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Deliverable D3.1
Definition of the novel energy services for residential consumers

Deliverable number	D3.1
Deliverable name	Definition of the novel energy services for residential consumers
Lead beneficiary	CIRCE
Description	Description of the characteristics of each energy services studied, indicating the value offered to the end-users, the energy assets involved, new systems that must be installed for the provision of the services and terms and conditions of the service delivered
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ABBREVIATIONS

Abbreviation	Meaning
AI	Artificial Intelligence
BRP	Balance Responsible Party
CA	Consortium Agreement
D	Deliverable
DB	Database
DER	Distributed Energy Resource
DHW	Domestic Hot Water
DoA	Description of Action
DR	Demand Response
DSM	Demand Side Management
DSO	Distribution System Operator
EC	European Commission
EE	Energy Efficiency
EU	European Union
EPC	Energy Performance Contract
ESC	Energy Sales Contract
ESCO	Energy Service Company
EV	Electric Vehicle
FP	Framework Programme
GDPR	General Data Protection Regulation
H2020	Horizon 2020 EU Framework Programme for Research and Innovation
HVAC	Heating, Ventilation and Air Conditioning

IPMVP	International Performance Measurement and Verification Protocol
IPR	Intellectual Property Right
MA/CP	Mitigation Action / Contingency Plan
P4P	Pay for Performance
PMV	Performance Measurement and Verification
PV	Photovoltaic
RES	Renewable Energy Sources
SME	Small and Medium Enterprise
T	Temperature
TSO	Transport System Operator
VPP	Virtual Power Plant
WP	Work Package

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EXECUTIVE SUMMARY

This document describes and summarises the new generation of hybrid energy services for ESCOs and aggregators that combine both the provision of energy efficiency and demand flexibility in the residential sector. The new energy services are designed under the Pay-for-Performance principle, that ensure an accurate and transparent performance measurement to assess the energy savings and the demand flexibility dispatched for grid congestion and management. These new P4P energy services build upon the existing Energy-Performance Contracts model currently offered by ESCOs but scarcely developed in the domestic consumer sector due to the low energy demand and high transaction costs, which render the current model economically unfeasible in a large number of cases.

The new energy services are supported by Artificial Intelligence algorithms that run on a digital big data platform. Real time energy consumption, temperature and comfort parameters are continuously read from on-site meters and sensors installed at the consumers' premises. This data is carefully ingested and curated with full respect to personal data privacy, and then used in advance forecast algorithms to assess energy efficiency potential at medium and short terms, and demand flexibility at short terms to respond to provide services to the grid (congestion management, grid balancing and ancillary services).

Energy efficiency services provide quantifiable energy savings while demand response services exchange demand flexibility for a fair market remuneration. The joint revenue streams of both services should cover the service delivery costs and the digital platform set up costs, and additionally deliver a benefit for both the energy service provider (ESCOs and aggregators) and the consumers / prosumers, who are the ultimate beneficiaries of the services. Besides, a number of value-added non-energy services can be offered with the same infrastructure, among which some related to comfort, air quality, noise control or surveillance are proposed in the document.

The result is a complete, splitable and comprehensive set of new energy services that can be offered in parallel to traditional EPC services, thus completing the service portfolio of ESCOs in the domain of residential buildings, with possible extension to flexibility services to the grid and non-energy services to building residents.

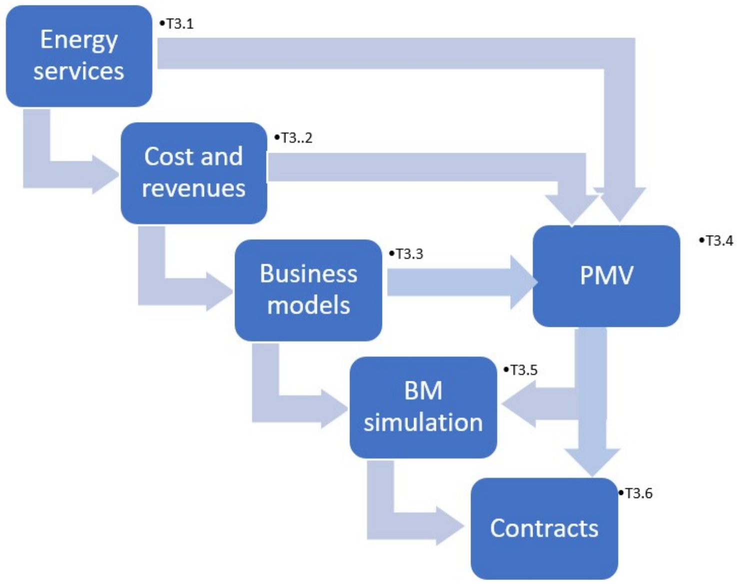
1 OBJECTIVES AND SCOPE

This document has been elaborated to compile the results of task T3.1 “Design of the novel energy services for residential consumers”, of the frESCO project, funded by the European Commission under the H2020 programme. The objective of this document is the identification of the most suitable innovative energy services for residential consumers based on a Pay-for-Performance model, the description of the characteristics of each energy services studied, indicating the value offered to the end-users, the energy assets involved, the new systems that must be installed for the provision of the services and the terms and conditions of the service offered. The task starts from the business end users’ requirements elicited in WP2 and propose a number of energy services integrated in service bundles, in order to exploit their synergies and enable the development of appealing business models by combining a double revenue source by means of energy savings, and demand flexibility remuneration.

The frESCO energy services are provided on the basis of a new innovative digital data platform and a novel performance measurement and verification method, developed in T3.4, to ensure payments are directly linked to verified performance, enabling a P4P contract model that guarantees fair remuneration to consumers and business actors (ESCOs and aggregators). This is the first step towards a comprehensive business model approach, that will be completed with the identification of the service value-added chain and the revenue stream mapping in T3.2 and the deployment in attractive business models for ESCOs and aggregators in T3.3. Business models will be simulated in T3.5 and adequate contract templates developed in T3.6.

The Work Package 3 schematic flow is depicted below in Figure 1 .

Figure 1. WP3 scheme for novel Performance-based Business Models and Verification Methods for bundled energy services.



2 INTRODUCTION

Despite the large economic energy saving potential in the EU the energy service companies (ESCOs) market for residential buildings is much less developed than in other demand sectors (e.g. the industry or public/service sectors). Energy performance contracting (EPC) providers have been most active in the services and the public building sector, since they are mainly targeting energy contracting offerings to large customers, partly explained by the large transaction costs of energy performance contracts. As a result, very few ESCOs work in the residential market, mainly targeting large multi-family and public housing facilities.

Besides sector cross-cutting barriers (e.g. low level of energy prices, lack of information and awareness, lack of appropriate forms of finance) there are indeed specific barriers which make a large-scale application of the conventional ESCO model for residential buildings particularly difficult. The EPC arrangement has primarily been used in the public and commercial sectors and not among households, since residential buildings lack scale, both in per-unit consumption and in the number of readily identifiable homogenous units, and they lack the necessary energy intensity to justify investment within the structure of present-day EPC business models. Moreover, the decentralised structure of the residential sector and high transaction costs of face-to-face interaction hinder the uptake of EPC.

However, the increasing penetration of smart solutions for residential dwellings (smart home technologies) and the generation of huge data streams that can facilitate better knowledge of the demand side, the drastic reduction of the costs for on-site generation and storage, the proliferation of self-consumption models and energy communities, together with the growing de-centralization of the energy system that intensifies the need for introduction of small residential consumers in smart grid management strategies, point the way towards the definition and deployment on innovative energy services that can transform small residential consumers as active energy actors and equal participants in progressively opening energy markets. Such favourable conditions are further enhanced by the political commitment at EU and national levels for the empowerment of small consumers to become active elements of the future energy system and an integral part of the integrated EU Energy Market, thus necessitating for new business models and services that can facilitate this transition of the EU energy landscape. Nevertheless, with the drastic reduction of technology costs and the opportunity raised for the creation of significantly high revenue streams through energy markets, it becomes obvious that a new era arises for the residential buildings market associated with very attractive payback periods for targeted investments towards energy efficiency, self-consumption optimization and provision of services to energy grids through demand response and flexibility.

An analysis of the framework conditions reveals important factors that can impact the technology deployment in the market in the future:

- Political and legal factors: The concepts above are developed in the framework of the Energy Efficiency Directive (EED), which establishes a set of binding measures to help the EU reach its 20% energy efficiency target by 2020. Although this Directive aims at boosting energy efficiency investments, its transposition, along with other national and local regulations have posed barriers to ESCOs activities and particularly to the utilisation of EPC model. These barriers include legal aspects related to the installation of equipment, procurement procedure rules for public authorities, legal issues with tenancy laws, etc. On the other hand, there are still major barriers in the Demand Response market in Europe that need to be addressed. Despite the latest progress and an increasing regulatory interest, the market is still quite fragmented, and this could limit the adoption of some of the energy services in some member states, (for example the provision of flexibility and demand response services is not regulated yet in Spain) and hinder their overall viability. In addition, the lack of standardised procedures for measurement and verification of energy savings can lead to disputes between participants due to the impossibility of credibly proving the energy savings, thus limiting the adoption of energy efficiency services.
- Economic factors: Despite the untapped energy saving potential in residential buildings, there are still economic barriers that impede the adoption of energy efficiency services. One of the main important ones are the high transaction costs for ESCOs compared to the small amount of energy savings (and hence incomes) achieved per residential household, making the economic return lower than in other sectors. While the digital solutions are not very CAPEX-intensive, dispersion of the residential consumers implies that the amount of devices to be installed are higher than other sectors (especially for buildings with low smart readiness), which could limit the attractiveness of the services. This is also affected by energy price

volatility, since this has a significant impact on the feasibility of many energy efficiency measures. In particular, low energy prices make it difficult to guarantee short-term returns on energy efficiency investments. This could be intensified in some Member States, where energy prices are highly subsidised, and hence, there is no incentive from consumers to reduce their energy consumption. Finally, there are financial barriers for ESCOs, since banks have generally a low awareness in the area of energy efficiency and there is a lack of dedicated financing products tailored to energy efficiency investment on the market.

- Social factors: Thus far, consumer's trust and behaviour towards ESCOs and EPC models has been one of the main limiting factors in the adoption of these services in the residential sector. While ESCOs often work in a context of well-defined user behaviour –public and tertiary sector-, the unpredictability of residential consumer behaviour hampers the implementation of their services due to the risk associated to volatility of incomes and more difficulties to reach long-term agreements. Besides, general distrust on EPC models, limited confidence in ESCO services, or preferences for in-house solutions are also important barriers for the adoption of energy services in the residential sector. In this framework, the new service bundles aim at overcoming these limitations by developing and enhancing techniques for consumer profiling and savings PMV, thus minimising the risk associated with the volatile behaviour of residential consumers.
- Technological factors: The need for implementation of proper technology –namely ICTs- in most of the residential buildings, as well as their fine-tuning to comply with the energy services characteristics, may slow down the adoption of these services in the short term. In particular, for old buildings, the potential needs for adaptation for the proper implementation of ICT tools would lead to higher CAPEX costs for the services and, while the energy savings would be generally higher, this could imply a lower attractiveness due to the upfront costs. Hidden costs, such as unexpected maintenance or training needs, may also arise, reducing the savings from efficiency measures.
- Environmental factors: The adoption of the new energy services will lead to lower energy consumption –both fuel and electricity- at consumer level, while at the same time easing the integration of renewable energies in the grid –thanks to flexibility services- and the implementation of distributed energy generation. Consequently, these services will

contribute to reduce GHG and pollutant emissions and hence, there are no significant environmental barriers limiting developments.

The novel services presented in this document are being worked out in the frame of the frESCO project and they are based on services that use enhanced performance measurement and verification (PMV) protocols to construct continuous consumption (and generation) baselines based on real-time data (metering and sensing). This PMV is the foundation of the Pay for Performance (P4P) principle of the new energy services, that goes beyond the current traditional Energy Performance Contract (EPC) in use by ESCOs for retrofitting solutions in buildings.

2.1 CURRENT STATUS OF EPC CONTRACTS IN THE RESIDENTIAL SECTOR.

The first mention of the modern ESCO concept in the European legal framework comes from Directive 2006/32/EU. The aim of this Directive is to promote the economical and efficient use of energy in the Member States developing the market for energy services. This directive defines the Energy Service Companies as corporations that provide energy services in the facilities/building of a consumer during a contracting period. This definition is further enhanced by the EU directive 2012/27/UE on Energy Efficiency that explicitly states that the payment for those services should be based, partially or totally, on the achievements of energy savings. The savings are obtained by implementing improvements in the facilities or by using renewable energy sources.

With this definition, the scope of the possible energy services is very broad and encompasses all possible energy services. ESCOs can design, finance, install, implement and monitor a project aiming at obtaining energy savings on-premises. ESCOs can fully or partially assume the technical and economic risk of the project. The economic risk is derived from a total or partial retribution according to the energy performance. Thus, sustained energy savings along the service contractual time are the main financing tool following a project-finance approach where the risk is mainly borne by the ESCO. The ESCO also contributes with the technical leadership of the project.

The ultimate objective of Directive 2012/27/EU is to involve private sector capital and initiative in the 20/20/20 targets, with three main vectors as the core of the strategy: rely on efficient cogeneration systems and District Heating and Cooling (DHC), make the public sector play an exemplary role in energy efficiency and the added value of the ESCOs with the EPC contracts to guarantee savings to the customers.

Going down to the definition of energy services, the traditional concept of energy service is a set of services that include tangible and intangible investments, works or supplies needed to optimise the final energy performance in the customer facilities and processes. The immediate consequence is the reduction of energy-associated costs (acquisition, installation, operation, maintenance, decommissioning, ...). The energy service thus defined should be paid based on a contract which must be associated with a saving of energy that is verifiable, measurable or possible to estimate. In other words, an Energy Performance Contract ensures the delivery of services along a determined duration that is often assessed according to the capital investment payback period.

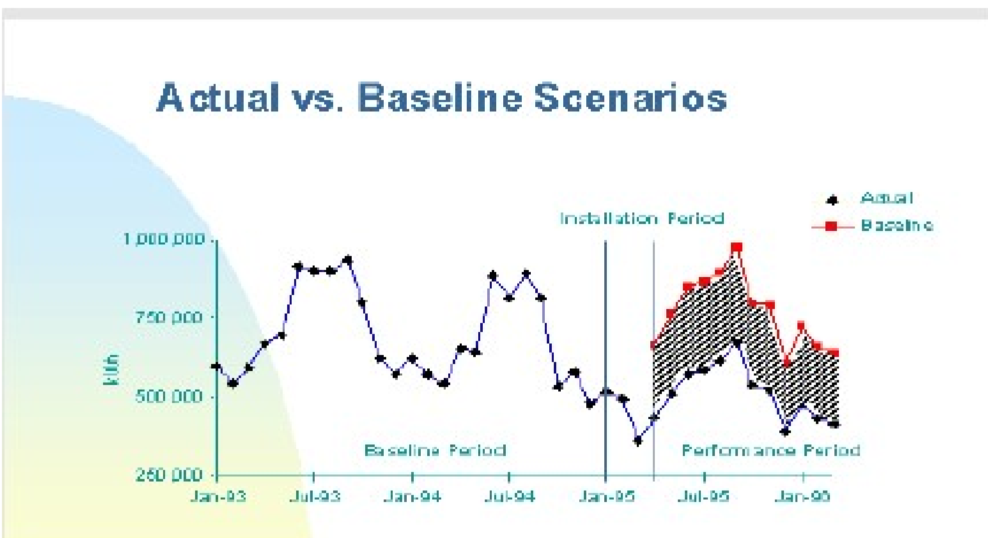
Related to Energy services to buildings, an EPC is a proven and internationally recognized procurement method for reducing the operating costs and environmental impacts of buildings at low risk to property owners. Under a performance contract, an Energy Services Company brings its technical know-how to provide complete turnkey responsibility for a comprehensive set of energy efficiency, water efficiency, operations and maintenance cost efficiency, renewable energy, and / or distributed generation improvement measures. The ESCO manages all aspects of the project from the start to the end: building energy audits, detailed design and engineering, business case analysis, installation, commissioning, and ongoing performance measurement and verification. Also important, the ESCO assumes the performance risk for the project in the form of a long-term financial endorsement to ensure that the projected energy, water, and operational cost savings materialize and are preserved over time.

Energy Performance Contracts differ from the so-called Energy Sales Contract (ESC) in the way the energy efficiency is provided. EPCs ensure performance of energy transformation equipment, usually in the customers' facilities. New equipment purchase financed by ESCOs belong to the ESCO and the property is transferred to the customer at the end of the EPC.

ESCs, on the contrary, ensure transformed energy prices. The customer here pays a price for the supply of final energy that is more advantageous than other market supply energy sources. This is the case of large energy producers and generators that sell the energy surplus to other consumers for a period and at a price stated in the contract. The decrease in energy price can come up for price negotiation, optimization of invoices, volume, or greater efficiency that results in a lower price-per-unit of final energy transformed. In ESC the energy transformation equipment property always resides with the ESCO. The combination of a performance and a sale contract is denominated Energy Sales and Performance Contract (ESPC).

EPC contracts need a protocol to measure savings in an accurate, repeatable, fair and trustworthy way. An adequate Performance Measurement and Verification method has to be proposed and agreed with the customer to verify the savings. Since savings cannot be measured, they are estimated as a comparison between actual and baseline scenarios in the following way:

Savings = actual energy consumption - Baseline + - adjustments.



A measurement and verification protocol is used to verify savings. It should be standard and be reflected in the contract. It shall establish measures, calculations and adjustments to be made to determine the amount of energy saved by the EE measures. The protocol can be internally designed. However, there are different types of international protocols like the International Performance Measurement and Verification Protocol (IPMVP), prepared by EVO (Efficiency Valuation Organization). Whatever the PMV is, it is part of the EPC.

ESCO EPCs use the PMVs to assess the savings and the retribution sharing between consumer and ESCO to ensure the payback of the capital costs, and a fair remuneration for both sides. However, in practice, there is no standard in PMV methodology, and the commercial alternatives are expensive, thus they are only applied in large ESCO contracts where the customer demands this approach, like large public EPCs or large company EPCs. The cost of setting up a PMV system, the complexity of some baseline models, the continuous baseline adjustments and the mistrust of users not familiar with PMV methodologies are behind the reasons why EPCs are not extended in the domestic sector. In this sector, a vendor/installer approach is much more frequent than the EPC model. Vendors install equipment acting upon customers' requests and following a shallow assessment of solution choice and suitability. In this model savings are never estimated methodologically.

High transaction costs and fragmented consumption are also factors that have historically led to a poor development of the ESCO market in the residential sector. Other reasons why the EPC model has not been successful in the residential sector so far is the low consumption levels that make ESCO projects economically unfeasible. Only large-scale projects at district or condominium level delivering services to whole residential areas are attractive for ESCOs.

Finally, although the recast directive of Energy Efficiency in Buildings sets ambitious performance targets for new buildings, the economic downturn in 2010 and 2020 has slowed down the building rate in Europe. A higher effort should be paid to refurbish the existing building stock to the new regulation standards, as part of extended ESCO services

3 FRESCO ENERGY SERVICES CHARACTERISTICS

3.1 BUSINESS ACTORS AND USER SPECIFIC REQUIREMENTS

frESCO energy services are targeted to domestic consumers and prosumers. Depending on the nature of the service there is two main groups of service providers or business actors:

- Energy Efficiency service providers: ESCOs, building owners and facility managers.
- Demand Flexibility service providers: demand response aggregators

A possible additional business actor is the ICT companies selling the digital platform solution service but this role is outside the frESCO project scope.

The business users set of requirements are elicited and described in D2.3 of the frESCO project. Summarising the requirements for ESCOs the following items are required:

- Users are more in favour of explicit services with automatic operation of DERs to ensure control and make sure efficiency is obtained
- Users' economic feasibility threshold for the new services is from 2 to 3 years payback time.
- Users want to have near-real-time monitoring of the energy consumption and performance and share these metrics with the consumers / prosumers
- Users want to be able to communicate, monitor and control legacy systems through openADR communication gateway
- Users want to have a module specifically focused to maximise savings for prosumers.
- Users want an opt-out feature enabling consumers to override actions at will.
- Facility managers of hotels would like to have implicit efficiency tools to motivate guests to take their own decisions on energy usage and be rewarded if positive.
- Users would like to have intuitive, easy-to-use interfaces allowing non-technology lovers to deal with the system.
- Users would like to have accurate forecasting tools to be able to assess efficiency potential and verify it in a fair way.
- Users would like to keep the door open to the former EPC traditional services and add the new services in a compatible manner.

From the side of Demand Flexibility, an interview conducted with an aggregator in the frame of T2.3 revealed the following user requirements from the point of view of the aggregator:

- User needs to perform demand side aggregation in real time, real time is about 5 seconds-delay.
- User needs to have short-term demand forecast and PV generation forecast (if prosumer). Minimum forecast horizon: daily forecasts for day-ahead market participation.
- User needs a visualization and control interface and another one for the customer.
- User identifies the following information required: demand forecast, generation forecast, market flexibility request, market bid prices, DER management and VPP configuration criteria, connection status, localization, mapping of DERs with contracts (consumers), energy dispatch, final flexibility delivery, remuneration parameters.
- User needs a proper, well designed DER registry where it is possible to list, visualise and cluster available DERs under the service contract agreement.
- User identifies as suitable domestic DERs for flexibility the following DERs: electric heaters, heat pumps, hot water tanks, EV chargers, PV generation.
- User identifies as clustering criteria the following factors: type of DER (heaters, chargers, generators), reliability factor based on historic participation.
- User needs a VPP configuration module able to group and aggregate different available DERs based on the clustering criteria as a response to a flexibility event.
- User needs a marketplace interface to visualise, propose, and sign flexibility contracts with prosumers, with security access.
- User would be in favour of an individual settlement and remuneration module per event and DER if it were technically possible. Currently they apply monthly subscription contracts with minimum constant remuneration and only for electric heating systems using building thermal inertia as an energy storage.
- User needs to provide a periodic report of activity to every user on a regular basis (monthly minimum). User needs a system to provide transparent information to users at billing.

- User is not convinced about the offer of implicit DR services. At least not in aggregated way to be traded in flexibility market.

With these high-level requirement in sight and the P4P contract model, the energy services are depicted in chapter 4.

3.2 ENERGY SERVICE P4P MODEL

The P4P contracts demand a direct relation between service payment and energy performance. Hence, this performance has to be accurately measured and verified. Indeed, P4P energy services are based on a specific Measurement and Verification Methodology (PMV) that uses real-time data streams to ensure (i) objective validation and assessment of the feasibility and effectiveness of the new business models and (ii) transparent remuneration of the involved actors for the achievement of energy savings and the provision of flexibility to the grid. The PMV methodology focuses on the establishment of a robust and transparent method, based on data streams from local resources and blockchain technology. The new PMV method offers fairness, simplicity, accuracy and replicability in order to foster end users' trust in the remuneration mechanism.

The frESCO PMV approach for the performance measurement of flexibility and efficiency events is developed in T3.4 and consists of a continuous and dynamic baselining of generation and consumption of the controllable DERs included in the contracts. Baselines created use real-time data according to modelling forecast algorithms previously trained to adapt to the building thermal performance and users' comfort preferences. This baseline enables a comparison with actual energy metering to assess how much energy has been saved, how much has been self-consumed and how much has been shifted, upward or downward, after a flexibility event has gone past. With this available data, service charge and remuneration settlements can be made depending on the service outcome in accordance with the Pay for Performance approach.

The frESCO new services and business models bring under common Pay for Performance Contracts (extended form of current EPCs) two currently differentiated service offerings to enable the realization of next-generation smart energy service packages. The new services combine remuneration from energy efficiency management (savings) and demand response trading in markets (revenues). Both type of services, plus additional non-energy services related to comfort, air quality and security, can be delivered with the same big-data platform, thus increasing the total revenue stream stemming from different services and reducing the payback time. Revenue streams are analysed in T3.2.

4 DESCRIPTION OF FRESCO ENERGY SERVICES

This section uses the data template in Annex 1 to describe and collect all aspects related to the definition of new hybrid Pay-for-Performance (P4P) energy services within the frame of T3.1. The template is then used to describe a number of energy services according to the agreed list below.

- RT. Smart equipment retrofitting. This set of energy services include the assessment of smart readiness, the installation of the digital platform hardware, sensors, and data communication gate, along with the information interface with the user.
- EE. Energy Efficiency and self-consumption optimisation services. This set of services use the big data platform to deliver implicit and explicit energy efficiency services and self-consumption optimisation.
- FL. Demand flexibility services. This set of services deliver implicit and explicit demand response services for grid management
- NE. Non-energy services. This set of services rely on the digital platform to convey services related to automation, comfort, air quality, noise reduction, surveillance and other non-energy services

Table 1 shows an overview of the elicited frESCO P4P energy services.

Sensoring and smart equipment retrofitting		Related tasks	Comments	Revenue stream	Expected output for user
RT1	Smart equipment retrofitting, sensors and meters	T4.2	Mandatory. Enables all the other services. Include installation, training and coaching	Initial fee	frESCO big data platform infrastructure
RT2	Data monitoring and Personalized Informative Billing	T4.4, T5.4	Analytics of energy usage and invoicing in a billing period.	Initial fee + regular fee: Licence fee	Monitoring and data interface
RT3	Smart readiness assessment and Certification	T4.2	Audit for pre assessment of building efficiency, equipment and smart readiness	service charge	Smart readiness level prior to any new P4P service
Energy efficiency and self-consumption optimization services		**Related tasks**	**Comments**	**Revenue stream**	**Expected output for user**
EE1	Energy Management for Energy efficiency	T4.4, T5.1	Energy efficiency analytics awareness for EE management service. Use of platform data for energy management based on users' comfort choices	P4P on savings	Explicit energy savings
EE2	Personalized Energy Analytics for Energy Behaviour optimization	T4.4, T5.2, T5.4	Implicit EE service. Use of platform data for advice provision (recommendation) and energy mgmt.	P4P on savings	Implicit energy savings
EE3	Holistic self-consumption maximization service	T4.4; T5.2	Maximization of Energy self-consumed by Energy management service for prosumers	P4P on savings	energy savings from PV optimization
EE4	Automation and optimal device scheduling	T4.4, T5.4	Explicit automated dispatch of efficiency events stemming from EE awareness and price-based scheduling.	P4P on savings	Economic savings
Flexibility services		**Related tasks**	**Comments**	**Revenue stream**	**Expected output for user**
FL1	Flexibility analytics services (Awareness and Knowledge of Users' flexibility)	T4.4, T5.3	Information towards Flexibility analytics for Flexibility market participation	P4P on flexibility	Flexibility analytics
FL2	Explicit automatic DR services	T5.3, T5.5	Implementation of the DR event scheduled. Remuneration for flexibility provision.	P4P on flexibility	Revenues from ancillary service market or grid operators
FL3	Virtual Power Plant and Optimal Flexibility Activation Scheduling	T5.3	Schedule of flexibility activation for a future activation. Configuration of VPP	P4P on flexibility	Revenues for flexibility trading in flexibility market
Non-energy services		**Related tasks**	**Comments**	**Revenue stream**	**Expected output for user**
NE1	Thermal Comfort services	T5.4	Comfort preservation and automation at minimum energy costs. Requires smart controls and switches	P4P on service performance	Comfort, automation
NE2	Indoor air quality preservation	T5.4	Preservation of Indoor air quality by means of air quality sensors. Smart ventilation.	P4P on service performance	Air quality control
NE3	Noise reduction services	T5.4	Noise sensors. Scheduling of noise devices and appliances at certain periods of time, smart ventilation, others.	P4P on service performance	Noise reduction and control
NE4	Security and surveillance services	T5.4	Presence sensors, scheduling of lighting at night / absences to create a dissuasive security system	P4P on service performance	Security and surveillance

Table 1. List of frESCO P4P innovative energy services.

4.1 SMART RETROFITTING SERVICES

This group of services integrate the physical commissioning and installation of the hardware needed to set up the digital big-data platform. Basically, this set of services includes the Energy Box (datalogger), the sensors according to the services contracted, the smart meter and clamps connections for energy metering at device and dwelling level and the connections to the controllable DERs. These services are one-time services; but the operation, maintenance and payback span through the duration of the contract. These services are physically delivered on-premises. In this group we can include other traditional ESCO retrofitting services that could be adopted to follow the P4P methodology using the big-data platform data and forecast algorithms for baselining and optimal efficiency measurement and verification towards fair remuneration of both sides based on performance.

Three services are proposed in this group:

- RT1: Smart equipment retrofitting, sensors and meters
- RT2: Data monitoring and Personalized Informative Billing
- RT3: Smart readiness assessment and Certification

Service number: RT1

Energy Service short description:
Smart equipment retrofitting, sensors and meters in buildings and dwellings

Energy Service category
1- Building retrofitting and investments for the installation of smart equipment

Service providers
ESCOs, retailers, installers, developer/builder, aggregators, … alternatively ICT providers.

Target beneficiary
Residents, facility managers and owners, energy communities.

Service definition and scope
This service is a one-time installation that happens prior to the delivery of any other Energy Service. The contracting is then mandatory. This service enables all the other services. It includes the installation of the Energy box (data logger) with the comfort sensors pre-installed, according to the rest of the service bundles contracted. It can also include training and coaching on how to use the system and the associated personal data interface (RT2). Installation may be done by the user in cases with high smart readiness levels where metering clamps may not be needed, using online support and

precise installation instructions. In most of the cases, a specialised installing company should go onsite and proceed with the installation and testing.
This service may eventually include further building refurbishment and retrofitting ESCO services. Users will keep benefiting of the traditional EPC ESCO retrofitting services and will gain in performance measurement accuracy and reliability evolving towards a fair P4P remuneration system for the savings verified due to the building retrofitting.

Value added for users.

This service provides the necessary installations and equipment to deliver any frESCO service. It is then, mandatory with any other service. This service does not provide a significant value added for users unless combined with the RTL2 that provides the interfaces to visualise personalised data and billing information to teach the beneficiaries how they are using the energy and how much their consumption decision impacts on the bills.
For other common building retrofitting services, users gain in accuracy and reliability of the new P4P energy saving verification and remuneration models based on accurate dynamic baselining of the dwelling consumptions.

Market acceptance

Market acceptance is assessed only when combined with RTL2 as a minimum bundle. See RTL2 service.

Pre-requisites for service delivery

- User profile
    - Users should be ready to accept the contract terms, grant onsite access for system installation, and be ready to grant consent for data sharing to the service provider.
    - Users should have electrical loads to control and monitor, mainly for HVAC, but also important if they had electric DHW, PV generation, EV charging or energy storage systems.
    - To maximise the impact, annual electricity consumption should have a high starting baseline.
- Minimum smart readiness level: Permanent wifi connection. Important to have smart HVAC and DHW systems.

DERs and loads involved.

Almost any building energy consuming system running on electricity. HVAC and DHW systems. EV charging system. PV facility, Battery storage status and charging system. The hardware will be configured according to the energy services contracted and the controlled DERs. This will determine the type and number of sensor devices, clamps, meters, and features to install.

Data needs

- Current smart readiness level (sensors, smart appliances, connectivity). This information will be the base of the tailored RT1 service configuration.
- HVAC parameters (indoor and outdoor temperature, indoor temp. setpoint, HP / radiator real-time consumption metering). The assumption is that electricity-driven HVAC is always included in some of the services.
- PV instant generation metering (if existent and contracted)

- Other controllable DER parameters according to the service bundle contracted. (i.e. DHW: network water temp, water tank temp., temp. setpoint)

Assets and equipment needed.

- Energy box (datalogger)
- Meter clamps for every monitored load (HVAC, DHW, EV, PV, battery,…)
- Access to smart meter readings.
- Temperature sensors in the representative areas to manage.
- Permanent Wifi connection

Preliminary cost assessment

- Upfront costs: energy box, sensors (150 €/unit), pre-installation and testing (TBD), delivery and on-premises installation (TBD), User training (TBD). Prototype Energy Box + installation + tests estimated around 1000 €/u.
- Operation costs. System maintenance per year (TBD)

Revenue Stream

- Initial installation fee.
- Alternatively, the price could be included in any service bundle, or combination of service bundles, and the cost be paid as service monthly instalments for a given payment period.
- The charge could be included in any service bundle, or combination of service bundles, and the cost be paid back as part of the service revenues to the ESCO / Aggregator / Service Provider. In this case, a minimum contract duration should be settled, and the revenue share between user and service provider be calculated to account for the initial installation and upfront costs.

Barriers for deployment / implementation

- Technical barriers
    - Level of smart readiness of the dwelling.
    - Low usage rate of smart electricity-driven controllable DERs for the main domestic demands.
    - Router connection problems, bad internet connection signal or internet unavailability issues.
    - Number of sensors needed.
    - Standardisation and compatibility of sensors and meters with energy box communication protocols.
- Social barriers
    - Intrusive system to be installed on premises.
    - Personal data management mistrust
    - Lack of confidence on new disruptive technology
    - Not used to block-chain enabled contracts.

- Lack of transparency about the data usage and data protection mechanisms.
    - Reluctance to grant home device control to a service provider.
- Economic barriers
    - Initial upfront costs. Initial estimation: 1000 €/unit
    - Service delivery and maintenance costs. Estimated to be low or very low.
    - Electricity markets shut now for aggregated DR.
    - Low remuneration for traded demand flexibility in the DR open markets.
    - Low penetration of RES and storage systems in the domestic sector.
    - Low consumption level per dwelling in the residential sector.

Possible bundling services

This service is prior to any other and mandatory with any additional service contracted since it provides the base of the frESCO big-data platform. This service needs to have a monitoring user interface which is provided with RT2.

In addition, it could be provided jointly with RT3 (recommendable) and at least some energy efficiency services and/or flexibility services.

Contractual arrangements and issues.

- Type of contract: Product or service contract between the Service Provider and the Recipient.
- Terms and conditions of the service delivered.
- Contract duration. The installation is a one-time service. However, this service goes with RT2 providing visualisation and monitoring of real time energy performance. This is a service that can be provided as long as it is demanded. From 1 to 10 years.

frESCO Development tasks and partners.

- Energy Box: CIRCE, VOLT
- Hard Building retrofitting components: Sensor selection: CIRCE, VOLT. Procurement: COMSA, PONIKIVE, VOLT, VERD
- Development tasks: T4.2 (CIRCE)

frESCO demo site testing beds

All demo sites.

- Croatia, Greece, Spain install CIRCE's energy box
- Spanish demo installs a PV facility as a retrofitting equipment that will enable Energy Efficiency and self-consumption optimization service testing.
- France installs VOLT's energy box.

Service number: RT2

Energy Service short description:
Data monitoring and Personalized Informative Billing

Energy Service category
1- Building retrofitting and investments for the installation of smart equipment

Service providers
ESCOs, Retailers, Installers, Constructors, … alternatively ICT providers.

Target beneficiary
Residents, facility managers and owners, energy communities.

Service definition and scope
This service is delivered along with RT1 and provides the user interface and the data analytics of energy usage and invoicing in a billing period. This service includes the energy monitoring on real-time and aggregated in periods, both in energy and economic terms. This monitorization capabilities can be configured to the user's needs and provides the basis for energy consumption awareness and informed decision making about energy usage at home. Information would break down energy costs in components to enable an easy identification of the main cost drivers. Additionally, this could be extended to provision of information about flexibility remuneration, and self-generation surplus compensation.

Value added for users.
This service provides the necessary information to the user and provides the interfaces to visualise personalised data and billing information to show the beneficiaries how they are using the energy in real time, and how much their consumption decision impacts on the bills.

Market acceptance
RT1 and RT2 are the base for a set of services that are targeted for domestic users concerned about sustainability issues and/or about their energy bills. These domestic consumers require a service based on continuous monitoring of energy consumption and parameters related to energy consumption to know more about how they make use of the energy at home and what their energy performance is, with the final target to improve energy performance, and participate indirectly in energy markets. Market acceptance is likely to be higher among young people, who are more open to digital technology and data-driven solutions and are less reluctant to share information with the service providers. Early adopters of technological solutions are more likely to feel interested about the novel energy services.

Pre-requisites for service delivery

- User profile
    - Users should be ready to accept the contract terms, grant onsite access for system installation, and be ready to grant consent for data sharing to the service provider.
    - Users should have electrical loads to control and monitor, mainly for HVAC, but also important if they had electric DHW, PV generation, EV charging or energy storage systems.
    - To maximise the impact, annual electricity consumption should have a high starting baseline.

- Minimum smart readiness level: Permanent Wi-Fi connection.

DERs and loads involved.

Any electricity consuming DER that can be monitored. e.g: HVAC and DHW systems, EV charging system, PV facility, Battery storage status and charging system.

Data needs

- All data needed for RT1 service. Basically, electricity consumption.
- PV instant generation metering (if existent and contracted)

Assets and equipment needed.

- Energy box (datalogger), meters and sensors (RT1)
- Permanent Wifi connection.
- Web interface for computer monitoring.

Preliminary cost assessment

- Upfront costs. RT1 upfront costs: Energy box + installation + tests estimated around 1000 €/u.
- Operation costs. System maintenance per year (TBD).

Revenue Stream

- Initial RT1 system installation fee. Alternatively:
- Interface licence for a given period (1 year, 5 years, 10 years).
- The charge could be included in any service bundle, or combination of service bundles, and the cost be paid back as part of the service revenues to the ESCO / Aggregator / Service Provider. In this case, a minimum contract duration should be settled, and the revenue share between user and service provider be calculated to account for the initial installation and upfront costs.

Barriers for deployment / implementation

- Technical barriers
    - Level of smart readiness of the dwelling.
    - Router connection problems, bad internet connection signal or internet unavailability issues. What to do with blanks or periods of missing data.
    - Technical complexity of a flexible interface that is capable to show varied configurable information from different DERs and sensors.
    - Legacy equipment (home appliances and equipment) that are outdated, obsolete or not possible to interact with them.
- Social barriers
    - Intrusive system to be installed on premises.
    - Personal data management mistrust
    - Lack of confidence on new disruptive technology

- Not used to block-chain enabled contracts.
    - Lack of transparency about the data usage and data protection mechanisms.
    - Complexity of the system configuration and interpretation of the information and indicators shown through the interface
- Economic barriers
    - Initial upfront costs. Initial estimation: 1000 €/unit
    - Service delivery and maintenance costs. Estimated to be low or very low.
    - Low impact of user-driven behavioural efficiency measures in a residential dwelling to pay back for the initial investment. RT1-RT2 are probably not economically feasible if they are provided with no other services that can provide additional savings/revenues.

Possible bundling services

This service is provided along with RT1 and is a minimum service enabling to show in a comprehensive manner the real-time pre-treated data captured by the big-data platform. It can be complemented with service EE2 "Personalized Energy Analytics for Energy Behaviour optimization", to provide the basis for an implicit EE service to support implicit Energy Efficiency measures from a user's behaviour perspective.

Contractual arrangements and issues.

- Type of contract: Service contract between the Service Provider and the Recipient.
- Terms and conditions of the service delivered. TBD
- Contract duration. This is a service that can be provided as long as it is demanded. From 1 to 10 years.

frESCO system modules, development tasks and partners.

- frESCO system modules:
    - Local demand manager, energy performance module.
    - User Visualization toolkit.
    - Home Monitoring and control dispatch module.
- Development tasks:
    - The baseline flexibility analytics is developed in T4.4
    - The EE and self-consumption performance monitoring is developed in T5.2
    - The basic analytic module and user visualization toolkit are developed in task T5.4

frESCO demo site testing beds

All demo sites. Special focus in the Croatian demo site.

- Croatia, Greece, Spain installs CIRCE's energy box
- France installs VOLT's energy box. VOLT uses their own data interface.

Service number: RT3

Energy Service short description:
Smart readiness assessment and Certification

Energy Service category
1- Building retrofitting and investments for the installation of smart equipment

Service providers
ESCOs, Installers, Constructors, … alternatively retailers and aggregators.

Target beneficiary
Residents, building managers and owners, energy communities.

Service definition and scope
This service is complementary to RT1 and RT2 and consists of an on-site audit for the pre-assessment of building efficiency, equipment and smart readiness. This service is a one-time service, but it can be repeated periodically to check changes in the smart readiness index. This index assesses the different DERs available looking at their degree of smartness (automation and control), connectivity and protocols used. This assessment is important to check how easy is to deploy the frESCO big data platform into the user's premises, what the necessary hardware requirements are, what frESCO services could be supported at a reasonable investment level and what would be needed to extend frESCO services scope. It also collects the users' type and source of data, as well as personal preferences in terms of contracts, market participation, comfort, privacy and other parameters chosen by the user.
If, as a result of the readiness audit, other retrofitting investments are contracted via P4P ESCO service, it will be handled as a traditional energy service by the ESCO. Savings obtained from these investments (envelope insulation, HVAC equipment renovation, new smart efficient equipment refurbishment, ….) will be monitored by the frESCO data platform and monitoring tools (RT2) and the performance measurement will be done by means of dwelling level medium and long-term forecast algorithms that will generate dynamic baselines on a continuous basis that take into account seasonal aspects (weather changes) and user behavioural aspects.

Value added for users.
This service provides the necessary tailored pre-assessment of the requirements of every particular dwelling for an optimal deployment of the frESCO big-data platform. This service allows to reduce installation costs and make the best of the existing DERs to optimise the services outputs, both for efficiency and for flexibility. The service also makes sure that the personal preferences and concerns of the user are taken into account. The audit also gives advice on future DER replacement, retrofitting or extensions to maximise the smart readiness of the building. This service may evolve towards a smart readiness certification responding to future legal requirements of smart buildings.
This service may eventually include further building refurbishment and retrofitting ESCO services. Users will keep benefiting of the traditional EPC ESCO retrofitting services and will gain in performance measurement accuracy and reliability evolving towards a fair P4P remuneration system for the savings verified due to the building retrofitting.

Market acceptance
Smart readiness is still an innovative concept not demanded by the market. The acceptance is supposed to be better for facility managers and owners as a way to obtain expert advice to optimise

the results of the investments made on the frESCO big-data platform. Assessments at building level and energy community level are expected to get a higher acceptance level as costs are shared.
It can also be valued by Constructors and building owners to certify the smart readiness of their building to make it more attractive for renting or sale in the Real-State market.

Pre-requisites for service delivery

- User profile
  - Users should be ready to accept the contract terms, grant onsite access for the audit and the system installation, and be ready to grant consent for data sharing to the service provider.
  - Users should have electrical loads to control and monitor, mainly for HVAC, but also important if they had electric DHW, PV generation, EV charging or energy storage systems.
- Minimum smart readiness level: This is to be assessed during the audit.

DERs and loads involved.

Almost any building energy consuming system running on electricity. HVAC and DHW systems. EV charging system. PV facility, Battery storage status and charging system. The interface will be configured according to the energy services contracted and the controlled DERs. These contractual choices determine the type and number of sensor devices, clamps, meters, and features to install, and therefore, the amount of information made available to the user.

Data needs

- None. Data needs would be collected on-site during the audit.

Assets and equipment needed.

None.

Preliminary cost assessment

- Upfront costs. None.
- Operation costs. On-site audit, data processing, report elaboration and recommendations.

Revenue Stream

- RT3 one-time service fee.
- Included in the initial RT1-RT2 system installation fee.
- The charge could be included in any service bundle, or combination of service bundles, and the cost be paid back as part of the service revenues to the ESCO / Aggregator / Service Provider. In this case, a minimum contract duration should be settled, and the revenue share between user and service provider be calculated to account for the initial installation and upfront costs.

Barriers for deployment / implementation

- Technical barriers
  - Smart readiness indicator is still to be implemented in the regulation, covering a multitude of possible DERs, protocols, type of users, buildings....

- Social barriers
    - Users need to grant access to premises to technicians.
    - Personal data management mistrust
    - Lack of confidence on new disruptive technology
    - Not used to block-chain enabled contracts.
    - Lack of transparency about the data usage and data protection mechanisms.
- Economic barriers
    - Low level of smart readiness of the dwelling and low potential revenues may render the service unfeasible from an economic point of view.

Possible bundling services

This service should be offered prior to RT1-RT2 which entails the deployment of the frESCO big-data platform. The desirable output is the readiness validity and recommendations to best install de platform and the most fitted services to run. Hence, this service should bundle with RT1-RT2 and a number of EE and Flexibility additional services.

Contractual arrangements and issues.

- Type of contract: pre-contract for a one-time service.
- Terms and conditions of the service delivered. On-premises service. Scope of the audit, results and recommendations.
- Contract duration. One-time service.

frESCO Development tasks and partners.

- Energy Box: CIRCE, VOLT
- Hard Building retrofitting components: Sensor selection: CIRCE, VOLT. Procurement: COMSA, PONIKIVE, VOLT, VERD
- Development tasks: This service deals with the assessment of the hardware needs to enable the frESCO platform. This is done in task T4.2

frESCO demo site testing beds

Croatia, Greece, Spain where the CIRCE's energy box is going to be installed. In these demo sites T2.1 already provides a thorough analysis of the buildings starting point, equipment and smart readiness status.

4.2 ENERGY EFFICIENCY P4P SERVICES

This set of services focuses on obtaining energy savings in different ways: from powerful energy analytics that can assess and forecast energy performance and provide the best efficiency strategies to a) give recommendations to users for implicit triggering of EE actions, and b) trigger automatic actions on controllable DERs. There is one service specifically addressed to prosumers, aiming at optimising self-consumption from distributed generation assets.

Four services are proposed in this group.

- EE1: Energy Management for Energy efficiency. Energy efficiency analytics awareness for EE management service. Use of platform data for energy management based on users' comfort choices
- EE2: Personalized Energy Analytics for Energy Behaviour optimization. Implicit EE service. Use of platform data for advice provision (recommendation) and energy management.
- EE3: Holistic self-consumption maximization service. Maximization of Energy self-consumed by Energy management service for prosumers.
- EE4: Automation and optimal device scheduling. Explicit automated dispatch of efficiency events stemming from EE awareness and price-based scheduling.

Although self-consumption optimisation can be measured and verified at event level, most of these efficiency services need a medium to long term forecast demand with a reference period prior to the service deployment, in order to assess holistically the impact of the service deployment.

Service number: EE1

Energy Service short description:
Energy Management for Energy efficiency

Energy Service category
2- Energy efficiency and self-consumption optimization services

Service providers
ESCOs, Facility managers

Target beneficiary
Residents, facility managers and owners, energy communities.

Service definition and scope
This service makes use of the platform data for the provision of analytics that allow the occupant/ building manager to have an overview of their energy performance, understand (at a high-level) their EE potential (by pinpointing outliers and weak performance points), receive information about generic energy efficiency strategies and (possibly) declare their preference on specific strategies. The results of the service analytics reveal the potential of energy efficiency, and this awareness can be either made available to users for implicit energy behaviour optimisation (EE2) or used explicitly in an automated way to act occasionally on the controllable DERs to reduce the energy consumption during the events while keeping the comfort parameters well within the users' dynamic preferences (EE4). This EE potential will be further instantiated in EE2 and EE4 in the form of detailed services such as targeted advice for behaviour change in EE2 or direct control actions over specific devices in EE4.

Value added for users.
This service provides the analytics for energy savings and the basis for a subsequent implicit or explicit deployment of eventual energy savings. There are energy savings produced at short events that can result in significant energy savings for the controlled loads at the end of the billing period. The analytics also provide insights about how the energy is used and what potential for energy efficiency each user has at home.

Market acceptance
Energy bills are one of the major concerns of dwellers. The market is open to incorporate technology to make energy savings at home. However, some users are not willing to lose control of their data and mistrust new technology. The safeguarding operation of user data should be well communicated and handled to overcome user's lack of confidence. This service should enhance the functionality by means of EE2 service that translates the analytics into specific user-driven actions or EE4 that uses the results to automatically operate equipment and devices.

Pre-requisites for service delivery

- User profile
    - Users should be ready to accept the contract terms, grant onsite access for system installation, and be ready to grant consent for data sharing to the service provider.
    - Users should be able to accept partial DER automated control as long as their comfort preferences are observed.

    - Users should have electrical loads to control and monitor, mainly for HVAC, but also important if they had electric DHW, PV generation, EV charging or energy storage systems.
    - To maximise the impact, annual electricity consumption should have a high starting baseline.
- Minimum smart readiness level: Permanent wifi connection. Important to have electric smart HVAC and DHW systems.

DERs and loads involved.

Almost any building energy consuming system running on electricity: HVAC and DHW systems, EV charging system, PV facility, Battery storage status and charging system. The interface will be configured according to the energy services contracted and the controllable available DERs. The higher the amount of DERs in control the larger the potential savings.

Data needs

- HVAC parameters (indoor and outdoor temperature, indoor temp. setpoint, HP / radiator real-time consumption metering). The assumption is that electricity-driven HVAC is always included in some of the services.
- Other controllable DER parameters according to the service bundle contracted. (i.e. DHW: network water temp, water tank temp., temp. setpoint)
- External weather conditions for HVAC demand forecast.
- Although the frESCO system can be trained to learn the always-changing users' comfort preferences, the consumption profile and the maximum and minimum comfort thresholds should be provided.

Assets and equipment needed.

- Energy box (datalogger), meters and sensors (RT1)
- Meter clamps for every monitored load (HVAC, DHW, EV, PV, battery,…)
- Access to smart meter readings.
- Permanent Wifi connection.
- Web interface for computer monitoring.

Preliminary cost assessment

- Upfront costs. RT1-RT2 upfront costs: Energy box + installation + tests estimated around 1000 €/u.
- Operation costs. System maintenance per year (TBD).

Revenue Stream

Energy savings for energy efficiency events, verified with the frESCO Performance Measurement methodology and paid according to the Pay for Performance contract. Savings are directly enjoyed by the consumers/prosumers. A part of it would be dedicated to pay back the ESCO proportionally to the results achieved. These payments would be aggregated and settled at the end of a period (monthly), together with the service report detailing savings per event / service.

Barriers for deployment / implementation

- Technical barriers
  - Level of smart readiness of the dwelling.
  - Router connection problems, bad internet connection signal or internet unavailability issues. What to do with blanks or periods of missing data.
  - Inaccessible control protocols for legacy equipment.
  - Lack of accuracy of the demand forecast.
- Social barriers
  - Rejection to lack of control of own equipment at home for automated operation.
  - Intrusive system to be installed on premises.
  - Personal data management mistrust
  - Lack of confidence on new disruptive technology
  - Not used to block-chain enabled contracts.
  - Lack of transparency about the data usage and data protection mechanisms.
- Economic barriers
  - Initial upfront costs. Initial estimation: 1000 €/unit
  - Service delivery and maintenance costs. Estimated to be low or very low.
  - Low impact for efficient dwellings or dwellings with low consumption.
  - Mistrust on black box forecast algorithms to calculate the baselines and assess savings on a P4P basis.

Possible bundling services

This service provides the efficiency awareness and bundles with all the energy efficiency services EE2, EE3 and EE4. In particular with EE2 for implicit triggering of EE events driven by the user supported by clear and understandable metrics and information, and with EE4 that provides automated operation of DERs driven by price signals to shift loads explicitly from peak price periods to valley time periods and hence, realise economic benefits.
All EE services can bundle with some non-energy services with little additional system costs.

Contractual arrangements and issues.

- Type of contract: Pay for Performance Energy Service contract.
- Terms and conditions of the service delivered. Opt-out clauses.
- Contract duration. This is a service that can be provided as long as it is demanded. From 1 to 10 years, but the minimum is given by the time needed to return the initial upfront costs.

frESCO system modules, development tasks and partners.

- System modules involved:

- Energy efficiency analytics module (T5.2)
- Local Demand Manager Energy Performance and forecasting Module (T5.1)
- Home Monitoring and Control Dispatch Module (T5.4)
- User Visualization toolkit. (T5.4)

- Development tasks: The basic analytic modules are developed in tasks T4.4 (S5), T5.1 (CIRCE), T5.2 (UBITECH) and T5.4 (CARTIF).

frESCO demo site testing beds

All demo sites. There is a particular interest in France.

- Croatia, Greece, Spain installs CIRCE's energy box
- France installs VOLT's energy box. VOLT uses their own data interface.

Service number: EE2

Energy Service short description:
Personalised Energy Analytics for Energy Behaviour optimization

Energy Service category
2- Energy efficiency and self-consumption optimization services

Service providers
ESCOs, Facility managers

Target beneficiary
Residents, facility managers and owners, energy communities.

Service definition and scope
This service makes use of the platform real-time data for the provision of recommendations and energy counselling services and energy management based on users' energy behaviour optimization. It is then an implicit energy efficiency service supported by a module of personalised energy analytics to give the user enough insights about the way the energy is used at home. The algorithms can also recommend load shifts and behavioural changes to deliver energy savings and economic savings by means of platform data, and monitoring and performance indicator calculations. This service can bundle with RT2 about data monitoring and personalised informative billing. It is not recommended in combination with the other EE services as there could be conflicts between automated explicit operation of DERs and implicit, user-driven operation of the same DERs.

Value added for users.
This service provides implicit energy savings by showing clear performance metrics to support decision making towards a more efficient use of the energy at home and reducing eventually the energy consumption and the energy expenditure.

Market acceptance
Energy bills are one of the major concerns of dwellers. The market is open to incorporate technology to make energy savings at home. However, not all users are willing to lose control of their decisions and mistrust new technology. Many want to keep the control of their decisions. This service is specifically meant for those users who do not trust explicit automated DER operation by third parties and want to keep conscious control of their actions towards energy efficiency. However, the impact of recommendations and user behaviour in energy management is variable, limited and random due to the lack of continuous and unpredictable focus of users on the information provided. This service may also be suitable to users with low smart readiness levels or inaccessible energy equipment that make automatic operation of their equipment unfeasible.

Pre-requisites for service delivery
- User profile
    - Users should be ready to accept the contract terms, grant onsite access for system installation, and be ready to grant consent for data sharing to the service provider.
    - Users should have electrical loads to control and monitor, mainly for HVAC, but also important if they had electric DHW, PV generation, EV charging or energy storage systems.

- To maximise the impact, annual electricity consumption should have a high starting baseline.
- Users should be motivated to consult the metric reporting and be ready to follow the recommendations provided.

- Minimum smart readiness level: Permanent wifi connection. Important to have smart HVAC and DHW systems.

DERs and loads involved.

Almost any building energy consuming system running on electricity: HVAC and DHW systems, EV charging system, PV facility, Battery storage status and charging system. The interface will be configured according to the energy services contracted and the controllable available DERs. The higher the amount of DERs in control the larger the potential savings.

Data needs

- HVAC parameters (indoor and outdoor temperature, indoor temp. setpoint, HP / radiator real-time consumption metering). The assumption is that electricity-driven HVAC is always included in some of the services.
- Other controllable DER parameters according to the service bundle contracted. (i.e. DHW: network water temp, water tank temp., temp. setpoint)
- External weather conditions for HVAC demand forecast.
- Although the frESCO system can be trained to learn the always-changing users' comfort preferences, the consumption profile and the maximum and minimum comfort thresholds should be provided.

Assets and equipment needed.

- Energy box (datalogger), meters and sensors (RT1)
- Meter clamps for every monitored load (HVAC, DHW, EV, PV, battery,…)
- Access to smart meter readings.
- Permanent Wifi connection.
- Web interface for computer monitoring.

Preliminary cost assessment

- Upfront costs. RT1-RT2 upfront costs: Energy box + installation + tests estimated around 1000 €/u.
- Operation costs. System maintenance per year (TBD).

Revenue Stream

- Energy savings for energy efficiency behavioural changes and recommendation implementation. Savings are directly enjoyed by the consumers/prosumers. A part of it would be dedicated to pay back the ESCO proportionally to the results achieved. These payments would be aggregated and settled at the end of a period (monthly), together with the service report detailing savings per event.

- The results obtained by this service depend a lot on the ability of the user to follow the recommendations given and the continuity of this behavioural change. In the long run and as the users' behaviour changes permanently, savings become more apparent. Due to the different nature of the efficiency actions, it is still to be assessed how these savings can be verified with the frESCO Performance Measurement methodology and paid according to the Pay for Performance contract. Guaranteed saving contracts are not recommended with this energy service.

Barriers for deployment / implementation

- Technical barriers
    - Level of smart readiness of the dwelling.
    - Router connection problems, bad internet connection signal or internet unavailability issues. What to do with blanks or periods of missing data.
    - Inaccessible control protocols for Heat Pumps and other equipment.
    - Lack of accuracy of the demand forecast algorithms.
    - Inaccessible control protocols for legacy equipment.
    - PMV methodology needs to be reviewed carefully to see how this user-triggered efficiency can be measured efficiently. User may have to specify intervals of measurement. Other more classic EPC approaches may be followed.
- Social barriers
    - High personal effort needed to implement recommendations and apply lasting behavioural changes.
    - Personal data management mistrust.
    - Lack of confidence on new disruptive technology
    - Not used to block-chain enabled contracts.
    - Lack of transparency about the data usage and data protection mechanisms.
- Economic barriers
    - Initial upfront costs. Initial estimation: 1000 €/unit
    - Service delivery and maintenance costs. Estimated to be low or very low.
    - Low impact for efficient dwellings or dwellings with low consumption.
    - Mistrust on black box forecast algorithms to calculate the baselines and assess savings on a P4P basis.

Possible bundling services

This service can bundle with all the Energy efficiency services but it is particularly linked with EE1 for the provision of the Energy management and efficiency awareness analytics. EE2 builds upon these analytics to provide the clear and understandable information for users to implement their own energy behaviour optimization. It can also bundle with RT2 Data monitoring and Personalized Informative Billing.

All EE services can bundle with some non-energy services with little additional system costs.

Contractual arrangements and issues.

- Type of contract: Pay for Performance Energy Service contract.
- Terms and conditions of the service delivered. Opt-out clauses.
- Contract duration. This is a service that can be provided as long as it is demanded. From 1 to 10 years, but the minimum is given by the time needed to return the initial upfront costs.

frESCO system modules, development tasks.

- System modules involved:
  - Local Demand Manager Energy Performance and forecasting Module (T5.1)
  - Energy efficiency analytics module (T5.2)
  - Home Monitoring and Control Dispatch Module (T5.4)
  - User Visualization toolkit (T5.4).
- Development tasks: The basic analytic modules are developed in tasks T4.4 (S5), T5.1 (CIRCE), T5.2 (UBITECH), T5.4 (CARTIF-

frESCO demo site testing beds

All demo sites.

- Croatia, Greece, Spain installs CIRCE's energy box
- France installs VOLT's energy box. VOLT uses their own data interface.

Service number: EE3

Energy Service short description:
Holistic self-consumption maximization service

Energy Service category
2- Energy efficiency and self-consumption optimization services

Service providers
ESCOs, Facility managers,

Target beneficiary
Residents, facility managers and owners, energy communities.

Service definition and scope
This service makes use of the platform real-time data for the maximization of Energy self-consumption (usually PV) for prosumers by energy management services. By means of short-term generation and demand forecast the smart algorithm is able to design highly efficient energy management strategies to maximise the energy consumed at high generation periods, thus maximising the self-consumption and reducing the energy surplus. The system operates similarly to EE1 but integrating a generation forecast engine that enables the optimal usage of the available solar resource for prosumers. This service bundles with the EE4 automation and optimal device scheduling to trigger the self-consumption optimisation strategy.

Value added for users.
This service provides energy savings by shifting eventually the energy consumption to periods of higher PV generation. There are economic savings produced at short events that can result in significant energy savings at the end of the billing period. Savings are directly enjoyed by the consumers/prosumers. A part of it would be dedicated to pay back the service provider (ESCO) proportionally to the results achieved. These payments would be aggregated and settled at the end of a period (monthly), together with the service report detailing savings per event.

Market acceptance
This service is meant for prosumers that want to reduce their PV payback time by increasing their energy coverage rate. The market may be open to incorporate technology to make energy savings. The main market barrier is the current low penetration of self-generation assets. The installed base is low. This service may not be interesting either for facilities with storage capacity as the excess of energy is stored in the batteries with no need of extra energy management.

Pre-requisites for service delivery

- User profile
    - Users should be ready to accept the contract terms, grant onsite access for system installation, and be ready to grant consent for data sharing to the service provider.
    - Users should be able to accept partial DER automated control as long as their comfort preferences are observed.
    - Users should have electrical loads to control and monitor, mainly for HVAC, but also important if they had electric DHW, PV generation, EV charging or energy storage systems.

- To maximise the impact, annual electricity consumption should have a high starting baseline.
- Users should hold an energy supply contract with time of use (ToU) tariffs.

- Minimum smart readiness level: Permanent wifi connection. Important to have smart HVAC and DHW systems.

DERs and loads involved.

Almost any building energy consuming system running on electricity: HVAC and DHW systems, EV charging system, PV facility, Battery storage status and charging system. The interface will be configured according to the energy services contracted and the controllable available DERs. The higher the amount of DERs in control the larger the potential.

Data needs

- HVAC parameters (indoor and outdoor temperature, indoor temp. setpoint, HP / radiator real-time consumption metering). The assumption is that electricity-driven HVAC is always included in some of the services.
- Other controllable DER parameters according to the service bundle contracted. (i.e. DHW: network water temp, water tank temp., temp. setpoint)
- PV real time generation metering.
- External weather conditions for PV and HVAC demand forecast.
- Although the frESCO system can be trained to learn the always-changing users' comfort preferences, the consumption profile and the maximum and minimum comfort thresholds should be provided.

Assets and equipment needed.

- Energy box (datalogger), meters and sensors (RT1)
- Meter clamps for every monitored load (HVAC, DHW, EV, PV, battery,…)
- Access to smart meter readings.
- Permanent Wifi connection.
- Web interface for computer monitoring.
- PV or RES facility for self-consumption with smart metering.

Preliminary cost assessment

- Upfront costs. RT1-RT2 upfront costs: Energy box + installation + tests estimated around 1000 €/u.
- Operation costs. System maintenance per year (TBD).

Revenue Stream

Economic savings from the additional savings made when increasing the self-consumption energy and verified with the frESCO Performance Measurement methodology and paid according to the Pay for Performance contract. The savings are made by decreasing the energy supply from the grid and make use of the otherwise PV energy surpluses. It is not expected that this service delivers any actual energy savings since, moving loads from periods of PV energy surplus to others with PV energy shortage may not bring about any energy reduction. The economic savings then are calculated as the difference in cost between energy supply tariffs and compensation / sales tariffs of energy surplus according to the national self-consumption scheme in place. The PMV method will use the forecasting algorithms to calculate the load shifted during the event and from it, the actual remuneration derived from it.

Barriers for deployment / implementation

- Technical barriers
    - Level of smart readiness of the dwelling.
    - Router connection problems, bad internet connection signal or internet unavailability issues. What to do with blanks or periods of missing data.
    - Technical complexity of a flexible interface that is capable to show varied configurable information from different DERs and sensors.
    - Inaccessible control protocols for Legacy equipment.
    - Lack of accuracy of the demand and generation forecast algorithms
    - To the demand uncertainty we need to add the weather forecast and the generation forecast errors.
- Social barriers
    - Rejection to lack of control of own equipment at home for automated operation.
    - Intrusive system to be installed on premises.
    - Personal data management mistrust
    - Lack of confidence on new disruptive technology
    - Not used to block-chain enabled contracts.
    - Lack of transparency about the data usage and data protection mechanisms.
- Economic barriers
    - Initial upfront costs. Initial estimation: 1000 €/unit
    - Service delivery and maintenance costs. Estimated to be low or very low.
    - For small PV facilities with little energy surplus, the amount of additional savings may be small.
    - Mistrust on black box forecast algorithms to calculate the baselines and assess savings on a P4P basis.

Possible bundling services

This service can bundle with all the energy efficiency services EE1, EE2 and EE4. In particular, it should be linked to EE2 for manual operation or EE4 for Automation and optimal device scheduling for the optimal and automatic deployment of the self-consumption optimisation strategy.
All EE services can bundle with some non-energy services with little additional system costs.

Contractual arrangements and issues.

- Type of contract: Pay for Performance Energy Service contract.

- Terms and conditions of the service delivered. Opt-out clauses.
- Contract duration. This is a service that can be provided as long as it is demanded. From 1 to 10 years, but the minimum is given by the time needed to return the initial upfront costs.

frESCO system modules, development tasks and partners.

- System modules involved:
  - Local Demand Manager Energy Performance and forecasting Module (T5.1)
  - Energy efficiency analytics and self-consumption optimisation module (T5.2)
  - Home Monitoring and Control Dispatch Module (T5.4)
  - User Visualization toolkit (T5.4).

- Development tasks: The basic analytic modules are developed in tasks T4.4 (S5), T5.1 (CIRCE), T5.2 (UBITECH), T5.4 (CARTIF)

frESCO demo site testing beds

The demos where this functionality will be tested are Croatia, Greece and Spain, all featuring the CIRCE's energy box.

Spanish demo installs a PV facility as a retrofitting equipment that will enable Energy Efficiency and self-consumption optimization service testing**.**

Greek demo already features PV self-consumption facility.

In Croatia, a number of dwellings do already feature PV self-consumption facilities.

Service number: EE4

Energy Service short description:
Automation and optimal device scheduling

Energy Service category
2- Energy efficiency and self-consumption optimization services

Service providers
ESCOs, Facility managers

Target beneficiary
Residents, facility managers and owners, energy communities.

Service definition and scope
This service makes use of the platform real-time data for the provision of automated energy management services based on users' comfort choices. It is then an explicit energy efficiency service that monitors the comfort parameters on real-time and automatically acts occasionally on the controllable DERs to shift loads from peak price periods to valley price periods. The service exploits the price elasticity of the demand using a price-based scheduling by means of the remote control and automation features with dynamic pricing of the frESCO platform. The system operates automatically as soon as the forecasting algorithms predict the chance of energy reduction.

Value added for users.
This service provides energy savings by shifting eventually the energy consumption to periods of lower prices. There are economic savings produced at short events that can result in significant energy savings for the controlled loads at the end of the billing period.

Market acceptance
Energy bills are one of the major concerns of dwellers. The market is open to incorporate technology to make energy savings. However, not all users are willing to lose control of their decisions and mistrust new technology. Many want to keep the control of their decisions or, at least, be informed of automated events and be able to override them at will. Options to override the automatic system should be in place.

Pre-requisites for service delivery

- User profile
    - Users should be ready to accept the contract terms, grant onsite access for system installation, and be ready to grant consent for data sharing to the service provider.
    - Users should be able to accept partial DER automated control as long as their comfort preferences are observed.
    - Users should have electrical loads to control and monitor, mainly for HVAC, but also important if they had electric DHW, PV generation, EV charging or energy storage systems.
    - To maximise the impact, annual electricity consumption should have a high starting baseline.
    - Users should hold an energy supply contract with time of use (ToU) tariffs.

- Minimum smart readiness level: Permanent wifi connection. Important to have smart HVAC and DHW systems.

DERs and loads involved.

Almost any building energy consuming system running on electricity. HVAC and DHW systems. EV charging system. PV facility, Battery storage status and charging system. The interface will be configured according to the energy services contracted and the controllable available DERs. The higher the amount of DERs in control the larger the potential savings.

Data needs

- HVAC parameters (indoor and outdoor temperature, indoor temp. setpoint, HP / radiator real-time consumption metering). The assumption is that electricity-driven HVAC is always included in some of the services.
- Other controllable DER parameters according to the service bundle contracted. (i.e. DHW: network water temp, water tank temp., temp. setpoint)
- External weather conditions for HVAC demand forecast.
- Current tariff prices per hour.
- Although the frESCO system can be trained to learn the always-changing users' comfort preferences, the consumption profile and the maximum and minimum comfort thresholds should be provided.

Assets and equipment needed.

- Energy box (datalogger), meters and sensors (RT1)
- Actuators/controllers for controllable non-smart loads.
- Metering clamps for every monitored load (HVAC, DHW, EV, PV, battery,…)
- Access to smart meter readings.
- Permanent Wifi connection.
- Web interface for computer monitoring.

Preliminary cost assessment

- Upfront costs. RT1-RT2 upfront costs: Energy box + installation + tests estimated around 1000 €/u.
- Operation costs. System maintenance per year (TBD).

Revenue Stream

- Economic savings for energy price elasticity events, verified with the frESCO Performance Measurement methodology and paid according to the Pay for Performance contract. Savings are directly enjoyed by the consumers/prosumers. A part of it would be dedicated to pay back the ESCO proportionally to the results achieved. These payments would be aggregated and settled at the end of a period (monthly), together with the service report detailing savings per event.
- If savings come from a market price-signal device scheduling (shifting loads from peak periods to valley periods) there may not be any energy savings at all. In this case, this is an event-type efficiency action and the economic savings are derived from the difference of tariff prices between

the periods. The P4P model will use the PMV to calculate the actual energy shifted during the event to calculate the final remuneration.

Barriers for deployment / implementation

- Technical barriers
    - Level of smart readiness of the dwelling.
    - Router connection problems, bad internet connection signal or internet unavailability issues. What to do with blanks or periods of missing data.
    - Inaccessible control protocols for legacy equipment.
    - Lack of accuracy of the demand forecast algorithms.
    - Technical complexity of a flexible interface that is capable to show varied configurable information from different DERs and sensors.
- Social barriers
    - Rejection to lack of control of own equipment at home for automated operation.
    - Intrusive system to be installed on premises.
    - Personal data management mistrust
    - Lack of confidence on new disruptive technology
    - Not used to block-chain enabled contracts.
    - Lack of transparency about the data usage and data protection mechanisms.
- Economic barriers
    - Initial upfront costs. Initial estimation: 1000 €/unit
    - Service delivery and maintenance costs. Estimated to be low or very low.
    - Low impact for efficient dwellings or dwellings with low consumption.
    - Mistrust on black box forecast algorithms to calculate the baselines and assess savings on a P4P basis.
    - Low price signals in many supply contracts.

Possible bundling services

This service can bundle with all the energy efficiency services EE1, EE2 and EE3. In particular, EE4 is fully linked with EE1 energy management for efficiency analytics and provides automated operation of DERs driven by energy efficiency events.
All EE services can bundle with some non-energy services with little additional system costs.

Contractual arrangements and issues.

- Type of contract: Pay for Performance Energy Service contract.
- Terms and conditions of the service delivered. Acceptance of explicit operation of DERs while respecting users' comfort preferences. Opt-out clauses

- Contract duration. This is a service that can be provided as long as it is demanded. From 1 to 10 years, but the minimum is given by the time needed to return the initial upfront costs.

frESCO system modules, development tasks.

- System modules involved:
  - Local Demand Manager Energy Performance and forecasting Module (T5.1)
  - Energy efficiency analytics and self-consumption optimisation module (T5.2)
  - Home Monitoring and Control Dispatch Module (T5.4)
  - User Visualization toolkit (T5.4).
- Development tasks: The basic analytic modules are developed in tasks T4.4 (S5), T5.1 (CIRCE), T5.2 (UBITECH) and T5.4 (CARTIF)

frESCO demo site testing beds

TBD.

- Croatia, Greece, Spain install CIRCE's energy box
- France installs VOLT's energy box. VOLT uses their own data interface.

4.3 DEMAND FLEXIBILITY P4P SERVICES

This set of services is devoted to the extraction of demand flexibility from domestic users to be used in grid management in two ways: a) balancing services to DSOs, TSOs and BRPs, and b) grid congestion management to alleviate transport and distribution congestion problems at local and global level, and avoid costly grid expansion investments and storage systems to accommodate an increasing amount of renewable energy sources with high generation uncertainty. As detailed in D2.2 the regulatory framework is still not receptive to these kind of services, but following the recent Electricity Directive markets are expected to be open to this energy source in most of the European Countries before 2030.

Three services are proposed within this group, namely:

- FL1: Flexibility analytics services. Information and analytics towards awareness and Knowledge of Users' flexibility for market participation
- FL2: Explicit automatic DR services. Implementation of the DR event scheduled. Remuneration for flexibility provision.
- FL3: Virtual Power Plant and Optimal Flexibility Activation Scheduling. Schedule of flexibility activation for a future activation

Service number: FL1

Energy Service short description:
Flexibility analytics services; Awareness and Knowledge of Users' flexibility

Energy Service category
3- Flexibility services

Service providers
Aggregators, Retailers

Target beneficiary
Residents, facility managers and owners, energy communities.

Service definition and scope
This service makes use of the platform data for the provision of demand flexibility services and analytics towards the participation in demand flexibility markets. This service allows consumers/ prosumers to become aware and understand their flexibility potential. It is a preparatory step prior to getting engaged in flexibility contract negotiation and (finally) participation in DR schemes. This service comprises the tailored data analytics to assess the amount of available upwards or downwards demand flexibility of a DER, based on short or very short time forecasts generated with real-time data that is continuously collected through the big-data platform. The same demand forecasting algorithms are used to create a baseline consumption during a flexibility event to measure and verify the flexibility dispatched. Energy flexibility assessment services always take the users' comfort choices as the boundary limits. This service should bundle with all the other services of the FL group, FL2 and FL3.

Value added for users.
This service provides the information that is necessary to assess the user's demand flexibility based on short term forecasts. It is hence the base of any explicit automatic DR service or VPP configuration service and should be contracted with one or the other two flexibility services. The value added for users is the retribution obtained when trading this demand-side flexibility in open marketplaces such as Local Flexibility Markets run by a DSO for congestion management or ancillary service markets for grid balancing run by a TSO (FL2). When combining these services with Energy Efficiency services a hybrid revenue stream can be obtained out of the same big-data platform infrastructure.

Market acceptance
Most European electricity markets are still closed to demand-side response. However, the European Electricity Directive highlights the role of DR in the future common electricity market. Some national markets are already open to this resource, like the French electricity system.

Pre-requisites for service delivery
- User profile
  - Users should be ready to accept the contract terms, grant onsite access for system installation, and be ready to grant consent for data sharing to the service provider.
  - Users should be able to accept partial DER automated control as long as their comfort preferences are observed.

- Users should have electrical loads to control and monitor, mainly for HVAC, but also important if they had electric DHW, PV generation, EV charging or energy storage systems.
- To maximise the amount of flexibility, annual electricity consumption should have a high starting baseline, but it is not a “Must”. Distributed generation and storage assets can also help to increase the flexibility of demand.

- Minimum smart readiness level: Permanent wifi connection. Important to have smart electric HVAC and DHW systems.

DERs and loads involved.

Almost any building energy consuming system running on electricity. HVAC and DHW systems. EV charging system. PV facility, Battery storage status and charging system. The interface will be configured according to the energy services contracted and the controllable available DERs. The higher the amount of DERs in control the larger the demand flexibility potential.

Data needs

- HVAC parameters (indoor and outdoor temperature, indoor temp. setpoint, HP / radiator real-time consumption metering). The assumption is that electricity-driven HVAC is always included in some of the services.
- Other controllable DER parameters according to the service bundle contracted. (i.e. DHW: network water temp, water tank temp., temp. setpoint)
- External weather conditions for HVAC demand forecast.
- Although the frESCO system can be trained to learn the always-changing users’ comfort preferences, the consumption profile and the maximum and minimum comfort thresholds should be provided.

Assets and equipment needed.

- Energy box (datalogger), meters and sensors (RT1)
- Actuators/controllers for controllable non-smart loads.
- Metering clamps for every monitored load (HVAC, DHW, EV, PV, battery,…)
- Permanent Wifi connection.
- Web interface for computer monitoring.

Preliminary cost assessment

- Upfront costs. RT1-RT2 upfront costs: Energy box + installation + tests estimated around 1000 €/u.
- Operation costs. System maintenance per year (TBD).

Revenue Stream

- Amount of Flexibility dispatched in the demand response events, verified with the frESCO Performance Measurement methodology and paid according to the Pay for Performance contract. The amount of flexibility upward and downward is measured and reported along with the bid prices obtained at DSO-managed local flexibility markets or TSO-managed balancing markets. The final revenue paid by those markets is transferred to the flexibility providers (consumers and prosumers) after deducting a percentage for the aggregator as a payment of the flexibility management, aggregation and market trading.

- This service does not entail any remuneration by itself as it only provides the algorithms for flexibility awareness. Revenues are realised by using FL1 jointly with FL2 and/or FL3.

Barriers for deployment / implementation

- Technical barriers
  - Level of smart readiness of the dwelling.
  - Router connection problems, bad internet connection signal or internet unavailability issues. What to do with blanks or periods of missing data.
  - Inaccessible control protocols legacy equipment.
  - Technical complexity of short-term forecasting and baselining.
  - Need to create a different baseline for every event and for every participating load, once for flexibility awareness and assessment (with several iterative corrections as the flexibility event gets closer), and again for verification of the flexibility at the dispatching event.
- Social barriers
  - Rejection to lack of control of own equipment at home for automated operation.
  - Intrusive system to be installed on premises.
  - Personal data management mistrust
  - Lack of confidence on new disruptive technology
  - Not used to block-chain enabled contracts.
  - Lack of transparency about the data usage and data protection mechanisms.
- Economic barriers
  - Initial upfront costs. Initial estimation: 1000 €/unit
  - Service delivery and maintenance costs. Estimated to be low or very low.
  - Low impact for dwellings with low consumption.
  - Electricity markets still closed in many countries to DR or to aggregated DR.
  - Mistrust on black box forecast algorithms to calculate the baselines and assess savings on a P4P basis.
  - Low retribution rate for aggregated demand response flexibility.

Possible bundling services

This service should bundle with all the flexibility services FL2, FL3. In order to create a hybrid revenue stream, it may work in parallel with the Energy Efficiency bundle to combine both direct market retribution and energy savings from efficiency services.

All FL services can bundle with some non-energy services with little additional system costs.

Contractual arrangements and issues.

- Type of contract: P4P energy service contract.
- Terms and conditions of the service delivered. Acceptance of explicit operation of DERs while respecting users' comfort preferences. Opt-out clauses
- Contract duration. This is a service that can be provided as long as it is demanded. From 1 to 10 years, but the minimum is given by the time needed to return the initial upfront costs.

frESCO system modules, development tasks and partners.

- System modules involved:
  - The baseline flexibility analytics is developed in T4.4
  - Flexibility forecasting, segmentation and aggregation module (T5.3)
  - Home Monitoring and Control Dispatch Module (T5.4)
  - User Visualization toolkit (T5.4).
- Development tasks: The basic analytic modules are developed in tasks T4.4 (S5), T5.1 (CIRCE), T5.3 (UBITECH) and T5.4 (CARTIF)

frESCO demo site testing beds

- This group of flexibility services can only be tested in real conditions in France (VOLT).
- The Greek and the Spanish demos are also to test simulated flexibility events.

Service number: FL2

Energy Service short description:
Explicit automatic DR services

Energy Service category
3- Flexibility services

Service providers
Aggregators, Retailers

Target beneficiary
Residents, facility managers and owners, energy communities.

Service definition and scope
This service leverages on service FL1, flexibility potential awareness, and enables to aggregate and dispatch automatically the calculated demand flexibility availability in FL1, in response to a grid operator or market operator request. This service includes the verification of the final flexibility dispatched and remunerate the flexibility providers (building users) proportionally to their flexibility contribution to the DR event. Therefore, this service should bundle necessarily with FL1, but it can also be made compatible with FL3 VPP configuration and optimal activation scheduling.

Value added for users.
This service enables the actual disposition of demand side flexibility in the market, and the consequent market remuneration for the service provided, whether it is intended to solve a grid congestion management or to compensate an imbalance position of an electricity market actor. Users contribute to solve this grid management issue and receive a monetary compensation for this service. When combining these services with Energy Efficiency services a hybrid revenue stream can be obtained out of the same big-data platform infrastructure.

Market acceptance
Most European electricity markets are still closed to demand-side response. However, the European Electricity Directive highlights the role of DR in the future common electricity market. Some national markets are already open to this resource, like the French electricity system. On the other hand, there might be some reluctance to explicit control or automated management of user's DERs by third parties due to the invasive character of this service. Although users' comfort preferences and choices are respected, a correct service communication strategy should be put in place to avoid mistrust.

Pre-requisites for service delivery
- User profile
    - Users should be ready to accept the contract terms, grant onsite access for system installation, and be ready to grant consent for data sharing to the service provider.
    - Users should be able to accept partial DER automated control as long as their comfort preferences are observed.

- Users should have electrical loads to control and monitor, mainly for HVAC, but also important if they had electric DHW, PV generation, EV charging or energy storage systems.
- To maximise the impact, annual electricity consumption should have a high starting baseline.
- Users should agree on an aggregator to explicitly operate their home DERs automatically in response to a market flexibility request, aggregate this demand flexibility to other sources and trade it on behalf of the flexibility providers in the market. The remuneration should be proportional to the amount of flexibility delivered during the DR event.

- Minimum smart readiness level: Permanent wifi connection. Important to have smart electric HVAC and DHW systems.

DERs and loads involved.

Almost any building energy consuming system running on electricity. HVAC and DHW systems. EV charging system. PV facility, Battery storage status and charging system. The interface will be configured according to the energy services contracted and the controllable available DERs. The higher the amount of DERs in control the larger the demand flexibility potential.

Data needs

- HVAC parameters (indoor and outdoor temperature, indoor temp. setpoint, HP / radiator real-time consumption metering). The assumption is that electricity-driven HVAC is always included in some of the services.
- Other controllable DER parameters according to the service bundle contracted. (i.e. DHW: network water temp, water tank temp., temp. setpoint)
- Availability status of DER in an enhanced DER Registry
- External weather conditions for HVAC demand forecast.
- Flexibility request details provided by a qualified market operator (DSO, TSO), such as energy volume, event time, especial conditions, …

Assets and equipment needed.

- Energy box (datalogger), meters and sensors (RT1)
- Actuators/controllers for controllable non-smart loads.
- Meter clamps for every monitored load (HVAC, DHW, EV, PV, battery,…)
- Permanent Wifi connection.
- Web interface for computer monitoring.

Preliminary cost assessment

- Upfront costs. RT1-RT2 upfront costs: Energy box + installation + tests estimated around 1000 €/u.
- Operation costs. System maintenance per year (TBD).
- Costs of participating in the ancillary service market of Local flexibility markets

Revenue Stream

- Amount of Flexibility dispatched in the demand response events, verified with the frESCO Performance Measurement methodology and paid according to the Pay for Performance contract. The amount of flexibility upward and downward is measured and reported along with the bid prices obtained at DSO-managed local flexibility markets or TSO-managed balancing markets. The final revenue paid by those markets is transferred to the flexibility providers (consumers and prosumers) after deducting a percentage for the aggregator as a payment of the flexibility management, aggregation and market trading services.

Barriers for deployment / implementation

- Technical barriers
    - Level of smart readiness of the dwelling.
    - Router connection problems, bad internet connection signal or internet unavailability issues. What to do with blanks or periods of missing data.
    - Inaccessible control protocols for legacy equipment.
    - Technical complexity of short-term forecasting and baselining.
    - Minimum bid size for aggregated loads of 1 MW.
    - Need to create a different baseline for every event and for every participating load, once for flexibility awareness and assessment (with several iterative corrections as the flexibility event gets closer), and again for verification of the flexibility at the dispatching event.
- Social barriers
    - Rejection to lack of control of own equipment at home for automated operation.
    - Intrusive system to be installed on premises.
    - Personal data management mistrust
    - Lack of confidence on new disruptive technology
    - Not used to block-chain enabled contracts.
    - Lack of transparency about the data usage and data protection mechanisms.
- Economic barriers
    - Initial upfront costs. Initial estimation: 1000 €/unit
    - Service delivery and maintenance costs. Estimated to be low or very low.
    - Low impact for dwellings with low consumption.
    - Electricity markets still closed in many countries to DR or to aggregated DR.
    - Mistrust on black box forecast algorithms to calculate the baselines and assess savings on a P4P basis.
    - Low retribution rate for aggregated demand response flexibility.
    - Possible market penalties for flexibility delivery failure.

Possible bundling services

This service should bundle with all the flexibility services FL1 and FL3. In order to create a hybrid revenue stream, it may work in parallel with the Energy Efficiency bundle to combine both direct market retribution and energy savings from efficiency services.

All FL services can bundle with some non-energy services with little additional system costs.

Contractual arrangements and issues.

- Type of contract:
  - FL2 service contracting: P4P flexibility energy service contract.
  - Settlement mechanism: Smart, blockchain-enabled protected contract through the smart contract monitoring, settlement and remuneration module. Once a P4P contract is established between an aggregator and a prosumer, the aggregator will have the possibility, through an appropriate UI linked to the module, to introduce the contract and its parameters (e.g. contract duration, amount of nominal power to be delivered, ISPs and duration etc.) in a blockchain infrastructure, thus creating a smart contract that will continuously monitor flexibility volumes and safeguard the satisfaction of the terms of the physical contract. The blockchain implementation will ensure transparency over the contractual process, also allowing the establishment of an advanced Settlement and Remuneration process built on the principles of the frESCO Performance Measurement and Verification (PMV) protocol (defined in Task 3.4). Through this process and based on the terms that are agreed in the Smart Contract, the activated flexibility during a DR event can be verified and eventually respective remunerations can be calculated and attributed to the prosumers.

    All established contracts will be made available to aggregators (to the Flexibility forecasting, segmentation and aggregation module), so as to configure the required VPPs in relation to the needs of the grid manager.

- Terms and conditions of the service delivered. Acceptance of explicit operation of DERs while respecting users' comfort preferences.
- Contract duration. This is a service that can be provided as long as it is demanded. From 1 to 10 years, but the minimum is given by the time needed to return the initial upfront costs.

frESCO system modules, development tasks.

- System modules involved:
  - The baseline flexibility analytics is developed in T4.4
  - Flexibility forecasting, segmentation and aggregation module (T5.3)
  - Home Monitoring and Control Dispatch Module (T5.4)
  - User Visualization toolkit (T5.4).
  - Smart Contract monitoring, settlement and remuneration module (T5.5) (see contractual arrangements above)
- Development tasks: The basic analytic modules are developed in tasks T4.4 (S5), T5.1 (CIRCE), T5.3 (UBITECH), T5.4 (CARTIF) and T5.5 (S5).

frESCO demo site testing beds

- This group of flexibility services can only be tested in real conditions in France (VOLT).
- The Greek and the Spanish demos are also to test simulated flexibility events.

Service number: FL3

Energy Service short description:
Virtual Power Plant and Optimal Flexibility Activation Scheduling

Energy Service category
3- Flexibility services

Service providers
Aggregators, Retailers

Target beneficiary
Flexibility electricity market actors: DSO, TSO, BRP

Service definition and scope
This service leverages on service FL1 and enables to create and configure Virtual Power Plants with schedule of flexibility activation in a close future for a cluster of prosumers that have an active flexibility contract. This flexibility can be conveniently traded in flexibility markets and support DSOs, TSOs or other market actors in optimizing their operations through the provision of respective services (balancing and ancillary). The service utilizes contractual parameters coming from FL2 service to formulate effective and cost-efficient VPPs, according to the type of service requested by Network Operators. This service should bundle necessarily with FL1 and FL2 with the latter comprising in the implementation of the flexibility activation schedules at the local (building/ prosumer) level, through triggering of Explicit DR signals.

Value added for users.
This service enables the actual disposition of demand side flexibility in the energy market by means of VPP configuration, and the consequent market remuneration for the energy traded. When combining these services with other Flexibility services and the Energy Efficiency services a hybrid revenue stream can be obtained out of the same big-data platform infrastructure.

Market acceptance
Most European electricity markets are still closed to demand-side response in electricity markets and still do not recognize aggregators as possible members/traders and flexibility providers for ancillary services. However, the European Electricity Directive highlights the role of DR in the future common electricity market. This important energy source will eventually be allowed in energy markets throughout Europe. On the other hand, there might be some reluctance to explicit control or automated management of user's DERs by third parties due to the invasive character of this service. Although users' comfort preferences and choices are respected, a correct service communication strategy should be put in place to avoid mistrust.

Pre-requisites for service delivery

- User profile
    - Users should be ready to accept the contract terms, grant onsite access for system installation, and be ready to grant consent for data sharing to the service provider.
    - Users should be able to accept partial DER automated control as long as their comfort preferences are observed.

- Users should have electrical loads to control and monitor, mainly for HVAC, but also important if they had electric DHW, PV generation, EV charging or energy storage systems.
- To maximise the impact, annual electricity consumption should have a high starting baseline.
- Users should agree on an aggregator to explicitly operate their home DERs automatically in response to a market flexibility request, aggregate this demand flexibility to other sources and trade it on behalf of the flexibility providers in the market. The remuneration should be proportional to the amount of flexibility delivered during the DR event.

- Minimum smart readiness level: Permanent wifi connection. Important to have smart HVAC and DHW systems.

DERs and loads involved.

Almost any building energy consuming system running on electricity. HVAC and DHW systems. EV charging system. PV facility, Battery storage status and charging system. The interface will be configured according to the energy services contracted and the controllable available DERs. The higher the amount of DERs in control the larger the demand flexibility potential.

Data needs

- HVAC parameters (indoor and outdoor temperature, indoor temp. setpoint, HP / radiator real-time consumption metering). The assumption is that electricity-driven HVAC is always included in some of the services.
- Other controllable DER parameters according to the service bundle contracted. (i.e. DHW: network water temp, water tank temp., temp. setpoint)
- Availability status of DER in an enhanced DER Registry
- External weather conditions for HVAC demand forecast.
- Flexibility electricity market bids and prices triggered by the grid manager or the DSO / BRP.

Assets and equipment needed.

- Energy box (datalogger), meters and sensors (RT1)
- Actuators/controllers for controllable non-smart loads.
- Meter clamps for every monitored load (HVAC, DHW, EV, PV, battery,…)
- Permanent Wifi connection.
- Web interface for computer monitoring.

Preliminary cost assessment

- Upfront costs. RT1-RT2 upfront costs: Energy box + installation + tests estimated around 1000 €/u.
- Operation costs. System maintenance per year (TBD).
- Costs of participating in the flexibility markets.

Revenue Stream

- Amount of Flexibility dispatched by the VPP in the energy market, verified with the frESCO Performance Measurement methodology and paid according to the Pay for Performance contract. The amount of flexibility upward and downward is measured and reported along with the bid prices obtained at DSO-managed local flexibility markets or TSO-managed balancing markets. The final revenue paid by those markets is transferred to the flexibility providers (consumers and prosumers) after deducting a percentage for the aggregator as a payment of the flexibility management, aggregation and market trading service.

Barriers for deployment / implementation

- Technical barriers
    - Level of smart readiness of the dwelling.
    - Router connection problems, bad internet connection signal or internet unavailability issues. What to do with blanks or periods of missing data.
    - Inaccessible control protocols for legacy equipment.
    - Technical complexity of short-term forecasting and baselining.
    - Minimum bid size for aggregated loads of 1 MW.
    - Possible inaccuracy for medium term demand forecast for participation in day ahead market bids.
    - Need to create a different baseline for every event and for every participating load, once for flexibility awareness and assessment (with several iterative corrections as the flexibility event gets closer), and again for verification of the flexibility at the dispatching event.
- Social barriers
    - Rejection to lack of control of own equipment at home for automated operation.
    - Intrusive system to be installed on premises.
    - Personal data management mistrust
    - Lack of confidence on new disruptive technology
    - Not used to block-chain enabled contracts.
    - Lack of transparency about the data usage and data protection mechanisms.
- Economic barriers
    - Initial upfront costs. Initial estimation: 1000 €/unit
    - Service delivery and maintenance costs. Estimated to be low or very low.
    - Low impact for dwellings with low consumption.
    - Electricity markets still closed in many countries to DR or to aggregated DR.
    - Mistrust on black box forecast algorithms to calculate the baselines and assess savings on a P4P basis.
    - Low retribution rate for energy traded in spot markets.

- Possible market penalties for flexibility delivery failure.

Possible bundling services

This service should bundle with all the flexibility services FL1 and FL2. It is additional to FL2 Explicit automatic DR services. In order to create a hybrid revenue stream, it may work in parallel with the Energy Efficiency bundle to combine both direct market retribution and energy savings from efficiency services.

All FL services can bundle with some non-energy services with little additional system costs.

Contractual arrangements and issues.

- Type of contract: P4P flexibility energy services.
- Terms and conditions of the service delivered. Acceptance of explicit operation of DERs while respecting users' comfort preferences. Opt-out clauses
- Contract duration. This is a service that can be provided as long as it is demanded. From 1 to 10 years, but the minimum is given by the time needed to return the initial upfront costs.

frESCO Development tasks and partners.

- System modules involved:
  - The baseline flexibility analytics is developed in T4.4
  - Flexibility forecasting, segmentation and aggregation module (T5.3)
  - VPP Configuration module (T5.3)
  - Home Monitoring and Control Dispatch Module (T5.4)
  - User Visualization toolkit (T5.4).
  - Smart Contract monitoring, settlement and remuneration module (T5.5)
- Development tasks: The basic analytic modules are developed in tasks T4.4 (S5), T5.1 (CIRCE), T5.3 (UBITECH), T5.4 (CARTIF) and T5.5 (S5).

frESCO demo site testing beds

- This group of flexibility services can only be tested in real conditions in France (VOLT).
- The Greek and the Spanish demos are also to test simulated flexibility events.

4.4 NON-ENERGY SERVICES

This set of energy services deals with additional services for domestic users, not related with efficiency or flexibility. In other words, these services do not generate a revenue stream by means of the direct application but opportunistically take advantage of the digital platform and the analytic engines to offer value-added services for which users are willing to pay. Among these services, comfort preservation by monitoring of comfort parameters and automatic control of HVAC systems could be of high interest for many domestic users. Other parameters such as air quality, noise or presence / consumption for security service provision are envisaged.

Although it is difficult to offer these services under a P4P basis because they have no influence on energy performance and the intended benefit performance (comfort, noise, quality, security…) is rather subjective and difficult to measure, they are presented here as P4P services. Alternatively, constant service fees might be charged.

Four non-energy services are identified and offered but the list is not exhaustive.

- NE1: Thermal Comfort services. Comfort preservation and automation at minimum energy costs. Requires comfort parameter sensors, smart controls and switches.
- NE2: Indoor air quality preservation. Preservation of Indoor air quality by means of air quality sensors. Smart ventilation.
- NE3: Noise reduction services. Noise sensors. Scheduling of noise devices and appliances at certain periods of time, smart ventilation, others.
- NE4: Security and surveillance services. Presence sensors, scheduling of lighting at night / absences to create a dissuasive security system.

Service number: NE1

Energy Service short description:
Thermal Comfort preservation

Energy Service category
4- Non energy services

Service providers
ESCOs, Facility managers, Aggregators, Retailers

Target beneficiary
Residents, facility managers and owners.

Service definition and scope
This energy service uses real-time data to monitor comfort parameters and consumption and uses the frESCO forecasting algorithms to proactively operate the HVAC system to preserve the users' comfort preferences. The algorithms are trained to learn about the building thermal performance, the reaction time to setpoint changes and the user's preferences when they interact with the system. The service provides an automatic regulation and control of the HVAC systems based on this forecast at real time, the outside weather conditions and the building thermal performance, thus ensuring that the indoor temperature and other comfort parameters are kept within range at all times at the minimum energy cost.

Value added for users.
Users gain comfort in an automated way without an increase in energy consumption by means of artificial intelligence and trained forecast algorithms.

Market acceptance
Automatic control of comfort parameters and wellbeing has some acceptance in the energy management service market and even in the cutting-edge residential building sector. This service is probably more accepted among young consumers passionate of digital technology and domotics.

Pre-requisites for service delivery

- User profile
    - Users should be ready to accept the contract terms, grant onsite access for system installation, and be ready to grant consent for data sharing to the service provider.
    - Users should have electrical smart-control HVAC systems.
    - Users should be prepared to grant control of their HVAC systems although their final decision on comfort preferences remains on them.
- Minimum smart readiness level: Permanent wifi connection. Important to have smart control on HVAC.

DERs and loads involved.
Electric HVAC, mainly smart heat pumps. Smart-controlled ventilation systems.

Data needs

- HVAC parameters (indoor and outdoor temperature, indoor temp. setpoint, HP / radiator real-time consumption metering). The assumption is that electricity-driven HVAC is always included in some of the services.
- External weather conditions for HVAC demand forecast.
- Although the frESCO system can be trained to learn the always-changing users' comfort preferences, the consumption profile and the maximum and minimum comfort thresholds should be provided.

Assets and equipment needed.

- Energy box (datalogger), meters and sensors (RT1)
- Permanent Wifi connection.
- Actuators / controllers for automatic triggering of inaccessible HVAC equipment, or accessible smart heat pumps.
- Web interface for computer monitoring.

Preliminary cost assessment

- Upfront costs. RT1-RT2 upfront costs: Energy box + installation + tests estimated around 1000 €/u.
- Operation costs. System maintenance per year (TBD).

Revenue Stream

- Service monthly fee.
- P4P approach: service charges are calculated based on measurable performance metrics, such as the time that the system keeps the indoor temperature within the desired range chosen by the user. These temperature boundaries could be explicitly selected by the user or calculated by the system using the data platform to analyse the user interactions with the system to modify the temperature setpoint or operation conditions when they do not feel comfortable at home.
- P4P second approach: the service is provided at a constant monthly fee but a P4P variable penalty is deducted from this fee proportional to the time the indoor temperature stays off the comfort boundaries selected by the user.

Barriers for deployment / implementation

- Technical barriers
  - Level of smart readiness of the dwelling.
  - Inaccessible control protocols for Heat Pumps and other equipment.
  - Router connection problems, bad internet connection signal or internet unavailability issues. What to do with blanks or periods of missing data.
  - How to measure the comfort improvement beyond a subjective perception.
- Social barriers
  - Personal data management mistrust.
  - Lack of confidence on new disruptive technology

- Not used to block-chain enabled contracts.
- Lack of transparency about the data usage and data protection mechanisms.

- Economic barriers
    - Initial upfront costs. Initial estimation: 1000 €/unit
    - Service delivery and maintenance costs. Estimated to be low or very low.
    - Mistrust on black box forecast algorithms to calculate the baselines. This service is not expected to deliver any type of savings or revenues.

Possible bundling services

This service can bundle with other non-energy services and the smart retrofitting services. Although this service gives relevance to comfort preservation above other targets, it could ultimately bundle with EE and flexibility services as these services also care about comfort choices respect.

Contractual arrangements and issues.

- Type of contract: EPC or P4P energy service.
- Terms and conditions of the service delivered: Comfort boundaries, time of response.
- Contract duration. This is a service that can be provided as long as it is demanded. From 1 to 10 years. By itself, no payback of the initial investment is expected.

frESCO Development tasks.

Development tasks: The basic analytic modules are developed in task T5.4.

frESCO demo site testing beds

All demo sites. France's demo site specifically focuses on automation, related to this service.

- Croatia, Greece, Spain installs CIRCE's energy box
- France installs VOLT's energy box. VOLT uses their own data interface.

Service number: NE2,

Energy Service short description:
Indoor air quality

Energy Service category
4- Non energy services

Service providers
ESCOs, Facility managers, Aggregators, Retailers

Target beneficiary
Residents, facility managers and owners.

Service definition and scope
This energy service uses real-time data to monitor indoor air quality parameters (CO_2 concentration) and uses the frESCO forecasting algorithms to proactively operate the ventilation system to preserve the healthy concentration of CO_2 and the users' indoor temperature with the minimum energy consumption. The algorithms are trained to learn about the building thermal performance, the reaction time to setpoint changes and the user's preferences when they interact with the system. The service provides an automatic regulation and control of the ventilation system based on this forecast at real time, the outside air temperature and the building thermal performance, thus ensuring that the CO_2 concentration and other comfort parameters are kept within range at all times at the minimum energy cost.

Value added for users.
Users gain air quality in an automated way without an increase in energy consumption by means of artificial intelligence and trained forecast algorithms operating explicitly on the smart ventilation system.

Market acceptance
Automatic control of ventilation and wellbeing has some acceptance in the energy management service market and even in the cutting-edge residential building sector. This service is probably more accepted among young consumers passionate of digital technology and domotics.

Pre-requisites for service delivery

- User profile
  - Users should be ready to accept the contract terms, grant onsite access for system installation, and be ready to grant consent for data sharing to the service provider.
  - Users should have electrical smart-control HVAC systems.
  - Users should be prepared to grant control of their HVAC systems although their final decision on comfort preferences remains on them.
- Minimum smart readiness level: Permanent wifi connection. Important to have smart control on HVAC.

DERs and loads involved.
Electric smart ventilation system, smart heat pumps.

Data needs

- CO_2 concentration in the regulated spaces (sensors to add)
- Ventilation flows and air renewal power.
- HVAC parameters (indoor and outdoor temperature, indoor temp. setpoint, HP / radiator real-time consumption metering). The assumption is that electricity-driven HVAC is always included in some of the services.
- External weather conditions for HVAC demand forecast.
- Although the frESCO system can be trained to learn the always-changing users' comfort preferences, the consumption profile and the maximum and minimum comfort thresholds should be provided.

Assets and equipment needed.

- Energy box (datalogger), meters and air quality sensors (RT1)
- Permanent Wifi connection.
- Actuators / controllers for automatic triggering of inaccessible HVAC equipment.
- Web interface for computer monitoring.

Preliminary cost assessment

- Upfront costs. RT1-RT2 upfront costs: Energy box + installation + tests estimated around 1000 €/u.
- Operation costs. System maintenance per year (TBD).

Revenue Stream

- Service monthly fee.
- P4P approach: service charges are calculated based on measurable performance metrics, such as the time that the system keeps the air quality metrics within the desired limits chosen by the user or the recommended range.
- P4P second approach: the service is provided at a constant monthly fee but a P4P variable penalty is deducted from this fee proportional to the time the air quality metrics stay off the target boundaries.

Barriers for deployment / implementation

- Technical barriers
  - Level of smart readiness of the dwelling.
  - Router connection problems, bad internet connection signal or internet unavailability issues. What to do with blanks or periods of missing data.
- Social barriers
  - Personal data management mistrust.
  - Lack of confidence on new disruptive technology

- Not used to block-chain enabled contracts.
- Lack of transparency about the data usage and data protection mechanisms.

- Economic barriers
  - Initial upfront costs. Initial estimation: 1000 €/unit
  - Service delivery and maintenance costs. Estimated to be low or very low.
  - Mistrust on black box forecast algorithms to calculate the baselines. This service is not expected to deliver any type of savings or revenues.

Possible bundling services

This service can bundle with other non-energy services and the smart retrofitting services. Although this service gives relevance to air quality above other targets, it could ultimately bundle with EE and flexibility services as these services also care about comfort choices respect.

Contractual arrangements and issues.

- Type of contract: EPC or P4P energy service.
- Terms and conditions of the service delivered: Healthy air quality boundaries, time of response.
- Contract duration. This is a service that can be provided as long as it is demanded. From 1 to 10 years. By itself, no payback of the initial investment is expected.

frESCO Development tasks.

Development tasks: The basic analytic modules are developed in task T5.4.

frESCO demo site testing beds

All demo sites. France's demo site specifically focuses on automation, related to this service.

- Croatia, Greece, Spain installs CIRCE's energy box
- France installs VOLT's energy box. VOLT uses their own data interface.

Service number: NE3,

Energy Service short description:
Noise reduction

Energy Service category
4- Non energy services

Service providers
ESCOs, Facility managers, Aggregators, Retailers

Target beneficiary
Residents, facility managers and owners.

Service definition and scope
This energy service uses real-time data to monitor noise level and uses the frESCO automatiion systems and comfort forecasting algorithms to proactively operate the systems to preserve the noise level and the users' indoor temperature with the minimum energy consumption. The algorithms are trained to learn about the building thermal performance (thermal inertia), the reaction time to setpoint changes and the user's preferences when they interact with the system. The service provides an automatic regulation and control of the HVAC system based on this forecast at real time, to always keep noise levels under a certain threshold set by the user. Loads can be shifted from night to day-time to keep noise down at resting times according to the users' preferences while other comfort parameters are kept within range at all times at the minimum energy cost.

Value added for users.
Users gain noise reduction and control in an automated way without an increase in energy consumption by means of artificial intelligence and trained forecast algorithms operating explicitly on the HVAC systems.

Market acceptance
Automatic control of HVAC and wellbeing preservation has some acceptance in the energy management service market and even in the cutting-edge residential building sector. This service is probably more accepted among young consumers passionate of digital technology and domotics.

Pre-requisites for service delivery

- User profile
  - Users should be ready to accept the contract terms, grant onsite access for system installation, and be ready to grant consent for data sharing to the service provider.
  - Users should have electrical smart-control HVAC systems.
  - Users should be prepared to grant control of their HVAC systems although their final decision on comfort preferences remains on them.
- Minimum smart readiness level: Permanent wifi connection. Important to have smart control on HVAC.

DERs and loads involved.
Electric smart ventilation system, smart heat pumps.

Data needs

- Noise sensors in the regulated spaces (sensors to add) and maximum noise levels per day period.
- HVAC parameters (indoor and outdoor temperature, indoor temp. setpoint, HP / radiator real-time consumption metering). The assumption is that electricity-driven HVAC is always included in some of the services.
- External weather conditions for HVAC demand forecast.
- Although the frESCO system can be trained to learn the always-changing users' comfort preferences, the consumption profile and the maximum and minimum comfort thresholds should be provided.

Assets and equipment needed.

- Energy box (datalogger), with noise sensors (RT1)
- Permanent Wifi connection.
- Actuators / controllers for automatic triggering of inaccessible noisy equipment.
- Web interface for computer monitoring.

Preliminary cost assessment

- Upfront costs. RT1-RT2 upfront costs: Energy box + installation + tests estimated around 1000 €/u.
- Operation costs. System maintenance per year (TBD).

Revenue Stream

- Service monthly fee.
- P4P approach: service charges are calculated based on measurable performance metrics, such as the time that the system keeps the noise level within the desired target chosen by the user or the recommended range.
- P4P second approach: the service is provided at a constant monthly fee but a P4P variable penalty is deducted from this fee proportional to the time noise level stays off the target boundaries.

Barriers for deployment / implementation

- Technical barriers
    - Level of smart readiness of the dwelling.
    - Router connection problems, bad internet connection signal or internet unavailability issues. What to do with blanks or periods of missing data.
    - Placement of the noise sensors and sensitivity to ensure that signals reflect the subjective noise comfort of the users in the controlled rooms.
- Social barriers
    - Personal data management mistrust.

- Lack of confidence on new disruptive technology
- Not used to block-chain enabled contracts.
- Lack of transparency about the data usage and data protection mechanisms.

- Economic barriers
  - Initial upfront costs. Initial estimation: 1000 €/unit
  - Service delivery and maintenance costs. Estimated to be low or very low.
  - Mistrust on black box forecast algorithms to calculate the baselines. This service is not expected to deliver any type of savings or revenues.

Possible bundling services

This service can bundle with other non-energy services and the smart retrofitting services. Although this service gives relevance to noise reduction over other targets, it could ultimately bundle with EE and flexibility services as these services also care about comfort choices respect. This need to be assessed on a one-to-one case.

Contractual arrangements and issues.

- Type of contract: EPC or P4P energy service.
- Terms and conditions of the service delivered: Healthy air quality boundaries, time of response.
- Contract duration. This is a service that can be provided as long as it is demanded. From 1 to 10 years. By itself, no payback of the initial investment is expected.

frESCO Development tasks.

Development tasks: The basic analytic modules are developed in task T5.4.

frESCO demo site testing beds

All demo sites. France's demo site specifically focuses on automation, related to this service.

- Croatia, Greece, Spain installs CIRCE's energy box
- France installs VOLT's energy box. VOLT uses their own data interface.

Service number: NE4,

Energy Service short description:
Security and surveillance services

Energy Service category
4- Non energy services

Service providers
ESCOs, Facility managers, Aggregators, Retailers, Private security companies

Target beneficiary
Residents, facility managers and owners.

Service definition and scope
This energy service uses real-time data to monitor presence in a dwelling and uses the frESCO automation systems to schedule lights and appliances switch on and off at night or in absence of the dwellers, to create a dissuasive security system. Information about unexpected energy consumption can also be used to identify illegal occupation of dwellings. Ultimately, this system could communicate to the police, or to private security companies to set off alarms or give warnings of possible trespassing or private property violations.

Value added for users.
Use advanced digital technology and data platforms to add one important domestic service such as the security and surveillance.

Market acceptance
This service has optimal and efficient alternatives as a standalone service, but in combination with other frESCO services the digital platform can opportunistically include one more signal treatment to provide security and surveillance services at low extra cost.

Pre-requisites for service delivery

- User profile
  - Users should be ready to accept the contract terms, grant onsite access for system installation, and be ready to grant consent for data sharing to the service provider.
  - Users should permit the use of presence sensors at home and the data treatment by their service provider
- Minimum smart readiness level: Permanent wifi connection.

DERs and loads involved.
None

Data needs

- Presence sensor data in the monitored rooms.

Assets and equipment needed.

- Energy box (datalogger), meters and/or presence sensors (RT1)
- Permanent Wifi connection.
- Web interface for computer monitoring.

Preliminary cost assessment

- Upfront costs. RT1-RT2 upfront costs: Energy box + installation + tests estimated around 1000 €/u.
- Operation costs. System maintenance per year (TBD).

Revenue Stream

- Service monthly fee.
- P4P approach: service charges are calculated based on measurable performance metrics, to be defined.

Barriers for deployment / implementation

- Technical barriers
    - Level of smart readiness of the dwelling.
    - Router connection problems, bad internet connection signal or internet unavailability issues. What to do with blanks or periods of missing data.
    - Placement of the presence sensors and sensitivity to ensure that signals reflect the possible trespassing in the controlled rooms.
- Social barriers
    - Personal data management mistrust.
    - Lack of confidence on new disruptive technology
    - Not used to block-chain enabled contracts.
    - Lack of transparency about the data usage and data protection mechanisms.
- Economic barriers
    - Initial upfront costs. Initial estimation: 1000 €/unit
    - Service delivery and maintenance costs. Estimated to be low or very low.
    - Mistrust on black box forecast algorithms to calculate the baselines. This service is not expected to deliver any type of savings or revenues.

Possible bundling services

This service can bundle with other non-energy services and the smart retrofitting services. Although this service gives relevance to creating a dissuasive security system over other targets, it could ultimately bundle with EE and flexibility services. This need to be assessed on a one-to-one case.

Contractual arrangements and issues.

- Type of contract: EPC or P4P energy service.

- Terms and conditions of the service delivered: To be defined.
- Contract duration. This is a service that can be provided as long as it is demanded. From 1 to 10 years. By itself, no payback of the initial investment is expected.

frESCO Development tasks.

Development tasks: The basic analytic modules are developed in task T5.4.

frESCO demo site testing beds

All demo sites. France's demo site specifically focuses on automation, related to this service.

- Croatia, Greece, Spain installs CIRCE's energy box
- France installs VOLT's energy box. VOLT uses their own data interface.

5 SERVICE DEVELOPMENT AND TEST CRITERIA

This section is devoted to make a first attempt at describing how the frESCO digital platform and software analytics can underpin the energy services described in the previous section. The different components and modules delivering the necessary functionality are depicted in D2.5 frESCO conceptual architecture. Therefore, this section aims at providing a mapping of modules with services and functionalities required.

5.1 DEVELOPMENT OF NEXT GENERATION OF P4P SERVICES

The digital platform hardwares main piece is the OneM2M gateway that connects the smart energy devices and DERs (HVAC, lighting, DHW) and the ambience sensors with the big data platform. The type of device connection and sensors needed are identified as part of the RT3 service, smart readiness assessment, together with retrofitting recommendations to enable the full potential deployment of the frESCO services tailored to the dwelling equipment and consumer profile. The configuration of the Energy Box and the installation and testing on-premises is offered in RT1, along with basic data monitoring functionalities to provide personalised informative billing information to consumers. The Energy Box is developed in T4.2.

Efficiency service modules:

- Local Energy Performance and demand forecast. This forecast is the base for the efficiency awareness service EE1 and focuses on mid-term/ long-term forecasts at dwelling level. Such forecasts will allow ESCOs to set up the "Energy Performance Baseline" of the buildings based on actual data streams coming from them (mainly metering data). Having these forecasts in hand, and together with the actual data coming from buildings they will have the opportunity to continuously monitor the performance of their EE/ P4P contracts (forecast baseline vs actual performance), identify deviations against EE targets (by performing a parallel forecasting based on actual data following the activation of EE services) and trigger implicit (EE2) or explicit (EE4) strategies. This awareness engine is developed in T5.1
- Energy analytics and self-consumption optimization. This module uses the short-term forecasting algorithms developed in T4.4 and provide near-real time optimization of

energy performance or flexibility activation, either through targeted advice for EE or through automated control of devices. The module will be able to use the efficiency awareness results and use it to suggest recommendation for user behaviour change in EE2. This functionality will be replicated at global level to assess global energy efficiency and self -consumption strategies throughout the ESCO DER portfolio. It is developed in T5.2

- Home Monitoring and EE Control Dispatch module. This module addresses the price-based efficiency strategies and the automation for control dispatch, used by service EE4. It is developed in T5.4

Flexibility service modules.

- Baseline Flexibility Analytics: The short-term forecasting algorithms developed in T4.4 are used in FL1 to assess the amount of flexibility potential at local level, to be used by services FL2 and FL3.
- Flexibility Forecasting, Segmentation and Aggregation module. This module runs at global level and leverages the flexibility profile engine functionalities, being able to segment, cluster and aggregate flexibility to be made available in FL2. It is developed in T5.3
- VPP Configurer, DR monitoring and DR Control Dispatch Module. This module gives the necessary functionality to aggregators to configure VPPs and dispatch the contracted flexibility in the market in FL3. It is developed in T5.3

Visualisation tools

- Visualisation interface for ESCOs: This is a web-based interface developed in T5.2 that provides the visualization framework for ESCOs: EE/self-consumption performance monitoring.
- Visualisation interface for Aggregators: This is a web-based interface developed in T5.3 that provides the visualization framework for Aggregators: Flexibility analysis and DR strategy optimisation.
- Visualisation application for consumers: This interface could be alternatively a cell-phone app or a web-based tool to provide the consumer visualization toolkit with the informative Billing, scheduling and automation and asset monitoring. It is developed in T5.4

- Asset and Smart contract monitoring. This is a web-based tool for aggregators to monitor the smart contracts and the settlement and remuneration of DR campaigns. It is developed in T5.5.

5.2 ENERGY SERVICE TESTS AND DEMONSTRATION IN FRESCO LIVING LAB

The objective of the testing phase is to prove technical and commercial feasibility of the new frESCO energy services, both individually and in a bundle approach. The final testing strategy of the frESCO services will be decided according to a number of factors:

- Availability of DER and smart readiness levels at the demo site users according to D2.1.
- Technical deployment issues of the data platform onsite.
- Market openness to demand response sources according to D2.2.
- Interest of consumers and demo site partners in every type of services.

The selection of the pilots has been done to achieve a wide representation of climate, geographical, building typology and user behaviour factors, in order to facilitate the replicability and market uptake of frESCO services. In particular:

• In Greece: The aim is to represent consumption patterns on rental apartments with high seasonal variability. Comfort and efficiency will be tested in a different usage profile environment where guest hotels may be more concerned about comfort and low system interaction (automation), while hotel managers are seeking for efficiency and participation in future demand flexibility services. The presence of a PV self-consumption plant can also enable self-consumption optimisation testing by EE3.

• In Croatia: The main target are single-family buildings with low smart readiness that need to be retrofitted. Some of the dwellings do have PV generation. Efficiency services are targeted for these users but flexibility as well. Although demand response is not tradable yet in Croatia, simulation tests to check feasibility and potential are adequate in this demo site.

• In Spain: The main target are multi-family buildings, which is highly representative for the housing typologies in southern Europe (and particularly Spain), some include vulnerable consumers. Again, low smart readiness levels will challenge the applicability of frESCO services in this building typology of block of apartments with low thermal inertia. The installation of a PV facility for collective self-consumption will enable the testing of self-consumption optimisation strategies at block level (EE3), operating simultaneously in several apartments to achieve greater joint savings. Although demand response is not tradable yet in Spain, simulation tests to check feasibility and potential are adequate in this demo site too.

• In France: The main target are single-family buildings used as main residences. France is the only country where flexibility can be actually traded in the market, although the current approach is not under the P4P principle. The frESCO flexibility services will then be tested and the remuneration settlements of FL2 be done as per the frESCO PMV methodology (T3.4) using short term forecast algorithms (T4.4)

6 CONCLUSION

The new energy services described in this deliverable constitute an innovative portfolio expansion for ESCOs in the residential sector; where these companies hardly have any presence today, due to the low benefits derived from a scarce per capita consumption and the high transaction costs involved due to the high energy usage fragmentation. These factors and the difficulty to aggregate significant energy amounts to justify an investment in an energy management system has kept ESCOs away from a sector that represents 26 % of the EU's final energy consumption.

Today's digital technology can drive energy service costs down and make them available to many domestic consumers. In addition, ESCOs can extend the conventional concept of EPC models, traditionally suitable for retrofitting services, to a new set of attractive services delivered on a continuous basis and operating either implicitly or explicitly in an automated manner. These offerings are now expanded by novel services to the grid in the form of flexibility services for congestion management, grid balance and ancillary services. In addition, non-energy services can also be designed to suit consumers needs such as automation and comfort, air quality, noise control or safety and surveillance, among others.

The main problem with EPC services in the current domestic sector is the difficulty of establishing the right performance and verification procedures to ensure a fair remuneration for the services and adapt the verification methodology to non-monitored and changeable independent variables such as outdoor and indoor weather conditions, PV generation or user comfort preferences. The new frESCO energy service generation solves this problem by creating a Pay-for-Performance model, where performance is continuously being monitored by means of powerful and accurate near real-time forecast algorithms fed by the digital platform data captured from metering and system behaviour parameters. These P4P models enable a fair distribution of energy savings and flexibility market remuneration that shares proportionally the benefits for all market actors, the service providers on one side (ESCOs and /or aggregators) and the consumers/prosumers on the other side.

The new set of P4P hybrid energy services combine the traditional EPC retrofitting services with the savings from energy efficiency services based on artificial intelligence algorithms and with the potential remuneration of demand response traded in flexibility markets at the market or grid operator request. The combination of these revenue sources derived from the same digital platform can reduce the payback times greatly, thus making them more attractive to tenants and building managers.

These energy service sets are meant for pure ESCOs or aggregators, but the ideal scenario would be for service providers to become both and offer the two type of services, along with possible non-energy services, enabled by the digital platform.

This document sets the basis for the future frESCO platform tool suite and business models. The next steps consist of identifying the assets and actors in the service provision value chain, the costs incurred, and the potential revenue streams for the market stakeholders in several possible scenarios. This economic data will be used to map a set of business models that ensure the payback of the platform setup investments, and the fair remuneration of the value chain actors and the domestic consumers and prosumers. Some of these services will be totally or partially tested in the real frESCO living lab (4 demo sites). Others will be simulated in a variety of hypothetical scenarios that will set the basis of a near-future efficient residential sector with open and democratic participation of citizens in energy markets.

7 ANNEXES

7.1 Annex 1: Template for energy service description.

This is the service definition template followed to characterise each frESCO energy service.

Energy Service number:

Energy Service short description:

Service Category

- RT: Smart equipment retrofitting
- EE: Energy efficiency and self-consumption optimization services
- FL: Flexibility services
- NE: Non-energy services

Service providers

- ESCOs
- Building and Facility owners and managers.
- Aggregators, retailers
- ICT companies

Target beneficiary

- Domestic consumers and prosumers. Building residents
- Energy communities, RES communities.
- Building and facility owners and managers.

Service definition and scope

In this section a detailed description of the service and the scope is provided as a guideline for the system component design and test in a future stage.

Value added for users.

Sales pitch.

Market acceptance

Degree at which current markets are ready to uptake this service. Market competitors and barriers that may hinder the service acceptance by the market actors.

Pre-requisites for service delivery

- Consumer level: user profile
- Building level: minimum smart readiness level

DERs and loads involved.

- HVAC
- DHW
- EV charging
- PV systems
- Storage systems
- Lighting
- Other manageable loads

Data needs

Energy generation
Energy demand
Real time retail market prices
Real time flexibility market prices
Real time ancillary service market prices
Weather data for generation forecast
User comfort preferences: T setpoint, …
Comfort data: indoor temp, humidity, CO_2 concentration, presence, noise, luminosity
Event triggering data from DSO/TSO: time, duration, energy, price, conditions, …

Assets and equipment needed.

Datalogger
Internet router
Comfort sensors: T, humidity, CO_2, light, presence, noise
Smart meters
Servers for data handling
Local demand manager
Global demand manager
Aggregation tool
Human centric big data analytic module
Forecast and baselining module
User interface
PV facility with smart metering
Smart HVAC
Smart battery charger / EV charger
Smart DHW heater with accumulation tank
Other smart controllable devices

Preliminary cost assessment

- Upfront costs
- Operation costs

Revenue Stream

Direct sales of comfort and non-energy services
Savings from energy efficiency savings
Savings from RES self-consumption
Revenues for participation of DR in DSO-driven local flexibility markets
Revenues for participation of DR in TSO-driven balancing markets.
Fees for Maintenance, extensions and upgrades.

Barriers for deployment / implementation

- Technical barriers
    - datalogger installation
    - Communication protocol standardization
    - smart devices penetration
    - router connection needed
    - sensoring needed
    - Short term forecast algorithms
    - Local and Global demand manager algorithms.
    - Others
- Social barriers
    - Difficulty for most domestic users to understand concept
    - Electricity markets shut for DR
    - Personal data mgmt. mistrust
    - Lack of confidence on new tech
    - Reluctance to grant device control to 3rd parties
    - data handling mistrust
    - Not used to block-chain enabled contracts
    - Others
- Economic barriers
    - Upfront costs for sensoring and monitoring
    - Flexibility trading is only feasible at aggregated level
    - Low cost of wholesale market energy
    - Low cost of ancillary service market energy now
    - Low RES penetration yet and heavy impact in distribution grids
    - Retail tariff structure: Low variable energy prices and high taxes and fixed fees that translate into low impact of energy savings in domestic economies.
    - Low incomes for domestic households

- Others

Possible service bundles

Suggesting what services should be offered in connection with others or make sense to bundle to create a sensible value proposition for ESCOs and aggregators. In this sense, services that provide analytic services should bundle with those that complete the services with visualisation or automation tools. Similarly, services aiming at setting up the digital platform structure should be complemented with the maximum number of possible income-generating services to reduce the payback time of the former.

Contractual arrangements and issues.

- Type of contract: P4P contract, EPC contract or commercial sales contract
- Terms and conditions of the service delivered: DERs involved, maximum flexibility power, start and finish dates, times of operation, other conditions and usage limits, costs of the service (if applicable)
- Contract duration

frESCO system modules, development tasks and partners.

- **Provisional frESCO system modules**

Soft Components	
Local Demand Manager	
	Baseline Flexibility Analytics
	Energy analytics and self-consumption optimization
	Local energy performance
	Flexibility Analysis and Forecasting
	Home monitoring and control dispatch
Global Demand manager	
	Energy Efficiency and self-consumption strategy
	Flexibility forecasting, segmentation and aggregation
	VPP Configuration
	DR/EE monitoring and control dispatch
Visualization and end user toolkits	
	EE/self-consumption performance monitoring
	Flexibility analysis and DR strategy optimization
	Smart contract monitoring, settlement and remuneration
	Consumer Visualization platform
Hard Building retrofitting components	
	Ambience sensing
	HVAC, lighting, water heating control
	OneM2M gateway

- **frESCO Development tasks and partners**

4.1	Open Standards, Interoperability and Common Information Model Adaptation	S5
4.2	Data acquisition devices and big data platform backbone infrastructure	CIRCE
4.3	Core Big Data Ingestion, Curation and Management Services	S5
4.4	Personal and Enterprise Big Data and Edge Analytics Algorithms Definition as a baseline for advanced energy service bundles	S5
4.5	Data Assets Security, Encryption and Privacy Mechanisms	S5
5.1	Advanced Performance Monitoring/ Forecasting Module for Generation/ Storage/ Demand Assets	CIRCE
5.2	Energy Management Analytics and Self-Consumption Optimization Tool for ESCOs	UBITECH
5.3	Advanced Flexibility Analytics and Optimal VPP configuration tool for Consumer-Centric Demand Response Optimization	UBITECH
5.4	Personalized Energy Analytics and Human-Centric Automation tool for residential buildings, including smart readiness certification features	CARTIF
5.5	Blockchain-enabled Smart Contract Monitoring, Handling, Settlement and Remuneration	S5

frESCO demo site testing beds

- France (VOLT)
- Spain (LCTE, COMSA)
- Croatia (Ponikve, KONCAR)
- Greece (IOSA, VERD)