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Active managed Buildings with
Energy performaNce Contracting

Deliverable Number (D2.1)

The Active Building Energy Performance Contract concept and methodology

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EXECUTIVE SUMMARY

Deliverable D2.1 “The Active Building Energy Performance Contract concept and methodology” provides the concept development for the Active Building Energy Performance Contracts (AEPC) and the required methodology for its implementation. This document focuses on the aspects of AEPC that are specifically considered as an extension to the classic Energy Performance Contracting (EPC) and would require some changes in the process of developing and implementing an energy performance project.

In this deliverable, the comprehensive definition of AEPC is introduced in **Chapter 2**, highlighting the core intentions of AEPC in supporting the electrification and CO_2 emission reduction measures in the building sector. It will extend the scope of such performance contracts from energy efficiency guarantees (in relation to comfort and other well-being guarantees) to broader performance guarantees related to leveraging flexibility and storage capacities. The main achievement of electrification in the building sector along with the recent technologies is the improved smartness level, which both can effectively contribute to the obtainable flexibility level from a building. Although investing in flexible resources (such as solar panels, electric vehicle charging, energy management systems, etc.) is currently considered in the classic EPC procedure, the availability and responsiveness of the flexibility in the buildings have not been the focus. Therefore, using the AEPC’s approach would result in a new value chain for energy performance contracting. This chapter discusses the required changes and their impacts on the interactions between the stakeholders in EPC.

The main idea behind the concept of AEPC revolves around the addition of demand response (DR) to the procedure of energy performance contracting with a purpose of deploying the available flexibility in the buildings (already existing ones or through renovation) in a meaningful way that brings new value streams to the EPC business model. In **Chapter 3**, the role of DR in the EPC process and its impact from both implicit and explicit DR is presented. Moreover, the business value that the demand response will bring to an EPC project is discussed.

The AEPC development and implementation follow the main steps of a classic EPC process. However, the extended new concept necessitates taking extra quantitative and qualitative measures by the Energy Service Companies (ESCOs) during various phases of an active building energy performance contracting project. In **Chapter 4**, development phases of an AEPC project and the methodology for its implementation are presented. This methodology will describe the three phases in the AEPC and will provide strategies, procedures, technologies, integration guidelines and examples of best practices for each of the three phases. This should allow ESCOs interested in the concept of AEPC to embark on this new concept.

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1.INTRODUCTION AND BACKGROUND

1.1 THE CONTEXT

Energy Performance Contracting (EPC) is a mechanism for organising the energy efficiency financing which provides customers with a comprehensive set of energy efficiency, renewable energy and distributed generation measures and often is accompanied with guarantees that the savings produced by a project will be sufficient to finance the full cost of the project. A typical EPC project is delivered by an Energy Service Company (ESCO) who can unburden the client by proposing an optimal set of measures, and give performance guarantees for the projected savings and pay-back time.

The activities of ESCOs and the market for EPCs emerged alongside the demand side management (DSM) programs which have as the main goal encouraging the consumer to use less energy during peak hours, or to move the time of energy use to off-peak times such as night time and weekends. These modifications in energy demand could result in both energy savings and cost savings [1].

The implementation of DSM in buildings ranges from improving energy efficiency to fully autonomous energy systems that automatically respond to shifts in supply and demand.

Energy-related savings (either amount or cost) can basically be made in two ways: through Energy Efficiency (EE) or Demand Response (DR). EE relates to any program that encourages the end user to be saving energy in a long-term or permanent perspective, via EE measures such as lighting retrofits, building automation upgrades, HVAC improvements and building envelop insulation.

In contrary, DR refers to programs that encourage end users to make short-term reductions in energy demand. These short-term “responses” are triggered by price signals from the electricity hourly market or initiated by the Transmission System Operator (TSO) or Distribution System Operator (DSO). DR activations last from a couple of minutes to some hours depending on the DR program, and might include turning off or dimming lighting banks, adjusting HVAC levels, or shutting down a non-critical manufacturing process. On-site generation and storage systems can also be used to adjust loads drawn from the grid.

EPC is born from the idea that a significant part of costs and savings are concentrated on exploitation or operation phase of the building (incl. user behaviour), not only in the design and implementation part of buildings and their installation or energy saving investment. It also stems from the assessment that specialized actors (Energy Services Companies or ESCOs) may be better placed to optimize energy in buildings, including integration of advanced building control technology and monitoring, than building owners and users. The EPC model is based on outsourcing energy savings and management and shifting the risk of underperformance to a private party, i.e. the ESCO. It may be extended with the concept of ESCO financing to provide an overall integrated solution. It is a very flexible concept that is based on functional and performance driven tenders and contracts. From service contracts based on energy savings, it sometimes evolves into pure service contracts at a different level like Light-as-a-Service or Comfort-as-a-Service. In (classical) EPC, the focus is on designing and implementing various energy conservation measures (ECM) with the aim of achieving “guaranteed” energy consumption and cost savings, typically measured on a yearly basis. They include measures on regulation/(re)commissioning of existing installations, upgrades, and replacements of existing installations by new installations (HVAC, relighting, renewable energy) and building envelope insulation measures (e.g., roof or attic insulation, floor and wall insulation, new glazing or new doors and windows). Ambition levels can vary from simple optimisation of the operations to deep energy retrofits. EPC typically involves also more or less comprehensive maintenance, turning them de facto into Maintenance & Energy Performance Contracts. The key actor of EPC is the ESCO who is in charge of providing the EPC to the end customer as a DB(F)MO-like service (i.e., Design (D), Build (B), Finance (F), Maintain (M) and Operate (O)). Another important actor is the EPC project facilitator, who accompanies the end customer from A to Z through the assessment, feasibility study, competitive tendering, implementation control and follow-up. EPC typically uses the principles of Measurement & Verification (M&V), supervised by one or more Certified M&V Professionals, who may sit within the ESCO and or EPC project facilitator. Public or Public-Private One-stop-shops may act as Project or Program Facilitator, aggregating and/or pooling projects of multiple end customers or with multiple buildings. They may also act as Market facilitators to increase market demand and lift market development barriers [2]. A comprehensive study on various EPC models as well as the actors involved in the EPC procedures is presented in deliverable D1.2.

In DR/Flexibility, the aim is to change demand for energy in time, while leveraging price components (e.g., capacity based pricing), tariff structures (e.g., time-of-use pricing), temporary storage capacity (e.g., batteries) or other demand side parameters (e.g., shifting or stopping production or energy usage temporarily) that use this temporality to reduce and optimize energy costs. The reduction is a result of Energy suppliers or DSOs/TSOs may be willing to provide such dynamic pricing mechanisms to end customers (that are sufficiently big) or pay “aggregators” (that aggregate demand driven flexible consumption patterns from multiple end-customers), with the purpose of balancing the electricity network. DR/Flexibility typically uses advanced algorithms to optimize energy demand, while taking into account pricing and flexibility parameters as well as end customer constraints [3].

As comprehensively analysed in Deliverable D1.2 (Section 5.4 USAGE AND ANALYSIS OF DIFFERENT EPC TYPES WITH DEMAND RESPONSE), most of the EPC models do not consider flexibility. There are several barriers to be encountered for integration of flexibility and DR in EPC models such as the absence of dynamic tariffs. Moreover, the impact of this integration is highly dependent on the type of EPC and the business case considered for the EPC. Although most of the existing EPC models consider active control, they are being used for energy efficiency measures. Therefore, integrating the DR/Flexibility aspect and the active control in EPC model not only brings new value streams but also necessitates provisioning of a new EPC type.

The Active building Energy Performance Contracting (AEPC) concept aims to extend existing EPC concepts with elements for Demand Response and Flexibility. Today, most EPCs are focused on commercial and public buildings, whereas most DR services are offered towards large industrial users, although some initial implementations exist for tertiary and (multiple) residential buildings, like respectively demand driven regulation and neighbourhood batteries. The challenge in defining the Active building EPC concept is in merging two worlds with quite different technologies, services, business models, end customer profiles and actors into a single consistent new concept that can be implemented in a broader range of buildings, while creating an interesting new business model to enhance existing business models. The ultimate goal is to invite existing actors to develop new business models or to attract new actors into a market with interesting new business potential.

1.2 PURPOSE AND SCOPE OF THE DOCUMENT

The purpose of this document is to define the Active building Energy Performance Contract (EPC) concept and methodology. It will take as a basis the EPC concept and methodology and adapt and extend it to add demand response related value streams, as well as the specific features that are needed to make it applicable to a wider range of buildings and to clusters of buildings. The scope of the Deliverable D2.1 is to describe the general features of concept and methodology while the accompanying platform for the implementation of AEPC (i.e., Active Building Energy Performance Modelling (ABEPeM)) is covered in the deliverable D2.2. The extended business models related to AEPC will be presented in deliverable D2.3 and specific aspects related to the complexity of applying AEPC to a broader range of buildings including the multi- tenant buildings and clusters of buildings will be described in D2.4.

2.THE ACTIVE BUILDING EPC CONCEPT

In this chapter, the Active Building EPC concept is defined, extending the general definition of EPC that has been described in the previous chapter.

2.1 DEFINITION

"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."

In order to understand better the concept, each element of the definition is further explained and elaborated in Table 1:

TABLE 1 – REPRESENTATION OF TERMS IN THE CONCEPT DEFINITION

The term in the definition	What it represents
The concept is ***enhanced***	It provides additional services and business opportunities with regard to the current EPC model.
The concept is ***modular***	It consists of different building blocks or modules of services that can be included (or not) and tailored to meet customer specific requirements.
The concept is ***performance-based***	It is output-driven with the ESCO taking on performance guarantees on cost or energy savings, as is the case with EPC today. Additionally, in the AEPC, DR services also need to be performance-based.
The concept provides a ***delivery mechanism***	All the elements are provided to deliver full energy saving and demand response potential to the customer as an end-to-end product, including all hardware, software, and service components.
The concept uses a ***financing mechanism***	This means that the business concept includes (or at least strongly leverages) a financing solution or scheme that allows for a third party to pay upfront for the necessary investments while being reimbursed over a longer period of time, allowing for a profitable business case for both the financier and the customer. Although this aspect is mainly similar to the current approach for the EPC

	financing, it also considers the revenue from the DR programs and effects of DR implementation in the cost/saving.
The concept ***stimulates energetic renovation***	The typical EPC services that allow for energetic building renovation (e.g., HVAC, lighting, insulation) are included.
The concept ***stimulates energetic optimisation***	The demand side services that allow for the optimisation of energy consumption and costs are included.
The concept can be used in ***existing buildings***	It can be applied to existing buildings.
The concept can be used in ***new buildings***	It can be applied to new buildings, which may require some specific M&V methodologies
The concept leverages a comprehensive set of ***technical parameters***	It will use the technical characteristics of installations to introduce flexibility and allow the delivery of the active building energy services, e.g. (peak) power shaving.
The concept leverages a comprehensive set of ***operational parameters***	It will use the operational characteristics of installations to introduce flexibility and to allow the delivery of the active building energy services, e.g. temperature set points.
The concept leverages a comprehensive set of ***usage parameters***	It will use the technical characteristics of installations to introduce flexibility and allow the delivery of the active building energy services, e.g., comfort requirements, production schedules or opening hours.
The concept leverages a comprehensive set of ***behavioural parameters***	It will use the technical characteristics of installations to introduce flexibility and allow the delivery of the active building energy services, e.g., manual temperature controls and energy wasting behaviour.
The concept leverages a comprehensive set of ***dynamic energy pricing parameters***	Dynamic energy pricing can occur potentially through Implicit DR (involving tariff structure parameters, including incentives in the contract between the DSO/TSO and the ESCO on how to activate flexibility) and Explicit DR (based on ad hoc requests and negotiations of incentive-based prices per event)
The concept leverages a comprehensive set of ***dynamic CO_2 pricing parameters***	This could be both directly (through CO_2 trading) or indirectly (by stimulating the use of renewable electricity)

As mentioned before, the AEPC concept is an enhancement of the basic EPC concept. This means that it provides extra features (i.e., demand response/flexibility) but has all of the characteristics of a classical EPC (e.g., performance guarantees, use of Measurement & Verification, functional specifications & tenders, high scalability, etc.). Moreover, it 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 have flexibility potential and active control measures as the implementation of Active Control is what will allow automating the demand response.

Based on this definition, AEPC is a type of performance contract that has the potential to extend the performance guarantees leveraging from the flexibility in the buildings. In this sense, the scope of energy saving guarantee is extended to cost saving guarantee which is a direct result of DR activities in the building (e.g., load shifting, load shedding, self-consumption). As a result of increased electrification, CO_2 emission reduction is also guaranteed.

2.2 THE VALUE CHAIN

With an extended definition of energy performance contracting, it is important to provide the main stakeholder (i.e. the ESCO) with an extended and updated value proposition. The existing energy services value chain from the primary to the useful energy, with the respective business models is shown in Figure 1. Primary energy indicates the primary energy that can be saved such as crude oil, natural gas, coal, etc. Secondary energy is the type of energy that is considered as utilities and covers electricity, district heating, heating oil, natural gas, biomass, etc. Although there are business models for energy saving on secondary energy, this is not included within the business scope of ESCOs. On the other hand, the other two energy-contracting models, which are Energy Supply Contracting (ESC) and EPC, are covered by ESCOs while in performance contracting, the purchasing of secondary energy remains with the building owner and its contract with a retailer.

At Energy Supply Contracting, an efficient supply of final energy such as heat, steam or compressed air is contracted and measured in Megawatt hours (MWh) delivered. The model includes purchasing fuel and is comparable to district heating or cogeneration supply contracts. The energy efficiency measures in this contracting model usually include replacing boilers, fuel change, local heating networks biomass heating, combined heat and power plants, solar systems, etc. As for Energy Performance Contracting, which is the basis for AEPC, the focus is on reducing final energy consumption through energy efficiency measures such as thermal insulation of building envelope, lighting, energy management systems, peak load management, etc. The business model here is based on a savings guarantee compared to a predefined baseline which is stated as NegaWatt hours (NWh) [4, 5].

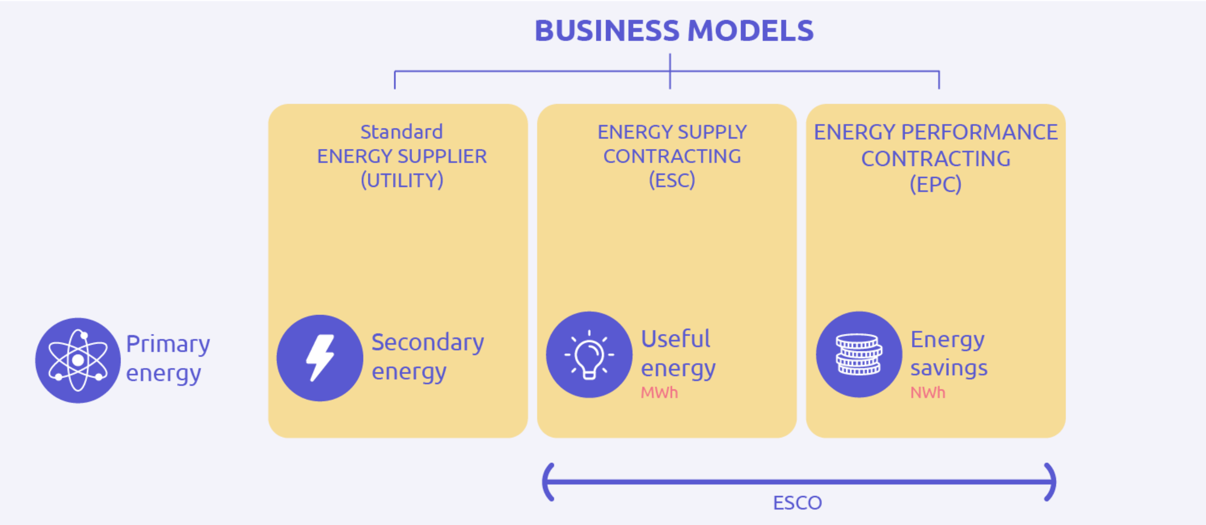

FIGURE 1- BASIC ENERGY SERVICES VALUE CHAIN (SOURCE: IEA TASK 16)

By adding the demand response programs/flexibility to the business model of the energy contracting, the value chain can be extended as shown in Figure 2. It shows that in AEPC the amount of flexibility or FlexiWatt hour (FWh) is an important measure as it focuses on the value that is obtained from DR and added flexibility.

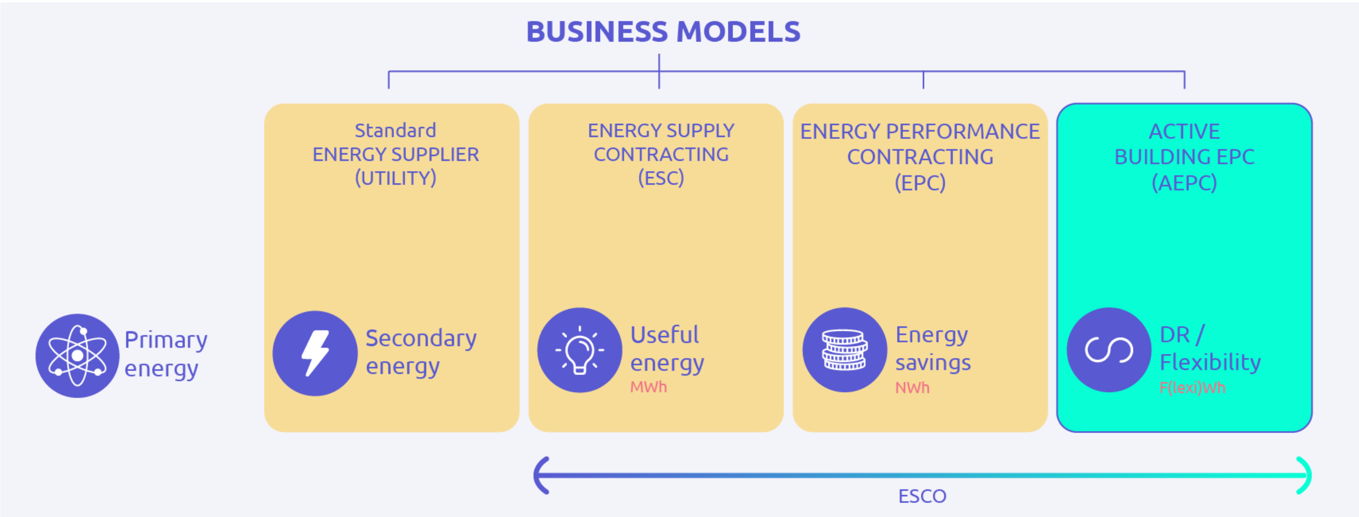

FIGURE 2- ACTIVE ENERGY SERVICES VALUE CHAIN (BASED ON IEA TASK 16)

As the DR/flexibility in buildings are usually treated by the aggregators, this “functional value chain,” in terms of (energy) services offered (as shown Figure 2), raises the question of what the role of an aggregator is with respect to the role of an ESCO. Although the ESCO may itself play the role of that aggregator, the following scheme provides an “actors value chain” where both roles are separated.

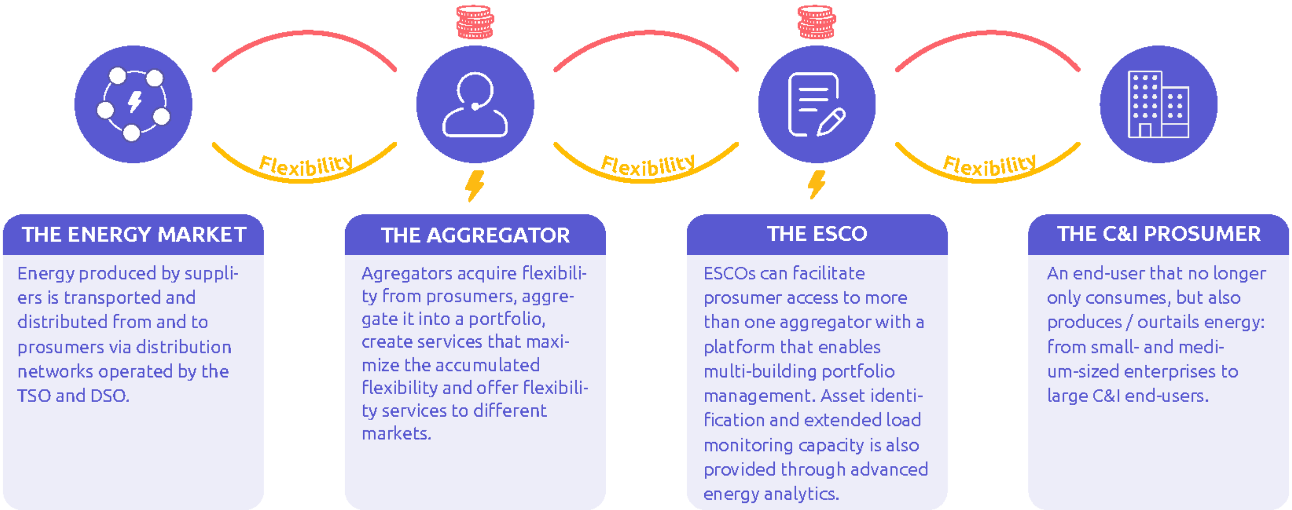

FIGURE 3- ACTIVE ENERGY SERVICES "ACTORS" VALUE CHAIN (BASED ON [3])

In Figure 3- Active energy services "actors" value chain (Based on [3]), the main actors in the active energy services value chain are shown. It also specifies the roles that each of these actors needs to play. It is clear that in an AEPC the main actors and stakeholders are mostly similar to a classic EPC with the exception of a more distinctive role for the aggregator. Moreover, the necessity of having flexibility and the possibility of participating in DR programs would make the prosumers the potential end-users for EPC projects and consequently an actor in Active energy services. Moreover, currently DR programs are implemented in commercial and industrial energy users, therefore, they are considered as preliminary actors of active energy services.

2.3 INTERACTIONS BETWEEN THE MAIN ACTORS

As mentioned, the main actors and stakeholders in an AEPC are mainly the same as in classic EPC. However, as the value proposition in AEPC and active energy service is flexibility, the trade process of this flexibility through DR and hence the aggregator gains importance. Within the NOVICE project [6], the role of the aggregator in energy upgrade projects and their interactions with ESCOs have been introduced. The scheme shown in Figure 4 describes the existing differentiated market players' interactions. In the traditional market model, both ESCOs and aggregators operate independently from each other, with the only link between them being the client. In the case of buildings, today, there is little activity of aggregators around DR services. While this model may also have a few different structures, depending on who is assisting the client in their relationship with both ESCO and aggregator (e.g., external energy consultant, EPC facilitator, Facility Management company, or a combination of other organisations), the typical interaction in the marketplace is depicted. The comprehensive analysis of the interaction of the actors in different EPC models is presented in Deliverable D1.2.

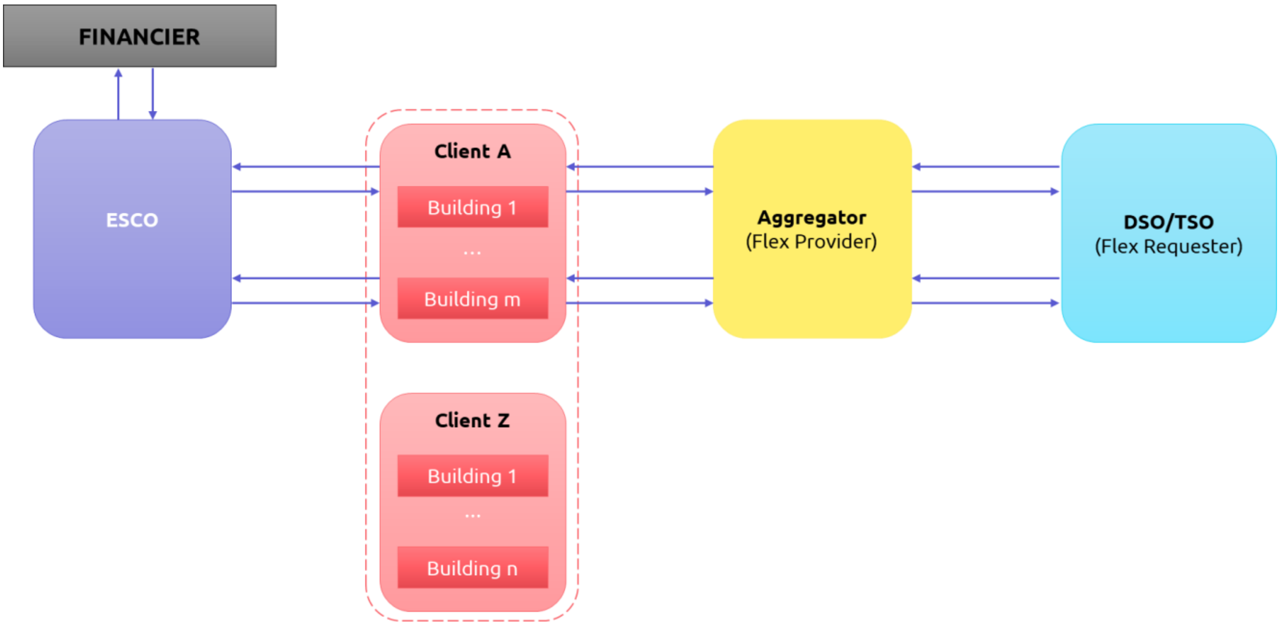

FIGURE 4: MARKED INTERACTION IN THE TRADITIONAL SYSTEM (BASED ON: NOVICE PROJECT)

On the other hand, the AEPC model will provide some new dynamics between market players. The concept of AEPC not only considers the role of the aggregator but also extends the range of the clients that can be included in an AEPC project, namely multi-tenant buildings and clusters of buildings. With these premises, the scheme in Figure 5 is envisaged for the general interactions of the main actors. It shows that the ESCO can also assume the role of an aggregator resulting in dividing the tasks of the aggregator between a technical and market aggregator. The standard model for the AEPC will move most of the clients' interaction to the ESCO side of the business, with the market aggregator featuring as a partner or subcontractor to the ESCO. The ESCO acts as a technical aggregator, for multiple clients (customer aggregation) and multiple buildings (pooling), handing the flexibility to the market aggregators, who sell it to DSOs and/or TSOs. Due to the complexities and legal requirements, the interaction with the TSO / DSO as well as payments for DR services must be through the market aggregator.

Depending on the type of business model that the ESCO would employ for each of its clients, the scheme presented in Figure 5 can assume different arrangements. The details of these arrangements and interactions according to different business cases are provided in Deliverable D2.3.

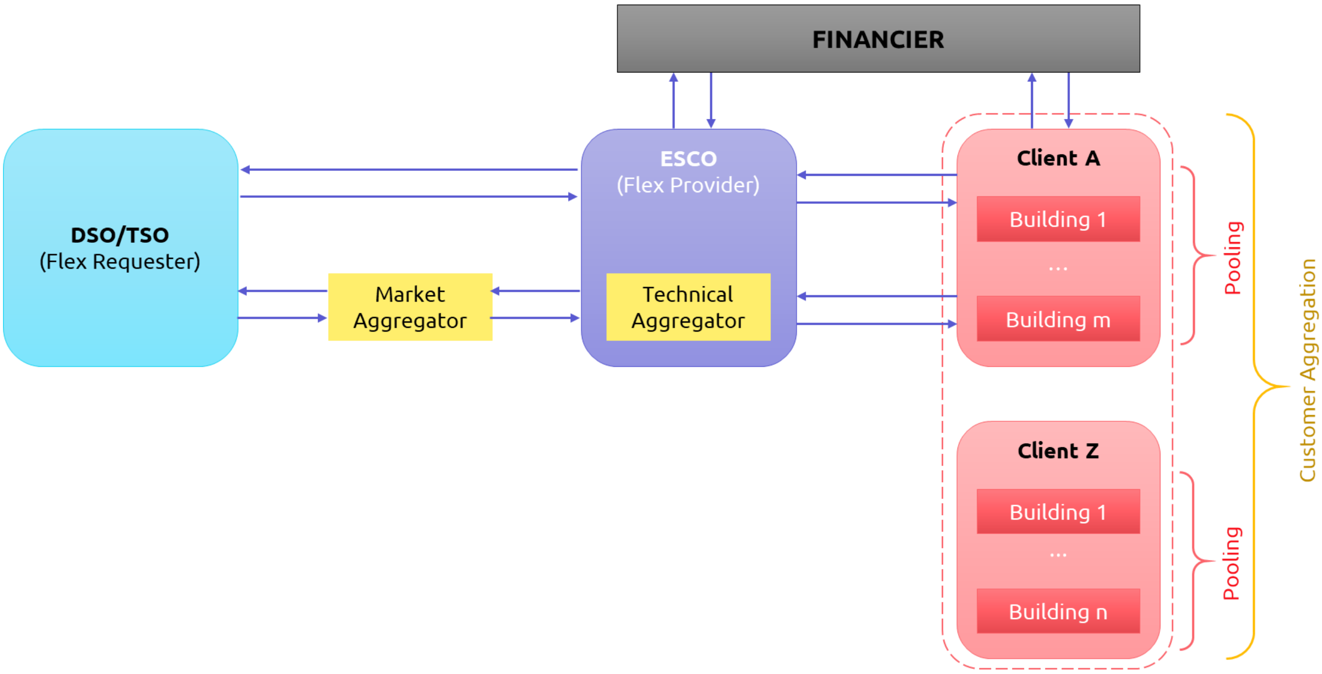

FIGURE 5: GENERAL AEPC ACTOR INTERACTIONS

3.THE ROLE OF DEMAND RESPONSE IN AEPC

3.1 GENERAL

Introducing flexibility will allow to achieve more energy and cost savings than in traditional EPC. These savings and incentives result from both implicit and explicit demand response opportunities.

Indeed, two types of Demand Response can be distinguished [7]:

- Explicit Demand Response is committed, dispatchable flexibility that can be traded (similar to generation flexibility) on the different energy markets (wholesale, balancing, system support and reserves markets). This is usually facilitated and managed by an aggregator that can be an independent service provider or a supplier. This form of demand response is often referred to as "incentive driven" DR.
- Implicit Demand Response is the consumer's reaction to price signals. Where consumers have the possibility to choose hourly or shorter-term market pricing, reflecting variability on the market and the network, they can adapt their behaviour (through automation or personal choices) to save on energy expenses. This type of DR is often referred to as "price-based" DR.

In AEPC, both types of demand response are complementary and should coexist to allow for consumer choices and enable an efficient energy system. It is important to note that enabling both types is necessary to accommodate different consumer preferences and to exploit the full spectrum of consumer and system benefits from DR.

3.2 DIFFERENT CONSUMER PREFERENCES AND NEEDS

Consumers have different preferences and abilities. Some consumer groups can directly manage their own demand based on variable market price signals. This is true for large businesses, but increasingly also for smaller market participants equipped with smart monitoring and/or automation solutions. These consumers would typically opt to participate in implicit DR.

Other consumers prefer to rely on a stable retail price without direct market-related variability. These electricity consumers may still have significant flexible resources that can be activated and typically marketed via an aggregator, usually without directly affecting the consumer's behaviour. These consumers would opt for participation in an explicit DR scheme.

Finally, some consumers – especially the larger businesses and industrial sites – would engage in both implicit and explicit Demand Response for different applications and timescales.

It would be a severe limitation of consumer choice if only one type of DR was allowed in a certain market, in which case many consumers could be expected not to provide any flexibility to the system at all.

3.3 DIFFERENT SERVICE PROVISIONS

The need for diverse types of consumer engagement is not only driven by consumer preferences and capabilities, but also by technical reasons: certain flexibility functions can only be provided by either explicit or implicit Demand Response.

For example, explicit DR is very well suited to provide dispatchable and reliable capacity, balancing and ancillary services to TSO and DSO, a function that cannot be provided so easily by implicit DR. Explicit DR is a resource, which can be measured in terms of capacity available, and hence can be incorporated in system adequacy assessments, in a comparable way to generation.

On the other hand, implicit DR does not require firm commitment by the consumer to adjust consumption at specific times, but leaves it to the consumer's discretion, how and when to react to the price signals given. Nevertheless, automation processes can imply a decrease in demand above a certain price. With an increasingly wide consumer participation and automation of energy using appliances and processes, the predictability and reliability of implicit DR can therefore be expected to grow.

With the above premises, it is clear that by including DR in AEPC the energy services that are offered in a classic EPC are extended. The energy services in a classic EPC are mainly energy efficiency services that are delivered based on the contract and lead to measurable energy efficiency improvement. As the implementation of DR programs will result in a higher energy efficiency level, it is categorised as an energy service. However, along-side the energy services, non-energy multiple benefit services are also offered in EPCs.

Non-energy multiple benefit services are considered as diverse benefits that are produced by energy efficiency measure in addition to the energy and demand savings. There are some typical non-energy multiple benefit services in classic EPCs that are obtained by different beneficiaries. Table 2 shows some examples of these services [8].

TABLE 2 – NON-ENERGY MULTIPLE BENEFIT SERVICES IN CLASSIC EPC

Utility System	ESCOs and Customers	Society
• Reduced ancillary services costs, • Lower transmission and distribution losses.	• Improved comfort, • Improved indoor air quality, • Lower operation and maintenance costs.	• Improved air quality by CO_2 emission reduction, • Increased EE business.

In AEPC, due to an increased ICT and sensorization equipment and promoting automated active control, the possibility of obtaining the above-mentioned non-energy multiple benefits improves. For example, the DR implementation in AEPC will extend the ancillary services cost reduction for the system operators. Increasing self-consumption in AEPC projects will reduce the energy flow in transmission and distribution systems, further reducing the energy loss on the network. Moreover, electrification as a core intention of

AEPC would significantly contribute to environmental benefit and CO_2 emission reduction. Although increasing the flexibility level and DR implementation can interfere with end-users' comfort level, AEPC ensures that not only the DR programs run according to the plan, but also the comfort level is not being compromised. Other than the typical non-energy multiple benefit services mentioned in Table 2, the followings are achieved in AEPC:

- Cost saving; in classic EPC the calculation of the cost saving is a result of energy savings meaning that the energy saving is the direct service offered by a classic EPC and the euro savings are calculated based on the amount of energy that has been saved. In AEPC, cost saving is computed directly from the results of implementing AEPC and considered as a non-energy service;
- Increased aggregator business; in classic EPC no role is attributed to the aggregators, while in AEPC the conversation between the ESCO and aggregators are initiated and the required equipment for DR implementation are installed. Therefore, the DR options for aggregators to offer in the market will increase.

3.4 THE BUSINESS VALUE OF DEMAND RESPONSE IN ACTIVE BUILDING EPC

Figure 6 provides a summary of the type of DR services that are typically offered and that deliver an increased value to the customers, the ESCO, and the utility against an increased investment from the part of the customer (= prosumer) and/or the ESCO/Aggregator.

The possibility of having DR services varies based on the available flexibility on the demand side and the time horizon of its implementation. Storage and autonomous generation can act as enablers for these DR services. As shown in the figure, load shedding DR, which provides the option of reducing the amount of load on peak hours and consequently helping the grid operation during the peak load hours, relies on the availability of local generation capacity or the agreement of the consumer to reduce its consumption in return for certain incentives.

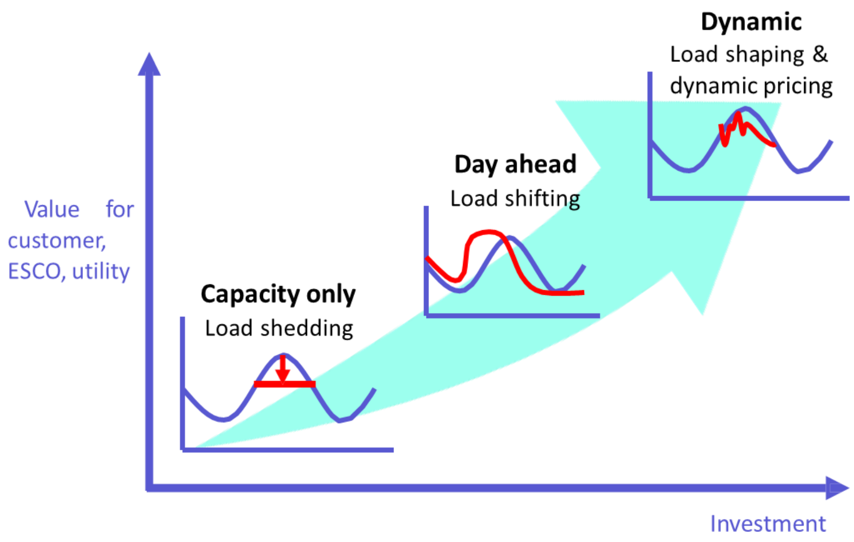

FIGURE 6: THE VALUE OF DR FOR RELEVANT ACTORS (SOURCE: IEA TASK 16)

The load shifting DR is a type of DR that moves the electricity consumption of the end-customer to another period of time. Load shifting is derived from the flexibility of the consumer to change its consumption pattern upon a request from the aggregator. This request can be triggered by a flexibility request from the system operator (i.e., DSO or TSO) or by energy market price signals, both resulting in cost savings. The schedule for load shifting usually is presented on a day-ahead basis; therefore, it requires smarter metering on the demand side as well as near-real-time communication with the aggregator.

More advanced types of DR require higher smartness level on the demand side. For example, load shaping is a type of DR that adjusts the consumption power with dispatchable load and dynamic pricing. Using the dispatchable load indicates the intervention of the flexibility provider (i.e. the aggregator) with methods such as direct load control or implementation of dynamic pricing models. As this type of DR is more dynamic and follows closely the system requirements and price changes, it results in higher energy saving and more efficient energy consumption. It is clear that this DR necessitates more ICT solutions to be available on the demand side, therefore, implies higher level of investment. However, as shown in Figure 6, although enabling more advanced DR application demands higher investment, it also produces higher value for the beneficiaries (i.e., customer, ESCO, system operator, and aggregator).

The value of DR for the end-customer (= prosumer) lies in:

- Cost reductions as demand response allows businesses to avoid higher energy prices at peak demand times;
- The creation of additional revenue streams for end-users with onsite generation, storage, or shiftable loads (when the grid uses it);
- Consumers, including businesses, can understand their consumption patterns better - and access a wider range of choices among innovative services.

For DSO/TSOs, the value of DR lies in:

- Increased system adequacy: security of supply and reduced possibility of outages when the grid is balanced;
- Reduced investment in peak generation and electrical networks;
- Balancing resources for renewable generation: demand response is a green power enabler, supporting a greener grid by encouraging end-users to increase energy use during periods of peak renewable generation (when there is an excess of green energy available);
- Reduced need for coal and gas-fired spinning reserves resulting in lower carbon emissions.

The value of DR for ESCOs lies in:

- Extending their current business offerings and generating new revenue streams;
- Extending their services offering to residential, commercial, or industrial consumers;
- Improving customer loyalty buy offering a wider range of solutions to customers' needs.

For Aggregators it lies in an increased availability of flexibility, providing more revenues.

4.THE METHODOLOGY FOR DEVELOPING AN ACTIVE BUILDING EPC

In this chapter, the main steps that are needed for undertaking an active building energy performance project are presented. The approach presented in this chapter follows the common practice for EPC projects highlighting the main differences and changes that should be considered when an AEPC project is going to be implemented. In this regard, the general procedure for an AEPC project is divided into three main phases and is shown in Figure 7. The main phases are:

- Pre-Contracting phase,
- Contracting Phase,
- Performance phase.

Each of these phases includes further steps during each phase which are described in detail in the following.

4.1 PRE-CONTRACTING PHASE

The first stage for identifying a potential project is to ensure that it has the robust basis for commencing a project, namely conducting the required communications, getting the required approvals, and ultimately implementing the energy performance contract. Therefore, it is important to define the main objective of the project and first evaluation of the potential case. In this regard, the pre-contracting phase is performed through two main steps:

- Pre-feasibility Study,
- Feasibility Study.

The main steps in this phase are described below.

4.1.1 PRE-FEASIBILITY STUDY

The pre-feasibility study involves the collection and analysis of data related to energy users, the benchmarking of all significant consumptions in the evaluated facility, and the development of a simple energy audit analysing equipment, estimating consumption factors based on the energy bills of the previous years. The potential of flexibility available should be verified by evidencing the flexible appliances available in the building and a preliminary analysis of possible new equipment to be added/installed (design options). This step is usually done within weeks through a site visit and a survey with the client.

4.1.2 FEASIBILITY STUDY

The feasibility study (FS) aims to objectively and rationally uncover the strengths and weaknesses of the existing business or proposed opportunities and threats as presented by the environment, the resources required to carry through, and ultimately the prospects for success. The results determine whether the solution should be implemented. In an AEPC, the feasibility study would also determine if the case should be considered for an AEPC or is better suited for a classic EPC.

The feasibility study usually consists of:

1) A technical feasibility study that checks every condition for the realization, the installation and maintenance of the new energy saving measures;
2) An economic and financial analysis that uses the technical feasibility study to develop a preliminary cost estimation which includes all possible project expenditures and revenues;
3) A social and environmental sustainability analysis that considers environmental and social costs and benefits of the proposal. It specifically checks:
    - (Avoided) carbon emission,
    - Other produced/avoided impacts (for example, increase or cut of noise and vibration).

The process of conducting a FS usually takes months to be performed depending on the availability of the data and the extent of the project. The outcome of this phase is a potential AEPC business case with a rough estimation of the financial requirements of the project. The ESCO or EPC facilitator can take such a business case to an investor.

4.2 CONTRACTING PHASE

The contracting phase as foreseen in the AEPC is the pivotal phase for the development and implementation of the project. In AmBIENCe, the process that is represented does not focus on the common steps that the ESCO needs to take to develop an EPC (e.g., tender preparation and publication, asking for expression of interests, etc.), but rather discusses the main steps that require enhancements or need extended activities for developing and AEPC. Therefore, the contracting phase in AmBIENCe highlights the two main steps:

- Contract design phase where the main calculations and quantifications on the terms of the contract and shaping the features of an Active Building EPC are performed.
- Deployment phase where the selected project design options are being installed and performed.

This phase is particularly important for a successful EPC project as the main measures and features of the contract are calculated in this phase. The accuracy and adequacy of terms defined in this phase will contribute to lower risks for the ESCO as well as better performance gain for the client.

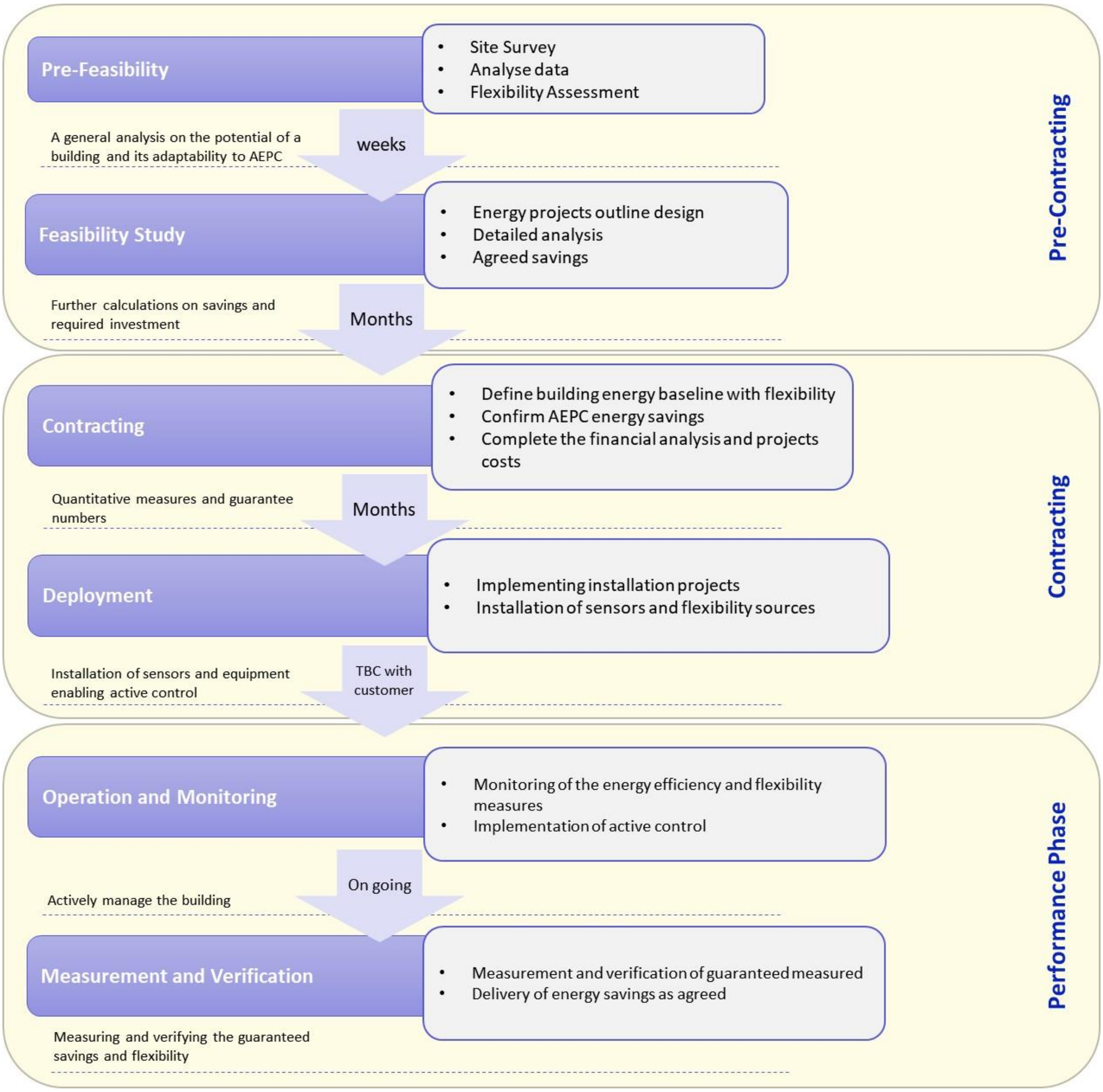

FIGURE 7- THE PROCESS OF ACTIVE BUILDING EPC DEVELOPMENT

4.2.1 CONTRACT DESIGN

In the process of shaping the AEPC, various calculations are required. In the following sub-sections, the methodology in AmBIENCe for achieving the required basis for the contract is described. Besides, the contractual clauses in AEPC are compared with a typical classic EPC and the main required extensions and added clauses are described.

Proof-of-concept Calculation Platform

In AmBIENCe project, a proof-of-concept platform is developed with various modules that serve the required calculations for designing the AEPC contract. The main methodology deployed by AEPC is enhanced by effective methods that are implemented in the ABEPeM platform. The detailed description of the platform is described in deliverable D2.2. However, in this chapter the main modules of this platform and how they are used in the process of AEPC are briefly presented. The interactions between the modules of the ABEPeM are shown in Figure 8.

The main modules of the ABEPeM platform are:

- Energy cost cash-flow quantification module
- Configuration form
- Flex model creation module
- Economic/financial calculation module
- Scenario creation module
- Scenario-based forecast creation module

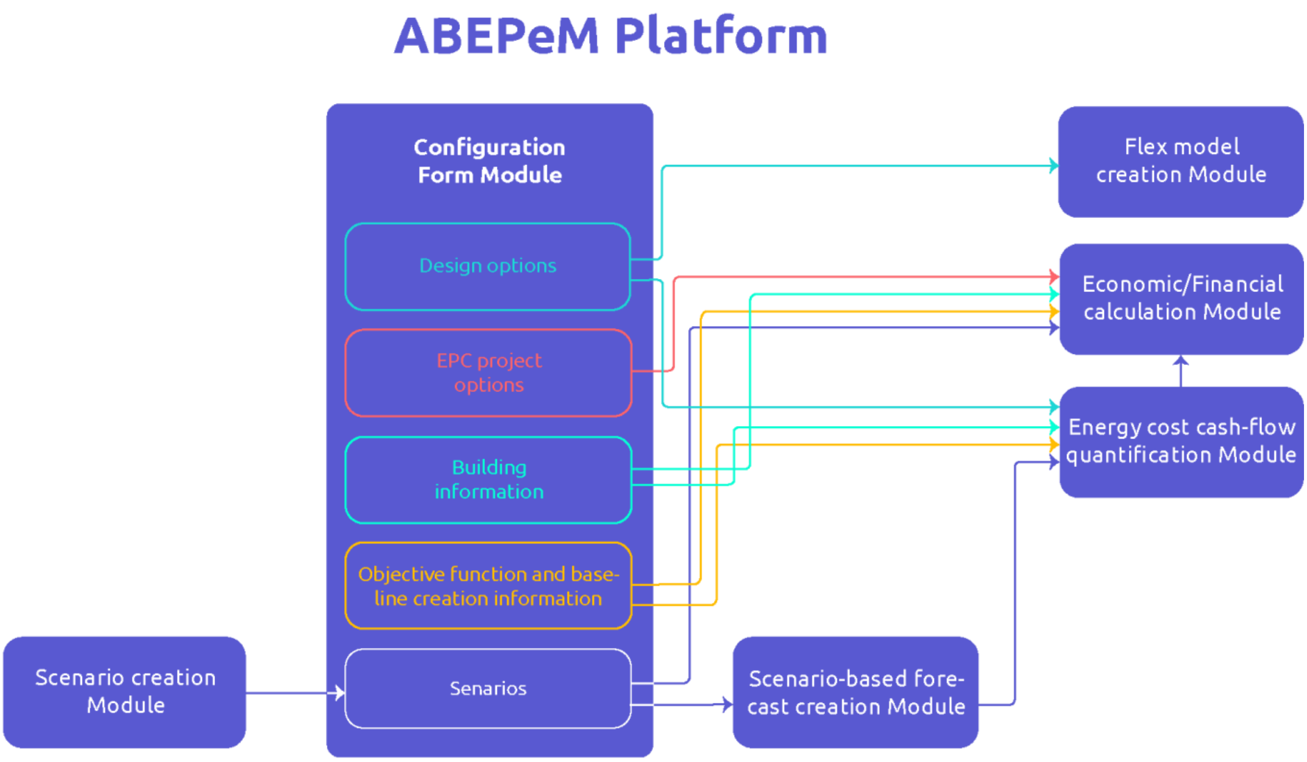

FIGURE 8- THE RELATION OF MODULES IN ABEPEM PLATFORM

(1) The Energy Cost Cash-flow Quantification Module

The purpose of this module is to provide a scenario-driven model-based quantification of a building's energy cost through optimization using a model predictive control method. This module gives the optimal power consumption profile with appropriate temporal resolution. The temporal resolution mainly assumes high resolution as the objective of the optimization is to manage the energy consumption in the building considering the flexibility requirements/availability as well as the DR activities. This module supports the ESCO in calculating the energy consumption profile according to the EE measures and DR/Flexibility measures and its outputs are considered as inputs for calculating the energy cost profile and emission profile calculations.

(2) Configuration form

This module provides the template for acquiring the required inputs for energy cost cash flow quantification module, the Flex Model Creation module, and the Economic/Financial KPI Calculation module. It includes several excel sheet forms gathering several information including:

- The EPC project options information including beneficiaries, contract duration, total investment, etc.;
- Building information;
- Measures information;
- Optimization objective'
- Scenario information including price scenarios.

(3) Flex model creation module

The purpose of this module is to determine relevant flex-characterization parameters of the building and selected flexibility assets.

(4) Economic/financial calculation module

The purpose of this module is to support the ESCO and other AEPC beneficiaries in the process of decision making for an investment in the selected energy efficiency measures combined with DR flexibility from a financial and economic point of view. This module has a key role in the process of AEPC development because it determines the savings and revenues of the project by providing the relevant cash flows and the financial key performance indicators (KPIs).

(5) Scenario creation module

The purpose of this module is to provide scenarios of future evolution during the project to predict and compare performance KPIs for various design options. The module produces a set of scenarios and the agreed ones will be included in the contract. These scenarios are later being used for adjusting the performance guarantees in the M&V procedure.

(6) Scenario-based forecast creation module

The purpose of this module is to provide forecasts of the scenarios created in the above-mentioned module. These forecasts are being used in the optimization model to avoid over optimistic performance results.

Performance guarantee

Another central aspect of the contracting phase of AEPC is to define the performance guarantee measures and calculate them. From a strategic perspective, and considering the main vision of the AEPC towards CO_2 emission reduction, minimum performance targets such as CO_2 savings, energy savings, energy cost savings, and/or the generation of a certain kiloWatt hour (kWh) level of renewable energy per annum can be defined as the performance guarantee of the contract. It is important to mention that AEPC, along with the kWh saving, delivers euro savings as a performance target that is another extension from classic EPC. The reason is that only stating the kWh savings may discourage some cost-saving measures when it comes to DR implementation. An example is the load shifting DR which does not necessarily reduce the amount of kWh consumed but rather shifts it to a cheaper period of consumption resulting in higher energy cost saving.

The performance guarantees are also being defined in the process of running the ABEPeM platform in agreement between ESCOs and beneficiaries because these guarantees underline M&V adjustment factors affecting the ESCO compensations as well as the behavioural responsibilities of the end-user in energy consumption and DR activities.

Contractual Clauses

Usually, each ESCO has its own template and the main items to be identified in the contract depend on the case and the client. However, every EPC project's contract has certain items that need to be included within each template that is going to be used. In the following Table 3, the main clauses of the EPC contract and how it should be changed in an AEPC contract are listed.

TABLE 3 – CONTRACTUAL CLAUSES IN EPC AND AEPC

Main Clause	EPC	AEPC
Energy management plan	Presents the results from the energy audit and considers them as a reference for the contract.	The results from the energy audit with a focus on flexibility resources and DR options are to be considered in an AEPC.
Energy records and data management	Describes the main agreements on the required energy measurements and data records.	As the energy input is important for the smooth operation of AEPC modules, the required data and necessary granularity for calculating the flexibility and optimization procedure should be agreed. Some added data to introduce in the AEPC may include building usage patterns and the occupancy model.
Starting date and terms of contract	Mentions the start date of the contract as well as the contract duration.	Should follow the same approach as for classic EPC.
Payment to ESCO	Includes the terms for the energy savings guarantee and how the payments should be	This section needs to be carefully modified in an AEPC according to the

	made to ESCO. This section also covers the review and reimbursement process and the compensation and fees.	possible interaction model that is considered between the ESCO, the aggregator and the client. The flexibility usage estimation and any possible Explicit DR plan of the building should be considered for modification of the clauses in dealing with possible disagreements. The compensations to the ESCO and risk burden should also be associated to these plans.
Coordination and approvals	Specifies the ESCO requirements for equipment installations.	Should follow the same approach as for classic EPC.
Location and access	Describes the responsibilities of both parties for the installed equipment in terms of protection and access.	Depending on the types of DR plans and interaction models that are considered in an AEPC, this section should also specify the access margin that is allowed for the aggregator (technical or market).
ESCO Responsibility	Specifies the responsibilities of the ESCO in regard to possible damages to the premises and its content during the installation period.	Should follow the same approach as a classic EPC except when new DR programs are considered within AEPC which entail some activities from the aggregator and in that case the margin of responsibilities of the ESCO should be identified in this section.
Construction and equipment installation	Specifies the conditions during the deployment phase.	Should follow the same approach as for classic EPC.
Standards of comfort	Specifies the comfort standard level that needs to be followed by the ESCO in the operational phase (including temperature, lighting level, heating, cooling, water temperature, Indoor air quality)	This section should be designed carefully with all DR programs that are considered in AEPC, active control measures, as well as the agreements that either the ESCO or the end-user will have with an aggregator if that could interfere with the comfort level.
Equipment warranty	Specifies the warranty of the installed equipment.	Should follow the same specifications as for a classic EPC.
Training	Describes a training period for the end-user on how to use and operate the newly installed equipment.	Should follow the same procedure as for a classic EPC with an emphasis on the active control measures, DR programs, and flexible resources that are added for AEPC.

Equipment service	Specifies the responsibilities of both parties for repair and maintenance of the equipment due to a malfunction or emergency.	Depending on the business model that is chosen for the AEPC, this section should be extended to all parties involved (i.e., the aggregator)
Upgrading or altering the equipment	Describes the terms and conditions for changing the equipment or its operating procedure.	These terms and conditions should be aligned with the requirements of the DR program in the AEPC as well as the taken business model interaction to include the responsibilities that may be considered for the aggregator.
Material changes	Outlines the definition of the term material changes which covers any condition, other than weather, that affects building energy use by more than the negotiated percentage.	In AEPC, this part needs to cover all conditions that will cause deviations in the annual energy consumption and flexibility calculations. These items include any changes in the structure, operation, hours of occupancy, and number of occupants. These items will be used as baseline and savings adjustment factors in the M&V plan. It is the responsibility of the client to inform the ESCO of any possible changes in this regard either due to changes in the premise or as a result of certain DR program by an external aggregator.
Representation and warranties	Indicates the pre-requisite and the authority of each party in the contract.	Should follow the same approach as for a classic EPC.
Additional representation of the parties	Mentions the method for ESCO to supervise the client's compliancy with its obligations.	Should follow the same approach as for a classic EPC with an extended supervision on the client's compliance according to the DR/flexibility plan.
Casualty and indemnification	Indicates the requirements for insurance and indemnification.	Should follow the same approach as for a classic EPC.
Ownership	Identifies the main Proprietary Property Rights. These rights are related to the software used by the ESCO for the calculations and adjustments in the contract, the ownership of the existing and installed equipment, and the results produced in the project.	For AEPC, the ABEPeM platform (in its extended form) is the main software to produce the energy management plan of the project which should be considered the property of the ESCO. However, in the case of already existing DR programs with equipment owned/installed by an external aggregator the rights of ownership need to be specified in this clause.

		Usually, the diagrams and profiles created for the implementation of the project are the property of the client. In the case of AEPC, depending on the business model and involvement of market aggregator (who may also use the profiles produced for the project) the rights need to be clarified in this clause.
Default and remedies	Mentions default events and the responsibilities of ESCO and client in response to them as well as the dispute resolution procedure.	In AEPC, the same procedure is followed as in classic EPC with extending the default event definitions to explicitly define DR related defaults and possible responsibilities/actions to be undertaken by the aggregator.
Force majeure	Describes the reaction procedure (actions and timing) to unexpected force majeure situations.	This clause in AEPC extends the force majeure situations to events that affect the flexibility service providing (either for implicit or explicit DR). Some actions may be assigned to coordinated remedies between ESCO and aggregator.
Assignment	Discusses the possibility of assigning the contract to another party by the ESCO and mentions that the new contractor needs to comply with all the existing terms and conditions.	Should follow the same approach as the classic EPC since the flexibility and DR are already included in the terms and conditions of the AEPC.
Miscellaneous	Describes any other condition which do not adapt in other clauses.	Should follow the same approach as the classic EPC.
External/third party DR activities	-	This clause needs to be added to AEPC in the case of the existence of an external aggregator to take responsibility for providing certain DR activities.
Agreement on the basis of price	-	In general, in classic EPC, the prices are fixed (average price). This clause in AEPC determines the basis for energy prices that need to be extended based on the types of DR that are included in the contract and most likely need to include dynamic tariffs.

Normally energy performance contract clauses are accompanied by different annexes that describe in detail the procedures to be undertaken during the project. The following annexes are the main ones that are extended and enhanced in AEPC in comparison to classic EPC:

- **Annex for baseline creation:** The baseline energy consumption is the key element in any energy performance contract that is used as the basis for calculating the savings and controlling and monitoring the performance of the contract. In AEPC, the baseline creation is done using the ABEPeM platform modules through a model predictive control optimization technique considering the flexibility assets and both implicit and explicit DR. This annex is considerably enhanced in comparison to the classic EPC as it incorporates flexibility, active control, and DR in the baseline creation.
- **Annex for savings guarantee:** In a classic EPC, the guarantee annex covers the energy savings covered by ESCO. However, in AEPC, other than the energy saving, cost saving is also guaranteed in the contract. This annex describes the details of how these savings are being calculated using the ABEPeM platform (Deliverable D2.2).
- **Annex for ESCO compensation:** The ESCO is compensated according to the quantity of the achieved savings. In AEPC, the ESCO compensation should be carefully detailed in response to the achieved guarantees due to the EEM and DR measures within the scope of the contract. The annex for compensation should also take into account the possibility of dual flexibility services in case of external/third party DR activities.
- **Annex for Measurement and verifications methodology of savings and performance:** In this annex, the methodology for the measurement and verification is specified. As is the case for classic EPC, AEPC follows most likely the International Performance Measurement and Verification Protocol (IPMVP) standard for the measurement and verification, however, in this annex, the details of the methodology and the adjustments to be made in the performance analysis due to the implementation of the DR projects and flexibility availability are described.

4.2.2 DEPLOYMENT PHASE

After the design of the contract and the identification of the engineering projects required for the implementation of the AEPC, the interactions for the purchase of the required equipment and contracts with the construction companies (if required) will be done by the ESCO. The duration of this phase depends on each case and the number of engineering projects to be implemented. Therefore, it is defined based on an agreement between ESCO and the client.

4.3 PERFORMANCE PHASE

After the installation of the equipment and the signing of the contract, the performance phase of the project starts. This phase refers to the period that the operational activities under the scope of the contract (such as the operation of installed equipment and monitoring of the consumption) start until the end of the project. There are two main actions in this phase: 1) operation and monitoring and 2) Measurement and Verification. As shown in Figure 7, these two actions are ongoing processes during the whole project even though they may have different starting points based on the availability of data and the agreements between ESCO and the client.

4.3.1 OPERATION AND MONITORING

The operation and monitoring activities in an AEPC mainly follow the same approach as being used in classic EPC, such as the training of the end-users and supervising the operation of the energy management plan, which is carried out by the ESCO. However, in an AEPC, the proper data metering and records are crucial for meeting the requirements of optimizing the equipment operation as well as complying with the DR schedules. Therefore, it is necessary to check that the information sent by the new sensors and smart meters are well recorded and do not cause any delays in the operation of the DR activities.

4.3.2 MEASUREMENT AND VERIFICATION

In any performance-based energy contract, a regular measurement and verification procedure is done during the course of the project to determine the savings (energy and cost) that result from the implemented EEM. This procedure is performed along with general operations and maintenance activities, until the end of the contract term when all financial and other obligations are fulfilled. The most common used protocol for M&V in EPCs is IPMVP which is also considered as the main standard in AEPC.

The framework of IPMVP is based on determining the savings by comparing the measured consumption before and after the implementation of a program, making suitable adjustments for changes in conditions. For this purpose, a set of routine and non-routine adjustment factors are defined to be applied to the measured performance profile (actual performance) in comparison to the guaranteed performance profile to reduce the deviations. According to the IPMVP standard [9], the definition of routine and non-routine adjustments are as follows:

- Routine Adjustments: For any energy-governing factors expected to change routinely during the reporting period (e.g., weather conditions or energy production volume) a variety of techniques can be used to define the adjustment methodology. Techniques may be as simple as a constant value (no adjustment) or as complex as several multiple parameters non-linear equations, each correlating energy with one or more independent variables. Valid mathematical techniques must be used to derive the adjustment method for each M&V plan.
- Non-Routine Adjustments: For those energy-governing factors that are not usually expected to change (e.g., the facility size, the design and operation of installed equipment, the number of weekly production shifts, or the type or number of occupants) the associated static factors must be monitored for change throughout the reporting period.

In AEPC, both routine and non-routine adjustments are considered in the process of M&V to normalize the guaranteed performance profile. In this regard, a number of adjustment factors are determined based on the scenarios that are developed during the contracting phase and in the ABEPeM platform. The adjustment factors in AEPC are not only determined by the EEM measures but also by the DR/flexibility aspects of the contract. As described in Deliverable D2.2, four main sets of scenarios are developed in AmBIENCe:

- Weather conditions;
- Energy prices;
- Non-controllable load/consumption;
- Flex related user behaviour/usage patterns.

The following adjustment factors are to be considered in AEPC in relation to the scenarios above.

- **Routine Adjustment factors:**
  - Degree days (related to weather condition scenarios): A degree day is a measure of the heating or cooling load on a facility created by outdoor temperature. Degree days are usually described as Heating Degree Days (HDD) and Cooling Degree Days (CDD) indices. HDD index reflects the severity of the cold in a specific time period taking into consideration outdoor temperature and average room temperature (in other words the need for heating). The calculation of HDD relies on the base temperature, defined as the lowest daily mean air temperature not leading to indoor heating. The value of the base temperature depends in principle on several factors associated with the building and the surrounding environment. An example for calculating HDD index based on [10] is to set the base temperature to a constant value of 15°C in the calculation, therefore, If $T_m \leq 15°C$ Then $[HDD = \sum i(18°C - T^i_m)]$ Else $[HDD = 0]$ where T^i_m is the mean air temperature of day *i.*

    On the other hand, CDD index refers to the severity of the heat in a specific time period taking into consideration outdoor temperature and average room temperature (in other words the need for cooling). The calculation of CDD relies on the base temperature, defined as the highest daily mean air temperature not leading to indoor cooling. The value of the base temperature depends in principle on several factors associated with the building and the surrounding environment. An example for calculating CDD index based on [10] is to set the base temperature to constant value of 24°C, therefore, If $T_m \geq 24°C$ Then $[CDD = \sum iT^i_m - 21°C)]$ Else $[CDD = 0]$ where T^i_m is the mean air temperature of day *i*.
  - Price (related to price scenarios): The price scenarios are the main factor affecting the decision on the DR implementation. In the case of explicit DR, the energy market price and its variation affect the decisions/requests of the market aggregator, while the implicit DRs are inherently price-driven and, therefore, significantly affected by price variations. In this regard, price and its variation affect the performance of AEPC and need to be considered as a routine factor. The average energy consumption and average injection prices are considered as routine adjustment factors to be used for the calibration of the performance profiles. The calculation of these factors uses historical data from the energy market and market aggregator as well as the energy tariffs. A regression-based approach is used for the normalization of the energy performance profile. In this approach, the correlation of price factor with the energy consumption profile is computed using the regression analysis then used for the normalization of the performance profile.

- **Non-routine adjustment factor:**
  - Occupancy (related to user usage pattern scenario): if a sudden change in the usage of the building in terms of the number of building users as well as the number of zones/areas that are being used occurs in the premise of AEPC, it should be considered as an adjustment factor.
  - Facility and end-user equipment (related to Non-controllable load/consumption scenario): in case of any changes (addition or removal) in the amount, type, or use of equipment occurs.

According to IPMVP, four main options for the implementation of the M&V process are foreseen:

- Option A, also known as "Retrofit-isolation: Key Parameter Measurement," where savings are determined by field measurement of the key parameter and the measurement frequency ranges from short-term to continuous, depending on the expected variations in the measured parameter and the length of the reporting period.
- Option B, also known as "Retrofit-isolation: All Parameter Measurement," where savings are determined by field measurement of the energy consumption and demand and all parameters affecting the system. The measurement frequency in this option varies from short-term to continuous depending on the expected variations in savings and length of the reporting period. Both routine and non-routine adjustments are required.
- Option C, also known as "Whole Facility," where savings are determined by measuring energy consumption and demand at the whole facility utility meter level. Continuous measurements of the entire facility's energy consumption and demand are taken throughout the reporting period. Both routine and non-routine adjustments are required.
- Option D, also known as "Calibrated Simulation," where savings are determined through simulation of the energy consumption and demand of the whole facility, or of a sub-facility. Simulation routines are demonstrated to adequately model actual energy performance in the facility. The calibration of the consumption profile is done using utility billing data.

Table 4 summarizes these options and their typical application. Details of these options can be found in [9]. According to these definitions, the options applicable to AEPC are option C for already existing buildings and option D for new buildings. However, as AEPC uses a comprehensive model-based approach in the ABEPeM platform, it provides the possibility of using either of these options in the existing buildings. As the approach in Option C relies mainly on the billing data that are available in the buildings, AEPC's methodology and its ABEPeM platform help the ESCOs to move towards option D by installing smarter meters on existing buildings, consequently improving the available data in buildings, as well as increasing the calibration accuracy by using hourly data from smart meters and optimization techniques of ABEPeM.

TABLE 4 – SUMMARY OF IPMVP OPTIONS AND THEIR APPLICATION

IPMVP Option	Description	Typical Applications
Option A	Isolated Measure, single parameter	Lighting retrofit where pre– and post- retrofit fixture Wattages are measured. Operating hours of the lights are typically agreed upon
Option B	Isolated Measure, all parameters	Replacing old chiller with an efficient one to serve the same cooling load.
Option C	Whole building, all parameters	Several EEMs affecting many systems in a building. Utility Bills are used for savings calculation.
Option D	Comparison with model	Incorporating energy efficiency into the design of a new building or when no historical baseline data is available or can be retrieved. Savings are the difference between modelled or actual building energy use and the energy model of a comparable building built to code. Often the model is recalibrated based on real performance.

5.CONCLUSIONS

This deliverable introduced the Active Building Energy Performance Contracting concept describing the key features that are different in an AEPC in comparison to classic EPC. Benefiting from the flexibility in the buildings due to increased electrification, AEPC considers both implicit and explicit DR programs within its business model and consequently aims for improved measures. AEPC follows a modular approach that makes it applicable to both existing and new buildings with or without ongoing energy performance contracting. The enhanced performance achieved through DR activities was described by discussing the role of DR in AEPC and the benefits and business value that the DR can bring to the stakeholders of AEPC.

The main phases for developing an AEPC project were also described in this deliverable highlighting the main differences with the common procedure of EPCs and the modifications that need to be made specifically in the contract model of AEPC. The design of the contract in an AEPC is the part that experiences the main changes and therefore is supported by the Active Building Energy Performance Modelling (ABEPeM) platform. Although the details of features on functionalities of ABEPeM are described in Deliverable D2.2., in Chapter 4, its usage in the process of developing AEPC is described. Active control and DR activities in buildings entail increased granularity in monitoring the performance of the buildings with AEPC. Therefore, the M&V procedure is improved to comply with the enhancements in AEPC.

In summary, this deliverable provides the basis for the AEPC concept and methodology. Deliverable D2.2- Proof-of-Concept of an Active Building Energy Performance Modelling framework provides the details of calculating the performance guarantees, and Deliverable D2.3- Business Models for the Active Building EPC concept provides the details on AEPC ecosystem and business models. In section 2, in the definition of the AEPC concept, it was mentioned that AEPC is foreseen to be applied to a broader range of buildings as well as clusters of buildings which is going to be provided in Deliverable D2.4 - The Collective Active Building EPC concept and business model.

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ABBREVIATIONS AND ACCRONYMS

ABEPeM	Active Building Energy Performance Modelling
AEPC	Active Building EPC
CDD	Cooling Degree Days
DR	Demand Response
DSM	Demand Side Management
DSO	Distribution System Operator
ECM	Energy Conservation Measures
EE	Energy Efficiency
EPC	Energy Performance Contract
ESCO	Energy Services Company
FWh	FlexiWatt hour
FS	Feasibility study
HDD	Heating Degree Days
HVAC	Heating Ventilation and Air-Conditioning
KPI	key performance indicators
kWh	kiloWatt hour
M&V	Measurement and Verification
NWh	NegaWatt hours
TSO	Transmission System Operator

ANNEX I.DIFFERENCE CHECK-LIST IN PRE-CONTRACTING PHASE

	EPC	AEPC
Interaction with the user - Behavioural change		
Changes in energy consumption: minimization and optimization of the use of appliances	X	X
Changing settings on the thermostat, for example turning up air conditioner in the summer and turning down thermostat in winter	X	X
Adding/purchasing fuel-efficient car	X	X
Add of renewable energy: installation of photovoltaic panels	X	X
Change of energy supplier	X	X
Retrofit obsolete appliances with smart and automated ones	X	X
Change usage pattern of flexible devices		X
Evaluation of demand response options		X
Preliminary analysis		
The building has recent upgrades	X	X
Buildings characteristics	X	X
Equipment characteristics	X	X
Utility information	X	X
Potential improvements	X	X
Recurring maintenance problems	X	X
Financial analysis		
Payments can be covered by the cost savings because of energy savings	X	X
Payments can be covered by the cost savings from the DR implementation		X

ANNEX II.DIFFERENCE CHECK-LIST IN CONTRACTING PHASE

	EPC	AEPC
Guaranteed energy savings	X	X
Guaranteed cost savings		
Renewable energy generation	X	X
Considering the impact of dynamic price		X
CO_2 reductions	X	X
Improving or maintain the building environment and comfort for occupants	X	X
Creating a safer environment through improved better building management systems to help identify issues	X	X
Demand response integration		X
Third party implication		X
Measurements necessary to the calculation of the flexibility and DR		X
Flexibility estimation methods		X
Creation of scenarios with DR		X

ANNEX III.DIFFERENCE CHECK-LIST IN PERFORMANCE PHASE

	EPC	AEPC
Installation of selected solution	X	X
Development and application of the method to forecast EPC baseline	X	X
Calculation of CO_2 reductions	X	X
Calculation of energy savings	X	X
Calculation of cost savings		X
Implementation of methods to re-evaluate the flexibility estimation		X
Implementation of performance methods to re-evaluate the baseline	X	X
Implementation of methods to re-evaluate risk analysis	X	X