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frESCO Implementation Guidelines and Recommendations

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ABBREVIATIONS

Abbreviation	Name
A/C	Air Conditioning
API	Application Programming Interface
BDMP	Big Data Management Platform
CA	Consortium Agreement
CIM	Common Information Model
CSV	Comma Separated Values
D	Deliverable
DER	Distributed Energy Resources
DMP	Data Management Platform
EC	European Commission
ESCO	Energy Service Company
EU	European Union
GA	Grant Agreement
HVAC	Heating, Ventilation and Air Conditioning
H2020	Horizon 2020 The EU Framework Programme for Research and Innovation
ICT	Information and Communication Technology
JSON	JavaScript Object Notation
ML	Machine Learning
MQTT	Message Queuing Telemetry Transport
MV	Measure and Verification
PDF	Portable Document Format
PMV	Performance Measurement & Verification
PV	Photovoltaic
SRI	Smart Readiness Indicator
UI	User Interface
URL	Uniform Resource Locator
XML	Extensible Markup Language
WP	Work package

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EXECUTIVE SUMMARY

This document aims to serve as a comprehensive proposal outlining the guidelines and recommendations for the implementation and wider deployment of the frESCO project, based on the lessons learned and the realizations from the results and experience from the three demonstration sites. The primary objective is to ensure that all critical aspects of the project are adequately addressed. In that essence, the document also covers three key pillars such as:

- Lessons Learned and Best Practices, with the aim to distil insights and best practices from the demonstration sites, using these experiences to enhance our approach.
- Our scope expands to encompass global recommendations for Integrators and Policy Makers. In this context, we will provide a set of recommendations that will be valued for policy makers in the energy sector. The primary focus of this undertaking lies in the thorough analysis of the results obtained through the application impact assessment framework (T6.2) within the pilot sites. By making comparisons across the different demonstration sites, we aim to derive valuable conclusions that can translate into actionable recommendations technical integrators and regulators.
- The project will be also enriched by the development of updated business models and refined service definitions, which are vital for its success. The document addresses the fine tune of business models and technical solutions trailed in the demo sites. These adaptations will be based on the performance data and feedback gathered from end-users. This process will ensure that these solutions align seamlessly with user requirements and are well-suited for the market. The key findings will play a crucial role in supporting business models and facilitating the exploitation activities outlined in WP7.

Furthermore, to achieve the objectives, we emphasize among others in the following key areas:

<u>Data Interoperability.</u>

This involves the ability to share information and data seamlessly among various ICT systems, contributing to effective e-government information systems and data sharing.

Data Gathering.

We stress the importance of collecting data through electronic devices, such as sensors and gateways, as well as third-party sources. This approach relies on specific ICT strategies to enhance data quality while reducing the associated labour burden.

Automation Module.

The adoption of automation tools is instrumental in streamlining time-consuming tasks. These tools leverage digital technologies to interact with third-party devices and expedite the response to energy service events. This is particularly valuable in managing the complexity of hybrid cloud and edge environments.

Business Model Exploration.

The document searches into the exploration of new business models that foster power system flexibility and encourage consumer participation. It outlines innovative schemes, such as "Pay for Performance" (P4P) and highlights the role of aggregators and Energy Service Companies (ESCOs) in offering "Energy-as-a-Service" within the residential energy market segment.

1 INTRODUCTION

1.1 Purpose and target group

The purpose of next pages is to provide a comprehensive overview for the successful demonstration reproducing guidelines and recommendations to ensure that all critical aspects of the project are addressed effectively.

The target group for this document includes stakeholders and individuals involved in the frESCO project, such as project managers, researchers, policymakers and regulators, integrators, and those responsible for the project's successful implementation. It is intended for those who are engaged in the development, management, and replication of the frESCO project, both at the demonstration site level and on a broader scale, including national and European levels. Additionally, this document serves as a valuable resource for business professionals interested in exploiting the project's results and refining their service offerings based on user requirements and market trends.

1.2 Scope of the document

The scope of the project is defined within the following key areas:

Lessons Learned and Best Practices. Analysing the results of the application impact assessment framework in the pilot sites and drawing conclusions by comparing the outcomes across different demonstration sites.

Global Recommendations for Integrators and Policy Makers. Extending the scope to provide global recommendations by extrapolating the project's results to national and European levels. These recommendations will be used to support business models and exploitation activities in the replication of project results.

Business Models fine-tuning and Refined Service Definitions. Incorporating feedback from end-users to align the project with their requirements and facilitate market uptake.

1.3 Structure of the document

After this introductory section, we delve into various key topics where we discuss the valuable lessons learned and best practices. Towards the conclusion, you will find a summary in the form of an abstract presented in a tabular format.

Following this, we provide a set of recommendations, which can be categorized into technical and regulatory aspects.

Subsequently, we explore the fine-tuning of business models associated with the implementation of digital energy services within residential buildings.

2 LESSONS LEARNED

This is a compendium of Lessons Learned and Best Practices, focused to squeeze out valuable insights and optimal methods derived from the implementation and operation of our demonstration sites. Our primary objective is to leverage these experiences to improve our overall approach by understanding the shortcomings and challenges encountered over technical aspects, and the business model in the different project stages such as deployment, rollout, engagement. We aim to explore what didn't work as expected in the following key areas and use this knowledge to enhance the future outcomes. It can be found an abstract in this Table 1.

2.1 Common Information Model

Wrong data mapping is hard to detect until it is consumed by a service provider or App developer, leading to delays in the implementation. This is a common mistake when creating new data sets and it is easy to fix if early detected. The solution involves the creation of correctly mapped data sets and the removal of the wrongly mapped data. This means the correct information model should be imposed on the gathered data as soon as possible in the data value chain.

The real problem shows up when there is a long delay between the time the data sets are (wrongly) mapped and the time it is revealed that the mapping is incorrect and the dataset is useless (or requires major restructuring), as it may imply the loss of large amount of historical data, valuable for data model training or long-term monitoring. In the case of frESCO this happened with metering information in the Greek demo site. Data were available since the beginning of the demo site activities as early as March 2022, but further down the line it was revealed that the mapping was wrong, when the apps were fully deployed in January 2023. The metering data in between these two dates (9 months) could not be restructured and were thus useless

Dealing with data from various sensors, meters, and devices presented a significant challenge for both the data harmonization process within the frESCO Big Data Management Platform and for the development of modules that needed to process these diverse data streams (applications as data consumers). While successful harmonization was achieved for data ingested through the API mechanism and integrated into the frESCO Common Information Model (CIM), it posed unique challenges for MQTT-transferred data.

Harmonizing data from MQTT streams proved to be more complex due to the generic nature of the original data structure, which impacted the harmonization process. This necessitated extra data processing efforts at the application level to effectively leverage the available data. The necessity for addressing data accuracy issues often arises when the data is being actively utilized by service providers or application developers. Unfortunately, this can lead to significant delays in the implementation of the respective module services and functionalities. These delays are a result of the requirement to perform on-the-fly data transformations at the local level to address inaccuracies and inconsistencies in the data streams.

2.2 Demo Implementation

The diversity in the characteristics of residential buildings and their equipment presents a substantial challenge when attempting to implement a standardized frESCO solution across the European Union. The considerable variation in building types, sizes, ages, and most important the existing electrical equipment configurations necessitates a flexible and adaptable approach.

Insisting on fully equipped dwellings right from the project’s outset could, indeed, become a significant hindrance to its success. This is because many residential buildings may require significant upgrades or modifications to achieve the desired energy efficiency and sustainability standards. Such an approach could impose an impractical and costly burden on both property owners and the project’s overall feasibility.

As demonstrated by the experiences gained from the pilot program in Croatia, a gradual rollout strategy is advisable, since the processes can be better streamlined. This phased approach allows for a more efficient adaptation of frESCO solutions to the specific needs and constraints of different buildings. It acknowledges the fact that a one-size-fits-all approach may not be practical or effective in this context.

To overcome these challenges, it is essential to strike a balance between standardization and adaptability, allowing for a more inclusive and efficient implementation of frESCO solutions in the diverse landscape of EU residential buildings.

While creating the first characterization of the building and identify the current situation of the energy systems, it is useful to appoint visits and contact other stakeholders to get extra information from the demo (Ex. utilities, electricians, building managers, building promotor, building promotors, etc.), while also having a main contact in the demo site ease the flow of information.

It is important to care about a smooth implementation and testing, without disturbing daily activities to end users and facilitate their experience and use of the services. In this development stage, it is important to do some previous visits and know in advance the characteristics and details of each household and pay attention to details in installation (ej. Avoid visible equipment, easy installation, integration with existing equipment, good internet signal, good connectivity of equipment installed to frESCO services, etc.)

2.3 Data Interoperability

Power control for automation cannot be performed for third-party assets such as smart Heat Pumps. The only possible control is on-off control with low flexibility possibilities. It is well known that limitations in legacy equipment such as Smart Heat Pumps and other third-party assets often come with proprietary control systems that limit the extent to which external automation can be applied. These systems may lack the necessary interfaces or protocols to seamlessly integrate them into broader automation networks. To enhance the flexibility of legacy equipment and integrate it into modern automation systems, you would typically need to establish a communication link, an interface. This would involve adding an electronic communications device that allows you to send and receive commands, thereby enabling more sophisticated control. Due to these limitations, the most basic form of control available is on-off control. This means that you can turn the device on or off, but you have limited control over the device's operation in between these states. This lack of flexibility can be a significant drawback, especially in applications where precise temperature control or dynamic operation is required. Unfortunately, many legacy devices lack native support for any form of electronic communication. They might not have the "smart" capabilities needed to integrate with external control systems, which can be a roadblock for automation efforts. Introducing Smart relays when direct integration is not feasible, a workaround is to intervene in the electrical power circuit. This involves introducing an external component known as a smart relay. The smart relay is equipped with advanced circuitry that can be controlled remotely, allowing you to activate or deactivate the equipment from a distance. However, it’s essential to recognize that while the smart relay provides remote control, its functionality is primarily limited to the act of connecting or disconnecting the power supply. It lacks the ability to finely regulate the device's operation in the way that a fully integrated digital control system would. This limitation can be particularly significant in scenarios where precise and continuous control is required. So, in essence, the challenge of automating third-party assets like smart Heat Pumps often arises from compatibility issues, especially when these assets lack native communication capabilities. While smart relays offer a cost-effective workaround, they are primarily limited to basic control functions and may not provide the fine-grained control that more advanced digital systems can offer.

A universal open-source gateway such as the Energy Box highly depends on external third-party libraries to control commercial sensors and devices developed by third parties. Random communication issues with some of these commercial devices are hard and difficult to solve without the collaboration of the commercial device manufacturers. This issue was relevant in Madrid and Thasos demo sites featuring Zigbee sensors and Ebox gateways. In these demo site buildings, there were continuous communication problems resulting in random disconnections between the gateways and the sensors whenever the signal strength was weak. Dependency on third party libraries impeded the correct troubleshooting and fixing of the connection issues. The random nature of the problem made it even harder to reproduce and fix the issues. In the Madrid demo site building the issue was mitigated by installing a single Ebox per dwelling to limit the distance and barriers between the sensors and the gateway. In Greece and Croatia, commercial gateways produced by the same sensor manufacturer (Develco) had to be purchased and set to work together with the Ebox (Thasos hotel), associating Modbus devices to the Ebox and Zigbee sensors to the Develco, or as a standalone gateway (Krk dwellings).

Commercial gateways are commonly not open-source and admit low or no access to internal codes for new solution development. They are specifically recommended to work with the equipment from the same manufacturer, however, show problems with other manufacturers' equipment. For the pilot sites, the technical team has chosen Develco devices that are relatively open and allow the development of custom Linux-based firmware. Given the time and resource restrictions, the pilot technical team decided to rely on Develco data packaging and develop a repackaging infrastructure which is essentially a set of scripts connected to MQTT message broker that repackages the data captured by the Develco devices into the format suitable for the BDP.

Besides, a homogenous equipment could have affected positively the project development. By ensuring that the same types of equipment (common data collection equipment, actuators, gateways) are used at all demo sites, the entire process would become much more straightforward and efficient. It would be easier to set up and install equipment, reducing the complexity associated with different hardware and configurations and solving possible problems could have appeared. Maintenance tasks would also be streamlined as there would be fewer variations to manage, and troubleshooting would become more standardized. Moreover, the development of the application that interfaces with this equipment would be greatly facilitated not having to solve different problems in different demosites. This would not only save time and effort in software development but also enhance the user experience by providing a consistent interface and functionality. The principal lesson learned here is that the devices deployed in the field must reach quite high level of maturity, otherwise along the project execution this requires considerable amount of resources to keep in operation.

Despite the existence of a data harmonization process, it is important to note that the manner in which data is extracted from the various demonstration sites is not entirely uniform. In the case of different demonstrations, data may be aggregated together or kept separate in distinct datasets, filtered using diverse parameters, and the structural organization may not always be consistent. This variation in data handling poses a challenge for application developers, as they are unable to employ a standardized approach and instead must tailor their development efforts to accommodate the unique requirements of each demonstration site. This lack of data consistency can be a significant barrier for app developers, because they have to adapt and customize their applications for each demo, making it a more time-consuming and complex process.

Data from PV inverters is hard to get for service providers. After several attempts to get directly the PV generation in Madrid it was decided to install a dedicated meter for this record set. In some situations, you may come across pre-existing equipment that is equipped with communication interfaces designed for data exchange. However, these devices may utilize property or uncommon communication protocols that are not readily compatible with standard systems. Integrating such equipment into a new application can be a daunting task, requiring a significant investment of both time and the expertise of highly specialized technical personnel. This can result in the integration process becoming economically impractical, especially when it's intended for a specific, one-time or ad hoc application. As a result, there is a need to explore alternative solutions to address this issue. One such solution is to install external sensors that are capable of gathering the required data independently. Although initially, the data might have been obtained directly from the existing equipment using different methods, the inherent complexities and challenges associated with integrating this equipment prompt the choice to install new sensors as a more pragmatic and cost-effective approach. A real-world example of this situation can be found at the Madrid demonstration site. In this context, it was determined that installing a three-phase energy meter and subsequently integrating the data collected by this meter into the BDMP (or Big Data Management Platform) offered a more efficient and cost-effective solution than attempting to directly extract the necessary data from the PV inverter, which, in theory, had the capability to provide this data but was impractical due to the challenges of the proprietary or unconventional communication protocols used.

Commercial gateways even when they support MQTT protocol do not have their default semantics of the data aligned with the CIM. Although we have used a fairly open and customizable solution, effectively we needed a repackaging alignment step is needed in the ingestion so a custom-made solution for repackaging the data is developed. Similarly, Modbus data are interpreted semantically and packaged appropriately. Data harmonization might be a part of the platform's ingestion layer, or a small and effective harmonization and data abstraction solution could be developed to help proliferation of frESCO platform.

2.4 Data Gathering

Each time an energy meter is replaced within the BDPM system, it becomes imperative to generate a new data set. This practice ensures that historical data analytics application developers can access distinct data sets associated with the same measurement point. Webeee energy meters are equipped with a unique product code reference, primarily utilized for API Get calls when requesting data from them. Consequently, if there is a need to replace an energy meter, its unique ID changes as well. As a result, developers need to create a new data set associated with the updated ID because the old data set cannot be modified to reflect the changes in the meter's identity. This situation creates inconveniences for application developers, as they are forced to manage multiple data sets to obtain a complete record set of data from the same measurement point. This complexity in data management can lead to difficulties in the code of their applications. To adapt to these unique references or IDs, developers may need to make ad hoc changes to their code to ensure it works seamlessly with the changing IDs associated with energy meters that actually refer to the same energy asset. This additional effort and complexity in managing data and adapting code can be challenging for developers and may impact the efficiency and performance of their applications.

2.5 Novel PMV

A major difficulty related to the existence of historical data for baseline construction. This was the case in Croatia as the sampled dwelling were fitted with analogue energy meters, thus not storing historical data for long term EE baselining. Without it, no verified demand reductions could be measured.

In the case of Greece, there was a low correlation of summer room demand with weather variables. This problem may arise in well insulated buildings or under mild weather conditions. In the case of Greece, weather in summer was very mild except for a few days in August. There was no clear signal of HVAC energy consumption in front of smooth temperature changes, and this made it hard to verify accurately efficiency savings. The likely long periods of guests staying off their rooms limited even more the clear HVAC demand with the outdoor temperature. The low correlation ratio with Cooling Degree Days or even with other variables such as occupancy hindered the verification of demand savings in the hotel rooms. Should the HVAC consumption be correlated with stronger signals as it might have been the case for the winter period, had the rooms been in use in winter, the baselining exercise with Heating Degree Days would have been more fruitful.

2.6 Automation Module

The process of retrieving data from the BDMP can be occasionally time-consuming, primarily due to the considerable delay in accessing the most recent data within extensive datasets. This delay in data retrieval can lead to a cascading delay in automation services that rely on this data. This phenomenon assumes high significance in the context of flexibility services when events are time-sensitive and bound by a fixed schedule. The presence of this lag constraint in data retrieval compromises the precise determination of the exact moment at which automation orders can be dispatched. Consequently, this poses challenges for maintaining the time-sensitive nature of such orders, as their execution depends on the timely receipt of the relevant data, which in turn depends on the delay associated with accessing voluminous data sets.

2.7 Machine Learning

As a result of this inherent uncertainty, machine learning (ML) algorithms that rely on these short-term demand forecasts face a substantial reliability issue. For instance, day-ahead energy management strategies, that aim to optimize energy generation and consumption for the following day, may fall short of their efficiency goals if the input forecasts are not accurate. Similarly, flexibility assessments that depend on these predictions to manage resources or allocate flexibility in real-time can be less effective, potentially leading to suboptimal resource allocation and potentially higher costs.

Considering these challenges, improving the accuracy of short-term demand forecasting is a critical task for enhancing the reliability and efficiency of ML-driven systems, particularly in areas like energy management and resource allocation where timely and precise decisions are vital. Developing more robust forecasting models that can better account for uncertainty and adapt to changing conditions is a key focus for researchers and practitioners in these domains.

2.8 Hardware

Third-party commercial equipment, like the case of the Webeee energy meters issue in Madrid, is susceptible to malfunctions that may necessitate warranty-based replacements within the demonstration building. In this specific scenario, a total of six energy meters exhibited issues after a few weeks of regular operation following their initial commissioning. Upon identifying the problem, it was promptly reported to the manufacturer's customer support service. After conducting local assessments and realizing the inability to salvage the malfunctioning devices, a decision was made to dispatch the hardware to the manufacturer's technical service. Subsequently, it was determined that all six devices suffered from a similar flaw, namely, the failure of their LEDs to flashy was due to an unusual data writing error in the devices' flash memory. This error hindered the microprocessor from executing the correct code, causing the devices to malfunction. To rectify the situation, the manufacturer sent replacement meters to replace the faulty ones. As previously mentioned, these new meters come with their own unique identification codes, which, in turn, necessitated the creation of new data sets. Given that each meter has two channels, this translated into generating a total of twelve data sets within the BDMP, each corresponding to an URL Request HTTP method.

2.9 Flexibility Events

In the process of implementing frESCO's flexibility provision framework, various insights were gained concerning the flexibility events. One major realization was that actual activation/deactivation on demand presents a significantly tougher challenge compared to passive data acquisition. The intricacies of real-time demand response and the necessity for robust automation systems were underscored through various trials. Moreover, ensuring seamless activation/deactivation required a well-orchestrated interplay between the software of the modules, the Big Data Management Platform, the hardware, and the aggregator's dashboard, which was an order of magnitude more complex process than initially anticipated. Furthermore, flexibility events brought to light serious concerns of the residents regarding the risks of damage and potential outages due to the automation actions.

2.10 Business Models

The consortium encountered several challenges when attempting to implement the initial demosites within residential buildings. This was particularly evident in the low levels of interest exhibited by the residents of these buildings. In response to this issue, the consortium made the strategic decision to change the selection of demo site buildings, substituting two buildings in Madrid and France, while also grappling with difficulties in securing suitable buildings in Croatia. In fact, the low interest of building residents in digital energy services is a significant issue that many energy providers, technology companies, and sustainability initiatives encounter when trying to introduce and promote new solutions for energy management. As it was observed that individuals commonly showed minimal enthusiasm for matters pertaining to domestic energy management and the adoption of novel digital technologies or smart energy services. This prevailing behavior could be attributed to a variety of factors. Firstly, there may exist a certain degree of reluctance on the part of residents to embrace new technologies, especially when it involves altering established routines or systems within their households. Additionally, individuals may not fully comprehend the potential benefits that these digital energy services offer, leading to a lack of motivation to engage with them. Consequently, the consortium faced a considerable challenge to change some of the the sites for the trials, and worked towards increasing awareness and understanding among residents to enhance their interest and participation in the program. This shift in perspective was undoubtedly vital in realizing the full potential of these innovative solutions and the optimization of energy management within residential domain.

The majority of European Union (EU) countries have limited - or none at all- demand response programs for residential customers due to regulatory and technical constraints. The regulatory landscape can vary from country to country, but several common challenges and barriers have been identified, such as data privacy concerns, metering infrastructure, and market design. An additional point is the lack of standardized approaches for integrating residential demand response into the energy market. That in turn meant that all the Flexibility contracts and the relevant tests were emulated by the Aggregator entities of the project and not tested in real market environment, prices, and operating conditions. At the same time low Smart grid penetration, creates obstacles in the real life implementation of the proposed business models.

Residential buildings with no PV show low potential for the energy services developed in frESCO. The decision of installing shared PV assets in apartment buildings is a long process because it is needed the necessary agreement among all residents which lead to a great effort on coordinating, inform by promoters and installing companies. The first building in Madrid showed no such agreement in the first 6 months of the project and had to be exchange with another building with a previous PV system installed.

In the context of the Croatian demosite, the inhabitants of the buildings exhibit a noteworthy resistance to the idea of permitting external parties to engage in explicit operations of Distributed Energy Resources (DERs) for the activation of flexibility events. This reluctance might stem from concerns related to privacy, control over their energy resources, or simply a lack of familiarity with the concept of Demand Response and their potential benefits in contributing to a more flexible and sustainable energy smart grid. As a result, this hesitancy poses a significant challenge when it comes to harnessing the full potential of DERs for enhancing the reliability and efficiency of the local energy system. Efforts to address this issue should involve comprehensive education and communication initiatives, as well as addressing any genuine concerns that residents may have, to foster a more open and collaborative approach to leveraging DERs for the benefit of the entire community.

In another demosite, low participation in implicit Energy Efficiency measures prescribed by the platform was registered due to difficulties in understanding them and the usability of the platform. According to the survey launched to Madrid demo, users find *"notification for PV production surplus detection"* the most useful service.

Establishing infrastructure on remote vacation destinations such as Kirk Island and Thasos Island resorts presents formidable challenges due to the complexities and extra-costs involved. The feasibility of these installations is closely tied to the number of occupied dwellings or rooms, making it a highly contingent factor. Additionally, the testing windows for such endeavours are often confined to the summer months and intermittent or sporadic holiday seasons further complicating the planning and execution of these projects. Moreover, the feasibility of initiating and maintaining these installations hinges significantly on the temporal limitations imposed by the calendar, adding a layer of complexity to the planning and execution of these endeavours.
The isolation and unique characteristics of these remote destinations further compound the challenges associated with infrastructure development. The remoteness typically translates to limited access to essential resources and services, necessitating meticulous logistical planning and, often, specialized equipment or construction methods. Consequently, this exclusivity may also lead to higher costs, as both materials and labour may need to be transported from more distant locations, further driving up the expenses. Therefore, the establishment of infrastructure in such remote paradises not only demands substantial financial investments but also requires a deep understanding of the seasonal nature of these destinations and the complexities that arise from their geographical isolation.

Implementing demand response (and/or flexibility) programs in hotel rooms, where guests may be on vacation or for business purposes, presents unique challenges compared to residential applications. Hotel guests have different expectations and priorities, and they may not be as willing to change their behaviour when compared to permanent residents. Hotel guests often have high expectations for comfort and convenience during their stay. They may be less willing to make energy-saving adjustments that could affect their comfort, such as adjusting room temperature, lighting, or the use of amenities. Guests typically have short stays in hotel rooms, making it less likely that they will invest time in learning about and participating in demand response programs. Many hotel guests are on vacation or a leisure trip, and their primary focus is on relaxation and enjoyment, rather than energy conservation. Some guests may be concerned about privacy issues related to smart meters or in-room sensors that monitor their energy usage.

While the frESCO system undoubtedly offers a cost-effective solution on a per-building basis, it faces certain challenges that diminish its immediate appeal to potential investors. One of the primary hurdles is the initially low Smart Readiness Indicator (SRI), a critical metric used to assess the smartness and efficiency of a building. This low SRI rating, at first glance, may seem unattractive to investors who seek swift returns on their investments.

Moreover, the revenue generated from the services provided by the frESCO system is also relatively modest, which compounds the issue. The combination of a low SRI and limited service-generated income results in extended payback periods. These overlong payback times can deter investors, especially those with a preference for projects offering quicker returns on their capital.

In essence, while the frESCO system is cost-effective per building, it requires investors to display patience and a long-term vision. However, it's essential to recognize that this system's value extends beyond immediate financial returns. Its long-term benefits in terms of sustainability, energy efficiency, and future-proofing buildings may make it a wise choice for those with a commitment to environmentally responsible and forward-thinking investments. By considering the broader picture, investors can better appreciate the frESCO energy services a true potential and the positive impacts it can have on both the environment and their portfolios in the years to come.

frESCO solutions for homeowners and end users face the challenge of articulating the tangible advantages they offer. This task is particularly demanding when communicating with homeowners, especially in areas with a emerging energy market and relatively modest service revenues. To address this issue and simultaneously address data ingestion troubleshooting, the KONČAR team has developed a straightforward dashboard for each user. This dashboard provides users with real-time visibility into the data flowing into the platform. This innovation proved highly beneficial during the pilot phase, allowing users to detect potential acquisition errors early on. Moreover, it enhanced the appeal and dynamism of the solution. Introducing similar, user-friendly "low-hanging fruit" features could present an enticing opportunity for expanding the reach of frESCO solutions.

2.11 User Engagement

The frESCO project underscored the critical importance of adopting a user-centric approach in the development of tools and services. Lessons learned revealed that ease of use is a fundamental factor in facilitating better engagement with frESCO services. The user interfaces were found to be directly correlated with the uptake and overall success of the service offerings. Additionally, establishing open channels for feedback within the project proved to be invaluable. It not only provided real-time insights into user experiences, but also created a mechanism for continuous improvement. Moreover, engaging users in the development process through feedback channels fostered a sense of community and ownership among the participants. It also facilitated a deeper understanding of the user needs and preferences, which in turn, significantly enriched the design and functionality of the frESCO tools.

Trying to involve end users or other third parties in any project activity such as surveys, demo, dissemination activities or workshops, it's essential to design those experiences to meet their interests which could be for example: increase their knowledge, share their ideas, improve energy costs, socialising, improve professional network, etc. Also, it is a good idea to give something in exchange to imply them more in the project. Ex: free devices, small experiences, discount coupons, etc.

To have a successful implementation and get end users implication to participate in a pilot project it is important to be able to convey the investigation, innovation and technical concepts to ordinary language and have a person in the team with a divulgative role in the project.

Close relationships with participants in experimental phases ease the acceptance of the technology. One of the key factors that condition the success of the project, and the use of frESCO services is that the end user finds: clarity in implementation, ease of use of the developed applications, usefulness of the services provided, little hassle in installing devices and testing. To have a user-centric approach during the development of services and platforms, and establishing communication channels to involve active end users in the development of the project is of great value, since their feedback can improve services and adapt to the market. Caring about user needs and motivations to participate is essential.

Regarding hotel user Engagement, several possible approaches can be taken to involve them in a flexibility program despite the peculiar nature of the “hotel guest” in comparison to a house owner:

- Hotels could implement opt-in flexibility programs, allowing guests to choose to participate if they are interested. Those who opt-in could receive incentives or discounts.
- Hotels could provide information to guests about the environmental benefits and cost savings associated with demand response. Clear and simple instructions on how to participate can also help.
- Hotels might offer guests the ability to customize their preferences within certain energy-saving limits. For instance, guests could adjust their room temperature within a set range.
- Finally, to a specific target audience Hotels should clearly communicate the benefits of demand response to guests, not only in terms of energy conservation but also in relation to the hotel's commitment to sustainability and eco-friendliness.

The Inefficient data gathered within certain dwellings can exert a profound impact on the overall quality of energy services provided. Consequently, this deficiency may significantly influence the inclination of users to either experiment with or utilize the services that have been put into effect. When certain sensors apartments lack real time data, it impedes the service provider's ability to monitor and manage the energy consumption effectively. Without access to this valuable data, the energy services offered may become less efficient and responsive to the unique requirements of each apartment, potentially resulting in suboptimal user experiences and the willingness of users to engage with and benefit from these services. In turn, this could lead to user dissatisfaction, reluctance to embrace the energy services, and, eventually, a reluctance to explore or adopt the implemented solutions. Thus, it is imperative that sensors are made available and regularly updated in all relevant dwellings.

2.12 Dissemination

In our ongoing commitment to fostering a more informed and engaged community, we recognize that transparency and open communication play crucial roles in achieving these goals. The frESCO project, with its innovative approach to addressing energy challenges, stands as a testament to the potential for positive change building by building, dwelling by dwelling.

By actively promoting curiosity and interest in the community (Madrid), we aimed to create a dynamic atmosphere where individuals were not only stayed informed about the latest developments in the frESCO project but also actively participated in the implementation process (like the case of IT neighbour). Energy issues have become increasingly relevant in today's world, and we believe that an educated and engaged community is key to navigating the complexities of our evolving energy landscape.

In addition to disseminating information, we were exploring avenues to organize events such as workshops, that empower individuals to delve deeper into energy-related topics. By fostering a culture of continuous learning, ensuring that everyone has the tools and knowledge needed to make informed decisions about energy use and sustainability.

To further facilitate understanding, we were committed to providing regular updates on the project's progress, sharing insights gained from its development, and creating opportunities for meaningful interactions. As example, in the held workshop, we encouraged our community members to ask questions, share their thoughts, and contribute to the collective knowledge that drives the frESCO project forward.

The success of the frESCO project relies not only on technological advancements but also on the collective understanding and commitment of our community members.

2.13 Lessons Learned Summary

COMMON INFORMATION MODEL	
i.	Wrong data mapping is hard to detect until it is consumed by a service provider or App developer, leading to delays in the implementation. The solution involves the creation of correctly mapped data sets and the loss of the wrongly mapped data.
ii.	High heterogeneity of data from different sensor, meters and devices made it difficult for App developers to work with them all without a specific previous transformation of this data to make them ready to be consumed. This harmonization is successfully done in the Data Base for API-ingested data but cannot be done for MQTT-transferred data. A repackaging special software was put in place in Croatia and Greece to harmonize Develco data before being sent to the database.
DEMO IMPLEMENTATION	
iii.	Characteristics of the buildings and equipment are very heterogeneous and it is difficult to adapt a unique frESCO solution for all the residential buildings in the EU. A degree of gradual roll-out will be needed as seen from Croatian pilot experiences - it will be a very big obstacle for the project success if we need to have fully equipped dwellings only.
iv.	It is important to care about a smooth implementation and testing, without disturbing end users to facilitate their experience and use of the services. It is important to do some previous visits and know in advance the characteristics and details of each family and household and pay attention to detail.
v.	To have a successful demo implementation and implication for end users, it is important to care for personal relations and pay attention to users' needs and questions. It is important to have a dissemination role in the project to connect investigation with simple explanations for the users. It is important to maintain the motivation and involve the users who wants to learn.
vi.	It is important to have a close and good network to involve other stakeholders to get extra information from the demo (Ex. utilities, installers, building managers, building promotor, architecture, etc.), also a main contact in the demosite.

DATA INTEROPERABILITY	
vii.	Power control for automation cannot be performed for third-party assets such as smart Heat Pumps. The only possible control is on-off control which is highly intrusive and offers low flexibility possibilities.
viii.	A universal open-source gateway depends on external third-party libraries to control commercial sensors and devices. Random communication issues with some of these commercial devices are hard and difficult to solve without the collaboration of the manufacturers (Zigbee - Ebox communication problems in Madrid and Thasos).
ix.	Commercial gateways are not open-source and admit low or no access to internal codes for new solution development. They are specially recommended to work with equipment from the same manufacturer but show problems with other manufacturers' equipment (Develco and Modbus devices in Greece and Croatia).
x.	Homogenization and use of common data collection equipment and gateways in all demo sites would have simplified enormously the installation, maintenance and commissioning of equipment, but also the App development.
xi.	Data from PV inverters is hard to get for service providers. After several attempts to get directly the PV generation in Madrid it was decided to install a dedicated meter for this dataset.
xii.	Industrial gateways even when they support MQTT protocol do not have their default semantics of the data aligned with the CIM. Although we have used a fairly open and customizable solution, effectively we needed a repackaging alignment step is needed in the ingestion so a custom-made solution for repackaging the data is developed. Similarly, Modbus data are interpreted semantically and packaged appropriately. Data harmonization might be a part of the platform's ingestion layer or a small and effective harmonization and data abstraction solution could be developed to help proliferation of frESCO platform.
xiii.	Although there is a data harmonisation process, the way data is retrieved from the different demonstration sites is not exactly the same (for the different demos the data are together or separated in different datasets, filtered by different parameters, the MQTT message structure varies, etc.). It is a problem for the app developers, who cannot use a standard ingestion process, and it has to be adapted to each demo site's datasets.

DATA GATHERING	
xiv.	Necessary to create a Data Set every time an Energy meter is being replaced. Thus, for historical data analytics App developers need to access to different Data Sets for the same measurement point.
NOVEL M&V (PMV)	
xv.	Difficulty in getting historical data for long term EE baselining in Croatia (no digital metering) and the low correlation with weather changes in well insulated buildings under mild weather conditions in Madrid and Greece (cooling demand mainly) made it hard to verify accurately efficiency savings.
AUTOMATION MODULE	
xvi.	When trying to launch a flexibility event, the automation engine takes way too long to perform the preliminary checks due to the large quantity of data being analysed prior to sending flexibility commands. That makes difficult to scale up.
MACHINE LEARNING	
xvii.	Low accuracy of short-term demand forecasts due to the very high uncertainty in domestic demand profiling. This leads algorithms that use these forecasts to be rather unreliable such as the day-ahead energy management strategy or the flexibility assessment.
HARDWARE	
xviii.	Third party commercial equipment is also subject to failures such as the Webeee issue in Madrid, which affected 6 meters that had to be replaced under warranty in the demo building, due to a firmware issue.

FLEXIBILITY EVENTS	
xix.	A big challenge was that actual activation/deactivation on demand (real time) presents a significantly tougher challenge compared to passive or static data. That results on the need of real-time demand response and the necessity for robust automation systems.

BUSINESS MODELS	
xx.	Low interest of building residents in digital energy services made the consortium change two demo site buildings in Madrid and France and posed a lot of problems to find buildings in Croatia.
xxi.	No interest in Flexibility tests by building residents as markets are closed at present. This resulted in low collaboration for flexibility testing by end users.
xxii.	Residential buildings with no PV show low potential for energy services. The installation of shared PV assets in a building is a very complex project if undertaken by the neighbourhood for the necessary agreement among residents and prepayment of a long payback-time investment. The first building in Madrid showed no such agreement in the first 6 months of the project and had to be dropped.
xxiii.	High rejection of building residents to external explicit operation of DERs for Flexibility activation.
xxiv.	Low participation in implicit Energy Efficiency measures prescribed by the system.
xxv.	Remote holiday resorts like Krk and Thasos islands make installation difficult and expensive and highly dependent on the occupancy of the dwellings / rooms, thus limiting the testing periods to summer and occasional holiday seasons.
xxvi.	Holiday resorts are less likely to participate in such energy savings/ flexibility events. Vacation period is not appealing to add such overheads.

xxvii.	Despite the low cost of the frESCO system per building, the low initial SRI and the low revenues of the services, especially flexibility, make payback times long.
xxviii.	frESCO solutions for homeowners and end users have a difficulty of figuring out tangible benefits of the solutions. It is hard to make homeowners aware of the benefits, especially in the comparatively low development of the local energy market and relatively low service revenues. To alleviate this and handle the debugging of data ingestion at the same time, KONČAR team has created a very simplified dashboard for each user where the user sees the data as it goes to the platform. This helped during the pilot as it makes the user able to identify possible acquisition errors early, but also made the solution attractive and dynamic. Similar, simple to use "low hanging fruits" would be a very attractive proposition to widen the reach of frESCO solutions.

USER ENGAGEMENT	
xxix.	Development of tools must have a user-centric approach in order to ease the use of the frESCO services. It is important to open channels in the project to canalise that feedback.
xxx.	Trying to involve end users or other third parties in any activity (surveys, demo, dissemination activities, workshops...) it is good idea to give something in exchange to engage them more in the project. Ex: free devices, small experiences, discount coupons, etc.
xxxi.	Not having available sensors (with updated data) in some specific apartments can affect the quality of the services and consequently the user’s willingness to test or use the services.
DISSEMINATION	

xxxii.	There was some curiosity and interest about the frESCO project in the Madrid community. It is important to disseminate the project development and project learning among the end users to make them feel part of the project. Nowadays public and end users are willing to get closer and learn more about energy issues.

Table 1: Lessons Learned Summary

3 GLOBAL RECOMMENDATIONS.

As it stems from the insights presented in the preceding chapter, global recommendations and guidance have been outlined, categorized into technical and policy aspects.

3.1 Technical Recommendations

Common Information Model

Evaluate the scalability and performance of the API mechanism and the CIM. Ensure that they can handle increasing data volumes and continue to deliver reliable results. Be prepared to adapt the API mechanism and CIM as needed to remain competitive and up-to-date. Maintain comprehensive documentation that outlines the standards and protocols used for data ingestion and integration. Strengthen data governance practices to protect the integrity and security of ingested data. Implement access controls and encryption where necessary. Implement a version control system for the CIM and API mechanisms to track changes and ensure backward compatibility. This will help manage updates and modifications effectively.

frESCO Service Deployment

These recommendations can help to ensure a successful and well-planned solution deployment that enhances the energy systems of the building while minimizing disruption and providing better services to the end users.

Before starting any work, conduct thorough research on the building's existing energy systems. This includes studying blueprints, energy consumption data, and any historical maintenance or upgrades. Arrange visits to the building to gain firsthand knowledge of its layout, energy infrastructure, and how energy is currently being used. Engage with the building's staff and maintenance personnel to understand their experiences and challenges. Gather detailed information about each household or tenant within the building, including their energy consumption patterns and specific needs. This will help tailor energy solutions to individual requirements.

Identify all relevant stakeholders in the project, such as building owners, tenants, energy suppliers, and regulatory authorities. Collaborate with energy experts, engineers, and

architects to ensure a comprehensive understanding of the building's energy systems and potential improvements. Contact them to gather their perspectives and requirements.
Plan implementation and testing phases with minimal disruption to the daily lives of end users. Consider scheduling maintenance and upgrades during off-peak hours or in stages to ensure continuous service availability. Communicate any potential disruptions well in advance to all stakeholders and provide clear timelines for the work.
Pay close attention to the installation process and details. Ensure that installations are carried out by experienced professionals and that all safety protocols are followed. Regularly inspect and monitor the progress of the work to maintain quality control.
Maintain comprehensive records of all activities, from initial assessments to implementation and testing phases. This documentation will help in tracking progress and identifying any issues that arise. offer clear and accessible support channels for users to address any issues or concerns and report any relevant issues happened during activities performed.
After implementation, continuously monitor the performance of the new energy systems and gather feedback from end users. Make necessary adjustments based on this feedback to further improve the services.

Data Interoperability

One point to take into considerations is having data in one harmonised way. For that, having a homogeneous equipment can help all along the process. If this it is not possible it is important that the harmonisation process is well defined and perfectly applied, in the way that all the values form the different sensors can be retrieved form the Big Data Management Platform in the same way, using the same filters, without the differences that could arise from using data from different equipment. The same applies to the actuators.

Data Gathering

Allow data consumers to easily modify job configurations, particularly those related to data collection and storage. Data consumers should be able to update specific fields, such as unique identifiers or data source references, without the need for complex ad hoc changes. This flexibility will simplify the process of replacing devices. When a device is replaced, the platform should create a new version of the data set while retaining the historical data from the previous device. This enables developers to access distinct data sets associated with the same measurement point over time.

Design the platform to dynamically can generate data sets for each device based on a combination of parameters, including the unique product code reference, device IDs, and other relevant metadata. This way, when a device is replaced, the platform can automatically associate an old data set to a new equipment, associating it with the unique product code or device ID.

Novel M&V (PMV)

In terms of PMV, it is necessary to ensure that enough historical data exists and can be made available to calculate long-term efficiency baselines.

Automation Module

Regarding the problem encountered with the automation module and the flexibility events, the recommendations are the following:

- to improve the data acquisition process, to decrease the delay retrieving information.
- to prioritize flexibility events and skip other automation services where there are flexibility elements.

Flexibility Events

Based on the lessons learned from frESCO's implementation, the following recommendations are proposed for addressing the challenges associated with flexibility events:

Robust Automation Systems: Given the complexities in real-time demand response, investment in robust automation systems is crucial. These systems should be designed to swiftly and accurately handle activation/deactivation on demand, minimizing delays and ensuring reliability.

- Integrated Approach. A well-orchestrated integration between software modules, the Big Data Platform, hardware, and the aggregator’s dashboard is essential. This integration should ensure seamless communication and coordination among all components, facilitating smooth operation of flexibility events.

- User Education and Communication. Educate residents about the automation actions, the associated benefits, and any potential risks. Clear communication on how the system operates and how potential risks of damage or outages are mitigated will be key to gaining and maintaining user trust.
- Real-Time Monitoring and Alert Systems. Implement real-time monitoring and alert systems to promptly identify and address any issues arising from automation actions. This will help in preventing or minimizing damage and service disruptions.
- Transparency and Data Privacy Assurance. Ensure transparency in data handling and provide assurances on data privacy, which will be pivotal in building trust and encouraging user participation in flexibility events.

User Engagement

Based on the insights derived from the frESCO project regarding user engagement, the following global recommendations are proposed to ensure the success of similar initiatives in the future:

- User-Centric Design. Prioritize a user-centric design approach in the development of tools and services to ensure ease of use, which is fundamental for better engagement and user satisfaction.
- Interactive User Interfaces. Develop interactive and intuitive user interfaces that cater to a wide range of user capabilities and preferences, thereby promoting higher uptake and success of the service offerings.
- Continuous Improvement Mechanisms. Utilize the feedback obtained to create a mechanism for continuous improvement, ensuring that the services evolve in line with user needs and expectations.
- Community Building. Foster a sense of community and ownership among users by engaging them in the development process. This can be achieved through fora, workshops, surveys, and interactive sessions that allow users to voice their opinions and contribute ideas.
- Education and Training. Provide adequate education and training to users on the utilization of the tools and services, ensuring they are well-equipped to make the most out of the offerings.

- Transparency and Communication. Maintain transparency in operations and communicate clearly with users regarding any changes, updates, or issues that may arise. This will build trust and keep users informed.
- Accessibility. Ensure that the tools and services are accessible to all users, taking into account different levels of technical expertise and potential disabilities.
- Data Privacy and Security Assurance. Uphold stringent data privacy and security standards to assure users that their information is safe. Clear communication regarding data handling practices is crucial.
- Performance Monitoring and Analytics. Implement performance monitoring and analytics to measure user engagement and satisfaction over time. The insights gained from such analytics can be invaluable for refining and enhancing the user experience.
- Collaborative Development. Explore collaborative development approaches, possibly involving users in beta testing or co-creation workshops, to ensure that the tools and services are tailored to meet the actual needs and preferences of the users.

3.2 Policy Recommendations

As a result of the main regulatory barriers elicited in T2.2 and the learnings from the demo sites in the testing phase, some policy recommendations can be given in different domains.

3.2.1 Energy Service Markets

- Clear mechanisms should be put in place to allow third-party service providers, aggregators and ESCOs to directly connect to DSO's metering devices (Spain, Croatia). In the case of the frESCO demo sites, additional metering systems had to be installed onsite, which increase the cost of real-time data collection and actually represents a barrier to the proliferation for the frESCO BDP and solutions. Current legislation in the European Union obliges the DSOs (or metering service operators) to allow the end users to access the data. Besides the data hub approaches for the DSOs that have enough throughput and robust infrastructure, there is also a hardware approach where devices connect to the meter user port. This is, however, challenging from the cost and installation complexity perspective. The general takeaway is that the DSOs should open their user-generated metering data to other purposes.

- Self-consumption assets in the domestic sector are still scarce in all the demo site countries analysed, thus jeopardizing the achievement of further savings and limiting the amount of flexibility buildings have to optimise their energy efficiency. The decreasing costs of PV silicon and battery storage and the incentives given by many national energy authorities may be a catalyser for the future.

3.2.2 Energy Markets

- Flexibility trading is only partially allowed in some countries. It is critical that demand-response resources be open for consumer and prosumers in aggregated terms or in small energy packages. In frESCO none of the demosites could demonstrate flexibility trading but on simulation basis.
- In some countries like in Croatia, the smart meter rollout is still on its way, thus hindering the collection of at least, one-year historic data for long term baselining. Similarly, in those places where digital meters are rolled out, access may only be obtained prior consent of the data owners, with one day delay, thus rendering them unfit for real-time energy services.

3.2.3 Data Transaction

- There is no clear data life cycle process all the way down to the end of life to ensure proper handling of data and final deletion after having been consumed. Stressing out these policies would increase consumers' confidence and trust on new data-driven services.
- There is clearly a misperception of the value of data from the side of the end-users, who should be better informed about the benefits that these data streams may bring them. Specific awareness campaigns should be designed to let building residents know about the opportunities provided by data sharing and AI.

3.2.4 Standardization

The principal lessons learned regarding standardization, learned during the project development but specifically from the pilot site are already mostly referred from the pilot site. Seen from the point of standardization, this can be summarised in the following points:

1) In a project primarily targeting end users, the data collection requires significant amount of connection to their devices. These devices, e.g., solar panel inverters and

heat pumps, are commonly equipped with simple protocols such as Modbus. Robust and easy integration of these devices is challenging as up-to-date vendor documentation is critical. There are efforts to standardize the semantics of the data shared over such protocols with limited traction. As the lifecycle of these devices is quite long and the capital and labour expenditures for an upgrade is high, it is not feasible to expect new standard compliant devices will supersede the ones already running. So, a strategy of covering legacy devices in the field is absolutely necessary, and it will most probably be specific to each country.

2) Consistent data model and data message payload format is a challenging issue as well, as the carrier protocols, both legacy ones such as Modbus and newer ones such as MQTT do not specify the data semantics. Enforcing a common information model as soon as possible, as close to the system edges, and preferably in line with recently developed data standards is the proper way to go.
3) Connectivity, compatibility and cost issues for the in-house (end user premises) are still a notable barrier for the scalability and replication of frESCO solution. This is a barrier to entry for many users. Technical challenges can be an equally prohibitive barrier as the technical incompatibility.

There are two principal directions future development needs to take place:

1) **Development of standardized protocols and data models,** especially within the buildings: there are several projects and initiatives challenging this, such as the BRIDGE initiative to provide a standardized data exchange reference infrastructure, currently in its third version[1].
2) **Standardizing the simple, reliable and cost-effective data acquisition end-user premises devices,** compatible with the existing equipment and comparatively simple to install and manage. This would unlock the barrier to entry for the frESCO-like solutions.

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[1] Directorate-General for Energy (European Commission), M. J. Couto, K. Kotsalos, and K. Kukk, *European (energy) data exchange reference architecture 3.0. LU: Publications Office of the European Union, 2023. Accessed: Oct. 20, 2023. [Online]. Available: https://data.europa.eu/doi/10.2833/815043*

4 BUSINESS MODEL FINE TUNNING

The key challenges and issues related to the implementation of digital energy services in residential buildings that affect the frESCO proposed business models can be summarized as follows:

- Low Resident Interest: Some building residents have shown little interest in adopting digital energy services.
- Regulatory Constraints: Many EU countries lack demand response programs for residential customers due to regulatory limitations. Challenges include data privacy concerns, metering infrastructure, market design, and a lack of standardized approaches for integrating residential demand response into the energy market.
- Lack of Real-World Testing: The absence of resident interest led to flexibility contracts and tests being emulated by aggregator entities instead of being tested in real market conditions, prices, and operating environments.
- Limited Potential for Buildings without PV: Residential buildings without photovoltaic (PV) installations have shown low potential for energy services. Installing shared PV assets is complex and often requires agreement among residents and prepayment of long-term investments.
- Rejection of External DER Operation. Many building residents are against external explicit operation of Distributed Energy Resources (DERs) for flexibility activation.
- Low Participation in Energy Efficiency Measures. There is low participation in implicit energy efficiency measures prescribed by the system.
- Challenges in Remote Resorts. Installing energy services in remote holiday resorts like Krk and Thasos islands is difficult and expensive, dependent on dwelling occupancy, and limited to summer and holiday seasons.
- Hotel Guest Challenges. Implementing demand response and flexibility programs in hotel rooms or resorts is challenging due to the different expectations and priorities of guests/ residents, who may not be willing to change their behaviour for energy savings.
- Limited Payback. Despite the low cost of the frESCO system per building, low initial revenues and service income result in long payback times.

- Difficulty in Explaining Benefits. Homeowners and end users struggle to see tangible benefits of the solutions, especially in areas with a less developed energy market and relatively low service revenues.
- User-Friendly Solutions. To address user concerns and debugging issues with data ingestion, a simplified dashboard has been created to make the solution more attractive and dynamic.

These observations affect the proposed frESCO business models in more than one way. If residents are not willing to participate in demand response programs or energy-saving initiatives, it can limit the potential for revenue generation for ESCOs and aggregators. If the regulatory framework is not complete in order for residential consumers to be involved in the flexibility markets, ESCOs and aggregators may face legal and compliance challenges, which could result in increased costs and decreased profitability. The low potential for energy services in buildings without photovoltaic installations can limit the scope of the business models. If shared PV assets are not viable in residential buildings due to resident reluctance or other issues, it can reduce the revenue opportunities for ESCOs and aggregators. In addition to that, when building residents reject external operation of Distributed Energy Resources (DERs), what they actually do is to hinder the business models' effectiveness. ESCOs and aggregators may not be able to leverage DERs to provide energy efficiency and flexibility services as intended. When energy efficiency measures are not automated, then low participation can reduce the potential for cost savings and revenue generation in the business models. If residents are not actively engaged in energy-saving practices, the operations may fall short of their expected outcomes and thus, service providers may face challenges in recouping their investments within a reasonable timeframe.

Some alterations in the original business models in order to mitigate the effect of the identified issues could include creating alternative revenue streams such as:

i) diversify revenue streams by exploring additional services that can be offered to residents, such as home security, comfort optimization, or smart home solutions or

ii) partner with third-party service providers (suppliers or internet companies) to offer bundled services that increase the overall value proposition for residents. In addition to that the offering of energy audits as part of the bundled services or the launch of energy efficiency campaigns and programs to promote energy-saving practices among residents, prior to the deployment of the services may be important for acceptance purposes. In addition to that, as PV installations are practically essential, financial incentives or subsidies for the installation of PV assets to make it more appealing to residents and flexibility options that allow residents to maintain a degree of control over DERs while still participating in demand response programs should be considered jointly as part of the Value proposition offering. Finally, in order for installations in resorts (hotels or privately owned houses) to become more appealing, specific programs and adaptations to seasonal variations should be considered. This can be done by flexible pricing models that accommodate the fluctuating demand in these regions, and tailored digital energy services focused to the seasonal occupancy patterns.

5 CONCLUSIONS

In conclusion, the purpose of this document is to highlight the key pillars of focus in the context of frESCO breakthroughs. The document aims to distil insights of lessons learned and best practices from demonstration sites to enhance the overall approach, making it more efficient and effective.

By analysing results from the pilot sites, valuable conclusions have been drawn, leading to actionable global recommendations for integrators and policy makers, ultimately benefiting the energy sector.

The global recommendations and guidance provided encompass areas such as data interoperability, data gathering, automation modules, common information models, user engagement, business model exploration and dissemination.

The document emphasizes the importance of adapting business models and technical solutions aligned with the validation activities in frESCO, based on performance data and end-user feedback, ensuring alignment with user requirements and market suitability.

Furthermore, the document offers policy recommendations in domains such as energy service markets, energy markets, data transactions. These recommendations aim to foster flexibility, consumer participation, and revenue generation while addressing legal and compliance challenges, ultimately contributing to the progress of the energy sector's development.