 10 in heat pumps, alongside 30 energy meters installed across various households. This setup aims to transform conventional HVAC appliances into smart, flexible assets capable of participating in explicit DR strategies. The goal is to extend this infrastructure further for the full pilot operational phase (until M25), aiming to install a total of 70-80 heating controllers for both gas boiler systems and heat pumps, and increase the number of energy meters to 50. Additionally, there are plans to implement 30-50 indoor air quality sensors to enhance the living environments of the residents.

The DOM-X platform within the Greek pilot site is currently undergoing significant advancements. All device types, including heating controllers, energy meters, and sensors, are now fully integrated with the platform, facilitating a unified management system. Additionally, a newly released API is enhancing the capability to access and utilize the data acquired from these devices, bolstering the effective implementation of the DEDALUS services (TE-1, TE-9). Key ongoing developments include enhancing the platform with DR in conjunction with the integration of nudging into the users' application (TE-10).

5.1.1.2. *HERON*

As of now, 92 smart meters have been installed across 90 households, with three designated as "super" households equipped with additional smart plugs. In total, 48 households have been equipped with 93 flexible assets, including various appliances like washing machines, air conditioning units, dryers, dishwashers, and electric boilers with remote control capabilities. The pilot aims to expand further, targeting installations in 100 households, with 10-15 of them becoming "super" households having up to 10 equipped with 5 ARC plugs each. Additionally, there are goals to enhance 60 households with flexible assets and integrate advanced ARC DR-read air conditioning systems in 20 households (TE-2).

In addition, HERON Energy Control has been updated through API changes with the introduction of "Home". This update is a significant step towards integrating multiple flexible assets under a unified concept which allows for scalable and efficient energy management across a larger network of interconnected devices (TE-4). HERON has introduced dynamic tariffs, which are visually represented in the HERON EnergiQ mobile app (TE-10). This initiative aims to motivate consumers to shift their energy demands to periods with high Renewable Energy Sources (RES),



processed from day-ahead market data and ISP data from the Transmission System Operator (TSO) (TE-8, TE-11).

5.1.2. Data sources and availability

No new data sources from the deployed infrastructure have been generated in the pre-pilot cycle. All the available data sources for the Greek pilot site are reported in section 6.1.4 of D5.1.

5.2. Impact analysis

5.2.1. Progress on the Key Performance Indicators

The following table presents how each KPI progressed for the Greek pilot site, along with their respective values at the conclusion of the pre-pilot cycle.

Table 18: Progress and current values of KPIs at the end of the pre-pilot cycle for the Greek pilot site

	KPI	Name	Baseline	Progress during the pre-pilot cycle	Value at M16
TECHNOLOGICAL	KPI _{TE1_NG}	Increased buildings energy efficiency due to DR programs measured in the pilots	32% energy savings on average	Waiting for the upcoming heating season to calculate the energy savings for more than 100 households participating in the gas pilot.	N/A
	KPI _{TE1_EL}	Increased buildings energy efficiency due to DR programs measured in the pilots	0%	During the pre-pilot phase, the services (TE-10, TE-11) for the DR programs were still under development. As a result, no DR programs were in place during this phase. Currently, 92 households with electricity meters have been recruited in the pilot and historical data for baseline calculation is being collected.	N/A
	KPI _{TE2}	Increased share of aggregated flexibility mobilised by piloted assets	0	Services under the umbrella of TE-8, TE-11 are under development. As a result, piloted assets have not yet been activated for flexibility mobilization. During the pre-pilot cycle, residents were encouraged to try smart plugs as a mean of validating disaggregation and estimating flexibility potential. Currently, 48 of the 92 households (52%) have flexible assets.	N/A



	KPI	Name	Baseline	Progress during the pre-pilot cycle	Value at M16
	KPI _{TE3}	Increased ratio of exploited vs planned aggregated flexibility validated through pilots	0	During the pre-pilot phase, the services (TE-10, TE-11) for the DR programs were still under development. As a result, there was no exploited flexibility. Households with flexible assets that were not monitored were encouraged to try smart plugs, resulting in 1.94 smart plugs per household with smart plugs. Monitoring capabilities of specific appliances were offered through EnergiQ mobile app.	N/A
SOCIAL	KPI _{S01}	No of consumers engaged in residential DR	0	End-users have been engaged through the co-creation workshop as well as in the newsletters we sent out for the upcoming DR interventions. At this stage of the project, the ones with highest energy-savings potential were selected as candidates in the DR actions.	10-15 electricity users with up to 10 smart plugs installed
	KPI _{S02}	Reduction of number of complaints from tenants regarding temperature comfort and indoor climate	0	To be measured in the upcoming heating season	N/A
	KPI _{S03}	Different types of actors engaged by DEDALUS services	0	. Several actors have been engaged in this pre-pilot phase, including the end-users, the energy retailer and DR aggregator.	3
BUSINESS	KPI _{BU1_NG}	Energy system cost reduction, by providing flexibility services to gas grid	44214 kWh energy savings	New measurements will be provided for the upcoming heating season	N/A
BUSINESS	KPI _{BU1_EL}	Energy system consumption reduction, by providing flexibility services to the electrical grid	13425 kWh yearly electricity saving consumption on average household	Service under the umbrella of TE-11 is under development. As a result, there is no flexibility provided to the electrical grid	N/A



	KPI	Name	Baseline	Progress during the pre-pilot cycle	Value at M16
ENVIRONMENTAL	KPI _{EN1_NG}	Carbon emissions reduction (gas): environmental benefit for the gas grid measured at piloted local community level	8,9 tones CO2	New measurements will be provided for the upcoming heating season	N/A
	KPI _{EN1_EL}	Carbon emissions reduction through increase in RES (%): environmental benefit for the electrical grid measured at piloted local community level	0%	Service under the umbrella of TE-11 is under development.	0%
	KPI _{EN2}	Thermal comfort assurance	-	The sensors that acquire the information required to calculate the percentage of time each household is within the comfort limits are currently being installed. Once these sensors are deployed, the KPI will be calculated.	No recorded data yet
	KPI _{EN3}	Thermal discomfort mitigation	-	The sensors that acquire the information required to calculate the average proposed heating balance increase for the households that don't respect the end-user's comfort limits are currently being installed. Once these sensors are deployed, the KPI will be calculated.	No recorded data yet
	KPI _{EN4}	Indoor Air Quality assurance	-	The sensors that acquire the information required to calculate the percentage of time in which each household is within the appropriate environmental limits are currently being installed. Once these sensors are deployed, the KPI will be calculated.	No recorded data yet

5.2.2. Technology enablers evaluation in the pre-pilot cycle

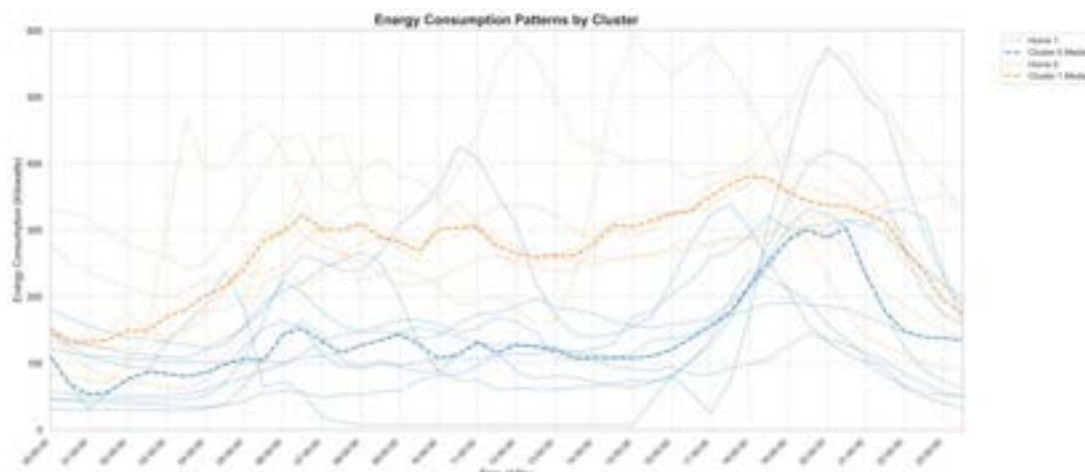
The following tables present the evaluation of the TEs demonstrated in the pre-pilot cycle.



Table 19: TE-1 evaluation in the Greek pilot site

TE – 1 Consumers clustering and segmentation models	
Demonstration in this pilot cycle	The machine learning based clustering framework that we have developed is applied on 15 households from the Greek pilot 1. Furthermore, the results of the questionnaire-based segmentation were conducted as well. Finally, a mapping of the questionnaires to real household consumption data were done by our partners in the Greek pilot 1 and a combination of the two approaches took place. A questionnaire was formed covering user features about demographics, energy literacy, energy behaviour, attitude, and DR barriers. Every pilot translated it in the local language and shared it with participants either in person or digitally. The questionnaire responses were used to produce a visualisation dashboard, which assisted in gaining insights to delineate a generic pilot persona. Thereafter, a segmentation was performed to split the population into groups of distinctive character. The utter goal is to identify users with similar attributes so as to plan a tailored approach strategy.
Key metrics measuring the successful implementation	The optimal number of clusters for our machine learning based analysis was 2. The same happened, for the questionnaire segmentation. We also showed that all the users from one cluster belong to the same segment showcasing the differences between the two approaches. Regarding the questionnaire, the analysis produced 4 different clusters: 1) Willing & Familiar: advanced education, liberal spenders, generally high scoring, higher social attitude – high DR prospects. 2) Willing & Unfamiliar: lower age, lower education, generally high scoring, lacking awareness – high DR prospects. 3) Unwilling & Familiar: female, liberal spenders, generally high scoring, least positive attitude across pilot, identified barriers – high DR prospects. 4) Unwilling & Unfamiliar: Generally lower scoring, lowest environmental attitude – mid DR prospects.
Input	Data from 15 households in the Greek pilot 1 for ML clustering. Data from 69 respondents for questionnaire segmentation.
Output	Data analysis results The optimal number of clusters for all indices and clustering algorithms was 2 in this case. The formulated clusters can be witnessed here (Home 0 are households in Cluster 0, which is the first cluster and Home 1 accordingly are houses that belong to Cluster 1):





Questionnaire segmentation results

		Segment A Willing & Familiar	Segment B Willing & Unfamiliar	Segment C Unwilling & Familiar	Segment D Unwilling & Unfamiliar
Population	Number of Participants	22 [32%]	19 [28%]	11 [16%]	17 [25%]
Segmenting Metrics	Overall Willingness DR	2-6	2-6	0-1	0-1
	DR Familiarity	3-5	1-2	3-5	1-2
Energy Literacy	Average	3.9	3.7	3.4	3.1
Demographics	Gender	6 Female (relatively dominant)	16 Male (dominant)	3 Female (relatively dominant)	13 Male 4 Female
	Age	30+	18-29 (relatively dominant)	30-49	No pattern
	Education	Master / PhD (dominant)	Secondary-Higher	No pattern	No pattern
	Digital Expertise	Mid-High	High	Mid-High	High
	Occupation	Employed	No pattern	Employed	Employed
	Adults	No pattern	No pattern	2	1-2
	Seniors	0-1	No pattern	0	0
	Children	0-2	No pattern	0-2	0-1
	Income	High	Mid-High	High	Mid-High
	Spending Behaviour	Liberal (relatively dominant)	Conservative	Liberal (relatively dominant)	Conservative



	Energy Behaviour		Space cooling@afternoon, All peak@evening	Low activity up to 08:00, Space cooling@afternoon	No pattern	Escalation after 12:00
	Attitude	Eco	High	High	High	Mid
		Fin	Very high	Very high	Mid-High	High
		Tech	Very high	Very high	Mid-High	High
		Social	Mid-High	Mid	Mid-Low	Low
	DR Barriers		Limited fin rewards / Lack of awareness / Daily impact	Lack of awareness / Limited fin rewards	Limited fin rewards / Tech Challenges / Daily impact	Lack of awareness / Daily impact / Limited fin rewards
End user	Building manager, energy retailer, DR service provider					
Further improvements	Further improvements may include mapping the questionnaire responses to real household consumption data and combining our approaches for the pilot. More data may be provided for the algorithms to scale on a bigger dataset and find more intricacies between load profiles in the Greek pilot.					

Table 20: TE-2 evaluation in the Greek pilot site

TE – 2 DR-ready connected smart appliances control and interoperability	
Demonstration in this pilot cycle	Initial batch of smart plugs (7) and gateways (2) from ARC have been installed. Air Condition (A/C) BTU specifications have been defined and order for 20 units of various sizes has been given to ARC.
Key metrics measuring the successful implementation	DR-ready smart appliance IoT platform HomeWhiz with open APIs, service enablers and respective tools for integration with legacy device types will be achieved through smart controllers Secure edge gateways will be locally employed to fuse data collected from various devices over the dominant wireless protocols and to expose vendor specific APIs in a common format through home automation frameworks.
Input	Applicable protocols and standards: BACnet, Modbus, LonWorks, Opentherm, OCPP Wireless protocols: Wi-Fi, ZigBee, LoRa Specific APIs in a common format through home automation frameworks: OpenHAB, HomeAssistant



TE – 2 DR-ready connected smart appliances control and interoperability	
	Data brokers: MQTT, REST APIs Local/external data repositories: Microsoft SQL Server and openly available European Data Spaces
Output	The collected data from multiple data sources, such as smart meters, thermostats, sensors, smart appliances, EV chargers, etc. will be harmonised and integrated with open and standardisable connectors over data brokers and local/external data repositories.
End user	Residential consumers
Further improvements	Integration with other IoT platforms in the consortium. Building the communication for the comfort data and the heat pumps. Matterization by updating existing products, such as smart plugs, gateways, and refrigerators, to ensure they comply with the technical specifications established by the Matter protocol.

Table 21: TE-11 evaluation in the Greek pilot site

TE – 11 Multi-value DR for virtual cluster of buildings	
Demonstration in this pilot cycle	Data collection from smart meters and smart plugs is streamlined and flexibility potential is identified. Tariff designs were circulated among pilot participants for feedback collection. Pilot participants receive visualisations of RES acting as sustainability driven tariffs that can motivate DR through load shifting.
Key metrics measuring the successful implementation	Installation of smart meters up to 92 homes. Installation of up to 93 flexible assets in up to 48 households. Monitor connectivity at initially 70% of assets. Motivate connectivity through flexibility services.
Input	Smart meter data consumption > DEDALUS disaggregation (TE1) DEDALUS sustainability driven dynamic tariff based on RES share projections.
Output	JSON file that includes information on the devices to be activated and the household they belong in, schedule and flexibility characteristics. This information is communicated to the consumers via notifications from HERON's EnergiQ mobile app.
End user	Residential Consumer Energy Supplier (acting as DR Aggregator)
Further improvements	Currently design applies recommendation at household level. By properly integrating disaggregation techniques, advice will focus at appliance level.



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Monitoring tools will assess follow-up of Implicit DR recommendations and modify strategies accordingly.



5.3. Pilot-specific implementation plan up to M25

This section includes the Gantt Chart with all the activities demonstrated in the Greek pilot site, the timelines for the TEs implementation, and the table with the evaluation phase check list for each TE.

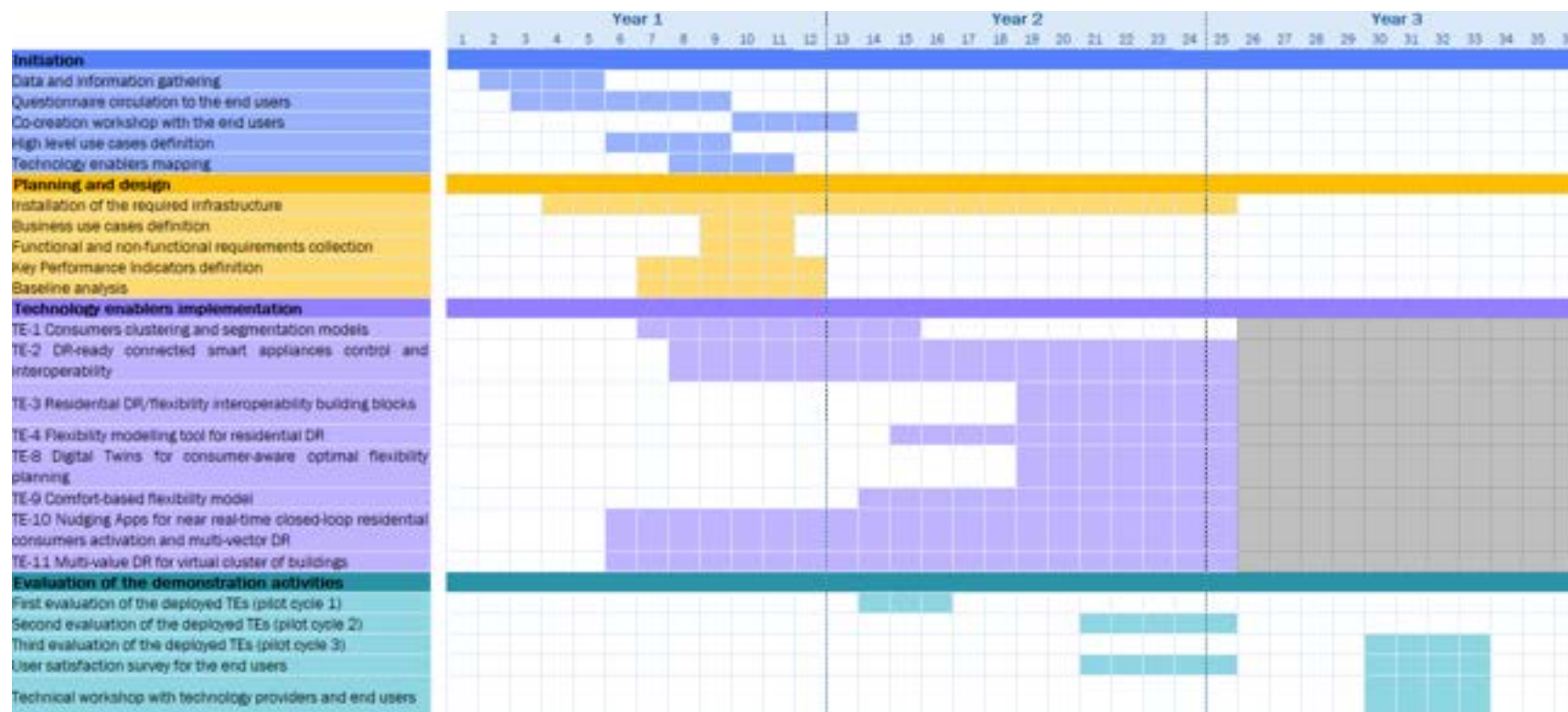


Figure 10: Gantt chart for the implementation plan in the Greek pilot

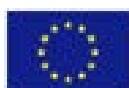
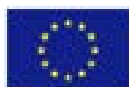


Table 22: Evaluation phase check list for the TEs in the Greek pilot

	Evaluated in the pre-pilot cycle (until M16)	Evaluated in the full-pilot cycle (until M25)	Evaluated in the large scale-pilot cycle (until M33)
TE-1 Consumers clustering and segmentation models	Yes	Yes	TBD
TE-2 DR-ready connected smart appliances control and interoperability	Yes	Yes	TBD
TE-3 Residential DR/flexibility interoperability building blocks	No	Yes	TBD
TE-4 Flexibility modelling tool for residential DR	No	Yes	Yes
TE-8 Digital Twins for consumer-aware optimal flexibility planning	No	Yes	Yes
TE-9 Comfort-based flexibility model	No	No	Yes
TE-10 Nudging Apps for near real-time closed-loop residential consumers activation and multi-vector DR	No	Yes	Yes
TE-11 Multi-value DR for virtual cluster of buildings	Yes	Yes	Yes



6. Pilot 4 – Italy

6.1. Pilot status

6.1.1. Infrastructure and local business platform updates

The pilot site in Italy has made significant progress in enhancing the physical and digital infrastructure to better serve its elderly residents. The installation of energy meters and indoor air quality (IAQ) sensors, including light sensors, in 16 apartments within the pilot site has been completed. The IoT-based platform provided by DOM-X allows for comprehensive monitoring of real-time energy consumption and environmental parameters such as humidity, and temperature. ISRAA's technical office now has direct access to this platform, enabling them to continuously monitor and manage energy and environmental conditions. Additionally, ENG and UNIVPM has been granted access to the collected data for the implementation of their services.

A notable development in this project is the implementation of the Digital Twin (**TE-8**), in order to assist ISRAA's technical office in monitoring energy consumption across the pilot apartments. The digital twin will provide valuable insights by simulating real-world conditions, allowing for the analysis of energy usage patterns and the effectiveness of various energy-saving measures. A draft version of the user interface (UI) for this system has been presented by ENG, and discussions are ongoing to refine and optimize its functionality in the coming weeks.

Parallel to the digital twin, the comfort flexibility model is being deployed (**TE-9**), focusing on the subjective aspects of the residents' living experience. This model involves the analysis and integration of historical data to better understand and cater to the individual comfort preferences of the elderly residents. The system aims at collecting users' feedback on thermal perception along with the collection of environmental data. The feedback trains and tests AI algorithms to improve thermal comfort measurements and provide suggestions to guarantee optimal comfort conditions.

In order to facilitate this, and similarly to case of the Danish pilot, UNIVPM has developed an initial version of a **user-friendly web interface** where residents can directly express their comfort perceptions. Based on the feedback provided, the interface was designed to be intuitive and accessible, considering the specific needs of the target demographic and marking a significant step towards adaptive, resident-centered energy management and living comfort enhancement in the pilot site.

This interface was connected to a communication app, Telegram, that users already use or can easily install. A Python script has been implemented to create a **feedback collector bot**. This was designed to simplify users' engagement by sending hourly reminder notification to a public Telegram group (accessible through the link https://t.me/Dedalus_ISRAA). Each reminder includes a link to an online questionnaire <https://digibuild-demo.eu/dedalus/ISRAA>), that encourages users to provide feedback.



ISRAA plans to equip with tablets those who feel less confident in using smartphones, in order to facilitate access to the questionnaire, enhancing their interaction with the system.

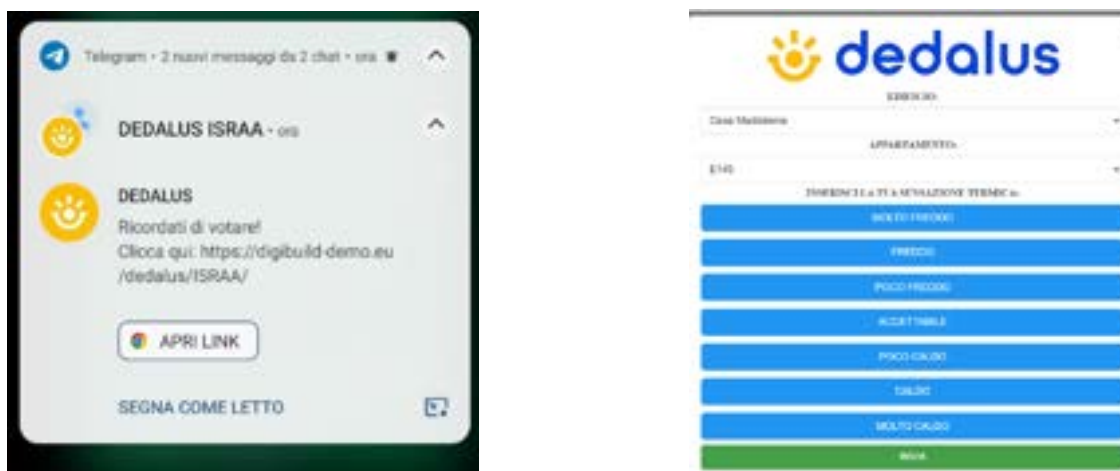


Figure 11: User interface for the feedback collector bot (left) and the web interface (right)

6.1.2. Available data sources

No new data sources from the deployed infrastructure have been generated in the pre-pilot cycle. All the available data sources for the Italian pilot site are reported in section 7.1.4 of D5.1.

6.2. Impact analysis

6.2.1. Progress on the Key Performance Indicators

The following table presents how each KPI progressed for the Italian pilot site, along with their respective values at the conclusion of the pre-pilot cycle.

Table 23: Progress and current values of KPIs at the end of the pre-pilot cycle for the Italian pilot site

	KPI	Name	Baseline	Progress during the pre-pilot cycle	Value at M16
TECHNOLOGICAL	KPI _{TE1}	Increased buildings energy efficiency due to DR programs measured in the pilots	0%	During the pre-pilot cycle, this service was still under development. However, energy meters to measure real-time energy consumption have been installed in the selected apartments and the technical department responsible for the management of energy efficiency is now able to monitor real-time consumption.	0%

	KPI	Name	Baseline	Progress during the pre-pilot cycle	Value at M16
	KPI _{TE2}	Increased share of aggregated flexibility mobilised by piloted assets	0	No progress can be measured yet as the DR service is still not in place. However, the hourly energy consumption can now be measured from the installed meters.	0
	KPI _{TE3}	Increased ratio of exploited vs planned aggregated flexibility validated through pilots	0	No progress can be measured yet as the DR service is still not in place. However, the hourly energy consumption can now be measured from the installed meters.	0
SOCIAL	KPI _{S01}	No of consumers engaged in residential DR	0	No direct involvement of residents to DR programmes, as the service is still in development stage. However, by the end of the pre-pilot cycle, 20 residents living in 16 apartments in the co-housing venue were engaged through face-to-face meetings, questionnaires and one co-creation workshop. The engagement process was facilitated by the support of the co-housing nurse and psychologist that helped define the right approach to follow.	20
	KPI _{S02}	Reduction of number of complaints from tenants regarding temperature comfort and indoor climate	24 per year	During the pre-pilot phase, many services were still under development. Therefore, there has been no progress in the collection of complaints so far. The number of new complaints will be measured after the demonstration. UNIVPM provided the pilot with a Thermal Sensation Vote questionnaire, which will be used to assess tenants' perceptions of their environment	24 per year
	KPI _{S03}	Different types of actors engaged by DEDALUS services	0	In the pre-pilot phase, different types of actors have been engaged, mainly internal to the organisation, such as the technical department, which is also the facility manager, psychologists, the co-housing coordinator and the healthcare staff supporting the co-housing. Even though these actors have not yet actively participated in the demonstration, a strong connection and interest for the project's actions have been established.	6



	KPI	Name	Baseline	Progress during the pre-pilot cycle	Value at M16
BUSINESS	KPI _{BU1}	Energy system cost reduction, by providing flexibility services to electrical, gas and district heating grids	0	In the pre-pilot cycle, the services were still under development, so no progress in the cost reduction calculation has been made. However, the partner Dyname carried out an analysis of the energy bills of 2022/2023 and the energy contracts in place. The aim was to understand the costs for the organisation which is legally bound to specific contracts (Consip) due to legislation for public bodies, compared to other energy providers on the market.	0
	KPI _{EN1}	Carbon emissions reduction (environmental benefit) for the energy grids measured at piloted local community level	Building 1: 6,83 t/year (year 2023) Building 2: 34,59 t/year (year 2023)	No progress can be measured yet as the DR service is still not in place. However, the hourly energy consumption can now be measured from the installed meters. By utilizing emission factors and the energy meter readings, carbon emissions can be estimated.	N/A
ENVIRONMENTAL	KPI _{EN2}	Thermal comfort assurance	-	During the pre-pilot cycle, this service was still under development. No progress can be measured yet. However, an IAQ sensor and a light sensor have been installed in the 16 apartments to measure internal temperature, humidity, PM10, PM5, CO2. This will provide essential parameters to develop the comfort flexibility model when the comfort-based optimization model will be ready, feedback will be provided to the occupants to improve the environmental condition.	N/A-
	KPI _{EN3}	Thermal discomfort mitigation	-	During the pre-pilot cycle, the comfort flexibility model was still under development in order to calculate this KPI. No progress can be measured yet. Thermal discomfort mitigation will be provided to the occupants when the comfort-based optimization model will be ready	-N/A



	KPI	Name	Baseline	Progress during the pre-pilot cycle	Value at M16
	KPI _{EN4}	Indoor Air Quality assurance	-	During the pre-pilot cycle, the comfort flexibility model was still under development in order to calculate this KPI. No progress can be measured yet. However, the all the relevant sensors have been installed and data collection is currently feasible.	N/A
	KPI _{EN5}	Visual comfort assurance	-	During the pre-pilot cycle, the comfort flexibility model was still under development in order to calculate this KPI. No progress can be measured yet. However, all the relevant sensors have been installed and data collection is currently feasible.	-

6.2.2. Technology enablers evaluation in the pre-pilot cycle

The following tables present the evaluation of the TEs demonstrated in the pre-pilot cycle.

Table 24: TE-1 evaluation in the Italian pilot site

TE – 1 Consumers clustering and segmentation models				
Demonstration in this pilot cycle	A questionnaire was formed covering user features about demographics, energy literacy, energy behaviour, attitude, and DR barriers. Every pilot translated it in the local language and shared it with participants either in person or digitally. The questionnaire responses were used to produce a visualisation dashboard, which assisted in gaining insights to delineate a generic pilot persona. Thereafter, a segmentation was performed to split the population into groups of distinctive character. The utter goal is to identify users with similar attributes so as to plan a tailored approach strategy.			
Key metrics measuring the successful implementation	Regarding the questionnaire, the analysis produced 2 different clusters: 1) Willing: male, higher energy literacy / familiarity, highest scoring in pilot – higher DR prospects. 2) Unwilling: female, very low energy literacy, low general scoring, tech barriers – low DR prospects.			
Input	Data from 17 questionnaire responses were provided for the segmentation analysis.			
Output	Questionnaire segmentation results			
			Segment A Willing	Segment C Unwilling
	Population	Number of Participants	9 [53%]	8 [47%]
	Segmenting Metrics	Overall DR Willingness	4-5	0-3
		DR Familiarity	3.1	2.5



	Energy Literacy	Average	3.0	1.8
	Demographics	Gender	Male	Female
		Age	65+	65+
		Education	N/A	N/A
		Digital Expertise	Mid	Low-Mid
		Occupation	Retired	Retired
		Adults	0	0
		Seniors	1-2	1-2
		Children	0	0
		Income	Mid	Mid
		Spending Behaviour	Conservative	Conservative
	Energy Behaviour		Follows Total	Low on Laundry
	Attitude	Eco	High	High
		Fin	Low	Low
		Tech	High	Low
		Social	High	Low-Mid
	DR Barriers		Lack of awareness / Daily Impact	Tech Challenges
End user	Building manager, Energy retailer, Services provider			
Further improvements	Further improvements may include mapping the questionnaire responses to real household consumption data and combining our approaches for the pilot.			



6.3. Pilot-specific implementation plan up to M25

This section includes the Gantt Chart with all the activities demonstrated in the Italian pilot site, the timelines for the TEs implementation, and the table with the evaluation phase check list for each TE.

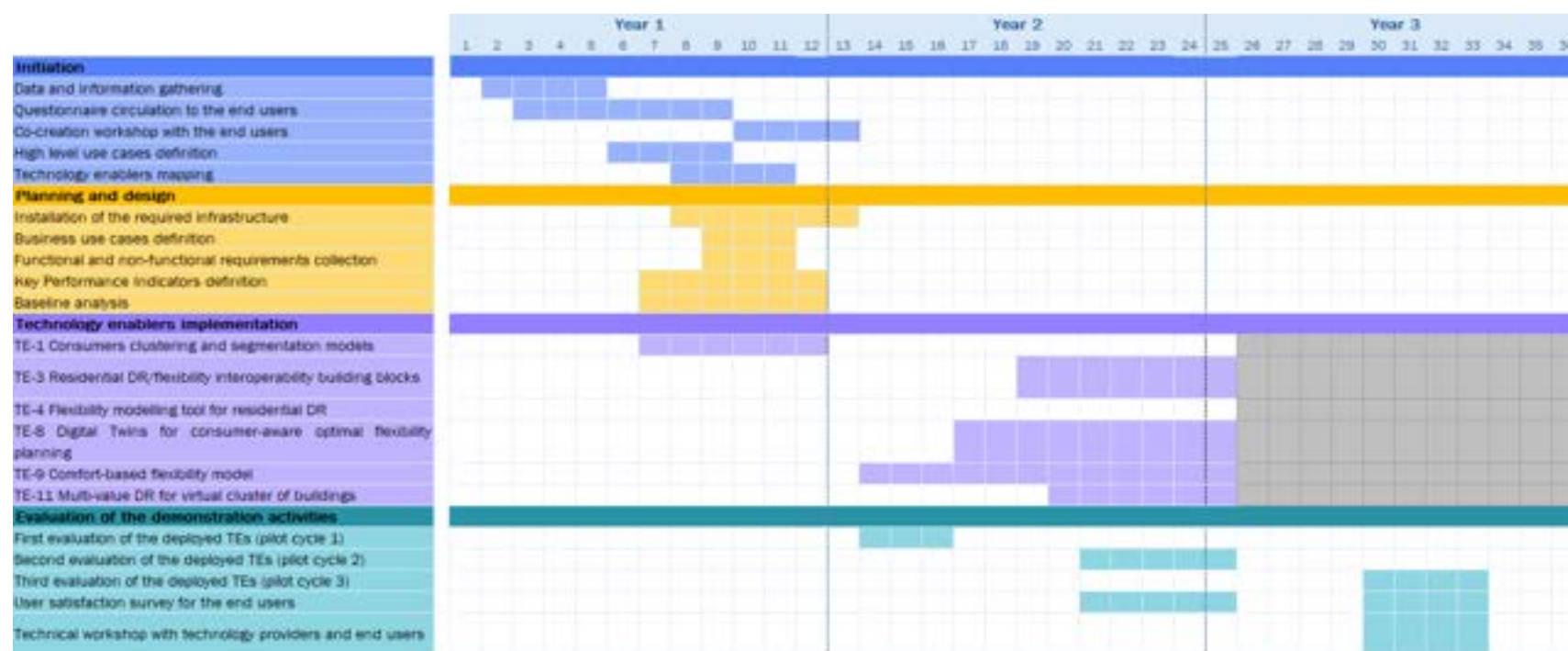


Figure 12: Gantt chart for the implementation plan in the Italian pilot

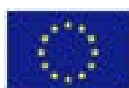


Table 25: Evaluation phase check list for the TEs in the Italian pilot

	Evaluated in the pre-pilot cycle (until M16)	Evaluated in the full-pilot cycle (until M25)	Evaluated in the large scale-pilot cycle (until M33)
TE-1 Consumers clustering and segmentation models	Yes	No	TBD
TE-3 Residential DR/flexibility interoperability building blocks	No	Yes	TBD
TE-4 Flexibility modelling tool for residential DR	No	No	TBD
TE-8 Digital Twins for consumer-aware optimal flexibility planning	No	Yes	Yes
TE-9 Comfort-based flexibility model	No	Yes	Yes
TE-11 Multi-value DR for virtual cluster of buildings	No	Yes	Yes



7. Pilot 5 – Spain

7.1. Pilot status

7.1.1. Infrastructure and local business platform updates

The Spanish pilot in La Seu d'Urgell is making substantial progress in its infrastructure and local business platform. Below are the most significant updates:

Infrastructure Developments:

- A district level battery has been successfully installed and integrated into the low voltage network of PEUSA, enhancing the community's energy storage capabilities (**TE-13**).
- The agreement with ARC to install 26 smart devices across 12 households is advancing, with five smart plugs already delivered to CIMNE for testing. Additionally, PEUSA has procured and is in the process of installing 12 smart meters for real-time electricity monitoring in homes. The setup of ARCELIK's IoT infrastructure is in process of being sent to Spain, with the installation of communication gateways pending (**TE-2**).
- Finally, there are installation plans to be conducted within the full operation phase (until M25) which include three smart heat pumps that will provide efficient heating and cooling solutions with remote control capabilities (**TE-2**).

Local Business Platform Development:

- The integration of user electricity consumption data from fiscal meters using the PRIME protocol into the ENMA platform is scheduled for the upcoming weeks.
- A connection process using Message Queuing Telemetry Transport (MQTT) between CIMNE and the ARC IoT platforms is being established to facilitate real-time data sharing from the smart plugs, comfort sensors and Heat pumps (**TE-2**).
- A middleware cloud platform has been installed, and a REST-API is currently being integrated into the CIMNE architecture to enhance data communication and management.
- Real-time monitoring and control of the district battery and the overall energy system has been established, supported by the newly installed middleware platform and ongoing API integrations.
- The API layer is configured, and the data ontology has been defined and the integration to the DEDALUS ontology is ongoing (**TE-3**). The development of the data model is in progress, aiming to optimize data utilization and analytics.
- The requirements for the nudging user interface (**TE-10**) have been established, with mock-ups currently being developed. This interface will enable effective communication of energy-saving tips and DR actions to residents (**TE-11**).

7.1.2. Available data sources

No new data sources from the deployed infrastructure have been generated in the pre-pilot cycle. All the available data sources for the Spanish pilot site are reported in section 8.1.4 of D5.1.



7.2. Impact analysis

7.2.1. Progress on the Key Performance Indicators

The following table presents how each KPI progressed for the Spanish pilot site, along with their respective values at the conclusion of the pre-pilot cycle.

Table 26: Progress and current values of KPIs at the end of the pre-pilot cycle for the Spanish pilot site

	KPI	Name	Baseline	Progress during the pre-pilot cycle	Value at M16
TECHNOLOGICAL	KPI _{TE1}	Increased buildings energy efficiency due to DR programs measured in the pilots	0	In the pre-pilot cycle, the services were still under development, so no progress can be measured yet.	N/A
	KPI _{TE2}	Increased share of aggregated flexibility mobilised by piloted assets	0	In the pre-pilot cycle, the services were still under development, so no progress can be measured yet.	N/A
SOCIAL	KPI _{SO1}	No of consumers engaged in residential DR	0	No direct involvement of residents to DR programmes, as the service is still in development stage. However, all the consumers in the pilot site have been contacted and engaged indirectly (questionnaire, workshop) in residential DR.	12
	KPI _{SO3}	Different types of actors engaged by DEDALUS services	0	The actors directly involved in the demonstration have been engaged: the DSO, the battery provider, the IoT provider and the city council of La Seu	5
BUSINESS	KPI _{BU1}	Energy system cost reduction, by providing flexibility services to electrical, gas and district heating grids	0	In the pre-pilot cycle, the services were still under development, so no progress can be measured yet.	N/A
	KPI _{BU2}	Increased rate of self-consumption of locally generated renewable energy	0	In the pre-pilot cycle, the services were still under development, so no progress can be measured yet.	N/A



	KPI	Name	Baseline	Progress during the pre-pilot cycle	Value at M16
ENVIRONMENTAL	KPI _{EN1}	Carbon emissions reduction (environmental benefit) for the energy grids measured at piloted local community level	0	In the pre-pilot cycle, the services were still under development, so no progress can be measured yet.	0
	KPI _{EN2}	Thermal comfort assurance	-	The installations of the ARC gateways to measure the indoor temperature and humidity are expected in the following months (TE-2), enabling the deployment of the comfort-based flexibility models (TE-9).	N/A
	KPI _{EN3}	Thermal discomfort mitigation	-	The installations of the ARC gateways to measure the indoor temperature and humidity are expected in the following months (TE-2), enabling the deployment of the comfort-based flexibility models (TE-9).	N/A

7.2.2. Technology enablers evaluation in the pre-pilot cycle

The following tables present the evaluation of the TEs demonstrated in the pre-pilot cycle.

Table 27: TE-1 evaluation in the Spanish pilot site

TE – 1 Consumers clustering and segmentation models	
Demonstration in this pilot cycle	A questionnaire was formed covering user features about demographics, energy literacy, energy behaviour, attitude, and DR barriers. Every pilot translated it in the local language and shared it with participants either in person or digitally. The questionnaire responses were used to produce a visualisation dashboard, which assisted in gaining insights to delineate a generic pilot persona. Thereafter, a segmentation was performed to split the population into groups of distinctive character. The utter goal is to identify users with similar attributes so as to plan a tailored approach strategy.
Key metrics measuring the successful implementation	Regarding the questionnaire, the analysis produced 2 different clusters: 1) Familiar: male, higher education, higher digital expertise, most positive attitude – high DR prospects. 2) Unfamiliar: female, lower digital expertise, least positive attitude – low DR prospects.
Input	Data from 17 questionnaire responses were provided for the segmentation analysis.



TE – 1 Consumers clustering and segmentation models

Output	Questionnaire segmentation results			
			Segment A Familiar	Segment B Unfamiliar
	Population	Number of Participants	11 [65%]	6 [35%]
	Segmenting Metrics	Overall DR Willingness average	3	2
		DR Familiarity	3-4	1-2
	Energy Literacy	Average	3.5	3.3
	Demographics	Gender	11 Male (all-male segment)	3 Female (all pilot females)
		Age	No dominant	No dominant
		Education	Higher+	No dominant
		Digital Expertise	Mid-High	Low-Mid
		Occupation	Employed	Employed
		Adults	No dominant	No dominant
		Seniors	0	0
		Children	No dominant	No dominant
		Income	N/A	N/A
		Spending Behaviour	Liberal	Very Liberal
	Energy Behaviour		No pattern	No pattern
	Attitude	Eco	High	Low-Mid
		Fin	N/A	N/A
		Tech	Mid-High	Mid-High
		Social	Mid-High	Mid-Low
	DR Barriers		Lack of awareness	Lack of awareness
End user	Building manager, energy supplier			
Further improvements	Further improvements may include mapping the questionnaire responses to real household consumption data and combining our approaches for the pilot.			

Table 28: TE-2 evaluation in the Spanish pilot site

TE – 2 DR-ready connected smart appliances control and interoperability

Demonstration in this pilot cycle	<i>Test smart meters have been connected and the communication layer has been defined. The start of the first communication test have started and have been successful. The specific heat pump sizes are starting to be defined.</i>		
Key metrics measuring the successful implementation	DR-ready smart appliance IoT platform HomeWhiz with open APIs, service enablers and respective tools for integration with legacy device types will be achieved through smart controllers		
	Secure edge gateways will be locally employed to fuse data collected from various devices over the dominant wireless protocols and to expose		



	vendor specific APIs in a common format through home automation frameworks.
Input	Applicable protocols and standards: BACnet, Modbus, LonWorks, Opentherm, OCPP Wireless protocols: Wi-Fi, ZigBee, LoRa Specific APIs in a common format through home automation frameworks: OpenHAB, HomeAssistant Data brokers: MQTT, REST APIs Local/external data repositories: Microsoft SQL Server and openly available European Data Spaces
Output	Information of appliances and heat pumps consumption, important for TE13. Temperature and humidity and heat pump settings important for determining comfort levels. The collected data from multiple data sources, such as smart meters, thermostats, sensors, smart appliances, Electric Vehicle (EV) chargers, etc. will be harmonised and integrated with open and standardisable connectors over data brokers and local/external data repositories
End user	Residential consumers, by being able to manage loads to shift their consumption and monitor the consumption from specific appliances.
Further improvements	Integration with other IoT platforms in the consortium. Building the communication for the comfort data and the heat pumps. Matterization by updating existing products, such as smart plugs, gateways, and refrigerators, to ensure they comply with the technical specifications established by the Matter protocol.

Table 29: TE-13 evaluation in the Spanish pilot site

	TE-13 District-level DR for self-consumption and cost optimisation
Demonstration in this pilot cycle	Several studies on the possible optimization of the cost and self-consumption have been developed in data similar to the pilot. The different studies have been developed with historical data to validate the Linear programming optimization of the usage of the district battery. Moreover, the battery has been deployed and connected. The real-time acquisition metering has been deployed and several devices from the TE-2 will be integrated as well.



Key metrics measuring the successful implementation	No key metrics were measured during this part of the pilot.
Input	Electric consumption, forecast of the electrical consumption, forecast of the electrical generation and price from the Spanish electrical pilot.
Output	Schedules on how the different DR systems should operate, more specifically how the battery has to operate.
End user	Residential consumers and energy supplier
Further improvements	Data and resources from TE-2 have to be implemented on the lineal programming. Regarding the Austrian pilot different energy resources have to be incorporated.



7.3. Pilot-specific implementation plan up to M25

This section includes the Gantt Chart with all the activities demonstrated in the Spanish pilot site, the timelines for the TEs implementation, and the table with the evaluation phase check list for each TE.

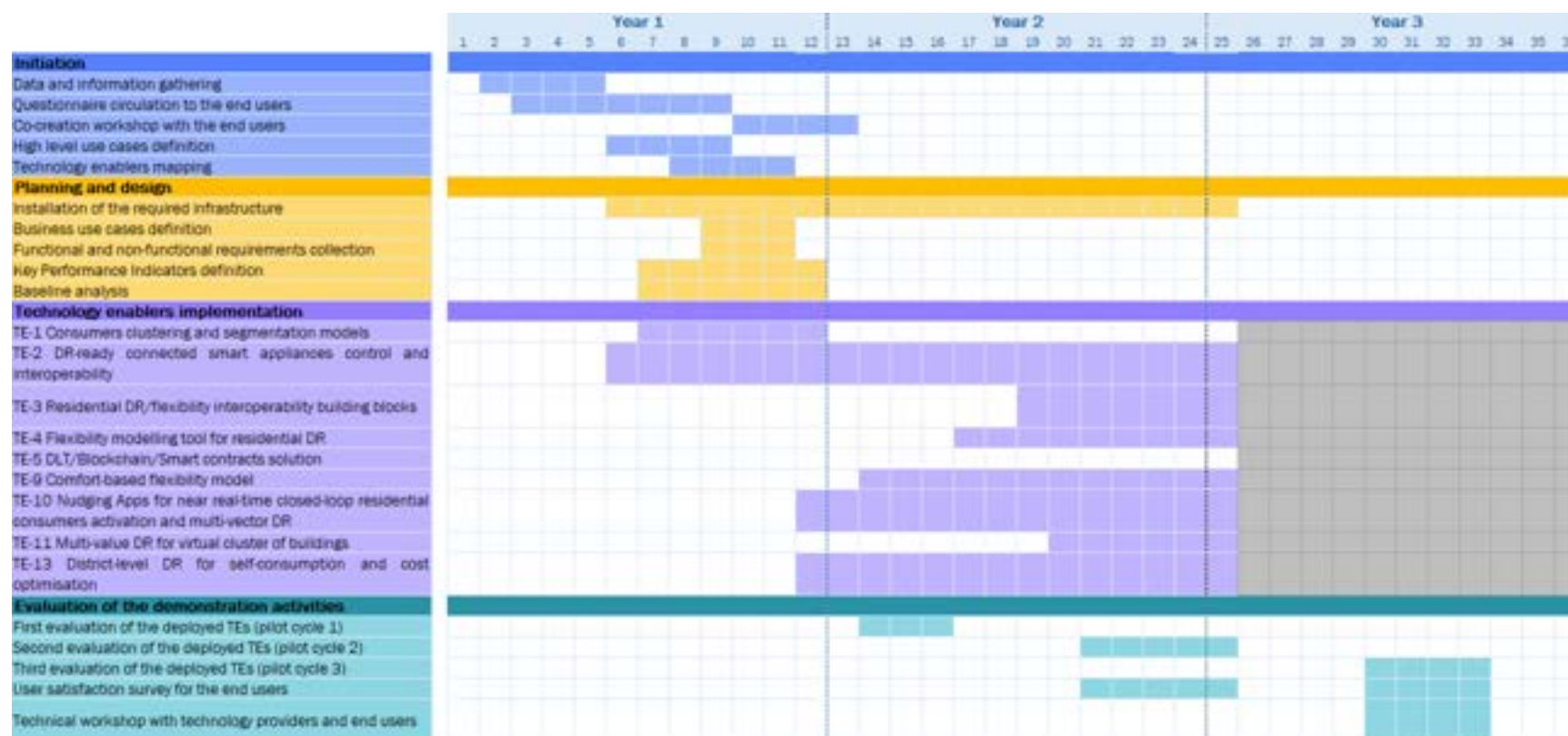


Figure 13: Gantt chart for the implementation plan in the Spanish pilot



Table 30: Evaluation phase check list for the TEs in the Spanish pilot

	Evaluated in the pre-pilot cycle (until M16)	Evaluated in the full-pilot cycle (until M25)	Evaluated in the large scale-pilot cycle (until M33)
TE-1 Consumers clustering and segmentation models	Yes	No	TBD
TE-2 DR-ready connected smart appliances control and interoperability	Yes	Yes	TBD
TE-3 Residential DR/flexibility interoperability building blocks	No	Yes	TBD
TE-4 Flexibility modelling tool for residential DR	No	Yes	TBD
TE-5 DLT/Blockchain/Smart contracts solution	No	No	Yes
TE-9 Comfort-based flexibility model	No	No	Yes
TE-10 Nudging Apps for near real-time closed-loop residential consumers activation and multi-vector DR	No	No	Yes
TE-11 Multi-value DR for virtual cluster of buildings	No	Yes	Yes
TE-13 District-level DR for self-consumption and cost optimisation	Yes	Yes	Yes



8. Pilot 6 – Ireland

Pilot 6 in Ireland is one of the DEDALUS multiplier pilots, aimed at developing a framework for deploying DR in a social housing context to address energy poverty. This pilot focuses on implementing DR across three social housing associations, each comprising 10 houses equipped with air-to-water heat pumps.

As outlined in the previous deliverable for this WP (D5.1), due to complications with the heat pump provider for the Irish demonstration, CENTRICA, as the pilot leader, lost access to the original site and had to search for an alternative pilot.

Since May 2024, Centrica has made significant efforts to identify a replacement pilot site. The company contacted 38 different organizations across various sectors, including heat pump providers, social housing associations, pilot partners from similar projects, Irish energy providers, and the Flemish government. Centrica had numerous discussions to explain the situation and the requirements for the pilot. In total, Centrica has engaged in over 170 interactions with these potential partners, including meetings, emails, and phone calls. These extensive communications have led to the identification of 11 potential pilot sites, primarily located in Ireland and Belgium. As of this deliverable's submission, the status of these potential pilot sites is as follows:

- 5 out of 11 pilot sites have provided negative responses.
- 4 out of the 11 stopped responding after some communications, despite multiple follow-up attempts.
- Discussions with 2 of the 11 pilot sites are still ongoing. These two sites are located in Ireland: one is a heat pump installer, and the other is an energy cooperative from an energy community. Centrica is continuing discussions with these two sites, assessing their suitability and addressing data-sharing concerns.

The next steps involve finalizing discussions with these two pilot sites and choose one of these two pilots, consulting with the project officer. Once finalized, an amendment will be submitted to the European Commission (EC) portal, and a revised version of this deliverable will be resubmitted, including all relevant information regarding the new pilot site and updates from the other pilot sites.



9. Pilot 7 – Romania

9.1. Pilot status

9.1.1. Local business platform and infrastructure updates

There are no major updates about the infrastructure of the local business platform for Pilot 7, the energy consumption data are collected with a Building Energy Management System (BEMS), a solution based on the Siemens WinCC product that is described in deliverable D5.1. We resume below some development updates for the local business platform, more related to the technological enablers that were/will be tested in the evaluation cycles:

- **TE-1 (Consumers clustering and segmentation models):** we have engaged 112 residents (students) that filled the DEDALUS questionnaire defined for TE-1. The questionnaire has been provided online, instructions have been given and the obtained answers were directly collected by TE-1 leader. Additionally, we have involved the other actors (building owner and operator) in workshops and discussions regarding DEDALUS DR-enabled technologies.
- **TE-4 (Flexibility modelling tool for residential DR):** we have extracted historical data from Pilot 7 and made it available for TE-4 to be used for training in the flexibility prediction methodology, more specifically to predict the next day's consumption and production of flexibility using a Long Short-Term Memory (LSTM) based predictor.
- **TE-5 (blockchain-based interoperability for flexibility tokenization & DR settlement) – to be evaluated in the full and large scale pilot cycles**
 - We have designed and implemented a data model for TE-5 that follows and is compliant with the DEDALUS ontology to support various configurations of the assets and to ensure interoperability with other project components and services.
 - We have developed and integrated a data ingestion component that uses a FTP Data Collector to retrieve automatically sensor data from the FTP server (where it is stored by Pilot 7 BEMS) and that feeds the information in the above data model. The collector has a timer task which is currently configured to collect data at one hour time interval. Apart from copying new files (CSV) from the server, it reads monitored data from files, aggregates this data and sends the monitored data to the data storage component of TE-5.
 - We have developed a forecasting component that is responsible for making predictions on request or scheduled for Pilot 7 case. It uses as input data collected using the data ingestion component for training the algorithms. An integration API allows for integrating the currently implemented prediction models from TE-4 flexibility modeling tool and its future updates that are under development (e.g. Transformer model, Kolmogorov-Arnold Networks).

9.1.2. Available data sources

No new data sources from the deployed infrastructure have been generated in the pre-pilot cycle. All the available data sources for the Romanian pilot site are reported in section 10.1.4 of D5.1.



9.2. Impact analysis

9.2.1. Progress on the Key Performance Indicators

The following table presents how each KPI progressed for the Romanian pilot site, along with their respective values at the conclusion of the pre-pilot cycle.

Table 31: Progress and current values of KPIs at the end of the pre-pilot cycle for the Romanian pilot site

	KPI	Name	Baseline	Progress during the pre-pilot cycle	Value at M16
TECHNOLOGICAL	KPI _{TE1}	Increased buildings energy efficiency due to DR programs measured in the pilots	Energy consumption baseline shown in the Figures provided in D5.1.	During the pre-pilot phase, the DEDALUS service(s) (TE-5 and TE-8) were still under development, so no progress can be measure yet. The results of TE-5 evaluation in the next testing cycle can be used to assess this KPI.	-
	KPI _{TE2}	Increased share of aggregated flexibility mobilised by piloted assets	0	During the pre-pilot phase, the DEDALUS service(s) (TE-5 and TE-8) were still under development, so no progress can be measure yet. The results of TE-5 evaluation in the next testing cycle can be used to assess this KPI.	0
SOCIAL	KPI _{S01}	No of consumers engaged in residential DR	0	No direct involvement of residents to DR programmes, as the service is still in development stage. However, 127 consumers (112 residents that filled the DEDALUS questionnaire, 13 residents that participated to the physical workshop, building owner and building manager) have been engaged indirectly in residential DR.	127 consumers
	KPI _{S03}	Different types of actors engaged by DEDALUS services	Building managers/residents	Building Owner; Building operator (manager); Apartment residents (students)	Building Owner; Building operator (manager); Apartment residents (students)
ENVIRONMENTAL	KPI _{EN1}	Carbon emissions reduction (environmental benefit) for the energy grids measured at piloted local community level	Average yearly value of buildings: 2.2 t CO ₂ eq	N/A	N/A



9.2.2. Technology enablers evaluation in the pre-pilot cycle

The following tables present the evaluation of the TEs demonstrated in the pre-pilot cycle.

Table 32: TE-1 evaluation in the Romanian pilot site

TE-1 Consumers clustering and segmentation models																																																																																					
Demonstration in this pilot cycle	A questionnaire was formed covering user features about demographics, energy literacy, energy behaviour, attitude, and DR barriers. Every pilot translated it in the local language and shared it with participants either in person or digitally. The questionnaire responses were used to produce a visualisation dashboard, which assisted in gaining insights to delineate a generic pilot persona. Thereafter, a segmentation was performed to split the population into groups of distinctive character. The utter goal is to identify users with similar attributes so as to plan a tailored approach strategy.																																																																																				
Key metrics measuring the successful implementation	The questionnaire analysis produced 4 different clusters: 1) Willing & Familiar: male, higher digital expertise – high DR prospects. 2) Willing & Unfamiliar: female, highly positive attitude and DR willingness – potentially high DR prospects. 3) Unwilling & Familiar: male, highly positive attitude and familiarity – potentially high DR prospects. 4) Unwilling & Unfamiliar: female, higher digital expertise, highly positive attitude – potentially good DR prospects.																																																																																				
Input	Data from 112 questionnaire responses were provided for the segmentation analysis.																																																																																				
Output	Questionnaire segmentation analysis <table> <tr> <th colspan="2"></th><th>Segment A Willing & Familiar</th><th>Segment B Willing & Unfamiliar</th><th>Segment C Unwilling & Familiar</th><th>Segment D Unwilling & Unfamiliar</th></tr> <tr> <td>Population</td><td>Number of Participants</td><td>30 [27%]</td><td>31 [28%]</td><td>23 [21%]</td><td>28 [25%]</td></tr> <tr> <td rowspan="2">Segmenting Metrics</td><td>Overall DR Willingness</td><td>2-6</td><td>2-6</td><td>0-1</td><td>0-1</td></tr> <tr> <td>DR Familiarity</td><td>3-5</td><td>1-2</td><td>3-5</td><td>1-2</td></tr> <tr> <td>Energy Literacy</td><td>Average</td><td>3.1</td><td>3.1</td><td>3.0</td><td>3.0</td></tr> <tr> <td rowspan="10">Demographics</td><td>Gender</td><td>21 Male (dominant)</td><td>12 Female (relatively dominant)</td><td>16 Male (dominant)</td><td>11 Female (relatively dominant)</td></tr> <tr> <td>Age</td><td>18-29</td><td>18-29</td><td>18-29</td><td>18-29</td></tr> <tr> <td>Education</td><td>Higher</td><td>Higher</td><td>Higher</td><td>Higher</td></tr> <tr> <td>Digital Expertise</td><td>High</td><td>Mid-High</td><td>Mid</td><td>High</td></tr> <tr> <td>Occupation</td><td>Student</td><td>Student</td><td>Student</td><td>Student</td></tr> <tr> <td>Adults</td><td>2-4</td><td>2-4</td><td>2-4</td><td>2-4</td></tr> <tr> <td>Seniors</td><td>0</td><td>0</td><td>0</td><td>0</td></tr> <tr> <td>Children</td><td>0-1</td><td>0-1</td><td>0-1</td><td>0-1</td></tr> <tr> <td>Income</td><td>High</td><td>Mid-High</td><td>Mid-High</td><td>Mid-High</td></tr> <tr> <td>Spending Behaviour</td><td>Liberal</td><td>Mid</td><td>Mid</td><td>Low-Mid</td></tr> </table>							Segment A Willing & Familiar	Segment B Willing & Unfamiliar	Segment C Unwilling & Familiar	Segment D Unwilling & Unfamiliar	Population	Number of Participants	30 [27%]	31 [28%]	23 [21%]	28 [25%]	Segmenting Metrics	Overall DR Willingness	2-6	2-6	0-1	0-1	DR Familiarity	3-5	1-2	3-5	1-2	Energy Literacy	Average	3.1	3.1	3.0	3.0	Demographics	Gender	21 Male (dominant)	12 Female (relatively dominant)	16 Male (dominant)	11 Female (relatively dominant)	Age	18-29	18-29	18-29	18-29	Education	Higher	Higher	Higher	Higher	Digital Expertise	High	Mid-High	Mid	High	Occupation	Student	Student	Student	Student	Adults	2-4	2-4	2-4	2-4	Seniors	0	0	0	0	Children	0-1	0-1	0-1	0-1	Income	High	Mid-High	Mid-High	Mid-High	Spending Behaviour	Liberal	Mid	Mid	Low-Mid
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	Income	High	Mid-High	Mid-High	Mid-High																																																																																
	Spending Behaviour	Liberal	Mid	Mid	Low-Mid																																																																																



	Energy Behaviour		No pattern	No pattern	No pattern	No pattern
	Attitude	Eco	Mid	Mid	Mid-High	Mid
		Fin	High	High	High	High
		Tech	High	High	High	High
		Social	Mid	High	Mid	Mid
	DR Barriers		Daily impact / Lack of awareness / Limited fin rewards	Daily impact / Lack of awareness / Limited fin rewards	Daily impact / Lack of awareness / Limited fin rewards	Daily impact / Lack of awareness / Limited fin rewards
End user	The end user for TE1 can be a building operator/manager, an energy supplier or an energy community, as well as workshop organisers.					
Further improvements	Further improvements may include mapping the questionnaire responses to real household consumption data and combining our approaches for the pilot.					

Table 33: TE-4 evaluation in the Romanian pilot site

TE-4 Flexibility modelling tool for residential DR	
Demonstration in this pilot cycle	The flexibility prediction methodology that we have developed was incorporated on the flexibility modelling tool. The tool uses historical building energy consumption and photovoltaic panel production data (if available) to predict the next day's consumption and production flexibility, leveraging Long Short-Term Memory (LSTM) models. These models were trained using building-level data to forecast energy flexibility for each hour, identifying upper and lower flexibility levels.
Key metrics measuring the successful implementation	The following key metrics were used to measure the successful implementation of the TE in the pilot: • Energy Forecasting Accuracy: The model's performance was evaluated using metrics like Mean Absolute Error (MAE), Mean Squared Error (MSE), and R^2 for both consumption and production predictions. Electricity consumption prediction achieved an MAE of 1.06, an MSE of 2.23, and an R^2 of 0.74 while electricity production forecast achieved an MAE of 1.21, an MSE of 2.95, and an R^2 of 0.93. • Flexibility Calculation: The flexibility baseline, maximum, and minimum levels were computed for both energy consumption and production, providing insights into potential adjustments for each hour of the target day.
Input	The data included energy consumption from the pilot site, collected over two years with a one-hour granularity.



Output	The final output of the TE implementation included: Charts: The flexibility prediction was visualized through charts. These charts showcased the flexibility metrics, including the baseline, maximum, and minimum flexibility for both energy consumption and production, represented graphically. Energy Flexibility Indicators: EFIs provided quantitative measures of flexibility, enabling a more precise assessment of potential upward or downward adjustments in energy consumption or production for each hour and for specific time intervals of the predicted day. A tool with user interfaces of the charts and energy flexibility indicators will be provided to the end users. More information about the tool will be reported in D3.2 – “DEDALUS technological enablers for multi value and energy carrier-agnostic residential DR (2nd technology release)”.
End user	The primary end users of this TE included: • Residents: Direct beneficiaries of improved energy management practices, leading to potential cost savings and more efficient energy use. • Building Managers: Used the flexibility predictions to better manage energy systems in residential buildings.
Further improvements	• Enhancing Forecasting Accuracy: Further refinement of the prediction models could improve prediction accuracy, particularly through the use of advanced machine learning techniques. • Device-level disaggregation will be incorporated to isolate and forecast the energy consumption flexibility of individual devices. This will provide a more granular understanding of how each device contributes to the overall energy flexibility, improving the precision of demand response strategies. • Frontend Development: Further development of the frontend dashboard to make the user interface more intuitive and user-friendly. Enhancements would include improved data visualization techniques, customizable reports, and analytics to offer end users a more interactive experience when viewing and interpreting flexibility data.



9.3. Pilot-specific implementation plan up to M25

This section includes the Gantt Chart with all the activities demonstrated in the Romanian pilot site, the timelines for the TEs implementation, and the table with the evaluation phase check list for each TE.

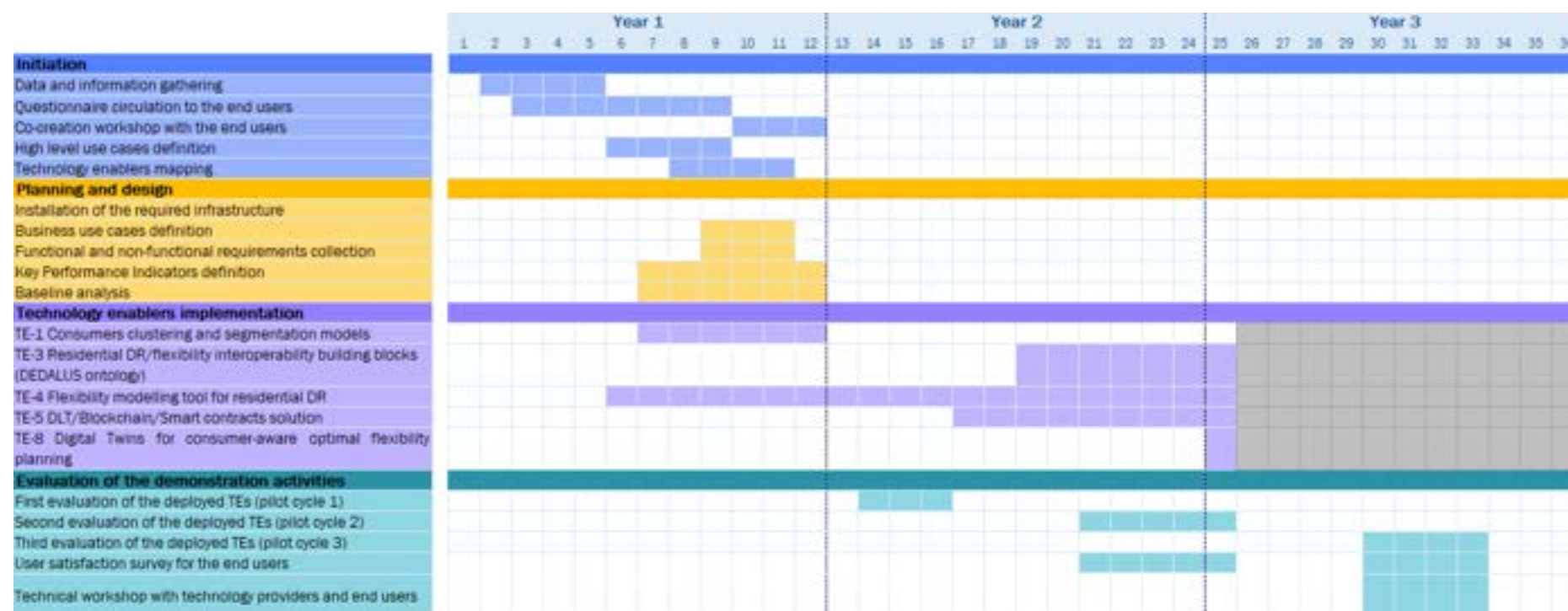


Figure 14: Gantt Chart of the implementation plan for the Romanian Pilot

Table 34 Evaluation phase check list for the TEs in the Romanian pilot

	Evaluated in the pre-pilot cycle (until M16)	Evaluated in the full-pilot cycle (until M25)	Evaluated in the large scale-pilot cycle (until M33)
TE-1 Consumers clustering and segmentation models	Yes	No	No
TE-3 Residential DR/flexibility interoperability building blocks (DEDALUS ontology)	No	Yes	TBD
TE-4 Flexibility modelling tool for residential DR	Yes	Yes	No
TE-5 DLT/Blockchain/Smart contracts solution	No	Yes	Yes
TE-8 Digital Twins for consumer-aware optimal flexibility planning	No	No	Yes



10. Conclusions

This document reports on the preliminary results of the demonstration activities conducted across the DEDALUS project's pilot sites during the pre-pilot cycle (M14-M16). It has detailed the installation and initial operation of most of the physical infrastructure, with only minor installations such as communication devices, smart plugs, and DR-ready appliances pending. These pending tasks do not currently hinder the deployment of TEs at the demonstration sites and are being closely monitored. Resolutions to these issues are anticipated in the coming months, setting the stage for full-scale pilot demonstrations.

The impact analysis conducted shows that while initial advancements in KPIs are modest due to the nascent stage of many TEs, the foundational work for a scalable deployment is well underway. Each pilot site's specific progress and challenges have been evaluated, providing valuable insights into the areas requiring attention as the project advances.

As the project moves forward into the full pilot operation phase, the document outlines comprehensive plans for each site, including timelines for addressing remaining installations and escalating the deployment and testing of the TEs. This phase will focus on enhanced monitoring and evaluation of the implemented technologies and strategies, tailored to ensure that the project's objectives are met and provide a thorough assessment of each pilot's impact. The next 9 months will be pivotal, and key next steps for the pilot sites include:

- Finalizing the installation of communication devices, smart plugs, energy meters, and DR-ready appliances to ensure all infrastructure is operational.
- Intensive tracking and reporting on the KPIs as the technologies reach full operational status. This will yield vital data on the TEs' effectiveness and their overall impact on achieving pilot objectives.
- Conducting workshops to collect direct feedback from various end-users, which will be instrumental in fine-tuning the deployment and functionality of the TEs to align with user needs and project aims.
- Developing and implementing customized user engagement strategies for each pilot site, aimed at maximizing participant involvement in the DR programs and catering to the distinct needs of each pilot's residential users.

All outcomes, from the detailed KPI analysis to the insights from technical workshops and user engagement efforts, will be comprehensively documented in the forthcoming D5.3 - "DEDALUS Pilots' execution documentation and consumers' engagement – full pilot operation phase". This report will provide an in-depth narrative of the advancements made and lessons learned, setting the foundation for the project's subsequent phases.

