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Deliverable D3.2
Mapping services and revenue streams across the value chain

Deliverable number	D3.2
Deliverable name	Mapping services and revenue streams across the value chain
Lead beneficiary	CIRCE
Description	List of all relevant stakeholders for the provision of the each of the services defined in D3.1 and their direct and indirect interactions. Recommendations of possible payment flows among these stakeholders for ensuring the remuneration of them all
WP	WP3
Related task(s)	T3.2
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ABBREVIATIONS

Abbreviation	Name
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
EED	Energy Efficiency Directive
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
M&V	Measurement and Verification
P4P	Pay for Performance
PMV	Performance Measurement and Verification
PV	Photovoltaic
RES	Renewable Energy Sources
SME	Small and Medium Enterprise
T	Temperature
ToU	Time of Use
TSO	Transport System Operator
VPP	Virtual Power Plant
WP	Work Package

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EXECUTIVE SUMMARY

This document provides an overview of the value chain involved in the delivery of the frESCO innovative energy services, the main stakeholders taking part at each stage and the type of costs incurred at every step or activity. The analysis covers the value added by the bundled service packages, the types of revenue expected and proposes a fair distribution of revenues among the different actors intervening in the value chain. This is a preliminary assessment made with best hypothesis and known data ranges. This assessment is mandatory to design efficient and economically self-sufficient business models based on the Pay-for-Performance model, that ensures a fair remuneration of the different services according to the energy performance measured and verified by means of the innovative Performance Measurement and Verification (PMV) protocols. The business models will be simulated in task T3.5 and finally tested in real-life environment in the four frESCO demo sites where the hypotheses formulated will be validated with real testing data.

The main stakeholders involved in the provision of the energy services are the energy service providing companies, Energy Service Companies (ESCOs) and Aggregators, and end users. Some activities in the value chain can be executed by external vendors, specialised installers or third-party companies, always under the supervision of the energy service providers. On the other side, facility managers and building occupants are the beneficiaries of the services. They play the role of energy consumers, enjoying the energy and economic savings, and / or energy flexibility providers, receiving a remuneration from the markets where the demand flexibility is pulled and traded. Both types of benefits are measured, verified, administered and settled by the energy service provider in their role of ESCO or Aggregator, or both.

By means of the data platform tools, end-user data is captured, treated, stored and used by the service providers to deliver savings or flexibility services to the grid on behalf of the domestic end-users that become real actors of the energy transition economy. Near real time data enables the possibility to create ad-hoc dynamic energy profile baselines to measure energy efficiency at dwelling level on one side, and event-based demand flexibility at load level on the other, to accurately and fairly assess the energy performance with which the service provider will obtain the revenues.

Three main energy service business models are contemplated in detail: on one side we have the ESCO business model where a combination of implicit, explicit services for consumers, and

optimisation strategies for prosumers lead to recurrent energy savings in the dwellings. On the other side we have the Aggregator business model where the service provider is capable of receiving market triggering signals from a grid or market operator, configuring virtual power plants to respond to the market signals from the demand side and executing the final programmed sequence to deliver the amount of aggregated flexibility to the system at the place and time requested. A third business model considers the delivery of both type of services simultaneously with the same data platform and benefiting from both revenue streams.

Preliminary results of the economic assessment show too wide a range of costs and revenues depending on a multitude of factors such as the type of building, the user profile, the scope of the services, energy demand curves, climate, equipment and markets where energy supply and flexibility are traded. Depending on the legacy equipment, the smart readiness, the contracted services and the installation issues, the upfront cost may also diverge widely. Values will be validated and narrowed down in the testing phase of the frESCO project.

The results show that some pre-qualification boundaries have to be worked out permitting the identification of users and dwellings better catered for the frESCO business models. Knowing these limits, it is easier to guarantee economic feasibility for the frESCO business models, using as a minimum requirement a payback time below 11 years.

This deliverable sets the basis of the new frESCO business models to be developed in task T3.3 based on the new PMV from task T3.4, simulated in task T3.5 with the contractual arrangements of task T3.5 and finally tested in work package 6 in the four frESCO demo sites.

1 OBJECTIVE AND SCOPE

This document follows on from the list of new innovative energy services defined in task T3.1 and designed under the premises of the pay-for-performance (P4P) frESCO contracts. The main objective of this deliverable D3.2 “Mapping of the interactions between stakeholders and accompanying cash flows” is to document the work done in task T3.2 “Mapping services and revenue streams across the value chain”. The first objective of this task is to define the main relevant stakeholders that take part in the provision of the new energy services, their potential role according to the part of the value chain they are involved in, and the types and ranges of costs incurred. The only way to ensure a successful and acceptable rollout of the new services is to ensure a fair remuneration of all the activities required along the value chain. Hence, this document also proposes an associated P4P payment flow and ensures fair and equitable distribution of revenues along the value chain, including the beneficiaries of the services.

Since the type of services in the frESCO portfolio are innovative and have not been tested yet, many of the costs and revenues are good estimations with the information available at the time of writing. Likewise, there is not a generic service case that can be used as a reference and all service economic assessments should be done individually. Therefore, it is best to speak about cost and revenue probable ranges where the final figures are likely to lay in. These hypotheses will be bundled in new business models in task T3.3, verified with the new Performance Measurement and Verification (PMV) methodologies in task T3.4, simulated and tested virtually in task T3.5, and finally formalised into specific P4P contract proposals in task T3.6. They will also be tested in real environment conditions with real users in WP6. The WP3 flowchart that binds the different tasks and their expected outputs follows hereafter.

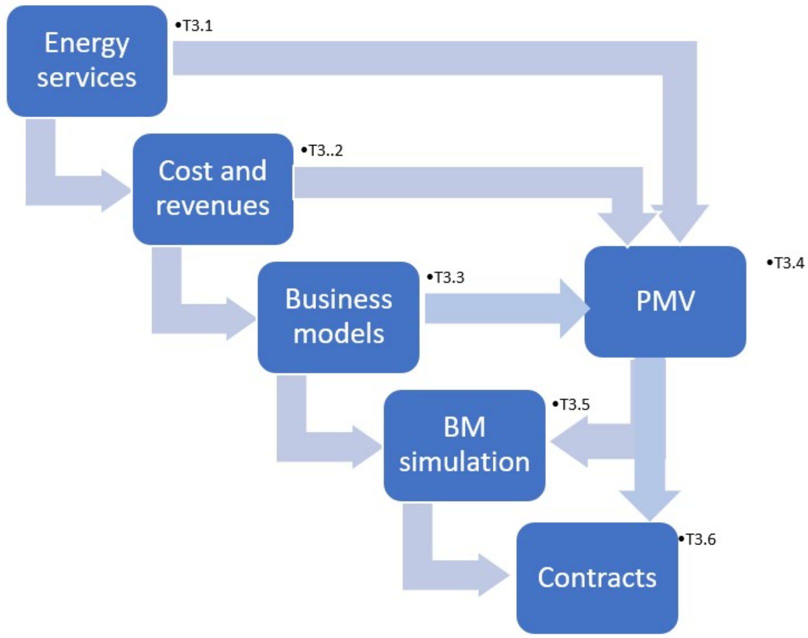

Figure* 1. *WP3 task flowchart.

2 CURRENT STATUS OF THE ENERGY SERVICE MARKET

2.1 Background of today's ESCO contracts.

There are variations in the ways ESCOs operate; the key differences being the type of contract and financing sources [1].

An energy service contract can be defined as the contractual relationship between an energy service provider and an energy end-user (customer). Among the most important contracts the following are worth mentioning.

2.1.1 Energy Performance Contracting (EPC)

Energy Performance Contracting (EPC) is a form of financing for capital improvement which allows funding energy upgrades from cost reductions. Under an EPC arrangement an external organisation (ESCO) implements a project to deliver energy efficiency, or a renewable energy project, and uses the stream of income from the cost savings, or the renewable energy produced, to repay the costs of the project, including the costs of the investment. Essentially, the ESCO will not receive its payment unless the project delivers energy savings as expected [2].

The approach is based on the transfer of technical risks from the client to the ESCO based on performance guarantees given by the ESCO [3]. In EPC, ESCO remuneration is based on demonstrated performance; a measure of performance is the level of energy savings or energy service. EPC is a tool to deliver retrofitting improvements to facilities/customers that lack energy engineering skills, manpower or management time, capital funding, understanding of risk, or technology information [4].

Within EPCs, the two most common types would be the "shared savings" model and the "guaranteed savings" model.

In an EPC-based guaranteed savings project, the customer is protected from any performance risk, as the ESCO designs and implements the project and guarantees the energy savings. If the savings are less than the guaranteed level, the ESCO covers the shortfall. If the savings exceed the guaranteed level, the additional savings are shared between the ESCO and client [5].

In the case of shared savings projects, savings are shared according to a pre-established percentage: there is no "standard" sharing, as it depends on the cost of the project, the duration of the contract and the risks assumed by the ESCO and the consumer.

Although in some countries, such as France, models are used equally. The overview shown in the below chart shows a greater interest in the "Guaranteed savings" model in Europe.

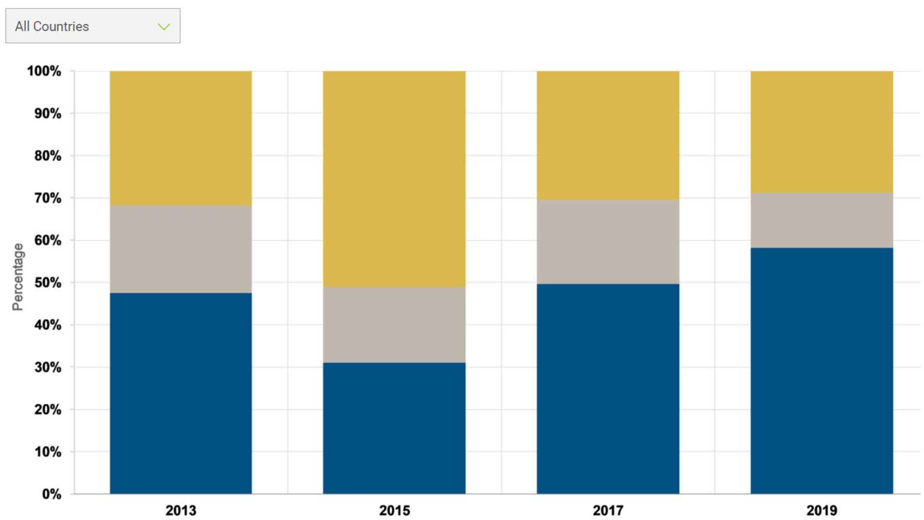

Figure 2. Energy saving model offered in Europe. In blue Guaranteed savings EPC, In grey Shared Savings EPC, in yellow both types together. Source: Qualitee EES market [6]

2.1.2 Energy Supply Contracting (ESC)

The subject of this contract type is the supply of energy, typically in the form of heat, whereby the ESCO undertakes installation works and supplies energy to the client. The focus of energy supply contracting is the reduction of supply costs rather than demand-side efficiency gains, with energy efficiency measures being typically limited to the energy supply and transformation side. These measures include the optimisation of the equipment (e.g., purchase of heat produced by a biomass boiler), production of electricity from cogeneration plants, etc. The energy supply contracts require longer terms (10-30 years) and are best suited for centralised systems such as heating and cooling. Once the ESCO completes the installation, it is paid for the quantity of energy supplied over the term of the contract. In France, this is also known as "chauffage" model which has been in use for more than 60 years. Under this type of contract, the costs of all equipment upgrades, repairs etc. are borne by the ESCO, while ownership typically remains with the customer. The customer pays a fee which is based on its existing energy bill minus a percentage savings (often in the range of 3-10%) or a fee based on the conditioned floor space [1].

2.1.3 Build-own-operate-transfer (BOOT)

Under a build-own-operate-transfer contract, the ESCO designs, builds, funds, owns and operates the scheme for a defined period of time and then transfers the ownership across to the customer. Customers enter into long term supply contracts and are charged according to the service delivered. The service charge includes capital and operating costs recovery and project profit. The contract type has been found to be more applicable when including large energy generation assets e.g., combined heat and power engines [1].

2.2 ESCO project financing options

When it comes to financing energy efficiency projects, 3 options can be distinguished:

- ESCO financing: ESCO financing refers to financing with internal funds of the ESCO and may involve own capital or equipment lease. ESCO rarely use equity for financing, as this option limits their capability of implementing projects on a sustainable basis [6].
- Energy-user/customer: Energy-user/customer financing usually involves financing with internal funds of the user/customer backed by an energy savings guarantee provided by the ESCO. Energy-user/customer financing may also be associated with borrowing in the case when the energy-user/customer as a direct borrower must provide a guarantee (collateral) to the finance institution [6].
- Third-party financing (TPF): Third-party financing refers solely to debt financing. As its name suggests, project financing comes from a third party, e.g., a finance institution, and not from internal funds of the ESCO or of the customer. The finance institution may either assume the rights to the energy savings or may take a security interest in the project equipment. There are two conceptually different TPF arrangements associated with EPC; the key difference between them is which party borrows the money: the ESCO or the client [6].

2.3 Status of the EPC market today

As far as the volume of the EPC market is concerned, clear differences between countries can be observed, as well as a large lack of data in some cases. The market is analysed comparatively in the European Union, with insights from France, Greece, and Spain..

As it might be expected, EPC revenues vary widely between markets, but a trend can be observed whereby many EPC revenues in European countries would be less than 10 M€ Euros or at most 50 M€.

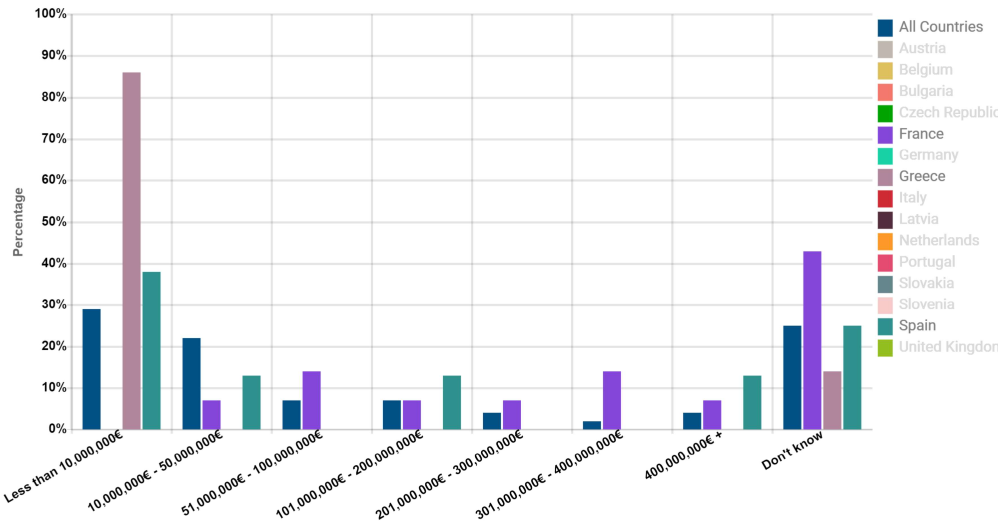

Figure 3. Revenue in Europe in 2016. Source: Qualitee EES market

However, in terms of customer type, the majority of EPC customers tend to be in the public sector.

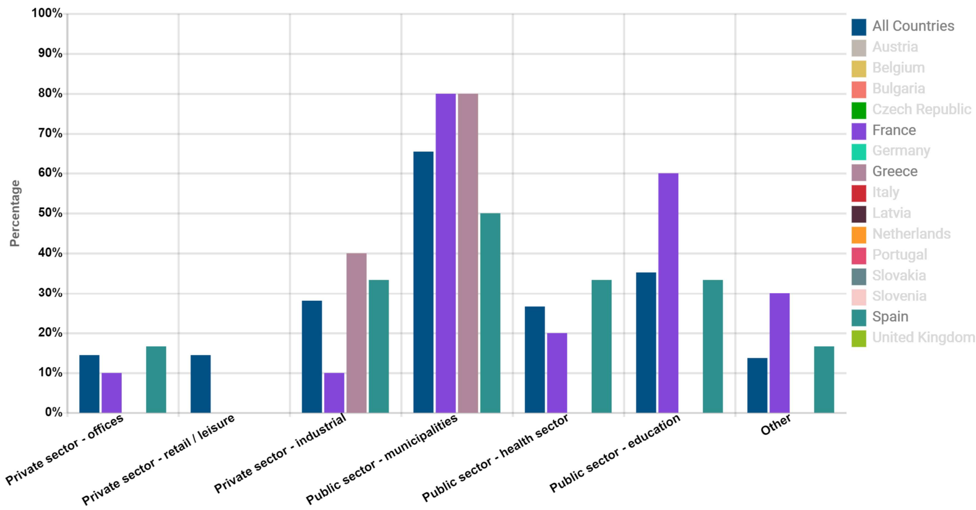

Figure 4. Sector customers come from. Source: Qualitee EES market

A Strength-Weakness-Opportunity-Threat (SWOT) analysis of the ESCO contracts in the residential sector has been made for the European EPC market showing the following results.

Table 1. SWOT analysis - Private sector - Residential buildings. Source: GuarantEE - Report on the European EPC Market [5]

Strengths	Weaknesses
• Option of financing through ESCO • Increased building value through EPC • Green image • Guaranteed cost savings • High-cost consciousness	• Resistance against outsourcing property management and operations to third parties • Split incentives dilemma • Behaviour of tenants has high influence, barely manageable • Challenging M&V situation • Mainly deep retrofit required – not possible with payback from savings alone
Opportunities	**Threats**
• Interest of tenants in energy cost savings • Interest of tenants in climate protection and energy (cost) savings • Significant saving potentials • Combination of Financing with energy services • Mandatory energy performance certificates draw attention to energy consumption and create value for good performing facilities • A good solution for the splitincentive-dilemma in rented facilities will open a large market segment	• Non-supportive legal frameworks • Vast majority of properties are owned by individual property owners • Individual owners can block decisions • Forfeiting not possible, ESCO financing too risky/costly • Complex contractual requirements (also with tenants) create a risk and subsequently raise project costs

As far as the duration of the projects is concerned, they can vary quite a lot from one project to another, but in general most projects last between 5 and 10 years according to the same sources. Long-term projects are more common in the Public Sector where they easily extend to 15 years for large projects.

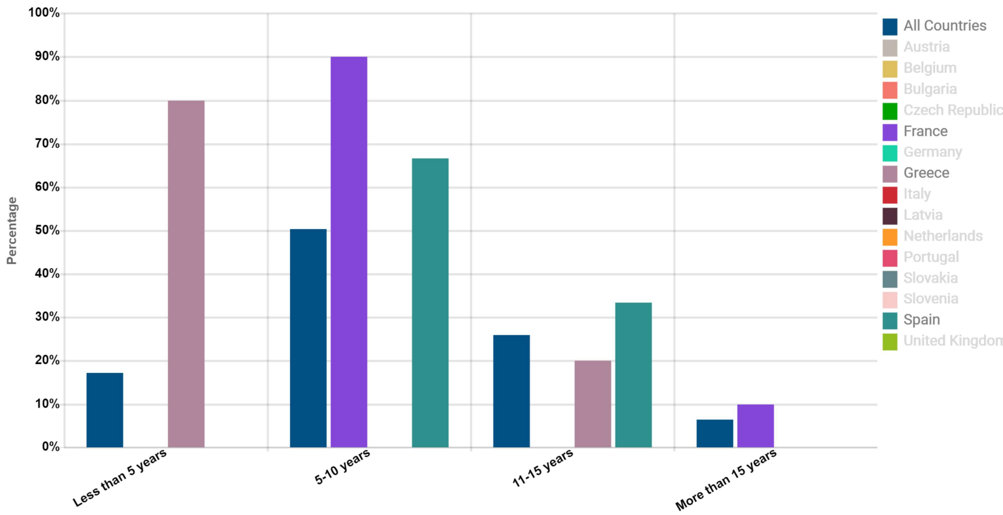

Figure 5. Average duration of EPC projects in Europe. Source: Qualitee EES market [6]

Level of investment also varies greatly from project to project and from country to country.

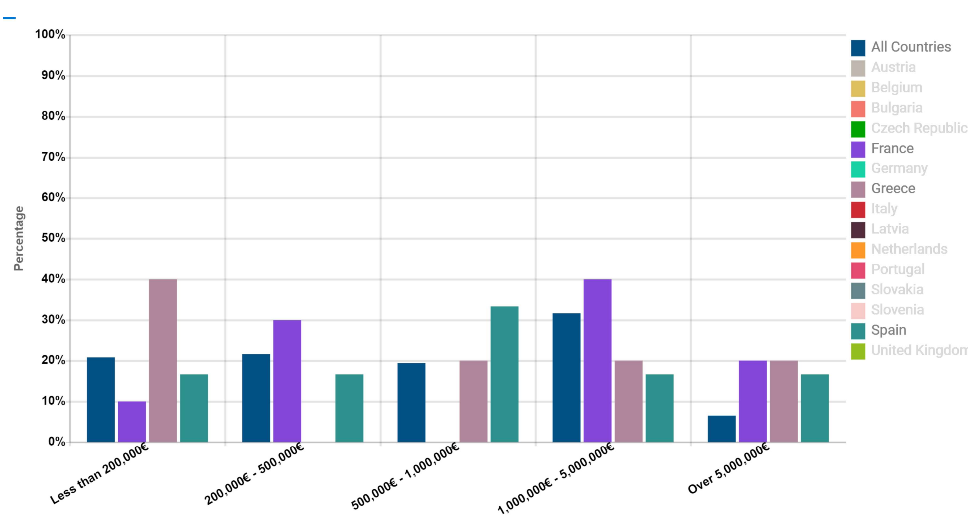

Figure 6. Distribution of EPC by level of investment. Source: Qualitee EES market [6]

World-wide, the value of the global ESCO market grew 8% to USD 28.6 billion in 2017, up from USD 26.8 billion in 2016. China continues to underpin the global ESCO market, growing 11%

to USD 16.8 billion in 2017. The market in the United States, where ESCOs have been operating for well over 30 years, grew to USD 7.6 billion in 2017. In Europe, the ESCO market remains somewhat underdeveloped compared to other major regions, representing 10% of the global total [7].

The average EU ESCO market was steadily increasing for several decades. Although the 2008 financial crisis caused a brief setback, the ESCO markets were able to overcome the challenges quite easily and turn financial constraints into an opportunity. From 2014-2016 onwards, markets were generally on a growing path, although this growth was not as widespread in all countries as it was in the period 2010-2013.

With regard to recent years, the 2018-19 market study shows that the overall development of the ESCO market in almost all European Member States has been stable or growing. In particular, in the period 2015-2018, the market has grown largely in Croatia as well as in France and Spain to a lower extent, whereas it has remained stagnant in Greece.

There are many ways to assess the size and value of the ESCO market, including the number of energy performance contracts, contract size and market revenue. Calculating the size of the ESCO market varies between EU countries, as some Member States have different methodologies for what is included. Globally, the ESCO market was estimated at US$30.9 billion in 2018. In terms of ESCO market revenue, Europe is the third largest market at approximately €3 billion, after China (US$16.4 billion) and the US (US$8.3 billion), and the second oldest, after the US [8].

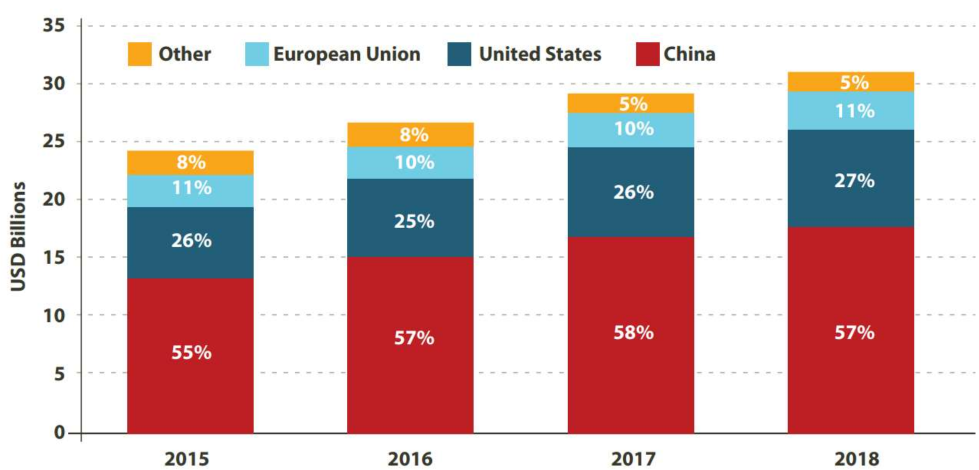

Figure 7. Global ESCO revenue, 2018. Source IEA 2019 [8]

The European total market value has grown 11%, from US$2.7 billion in 2015 to US$3 billion in 2018; however, it has not experienced the market traction the US or China have experienced, as these markets have strong public sector engagement and financial support with local and national governments engaging in EPCs. Similar to the US, the majority of ESCO projects in Europe occur in the non-residential buildings sector and largely take place in public sector projects (government buildings, schools, hospitals, etc.) [8].

The Joint Research Centre (JRC) has been assessing the state of the national energy services market for ESCOs for several years now; however, benchmarking is complicated for two main reasons. Firstly, despite the common definition at EU level, definitions vary from country to country. Secondly, there is still no standardised indicator to describe the level of development of an ESCO market.

Therefore, the following conditions were used for JRC's analysis of ESCO market maturity [9]:

- The ESCO concept is generally known and understood.
- The market is demand-driven.
- Trust in the ESCO market exists, or it is even high.
- There are alternative contract forms, several of them available in a standard format or supported by guidelines.
- There are alternative financial solutions, including client-financing and bank involvement.
- Transaction costs are relatively low, historical data on energy consumption are available.
- Monitoring and verification of savings is carried out with a standard and transparent method.
- There are facilitators, who can help clients decide about the available offers, while supporting the supplier side.
- The energy and procurement general policy framework does not hinder ESCO projects and there is rarely a need for dedicated legislation for ESCOs.
- Quality labels or certificates exist for companies or for projects.

- Grants or preferential loans.

According to these maturity parameters, the study concludes that the ESCO market is rather mature in countries like France or Spain, but with room for improvement in most aspects in Croatia and Greece.

Despite considerable efforts to promote the development of the ESCO market, there are still many barriers that limit the growth of European ESCO markets today. The barriers vary from country to country, but clearly the most relevant ones would be:

- Mistrust from the (potential) client

One of the main barriers to the development of ESCOs is the lack of trust. This often stems from the lack of homogeneity of ESCO offerings in the market, lack of competition, lack of experience of clients, ESCOs and financial institutions, lack of credible and visible reference cases with a clear client focus, unclear definitions and flawed contracts, and lack of standardised measurement and verification [9].

- Information and awareness

Another aspect that prevents the adoption of such projects and therefore limits the implementation of ESCOs is the lack of communication of successful examples and their positive impact. This lack of knowledge on the part of final consumers about the economic potential of energy savings continues to impede the adoption of energy contracting projects.

- Inexperience of actors

The lack of technical knowledge, handling of technical risks as well as lack of experience in procurement are issues faced by many countries [9].

- Ambiguities in the legislative framework

The ambiguities in the legislative framework supporting ESCO development have had a negative impact on the ESCO development [9].

- Market-size and transaction costs

Small scale projects are not compatible with energy performance contracting. For example, the reluctance of municipalities to engage in EPCs, which can be in part explained by the small structure of many municipalities, is an impeding factor for the uptake of energy performance contracting by the public sector [9].

2.4 ESCO Market analysis by countries

2.4.1 Greece

Market size and market development

Due to the country's economic instability and the resulting difficulties in financing EPC projects, the Greek energy services market has not developed since 2015. However, the implementation process of the EU Directive obliging Member States to renovate 3% of the floor area of public buildings is ongoing. In addition, an obligation for companies that are not SMEs to carry out energy audits is in force as of mid-2018.

Thanks to several initiatives promoting the development of the ESCO market in Greece, the register of ESCOs shows an increase in the number of ESCOs in recent years. However, although this number doubled between 2014 and 2017, it seems that ESCO markets have not yet really emerged in Greece.

Supply side

Based on the data provided by the ESCO registry, a total of 86 ESCOs are registered in Greece. The ESCO registry is split into the following four categories [9]:

- Category A1 – Companies that have implemented or are currently implementing energy efficiency projects with Energy Performance Contracts with a total budget of at least € 300,000 in the last five years
- Category A2 - Companies that have implemented or are currently implementing energy projects (energy efficiency and/or renewable energy) with a total budget of at least 1 M€ in the last five years. These need not be accompanied by an EPC contract.
- Category A3 – All the companies belonging to neither category A1 or A2.
- Category B – Natural persons that offer energy consultancy services.

Only category A1 are companies providing EPC projects. There are 3 companies registered in category A (ESCO's providing energy services through EPCs) and 83 are category B (ESCOs providing energy services without EPCs) [9].

Demand side

As in many other European countries, the typical client of ESCOs in Greece is the public and governmental sector, although the private sector has played a major role in the case of commercial office buildings, hotels and tourist facilities.

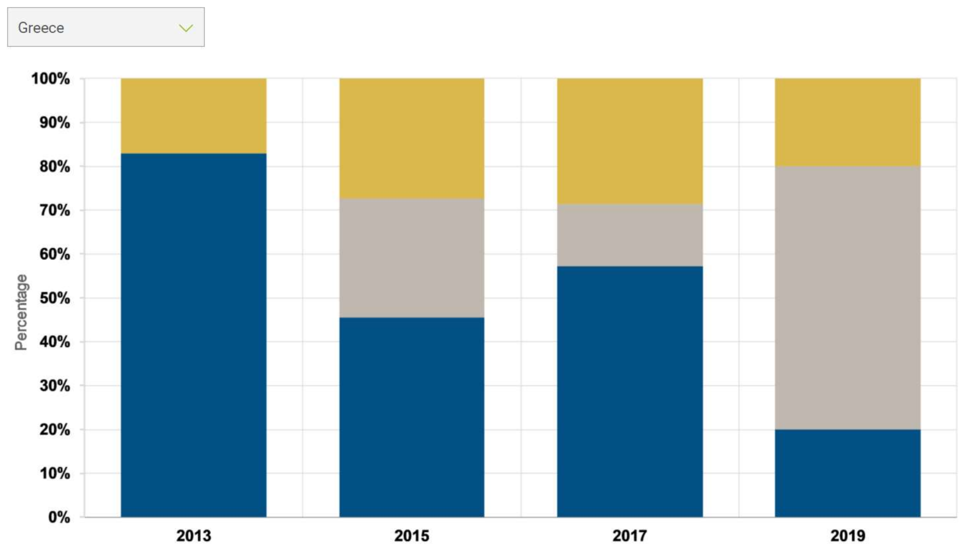

Figure 8. EPCs clients in Greece. Grey: Public and governmental sector, blue: Private business sector yellow: Mixture of both, Source: Qualitee EES market [6]

The main technologies implemented by ESCOs are in buildings as a whole (including active and passive systems, energy efficiency and RES), heating and heating systems in buildings, cooling and air conditioning, automation, and control systems as well as renewable supply. The average size of investments of ESCO/EPC projects is less than 200,000€. The average duration of ESCO projects is between 5 and 10 years. The estimated average energy savings are 15% of baseline consumption. The most common type of contract used by ESCOs is EPC with guaranteed savings and consultancy and technical guarantee [9].

Future perspectives and recommendations

The most important recommendations or changes in the regulatory, legal, financial, or informational framework of the ESCO market to further develop ESCOs [9]:

- Provide information on best practices for energy performance contracting
- Provide model contracts for EPC
- Build an authority that will monitor EPC contracts

o The key to further development is the actual implementation of the already-existing legal framework.

2.4.2 Croatia

Market size and market development

In the case of Croatia, the ESCO market has grown considerably thanks to the boost of EU subsidies and rising energy prices. However, it still requires many improvements in the legal environment, access to finance, and competition.

Supply side

In 2017 Croatia had more than 15 energy service providers and they are expected to increase due to rising energy prices, and the possibilities of obtaining subsidies and favourable loans with lower interest rates.

In 2018 there were 8-15 companies (rather small, with limited experience and limited source of capital for investment) providing and offering ESCO or EPC services.

Demand side

Public lighting is the typical sector for ESCO/EPC. The dominant technologies implemented by ESCOs are street lighting followed by building level heating and heating systems and building as a whole (including active and passive systems, energy efficiency and RES). This is a significant move away from the earlier dominant industry projects.

The average size of investments of ESCO/EPC project related to public lighting varies from 0.5 M€ to 1 M€. The average duration of such an ESCO projects is 10 years. The average energy consumption in a public lighting project can be reduced by 70%. The average duration of a project in the private sector (industry) is 6 years and the energy consumption might be reduced by 30% [9].

Future perspective and recommendations

The Croatian ESCO market is seen to have stepped out of its preliminary state, but it is still at a moderately developed level. The framework for public sector project has been well established, although more market support could further help replication. For a growth in private sector projects, further legal adjustments are recommended. Furthermore, the following recommendations were formulated in the 2018 JRC survey [9]:

- Introduce mandatory full project/life-cycle cost analysis and valuation of projects in public tendering
- Guides and support documents for the preparation of tender documentation along with contract model for EPC
- Ensuring the combination of EU grants and ESCO financing in the light of payback times, therefore increasing interventions with larger savings
- Trainings related to EPC contracting.

2.4.3 Spain

Market size and market development

The ESCO market in Spain has experienced a slow increase since 2015, due to rising energy prices. In addition, the increase in electricity prices in Spain has led to an increased interest in reducing energy costs. According to the ANESE Observatory, energy services in Spain are driven by the end customer using ESCOs to renovate buildings through EPC.

Supply side

According to the IDAE (Institute for Energy Diversification and Saving), there are currently more than 1,200 companies registered as ESCOs in Spain.

However, although many of these companies consider themselves ESCOs, they are only manufacturers, consultants, or financial companies, and therefore do not invest in energy efficiency, as is required of an EPC or an ESCO.

Demand side

In Spain, the main customers for these services would be public buildings, including hospitals, educational buildings, and offices, followed by commercial office buildings and hotels, and public lighting, as well as industrial sites and processes. According to the QualitEE report [10], ESCOs have increased their activities in the public administration and private sector market segments in Spain in recent years.

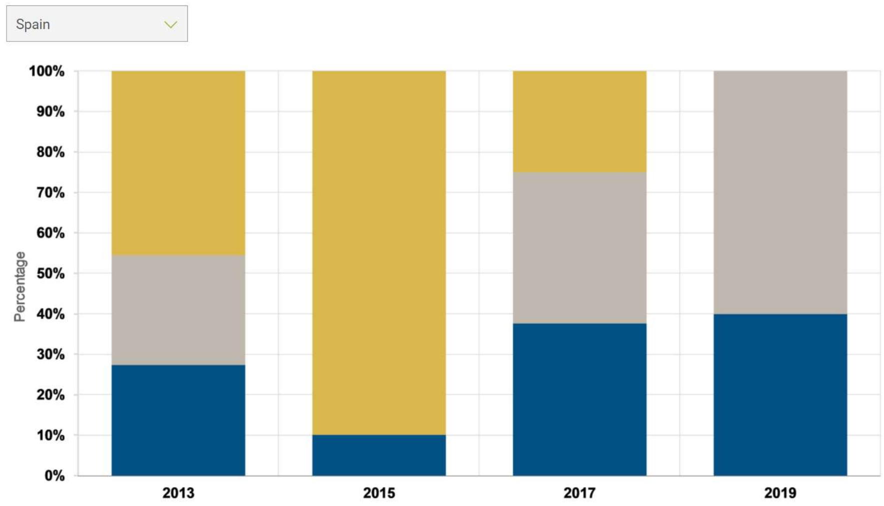

Figure 9. EPCs clients in Spain. Grey: Public and governmental sector, blue: Private business sector yellow: Mixture of both, Source: Qualitee EES market [6]

The technologies that have been implemented most by ESCOs so far would be building level heating and heating systems, industrial processes, horizontal technologies, motor systems and street lighting.

According to ANESE's Observatory of the Spanish ESCO Market, the average size of Spanish ESCO/EPC projects is 433,132 €. The average duration of ESCO projects is 7.8 years. The most common type of contract used by ESCOs is EPC with shared savings (ESCO and client share the savings, ESCOs take financial risk) [9].

Future perspective and recommendations

The most important recommendations or changes in the regulatory, legal, financial or informational framework of the ESCO market to further develop ESCOs are as follows:

- Create a white certificate scheme (The public information period for the draft regulation establishing a system of Energy Saving Certificates was recently closed).
- Link energy savings to tax advantages.
- Implement a Guarantee Fund to ESCO projects.
- Prepare and publish EPC models (buildings) for public procurements.
- Use the Spanish national energy saving fund to promote EPCs.
- Creation of a National Guarantee Fund for EPC projects.

o Assistance program for SMEs for the execution of energy audits and the implementation of identified energy efficiency measures.

2.4.4 France

Market size and market development

The French ESCO market is very well-developed, and almost all of the market structures are well-functioning. There are several ESCO associations, and facilitators assist the market. Monitoring and verification procedures are widely used. The market is partially demand driven, although ESCOs themselves and their associations take on a lot of promotion [9].

Supply side

The main suppliers of ESCOs are facility management and operation companies. The dominant ownership states of ESCOs in France are national private companies and international private companies. The dominant contract used by ESCOs is the EPC contract with guaranteed savings (ESCOs guarantee energy savings, customers bear the financial risk) [9].

Demand side

Public buildings, including educational establishments, offices, and hospitals, are the main customers of ESCOs, although public lighting, private commercial (office) buildings and private multi-storey residential buildings are expected to join the ranks of ESCO customers in the near future.

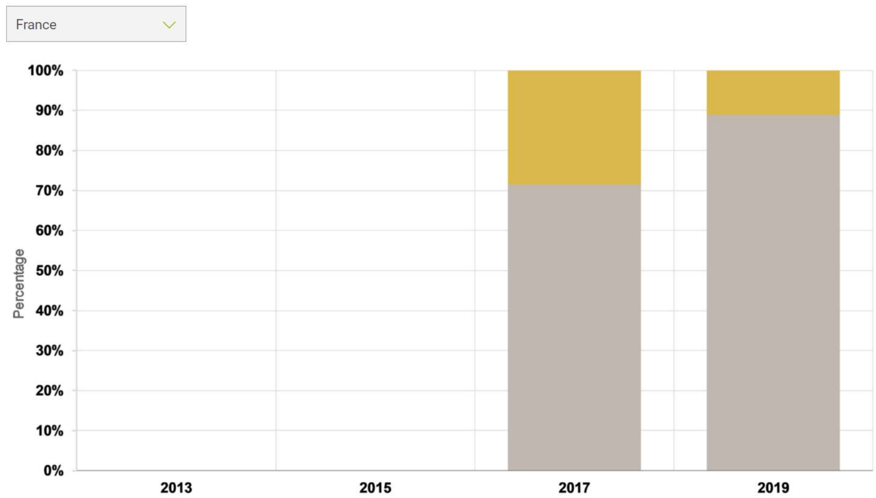

Figure 10. EPCs clients in France. Grey: Public and governmental sector, blue: Private business sector, yellow: Mixture of both. Source: Qualitee EES Market [6]

2.5 Demand Flexibility service sector

The flexibility services sector is currently separated from traditional EPCs. This sector is very incipient in some countries and non existent in others. The issues faced by aggregators in those markets where demand response aggregation is accepted have to do with the lack of baselining models that enable measurement and verification of the amount of flexibility delivered upon market request. The commonly accepted PMV methodologies are well catered for long term energy efficiency estimations that accommodate well to the EPC models. There is no consensus or official guidelines at the moment on how to estimate flexibility. This is a serious barrier since the retribution in a P4P model may vary depending on the PMV methodology used and the mathematical forecasting models used for the baseline. Current EPC models do not cover this gap for the demand response aggregation business.

This gap is addressed in frESCO's T3.4 PMV Methodology that encompasses both services, energy efficiency and demand response aggregation, using different data-driven baseline models and data horizon in a unique methodology. The use of this methodology should be clearly stated in the new P4P energy contracts signed between the service provider and the end-user and shall be developed in T3.6.

2.6 Summary of issues and barriers of the present EPC contracting model in the residential sector.

Nowadays the vast majority of energy service contracts are Energy Performance Contracts (EPC), whose terms are not regulated and depend on the competitive environment and the interest of the Energy Service Companies (ESCOs). This interest is proportional to the size of the project and the potential of energy savings realisation. Although the residential sector is huge and has a great average saving potential, it is too segmented and represents a large transaction effort to reach each and every household in Europe. Energy efficiency measures have to be deployed and implemented on a one-to-one basis and the final savings can only be proportional to the dwelling consumption, which is small in absolute terms.

These reasons explain the low penetration of the energy service sector in domestic consumption. Companies usually offer energy services complementary to energy supply and equipment retrofitting and maintenance. Hence, these services are not primary and often do not come with a guarantee of performance and the corresponding regular verification of savings for service settlements. Some companies offer a minimum warranty of top consumption in normal conditions.

An EPC is a proven procurement method accepted world-wide that is used to reduce 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 and water efficiency, operations and maintenance cost efficiency and renewable energy uptake. The ESCO manages all aspects of the project from the start to the end and 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.

The EPC contracts have 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.

Real EPC contracts need to define standard, robust, and fair performance and verification protocols to link the remuneration of the services to the savings really obtained, regardless of the contextual changes. These protocols shall establish performance models and adjustments to be made to determine the amount of energy saved by the EE measures. The protocols can be internally designed. However, there are different types of international protocols like the International Performance Measurement and Verification Protocol (IPMVP) which provide a standard framework that provides reliability and confidence to end-users.

It is often recommended that the PMV be developed and implemented by external third-party companies that design the baseline, perform the measurements ex-post and reports the savings to both end-users and energy service providers on a regular basis. This cost has to be deducted from the energy savings expected. If the verification is done by the ESCO itself, it may undermine trust and confidence in the procedure as their revenues are directly related to the result of the verification. The complexity of the process and the invariability of the baselines along time do not help to build trust either. The lack of old-enough representative data in the ex-ante scenario for the baseline creation is also a frequent issue to tackle by ESCO companies when setting up an EPC contract.

The new P4P model that is suggested in frESCO casts light on these issues by proposing PMV methodologies based on actual data, that can be constructed with little real initial data that refresh continuously as new data comes in, thus providing a dynamic baselining that is accurate and reliable adapting to the ever-changing environmental and contextual conditions. It also reduces dramatically the operational costs of the verification procedures since data is taken, treated and stored automatically on a continuous basis with little or no human intervention. To aid trust they should also use blockchain methodology to create a fair unalterable digital ledger. Therefore, it helps to reduce the traditional problems of the EPC contracts in the domestic sector and extend the feasible energy services to low saving sectors that currently have scarce access to these type of services such as the residential sector.

3 FRESCO SERVICE PACKAGES AND PRELIMINARY BUSINESS MODELS.

The frESCO energy service portfolio is described in D3.1 and a summary list provided in Annex 1. These services are divided into 4 main groups:

- Smart retrofitting services. The frESCO data platform relies on the collection of energy metering and real-time data from the buildings. Some services also require automation mechanisms to operate the selected Distributed Energy Resources (DERs) explicitly. Therefore, some degree of smart readiness of the building, and Internet-of-Things (IoT) equipment is needed. This includes not only the presence of smart equipment but also data collection interfaces (meters and sensors) and smart actuators, and a gateway to the data platform storage system. These services take care of the provision of the necessary data collection hardware, that could be extended to a smart readiness audit and certification service. Other equipment retrofitting recommended to enhance the results of the frESCO services may also be included, such as self-consumption and storage assets, electric smart Heating, Ventilation and Air Conditioned (HVAC) systems or building insulation to increase the thermal performance of the building.
- Energy efficiency services. These services could be implicit, delivering clear, comprehensive information towards an optimal user behaviour on energy usage, or explicit by automation and scheduling strategies. The expected outcome of these services is materialised as energy savings.
- Demand flexibility services. These services enable users to participate in Demand Response (DR) markets to provide flexibility services to a grid operator and get paid for it. The expected outcome is a revenue coming from the aggregated flexibility supply to the grid.
- Non-energy services. Other services not directly related to energy management can be offered by means of the data platform, and includes improvements in comfort, air quality, noise reduction or even safety and surveillance services.

In addition, there are specific services for prosumers, such as the self-consumption optimisation service that results in additional energy savings from load shifting strategies adapted to the energy generation profiles.

With this main classification in mind, the following Service Packages (SPs) can be identified in the following table, see Annex 1 for the full list of frESCO energy services:

Table 2. frESCO Service package list

SP number	Service pack name	Services (see Annex 1)	Revenues
SP 1	Implicit EE and user-driven energy management	RT1, RT2, EE1, EE2	Savings from implicit energy management
SP 2	Explicit EE and automation	RT1, RT2, EE1, EE4	Savings from implicit energy management
SP 3	Full EE and automation	RT1, RT2, EE1, EE2, EE4	Savings from implicit and explicit energy management
SP 4	Full EE and PhotoVoltaic (PV) self-consumption optimisation	RT1, RT2, EE1, EE2, EE3, EE4	Savings from energy management and PV optimisation
SP 5	DR explicit automation and participation	RT1, RT2, FL1, FL2, FL3	Remuneration for flexibility trading
SP 6	Energy efficiency and flexibility services	RT1, RT2, EE1, EE2, EE3, EE4, FL1, FL2, FL4	Savings from implicit and explicit energy management + Remuneration for flexibility trading
SP 7	Energy efficiency, PV optimisation and flexibility services	RT1, RT2, EE1, EE2, EE4, FL1, FL2, FL5	Savings from energy management + PV optimisation + Remuneration for flexibility trading
SP 8	Non-Energy services (comfort, air quality, noise, safety)	RT1, RT2, NEi	Service fee per unit of service delivered
SP 9	Smart readiness assessment and certification	RT3	Service charge

RT: 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, the sensors according to the services contracted, the energy metering and monitoring at device and dwelling level and the connections to the controllable DERs. In this group we can include other traditional ESCO retrofitting services

EE: Energy Efficiency 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.

FL: Flexibility 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.

NE: 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.

In table 2, SP8 on non-energy services and SP9 on smart readiness assessment are considered optional and discretionary and could always be contracted complementarily to any other service package. RT1 on data platform hardware retrofitting and RT2 on data monitoring and personalised informative billing are considered as the minimum/default services of any bundle. The rest of the services are to be chosen in sets according to the type of customer and building. The recommendation is always to offer the largest service choice as it increases the potential sources of revenue streams for the building residents, with similar levels of equipment and upfront costs. In this sense, energy efficiency services are applicable to every customer, with the possibility to opt for only implicit efficiency services (SP1), only explicit efficiency services (SP2) or both (SP3). SP1 would be recommended for those users who are sceptical about an intrusive system operation, prefer to have full control of their energy consumption devices and DERs and take informed decisions on the energy usage. SP2 is meant for those who rely on the automatic algorithms and are willing to grant control of their DERs, even if subject to user-defined constraints. The best for consumers would be to leverage value from both sources of efficiency to maximise the total savings, opting for a SP3. Prosumers have yet another option to add the self-consumption optimisation service included in the SP4 to obtain the maximum possible energy savings available in the frESCO solution. SP1 to SP5 packages are managed by an ESCO.

For users living in countries where aggregated demand response is an accepted energy asset in the energy markets and accept a certain degree of overridable intrusion that should not affect their comfort choices, the SP5 package with the demand flexibility awareness and aggregation capabilities is meant for them. SP5 is managed by an Aggregator.

The ultimate target of the frESCO energy services set is to combine revenues from both efficiency and flexibility services, ensuring a double revenue stream stemming from energy savings and from the remuneration of the demand flexibility in open markets. Consumers may then have the option to choose SP6 that combines energy efficiency and demand response services. In the case of prosumers, the flexibility potential increases, and so does the savings by the addition of the self-consumption optimisation service in SP7. This distribution by type of consumers is summarised in the table below.

Table 3. Service packages by type of end-user

SP number	Type of users
SP 1	Closed flexibility markets, does not accept remote operation
SP 2	Closed flexibility markets, does only accept remote operation
SP 3	Closed flexibility markets, does accept remote operation
SP 4	Prosumer that accepts remote operation in closed DR markets
SP 5	Consumer that accepts remote operation in open DR markets
SP 6	Consumer that accepts remote operation in open DR markets with efficiency
SP 7	Prosumer that accepts remote operation in open DR markets
SP 8	Consumers/prosumers that want non-energy additional services
SP 9	Consumers/prosumers that want smart readiness assessment and certification

The following chart depicts the different bundling of energy services as commented before.

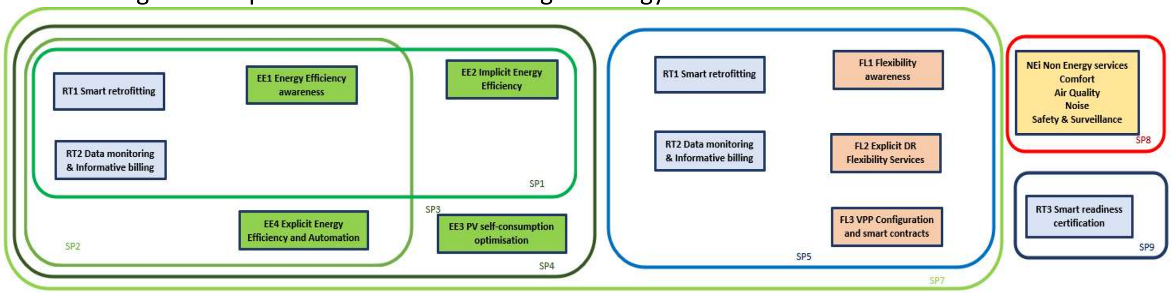

Figure 11. Service package bundling in frESCO

4 ENERGY SERVICE STAKEHOLDERS AND VALUE CHAIN DESCRIPTION IN FRESCO

In this document, a mapping of costs and revenues for the frESCO preliminary business models is depicted. Costs are associated to activities, and activities to roles and actors. Thus, the first step is to define what activities are required to deliver the proposed services, who should be doing them and what type of costs are incurred by each stakeholder in the value chain.

4.1 frESCO service stakeholders.

Besides building residents and facility managers, who are the final beneficiaries of the energy services, enjoy the energy savings and provide the demand flexibility to the grid operators, the two main business actors are ESCOs and Aggregators. ESCOs are interested in delivering energy efficiency services (SP1 to SP4) and aggregators extract and aggregate demand flexibility to valorise it in energy markets and distribute the economic payments to the participant flexibility providers (SP5).

An extension of the business role of either the ESCO or the Aggregator shows up as a result of the provision of hybrid energy services such as SP6 and SP7 packages, that combine efficiency and flexibility. Originally, it could be either an ESCO that extends the service portfolio towards the flexibility aggregation business or an Aggregator that additionally offers energy efficiency services.

Finally, there are a number of auxiliary companies that may take part, directly or indirectly in the frESCO service value chain, mainly to assist the ESCO/Aggregator service provider in the actual delivery of services. Some of them are:

- Hardware manufacturers/suppliers: Most of the hardware is standard and commercial, starting from the data gateway or energy box and following with the data sensors, meters, clamps, actuators, smart plugs and other IoT systems. Configuration and pre-installation of standard elements still lies with the service provider company.
- Local installers: Installation is not straight forward and, in most cases an onsite visit will be needed to install the system in premises. Due to the dispersion of users, this part of the value chain may be subcontracted to external local installers, supervised by the service provider.
- Information and Communication Technology (ICT) service companies: The data management, quality assurance and hosting services, together with the data analytics performed over the data generated by the building sector may be subcontracted to an ICT service company as this is not the core business of ESCOs or Aggregators. This way, there is no upfront costs, and the storage size may adapt easily to the customer base.
- Financing entities: Upfront costs may be borne by the users, by the energy service provider or by a financing third party company. This is especially relevant if the retrofitting scope goes beyond the data platform hardware needs, and hence, the initial costs increase substantially (new PV facility, a smart heat pump or building insulation improvements).

In the case of the flexibility services, there is another type of stakeholder who initiates the request of demand flexibility and pays the aggregator for the delivered demand response. This actor is usually a grid operator or manager such as a Distribution System Operator (DSO), that requests flexibility to resolve grid congestions or voltage violations, or a Transmission System Operator (TSO) that requests flexibility for grid balancing purposes. These actors do not participate directly in the provision of the service, but they are part of the value chain of flexibility services.

The summary of actors with activities and roles within frESCO business models is represented in the following table, showing in bold the most important stakeholders.

Table 4. Main stakeholders of the fresco business models.

Actors in frESCO energy efficiency business model	what does the actor do?	Role
Energy Box manufacturer	Manufacture, connect and configure E Boxes	hardware builder and provider partner
Equipment supplier	supply hardware equipment	hardware builder and provider partner
ESCO	Offer, analyse, deliver, manage	Business portfolio manager
Building / Facility manager	Contract, maintain, finance	Service demander and user
Users	Contract, finance, save	Service demander and user
Auditor	energy / smart readiness audit	Local business assistant / partner
Installer, maintainer	Install, connect, maintain, fix	Local business assistant / partner
ICT service provider	end-to-end data management and analytics	business assistant / partner
Financing institution	finance	Financing
Actors in frESCO demand flexibility business model	**what does the actor do?**	**Role**
Energy Box manufacturer	Manufacture, connect and configure Energy Boxes	hardware provider
Equipment supplier	supply hardware equipment	hardware builder and provider partner
Aggregator	Analyse, cluster, segmentate, aggregates, dispatches	Service deliverer and manager partner
Retailer	Information provider for users, ToU tariffs	
DSO	Request, auction, use, pay	Service demander and user
TSO	Request, auction, use, pay	Service demander and user
Users	Sign up in events, get paid	Flexibility provider
Installer, maintainer	Install, connect, maintain, fix	Local business assistant / partner
ICT service provider	Data management, quality assurance, hosting and analytics	business assistant / partner
Financing institution	finance	Financing partner

4.2 frESCO service value chain

There are four main phases in the fresco service value chain where different activities are carried out implying upfront and operational costs. These phases are:

- Business opportunity assessment and personalised offer for end-user engagement. This is mainly a technical and commercial phase led by the Service provider. This phase ends at the service contract signing. In order to assess the suitability of the fresco services and the efficiency and flexibility potential, this phase may involve some data analysis or energy pre-audit.

- Commissioning and installation of the frESCO data platform solution. Once the contract has been signed and following a smart readiness assessment to devise the needs of data sensors and meters, the commissioning of the hardware components follows. Next steps are the pre-installation and configuration of the Energy Box gateway, the delivery of the hardware and the installation in premises, along with additional metering equipment and smart actuators. All costs involved in this phase are upfront costs.
- Energy service delivery. This is the phase in which the efficiency and flexibility actions take place along the contract timeframe. During this phase a continuous PMV protocol is applied to measure efficiency on one side and eventual flexibility on the other, and share the revenues fairly between the energy service provider and the beneficiary. The settlement and remuneration are done by the service provider on a regular basis ensuring the upfront cost payback, the coverage of the redundant operational costs and leaving enough incentives to the end user.
- End of contract. At the end of the contract or when the parties decide to cancel the contract, a final settlement is done to compensate for the early-cancelation unpaid costs and to dismantle the platform related hardware. The end of the contract may be an opportunity for a better suited new commercial proposal for the continuation of the service delivery by means of a new contract signing.

The fresco service activities and associated costs per phase can be found in the following table.

Table 5. frESCO service value chain activities and associated costs.

Phase	Service	Who	Cost	Type of cost
Business opportunity and personalised offer	Energy and smart readiness pre audit	ESCO	Audit cost	Usually remote preaudit with data provided by customer
	P4P service proposal	ESCO	commercial costs	commercial costs
	P4P contract negotiation and signing	ESCO / User	commercial costs	commercial costs
	Upfront cost financing	ESCO / User / Financing institution	interests	If external financing needed
Commissioning and Installation	Smart readiness assessment	ESCO	Audit cost	May include on site audit if requested by end user or deemed necessary by ESCO
	Hardware commissioning and procurement	ESCO	Upfront cost	smart meters, sensors, clamps, actuators, other smart equipment
	Hardware manufacturing	manufacturer	Upfront cost	Energy box
	Retrofitting element procurement	ESCO	Upfront cost	smart equipment, envelope insulation, PV facility, other retrofitting
	System integration	ESCO / ICT service provider	Upfront cost	Energy box connections / data platform integration
	System installation. Connection and testing	ESCO / Installer	Upfront cost	On site installation
	Smart readiness certification	ESCO	Audit cost	Only if requested by end user
Service delivery	Energy efficiency services and PMV	ESCO	Operation cost	It includes EE service delivery together with associated data hosting and analytics costs
	Flexibility services to the grid and PMV	Aggregator	Operation cost	May include Virtual Power Plant (VPP) configuration, aggregation, market participation costs, biding, penalties – data hosting and analytics execution costs are included, as well
	P4P Service settlement and remuneration	ESCO / Aggregator	Operation cost	Includes PMV, reports, billing and settlement, together with data hosting and analytics execution costs

	Non-energy service provision	ESCO	Operation cost	It includes non-energy service delivery, together with associated data-relevant costs
	System maintenance	ESCO / Installer	Maintenance cost	May include Hardware and IT platform maintenance costs.
	Periodic service adjustments and adaptation	ESCO / Installer	Maintenance cost	Variable. Triggered by either ESCO / Aggregator or end user
End of contract	System dismantling	ESCO / Installer	Maintenance cost	Low, or none
	Final settlement. End of contract.	ESCO / User	commercial costs	Low, or none
	New service proposal	ESCO	commercial costs	commercial costs

The link of value chain activities per phase can be graphically seen in the following chart. The blue arrows represent the link of staggered sequence of activities. Supply, manufacture, install and maintain are all activities either performed by the service provider itself (ESCO / Aggregator) or subcontracted under the direct request and supervision of the service provider. Chart color coding is shown below.

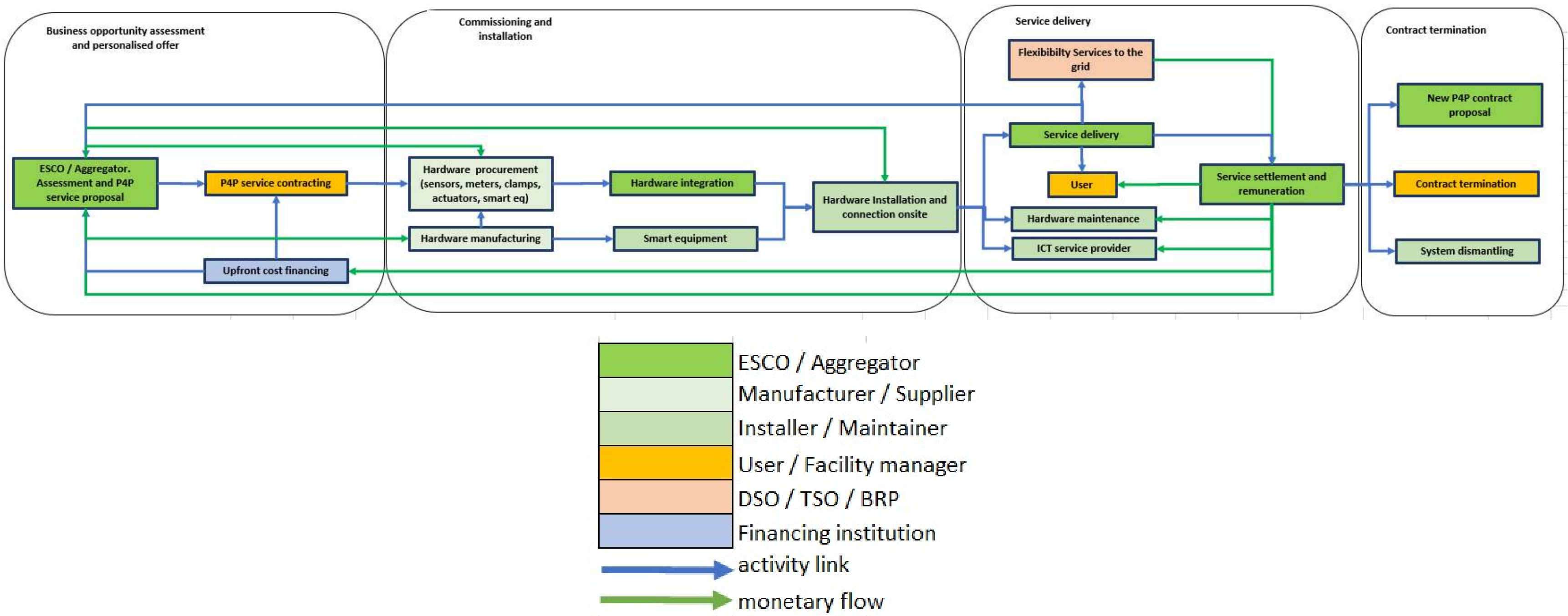

Figure 12. frESCO energy service activity mapping and value chain per phase and stakeholder involved.

5 ASSETS AND COSTS OF THE FRESCO ENERGY SERVICES

Once the map of activities per phase is clear, the next step is to assess the costs of every activity and phase. This is a challenging exercise since there is not real market reference for many of the activities as they are brand new and comprise innovations proposed in the frESCO project. Hence, we have chosen to approach this using approximate possible ranges of costs of the different activities in order to delimit the economic model boundaries at the upper and lower limits.

Costs are then separated between one-time upfront costs for the commissioning, retrofitting and installation of the platform, and operational costs that include operation and maintenance costs. The latter costs are considered to be recurrent on an annual basis.

5.1 Upfront costs

Services are deployed at dwelling level. Hence, a full platform that offers data collection, storage, and activation infrastructure, needs be installed in every dwelling. The economic analysis is then performed in euros per dwelling. However, there is a large range of systems and installations depending on various factors.

- Number of services contracted. It is considered a SP7 package including efficiency, PV optimization and flexibility services. The difference with a SP4 and SP5 only setup is minimum or none.
- Number of DERs to be controlled. The more controlled DERs the larger the saving and flexibility opportunities but the more complex the installation becomes. Each controllable DER requires a specific metering system (usually a metering clamp installed in the corresponding circuit of the inlet connection box). In addition, each DER may require control variable metering like water or ambient temperature sensors, presence sensors or others.
- Dwelling smart readiness. Number of smart DERs available with easy straight connection to the platform gateway. These devices may be controllable straight away with no need of further sensors, signals or actuation systems.

In most cases the following hardware is likely to be required:

- Energy box or communication gateway where all metering data and sensor signals are connected. This system ensures the data is collected and sent to the data platform. Internet connection available for the communication with the platform is necessary but assumed present (no additional costs). Synergies may be found to connect more than one dwelling to the same gateway but it may not be the general case. The cost depends a lot on the order size and the standardisation of the gateway ports and components.
- Sensors, according to the load and demand under control. Usually indoor temperature sensors, presence sensors and sensors associated to specific non-energy services (noise, air quality, …). From 1 to 3 per dwelling, no special sensors considered.
- Smart meters. They could be connected to the energy box for energy metering. They are supposed to be present or be replaced by metering clamps linked to every controllable load.
- Actuators and smart plugs for automation and remote DER control if they are not already equipped with controllable interfaces. From 1 to 3 planned per dwelling.
- System integration and testing. All the equipment, whether connected by cabling or remotely by wireless communication protocols, are supposed to be installed, configured and tested at the service provider premises to reduce uncertainties and overheads on site. This step could be skipped for easy or simple installations or when dealing with advanced users/installers. One hour work is assumed necessary.
- On site installation by a specialised subcontractor or installer.

Commercial costs for customer search, presentation of economic offers, negotiation and contract signing are not accounted for. With these hypotheses in mind the total cost for the onsite hardware installation ranges from 451 € to 1082 € per dwelling. Real and more concrete data will be gathered at the demo sites to narrow down the cost range.

5.2 Operational and maintenance costs

The platform runs autonomously and once installed requires very little operation and maintenance cost. These costs are fixed and at dwelling level, they get reduced depending on the number of customers served. The type of recurrent fixed costs for the service provider are:

- Maintenance costs of the hardware onsite. Sensors, meters and equipment are standard, commercial and reliable. If any problem occurs (communication loss, breakdowns, …) the most likely solution is the replacement of the affected component. The cost increases since it has to be done on site. Other than corrective, there is no preventive maintenance foreseen.
- Data hosting and analytics execution. The platform performs a variety of functions and services such as data storage, cleaning, quality assurance, security, interoperability, that entail some costs depending on the size and complexity of data. The main cost with regards to the platform comes with the execution of analytics that may be high enough based on the frequency of analytics execution, data involved in analytics etc. These operational costs involve EE service delivery, Virtual Power Plant (VPP) configuration, aggregation, market participation costs, biding, penalties, PMV, reports, settlement and billing.

Since once initially calibrated and fine-tuned, the platform is capable of dealing with many customers as low manual operation is required on exceptional basis, costs may be irrelevant compared to the per-dwelling upfront costs. From 1,000 users onwards, a first rough estimation is that operation requires from 1 to 2 persons full time, usually dealing with exceptional issues.

With the above hypotheses, fixed running costs per year are estimated from 35.500 € to 71.000 € /year. For a customer base of 1,000 users, this would represent from 36€ to 71 € per dwelling and year. These costs may only represent a serious setback for small customer basis. Again, these numbers should be validated at the testing phase.

On top of these, we need to include costs at the range of approximately 5000-10000 € per month per 1,000 customers for services provided by the platform (hosting/storage, cleaning, analytics execution). This estimation that may change depending on the volume/ granularity of data and the frequency of analytics execution. This adds from 60€ to 120€ per dwelling and year of operational costs.

6 REVENUE MODELS OF THE FRESCO ENERGY SERVICES

The revenues stemming from the frESCO energy services are obtained by the end-user and verified, managed and settled by the energy service provider. For the hybrid frESCO service packages there are three sources of revenues.

- Energy efficiency services: Implicit or explicit energy management should lead to the realisation of energy savings for consumers. Self-consumption optimisation may increase energy services for prosumers. Residents directly enjoy the economic and energy savings and pay the service provider in proportion to the measured and verified savings.
- Energy flexibility services: Participation in open demand response energy markets is enabled through the aggregator, who represents the users in the energy markets, aggregates the required flexibility, delivers it when it is needed by the grid operator or the balance responsible party and gets paid for it at the agreed bid price. This market payment is distributed among the participating consumers/prosumers according to the measured and verified energy flexibility provided.
- Non-energy services: End users contract other wellbeing services with two payment options in a P4P approach:
    - End users pay a fixed amount per billing period that is diminished according to the verified time or deviation from the ideal contracted conditions (indoor temperature, level of noise, CO2 concentration, others).
    - End users pay a variable amount according to the verified time or compliance with the ideal contracted conditions.

A sharing coefficient for energy savings or flexibility remuneration shall be agreed in the contract. This share depends on who bears the system upfront costs since the remuneration system should ensure a short and safe payback time. A high share for the user will represent a more interesting incentive for new customer engagement. In any case, revenues are directly linked to a P4P measurement and verification methodology.

6.1 Energy service performance verification and settlements

The assessment of revenues in the fresco P4P contract scheme is based on a fair and accurate measurement and verification methodology with data-driven baselines that are designed depending on the energy output to verify. Therefore, two different baselines and verification approaches are being developed in T3.4 to assess, on one side the energy savings stemming from energy efficiency services in a holistic view, and on the other side the energy flexibility at every single demand response event and per load according to the VPP configuration.

6.1.1 Energy efficiency savings. PMV and baseline needs

The objective of the PMV linked to the energy efficiency services is to measure objectively the energy savings obtained in every period as a result of the different energy efficiency and optimisation services contracted. The energy savings shall be determined in economic terms, to be aware of the benefit made by the service beneficiary and the amount to be paid back to the ESCO for investment payback and remuneration of running costs. Energy efficiency measures are of different kinds:

- Retrofitting measures, both smart equipment, but also other type of building retrofitting. This includes former traditional EPC services.
- Implicit efficiency measures based on customised recommendations for behavioural change, starting from informative billing information.
- Explicit efficiency measures based on the scheduling and automation strategies on the controllable DERs.
- Self-consumption optimisation for prosumers, saving energy from the grid.

The nature and type of efficiency measure is very broad and may encompass one or more type of loads. Hence the approach here is to assess savings from a holistic perspective at dwelling level. Savings may be subject to climatic seasonal variations. Hence the baseline should include all the dwelling demands in the long and medium term. Baselines should be at least annual but seasonal baselines could adapt better to the dwelling demands.

The new PMV for energy efficiency can be partially based on existing protocols such as the International Performance Measurement and Verification Protocol (IPMVP) by the Efficiency Valuation Organization (EVO). This standard Measurement and Verification (M&V) guideline has four measurement methods to reliably determine actual savings. The two applicable to frESCO are:

- IPMVP Option C. Whole Facility – Savings are quantified by measuring energy use at the whole facility or sub-facility over a given reporting period. Measurements are recorded continuously throughout the length of the reporting period. Adjustments can be routine or non-routine [5].
- IPMVP Option D. Calibrated Simulation – Savings are determined through a simulation of the energy use of the whole facility or sub-facility. The simulation aims to demonstrate and model actual projected energy performance [5].

The fresco PMV is a combination of the two above options with the main difference being the data-driven generation of the baseline. In this sense a seasonal and annual data collection is needed from the platform sensing and metering capabilities to build the long-term baseline. Once the baseline is set, it will be used periodically to compare the actual overall energy demand with the baseline, calculated with the seasonal parameters registered in the platform. Hence, adjustments are not deemed necessary and would only be done in exceptional cases. Refer to deliverable D3.4 for more information about the frESCO PMV methodology.

6.1.2 flexibility remuneration settlements. PMV and baseline needs

Demand flexibility is executed on demand and is event-based. Hence, demand response has to be assessed on event bases, to be able to measure the amount of flexibility delivered upwards (increase demand) or downwards (decrease demand). Those events are all short duration, between 15 min to 2 hours and they are triggered by the demand response market operator, usually DSOs, TSOs and BRPs. Hence the type of baseline needed in the measurement and verification of demand flexibility is completely different as it needs a short or very short time forecast prior to the scheduled starting time of the event. This baseline is dynamic and evolves as new data feeds the forecast models. Hence, the baseline gathers all climatic, human choices, and context variations taking place on a continuous basis.

Flexibility is extracted per controllable DER or dwelling energy demand (HVAC, Domestic Hot Water (DHW), PV, storage, …). Hence, baseline models are pre created to model the behaviour of each energy demand. To have an initial baseline, a minimum training period of the models for 15 days is to be planned, prior to the first event.

Every billing period should encompass several flexibility events. The energy shift delivered per load and per event is aggregated in the final bill, according to the sharing percentage in the aggregation contract.

6.2 Revenue estimation in different scenarios

In order to estimate accurately the revenues expected from the deployment of efficiency and flexibility services a range of energy performance targets should be worked out per type of service. Both energy efficiency and flexibility should have a correlation with the amount of energy demand of a dwelling. Hence, it is sensible to propose targets as a percentage of total annual consumption. Dwelling with higher energy consumption have higher chances to obtain larger savings or demand flexibility. This consumption is partially affected by the dwelling size, the number of residents, the climatic conditions, the type of building and thermal insulation and the users' consumption patterns.

However, there are many other factors per dwelling in this estimation such as the number of electric controllable DERs involved in the services and the right use of the platform data. There is not real data at the time of writing this document and hence, reasonable guesses have been taken, to be validated with real measurements at the demo sites in different dwellings throughout the four demo sites.

6.2.1 Energy efficiency target

The following energy efficiency targets in percentage of total electricity demand for every family of energy services have been assumed, coming from the frESCO proposal hypothesis:

- Retrofitting of smart equipment, consumption awareness and informative billing: from 5% to 15%. Assumed 10% energy savings.
- Energy efficiency implicit savings, based on informed decisions by users and behavioural change. From 5% to 14%. Assumed 12% with engaged users.
- Energy efficiency through price-based scheduling and automation strategies. Assumed 5%.
- Energy efficiency coming from the PV self-consumption optimisation of energy demand to shift loads from low to high generation availability. Assumed 5%.

Some implicit and explicit measures may overlap. The total energy efficiency is verified holistically with respect to the former energy baseline and settled together, whether they stem from implicit or explicit strategies. The total energy efficiency target is estimated to be 32 % but the range varies greatly from 12% to 51%.

These targets in percentage terms are applied to average residential energy demands and are calculated on monthly bases for billing and settlement, and annual bases for upfront cost payback estimations. Every dwelling has different consumption levels, depending on the dwelling size, average occupancy, climatic zone and heating energy source (gas, fuel, electricity, biomass or logs). Annual average consumption in Mediterranean countries such as Spain, Croatia or Greece is around 4,500 kWh/dwelling for a 70 - 90 m2 dwelling but the dispersion is huge, moving from 3,000 to 8,500 kWh/year.

Finally, energy efficiency is monetised at the variable cost of the electricity supply tariff that changes among retailers, countries and hours for Time-of-Use (ToU) tariffs. For final energy consumers, taxes related to the electricity are part of the economic savings. Tariffs including taxes may vary between 10 to 18 c€/kWh. An average price cost of 0.13 €/kWh has been taken. With these hypotheses, an average dwelling would obtain 183 €/year of savings, to be shared between the ESCO and the end users, as a reference value.

6.2.2 Demand response targets

Demand flexibility targets per dwelling are also hard to estimate. Flexibility depends on the width of the users' comfort preferences and the energy storage capabilities. The use of batteries increases enormously the flexibility targets as the energy can be stored and released on demand in the presence of a flexibility event. Other energy storage sources like building thermal storage can increase substantially the demand response capacity of a dwelling. This can be achieved by good insulation layers.

However, demand flexibility varies with time and users' energy profiles. This makes difficult to have an accurate assessment of the flexibility to be obtained from residential buildings. Another important factor is the market request of flexibility as events are triggered in response to grid unbalances or congestion issues and these grid issues can be addressed with other energy resources. A reasonable target could be 5% to 10%. Measurements taken in the FLEXCoop project in residential dwellings showed a 7% energy flexibility target.

Flexibility is compensated using competitive bids triggered by the grid operators in open markets and competing with other balancing and grid management energy sources. The price again depends on local markets and event times and are fixed by the market bids and subject to economic penalties in case of delivery failure.

Different flexibility markets have been analysed. The only open market within the frESCO demonstration sites is France, whose remuneration is between 0.13 €/kWh and 0.18 €/kWh (source: VOLTALIS). Other relevant markets open to flexibility sources in the ancillary service market is the UK market, paying from 0.05 €/kWh to 0.07 €/kWh. In the Netherlands the remuneration level in the manual Frequency Restoration Reserve (mFRR) market goes from 0.08 €/kWh to 0.17 €/kWh (source: FLEXCoop project D7.5). An average of these three markets gives a remuneration price range between 0.09 €/kWh to 0.14 €/kWh. For the standard case, it is taken as 12.8 c€/kWh. All these assumptions should be validated in the testing phase.

An average dwelling of 4,500 kWh/year would get 35.8 €/year of remuneration from the Aggregator for the annual flexibility. This amount should be distributed between aggregator and end user.

7 RECOMMENDATIONS FOR ECONOMIC FEASIBILITY OF THE DIFFERENT BUSINESS MODELS.

All the above values are based on a preliminary assessment and have to be validated in the testing phase. At this point, they provide a reference working ground to develop the frESCO business models in task T3.3. They can be used to estimate the boundary limits or minimum requirements that frESCO service beneficiaries should comply with to ensure economic feasibility of the business models. The economic feasibility criteria is set to 11 years maximum payback time for the provision of services that combine energy efficiency and flexibility. Let us depict several scenarios to find the extreme values for each parameter. Let us consider a 50% benefit sharing between service provider and user.

The worst-case values are economically unfeasible from any point of view. The average case has a payback of 12.9 years and overall annual incomes per dwelling of 220 €/year to be shared equally between consumer and service provider. The best-case values give a payback time of just 1,7 years and total incomes of 570 €/y. In between these two extreme and unlikely cases there is a variety of scenarios that can be assessed with a sensitivity analysis per main involved factor, always starting from the general average case and aiming at a minimum 11-year payback time. The following table shows the boundary max. and min. range values, the best and worst cases, the average case and the optimal case or combination of factors to reach this minimum 11-year payback time.

Table 6. Max and min values, average, worst, best and optimal case scenarios for economic feasibility of frESCO energy services.

Factor	Min values	Max values	best case	worst case	Average case	Optimal case for payback
Upfront costs in €/dwelling	451 €	1.082 €	451 €	1.082 €	767 €	600 €
Operation costs per year in €/y	35.000 €	70.000 €	35.000 €	70.000 €	52.500 €	52.500 €
ICT operation and Hw Maintenance costs in €/dwelling	70 €	140 €	70 €	140 €	105 €	100 €
% share for ESCO / Aggregator	60%	30%	60%	30%	50%	54%
average dwelling electricity consumption per year in kWh/year	3,000	8,500	8,500	3,000	4,500	5,500
average variable cost of electricity in € / kWh (taxes included)	0,10 €	0,18 €	0,18 €	0,10 €	0,13 €	0,14 €
average biding price of flexibility in electricity markets in €/MWh	88 €	139 €	139 €	88 €	114 €	114 €
Number of consumers/prosumers	1,000	10,000	10,000	1,000	3,000	3,000
Payback (years)	No payback	35,1	1,7	No payback	178	11

- Upfront costs: The average case shows a maximum upfront cost below 600 €/dwelling to ensure payback below 11 years. This target is lower than the average upfront costs calculated of 767 €/dwelling, so an effort to reduce these costs about 22% should be made. This is a very influencing factor in the feasibility equation and should be given a high priority.
- Operation costs: Operation costs should be kept around 20,000 €/year which is below the minimum estimated cost of 35,500 €/y. This can be achieved by increasing the number of users while keeping the operation cost constant.
- Average dwelling energy consumption: The average user should have a minimum consumption of 5,500 kWh/year to hit the 11-year payback target. This is well within the maximum expected value of 8,500 kWh/year per dwelling.

- The average price of electricity supply should be above 0.14 €/kWh to achieve feasibility. This is realistic and below the maximum price of 0,18 €/kWh for the domestic retail sector.
- Demand response average bidding price: should be above 182 €/MWh, what seems too high to be competitive with current generation-side services. The reason is because flexibility services contribute to a lower extent to the total new energy service remuneration, just 16% of all expected incomes.
- ICT Operation and HW maintenance costs should stay below 100 €/year per dwelling.
- Finally, the benefit sharing of the average case should be above 50 % (55%) for the service provider, in order to ensure the 11-year payback target, thus limiting the incentive of final customers that would receive a payment around 135 €/year benefit. This benefit may not be interesting enough to attract domestic residents towards new P4P service contracting.

This sensitivity analysis sheds the following final conclusions in the search of potential end users of the new FRESCO service packages as qualifying criteria.

1. Only the combination of energy efficiency and flexibility services may derive enough incentives for both main actors service providers and end users.
2. Upfront costs are critical and should be kept low. For that a good smartness level and low need of extra metering and sensing equipment is highly recommended to keep costs below 600 €/dwelling.
3. High electricity consumption dwellings above 5500 – 6000 kWh/year. Dwellings with main HVAC demands being supplied from other energy sources (gas, biomass, fuel) need a retrofitting or are not qualifiable for frESCO services a priori.
4. A minimum number of users of the platform to bear the operation costs are mandatory. This minimum level is estimated around 3,000 – 3,500 users. A critical customer base mass has to be achieved.
5. It is very likely that the benefit sharing coefficient between service provider and end user be higher than 35% for the company to ensure the minimum payback time target.
6. The lack of self-consumption or closed flexibility markets hinder the feasibility as only implicit and explicit energy efficiency can be obtained. In this case, the default scenario

leads to a payback of 27 years. In this case, the benefit sharing coefficient for a qualified end-user may go up to 50% for a minimum payback time of 11 years.

7. If all upfront costs are born by the ESCO / Aggregator, the income sharing ratio should be above 50% in favour of the service provider.
8. Additional revenues coming from other opportunistic services non-directly related to energy services are not included in the simulations but would imply a supplementary revenue stream that would cut payback times.

These recommendations will be validated in the testing phase along the project. However, the frESCO services feasibility analysis for every user has to be done on an individual basis since not all users may obtain enough revenues to payback the system costs.

8 CONCLUSIONS

The new frESCO business models for ESCOs and aggregators provide advanced data-driven energy services to residential consumers and prosumers under the Pay-for-Performance concept. This concept relies on precise and accurate dynamic baselining that allows to measure fairly the energy performance of the different energy services and distribute the benefits between the building users and the service providers. Service packs are being proposed, with different P4P approaches:

- Energy efficiency services include implicit (behavioural change based) and explicit (automated scheduling and DER control) services to obtain energy savings with respect to an ex-ante situation. Additionally, prosumers may benefit from an optimal self-consumption strategy that increases the energy savings from the distributed generation resources. Revenues are verified in a holistic way at dwelling level using data-created seasonal demand baselines and the savings are shared between the users and ESCOs.
- Demand flexibility services include the configuration of Virtual Power Plants that can be set up in response to a demand response event triggered by a grid / market operator. Flexibility is delivered in events and revenues are retributed by the market. These revenues are assessed by means of short-term demand baselines adapted to the loads involved and continuously fed with situation and consumption data retrieved by the platform. This dynamic data-driven baseline ensures a continuous measurement and verification of the flexibility delivered and enables the Aggregating company to settle payments proportionally to the individual consumer contributions.
- Non-energy services include other value-added services driven by the platform real-time data. Performance towards the objective (air quality, temperature, comfort, noise, presence, …) is continuously measured to charge users in accordance to the service output delivered.

On the side of the costs, there are two types of costs to be borne by the service providers:

- Data platform setting up costs per dwelling, including the manufacturing and purchase of equipment (gateway box, sensors, meters, clamps, actuators, …) and the installation and testing on site. It is the main cost of the services.

- Running costs: these recurrent costs include the platform operation costs, the storing and computing cloud resources and the maintenance. It also includes maintenance for the system installed in the users' premises and are estimated per year.

First estimated numbers show that the frESCO services are economically feasible, but some minimum pre-qualifying requisites are to be met by the dwellings and the service provider to ensure payback periods lower than 11 years. Among others, the main factors affecting the economic viability of the frESCO services are:

- Upfront costs need to be the lowest possible, leveraging from existing infrastructure and limiting the number of onsite visits. A reference value could be 600 €/dwelling
- The maximum number of services should be contracted simultaneously, thus increasing the revenue sources (efficiency, optimisation, flexibility and non-energy services)
- Dwellings should have a large electricity demand, above 5500 kWh/year
- The service provider customer base should be large enough to share the running costs. A reference number indicates above 3,500 users.
- The benefit sharing should not be lower than 35% in favour of the financing service provider.

Nevertheless, cases should be assessed one by one and real testing data are needed to validate or correct the assumptions made in these preliminary calculations. This is the purpose of the modelling and simulations of the business models in task T3.5 and the WP6 frESCO demo-site testing.

9 REFERENCES

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10 ANNEXES

10.1 Annex 1

Table 7. List of frESCO 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