ambience

Active managed Buildings with
Energy performaNce Contracting

Results and lessons learned from AmBIENCe:

Deploying active building energy performance contracting in the EU

The AmBIENCe Consortium

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1. EXECUTIVE SUMMARY

The purpose of the AmBIENCe project is to reduce the CO_2 emissions of buildings by introducing the flexible use of renewable energy sources in combination with electrification and demand response. By combining energy performance contracting with demand response, we have developed the concept of Active building Energy Performance Contracting (AEPC), which enables new services, new business models and new actors. In recent years, buildings have become more digital and smarter. AEPC extends the classic concept of energy performance contracting to include demand response value streams, and valorise the demand response flexibility that is available in active buildings. AEPC is applicable to a wide range of buildings (including residential buildings), and clusters of buildings. An Active Building Energy Performance Modelling (ABEPeM) platform has been developed to support the forecasting of demand resource value streams in the AEPC contracting phase. The AEPC concept and tool were validated in two pilot buildings.

The introduction of AEPC has several benefits:

Emissions reduction: Greenhouse gas emissions will be reduced by electrification in combination with flexible use of renewable energy which move electricity consumption to times where carbon intensity is the lowest.

Cost savings: Energy costs will be saved by shifting consumption to times when the electricity cost is low, or by offering flexibility services.

Energy system support: Increased flexibility from buildings can avoid or mitigate problems resulting from increased renewable energy and electrification. As a consequence, AEPC can support more investments in renewable energy and might avoid potential constraints to the distribution grid.

Enriched energy performance contracts: AEPC has a higher value and is applicable to a wider range of buildings than traditional energy performance contracts, providing Energy Service COmpanies (ESCOs) with additional business opportunities.

This report describes the path that was followed within the AmBIENCe project to develop the AEPC concept, the AEPC business models and other material to support the introduction of AEPC.

2. INTRODUCTION

Greenhouse gas emissions have been increasing over the last few decades, leading to global warming that will negatively affect life on earth. All sectors need to take steps to reduce emissions and limit temperature rise. According to statistics from the European Commission (1) buildings are responsible for approximately 40% of energy consumption and 36% of CO_2 emissions in the European Union (EU). Improving the energy and environmental performance of buildings is therefore key, taking advantage of the availability of renewable energy but without compromising the comfort of their users. On top of that, especially with the anticipated electrification of heating, cooling and hot water production, buildings are one of the most valuable resources for the provision of flexibility (as identified in Figure 1) on the demand-side. Identifying smart energy services that increase flexibility from demand-side resources in different sectors can unlock the potential of buildings to save energy and energy costs and to reduce CO_2 emissions. Given that many buildings in the EU are over 50 years old and a substantial part of them are energy inefficient, the renovation of the existing building stock has the potential to trigger significant emissions savings. The use of information and communications technology (ICT) solutions and tools, relying also on big data provided by smart meters and sensors, can help to achieve greater emission savings more cost-efficiently.

Energy performance schemes are an effective means to provide energy efficiency services that can bring added value to the whole chain and contribute to the empowerment of energy end-users. Dedicated service providers, such as ESCOs, aggregators or energy cooperatives can increase the overall benefits by grouping several smart energy services.

By combining demand response actions with efficient control of distributed generation, in particular those units based on renewable energy sources such as solar thermal and photovoltaic panels, it is possible to increase the integration of energy from “zero-emission” power generation through the management and use of these resources locally. This will avoid potential constraints to the distribution grid.

Advances in different technological fields such as ICT, sensors and automated control devices should enable energy savings and costs reductions by going beyond the passive buildings concept (typically involving measures affecting the building envelope, like better insulation and glazing) to actively control buildings’ energy consumption. This approach uses buildings’ inherent flexibility to further reduce losses or costs and maximise the use of self-generated renewable energy.

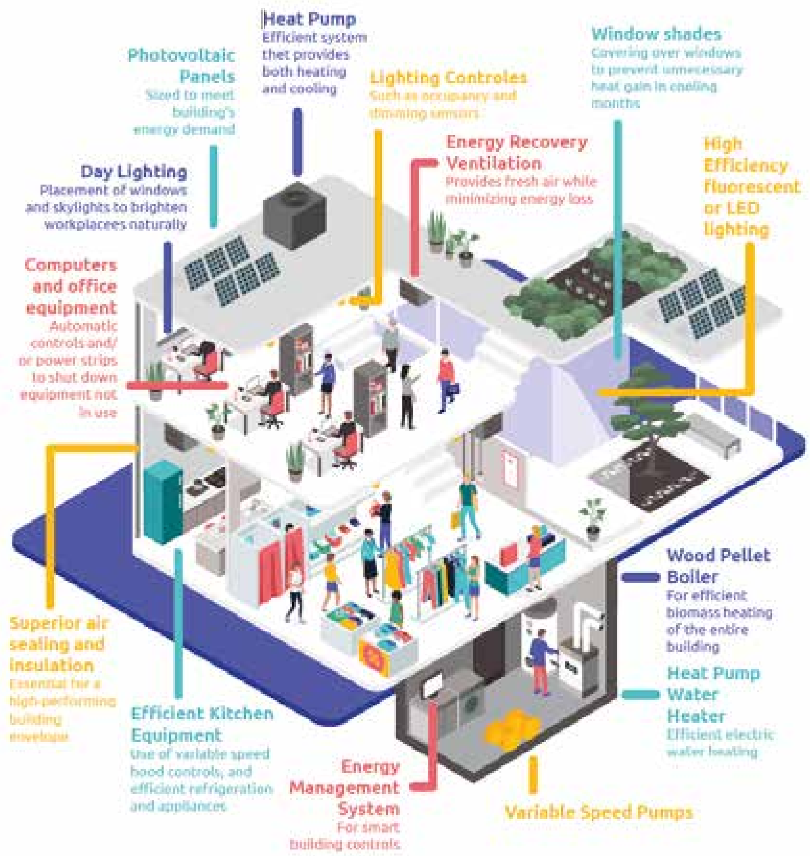
The combination of this approach with energy performance contracting schemes brings us to the AEPC. This implies the use of intelligent and real-time information that allows for new combined services, agreed performance criteria on comfort and safety, and new levels of flexibility.

The AmBIENCe project aims to extend the concept of energy performance contracting to active buildings and make it available and attractive to a wider range of buildings. AmBIENCe provides new concepts and business models for performance guarantees of active buildings, combining savings from energy efficiency measures with additional savings and earnings resulting from the active control of assets, leveraging for instance price-based incentive contracts.

Within the course of AmBIENCe, an integrated modular concept has been developed, as well as a proof-of-concept platform, to support the creation of AEPC.

In this report, we will take you on a tour of the work established in AmBIENCe:

Figure 1 – Flexible assets in a building



3. ASSESSMENT OF ENERGY PERFORMANCE CONTRACTING AND DEMAND RESPONSE SERVICES IN EUROPE

Europe appears to be making progress in fostering the energy transition by empowering end-users and putting them at the centre of the energy system.

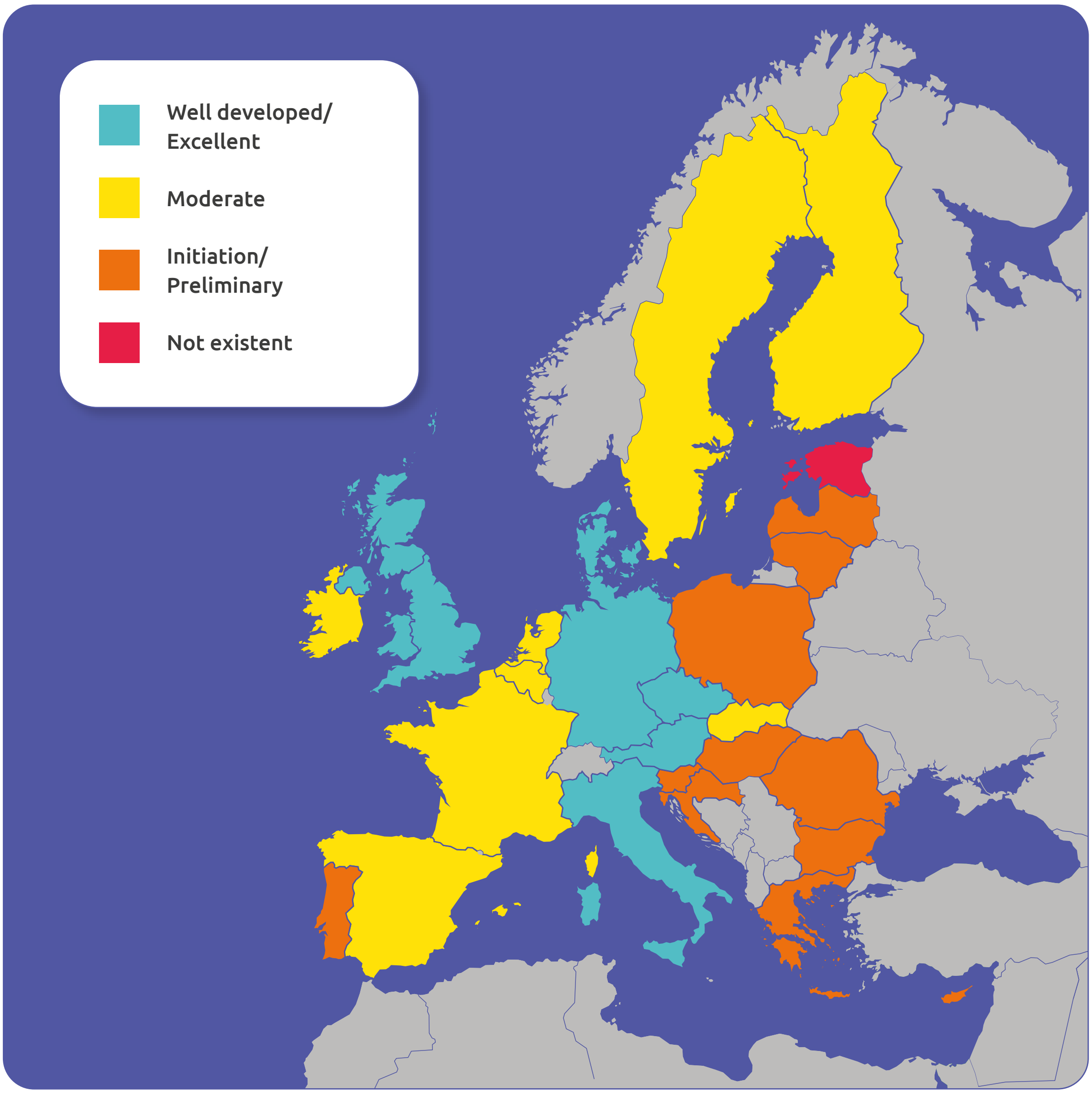
At Member State level, we developed a detailed country analysis for Italy, Belgium, Portugal and Spain, by evaluating the following key areas:

- Current status of Energy Performance Contracts (EPCs)/ESCOs, through the analysis of main regulations, directives and policies on EPC, main types of EPC implemented, and main actors involved in EPC and ESCO market;
- Current status of demand response services, through the analysis of implicit demand response [1] and main type of schemes implemented, explicit demand response[2] and demand access to the markets, to understand the extent to which demand response services can access electricity markets, independent aggregators, regulations/policies supporting aggregation of distributed energy resources, etc.

Italy was found to have the most advanced EPC/ESCO market in the consortium, and indeed the Italian ESCO market is still considered to be among the biggest and most developed in Europe. This is mainly due to the strong legislative background and standards established in Italy for energy efficiency in buildings. Italy is followed by Belgium, where the energy service market is considered stable and moderately-sized, and Spain, where a boom in the energy service market has been long-awaited, based on a complex set of government support measures. By contrast, the ESCO sector in Portugal is underdeveloped and small. Outside the members states of the consortium, the most advanced markets in Europe are Austria, the Czech Republic, Denmark, Germany and the United Kingdom, which are characterised by a well-developed legal framework addressing energy performance contracting and a wider variety of EPC offerings and project facilitators. In many more countries, especially in Eastern Europe, the ESCO/EPC market is still in an early phase, characterised by the lack of legal framework for energy performance contracting and EPC models, mainly due to policy instability and divergent political priorities (Figure 2).

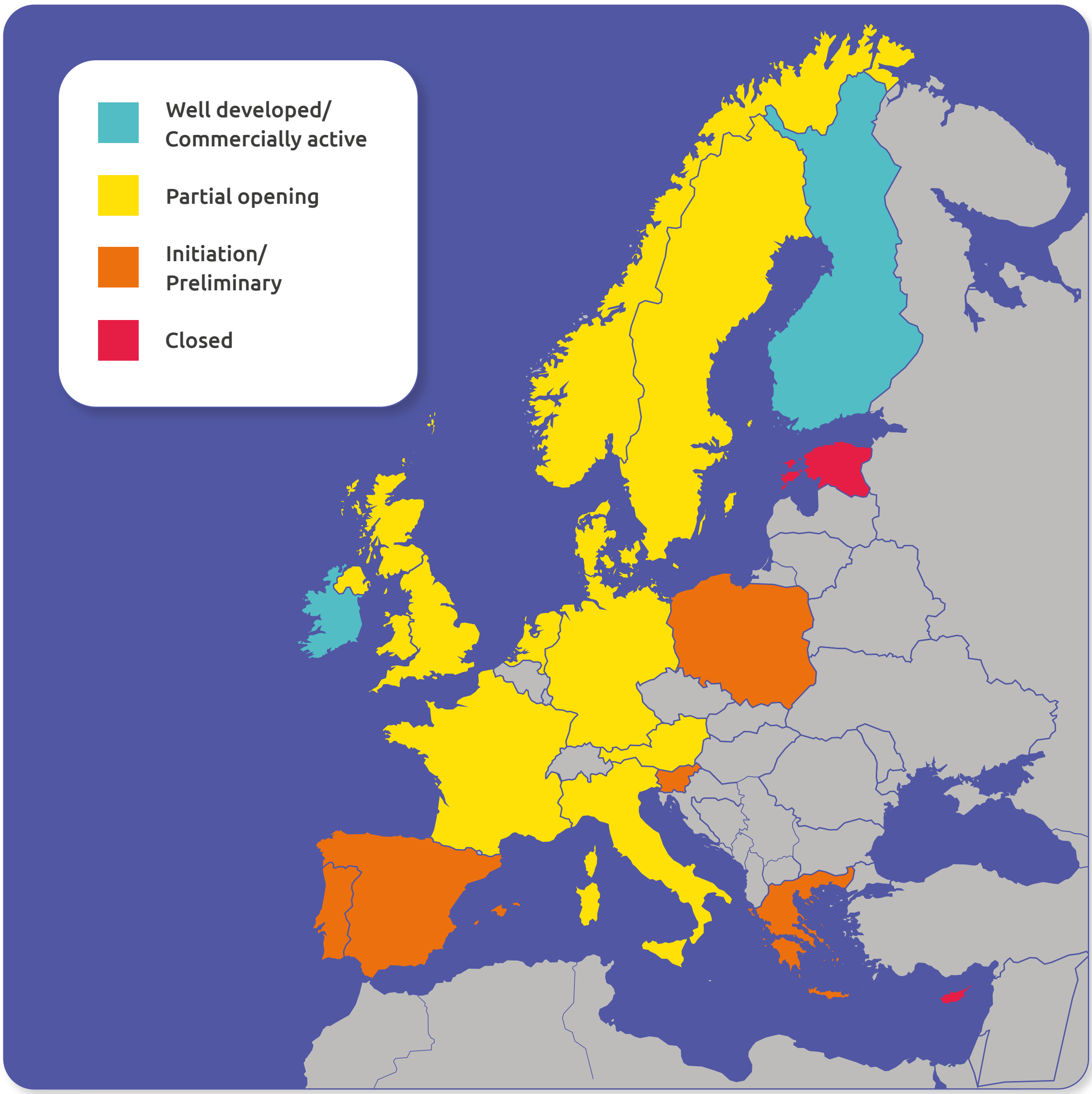
1 Implicit DR implies that end-users adjust their consumption behaviour to time-varying electricity prices
2 Explicit DR implies that end-users respond to a specific request to change their consumption pattern after that they have indicated in advance how much flexibility they have available at which moment.

Figure 2 – Status of ESCO/EPC development for EU countries



With reference to demand response services offered by clusters of buildings, Belgium is the most advanced country in the consortium. Over the last years, the Belgian transmission grid operator has created a new framework to enable participation of new energy sources (such as demand flexibility) with new types of market players (such as aggregators). Belgium is followed by Italy, for which the relevant regulatory framework has been subject to substantial changes since 2017. The Italian regulatory authority for electricity, gas and water undertook a complete review of the ancillary service market to enable the participation of new operators, including aggregators. The aim is to increase the supply of network services necessary for the national electricity system while also integrating these new participants into the electricity system. By contrast, Spain and Portugal are left behind, with regulatory regimes presenting significant barriers to demand response services and asset aggregation. In other EU member states, the most advanced opportunities for demand response services offered by clusters of buildings are found in Finland and Ireland, where demand response participation is allowed in multiple electricity markets thanks to a well-established regulatory framework and positive cooperation between stakeholders (new market actors, regulators and retailers). Once again, there is a much longer list of countries, especially in Eastern Europe, that present significant barriers, such as the absence of regulation allowing the adoption of demand response services, insufficient market players, and a lack of economic and contractual incentives (Figure 3).

Figure 3 – Status of building flexibility for demand response services for EU countries



Finally, the critical analysis performed across EU Member States allowed us to identify the main enablers and barriers for the implementation of AEPC. Belgium and Italy appear well placed to adopt AEPC, as they are in a good position for all the key areas investigated. The main enablers for energy performance contracting include:

- A strong legislative background and standards for energy efficiency in buildings;
- Highly competent ESCOs that can guarantee results, reassuring the customer that they will only pay if the proposed interventions lead to effective energy savings;
- The presence of national ESCO associations;
- Public one-stop-shops or actors facilitating energy saving projects.

The main enablers for demand response services offered by (clusters of) buildings are:

- Revisions to the regulatory framework that introduce the concept of "technology neutrality";
- A regulatory framework accepting independent aggregators and adapting the minimum performance requirements;
- Clear, standardised measurement and verification (M&V) procedures for all market players with digital meters;
- Real-time availability of consumer data.

Of course, there are still some barriers such as contractual complexity of EPCs, uncertainties about the type of contract, the absence of historical monitoring data, and so on.

Spain and Portugal need to overcome significant barriers to implement AEPC. Beyond the typical administrative and financial barriers, the biggest challenges around energy performance contracting are the lack of knowledge and trust, the lack of standardised and enforced M&V protocols, and the lack of a neutral third-party institution that certifies the accountability of a particular ESCO. Regarding demand response services offered by (clusters of) buildings, there are various legal, market, technical and social barriers.

More information can be found in **The Analysis of directives, policies, measures and regulation relevant for the Active Building EPC concept and business models** (2) and **The review of actors, roles and business models related to Enhanced EPC and Building Demand Response Services** (3).

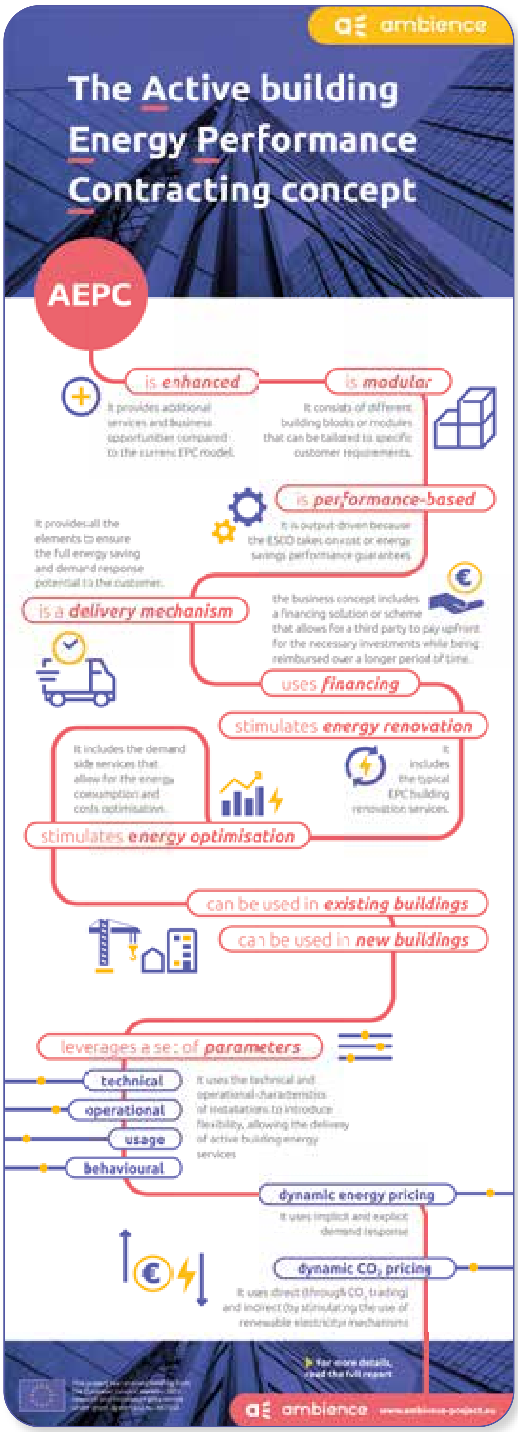
4.1 The AEPC concept

"The Active building EPC (AEPC) Concept is an enhanced modular and performance-based delivery mechanism, using the financing mechanism for the energetic renovation and optimisation of existing and new buildings, tapping into all passive and active energy and cost saving measures, while leveraging a comprehensive set of technical, operational, usage, behavioural and dynamic energy or CO_2 pricing parameters. The AEPC concept is an enhancement of the basic EPC concept, through a strong focus on the electrification (also of the local heat supply and including mobility) and the addition of Active Control measures". It is described in detail in The Active Building Energy Performance Contract concept and methodology (4). A schematic overview of the AEPC concept is shown in Figure 4.

The AEPC concept is an enhancement of the basic EPC concept. This means that it provides extra features (notably demand response and flexibility) but has all of the characteristics of a classical EPC (e.g., performance guarantees, use of M&V, functional specifications and tenders, high scalability). Moreover, AEPC puts a strong focus on electrification, specifically of the local heat supply as replacing existing gas-fired boilers with electrical heat pumps is key to flexibility potential and active control measures: active control is what will allow automation of demand response.

Based on this definition, the AEPC is a type of performance contract that has the potential to extend the performance guarantees by leveraging the flexibility in buildings. In this way, the scope of the energy-saving guarantee is extended to cost-saving guarantee as a direct

Figure 4 – Schematic overview of the AEPC concept



result of demand response activities in the building. As a result of increased electrification, CO_2 emission reduction is also guaranteed.

Like most EPC projects, an AEPC project is divided into three main phases: pre-contracting, contracting and performance:

The pre-contracting phase consists of identifying the potential of a project, defining the main objective of the project and a first evaluation of the potential through a pre-feasibility and feasibility study;

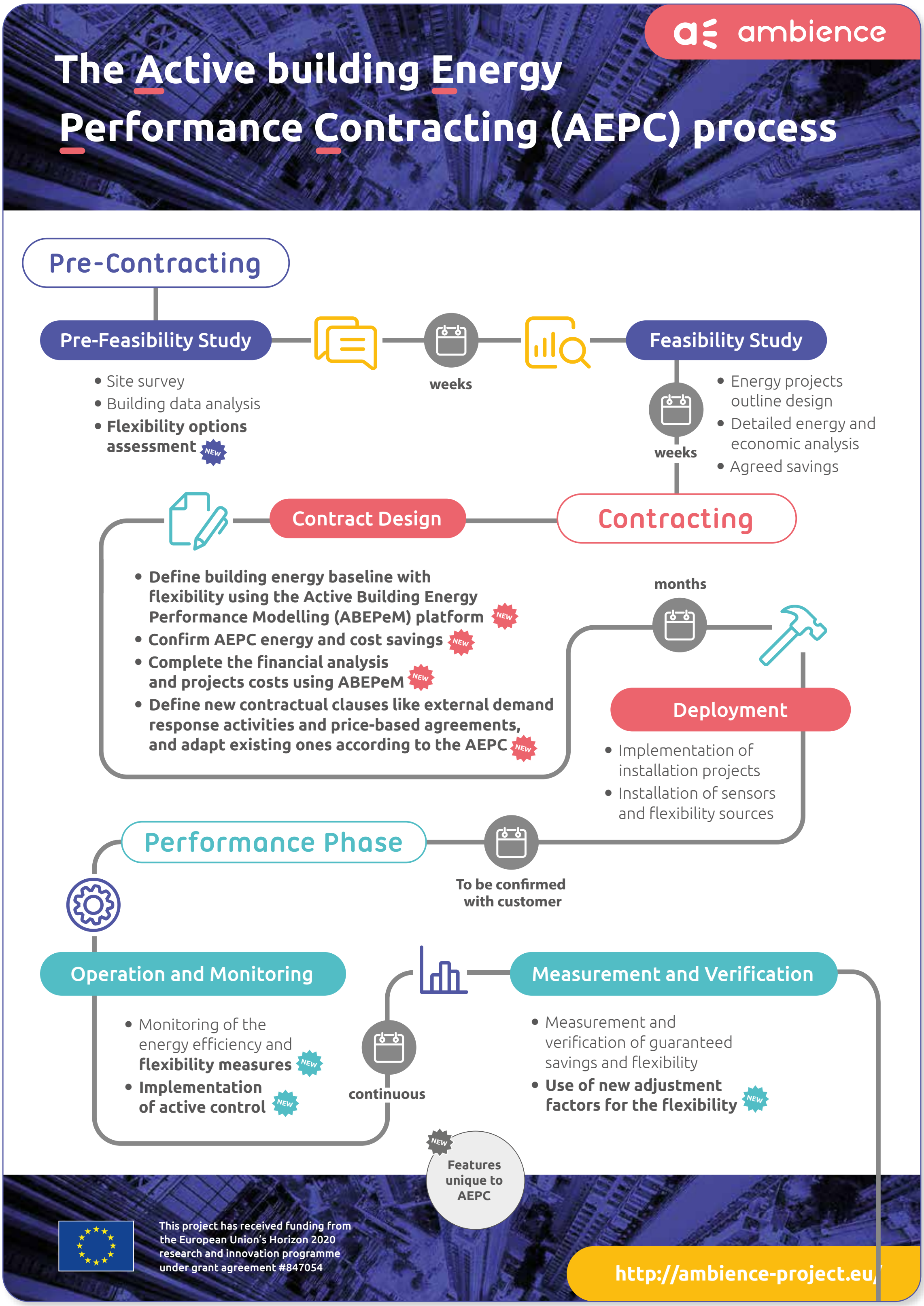
The contracting phase is divided into two main steps: (i) the contract design and (ii) the deployment. The main measures and features of the contract are calculated and the selected solution is deployed;

The performance phase refers to the period when the operational activities under the scope of the contract are carried out, and comprises (i) operation and monitoring, and (ii) measurement and verification.

The general procedure for an AEPC project is presented in Figure 5, detailed in The Active Building Energy Performance Contract concept and methodology (4) and explained in the video of the AmBIENCe academy (5).

To define the demand response valorisation potential in the AEPC pre-contracting phase the ABEPeM platform can be used (see section 4.2).

Figure 5 – AEPC general procedure



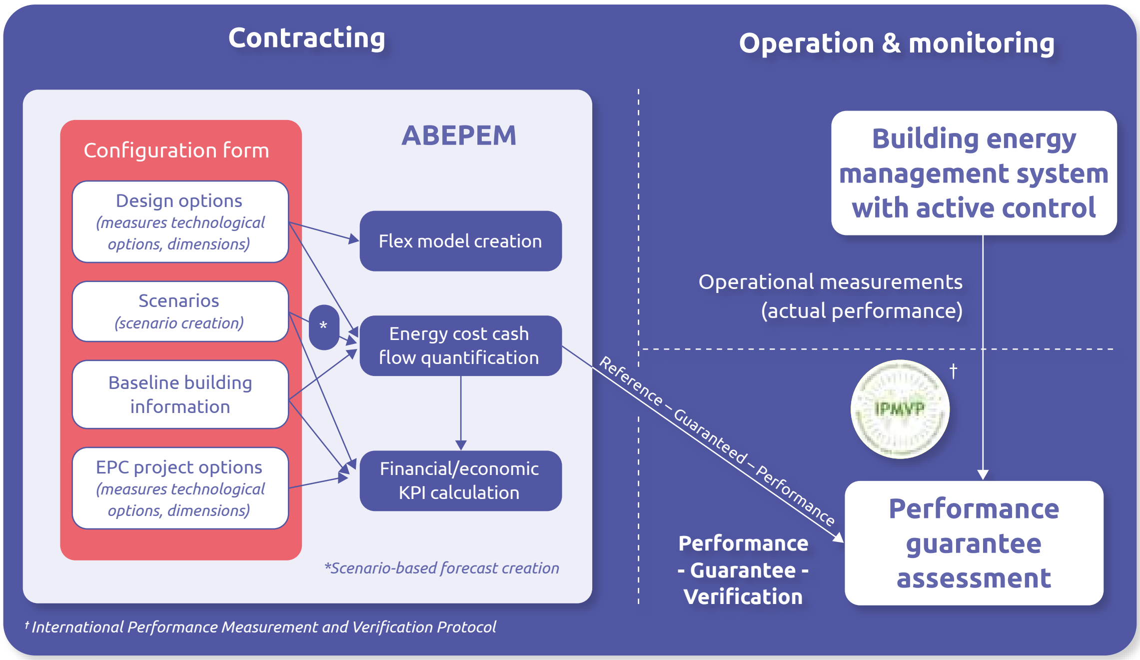
4.2 The ABEPeM platform

To support the AEPC concept and methodology, the ABEPeM platform was developed. The two key functionalities of ABEPeM are:

- The quantification/estimation of the energy cost cash flow before and after the measures included in the energy performance contract; specifically taking into account the impact of demand response-related measures and the active control of demand-side flexibility and storage;
- The calculation of economic and financial Key Performance Indicators (KPIs), taking into account the cash flows related to investments and optionally financing, and changed operational expenses and income-related cash flows, including energy cost cash flows.

A schematic overview of the ABEPeM platform is shown in Figure 6.

Figure 6 – ABEPeM platform key modules/functionalities and its place in the AEPC process



Briefly, the ABEPeM platform contains the following key functionalities/modules:

- The Configuration Form collects all relevant project information including design options and scenarios;
- The Flex Model creation module creates the necessary building and asset models that are required for the scenario-driven model-based performance quantification;
- The Energy Cost Cash Flow Quantification module performs the scenario-driven model-based performance quantification;
- The Financial/Economic KPI Calculation module determines the financial and economic KPIs to compare the impact of selected design options;
- The Scenario Creation module provides the scenario that will be used in the performance quantification and for which the performance could be guaranteed;
- The Scenario-based Forecast Creation module creates from the selected scenario a forecast that will be used for the performance quantification.

The target users of the ABEPeM platform are ESCOs that want to quantify the demand response valorisation potential for multiple design options including electrification, local renewable generation, flexibility and storage, and combine these results with an economic and financial analysis, embedded in an energy performance contracting concept.

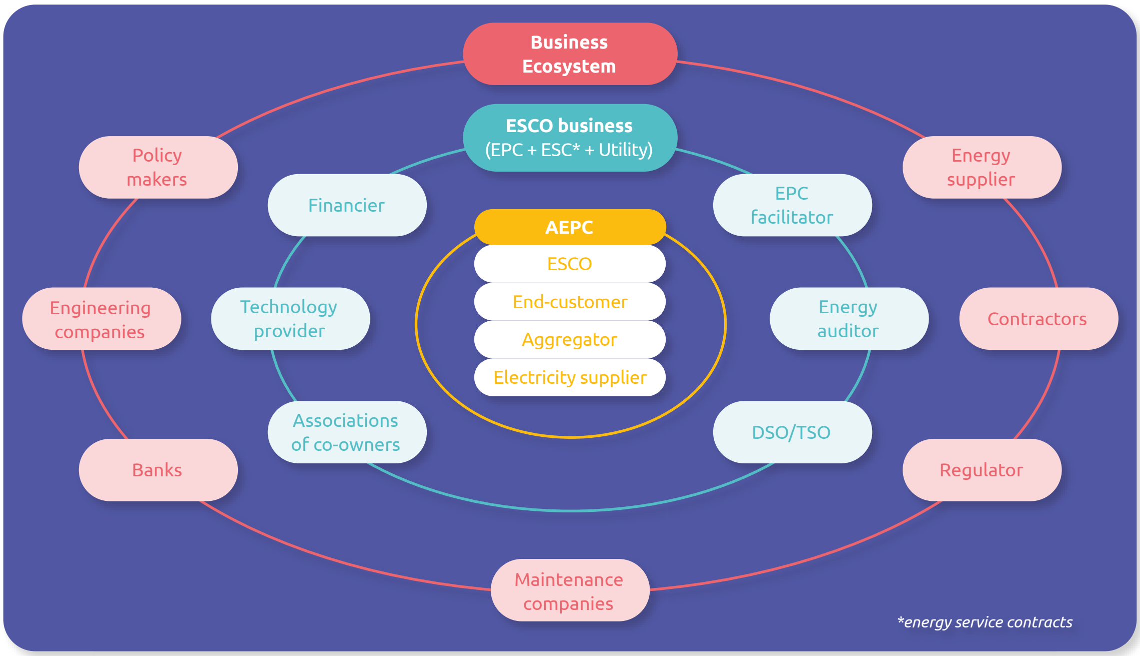
More information about the ABEPeM platform and its modules and a quantification experiment can be found in Proof-of-Concept of an Active Building Energy Performance Modelling framework (6) and is explained in the video of the AmBIENCe academy (5).

4.3 The AEPC business models

Different actors are involved in the AEPC as an integrated service. An integrated service is a customer-focused service that consists of one solution including the implementation and monitoring of the building performance, value streams from flexibility, energy savings, comfort, quality control and maintenance of the building(s). This way, the customer does not have to sign different contracts to meet different needs.

Figure 7 describes the AEPC ecosystem from a business point of view. The first inner ellipse shows the core stakeholders that are directly involved in the AEPC service delivery. The second ellipse shows those stakeholders that are more generally involved in the ESCO business and in delivering EPC or other energy contracting services. The final outer ellipse shows a third range of stakeholders that are only indirectly involved or influence the activity of the first two categories.

Figure 7 – AEPC most relevant stakeholders' business ecosystem



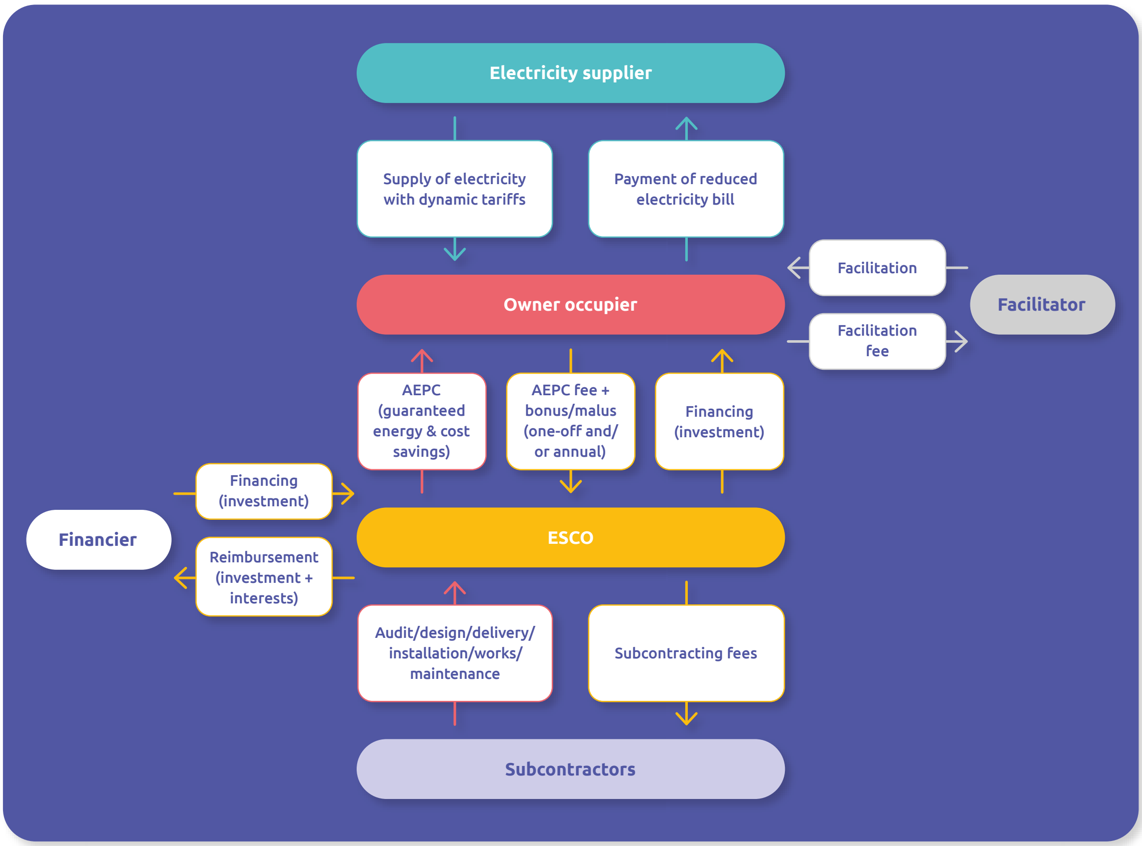
The analysis of the ecosystem, the AEPC concept and the way value can be created has led to the determination of the basic elements of the AEPC business model. The analysis of further parameters, like the type of buildings typically addressed by ESCOs, the way buildings are occupied, owned or rented, and the financing options available for AEPC financing, allows us to determine different variations of the business model. Finally, both implicit and explicit demand response options provide further variations to build the AEPC business model. In particular, variations in the way explicit demand response is being offered, focused on the role of the ESCO as an aggregator for the end-customer or working with aggregators, have allowed us to create a comprehensive picture of the AEPC business model and 13 variations: 5 are based on explicit demand response and 8 on implicit demand response. Table 1 summarises the 13 business model variations, they are also available in a webtool (7).

Table 1 – Summary of business model variations

Building type	Occupation model	Type of demand response	Owner/ tenant relation	Financing	Business model variations
Commercial building Public building Residential building	Individual	Implicit	Owner-occupier	ESCO	A.1
		Explicit (variations 1 to 5)			B.1
					B.2
					B.3
					B.4
					B.5
		Implicit		Financial institution (FI)	A.2
Residential building	Collective (association of co-owners)			ESCO	C.1
			Owner lessor & tenant		C.2
				FI	C.3
				FI to co-owners	C.4
Social housing	Individual Collective		Owner lessor & social tenant	ESCO	D.1
				Umbrella organisation financing	D.2

Figure 8 shows an example of a generic business model with implicit demand response and ESCO financing.

Figure 8 – Generic AEPC business model with implicit demand response and ESCO financing



The business model builds on the basic EPC Business model, offering scalability, performance guarantees and financing options and opportunities, but is extended with flexibility valorisation potential that can lead to extra cost savings and extra emission reductions.

More information on the business models can be found in Business Models for the Active Building EPC concept (8) and in the video of the AmBIENCe academy (5). The concept and business models for clusters for buildings are described in The Collective Active Building EPC concept and business model (9).

5. IMPORTANCE OF DATA

To define the possible savings of an energy performance contract, some basic input data is needed. For an AEPC, this also needs to include the demand response value streams in the contracting phase. Data related to demand response and flexibility also needs to be available.

The AmBIENCe project collected data from two pilot buildings, and developed a database of grey-box model parameters for EU building typologies. This data would support the use of the ABEPeM platform to calculate the cost savings from the use of flexibility, and to define the impact of AEPC on the energy system and emission reductions.

5.1 AmBIENCe pilot buildings

Two pilot sites were chosen to demonstrate that AEPC can appeal to building owners, and can generate new business for the business partners:

- A Portuguese pilot that is composed of one of the two buildings that make up the EDP national headquarters, located in Oporto, Portugal (Figure 9);
- A Belgian pilot based on a residential building "Château Parmentier", located in Seneffe, Belgium (Figure 10).

Figure 9 – Portuguese pilot building (left), EDP headquarters

Figure 10 – Belgian pilot building, overview and graphical representation

For both the office and the residential building, the following data was assembled (when available):

- General information about the pilot building: e.g., division of rooms, information on the heating/cooling/ventilation system, gas and electricity consumption;
- Data needed for static and dynamic simulations: e.g., thermal transmittance and thermal resistance for all surfaces (roof, walls, window, doors and floor), thermal power of the heating installations, indoor air temperatures, solar radiation and outdoor air temperature;
- Financial and economic data: e.g., assets general details, operating expenses, investment and financing details, annual energy costs.

More information about the data acquired can be found in the Data Management Plan (10).

The availability of this data supports the ABEPeM platform to estimate the impact of demand response-related measures and the active control of demand-side flexibility and storage. To gather this data for the pilots, additional sensors and monitoring were required. This is of course not possible for every building where AEPC is considered, so the AmBIENCe database was developed (see section 5.2).

5.2 AmBIENCe database

The AmBIENCe database (11) was developed and described in the Database of grey-box model parameter values for EU building typologies (12). This database includes information and data and grey-box model parameters that characterise the dynamic thermal behaviour of different EU building typologies which is needed to assess the impact of building flexibility. Where no data is available for a building, data from a similar building from the database can be used to estimate the possibilities of demand response-related measures in an AEPC.

5.3 Impact analysis

A calculation tool was developed to define the impact of the demand response and flexibility measures on the energy system and emission reductions. The tool offers a simple way to identify which buildings from the building stock could support demand response after the renovation measures, or in other words those buildings in which AEPC can be implemented. For these buildings, the tool calculates the minimum renovation needed to allow electrification combined with demand response, the corresponding cost and the emissions savings after renovation. More information can be found in the Report on the Methodology of creating the scenarios, integrating the models and adopt assumptions (13). Preliminary calculations indicate that through the combined adoption of electrification and active control within the building stock the EU can achieve a 26% reduction of CO_2 emissions by 2050.

6. EXPLOITATION OF THE PROJECT RESULTS

The following key exploitable results were obtained in the AmBIENCe project to support AEPC:

- AEPC contract template,
- Active building M&V methodology,
- Grey-box module,
- Flex value quantification model,
- ABEPeM.

They are unfortunately not yet available as user friendly tools. More information can be obtained from the project coordinator (Annick.Vastiau@vito.be).

7. COMMUNICATION

Social media followers

>750

Newsletter

6 issues sent and >300 subscribers

Media mentions

>150

Events organised and where AmBIENCe was presented

>30

Website visits

>4,300

Sister projects

>10

Factsheets and reports

>30

Audience reached

>10,000 stakeholders

8. CONCLUSIONS

In the AmBIENCe project, the energy performance contracting concept was extended to active buildings and made available to a wider range of buildings. AmBIENCe has provided new concepts and business models for performance guarantees of active buildings, combining savings from energy efficiency measures with additional savings and earnings resulting from the active control of assets, leveraging for instance price-based incentive contracts.

Within the course of AmBIENCe, an integrated modular concept has been developed, as well as a proof-of-concept platform, to support the creation of AEPC.

Briefly, the AmBIENCe project has achieved a number of results:

- An assessment of energy performance contracting and building demand response in Europe to define EU and Member States directives, policies, measures and regulations that are relevant to the AEPC concept and might support the proposed ideas and allow valorisation of flexibility;
- Development of the AEPC concept and business models for a single building as well as clusters of buildings;
- AEPC contract development in two pilot buildings in Belgium and Portugal and a database of grey-box model parameters for EU building typologies;
- The ABEPeM platform, a tool to calculate the cost savings from the use of flexibility and to define emission reductions and the impact of the AEPC on the energy system;
- More than 10,000 stakeholders reached thanks to the social media channels, targeted events and communication material developed.

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