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Active managed Buildings with
Energy performaNce Contracting

Deliverable Number (D1.2)

Overview of actors, roles and business models related to Enhanced EPC and Building Demand Response Services

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AUTHOR (S)	Di Somma Marialaura (ENEA), Vanschoenwinkel Janka (VITO), Vanstraelen Lieven (Energinvest).
OFFICIAL REVIEWER/s	Alonso Itziar (TEKNIKER), Caerts Chris (VITO), Caliano Martina (ENEA), Cancro Carmine (ENEA), Ramos Ricardo (EDP), Rossi Gabriella (ENEA), Santos Manuel Ricardo (EDP), Vastiau Annick (VITO).

EXECUTIVE SUMMARY

The AmBIENCe project aims to develop an Active building Energy Performance Contracting (AEPC) model, enhancing the classical Energy Performance Contracting (EPC) model by valorising Demand Response (DR) or flexibility potential in buildings. This is typically facilitated by a higher degree of electrification of heat demand in combination with dynamic tariffs.

The purpose of this report (Deliverable D1.2) is to analyse the actors, roles and business models related to extended EPC business models and the use of flexibility at the demand-side form buildings. To do so, we start from existing flexibility DR business models (chapter 4), and we examine how they could be (and if they are already) integrated with existing EPC business models (chapter 5 and 6). Methodology wise, we performed a literature study on the individual topics of EPC concepts and DR services, followed by stakeholder interviews to better understand how both of them are already integrated.

More specifically, in the **chapter 3**, we look at Flexibility/DR Services in buildings. In particular we formulate an answer to the question: Why are building flexibility services needed? The main reasons for the building owner are increasing self-consumption and for the network operators it is grid congestion management, grid balancing and infrastructure investment optimization. We look at different types of available flexibility, corresponding to different electrical installations in HVAC. Also, the use of that flexibility was analysed and we identify various common ways to modify the load profile. Specific political, technical or behavioural barriers for DR in buildings remain in place. Chapter 3 shows that buildings have flexibility available and that they could perform DR under the right conditions.

In **chapter 4** we identify various Flexibility/DR Business Models, to see if and how we could use some of them in the new AEPC concept. To do so we analyse the types of actors that typically intervene when delivering both DR and Energy Efficiency (EE) services. For the specific business models, we distinguish between implicit and explicit demand response. For implicit demand response, the key business model is contract optimization, which implies that an active building will adapt its behaviour based on for instance different price and tariff incentives. As such, we analyse different retail and tariff components, compare (dis)advantages and zoom in on certain countries to see how price and tariff practices tend to differ from one member state to the other. For explicit DR, it seems that business models are driven by the requirements of Flexibility Requesters (typically TSOs, DSOs and Balancing Responsibility Parties or BRPs). We identified five main explicit DR services, each with several products and looked at what the product requirements are, as well as what market access conditions are. We examined the key role of the aggregator as an intermediary party between the prosumer and the TSO/DSO/BRP in explicit DR and in general the role of different actors in the explicit DR business model. To illustrate these models, we identified several examples of applications in buildings and selected 8 cases that are somewhat representative of the various business models that we researched. Chapter 4 proves that currently there are already numerous business models available for DR, and these business models are expected to continue growing with the rise of digital meters and more dynamic pricing components.

As the AEPC model is an enhancement of the existing EPC model, we study the existing EPC business model and its various types or variations in **Chapter 5.** We start with a short history of EPC to indicate how and why EPC has been developed and used for achieving energy savings for over 30 years. We looked at the two most common savings models: guaranteed savings and shared savings and how they differ before analysing the different most common types of EPC, that differ either by scope of services, ambition level or performance approach. We performed a comparison of the common use of these different types of EPC for several EU countries and completed that with input from partners on which types are used in their specific countries. Finally, we studied the usage and analysis of different EPC types in combination with DR and re-evaluate the actors, roles and market models in relation to the EPC and AEPC model. Chapter 5 shows that numerous EPC models are well-used in different countries, yet that only a minority of them integrates flexibility and DR-services. Nevertheless, the different types of EPC can be the basis for AEPC models.

To complement this extensive literature study, in **chapter 6**, we conducted stakeholder interviews from flex providers and flex requesters, to enrich the first part with findings from practice. This allows us to understand how Energy Service Companies (ESCOs) in particular make use of active control and which potential their current practices offer in terms of adding flexibility. It also allows us to understand the type of requirements that DSOs/TSOs would have on flexibility provided by buildings. The interviews confirmed the results from chapter 5 by indicating that AEPC is currently not yet widely used, but also that Flex Requesters are keen on exploiting DR in Buildings, in particular if it comes with a high degree of reliability.

In conclusion, the report proves that demand response and EPC are often offered separately from one another and are not integrated yet. However, it provides significant evidence that an AEPC model makes sense to the extent that it can exploit energy efficiency measures, in particular including electrification of heat production in combination with building insulation, while adding active control to valorise flexibility in buildings. It also shows how Flex Requesters are interested in using that flexibility in buildings. This offers new business opportunities to ESCOs, that we will continue to explore in the other activities of the AmBIENCe project.

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1. INTRODUCTION AND BACKGROUND DELIVERABLE

1.1 CONTEXT, ACTIVE BUILDING EPC (AEPC) CONCEPT AND GOALS OF AMBIENCE

Buildings are responsible for approximately 40% of energy consumption and 36% of CO_2 emissions in the European Union (EU). Energy efficiency measures are essential to improve building's energy consumption, indoor environmental quality and environmental performance by taking advantage of the available technologies, without compromising the comfort and well-being of users. Besides lowering energy use, using energy in a smarter manner (e.g. using local and/or renewable energy sources (RES) and flexibility and storage) is a complementary approach to reduce buildings emissions. Developing new smart energy services that utilise flexibility from demand-side resources in different sectors is essential to fully unlock the potential of buildings towards energy and cost savings, and CO_2 emissions reduction, while ultimately meeting climate goals. The use of information and communication technologies (ICT) solutions and tools, relying also on big data provided by smart meters and sensors, can trigger significant savings with reduced investment, coupled to renovating the existing building stock.

Energy Performance Contracting (EPC) schemes are an effective means to provide energy efficiency services that can bring added value to the whole value chain and contribute to the empowerment of energy end users through innovative products and services offered by dedicated providers such as Energy Service Companies (ESCOs), aggregators or energy cooperatives/communities.

After several years of slow growth in the EU ESCO market due to legal, financial and administrative barriers facing EPCs, there are several European efforts to support the EPC process, including the 2017 Eurostat Guidance Note and the subsequent 2018 EPC Guide to the Statistical Treatment of EPCs. However, there are still several challenges facing the ESCO market. Typically, investments that result in a meaningful emission reduction are high and show poor economic and financial KPIs (e.g. pay-back time of well over 40 year and more). Therefore, EPCs are mostly applied for public buildings, and are hardly seen with commercial or residential buildings. On the other hand, demand response has a negative impact on users' perception of comfort, especially regarding the Heating, Ventilation and Air Conditioning (HVAC) system of the building, and estimating the financial benefits is hard for non-experts. These barriers can be addressed by using innovation in several technological fields that enables improvements not only in terms of guaranteed energy cost saving, but also in terms of non-energy services such as security and comfort.

The combination of Demand Response (DR) with current EPC schemes establishes the Active Building EPC concept, which uses intelligent and real-time information to offer new combined services, established comfort and safety performance criteria and new levels of flexibility activation and use. These principles are at the core of the EU-funded project AmBIENCe (Active managed Buildings with Energy PerformaNce Contracting). The project aims to extend the concept of Energy Performance Contracting to Active Buildings, which are buildings equipped with active control options that can actively participate in demand response and energy efficiency programmes, and make it available and attractive to a wider range of buildings. The proposed Active Building EPC concept and business model extends the traditional EPC in three dimensions:

1) Extending energy performance guarantees related to energy efficiency with guarantees related to the valorisation of flexibility through DR services;
2) Tailor EPCs to a broad scope of building types (residential, hospitals, education offices, commerce, etc.);
3) Extending the scope to groups/clusters of buildings under the concept of (local) energy communities.

AmBIENCe aims to provide new concepts and business models for performance guarantees of Active Buildings, combining savings from energy efficiency measures and the active control of assets, enabling the use of flexibility. The willingness to invest in additional sensors, ICT and the Internet of Things (IoT) will allow offering adjacent non-energy services. In detail, the new AmBIENCe contract model has the following features:

- Includes flexibility services through DR, distributed energy resources (DER) including RES storage, and electric vehicles (EVs);
- Integrates energy and non-energy services (security, access control, comfort, indoor environmental quality, and health, remote control and monitoring, automatic diagnosis and maintenance prediction, building condition, trouble shooting, environmental compliance, and information management);
- Is applicable to all types of buildings;
- Is founded on transparency and real-time information provision to empower end users;
- Relies on standards of Measurement and Verification (M&V);
  Takes into account energy exchange with other buildings under the concept of (local) energy communities.

1.2 PURPOSE AND SCOPE OF THE DOCUMENT

Deliverable D1.2 falls within the scope of Work Package1: "Assessment of (enhanced) Energy Performance Contracts and Building Demand Response services in Europe," with the main goal to provide an overview of the current situation in terms of actors, roles and business models, related to enhanced "Active building" EPC and Demand Response Services provided by Buildings.

The purpose was to collect information on and analyse practices, actors, roles and business models related to:

- best practices and standards related to extended EPC business models;
- the use of flexibility at the demand-side from buildings – and cluster of buildings like Local Energy Communities – as an energy resource in support of the energy transition and to foster energy efficiency;

The work was divided into two main activities:

- Part A (Chapters 3, 4 and 5): a desktop study of relevant resources on demand response services provided by buildings, and EPC contracts including DR value streams.
- Part B (Chapter 6): a stakeholder survey, aimed at Flexibility providers (typically Energy Service Companies or ESCOs) and Flexibility requesters (typically Distribution System Operators (DSOs) and Transmission System Operators (TSOs)).

Table 1 summarizes the overall approach:

Table 1 – Overall approach to D1.2

Objectives	Overview of Actors, Roles & Business Models	
Domain	Enhanced “Active building EPC” and Demand Response	
Methodology	Part A	Part B
	Desktop study	Stakeholder Survey
Deliverable	D1.2	

2. RESEARCH QUESTIONS AND APPROACH

The objective of the desktop study (Part A) is to study:

- the type of actors that would be involved in Active building EPC and the roles they have in the value chain;
- the business models that are being used for flexibility in buildings and how they can be combined with EPC to be the basis of an Active building EPC (AEPC) model;
- how DR services can improve the business case of EPC and under which conditions;
- common M&V practices used for DR, that could be adopted for the Active building EPC model.

The objective of the Stakeholder survey (Part B) is to get input from stakeholders on:

- The current services they – as flex providers - are currently offering in terms of demand response;
- The outlook of flex users or requesters to the possible use of DR from buildings and the criteria that apply to it;
- The business models they are using or envisaging and the timeframe in which they are doing so.

3. FLEXIBILITY/DR SERVICES AS A NEW BUILDING ENERGY SERVICE

DR is an articulated program of actions that allows the consumers (industrial, commercial or residential) to modify their own electrical load (lowering it or translating it horizontally) in response to existing problems on the grid, e.g. momentary unavailability of power caused by failures or intermittent production from non-programmable renewable sources, or in response to the dynamics of wholesale electricity prices, or to increase the use of locally or self-produced energy. DR can provide several environmental benefits while making the electric grid more reliable in the presence of high shares of renewables. It can contribute to save energy, reduce the use of fossil fuel power plants, and help integrate renewable energy into the electric grid by also providing increased stability and management, avoiding peak congestions. The incentive for end users to join DR programs comes from direct economic savings generated by the action implemented thanks to refined tariff structures or coming from a more complex remuneration system managed by the system operators of the electricity grid who essentially pay the end user to be available for more or less scheduled disconnections.

3.1 WHY ARE BUILDING FLEXIBILITY SERVICES NEEDED?

The production of renewable energy from wind and sun is not constant over the time. Typically, solar plants produce much more energy in summer than in winter, while the opposite happens for wind farms. High variability of production is recorded also during the single day and this is due to the natural variation of irradiation and windiness. There are different methods to forecast the production of renewable energy, based on meteorology and complex mathematical algorithms allowing the TSO to manage this variability, but, despite this, several times the energy production is larger than the demand and therefore the TSO is forced to issue dispatching orders to block some wind or photovoltaic plants, thereby creating economic and environmental damage.

At the level of individual users (homes, buildings, commercial users, etc.), the demand response concept can be applied by using specific control systems with the aim to mitigate this problem: some electric loads are activated preferably when the photovoltaic (PV) plants produce an excess of energy (e.g. household appliances, charging systems for electric cars, environmental conditioning, etc). Moreover, the use of energy storage systems (both electric and thermal) allows exploiting any additional energy surplus produced on site in the hours of day when production from renewables is low.

Several practical cases have shown that these methods allow individual users to increase their self-consumption of renewable energy from 30% to 80%, thus reducing the injection of an energy excess into the grid which could determine the need to block production from renewable plants.

At the grid management level, the demand response is activated through the energy flexibility market: the TSO can ask certain users (already accredited for this) to balance the grid by modifying their consumption baseline or by injecting energy into the grid.

In fact, in the event that the global production of energy is larger than the demand, these users will have to consume more energy than their habitual needs (for example by loading storage systems and / or activating programmable loads), otherwise, if the global demand is larger than the production, they have to disconnect some loads to consume less, or they will inject energy into the grid by discharging their electric storage systems.

This strategy is very useful to avoid the congestion problems of the distribution electric grid. They occur when the energy flows required in a part of the grid (both to meet the high demands and to transport the energy produced by renewable plants) are higher than those for which the electric grid components have been safely designed. The congestion problems are essentially due to the generation of sudden power flows, produced by solar and / or wind power plants, which generate power peaks that are difficult to forecast and to manage by the grid, especially in rural areas. The demand response tools both at building and at grid level allow reducing flow peaks and therefore contribute to avoid congestion problems.

TSO has always to guarantee the balancing of the electricity grid: the electricity consumption must be equal to the production of the plants at all times. When this balance is lost, special mechanisms are activated. In this case, three types of actions are implemented:

- primary regulation: it is automatically activated in a few seconds and allows a limited variation (typically ± 1.5% of the rated power) of the generators power, both in increasing and in decreasing.
- secondary regulation: it is always activated automatically, but within a few minutes and allows a wider range of power regulation, of the order of 10%.
- tertiary regulation: unlike primary and secondary regulation, it is activated manually by the producers on the basis of requests from the TSO and it serves to compensate for imbalances greater than those manageable by primary and secondary regulation.

In addition to traditional generators, which have specific obligations to contribute to the balancing of the grid, starting some years ago, electric storage systems (batteries and flywheels) have been used because: they allow rapid control of the grid and therefore can be used within primary regulation. Having a large storage capacity, even electric vehicles can also be used as common balancing tools. Renewable source plants, in general, allow an “asymmetrical” type of regulation, as it is only possible to reduce the power injected into the grid (even up to disconnection), but not to increase it. Since some years, the TSO acquires the necessary resources to guarantee grid balancing on the electric dispatching market. Furthermore, several pilot projects in Europe have started to open this market even to small operators gathered in an aggregation of prosumers and managed by a single entity called “aggregator”, able to interface with the TSO and provide it the flexibility resources against a payment for the provided service.

As already said, the last decade in Europe has been characterized by a progressive decrease in conventional thermoelectric and by an exponential increase in renewable energy plants, in particular photovoltaic and wind power. The reduction in the number of traditional programmable plants (mostly thermoelectric and hydroelectric) historically used by TSO to perform the balancing, has determined a decrease in the total power available for regulation, which is a percentage of the nominal power of the plants in operation.

Renewable plants, from their side, are non-programmable sources and their greater diffusion makes it even more important and necessary to find additional regulation sources than the classic ones. The further development and penetration of renewable sources, also envisaged by the Clean Energy Package, will only take place if advanced self-consumption techniques are disseminated at the building level or at the level of energy districts in order to minimize the imbalance effects on the external distribution network. This approach has two further advantages: the consumption of energy produced on site avoids the grid transmission losses, and reduces harmful emissions, since only energy produced on site and from renewable sources is used.

In any case, since a building or an energy district normally cannot self-consume all the self-produced energy, the greater penetration of these sources is closely linked to the finding of additional resources for grid balancing, which can be acquired only on the market of balancing services when it will be opened to an increasing number of operators.

3.2 WHAT TYPE OF FLEXIBILITY IS AVAILABLE IN/FROM BUILDINGS?

There are different sources of flexibility within buildings, that can be activated by shifting production of useful energy or usage of it. Some may require acceptable flexibility in the comfort levels or in the way installations are being used. The following list provides some examples of typical sources of flexibility in buildings, see also Figure 1:

- Electrical installations such as:
    - PV panels,
    - Heat pump,
    - Heat pump water heater,
    - Electric battery, EV,
    - Energy recovery ventilation
- Smart sensors among which
    - Lighting controls,
    - Energy management system,
    - Computer and office equipment automatic control
- Building elements:
    - Window shades,
    - LED lighting,
    - Variable speed pumps,
    - Efficient kitchen equipment,
    - Insulation,
    - Day lighting

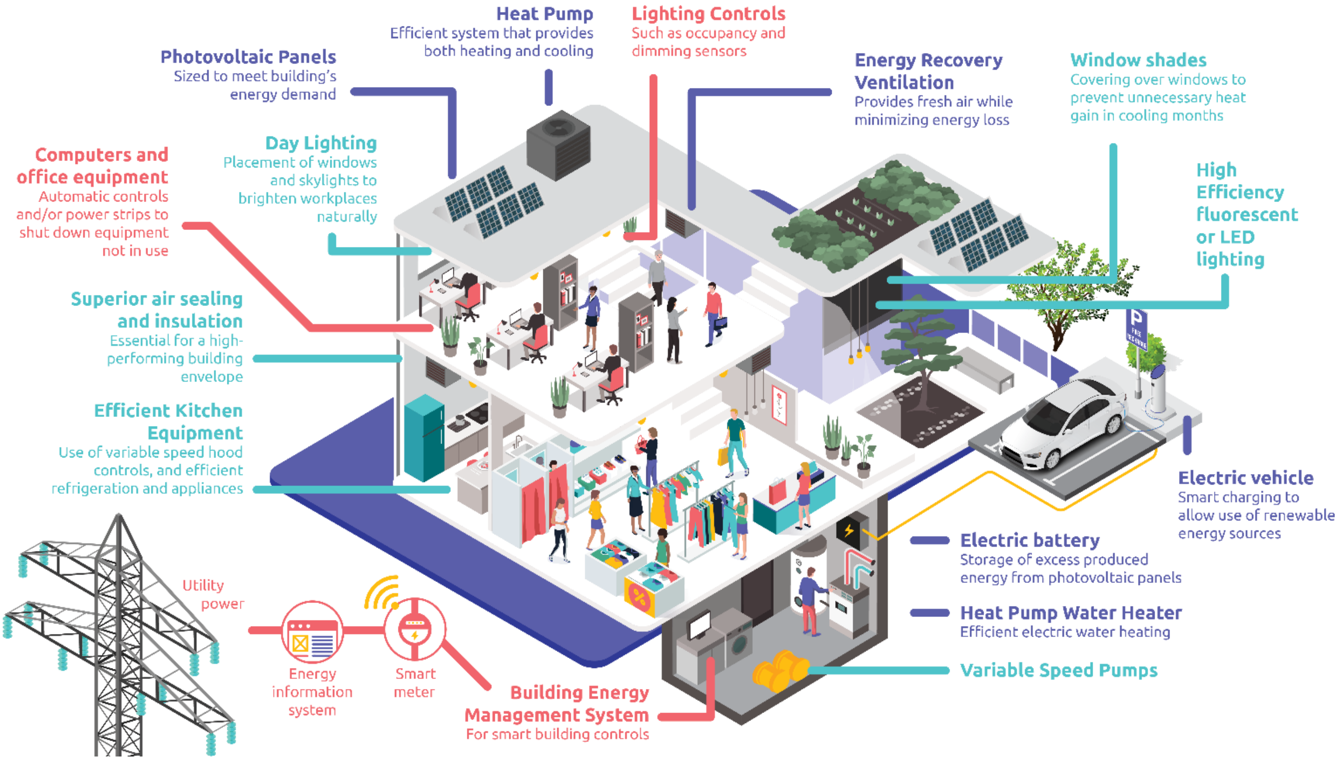


Figure 1 – Overview of different sources of flexibility in/from buildings (AmBIENCe; 2020)

3.3 IN WHAT MANNER IS THAT FLEXIBILITY USED?

With the increase of distributed and non-programmable renewable energy sources, load flexibility becomes even more important for an efficient, stable and economical energy system. *Consumer-empowerment* is taking on a leading role: thanks to advances in technological development and digitalization, people are beginning to play an active role in the energy system, to achieve savings on their energy bills, to improve comfort or to contribute to the energy transition. The load flexibility is a form of demand response that controls electricity usage in real time, also using common household appliances like smart thermostats and water heaters. The important role of this load flexibility rises as the grid faces issues balancing supply and demand with the use of more wind and solar energy, generators that are not programmable. Load flexibility can help by quickly lowering or shifting demand to balance the grid, without affecting the comfort conditions inside the buildings.

When discussing about load flexibility it is useful to distinguish between flexibility to shift load demand (load shifting), and flexibility to reduce and increase peak load demand (load shedding and increasing). Figure 2 shows a comparison between load shifting and load shedding over a typical load curve over the day, where there are peaks in the morning and afternoon, a somewhat lower load at mid-day, and much lower load during the night.

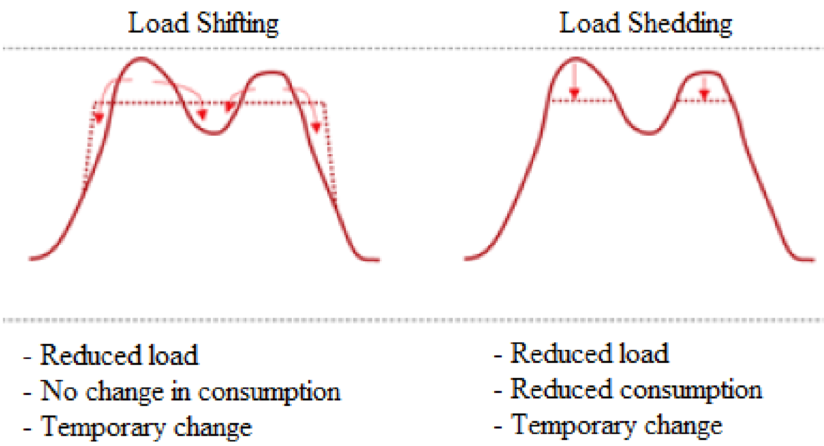


Figure 2 - Typology of options for load flexibility: load shifting vs. load shedding (Nordic Council of Ministers & Nordic Energy Research, 2017)

Load shifting, shown in the left side of Figure 2, essentially refers to scaling load up or down according to external pricing signals. Power consumption during peak load periods, times during the day when demand for electricity is high and the price expensive, is shifted to periods of lower demand and lower prices. Load shifting does not involve a reduction in electricity consumption than originally planned, allowing the electricity to be consumed at a different time. By shifting the load, the load profiles of electricity consumers often align with volatile power production at renewable energy plants: the low production costs of these assets (wind power, photovoltaics) cause lower prices on the electricity exchange. Load shedding, shown in the right side of Figure 2, involves the targeted reduction of total electricity consumption, implying a lower demand for power without compensating the adjacent periods. On the contrary, if the supply of energy surpasses demand, depending on the configuration of generation capacity, load increasing can be applied, using energy storage to arbitrage between periods of low and high demand. As a result, the electricity consumption increases.

The load shaping techniques also include the peak clipping, valley filling, and flexible load shape, shown in Figure 3.

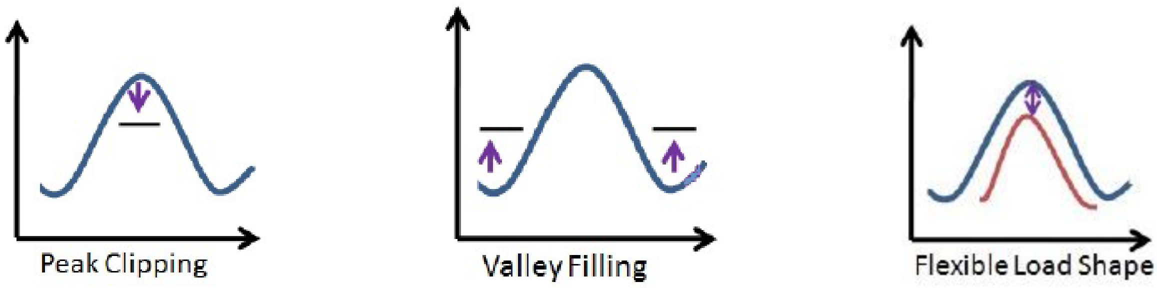


Figure 3 – Other load shaping methods: peak clipping, valley filling and flexible load shape (B. LOKESHGUPTA ET AL., 2017)

The first two parts of the Figure can be seen as a part of load shifting, while the last one as a combination of load shedding and load increasing. In the peak clipping (in left side of Figure 3), load reduction occurs during peak hours. As a result, both peak demand and total energy consumption are reduced; in the valley filling (in the central part of Figure 3), the off-peak areas are “filled”, by increasing the total energy consumption but not the peak load; finally, the flexible load shape (in the right side of Figure 3) is related to direct interruption of particular loads, when it is necessary. A small variation in energy consumption and peak load may be achieved.

3.4 FLEXIBLE DEMAND: SPECIFIC BARRIERS FOR BUILDINGS

The opportunities for realising DR programs vary across Europe, as they are dependent on the specific regulatory, market and technical contexts in different European countries. Although successful DR programs are becoming increasingly common for large industrial customers, the DR programs aimed at small and medium scale customers have mostly failed to meet their expected potential. Barriers in the diffusion of DR programs, in the building sector, can come in the form of political, technical and behavioural challenges.

From a political point of view, regulated utilities operate within an incentive structure that prefers building physical assets to the behaviour-dependent demand response. Incentive mechanisms are needed for the diffusion of demand response, as happens on the generation side, in order to stimulate the user to modulate withdrawals according to price changes. On the other side, wholesale markets have evolved around supply-side resources, without giving to supply and demand equal treatment. Moreover, complex and burdensome administrative and authorisation procedures still represent an important barrier for the competitiveness of small-scale self-consumption projects for buildings.

In general, blocks of buildings offer more flexibility in the timing of energy use, local energy generation and energy storage than single buildings, but also in this context, the potential value of DR strongly depends on the control technologies embedded in the building management systems.

The behavioural challenges depend on the lack of awareness of the users of their own load profiles, also due to a limited adoption of monitoring systems. The lack of information of end users about the regulatory and technical framework of demand response is also a crucial barrier. Moreover, many users have no confidence in the electricity market functions (CEER, 2011), because of its complexity and are quite low interested in energy related issues (Kim & Shcherbakova, 2011).

Within this report, we will identify further barriers and zoom deeper into those barriers that the AmBIENCe project will search solutions for.

4. FLEXIBILITY/DR BUSINESS MODELS

The previous chapter indicated several flexibility options for buildings. This chapter will zoom in on how such flexibility options can be valued through different DR business models.

Demand response (DR) is defined as "Changes in electric usage by end-use customers from their normal consumption patterns in response to changes in the price of electricity over time, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized." (p.1) (Murthy Balijepalli et al., 2011)

Through DR, different types of customers receive signals to adjust their demand at specific moments of time. These signals can be either "explicit" (e.g. leading to direct payments) or "implicit" (e.g. leading to price-based benefits that decrease their bill). Explicit demand response implies that demand-side resources are traded on markets (wholesale, balancing and ancillary services and where applicable also capacity mechanisms). Implicit demand response on the other hand implies that energy prices or network tariffs vary over time because they reflect the value and cost of (the transportation of) energy at different moments in time. (SEDC, 2017)

The two types of DR models are therefore activated at different times and serve different purposes (Zheng Ma et al., 2017). Consumers can participate in both models. Figure 44 (van der Veen et al., 2018) indicates the difference between implicit DR (left part of the Figure) and explicit DR (right part of the Figure). In case of implicit DR, the prosumer can value its flexibility itself. Possibly, this can be done through the support of an ESCO who helps the consumer to optimize its behaviour. In case of explicit DR, the consumer can trade its flexibility directly on the necessary markets to the benefit of Balancing Responsibility Parties (BRPs) and system operators. However, as indicated in the Figure, in most cases, an aggregator will act as a third party and trade the prosumers' flexibility on the markets.

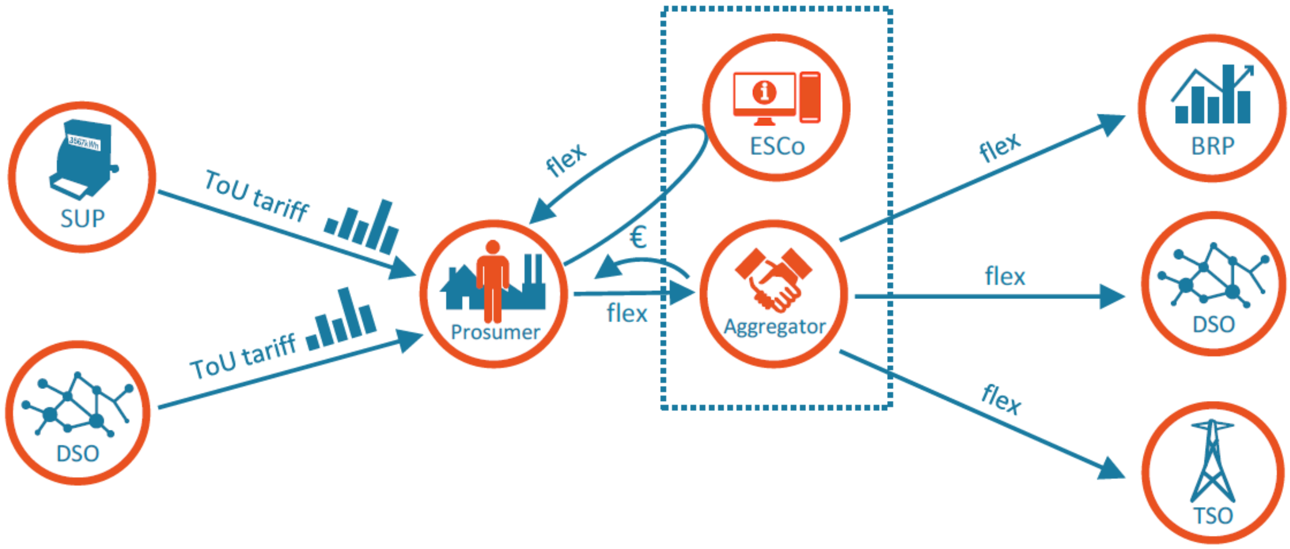


Figure 4 - Implicit and explicit demand flexibility (source: (VAN DER VEEN ET AL., 2018) – USEF)

In what follows, we will give more insights into these different actors, the different types of business models that exist for both implicit and explicit demand response, and the different challenges that go along with them.

4.1 ACTORS AND ROLES FOR DR

Different market players can be active in DR markets depending on the exact model chosen. Each market player has a specific role that characterizes its responsibilities and potential collaboration patterns (Delnooz et al., 2019). Below, we summarize the most important roles that can take place in DR markets. It is important to differentiate between the roles in the market and the actors that can adopt them (ENTSO-E, 2017b). The description of the different roles is adapted from (Delnooz et al., 2019; ENTSO-E, 2017a; IRENA, 2019a; Rivero et al., 2014; Zheng Ma et al., 2017).

- Supplier / retailer – actor that provides electricity to end consumers. The supplier has a contractual agreement with the grid operator. Suppliers have their own generators or buy electricity from other producers on the wholesale market.
- Consumer – actor that consumes the delivered electricity. Consumers that take active part in the grid system in the sense that they possess their own DER (such as solar panels) are also referred to as prosumers.
- Aggregator – grouping of agents in a power system (i.e., consumers, producers, prosumers) to act as a single entity when engaging in power system markets (both wholesale and retail) or selling services to the operator. An aggregator can help in better integration of renewable energy resources by providing both demand- and supply-side flexibility services to the grid.
- TSO – the actor responsible for operating and maintaining the transmission grid in a given area. Potentially, it is also responsible for the development of the grid in a given area and for the interconnections with other systems. The TSO is also responsible for connecting all DSOs in its control area and must ensure future demand for transmission of electricity.
- DSO – the actor responsible for operating and maintaining the distribution grid in a given area. If applicable, it is also in charge of developing the distribution grid in specific areas and responsible for the interconnections with other systems. The DSO must also ensure the ability of the system to meet future demand for distribution of electricity.
- BRP – the actor responsible for a specific portfolio of access points. It must ensure balance between injections and offtakes in its portfolio.
- Energy Community - energy communities can take up the role of a consumer/prosumer as such and sell to BRPs, aggregators… like normal consumers/prosumers would do. Given the fact that they are larger than traditional consumers/prosumers, they should have scale benefits. On the other hand, energy communities could change existing market models in the sense that they provide opportunities for peer-to-peer supply (P2P).

- ESCO – the actor that aims to offer fully integrated energy services to its customers. Generally, it focusses on energy savings and energy efficiency solutions in existing buildings. Yet, in the scope of the AmBIENCe project, it is examined how it could extend its scope to also offer DR services. We explain this actor in more detail in chapter 5.

Other actors could be regulators, policy makers, technology providers, data managers, metered data responsible, building managers, tenants, occupants, real estate developers, ESCO project facilitators… Additional stakeholders can be found in the following reference (Zheng Ma et al., 2017). However, in this report, we mostly focus on the stakeholders mentioned above.

4.2 IMPLICIT DEMAND RESPONSE

Implicit demand response implies that customers are subject to price and tariff signals that reflect system conditions (IRENA, 2019c). Customers can reduce their invoice expenses by responding to price variations. Business models for implicit demand response are therefore mostly business models related to contract optimization. Yet, other business models are also possible (van der Veen et al., 2018), Table 2.

Contract optimization: This implies that consumers can use flexibility in function of the applicable electricity rates (both commodity and distribution). By adjusting their behaviour to price volatility, the total electricity bill is lowered. This can be done by reducing grid utilization costs by means of peak load shaving. Or it can be done by adjusting to time-dependent energy tariffs (maximizing consumption at off-peak and minimizing it at peak hours) (Vallés et al., 2016).

Emergency power supply: In case the consumers have their own generators or specific storage facilities, another business model for implicit demand response could be the provision of emergency power supply. In case of grid outages, by adapting its behaviour, prosumers could be self-sufficient for a specific time period (van der Veen et al., 2018).

Self-balancing: Finally, another business model could be self-balancing. This is an option for consumers who generate their own energy. They could optimize the periods when they are buying or selling electricity depending on consumption or injection prices. This is, however, only economic when there are no regulations regarding net balancing (van der Veen et al., 2018).

In what follows, we will mostly focus on the business model of contract optimization. The way that contract optimization is implemented (peak control, time of use optimization…) highly depends on how the energy invoice looks in specific countries. We therefore start by explaining the different components of an energy invoice (energy, network and residual components) and we explain in what structure such components can be charged (volumetric, capacity, fixed…). Then we explain to what extent these cost structures can differ over different dimensions (temporal, spatial…).

Table 2 - Implicit DR flexibility services

What?	Products	To whom?	Where? How?
Benefits to networks (contract optimization)	Network tariffs (manage load peaks, avoid grid reinforcements)	DSO	DNO contract / Network tariff
Benefits to system balance (contract optimization)	Energy tariffs (adapt consumption to generation)	Supplier	Consumer retail contract / Energy prices
Self-balancing	Optimize own generation to consumption	Consumer	Self-interest
Emergency power supply	Provision of emergency power	Consumer	Self-interest

4.2.1 DIFFERENT RETAIL & TARIFF COMPONENTS AND STRUCTURES

Energy invoices are generally split up in three broad categories of cost components: energy & retail costs, network tariff costs, and taxes and other residual costs. Each of these cost categories can be charged to the consumer in different ways. Different authors give an extensive overview of the possibilities, which we summarize below.

Energy – retail components

The energy component is charged to consumers to retrieve costs of electricity production. Generally, the cost is charged based on the effective energy consumption of the consumer and is expressed in €/kWh.

- The energy component can be part of a **fixed** contract. In that case, the energy component is determined in advance and the consumer knows the exact amount he/she will pay per kWh consumed. If energy prices would increase during the contract period, the consumer is not affected. Yet, the consumer will also not benefit potential price decreases.
- In case the energy component is part of a **variable** energy contract, the price per kWh is variable and can therefore increase or decrease throughout the year. To determine such price fluctuations, energy suppliers make use of index parameters. They can use forward-parameters which make use of long-term energy trade markets, or they can use spot-parameters which are based on the day-ahead market. The volatility of spot-parameters is therefore higher than that of forward-parameters. (VREG, 2020) Yet, the volatility is not as high as in case of dynamic energy contracts as suppliers publish their offers (for instance) on a monthly basis (CREG, 2018). The exact regulations might differ, however, from country to county.
- Finally, there are also **dynamic or flexible** energy contracts, implying that the energy price fluctuates based on the wholesale prices. In theory, this implies that prices could change per day or even per hour. These tariffs could be beneficial for consumers who aim to adapt their behaviour to

different prices. In practice, for regular consumers, it is possible that energy suppliers publish dynamic tariffs public 24h in advance so that consumers have time to response and react.

Network tariff components

Network charges are charges that a consumer pays to get the electricity delivered at his place. There can be charges for distribution and transmission grids. There are multiple different ways to charge such tariffs. (CEER, 2017; Pinto-Bello, 2019)

- **Volumetric** – this tariff charges network costs depending on the electricity consumed by the consumer. It is usually expressed in €/kWh.
- **Capacity** – this tariff charges customers based on the capacity that they use as this is a cost driver for network costs. It is either charged based on the peak demand measured in a specific timeframe (measured in kW) or it can be charged based on contracted capacity (kVA). In the first case, such tariffs are also called capacity usage-based tariffs. In the second case, it is referred to as contracted capacity charges.
- **Fixed** – this tariff charges network costs independent of consumption. It is a set amount that is charged per year per connection. These are also called standing service charges.
- **Connection charges** – this is a one-time charge that is usually set when a customer is connected to the network. Such charges can be shallow or deep, or a mix of both. Shallow implies that loads only pay for the cost of equipment needed to make the connection to the grid. Upstream reinforcement costs are not taken into account. Deep connection charges imply that loads pay for all costs associated with its connection, including potential upstream network reinforcements. In case of mixed methods, shallow costs are still paid, and a proportion of the upstream network costs as well. (Knight et al., 2005)

Taxes

Finally, energy invoices also contain charges to recover residual costs which are not necessarily directly linked to energy consumption. These can be taxes, costs to recover subsidies… In theory, it is said that such costs should not be linked to energy consumption as they are not linked to the energy cost. They should thus be charged in the form of some fixed cost. Nevertheless, in a lot of cases, these costs are still charged per kW or kWh and therefore indirectly also give price signals that are not necessarily cost-reflective.

4.2.2 POSSIBLE TARIFF DIMENSIONS

The cost components discussed in the previous section can differ over different dimensions. Below we discuss how they can differ over time and space. Prices and tariffs can also differ depending on the consumer group. Different consumers can have different consumption profiles which would permit different price and tariff structures. The dimension of different consumers will, however, not be discussed explicitly in this report.

By combining different cost components over different dimensions, multiple variations in pricing and tariff designs can occur. A volumetric tariff can be fixed over time, or it can be highly dynamic (EURELECTRIC, 2017). More elaborate discussions can be found in (CEER, 2020a; IRENA, 2019c; PÉREZ-ARRIAGA & Knittel, 2016).

Over time, a price or tariff can be:

- **Static** – This implies that it does not change over time. This would mean that a customer knows in advance what (for instance) its capacity tariff or energy price will be for the rest of the contract period. The tariffs are set in advance and remain constant during that period. Usually, the prices apply over larger time blocks of multiple hours (such as day versus night pricing).
- **Time of use (TOU)** – Time-of use tariffs are tariffs that vary over time. In general, there are different types of TOU tariffs that can be categorized into static and dynamic TOU tariffs.
- **Dynamic** – Dynamic tariffs on the other hand fluctuate more frequently and are based on the actual system status. Dynamic tariffs can be set close to real-time consumption of electricity if they would be based on wholesale electricity prices. This is called “real time pricing”.
- **Mixed** – There can also be combinations of both static and dynamic pricing strategies. Two examples here are “Variable peak pricing” (VPP) and “Critical peak pricing” (CPP). VPP implies that different pricing periods are defined in advance, yet the height of the price is not fixed in advance and depends on the market conditions. CPP implies that only during a few days per year electricity prices increase significantly. Typically, this is linked to periods of increased wholesale prices. (IRENA, 2019c)

It also should be noted that the way prices or tariffs differ over time, is also highly dependent on how consumption is measured. The more granular data are recorded (for instance on a quarter hourly basis), the more variable charges can be over time. In case consumption is only recorded on a yearly basis, variation over time is more difficult. (EURELECTRIC, 2017) also highlights that the pricing period is also an important factor to take into account. Prices could be dynamic, but only in a specific period, leading to a partly dynamic price or tariff.

Over space, a price or tariff can vary depending on the location. If locational differences are present, the goal of higher special granularity is to be more cost reflective and to account for possible differences in network constraints (for instance by reflecting grid congestions). If such cost differences are taken into account through better price signals, redispatch costs caused by network congestion could be avoided, and network and DER investments in specific areas can be stimulated. The extent to which location is taken into account depends on how far one aims to go. Different degrees are possible (Irena, 2019):

- **Nodal pricing** – this is the highest degree of granularity with regard to taking into account spatial differences. Under this option, each node has a separate price.
- **Zonal pricing** – under this option, a price is defined for one pricing zone in which participants trade energy. The assumption is that within this zone, there are no constraints. This is the approach taken by the European electricity market, where in most cases bidding zones correspond to national borders.
- **Uniform pricing** – under this option, there is no price / tariff distinction between different nodes and zones.

Other ways to categorize tariffs based on location are for instance to distinguish uniform charges versus locational charges or charges at depending on the voltage level (EDSO, 2015).

Furthermore, (CEER, 2017) also indicates that interruptible tariffs are also a way to support flexibility in the sense that they allow the DSO to interrupt system usage of its customers. In that case, customers do not have a permanent connection to the grid and get a lower tariff instead. This reduction in tariff should reflect the flexibility value in order to avoid a socialisation of costs between different customer groups. For new connections to the grid (mainly distributed generation and wind turbines), this idea is extended to Smart Connection Arrangements (SCAs) in which the DSO is allowed to curtail their connection for a pre-determined amount of time (Schittekatte & Meeus, 2018).

Finally, it should be indicated that on top of the 'regular' tariffs and dimensions, there can be additional incentive schemes for distributed renewables or other technologies. These can also influence customer behaviour as they make it more or less interesting to inject electricity to the grid instead of consuming it. We discuss below Feed-in tariff (FiT) and Net metering (NEM).

- Feed-in tariff (FiT)

In case of FiT, electricity injection and consumption are registered through separate meters and are therefore accounted differently (IRENA, 2019b). Injection compensations can be higher or lower than the retail electricity price.

- Net metering (NEM)

With more and more decentralized energy production (for instance through PV installations on rooftops), it is also important to have proper pricing schemes for the production of energy from prosumers. Some countries therefore apply NEM schemes which imply that consumers are only charged for the net electricity consumption from the grid after that their injected electricity into the grid is deducted from their consumption (IRENA, 2019b). Consumers therefore get the retail electricity price as a compensation for the energy production.

Both NEM and FiT have been criticized significantly due to the fact that they do not value electricity injection at a cost-reflective level. For instance, during peak load hours, injection of electricity is more valuable than at off-load hours. In addition, NEM allows consumers to store electricity virtually in the grid for free as the benefit from full retail prices (which also include grid costs etc.). While this encourage renewable production, these systems do not incentive consumers to take into account the grid status. (IRENA, 2019b) (p. 3) defines proper net billing schemes as "*a way to charge but also compensate prosumers based on the actual market value of electricity, balancing what they consume against what they inject into the grid*". If done properly, such schemes ensure self-consumption and injection of electricity when prices are high, and withdrawal of electricity when prices are low (IRENA, 2019b).

As such, it is therefore important to also look at different methods for compensating excess electricity injected to the grid. (IRENA, 2019b) distinguishes three different pricing schemes:

- Time-of-use tariffs (as explained earlier);
- Location-varying tariffs, which are based on grid congestion at the different nodes;
- Tariffs based on the avoided cost of electricity, which looks at the marginal cost of electricity procurement that a retailer/system operator avoids due to the grid injection.

As discussed previously, it is important that such schemes are as close as possible to dynamic pricing so that prosumers as well get cost-reflective incentives.

It should be noted that this overview is not capturing all type of variations possible within tariffs. For instance, tariffs could in some countries also vary depending on the square meters of property, there can be increasing or decreasing block pricing… (Schittekatte & Meeus, 2018). The reader should therefore be aware of the fact that other possibilities exist, yet that they might be less relevant for demand response itself.

4.2.3 BENEFITS AND DISADVANTAGES OF THE DIFFERENT TARIFF STRUCTURES

From the previous section, it became clear that multiple options exist with regard to tariff structures. Each of these tariffs has its pros and cons, and there is no one-size-fits-all tariff. Instead, depending on the objectives that one aims to reach, and depending on the target customers, different tariffs might apply in different situations. Principles such as cost-reflectiveness, non-distortionary, non-discriminatory, transparency, predictability, cost-recovery, simplicity, fairness… are prioritized more or less through the tariff choice (CEER, 2017). Furthermore, depending on specific grid objectives on one location or moment of time, spatial or temporal dimensions might be highlighted more or less to answer to certain grid weaknesses. Because of differences in energy mix, infrastructure (smart metering devices, smart charging…) and grid specificities (Pinto-Bello, 2019) warns for the fact that one tariff design might have different impacts in two different countries.

In Table 3, we give an overview of the price and tariff structures discussed previously. Per price or tariff structure, and per dimension, we summarize the key advantages and disadvantages discussed in literature. If such benefits or disadvantages are likely to be for one or more specific stakeholders, these are mentioned in brackets. For more detailed discussions, we refer among others to (Antonopoulos et al., 2020; CEDEC, 2014; Faruqui & Lessem, 2012; FSR, 2019; Irena, 2019; Knight et al., 2005; Lu & Price, 2018; OFGEM, 2019, personal communication, 2020).

Table 3 - overview of price and tariff structures and their advantages and disadvantages

Invoice components		
	Disadvantage	**Advantage**
Energy		
Fixed	• Not cost-reflective • Does not incentivize consumers to behave in a system-optimal way	• Simple • Stable • Predictable
Variable	• Cost drivers are not necessarily taken into account in real time	• Potentially allows to better take into account seasonal variations
Dynamic	• Higher price volatility might lead to penalties for consumers who cannot adapt their consumption in time • More advanced measuring equipment needed	• Better reflects cost drivers and in real-time • Encourages energy efficiency and system flexibility
Network		
Fixed	• Does not reflect cost drivers • Does not encourage energy efficiency • Does not encourage system flexibility	• Simple • Stable & predictable
Volumetric	• Not a proper driver for network costs (DSO) • No proper incentives for investments in grid capacity (DSO) • Death Spiral risk (DSO)	• More possibilities for the development of flexibility services (supplier) • Leads to more energy efficiency as consumption directly leads to lower bills • Possibility of net-metering leads to higher benefits for distributed generation (prosumer)

Capacity	• Possibility of net-metering decreases / disappears and there will be less benefits for distributed generation (prosumer) • Less options for flexibility services (supplier) • Do not promote energy efficiency	• Real cost driver for network costs (DSO) • Better incentive for proper network investments (DSO) • More revenue stability for the DSO (DSO) • More predictable invoice as capacity is more stable (customer)
Connection Shallow	• Does not give sufficient locational signals • Additional charges (use of system charges) could be charged afterwards	• Reinforcement costs could be charged through tariffs • Costs are lower and transparent
Connection Deep	• A new entity connecting can end up paying for reinforcements caused by other parties • Difficult to determine network reinforcement costs • Potentially discriminatory for new distributed generation that have to pay much higher cost than old existing technologies	• Strong locational signals (DSO) • No additional follow-up costs (consumer)
Connection Mixed	• Challenging to set non-discriminatory rules to calculate the exact proportion of costs per new connection	• Provides more locational signals to new connections • Reinforcement costs are a function of usage of the new connection assets

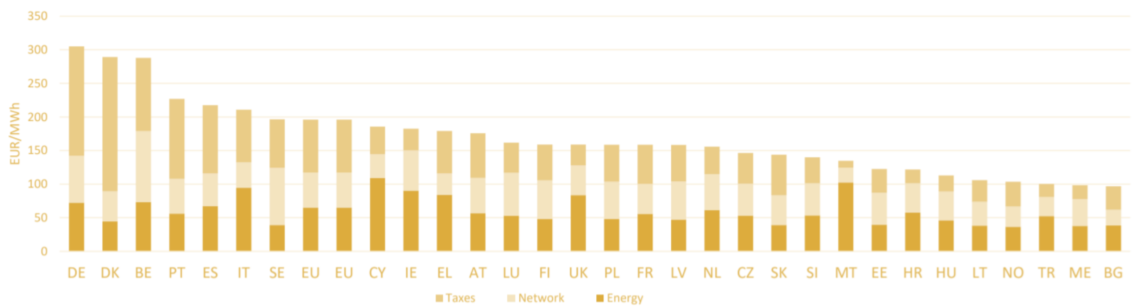
Dimensions		
	Disadvantage	**Advantage**
Time		
Static	• Could over-incentivise self-generation during moments that coincide with system peaks (DSO)	• Simple
Time of Use	• When badly designed, effects could be adverse (DSO) • Predicted peak times could be wrong and not coincide with actual system peaks • Less useful to address specific system issues in real-time	• Aims to better reflect costs • Aims to better reflect the value of flexibility • More stable, understandable and predictable • Fluctuations in energy invoices are more moderate • Possibility of good planning for the consumer
Dynamic	• Advanced metering is required • Flexibility providers / Consumers might wrong predict signals and respond accordingly • Traditional consumers who can't adapt face higher prices • Can be very volatile and risky for consumers • Without automating equipment it is hard to respond on an hourly basis or on even lower granular levels	• Signals real-time value of flexibility (consumer) • Signals system issues in real-time (DSO) • Reflects real-time costs (DSO)
Mixed	• There are concerns that such tariffs do not sufficiently help revenue stability of utilities • Only provides incentives during a limited amount of critical moments in the system	• CPP is for instance simple to understand, yet gives a strong signal • Invoice risks are still somehow limited as customers know when they are exposed in advance and as the time period is limited.

Location		
Nodal	• Not applicable in Europe and some other regions: implementation costs would be very high • Large data requirements and high computational burden (DSO) • Does not reflect network infrastructure costs sufficiently and therefore does not give sufficient incentives for grid expansion (DSO)	• Reduces dispatch costs as it decreases the amount of remedial actions needed • Accurate market signals to guide operational decisions • Possibility to differentiate between regions (nodes) to give better incentives regarding investments
Zonal	• Zones are predefined, yet in theory the zones could vary depending on the actual grid situation • Potential for market power • Location is not well taken into account	• Solves equity concerns • Less complex, more transparent
Uniform	• Does not reflect real-time cost • Does not take into account locational differences	• Simple, less complex, transparent

4.2.4 TARIFF PRACTICES IN DIFFERENT MEMBER STATES

From the previous discussions, it become clear that more dynamic tariffs are interesting for implicit demand response as they give the most options for consumers to adapt their behaviour. In case dynamic energy prices are offered to consumers by the energy supplier, over half of the consumers is assumed to see decreases in electricity bill expenses, if they don't change their load profile (Boeve et al., 2018). Such decreases are expected with consumers who have flatter consumption profiles. In case consumers do change their consumption profile by making it flatter or by ensuring that their peaks do not coincide with peak electricity price periods, more consumers are expected to benefit from more dynamic energy prices.

The exact benefits of dynamic energy prices and/or network tariffs depend on the height of these components and their percentage in the total energy invoice. As can be seen in the following graph (**Error! Reference source not found.**), the percentage of each of these highly differs over Europe. In Belgium, dynamic energy prices would therefore lead to comparatively limited benefits due to the fact that the energy price does not even take up 1/3th of the energy invoice. Note, however that larger consumers have energy tariffs that take up a larger percentage in their energy invoice.



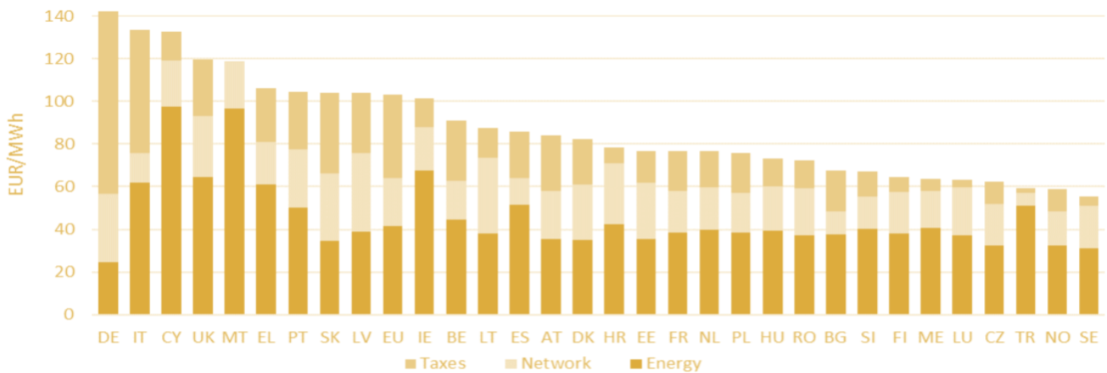


Figure 5 – Electricity prices in 2017 (top household, bottom industrial) (source: DG ENER IN-HOUSE DATA COLLECTION (EUROPEAN COMMISSION, 2019))

It is therefore important that one does not only focus on dynamic energy prices, but also on dynamic network tariffs as these take up a significant portion in the electricity bill.

Table 4 gives an overview of energy prices and network tariffs that are in general used in the different countries. It should, however, be noted that this table does not give a complete overview of all the possibilities per country, as the options depend from one consumer type to another. The table merely intends to give an idea of which countries already offer more cost-reflective and dynamic prices and tariffs. For a real cost analysis, a further and more detailed analysis per country would be needed. The table is developed up based on previous studies done by VITO, combined with literature (E-control, 2018; IRENA, 2019c; Pinto-Bello, 2019) and expertise from the consortium partners. It should be noted that for some countries this table is only accurate today given the current changes in energy and network tariffs. No distinction is made between different consumer types, but the table merely focusses on residential users and small enterprises. The table indicates if a specific pricing structure/tariff is available in a specific country, yet this might not apply to all consumer groups.

The table is only showing some European countries. Sweden for instance also offers spot-market based pricing through monthly average wholesale prices and through some suppliers even dynamic pricing. In the UK and Romania, CPP and dynamic real-time pricing is available, in Lithuania CPP is used and in Estonia dynamic real-time pricing is applied. This report, however, merely aims to give a first idea of the possibilities for implicit demand response and therefore does not give a complete overview of all countries.

Table 4 - Pricing and tariff options generally available for residential consumers and small enterprises in different Member states

		Belgium	Italy	Portugal	Spain	Austria	Denmark	Germany	Finland	France	Norway	The Netherlands
	Smart meter roll-out	80% completed by 2024, quarter hourly basis	>80% completed by 2020, quarter hourly basis	~60% completed by 2020, quarter hourly basis	Completed by 2019	Completed by 2023, quarter hourly basis	Completed by 2020, (quarter)hourly basis	Voluntary roll-out, only 5% of residentials possess it	Completed by 2020, (quarter) hourly basis	Completed by 2022	Completed in 2019, quarter hourly basis	Completed by 2022, quarter hourly basis
Commodity	**Components**											
	Fixed	No	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes
	Volumetric	kWh	kWh	kWh	kWh	kWh	Yes	Yes	Yes	Yes (kWh)	Yes	kWh
	Capacity	No	No	No	No	No	No	No	No	No	No	No
	Time Dimensions											
	Static	Yes	Yes		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	ToU	Day / Night	Yes	CPP	No	No	No	No	Yes	CPP (day-ahead warning)	No	Day / Night
	Dynamic parts	No	Dynamic real-time pricing	No	Dynamic real-time pricing	No	Spot-market-based pricing through monthly average wholesale price	No	Dynamic real-time pricing	Dynamic pricing sometimes possible	Spot-market-based pricing through monthly average wholesale price	No
Network	**Components**											
	Fixed	€	€	€	€	€	€	€	€	€	€	€
	Volumetric	€/kWh	€/kWh	€/kWh	€/kWh	€/kWh	€/kWh	€/kWh	€/kWh	€/kWh	€/kWh	No
	Capacity	No	€/kW	€/kWh	€/kW	€/kW	No	No	€/kW	€/kW	€/kVA	€/kVA
	Connection charge	€/kVA: Shallow	€/kW: depending on the connection voltage, the distance from the cabinet, and the power	€/kW: Semi-deep	€/kW: Shallow, but deep if contracted capacity is exceeded	€/kW: Shallow, but deep if contracted capacity is exceeded	Shallow	Shallow and deep	Shallow unless extra capacity is required, then deep	Shallow	€/kW: Semi-deep	€/kW: Shallow
	Time Dimensions											
	Static	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
	ToU	Day / Night	No	Volumetric: single, day/night, or two peak/off-peak periods	Volumetric: single, day/night, or two peak/off-peak periods	peak / off-peak summer / winter	Volumetric term is registered hour, tariffs: peak load period, high load period and low load period	Sometimes day/night	Capacity: seasonal variation, volumetric: day/night	Volumetric: single, day/night, or four peak/off-peak periods	Capacity term is in kW is monthly based	No

Dynamic	No	No	No	No	No	No	No	No	No	Volumetric term is charged per hour	No
Granularity of billing											
	Yearly	Yearly	Monthly	Yearly	Average load for peak load metered customers is registered on quarter hourly frequency	Quarter hourly	Yearly	Registered on an hourly basis	Quarter half-hourly measures	Volumetric and capacity term are measured per hour	Yearly
Expected changes	2022: shift to capacity tariff for the network costs (average monthly peak)	2022: end of the protected market; 2024: start of the capacity market	None	Possibility to contract different Capacities Unification of domestic access tariff to T2.D 3 Time periods will become standard	Annual flat network tariff charge replaced by capacity charge for all residential consumers	Changes to net metering More variable volumetric charge introduction capacity tariff	More cost-reflective tariffs are ambitioned, yet more smart meters needed	More dynamic and market-based control, replace fixed component with capacity tariff	4 time periods will become standard	Shift to more volumetric capacity-based tariff that reflects grid state Subscription capacity model Non-firm dynamic grid access	Shift to use-based capacity tariff (€/kW) Phase out net-metering Time-varying tariffs Introduce market-based mechanisms based on DSO tenders for flex.

As the table shows, most countries include some sort of TOU pricing or tariff structure such as day-night pricing. This is very common in Europe. Yet, Table 4 also shows that dynamic real-time pricing or approximations of dynamic pricing that have a lower price volatility (such as CPP, or monthly average wholesale prices) are also quite frequently available. However, these pricing structures mostly occur on an energy pricing level and are not frequently applied to network tariffs.

To give some concrete examples regarding the implementation of dynamic pricing in different countries, we will give some examples below:

- Finland: in Finland, approximately 10% of the consumers opt for a dynamic tariff. This tariff is based on the Nord Pool spot price and thus consists of an hourly price, combined with a retailer's premium and a typical monthly fixed fee. Customers can see these prices through a website where they are published each day around at 2 pm for the next 24h. Consumption is charged per hour, which is possible as all Finish consumers have hourly metering, (EURELECTRIC, 2017).
- Estonia: in Estonia, as well, the roll-out of smart meters has been linked to an increase in the number of spot agreements that energy suppliers offer to their clients. There are different packages that could be split up into *combined packages* and *exchange packages*. In *exchange packages* the electricity price depends entirely on the exchange price of electricity. The risk of price fluctuations is entirely for the consumer. In "combined packages", the electricity price depends only partly on the electricity price on the exchange market. The energy supplier / retailer also charges in part a sort of a fixed tariff so that price changes on the power exchange only minimally influence the electricity bill, (EURELECTRIC, 2017).
- Sweden: in Sweden, hourly contracts are already available on the market since late 2012, (CEER, 2019). By the end of 2016, one third of the Swedish suppliers offered such contract to their consumers. Originally, in Sweden, by 2009, the smart meter roll-out was already completed with regard to monthly measuring meters. As a result, Swedish consumers are used to have monthly variable price contracts. Such monthly prices were based on the average monthly spot price adjusted for different consumption profiles. Consumer energy contracts must specify how such consumption profile is determined. With the new hourly contracts, suppliers publish the hourly spot price at noon each day for the next day. On top of that, consumers also pay a supplier's mark-up and additional fixed costs and taxes as described in the contract, (CEER, 2019). Often, this supplier mark-up is lower in dynamic contracts, then in contracts with fixed prices.
- Norway: in Norway, already in 2017, about 65% of the electricity delivered is based on dynamic pricing based on spot pricing. As in Estonia, there are different models for dynamic pricing that hedge more or less price risks for consumers. Some examples are average monthly spot prices, average short prices for shorter periods, or dynamic prices that are not only based on sport prices but also on weekly and monthly contracts (future markets), (EURELECTRIC, 2017). Next to spot-based contracts, Norway also has variable and fixed price contracts. The later only takes up 2% of the market, while variable price contracts take up about 25% of the market. The price of variable price contracts can be changed with two weeks' notice, (CEER, 2019).

4.2.5 EXPECTED TARIFF CHANGES

From the previous discussion and Table 4, it could be derived that dynamic components are not yet available in pricing and tariff structures in most member states. For the commodity energy component, this will, however, change because the recast of the Electricity Directive states in Article 11 (1) that “Member States shall ensure that the national regulatory framework enables suppliers to offer dynamic electricity price contracts. Member States shall ensure that final customers who have a smart meter installed can request to conclude a dynamic electricity price contract with at least one supplier and with every supplier that has more than 200.000 final customers”.

Such dynamic electricity pricing contracts only reflect the price variation of the commodity energy component at the spot markets (including day ahead and intraday markets). This should be done at intervals that equal at least the market settlement frequency (Article 2 (15)).

In the nearby future, dynamic electricity pricing will therefore become more common than today is the case. In principle, within dynamic electricity pricing contracts, the price per kilowatt-hour of electricity is defined by the wholesale market. Yet, the supplier is allowed to add additional costs for handling imbalances, billing and other services. This is also referred to as an “add-on” to the wholesale price, (CEER, 2020b). This add-on can be charged per kilowatt-hour or as a fixed sum.

As stated by Article 2 of the recast of the Electricity Directive, dynamic prices should reflect price variation in the spot markets. However, it is expected that many dynamic pricing contracts will refer to the day-ahead market prices as these prices are published one day before delivery. This will make it is easier to communicate to the consumer and will allow the consumer to plan its consumption in advance. In case intra-day prices would be used, prices would need to be set on a constant and more continuous basis which makes it more complex and harder to implement, (CEER, 2020b).

(CEER, 2020b) also highlights that the Commission is not explicit with regard to the need of including price ceilings or floors to protect consumers or producers. They recommend, however, that such ceilings and/or floors are not installed as they reduce the pricing signals which are meant to be achieved through dynamic pricing. However, to a certain extent, extreme price fluctuations might not be accepted and in that case, suppliers could offer alternative contracts that limit this price volatility, for instance price caps while adding a hedging cost, (CEER, 2020b).

A significant difference with fixed pricing contract is also that consumers do not know electricity prices in advance. As such, suppliers need to disclose the exact pricing formula. All parameters used in the formula should transparently be made available in due time. Consumers should also be made aware about all the costs, risks and opportunities of dynamic price contracts and should give their consent before switch contracts.

4.2.6 ACTORS AND ROLES IN DIFFERENT IMPLICIT DEMAND RESPONSE BUSINESS MODELS

Within implicit demand response models there are three important actors. The foremost important actor is the consumer who has the ability to adapt its behaviour to the different price and tariff incentives explained above and who is responding to the different incentives to optimize his electricity invoice. In doing so, the **consumer** is in direct control and does not need to inform the energy supplier or other actors.

The consumer, however, will not adapt its behaviour if it does not receive enough incentives to adapt its behaviour. Incentives can be given at the level of energy prices, and network tariffs. Energy prices are set by the **energy supplier / retailer** who can set up a package with more variable/dynamic energy prices that fluctuate over time.

Depending on the role that consumers and energy suppliers take up, the price risk is transferred to one or the other actor. In case of the standard flat rate energy tariffs, it is the energy supplier who is exposed to wholesale price variations. For instance, if his forecasted power demand is higher than expected, the energy supplier must buy additional power at the spot market, potentially at a higher cost. Energy suppliers / retailers do hedge this risk in the sense that they charge a risk premium to consumers. When an energy supplier / retailer moves to more dynamic / real-time prices, the energy supplier has a lower risk on price variations and therefore can decrease the risk premium. Nevertheless, this implies that customer takes up more risks, (Boeve et al., 2018).

When dynamic energy tariffs become more mainstream, the European Commission states in Article 11(2) that: "Member States shall ensure that final customers are fully informed by the suppliers of the opportunities, costs and risks of such dynamic electricity price contracts, and shall ensure that suppliers are required to provide information to the final customer accordingly, including with regard to the need to have an adequate electricity meter installed…". When energy suppliers thus offer dynamic pricing contracts, they must ensure consumers have all necessary information. Generally, it is also recommended that billing information should be provided on a more frequent basis, at least monthly. The supplier most ensure that the consumer has access to data repository and adequate reporting tools so that he/she is able to analyse his/her consumption and so that he/she can see the price at all the different time intervals, (CEER, 2020b). The reason why proper communication towards and protection of the consumer is needed is that consumers that are exposed to dynamic tariffs could be penalised if they do not adapt their consumption patterns accordingly. This is not the case for explicit demand response where consumers would merely miss out a direct payment, (SEDC, 2015).

Network tariff incentives are in general set by the **regulator**, however, in some countries individual DSOs might also be allowed to set specific tariffs. Regulators in general also ensure that awareness for demand response and necessary regulations are in place to protect all actors. With regard to dynamic retail pricing, the European Commission states in Article 11(2) also that "*Regulatory authorities shall monitor the market developments and assess the risks that the new products and services may entail and deal with abusive practices*."

It should be noted that in case network tariffs also become more dynamic, it is plausible that also the energy supplier / retailer is responsible for ensuring that this is done in an administratively correct way and has to make sure that consumers have access to all the needed data.

Finally, the settlement (that is the determination of demand reductions and the corresponding payments) is done based on the measured consumption of the building. Consumers are then settled by multiplying the spot price with their actual measured consumption (CEER, 2019). To do this properly, consumers need proper measurement equipment that can record consumption and injection at a proper granularity level (on an hourly or quarter hourly basis). Figure 6 gives an overview of the roll out of electricity smart meters in the European Union. It shows that by 2025, most countries will have rolled out the smart meters with at least 80% of their consumers. Only a minority of countries (like Belgium, Germany, Poland, Croatia…) will not have reached such high levels of smart meter roll out by that time period, (Tractebel engie, 2019). For consumers that do not have smart meters, it is possible that the hourly price is charged to the consumer via consumption profiles (CEER, 2019). In case there are issues with reading consumption data from the meter, standardised consumption profiles can also be used in case of technical problems. The stakeholder responsible for the roll out of the smart meters (often the DSO) and the stakeholders who take the decision regarding the timing of the roll out (regulators, policymakers) therefore need to ensure that all consumers have adapted measurement equipment if one wants to implement more time-dependent tariffs and prices.

As will be the core of chapter 5, in the future, DR will become part of EPC-contracts. In that case, ESCOs will also become a major actor. This will be discussed in chapter 5.

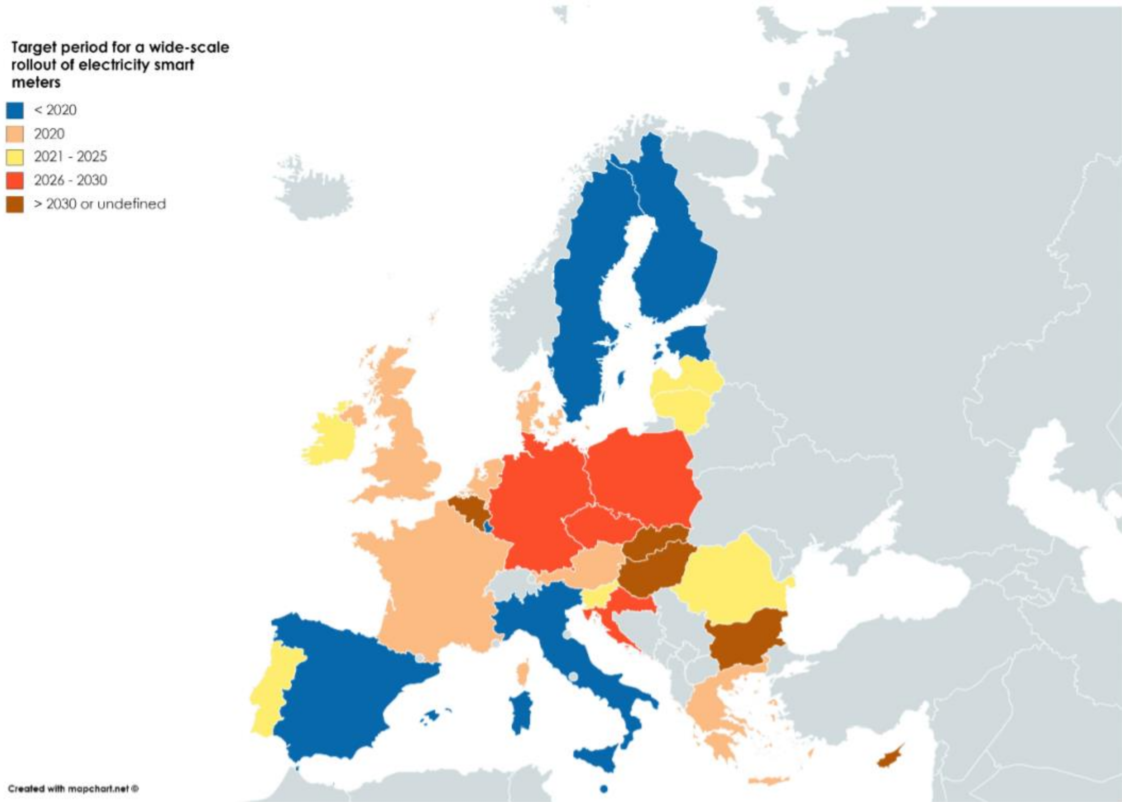


Figure 6 - Overview of Smart Meter Rollout of electricity smart meters with at least 80% of all consumers (source: (Tractebel engie, 2019)).

4.3 EXPLICIT DEMAND RESPONSE

Explicit demand response implies that demand-side resources are traded in wholesale markets (day-ahead, intraday and markets for ancillary services). Consumers can offer their services individually or through an aggregator.

4.3.1 FLEXIBILITY REQUESTERS & PRODUCTS

Key flexibility requesters in our electricity system are the system operators and the BRPs. They each have specific responsibilities for which they are in need of flexibility. They can obtain this flexibility through different flexibility services that are offered to them in the form of specific products by flexibility providers.

There are many ways to categorize these flexibility services and products. Different authors take different approaches. For instance, Directive 2019/944 (Article 2(48)) defines an ancillary service as such that it does not include congestion management, while the TSO-DSO report on active system management by (Brazier et al., 2019) does mention congestion management as part of ancillary services. For the purpose of this discussion, we group them based on the different business models that could flow out of them. In doing so, we took inspiration from (Delnooz et al., 2019; Hillberg et al., 2019; Vallés et al., 2016; van der Veen et al., 2018). In Table 5, we give an overview of the five categories of flexibility services that can be delivered to the different flexibility requesters.

First of all, there are the **Balancing grid services** (TSO): Energy balancing implies that system frequency needs to stay within a predefined stability range. If the balance between demand and supply cannot be maintained, this might lead to voltage fluctuations, power supply failure, etc.. Energy balancing is primarily the need of the TSO in case BRPs did not manage to avoid imbalances. If there remains an imbalance on the cumulative energy portfolio across all relevant BRPs, the grid operators have access to balancing services (FCR – Frequency containment reserves, FRR – Frequency restoration reserves, RR – Replacement reserves) to resolve the imbalances (ancillary services). The TSO buys these different reserve products on the balancing market. DR can contribute to this with the promise to reduce peak demand on the network where necessary.

Secondly, there are services for **Safe grid operation** (TSO & DSO): apart from its balancing responsibility, the TSO also needs to ensure a safe grid operation. In this regard, TSOs have access to ancillary services (voltage control, congestion management, black start…). As DR could potentially respond in very short time frames, balancing markets in which these grid services are offered, are relevant for DR. With higher levels of DER, distribution grids are also facing more challenges with regard to guaranteeing safe grid operation and managing grid constraints. As with ancillary services for TSOs, DR could also offer grid services to DSOs.

Thirdly, there are services for **Adequacy support** (TSO & BRP): such services aim to ensure that security of supply is guaranteed by reserving enough capacity in different time frames. This is mostly important for the TSO, yet in some countries (like France) regulation might obliged the BRP to be responsible for adequacy support as well.

Fourthly, one can trade on the **wholesale markets** (BRP). This implies that market players can offer and sell demand response actions on electricity markets (future markets (although most likely less applicable for DR), day ahead markets (DAM) and intraday markets (IM)). The DAM offers standardized products to sell and purchase electricity that is supposed to be delivered the day after. The IM also has standardized products to sell and purchase electricity until shortly before delivery. The later market therefore helps to correct for differences between real-time and predictions. Future markets are contracted months, to years, to multiple years before delivery and trade contracts for baseload power. If one wants to trade on this type of stock exchange markets, it is required to take up the role of a BRP which will then consolidate generation and consumption in one virtual group that he needs to balance (a portfolio).

Fifthly, one can provide services to help the BRP with its **Portfolio management**: a market participant could offer balancing services to a balancing responsible party (BRP). Each BRP is responsible for a portfolio of access points and he must ensure a balance between injection, offtake and commercial power trades within its own portfolio. If the BRP incurs an imbalance on a quarter-hourly basis, he is subject to imbalance tariffs. Different balancing options exist to manage a portfolio and DR could be one option as BRPs are aiming to have a variety of electricity products and resources in their portfolio to spread out balancing risks. DR could be used in day-ahead and in real-time portfolio management of the BRP. DR flexibility could be used to optimize the day-ahead scheduling of production and consumption or it could be assessed in real-time when there are deviations from the original scheduling.

Broadly spoken, there are balancing services for TSOs, grid services for TSOs and DSOs, and more commercial services by and for BRPs (or energy suppliers if they take up the role of a BRP).

Table 5 - Explicit DR flexibility services

What?	Products	To whom?	Where? How?
Balancing (Frequency Control Ancillary Services)	• FFR • FCR • Automatic FRR • Manual FRR • RR	TSO	Balancing markets
Safe grid operation (Network control & System Restart)	• Voltage Support (steady state reactive, dynamic reactive and active power) • Black start Support • Island Operation (see products for balancing and voltage control) • Inertial response • Congestion management (reserved and non-reserved) • Grid capacity management	DSO & TSO	Different DSO & TSO procurement markets
Adequacy support	• Strategic reserves • Capacity payments	TSO & BRP	National capacity markets
Trade on wholesale markets	• Long-term future markets • Short-term markets	BRP	Wholesale markets
Portfolio management	• BRP products	BRP	BRP/supplier trading platform

4.3.2 MARKET ACCESS AND PRODUCT REQUIREMENTS

The products summarized in the previous section, are products that flexibility providers can offer in different markets (such as balancing markets). However, as discussed in Deliverable 1.1, not in all countries demand-side resources are allowed to participate in such markets. In some countries, load participation is allowed, but not aggregated loads. This would imply that only large industrial consumers can access these markets (SEDC, 2017). It is therefore important that aggregated loads are allowed. The role of (independent) aggregators will therefore be important in facilitating explicit demand response. We will zoom in on this in section 0.

Next to market access, flexibility providers that aim to offer their flexibility through specific products also need to fulfil specific product requirements. Yet, as stated by (SEDC, 2017) much of these requirements block demand-side resources: "*For example, a system's physical need for reserves typically requires the resource to be available for between 30 minutes - 2 hours. However, the market participation requirements for some reserve markets may state that load must be available up to 12 hours and up to 60 hours over the weekend (p.33)*". Many product requirements are still oriented towards old coal-fired generation plants and therefore pose problems for demand-side resources. Figure 7 gives some example of (SEDC, 2017) where they give some of the most important issues with regard to product requirements.

- Over-sized minimum bids: a consumer or aggregator may need to provide up to 50 MW to participate – rather than the more standard 1 MW.
- Extended duration or availability requirements: some demand-side resources may not be available for extended periods of time or would present different availability characteristics from generation (difference between weekdays/weekend, business hours/night hours, etc.).
- Too frequent activations/short recovery periods: this is done when a TSO does not want to have to make multiple calls for resources but prefers to make a single call and then have the resources available. This is convenient for the TSO but reduces the ability of a range of resources – including demand and renewable resources – to participate.
- Symmetric bids: few consumers can increase and decrease consumption equally. A requirement for symmetrical bids acts as a significant market barrier to consumer participation. In Member States where the TSO is willing to enable Demand Response, asymmetrical bids are allowed.

Figure 7 - Examples of blocking product requirements (Source: SEDC (2017))

4.3.3 AGGREGATOR

An important point for explicit demand response is that demand-side resources could be traded either individually or aggregated. In the latter case, independent aggregators, or the consumers' retailers can be addressed to perform the aggregation (SEDC, 2017). Most consumers who want to valorise their flexibility do not have the means and the knowledge to do this directly via energy markets and therefore make use of an aggregator (Bertoldi et al., 2016). An aggregator creates one large pool with all smaller resources combined and sells it as a single resource (SEDC, 2017). By doing so, they can ensure that smaller consumer loads do have access to such markets. Apart from merely ensuring access to markets, the role of an aggregator encompasses a number of important competencies, ranging from experience in identifying flexibilities in different industries, understanding the limitations of such flexibilities, estimating customer flexibilities potential (as they might not know this themselves), and aggregators need the technical capability to physically connect consumers to integrated their load into their aggregated pool (SEDC, 2015). As visualized by Figure 8 of USEF (van der Veen et al., 2018), the aggregator facilitates flexibility provision from prosumers to flexibility requesters.

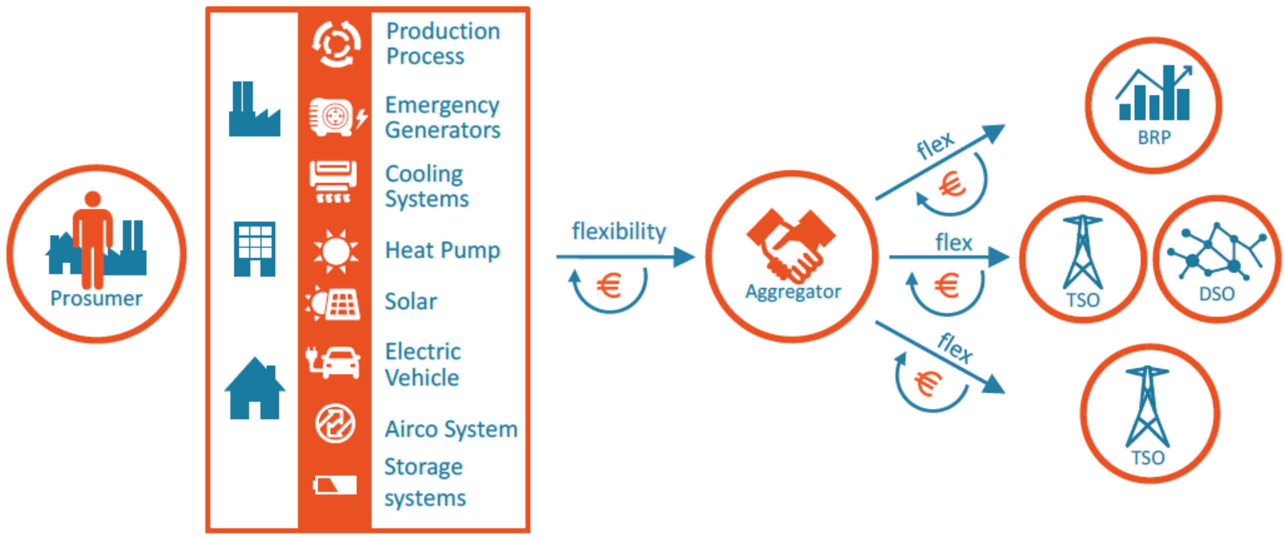


Figure 8 - The aggregator as an intermediate facilitating party between the prosumer and the BRP/TSO/DSO (Source: (van der Veen et al., 2018) – USEF)

The role of the aggregator can be taken up by the consumer retailer. However, this actor may have a potential conflict of interest (they may earn a large part of the annual reviews when prices are high) and might not be specialised enough (European Smart Grids Task Force Expert Group 3, 2019). As a result, the introduction of independent aggregators to markets is important. Competition between aggregators will also imply that DR becomes more interesting for consumers and this is necessary to make sure consumers are willing to behave flexibly, (SEDC, 2017).

4.3.4 ACTORS AND ROLES IN DIFFERENT EXPLICIT DEMAND RESPONSE BUSINESS MODELS

Unlike implicit DR, explicit DR requires more actors to be involved. The involved actors also take up different roles and responsibilities. (Zheng Ma et al., 2017)

First of all, the **consumer** is not anymore in direct control. It offers its demand profile to an aggregator who can then make sure that the consumer has access to flexibility markets. In case the consumer is very large, it can provide its flexibility direct to the correct markets without a third party being involved.

An **aggregator** thus makes sure that multiple consumers get access to markets by giving them attractive incentives to offer their flexibility. As such, the aggregator creates a pool of flexibility resources, which it can offer to **BRPs** and **network operators**. An aggregator can offer ancillary services to TSOs, congestion management services to DSOs, help BRPs to balance their portfolio (see Table 5). The role of suppliers is smaller in this case, as they could take up the role of aggregator for their consumers. For most consumers, the link with BRPs and network operators remains invisible as they are only in direct contact with the aggregator. The role of the aggregator is discussed in more detail in previous sections.

Finally, as was also the case in case of implicit DR, a **regulator** needs to ensure proper regulation is in place for all actors. In chapter 5, we discuss in more detail the potential new role of ESCOs in offering explicit DR.

4.3.5 FLEXIBILITY MARKET REQUIREMENTS AND REVENUE SHARING MODELS

Unlike implicit demand response, (where there is no obligation to deliver flexibility) in case of explicit demand response there is the need to quantify how much flexibility has been delivered. (European Smart Grids Task Force Expert Group 3, 2019) Quantifying flexibility is not always straightforward, and to do so, different steps and requirements are needed. Below an overview is given of some important issues that are to be taken into account.

- **Contract**: first of all, consumers need to sign a contract or agreement with an aggregator. In case the consumer wants to make use of the services of an aggregator, the aggregator will set up some sort of aggregator contract. Based on this contract, the aggregator receives the right to temporarily change the energy consumption of a consumer when there is a need for it (that is, when electricity prices are favourable) (BEUC, 2019) or through the contract the consumer commits upfront to alter its load himself within pre-defined boundary conditions (Van Ginkel et al., 2018). Such contracts also specify agreed flexibility requirements between the prosumer and the aggregator and the remuneration model. The contract itself will differ among different countries due to differences in regulation, in customer segments as well as in requirements for flexibility products (USEF, 2016). The contract also specifies how the settlement takes place.
- **Plan**: once a contract is signed, the aggregator makes flexibility forecasts for its portfolio of clients for the next day. The aggregator will compare how much flexibility is needed and how much flexibility can be offered with its portfolio.

- **Measurement and communication**: clear measurement standards and/or requirements are needed in order to properly collect consumption data. This is especially the case when an aggregator communicates with a system operator on behalf of a pool of loads, but also when an aggregator wants to verify how much flexibility a prosumer has delivered. Measurement and communication protocols should therefore not only count for individual consumers, but also allow an aggregator to combine data from its customers. (SEDC, 2017)
- **Prequalification**: apart from the measurement of the delivered flexibility itself, it is also important that prequalification protocols are clearly defined. As with measurement of flexibility, these should also be allowed to take place at the aggregated level. As such, there is no additional administrative and measurement burden on individual consumers given the fact that the aggregator can take up this task. (Bertoldi et al., 2016)
- **Verification**: after the flexibility has been used, it is necessary to verify if this flexibility has indeed been delivered properly by the prosumer and to determine how much flexibility has been delivered. To do so, there needs to be a way to quantify flexibility from demand-side resources. There is a large difference between generation as resources and load changes from demand. As stated by (Goldberg & Agnew, 2013): "*It is not possible to meter or otherwise directly observe load reductions*" (p. 14). This is done by comparing the actual measured consumption during a specific time period, with a baseline (that is the volume that the consumers normally consume). This baseline should determine properly what a consumer would have consumed in the absence of demand response (Rossetto, 2018). The difference is the delivered flexibility. The challenge in determining this flexibility lays in determining a proper baseline. Without the baseline, it would not be possible to verify the performance of the flexibility provider. Yet, estimating energy consumption depends on numerous factors such as weather, seasons, holidays, production schedules... A proper methodology takes all of this into account as accurately as possible, yet accuracy is not the only important criteria: the baseline also needs to be easily and rapidly calculatable, so that a flexibility provider can understand in real time if he is complying the obligations that he aims to commit to (Rossetto, 2018). Different methodologies exist to determine such a baseline, and each of them have their weak and strong points. It should be noted that some methodologies act well for the verification of one service, but not for another service. Most likely there is therefore no one-size-fits-all solutions as depending on the service delivered, different criteria (event duration, timing, frequency...) have to be taken into account. The methodologies also need to be very transparent to ensure that flexibility providers trust the methodology to be accurate. (SEDC, 2017)

As explained by (Rossetto, 2018), there are 5 baseline methodologies defined by NAESB (See Figure 9). Each of these methodologies have different variations. This deliverable will therefore not discuss all different baseline options, yet according to (Rossetto, 2018) BT-I methodologies are the most commonly adopted for demand reductions on energy markets, MBL methodologies are more common for capacity commitments, MBMA methodologies are common for ancillary services and MGO methodologies are used for on-site generation units. A general conclusion regarding baseline methodologies therefore is that the proper baseline should take into account the specific characteristics of the flexibility service delivered (Rossetto, 2018).

- Maximum Base Load (MBL): "a performance evaluation method based solely on a demand resource's ability to reduce to a specified level of electricity demand, regardless of its electricity consumption or demand at deployment".
- Meter Before / Meter after (MBMA): "a performance evaluation method where electricity demand over a prescribed period of time prior to deployment is compared to similar readings during the sustained response period".
- Baseline Type-I (BT-I): "a performance evaluation method based on a demand resource's historical interval meter data which may also include other variables such as weather and calendar data".
- Baseline Type-II (BT-II): "a performance evaluation method that uses statistical sampling to estimate the electricity consumption of an aggregated demand resource where interval metering is not available on the entire population".
- Metering Generator Output (MGO) or Behind-the-Meter Generation: "a performance evaluation method, used when a generation asset is located behind the demand resource's revenue meter, in which the demand reduction value is based on the output of the generation asset.

Figure 9 - Common baseline methodologies (Source: p4 (Rossetto, 2018))

- Settlement: finally, there needs to be a settlement of delivered flexibility. This implies that markets should pay for the flexibility provided. The payment criteria should be open and transparent to all stakeholders and similar services should be remunerated equally independent of the flexibility source (Bertoldi et al., 2016). In case of non-compliance, penalties should also be clearly defined without prioritizing one resource over another one (Bertoldi et al., 2016). Explicit demand response sources could benefit from two types of remunerations: on the one hand there are remunerations for activation of the DR flexibility (utilization), on the other hand, there might be remunerations for the availability of DR flexibility (capacity / reserve) independent of whether this flexibility is indeed activated. This is different for implicit demand response where there is no distinction between availability and activation. Remuneration for DR availability is arranged through long-term (capacity) or short-term (reserve) markets. (Pototschnig, 2017) When explicit demand response is offered to a market through an aggregator, it is also important to be aware of the revenue sharing model of the aggregator. An aggregator could for instance receive a fixed percentage of all revenues in the pool. The remaining revenues could then we shared over all units in the pool. This can be done based on a predetermined fixed price. Or, capacity revenues could be distributed among all units according to their effective average availability, energy revenues could be shared based on the marginal cost of the units in the pool (merit-order). These are just some examples of aggregator revenue sharing models. Different options exist and depend from aggregator to aggregator.

4.3.6 CHALLENGES TO PROVIDE EXPLICIT DEMAND RESPONSE

As indicated in this and the previous deliverables, there is still a significant amount of challenges for explicit demand response.

We already indicated that **market access and product requirements** are one major barrier for demand-side resources. In some countries they simply cannot access wholesale or flexibility markets. A second issue is that when they are allowed to enter, the product requirements are sometimes so stringent, that they cannot fulfil them. A solution to both of these issues could be to access the markets through aggregators who then could access markets through aggregated loads. However, in some countries aggregated loads or independent aggregators are not allowed. (SEDC, 2017)

The H2020 EU-Sysflex project is looking in more detail to the issues of product requirements. It aims to look at the new needs that the electricity system is having due to the increasing levels of distributed energy sources. Based on these needs, it aims to identify new types of services and adapted product requirements. In the Figure 10, EU-Sysflex highlights for renewable energy sources that there is a large amount of capacity installed that could be used on for instance balancing markets (Poncelet et al., 2020; Willeghems et al., 2020). Yet, due to the product requirements, only a very small percentage of this is eventually procured. It shows that the offered capacity increases depending on whether procurement occurs on a daily basis or not, and it shows that there are for instance seasonal differences. Although Figure 10 is not focusing on demand response technologies, it shows that by taking into account multiple factors (such as the temporality of the product), product requirements could be made more technology neutral. This will increase the capacity available on different flexibility markets.

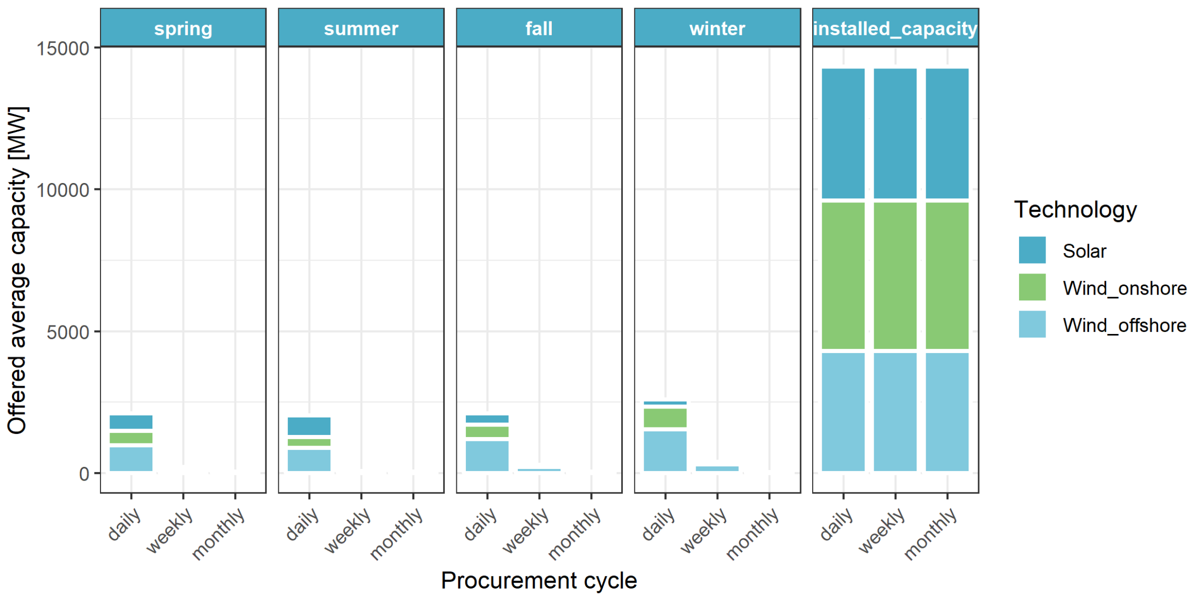


Figure 10 - Offered capacity in relation to procurement cycle, compared to installed capacity (source (Poncelet et al., 2020; Willeghems et al., 2020))

(European Smart Grids Task Force Expert Group 3, 2019) also highlights that when it comes to product requirements, products should contain more **locational information**. Such information becomes more important for grids when they come to services like congestion management.

In general, there is also a **significant lack of standardisation** across different countries which implies that technology providers have different technology requirements in different countries. For each market, they would have to adapt their devices and systems. This is expensive or it might not be worth doing so, implying that not all customers have access to the same technologies to be able to offer their services. (European Smart Grids Task Force Expert Group 3, 2019) Differences in technology requirements are also not convenient with regard to **data access and data sharing**. The latter is also complicated due to **GDPR** regulations. (European Smart Grids Task Force Expert Group 3, 2019) also points out that measuring at the connection point is not always the most optimal measuring point, and that the usage of sub-meters (potentially even embedded in specific appliances) could be useful. However, this is not always supported by the regulatory framework. In addition, for some countries, roll out of smart meters is going slow.

In many countries, there is also a **lack of framework** for demand side response providers. Proper remuneration systems exist often for generation, but not for demand side resources. Financial incentives are thus often lacking. In addition, there is no appropriate methodology for determining the baseline, nor are there always clear allocations of energy volumes with regard to the balance responsibility. To be able to work with independent aggregators, a Transfer of Energy framework is required that allows the procurement of flexibility at connection points in the low voltage grid via independent aggregators.

Another challenge is that consumers can participate both in implicit and explicit demand response at the same time. In that case it is important to verify and avoid **conflicts** on remuneration and accounting of energy flows when the consumers have two contracts. (European Smart Grids Task Force Expert Group 3, 2019) (USEF, 2016) illustrates this in Figure 11. Proper baseline methodologies therefore need to be able to separate the impacts of implicit and explicit demand response. It should be noted that we discussed challenges on baseline methodologies already earlier in this report.

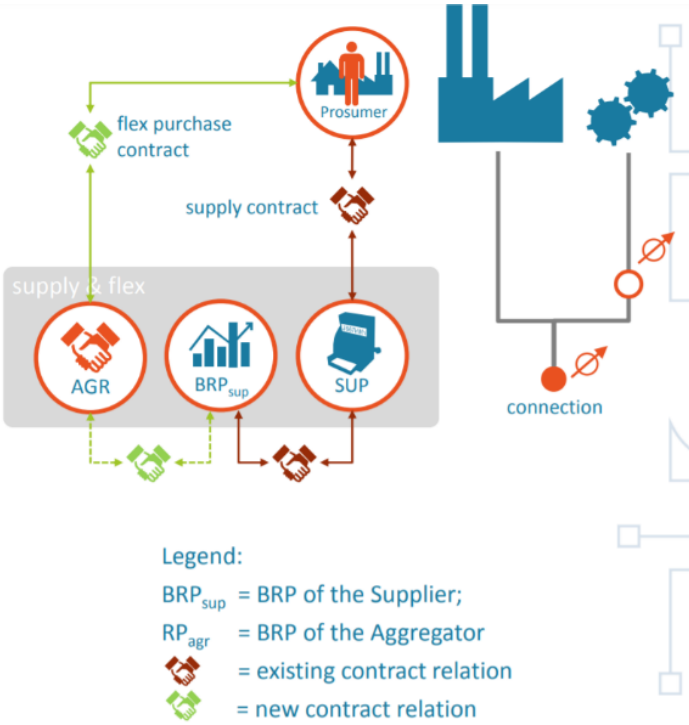


Figure 11 - implicit and explicit demand response with separate contracts (source (USEF, 2016))

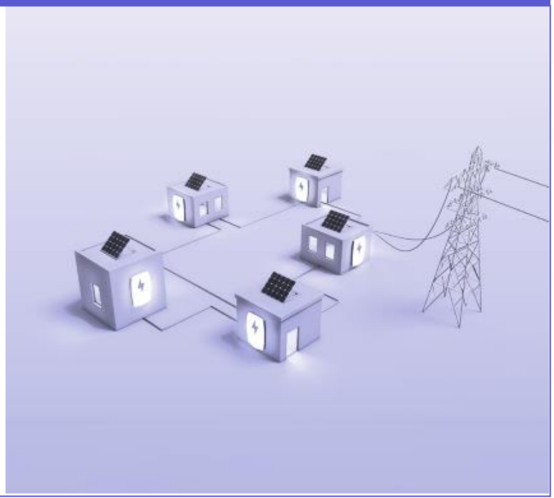
The challenges previously indicated are for demand response technologies in general. However, in the context of the AmBIENCe project is relevant to mention that there are specific challenges related to buildings providing demand response: buildings are more diverse and heterogeneous than general demand response technologies. In addition, a building consists of different technologies, can have different occupancy rates which influence its consumption, and lack standards given the facts that buildings are built in different time periods.

4.4 BUILDING EXAMPLES IN PRACTICE

Demand response projects and initiatives by buildings are popping up more frequently in different sectors and countries. Below, some examples are given of existing initiatives.

CrowdNett (ENECO NL)

CrowdNett is a network of smart batteries that are installed in different homes in the Netherlands. Home owners make investments in the battery, but at a reduced cost due to their participation in CrowdNett. In doing so, they give Eneco the possibility to steer the battery and to use it to balance the system. An Eneco-customer gets a remuneration for 5 years. Companies also get tax benefits when investing in the battery. As such, for commercial buildings, they can earn the battery back in about 5 years. (Eneco, 2020)



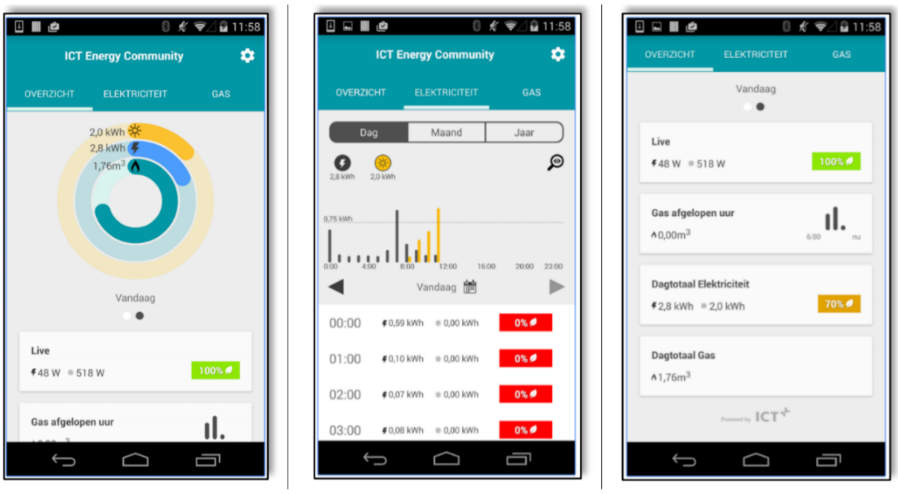
Thermovault (BE)

Thermovault developed a software and hardware IoT platform for electric energy services that turn water and space heaters into an energy-saving and lucrative grid-responsive energy storage device. Thermovault controls all these energy storage devices and uses them to provide system services by automatically controlling them. As such, they claim that they can provide consumers with electricity bill savings up to 30% without them losing comfort. The value streams that they claim to create for their customers are summarized here (Thermovault, 2020).

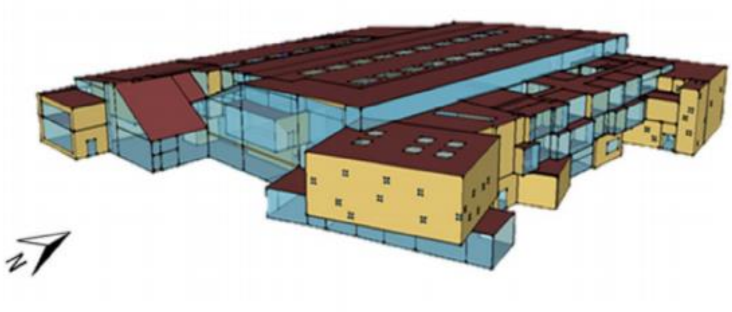
ENERGY EFFICIENCY EU EcoDesign verified savings	GRID BALANCING R1 Balancing for TSO's	SELF CONSUMPTION Integration of renewables	PEAK SHAVING Reduce consumption peaks
Water heaters: 12-28% Space heaters: 10+%	+1MW deployed +500k messages/day	Household: +50% Community:+70%	Household: >10% Community: 10-50%

energyNXT (NL) – Nijmegen local flexibility market at Business Park

A consortium of seven organisations at the Business Park South-East in Groningen is examining how they can bundle their energy consumption to anticipate fluctuating energy costs. Quite some initiatives are popping up for residential consumers and large industrial users. Yet, the small and medium companies often can't participate. The goal of this project is to examine how to adapt consumption of the group of companies so that the combined profile is flatter. As such, as an energy community, together they can have better energy prices and network peak tariffs. The companies in the project are two educational buildings, a cold store, a food retailer, a wholesale in electric transport, a medical company, and a battery producer. The energyNXT platform determines which companies have too much energy at which moment and at which companies that best deliver this. To do so, specific drivers need to be added to all the specific appliances. Given the fact that the project is still running, no details about the positivity of the business case are available yet. For the future, a next research question would be to see to which extent the Business Park can be self-sufficient with the solution. (ICT, 2017; Liander, 2020; van der Laan, 2020)



Implementation of demand response strategies in a multi-purpose commercial building (University College Dublin Ireland)



The Student Learning Leisure and Sports Facility (SLLS) building, located in University College Dublin (UCD) in Ireland, is selected as the testbed site for this research project. The project looks into control strategies to overwrite the scheduled operation of the HVAC systems in order to emulate DR strategies. The DR strategies themselves are targeted at different utility / aggregator requirements.

The steps followed in the research are the following: (p. 127 (Santos et al., 2019))

1. Model development: development of an EnergyPlus model to be used as a DR testbed,
2. Load analysis: conduct thermal load analysis to identify the important energy end-use categories,
3. Demand response strategy development: develop DR strategies targeting building HVAC systems,
4. Demand response strategy assessment: create a repository of DR strategies based on simulated results for a representative winter and summer weekday for different activation times and event durations, and
5. Demand response strategy selection scheme: a DR selection scheme which identifies the "best" strategy from the DR repository which meets the utility/aggregator requirements. The selection scheme is also updated to be executed with simulated data under real conditions in order to eliminate uncertainties derived from weather conditions or occupancy.

The results show that total electricity reduction is 15.8, 32.8 and 66.9 kWh for the one, two- and four-hour events, respectively. The results also show that rebound effects occur, which are higher for longer hour duration events.

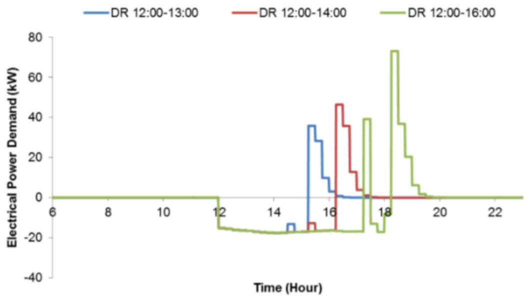


Figure 13.5 Difference in building electrical load demand for the CWT strategy for 20th January in 15-minute intervals (Christantoni et al., 2016).

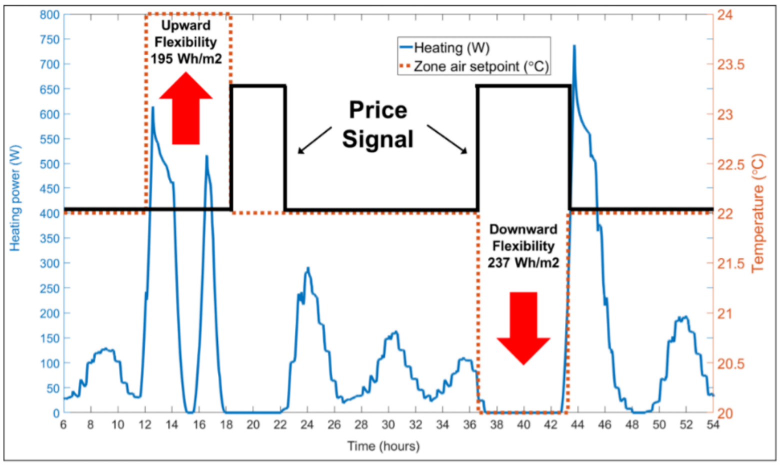
EnergieKoplopers Project in Heerhugowaard: local flexibility market for households

In a first phase, this project was an example of implicit demand response. 200 households with smart appliances in their house took part of the project. The project estimated demand and supply of electricity and estimated how much flexibility was needed to balance demand and supply. Households could then adapt their behavior in response to different prices to ensure system balance. Energy peaks could as such be avoided.

In a second phase, Liander tested to which extent this household flexibility could also be used in real market situations and allowed aggregators to participate. This helped to bring optimizations to the distribution grid as a whole. (Alliander, 2019)

Experimental assessment of energy flexibility potential of a zone with radiant floor heating system (Concordia University Canada)

This study simulates the conditions of an office space near a window which has a radiant floor heating system. The study examines how this floor heating system can provide flexibility by responding to specific price signal profiles. It concludes that adjusting the air temperature setpoint leads to significant changes in heating load and thus in energy flexibility potential. (Santos et al., 2019)



CO_2-aware heating of indoor swimming (Technical University of Denmark)

This project looked into indoor Swimming pools in Danish summer houses. The pools are heated by air-to-water heat pumps. In total 30 houses were controlled by activating heat pumps through temperature setpoints for the pool water. The objective was to minimize CO_2 emissions which are caused by power plants that produce the energy needed by the heat pumps. Flexibility was incentivized by having penalty signals that described the cost of consumption over time. For this pilot, first the CO_2-intensity was used as penalty signal, and later the prices from the Danish regulation market. Thus, it was first used to minimize CO_2 emission, and later to improve grid balancing. As such, the project manages to reduce emissions by 9,6%, without having invested significant budget in installations. (Santos et al., 2019)

Powerhouse (Spain & the Netherlands)

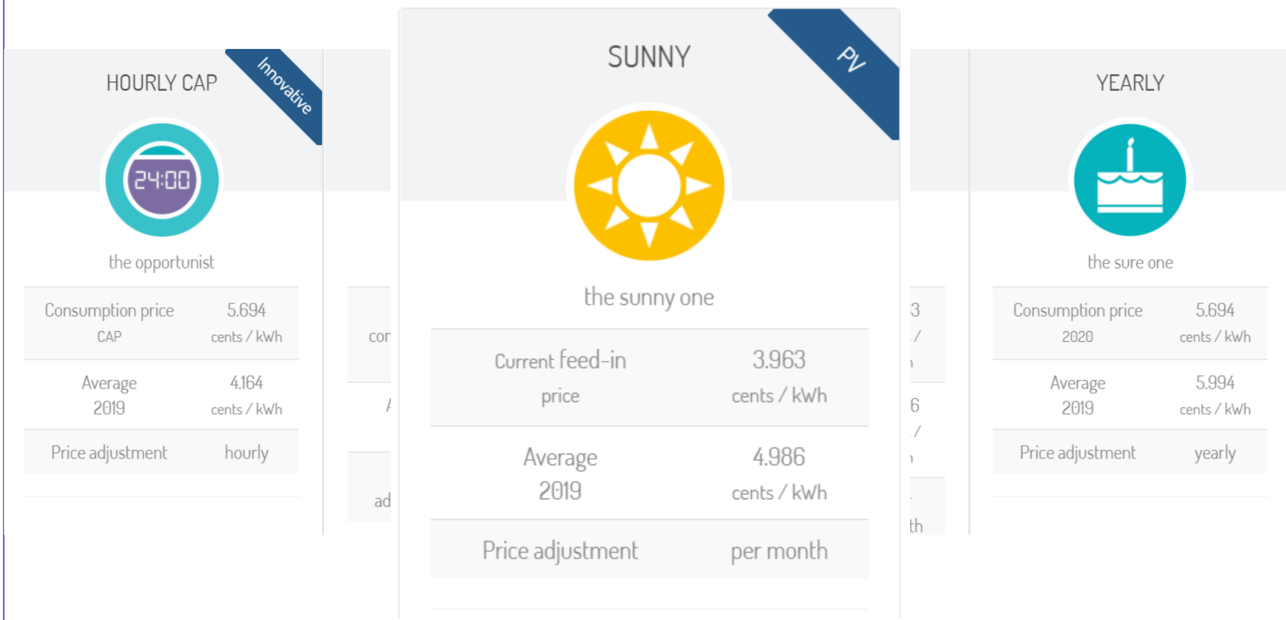
Powerhouse is a digital solution that ensures companies can automatically react to energy markets and prices through their energy platform. It offers flexible energy contracts and different energy service products. For instance, one of the services that a building can offer with powerhouse is emergency capacity. In case the building has a for instance combined heat & power (CHP), lighting that it can flexibly use, it can participate in services to balance the Dutch electricity grid. By doing so, they get a monthly remuneration with some extra payments in case they are activated. Other services that Powerhouse can offer are the options to trade automatically on DAM, IDM and forward markets. Powerhouse claims that participants can save up to 40% on their energy costs. (Powerhouse, 2020)

Jedlix

Jedlix is an app available for all Tesla models, the Renault ZOE and the Jaguar I-PACE (although this is dependent on the country in which the app is used). The app determines the optimal charging plan of the car, taking into account when the car needs to be ready to drive, the capacity on the grid, the amount of renewables available, and the energy price. The app steers the car battery in a smart way which as such leads to benefits for the electricity grid. These benefits lead to financial rewards. The exact financial rewards depend from country to country. In Belgium, rewards can mostly be gained by loading during non-peak hours. While in the Netherlands Jedlix cooperates with the grid operator Tennet who gives incentives per Smartly charged kWh. (JEDLIX, 2020)

aWATTar (Germany and Austria)

aWATTar is an electricity supplier that entered the electricity market with the goal is to make optimal use of green energy. They offer four different energy tariffs as can be seen below. They claim that by shifting consumption to cheap and sunny hours, consumers can save money. (aWATTar, 2020)



On top of that, they also offer feed in tariffs for PV. They also ensure that consumers have easy access to prices for the following day (as early as 2 PM). And they cooperate with applications that help to automate heat pumps and other applications so that consumption is shifted more easily to green and cheap hours. Examples are IDM-heat pumps, KNV heat pumps, ASKI – energy management, LOXONE, GO-e charger, IFTTT&Maker, nymea…

5. OVERVIEW OF EPC CONCEPTS AND BUSINESS MODELS

In previous chapters, we discussed the importance of flexibility and how this flexibility can be valorised. In what follows we discuss the concept of EPC to better understand the possibilities to offer flexibility services through EPC and as such to extend the concept to AEPC. We will look at what EPC really is and how its business model works and is being used to deliver energy efficiency and energetic renovation of buildings. We will also analyse and discuss the role of the ESCO (Energy Services Company) as the actor that is delivering the EPC to the beneficiary.

5.1 SHORT HISTORY OF EPC & POTENTIAL OPTIONS FOR IMPROVEMENT

The concept of Energy Performance Contracting was developed from the mid-eighties on in North America (US and Canada), driven by the opportunity to save energy costs and to renovate mainly technical installations in buildings without having to pay upfront for the investment. This is where the concept of third-party financing, i.e. an Energy Services Company or ESCO investing in EE measures and charging a monthly or annual fee in relation to the financing savings, was developed. (Hansen et al., 2009)

EPC was introduced in Europe mainly via the work of the Berlin Energy Agency in the mid-nineties. They developed a so-called Energy Saving Partnership (ESP) and applied EPC in many public projects (Vanstraelen et al., 2015). Through European projects like Eurocontract and Clearcontract, they spread a lot of the know-how to other organizations in other European countries. This accelerated from 2005 onwards. (Eurocontract, 2008) Today EPC is being used, in some form or the other, in at least 60 countries around the world and in virtually every European country. As is explained in more detail in the next paragraph, there are 2 main payment models, based on which part of the savings are used to pay for the investments in energy saving measures: Shared saving (in which an agreed percentage of obtained savings are shared between the ESCO and the customer, without necessarily commitment upfront to a specific minimum guaranteed level of savings) and Guaranteed Savings (in which the ESCO will commit to a minimum amount of savings that is the basis for the reimbursement of the investment). In the US, the shared savings model (often in combination with ESCO financing) is a very common model, In Europe, however, guaranteed savings are clearly the more dominant mechanism. (Boza-Kiss et al., 2017). Here, EPC is also much more seen as a delivery methodology for energy efficiency or building renovation, with financing by the ESCO being much more of an option, rather than an almost mandatory part of the concept. Often, instead of having the ESCO prefinance the investments as is the case in the US, many customers in Europe still finance their own EPC projects, either by own means or through a classical loan from a bank. (Berger & Schäfer, 2010)

In recent years, one of the main drivers of EPC has been to take action against Climate Change, by lowering energy consumption and consequently, by reducing $C0_2$ and other Green House Gas (GHG) emissions. (Monfils & Hauglustaine, 2016). Whereas early EPCs in this context also aimed at achieving relatively limited energy savings (of the order of 20 to 40%), today we see a growing number of projects and programs that aim at a more ambitious energy savings target of at least 50% and up to 75% or even 90% (Vanstraelen, 2018). The targets to be achieved are more and more expressed in terms of the energy class (e.g. Near Zero Energy Building or the energy label e.g. A+) they seek to achieve, than in the % savings, although the latter may sometimes still be the KPI against which the savings are measured (European Commission, 2017b).

Figure 12 shows a summary of typical required investment costs per square meter as a function of the percentage savings ambition that is being aimed at.

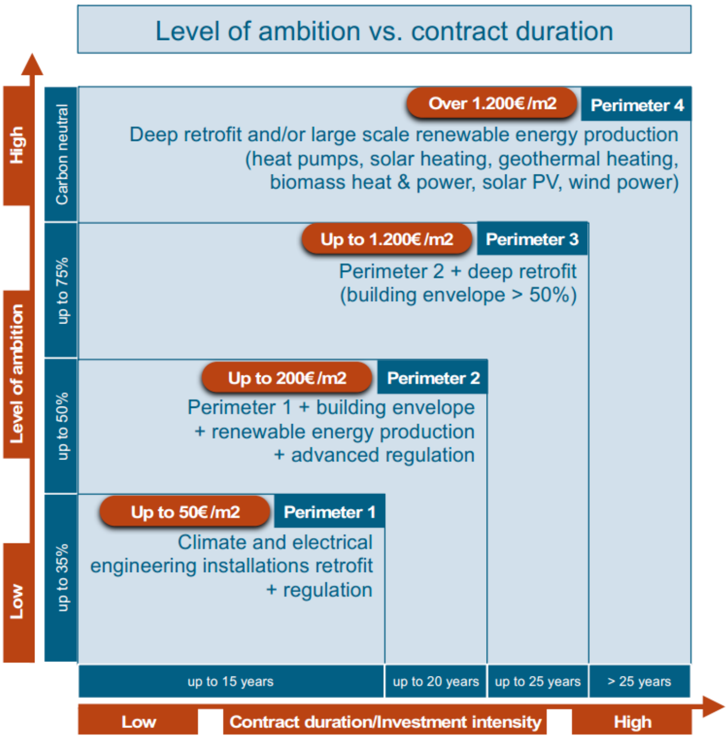


Figure 12 – Level of ambition vs. contract duration/investment intensity (Vanstraelen et al., 2015) (p.11 - fig.3) (CITYNVEST, 2015, P11, FIG. 3.)

The first perimeter corresponds to standard HVAC equipment renovations and relighting/relamping. It also includes regulation, (i.e. commissioning and control of technical installations, etc.) which is part of the basic measures for all ambition levels, with the aim to optimise energy efficiency and operations of technical installations. It is not used to actively control flexibility/DR however. The first two perimeters correspond to ambition levels that are common market practices in Europe. For many customers these are feasible projects and many ESCOs on the market will be interested to provide projects for these perimeters. The second one will include some but limited investment in the building envelope (e.g. roof or attic insulation, wall void insulation, replacement of simple glazing…). The third perimeter (and ambition level) involves a much deeper level of building envelope insulation (replacement of doors and windows, exterior wall insulation, floor insulation, etc.). It will typically require a significant increase of the investment beyond 300 €/m2 and even up to 1.200 €/m2 in case of a comprehensive building renovation when combining all building envelope measures and integration of some renewables to reduce GHG emissions on heat production. It corresponds to a fundamental paradigm shift in terms of energy consumption in the building, with up to a factor 4 (I.e. 75%) reduction in energy consumption. The Fourth perimeter is in line with the "Trias Energetica", in which after having reduced the energy demand by insulation, the remaining demand should be made as carbon neutral as possible. This perimeter leads to a total climate neutral renovation typically based on passive house standards and a full decarbonisation of the remaining energy demand based on local renewable production of heat, cold and electricity demand may even increase that amount to over 1.200 €/month creating a building that meets 2050 objectives today. Sometimes a perimeter 3 strategy may however be chosen to limit the investment cost or contract duration of the EPC.

EPCs overcome the typical barriers to the building renovation process such as its complexity, high transaction costs, lack of expertise and resources, the possible underperformance in the classical approach and the lack of trust induced by a fragmented value chain, by offering performance guarantees on the cost savings. Nevertheless, barriers related to economic KPIs remain (e.g. long pay-back time for measures that really have a large impact on GHG emissions). For that reason, EPCs are mainly seen in the public sector, where ambition levels are often higher, either under mandatory requirements from Europe or because of the voluntary role to set an example. In the private sector there is (too) often a focus on short pay-back times), typically less than 5 or even less than 3 years (Esser et al., 2019). This is one of the reasons why AmBIENCe is proposing the AEPC concept: introduce additional value streams of Demand Response and find an optimal combination of energy efficiency and electrification/ local generation/Demand Response. As such, pay-back periods can be further decreased and investments in energy efficiency can further increase in value.

If the ambition level needs to go up as part of an AEPC, so will the investment levels, even if the business case improves with the use of DR. Higher investment, means a larger loan and thus a potential higher public debt. In that case there may be serious constraints in the public sector as available budgets or debt capacity may lack. Using loans or ESCO financing may be obvious solution, but they will almost certainly increase public debt. This means that "off-balance" or "debt-deconsolidated" financing solutions that are neutral with respect to the European System of Accounts (ESA) may be required. Off-balance EPC financing is possible according to Eurostat since 2017. (Eurostat, 2017) There are however specific conditions imposed by Eurostat, so when combining AEPC with a requirement for off-balance EPC financing, it has to be checked that these conditions are met. (European Commission, 2017a)

5.2 INTRODUCTION TO EPC CONCEPTS AND MODELS

EPC can be considered a business model built around an “energy savings as a service” concept. The service delivered are the energy savings in the building, sometimes referred to as NegaWh (i.e. “negative” or “saved” Watthours, in analogy with the traditional supply of energy; i.e. Kilo or GigaWatthours to the building). (Bleyl-Androschin & Schinnerl, 2010)

When comparing different offers by an ESCO, in terms of financial criteria, the best EPC project is the one that delivers the highest Net Present Value (NPV) of benefits and costs over the duration of the contract or some other agreed period. This corresponds to an approach based on Total Cost of Ownership (TCO). Another way of looking at it is to obtain the lowest cost per kWh of saved energy (or per NegaWh). This can be compared to a Levelized Cost of Saved Energy methodology, by analogy to the Levelized Cost of Energy (Filippi Oberegger et al., 2020). In light of climate action, this could even be transformed into a Levelized Cost of saved emissions mechanisms for the AEPC model. Effectively the major driver for 2030 and 2030 climate objectives is not so much saved energy, but saved GHG emissions. This will likely also be the focus of the application of the AEPC model.

Figure 13 shows the basic business model of EPC where the initial investment is paid for by the energy savings over the duration of the contract, typically several years. This means that kWh and GHG savings are realised as soon as the Energy Conservation Measures (ECM) are implemented. The investment is either paid upfront by the customer or pre-financed by the ESCO or another third party (e.g a bank, financial institution, investment fund...). In the first case, the customer pays a one-off fee at the beginning of the contract, corresponding to the investment cost. In the latter cases, the customer pays an annual fee, including financing costs. They typically pay a second (quarterly or annual) fee covering maintenance and all other project (management) costs. The bulk of the financial savings come after the contract even though some limited amount of financial savings can be made during the contract. Sometimes customers can agree to increase their (annual) budget and investment beyond the financial capacity generated by the savings. This can for example be motivated by a higher energy savings ambition level or by a higher GHG emission reduction ambition level (e.g. switch from fuel to gas or to electricity). This budget may come from investments that were planned already or would anyway have been foreseen or from other sources. (Bleyl-Androschin & Schinnerl, 2010)

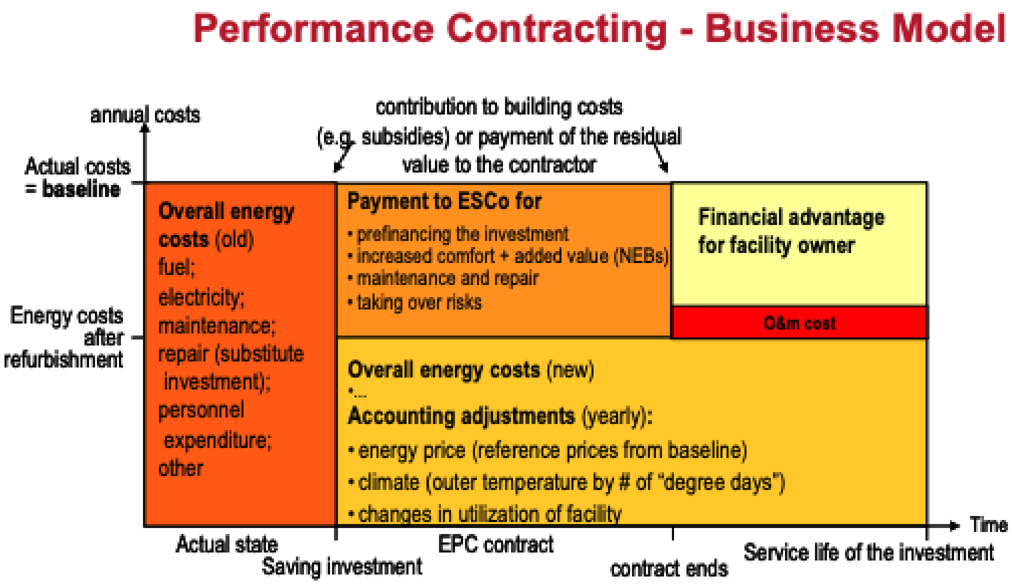


Figure 13 – Business model of energy performance contracting (Graz Energy Agency et al., 2008)

As explained in the introduction, there are 2 main business models that are being used and that can be seen as fundamental performance and payment mechanisms (JRC, 2020):

- In the Shared Savings agreement, the ESCO and beneficiary agree to each receive a pre-determined percentage of the savings over a given contract period (Typically 5, 10 or 15 years). The percentage of savings allocated to each party can vary over the period of the contract. The ESCO must ensure that the proceeds it receives will cover the costs it has incurred in implementing the project. In most projects, underlaying project costs and thus margins, are not necessarily disclosed by the ESCO. There is typically no bonus, nor penalty. (Fraser, 1996)
- In the Guaranteed Savings agreement the ESCO guarantees the beneficiary's energy costs will be reduced by a contractually agreed percentage. From the payments received, which are also a fixed amount, the ESCO must recover its expenses, either immediately or spread over the duration of the contract. Payments to the ESCO can be lower, higher or equal to the savings. Typically, a bonus and penalty scheme are included, in case of overperformance or underperformance. The ESCO generates a return by ensuring sufficient savings in addition to the discount received by the customer. (Fraser, In the US it is common to associate Shared Savings with ESCO financing, i.e. the ESCO finances the investment and shares the benefits with the customer. Guaranteed savings are then associated with the customers financing the investment themselves. In Europe this is not really the case and both Guaranteed and Shared savings are used with either ESCO financing or customer (or bank) financing, or even a mix. (JRC, 2020)

5.3 DESCRIPTION AND COMPARISON OF (COMMON) EPC TYPES

Taking the (basic) EPC model as a start, several variations of this model have been developed and documented over the years. The differences between these models are sometimes related to the level of ambition that is targeted in terms of renovation level. In that case, roles within the ESCO set-up (e.g. with a general contractor or a general planner) or ways to organize the EPC delivery have been introduced. Other variations relate to the scope of non-energy services (e.g. maintenance, comfort) or the way the maintenance is being set-up (e.g. using performance-based models or not). Still others relate to how ESC is combined with features of EPC to provide a more simplified model.

The following paragraphs provide an overview of the most common types of EPC used in Europe, with a description of the key features. It is based on the work of Jan Bleyl at the Grazer Energy Agency and in IEA Task 16 (Bleyl-Androschin & Schinnerl, 2010). The most used ones are described in Figure 14 - Energy contracting models .

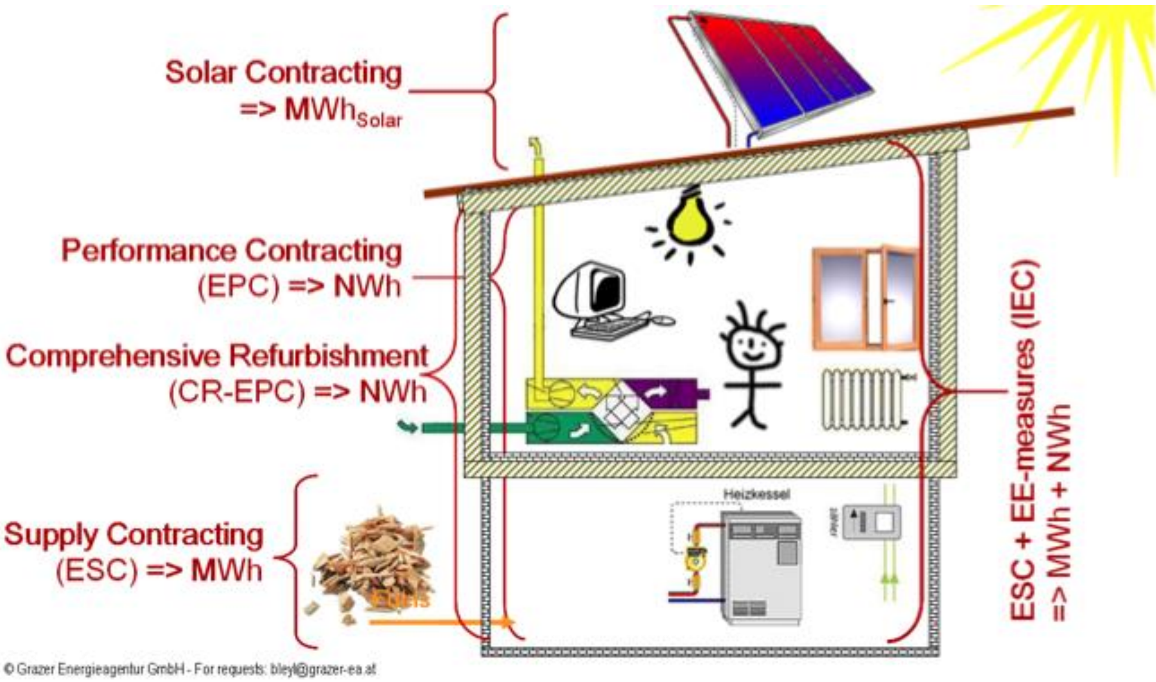


Figure 14 - Energy contracting models (Bleyl-Androschin, 2009, 2012)

- ESC – Energy Supply Contracting

  Energy Supply Contracting is one of the most basic forms of EnergyContracting or Energy Service. In this model the ESCO renovates or replaces a local installation for the production of “useful” energy (e.g. heat, cold, compressed air...). The ESCO delivers kWh of “useful” energy. This useful energy is typically heat, cold, compressed air or some other useful energy stream, delivered by a local production or transformation equipment (e.g. a gas boiler, a heat pump, a CHP or combined cold, heat & power plant or a compressed air installation), and installed, maintained and financed by the ESCO. The ESCO guarantees the "price" of this useful energy. The price may contain a fixed price component (i.e. covering the investment and maintenance costs) and a variable component (covering the gas, fuel or electricity supply). Essentially this means that the ESCO's risk is limited to guaranteeing the efficiency of the local useful energy production. There are no incentives for reducing energy demand in the building as is the case with EPC where this is the key element. If the customer is also interested in saving energy in the building via energy conservation measures, the EPC or IEC model is required.

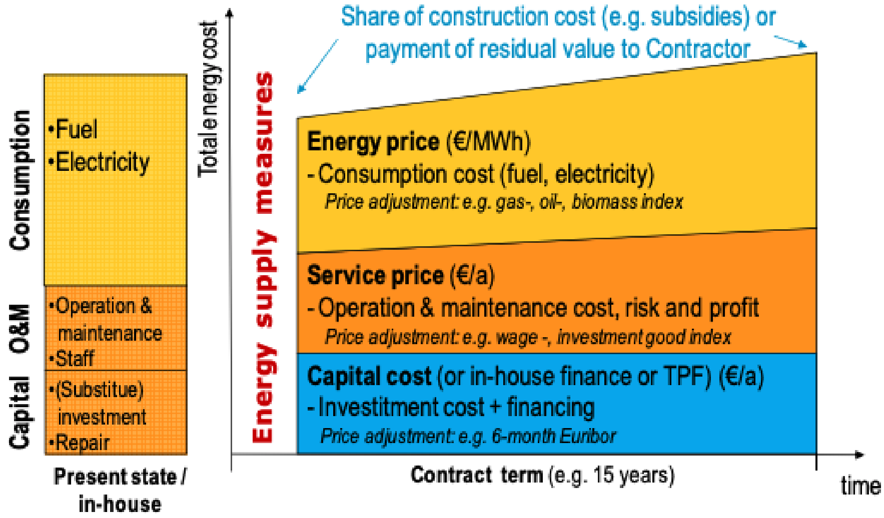


Figure 15 – Business model of energy supply contracting (Bleyl-Androschin & Schinnerl, 2010)

Solar Supply Contracting is a particular, but common form of ESC in which the ESCO installs thermal or PV solar panels, typically on the roof of the customer's building, and sells the renewable heat or electricity. This type of Solar Supply Contracting model, when applied to renewable electricity production from PV panels, is often called a Power Purchase Agreement (PPA), although not all PPA's are ESC, as in case of an ESC the PV installation is always on the building of the customer. With PPA the PV panels may sometimes be installed elsewhere. Figure 15 shows the basic mechanism of an ESC contract. The customer pays for the useful energy consumed, based on a guaranteed price mechanism. The price typically is composed of a fixed and a variable component. Often, both contain a price indexation mechanism. As the ESC model is about local production and supply and not really related to energy efficiency or demand in the building, we will not discuss it further in relation to Demand Response.

- EPC – Energy Performance Contracting

  EPC is the basic, most classic and well-known type of Energy Contracting and as such constitutes the basis and founding element of all other types described here. As explained earlier an EPC is an output driven delivery mechanism for Energy Efficiency (EE) or ECM in buildings. The ESCO designs, implements and optionally finances these ECMs and (in case of a Guaranteed savings agreement) provides a performance guarantee on the energy savings promised to the customer. So effectively the customer only pays for the energy savings or saved kWh, also called NegaWatthours (NWh). In case of underperformance, the ESCO pays a penalty, most often equal to the unachieved savings. In case of overperformance, the ESCO may get a bonus, often 50% of the additional savings, but the percentage can be higher or lower. Energy Prices are fixed in the contract, leading effectively to a fixed cost savings guarantee in case of a Guaranteed savings agreement. The ESCO takes on the design, implementation and exploitation risks. The customer takes on the risk of any variation of prices. Defining a good baseline and decent Measurement and Verification (M&V), mostly using the International Performance Measurement and Verification Protocol (IPMVP), are a key to a successful EPC. It includes defining the boundary of the measurement of the savings (e.g. at the level of the whole building or the level of individual ECMs). It also includes taking into consideration routine or non-routine correction factors. The use of “degree days” as a routine correction factor to take into account changing weather conditions in the winter is a very common practice. Other less common routine correction factors are building occupation or opening hours. Common non-routine correction factors are inoccupation periods, change of building destination or unexpected works by the customer.

- EPC Light

  EPC Light is not really a different type of EPC compared to the basic EPC, but the “Light” refers to the fact that the ambition level or energy savings level is significantly lower than with the basic EPC type. The ECMs are essentially “quick wins” with short Pay-Back Times. Often the number of ECMs is also limited to one or a few. This means that sometimes, not always, the contract is or can be simplified. Similarly, sometimes, not always, this type of contract uses so-called simplified M&V.

- Comprehensive Refurbishment EPC (CR-EPC)

  Figure 16 shows the business model for CR-EPC, which is very much based on the generic EPC business model.

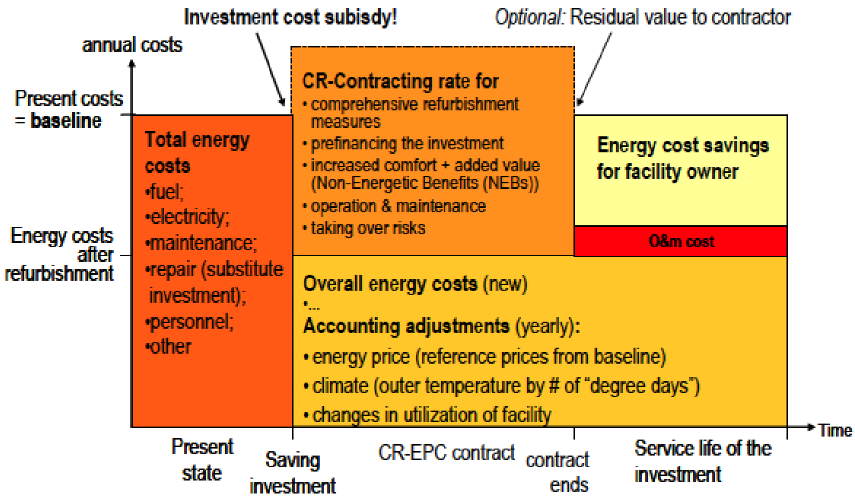


Figure 16 - Business Model of Comprehensive Refurbishment EPC

CR-EPC stands for "Comprehensive Refurbishment EPC". Even though there is in principle no reason that standard EPC should not be used for comprehensive refurbishment or Deep Energy Renovation and thus include a significant amount of building envelope measures (window replacement, roof or wall insulation, etc.) and/or other refurbishment measures, the basic EPC model has some limitations. Comprehensive refurbishment of buildings creates specific challenges in terms of business case, financing and contract duration. Including or allowing for such measures, when tendering, may require adding certain input-driven technical specifications in addition to the output driven performance-based specifications. Within the contract (and later extended within IEA Task 16) work has been done on defining this specific type of CR-EPC. The business model of CR-EPC is described below and is not all that different from the classical EPC business model. The main difference is the length of the contract (typically > 15 or even > 20 years), the fact that the business case is not budget neutral anymore AFTER renovation after are higher than costs BEFORE renovation. This is shown by the fact that the Contracting Rate (I.e. represented by the dark orange rectangle in Figure 16 - Business Model of Comprehensive Refurbishment EPC6) plus the remaining energy costs (represented by the light orange rectangle) are higher than the baseline (I.e. represented by the light red rectangle)) and the fact that some kind of residual value can be taken into account.

Three different variations have been proposed: A "General Contractor" (GC), a "General Planner" (GP) and a "Light" model.
Figure 17: Selection flow chart for CR-EPC variations shows a selection flow chart that indicates when one or the other model is best applied

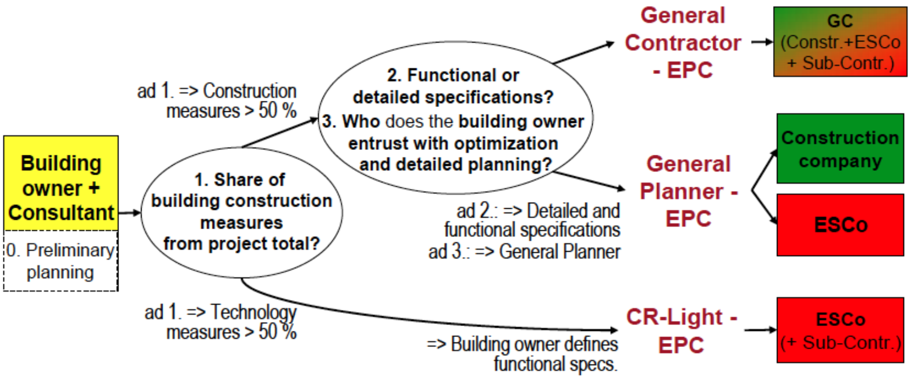


Figure 17: Selection flow chart for CR-EPC variations

The first selection criterium is the share of building construction measures in the project total. In case they represent less than 50%, meaning the technology measures represent > 50%, the CR-light EPC is appropriate. In case construction measures represent > 50%, it is one of the two other variations: GC CR-EPC or GP CR-EPC. The second selection criteria is related to the type of specifications that are used or the awarding of the CR works and services: detailed specifications or functional ones. The third criteria is related to who the beneficiary entrusts with overall optimization, detailed planning and supervision of the project: a general planner or a general contractor.

- IEC – Integrated Energy Contracting

  Integrated Energy Contracting was developed within the Grazer Energy Agency in Austria to address some of the perceived complexities with basic EPC and the associated M&V. (Bleyl-Androschin, 2009). The model is shown in Figure 188.

  Integrated Energy tries to avoid some of the complexities of EPC, by combining the easier ESC model with Energy efficiency measures, without guaranteeing the latter against a baseline as is the case with EPC. Performance guarantees are replaced by Quality Assurance Instruments (QAI). Although the model has some interest it is hardly used outside of Austria, where EPC (and its variations) remain the predominant model.

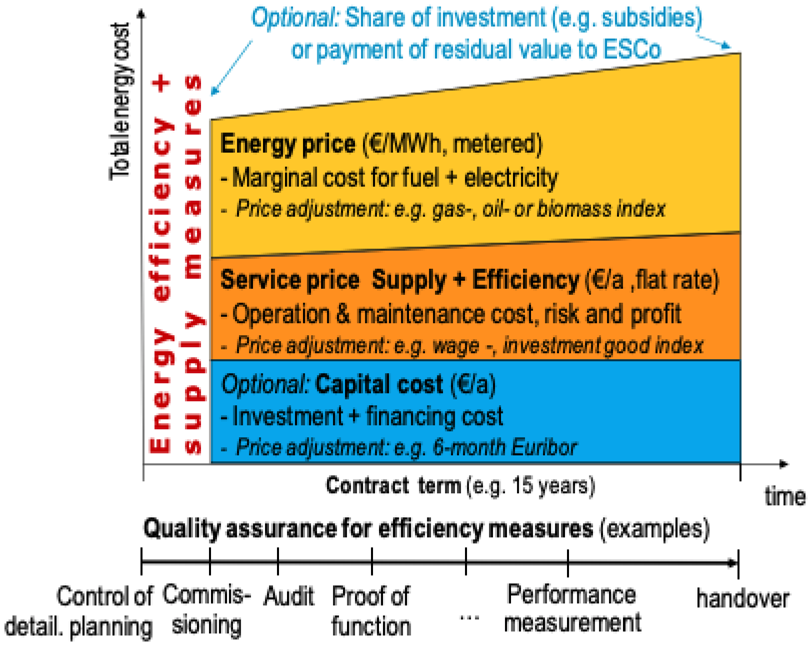


Figure 18 - Business models for Integrated Energy Contracting (Bleyl-Androschin, 2009)

- Maintenance and Energy Performance Contract (M-EPC)

  In basic EPC, maintenance is often limited to that of new installations or the installations concerned by the sole Energy Conservation Measures. However, the maintenance needs often extend well beyond those single installations to include all energy related equipment (e.g. non-renovated boiler rooms, non-upgraded lighting) or even non-energy related equipment maintenance (sanitary installations, elevators, fire equipment, access control, etc.). It may even include maintenance of building envelope related items, like doors and windows, roofs, etc.

  An EPC that includes the maintenance of the whole building is called a Maintenance and Energy Performance Contract or M-EPC. In some cases, this comprehensive maintenance may itself be performance-based as is the case for the M-EPC contracts based on the NEN2767 standard (NEN, 2019) widely used in the Netherlands and Belgium. Rather than using lengthy specifications for maintenance it uses condition scores to determine the quality of installations before the contract and the result of quality maintenance during and at the end of the contract. This output-driven methodology offers many advantages compared to the traditional input-driven method of doing maintenance. This methodology is also used within the next category of EPC.

- SmartEPC

  SmartEPC is an innovative EPC model, developed initially in Belgium for the Federal Government's public buildings and now applied in many other EPC projects, still mainly in Belgium. It is a very modular business model, based on the M-EPC model, using NEN2767 (see previous paragraph on M-EPC). It was designed to meet a number of specific requirements and options:

  - Variable contract durations between multiple buildings, which is sometimes the case in projects with multiple rented buildings
  - A solution for the split incentive between the owner/lessor and the tenant/lessee or occupier, through a quantification of building (rest) values based on a feature made possible by an extension of NEN2767, i.e. combining replacement values with condition scores.
  - Output driven solution for maintenance
  - Output driven solution for comfort
  - High degree of standardization possible
  - Modular
  - Flexible to adapt to future requirements

  SmartEPC has also been applied to Comprehensive Refurbishment projects and thus fits into the CR-EPC category. The rest value concept to deal with the split incentive was applied in a number of Belgian federal public buildings that were partially renovated by the tenant, in cooperation with the owner, after an earlier Sale & Leaseback operation, in the Fedimmo project. The underlaying idea is that when parties can quantify the rest value at the end of the rental contract for the owner, from an investment by the tenant, that this provides a basis for negotiating a fair contribution from the owner, based on this rest value that is offered to them. The other way around, it allows the owner who invest to negotiate for a contribution from the tenant that takes into account the value that is delivered to the tenant who is solely benefiting from the energy efficiency investments done by the owner. Although it is not a magic bullet, it allows to objectify the value for both parties and thus facilitation co-investments in building renovation. (energinvest, 2017)

Table 6 provides a summary of these types of EPC, commonly used in Europe, with an indication of typical ambition levels they are used for, scope and other features. The data in the table is based on various projects in Belgium and Europe (Vanstraelen, 2018). Other variations or hybrid models can be found. Also, more specific models like “Comfort as a Service” (CaaS) exist, where it is not the guaranteed energy savings that are contracted, but a guaranteed level of comfort in the building. This often means that the ESCO takes over the energy contract(s) (Helexia, 2019). Other models that have been documented are “Light as a Service” (LaaS), in which certain quality of light and light levels are guaranteed on a per square meter basis.

They may involve energy savings, but not always. The ESCO will often take over the energy contract or the cost of energy will in general be included in the price of the comfort or light service. Such “aaS” models could also be combined with Demand Response/Flexibility as long as the flexibility service falls within the boundaries and KPIs of the “aaS” service. Such solutions could combine demand management and energy efficiency services, facilitate the adoption of renewables and other decentralized supply sources, and also optimize the balance between demand and supply. The chief benefit for the consumer is in the simplification of an increasingly multifaceted service offering. (Deloitte, 2019) As they are specific and often even very tailored to customers‘ needs, we will not cover them here in detail. Having said this, the more common EPC types also contain comfort related criteria or KPIs. M-EPC and smartEPC are EPC models with a broader scope of services, but they can also apply to Deep Energy Renovations as is the case with the CR-EPC (Comprehensive Refurbishment) models.

Table 6 - EPC types, with ambition levels and service scope (AmBIENCe, 2020)

PC type	Definition	Scope		Ambition level (% of baseline)		Maintenance	Comfort	Typical contract (years)
		Supply	Demand	Energy	CO_2			
ESC	“Useful” Energy Supply Contract	x		15%-20%	40%-90%	Production only	No	5 - 15
EPC	(Classical) EPC	x	x	25%-40%	30%-60%	ECM only	Yes	5 – 12
EPC light	Quick wins	x	x	10%-15%	20%-25%	ECM only	Yes	3 – 5
CR-EPC	Comprehensive Refurbishment or Deep Energy Retrofit	x	x	50%-90%	50%-100%	ECM only	Yes	15 – 25
GC CR-EPC	CR with General Contractor	x	x	50%-90%	50%-100%	ECM only	Yes	15 – 25
GP CR-EPC	CR with General Planner	x	x	50%-90%	50%-100%	ECM only	Yes	15 – 25
CR-EPC light	CR with < 50% in building envelope investments	x	x	40%-60%	50%-80%	ECM only	Yes	10 - 15
IEC	Integrated EC = ESC + EPC	x	x	20%-30%	30%-80%	ECM only	Yes	5 - 15
M-EPC	EPC, Including global building maintenance	x	x	25%-40%	30%-60%	Whole building	Yes	10 – 12
smartEPC	Full performance model (energy, maintenance, comfort, asset value…)	x	x	10%-90%	20%-100%	Whole building (Perf.-Based NEN2767)	Yes (Option: Perf.- based)	5 – 25

From this table we learn that the models differ in terms of ambition level, the extent to which or the way in which certain services like maintenance or comfort are delivered or measured, and the typical duration of the contract. But they do not change that much in terms of how the basic business model works or the way they are financed. The smartEPC model is maybe an exception as it does go further in the sense that it introduces a model for calculating and guaranteeing building (rest) value. It can also use a performance-based comfort model, which allows for guaranteeing that comfort level and linking it to other quantifiable parameters as improved health or productivity.

CR-EPC and its three variations were designed to specifically address comprehensive refurbishment projects. They differ on the ambition level (i.e. CR-EPC Light typically only includes op to 50% of the investment in building envelope measures like roof insulation, wall insulation or door and window replacement). GC CR-EPC and GP CR-EPC differ in the way the ESCO relation is set-up either with a General Contractor or with a General Planner. This changes the type of actors involved in the EPC delivery value chain, but does not change the fundamental business model of providing energy savings guarantees.

There is no real difference in application according to the sector, either public or private, although M-EPC and in particular smartEPC, are particularly designed with the public sector needs in mind.

Also, in terms of financing, in theory all models can use beneficiary's own funds, ESCO financing (potentially refinanced by a bank) or bank financing (contracted by the beneficiary). SmartEPC today includes the option to do off-balance (i.e. ESA neutral) financing for public buildings, although other EPC models could also allow it. This is important if beneficiaries want do more comprehensive refurbishments and facilitate electrification, potentially in combination with DR, as the investment amount increases significantly. Governments' and Public building owners' debt capacity may be limited so that financing solutions that are off-balance or "deconsolidated" in terms of public debt become interesting or even mandatory. SmartEPC is designed to do "partial" off-balance ESCO financing (I.e. were part of the investments are deconsolidated) which may be more complicated with other models, unless they integrate similar features like distinguishing between asset types and maintenance categories. These considerations go beyond the scope of this report as they are not directly related to DR, so we will not develop them further. Table 7, compiled based on AmBIENCe partners' feedback, provides an overview of the types of EPC that are being used in a number of European countries, including the ones of the Consortium partners. The fact that it is used does not necessarily mean that it has a significant market share or is used very often, but that there have been cases reported of commercial offers, pilot projects or commercial projects.

Table 7 - EPC types used per country (AmBIENCe, 2020)

EPC type	IT	ES	PT	BE	DE	UK	FR	AT	NL
ESC	x	x	x	x	x	x	x	x	x
EPC	x	x	x	x	x	x	x	x	x
EPC light	x	x	x	x	x	x	x	x	x
CR-EPC	x	x			x	x	x	x	x
GC CR-EPC	x	x		x	x	x	x	x	x
GP CR-EPC	x	x			x	x	x	x	x
CR-EPC light	x	x		x	x	x	x	x	x
IEC					x			x	
M-EPC	x	x		x	x	x	x	x	x
smartEPC				x			x		x

All models can be used by owner-occupiers and owner-lessors. Most models could be used by lessees or tenants, but this is rather uncommon. The only exception again is the smartEPC model that has also been designed to be applied both by owner-lessors and/or tenant-lessees. This has been made feasible through the building or asset (rest) value concept that allows to quantify the financial rest value (at the end of the contract) of an investment (at the beginning of the contract).

Table 8 provides an overview of some EPC projects in different member states, in the public and private sector and some key numbers on investment and the ambition levels. This allows to illustrate that most current EPC projects don't go beyond 40% energy savings although there are some exceptions (Vanstraelen, 2018). The first and the sixth project are smartEPC projects. The Renowatt projects are GC CR-EPC projects, although in terms of ambition levels, they are more comparable to CR-light projects. The Slovakian and the first UK project are also examples of Deep Energy Retrofits or CR-EPC. In the 1st smartEPC project, at the municipality of Beersel, one out of 7 buildings has undergone a deep energy renovation.

Table 8 - Examples ambition levels in EPC projects (Qualitee H2020 project, 2019; Vanstraelen, 2018)

Country	Customer	Number of buildings	Surface (m^2)	Investment (€ per m2)	Energy savings
BE	Beersel Municipal Buildings (All) of *which Primary School Huizingen*	7	20.937 *2.235*	79,8 *293*	25% *80%*
	University of Antwerp		62.000	9,4	26%
	SGS Polderdijk	1			50%
	OPZC Rekem	22	46.000	15,6	30%
	Van der Poorten	1	10.000	10	18%
	Federal Building Agency (Fedimmo)	13	75.530	20	31%
	Province of Hainaut School	1	16.000	8	41%
	Renowatt Municipal Schools	48	190.738	128,9	30%
	Renowatt Municipal Sports Facilities	13	30.907	165	36%
	Renowatt Municipal Buildings	10	22.228	132,1	34%
	Ottignies Municipal Buildings	4	12.000	0	31%
BG	Katinutsa Municipal Kindergarten	1	2.561	79,9	43%
	Kostinbrod Municipal School	1	1.000	118,9	64%
CZ	City of Prague Academy of Arts	4	11.000	158,2	35%
DE	Office Building in Wiesbaden	1	400	53,8	71%
LV	Apartment Building in Riga	1	2.911	189,2	47%
SK	Municipal Service Centre in Novàky	1	829	676	78%
SL	Residential building in Bohinj	1	1.172	406,3	53%
UK	South Cambridgeshire Municipal buildings	1	5.200	365,4	57%
	Dundee City Council buildings	8	45.690	39,4	12%

5.4 USAGE AND ANALYSIS OF DIFFERENT EPC TYPES WITH DEMAND RESPONSE

In the previous section, we analysed the most important types of EPC and the specific project objectives that they are designed for. In this section, we zoom deeper in on EPC models that can be combined with DR or that bring specific features or characteristics to the business model that could become part of a dual service AEPC model.

When looking at the EPC model (guaranteed or shared savings) or the EPC type, there are models that are more adapted to the combination with Demand Response services. All Energy Contracting types, both ESC and the various EPC types, can include installations or ECMs that allow for flexibility, but electrification in combination with DR becomes more efficient when insulation levels are high but not too high.

However, it seems that currently, although the business and technical concepts are available, flexibility is not frequently implemented in EPC models. This is mainly because dynamic tariffs are still largely absent. Nevertheless, we argue that the business case of EPC could improve significantly if flexibility is added to the concept, as far as energy consumption is not reduced to zero. This is especially the case for business concepts with lower ambition levels but higher potential for electrification as DR can help to mitigate the energy cost disadvantage of electricity versus gas or fuel.

If there is a difference in that respect between the different types of EPC, it is not so much on the level of the technical scope or the business concept, but rather at the way the underlaying ambition level can influence the business case and thus the need to improve that business case by adding DR.

For example, an ambitious building renovation, using the CR-EPC model requires a much higher investment than an EPC light or even a basic classical EPC. Thus, as energy savings don't increase that quickly the pay-back time (PBT) will significantly increase and the NPV of the costs and benefits will be lower, even over a relatively long period. Therefore, the need for improving the business case of the EPC light renovation, via electrification and DR revenues, could be a driver for the customer to use an Active building EPC model.

Similarly, in a classical EPC, the installation of an electrical heat pump may represent an average or even bad business case in terms of PBT and/or NPV and IRR (Internal Rate of Return). However, when insulating the building, which has its own business case which may not be very good, the efficiency (expressed through the seasonal Coefficient Of Performance or COP) of the heat pump may be improved as the building can be heated at lower water temperatures (e.g. 30°C instead of 60°C). This can allow for a more global optimization of head demand and heat supply. Valorising the flexibility then offered by this Heat Pump, in combination with PV solar panels, can then allow to even further reduce GHG emissions, increase revenues or cost savings and thus improve the business case.

From this example we learn that is not so much the different types of EPC themselves that can improve the case for AEPC, but rather the underlaying drivers (ambition level, scope, contract duration, budget neutrality, off-balance financing needs, split incentive solution etc.) that lead to one or the other type of EPC (e.g. CR-EPC light versus GC CR-EPC or classical EPC versus smartEPC). The smartEPC model being much more designed to tackle certain barriers and opportunities, can possibly bring some features that are particularly well suited for the design and implementation of the AEPC model. This will need to be explored in the rest of the AmBIENCe project.

All of the EPC types already, without any significant difference between them, use some form of active control, but rather for energy efficiency. Typical examples are:

- Building Management Systems (BMS),
- Systems to control the boiler (temperature settings, clock settings, outside T sensors),
- Smart thermostats, thermostatic valves and presence detectors to control room temperature,
- Presence and daylight detectors to control lighting,
- Sunlight detectors to control solar shades or blinds.

This active control is done to further reduce the energy consumption (e.g. by not heating or lighting when there is no presence) and improve comfort (e.g. by avoiding overheating). None of them however really uses DR today to control the operation of the building based on dynamic price tariffs or explicit event triggers. This is where the AEPC model can combine DR models as described in Chapter 4 with EPC, taking advantage of active control not only for energy efficiency, but also for DR flexibility.

From the previous analysis, it seems that all energy contracting types can include installations or ECMs that allow for flexibility.

5.5 USE OF EPC IN MULTIPLE BUILDINGS

AmBIENCe looks at EPC in single buildings, but also in multiple buildings. The fact that we include a multiple buildings perspective into a single project is a common practice, facilitated by the fact that EPC is based on functional and performance-related output-driven specifications, rather than on technical or input-driven specifications. Thus, project complexity, transition costs and resources required don't increase linearly as is the case for the classical approach when the number of buildings increases. So, it is very common to see EPC projects with 10, 20, 50 or even more buildings.

Moreover, defining performance guarantees on energy savings at the building pool level, rather than on the single building level allows for risk distribution. Effectively, if one building underperforms, but this is compensated by another building overperforming, there would not be a penalty for the ESCO. This mutualizing of the performance risk can allow the ESCOs to either provide better guarantees or lower their prices.

This means that using an AEPC model for multiple buildings should not create any particular problems from a methodological point of view, as far as the DR related services can also be output-driven and functionally specified. (Lee et al., 2015). This aspect of AEPC with multiple buildings will further be addressed in Task 2.3 of the AmBIENCe project. Also, the role of the ESCO as an aggregator has been addressed in Chapter 4.

5.6 ACTORS, ROLES AND MARKET MODELS IN (A)EPC

Delivering EPC in general and AEPC in particular to customers is a complex process that involves different actors.

The key actors for the existing EPC model are:

- ESCOs,
- Customers,
- Subcontractors to the ESCO (typically installers, contractors, equipment suppliers, architects, engineering companies, software suppliers),
- Financiers (e.g. banks, third party investors...),
- ESCO Project facilitators.

In particular the essential role of Project Facilitators has been recognised in recent years. (Bleyl et al., 2013).

Sometimes the roles of these actors can be taken up by another actor. For example, ESCOs can finance projects and thus take over that role from separate financiers. Also, in some cases some actors may not be involved in a given project. For example, an ESCO may not need subcontractors if they have all skills in-house. In the private sector, some customers may decide to engage directly with an ESCO, without calling upon the expertise of an ESCO Project facilitator.

In case of AEPC, particularly when using explicit demand response, there are some additional actors that become part of the project delivery eco-system:

- Aggregators
- DSOs/TSOs

The actors have to collaborate and act within a dynamic market were demand and supply meet each other to deliver end-to-end services between actors and customers across the market. These relations can be described using a market model. This market model describes the different actors and the relations between them. It includes an overview of information flows, service delivery flows and financial flows between them.

Within the NOVICE project, when looking at market models, they started from the existing traditional model for delivering EE and DR separately and proposed a new combined model to deliver dual energy services to the customer. This is developed within Deliverable 4.1 of the NOVICE Project. (Vavallo, 2018). In Figure 19 they describe the **Traditional market model.**

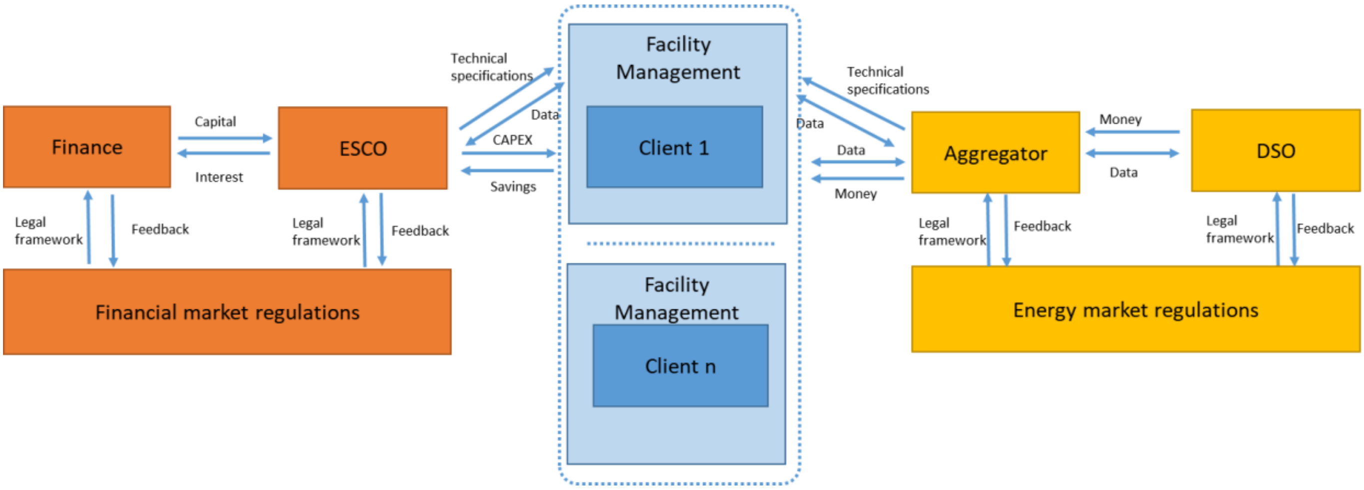


Figure 19 – Novice project (DELIVERABLE 4.1 (3)) Traditional market model (Vavallo, 2018) (FIG. 1, P.28)

In this model, both services are delivered independently. The ESCOs deliver energy (and cost) savings through ECM measures, implemented in the facility of the client. ESCOs may get financing from a financier, who is being repaid annually (CAPEX + interests), within the context of financial regulations. In parallel, an Aggregator collects DR capacity directly from the customer and monetizes it with the DSO, within the boundaries of the energy market regulations. All data and financial streams are running separately. There is no global optimization of the technical and economical business case.

A new combined market model was also proposed as shown in Figure 20.

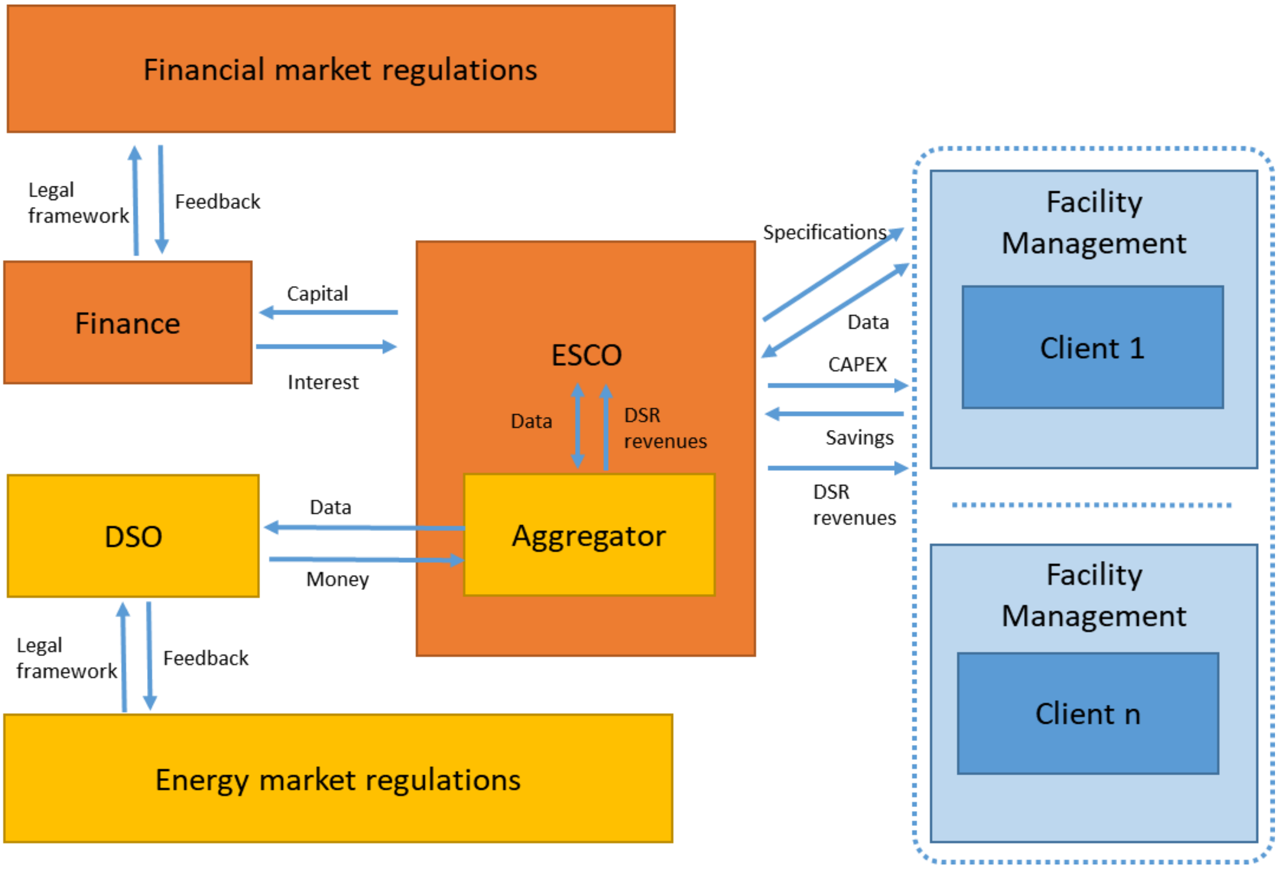


Figure 20 – Novice project (DELIVERABLE 4.1) New combined market model (Vavallo, 2018) (FIG. 2, P.28)

In this combined dual services model, the ESCO not only provides the EE measures but is also in charge of identifying and exploiting flexibility. Rather than the customer directly, it is now the ESCO that interacts with the Aggregator. As he aggregates flexibility of multiple customers and buildings, he may end up integrating the role of aggregator. Alternatively, ESCOs and Aggregators may work in unison or as a consortium. One of the main advantages for the customer is to have one single contact, one contract and one integrated optimisation of his energy saving opportunity.

This new model will allow us to build upon in order to define the Active building EPC model in our own AEPC business concept. Specifically, the role of Aggregator is of interest. Our purpose is to look at how ESCOs can become technical aggregators who interact with existing market aggregators. This would be a more specific evolution of the role of ESCOs than is the case in this combined market model. In other words, there is a case for splitting the role of aggregation in technical aggregation and market aggregation.

The reasons why ESCOs can interact with or potentially act as (technical) aggregators are:

1) They install, manage, maintain and sometimes own the equipment that allows for flexibility (e.g. heat pumps, electrical boilers, active control...) as part of an AEPC project;

2) They typically do this at a large scale with many customers, sometimes dozens or even hundreds. This in itself generates the conditions for aggregation of a high amount of energy savings but also of flexibility which is required to be of interest to flexibility requesters;
3) Many EPC projects are done within pools of multiple buildings, often of 5 or 10 buildings, sometimes 25 or 50 or even more. This additional level of aggregation is intrinsic to the EPC model and comes on top of the previous characteristic.

In addition to the overall market model, the NOVICE project in Deliverable 3.4 looked at the way in which the ESCO and Aggregator specifically are expected to be able to collaborate in 3 different manners, as is described below:

1) **ESCO and Aggregator as equal partners in a three-party agreement to provide EPC and DR services.** Specific roles and responsibilities are clearly highlighted in the contract and each party is contractually responsible for delivering the associated services. Finance is provided either by the client or by a specialized third party (typical to ESCO contracting)
2) **Aggregator as a named subcontractor for DR services in an EPC contract augmented with DR.** The aggregator will have certain contractual responsibilities (like data collection, software delivery or flex requester relations) for delivering DR services for the client but the main revenue risks will be held by the ESCO as the main contracting party.
3) **Aggregator as a generic service provider in an EPC contract augmented with DR services.** In this version, the ESCO will have the freedom to choose the aggregator and even switch DR suppliers for the duration of the EPC contracts. This may provide higher flexibility for the client but could also introduce higher volatility over the DR revenues due to different revenue models across the DR market.

6. FINDINGS FROM PRACTICE

This chapter provides findings from the stakeholder survey that was conducted to enrich the analysis with the feedback from relevant stakeholders operating in the field.

In detail, the scope of the survey was to collect information to:

- understand how buildings currently make use of active control and whether active control is already linked to demand-response, possibly in the context of EPC-contracts;
- investigate to which extent buildings can provide flexibility for demand-response and to which extent European organizations are using or are interested to use flexibility from buildings.

The survey focussed on two type of actors: Flexibility providers and Flexibility requesters.

- Flexibility providers are intermediary actors (typically ESCOs) that make it possible to generate and aggregate flexibility by dynamically using demand response in the buildings of their customers, according to the requirements of the Flexibility requesters.
- The Flexibility requesters (typically DSOs or TSOs) will make use of this flexibility offered to them by the ESCOs (via their customers' buildings) to do balancing or to influence electricity usage to optimize network performance.

The stakeholders belonging to the above two categories were identified and selected in different European Countries and were contacted via email and/or via telephone and/or skype. The obtained results, that are analysed in the next section, are related to the elaboration and assessment of the feedback obtained by those stakeholders that actually replied and participated to the survey. In total, we collected relevant information from the following eight countries: Belgium, Croatia, Cyprus, Denmark, Finland, Italy, Spain and Portugal (Figure 21).

Figure 21 – Map of countries covered by the stakeholder survey (AmBIENCe, 2020)

Table 9 provides an overview of the countries for which we received completed questionnaires (marked in red), for each of the two stakeholders' typologies (flexibility providers and flexibility requesters).

Table 9 – Countries covered by the stakeholder survey, by type of stakeholder (AmBIENCe, 2020)

	Stakeholder typology	
Country	**Flexibility *providers***	**Flexibility *requesters***
Belgium		
Croatia		
Cyprus		
Denmark		
Finland		
Italy		
Spain		
Portugal		

6.1 ANALYSIS OF THE SURVEY RESULTS

In what follows we discuss the results of the survey. The results are discussed separately for the flexibility providers and the flexibility requesters.

6.1.1 FLEX PROVIDER SURVEY

The survey results were analysed by adopting both quantitative and qualitative methods, that are complementary to each other. Specifically, a quantitative analysis was performed of the answers to the closed questions to obtain structured and statistical information. A qualitative analysis was carried out for the answers to the open questions to gain a deep understanding of stakeholder opinions and views.

(1) QUANTITATIVE ANALYSIS

When analysing the types of buildings in which flexibility providers currently have EE and/or EPC projects, almost all of them have projects in commercial buildings (Figure 22). Roughly 65% of the flexibility providers involved in the survey have projects in public buildings, whereas only 30% have projects in residential buildings. Furthermore, at least 30% of the stakeholders cover one or more of the types of buildings that are relevant for the AEPC model.

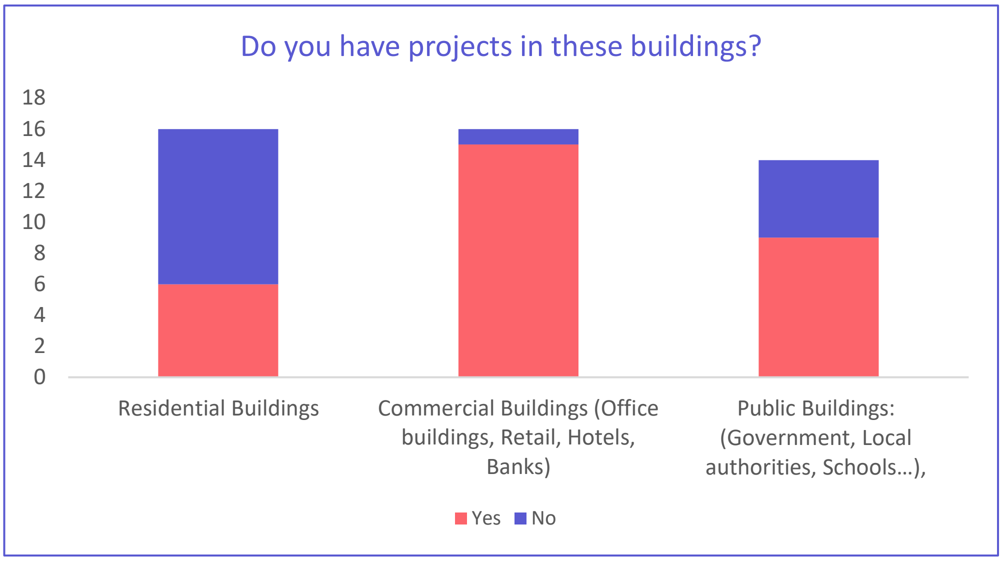


Figure 22 – Stakeholder survey – types of buildings for stakeholder projects (AmBIENCe, 2020)

Furthermore, more than 50% of the stakeholders stated that they act as an ESCO in these projects that are carried out as part of an Energy Performance Contract (Figure 23). It can be assumed that a majority of these projects is implemented in public and commercial buildings, taking into consideration that EPC is not widely developed in the residential sector.

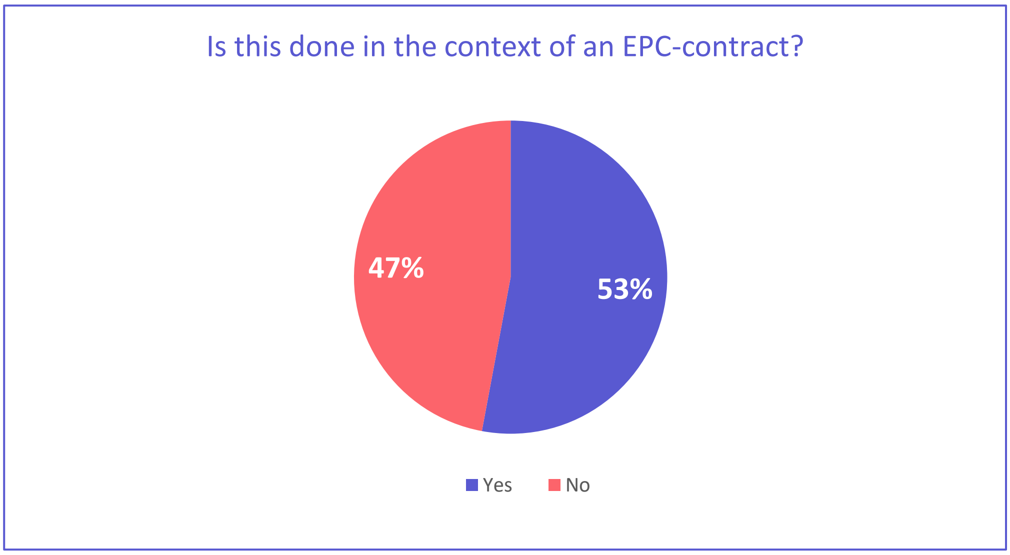


Figure 23 – Stakeholder survey – projects in context of an EPC contract (AmBIENCe, 2020)

The technologies that are typically used in the stakeholders' existing projects were also investigated as is shown in Figure 24. The goal was to understand whether electrification and active control were already commonly used. In addition, insights about the use of insulation and renewable energy (mainly PV) were useful for assessing the AEPC potential, since the use of electrical heat pumps often becomes more interesting only in case of Deeper Energy Renovations or Comprehensive Refurbishment. Effectively, a higher degree of insulation allows to operate at the lower heating water temperatures (either with existing radiators that don't need to work at such high temperatures or by switching to floor heating that typically works with lower heating water temperatures). This increases the seasonal COP of the heat pumps. As for solar power, having PV panels allows to increase the level of locally produced green electricity, which can also be stored locally in batteries. The results of the survey are shown in the corresponding figures.

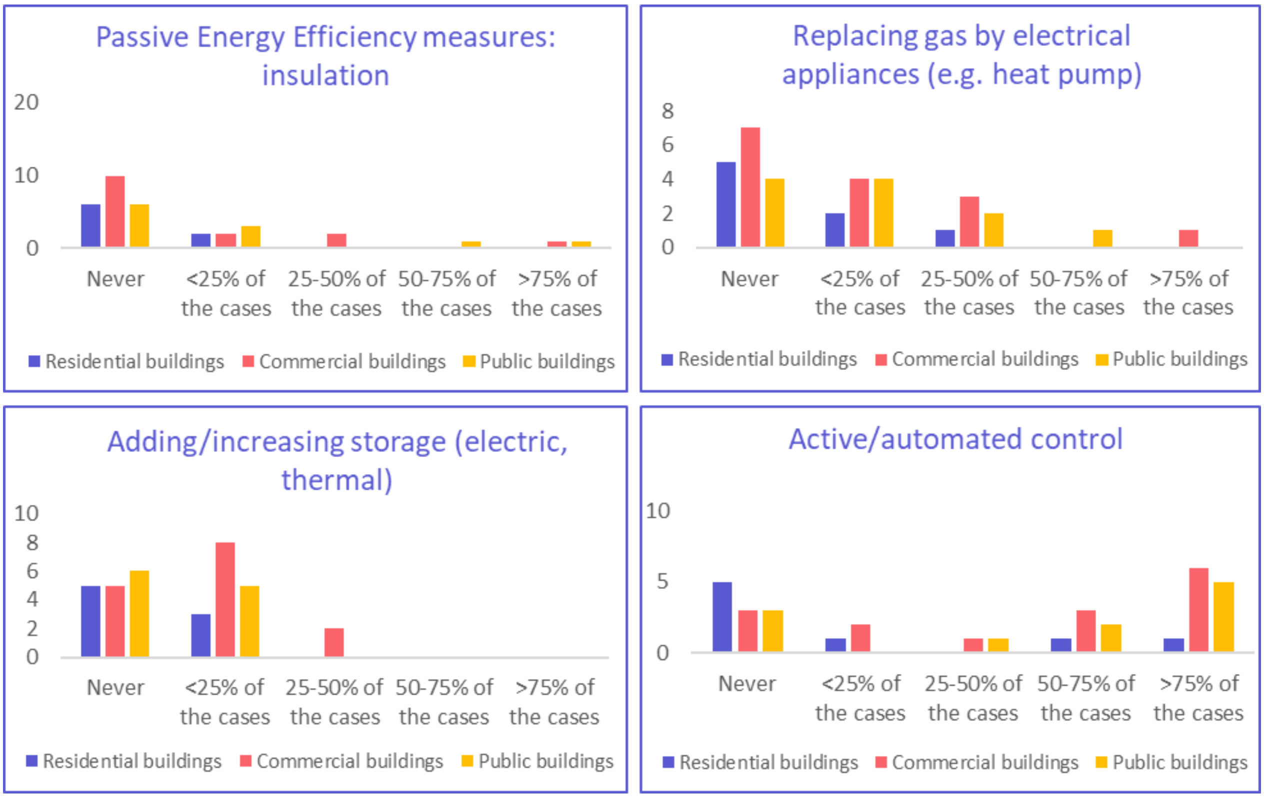


Figure 24 – Stakeholder survey – technologies used by flex providers in projects (AmBIENCe, 2020)

Even though about 40% to 50% never uses these technologies or applies these measures, a small majority uses them to some extent. These results show that most ESCOs still provide classical energy conservation measures like (gas fuelled) boiler replacements, upgrades of ventilation systems and relighting.

Insulation is only being used in a minority of the projects, which shows a limited ambition level in terms of energy savings level, by most end customers. As expected, insulation is more common in public buildings as public authorities are likely to show a higher ambition level with longer contracts. Moreover, from the survey emerged that replacing gas or fuel boilers by electrical heat pumps still represents an uncommon practice for almost 80% of the stakeholders. Commercial buildings score slightly better with almost 25% of actors substituting fuel boilers for electrical pumps in 25% to 50% of the projects.

As for the storage technologies, their adoption was also very low, with almost 50% of respondents never using it, particularly in residential and public buildings. For commercial building projects, in particular, the interviewed stakeholders declared that storage was used slightly more than in the 2 other types of buildings, with even some responders confirming its usage in between 25% to 50% of the projects. Concerning the type of used storage, stakeholders' answers show that the 3 most common types (i.e. stationary batteries, hot water vessels for sanitary warm water or space heating and charging poles for Electrical Vehicles (EV)) are being used and they are adopted in very similar proportions.

Active/automated control is more common in public and commercial buildings but poorly adopted in residential buildings. However, the obtained data for this technology are likely to need further analysis since it is to be taken into account that active control may include for certain respondents (in particular ESCOs) applications like temperature-based heating control or sunshine-controlled solar screens and this type of control does not allow for flexibility. Nevertheless, the survey has highlighted a common usage of control measures and a willingness to automate systems operations. It also shows willingness to invest in active control and digitization, which is a solid basis for DR.

One of the aims of the survey was to understand the drivers for active control. Figure 25 below shows the four common driving factors for the use of active/automated control.

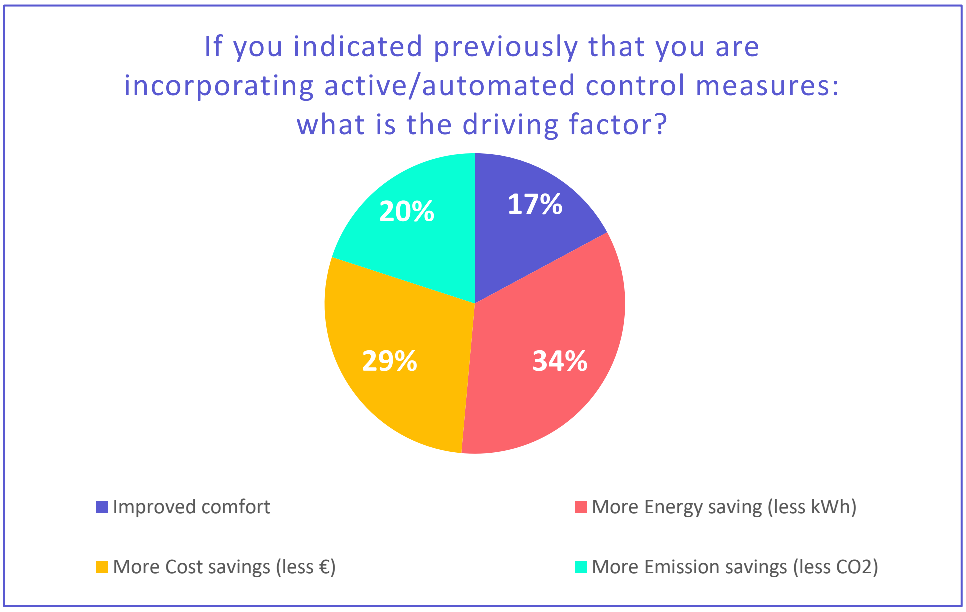


Figure 25 – Stakeholder survey – driving factors for active/automated control in projects (AmBIENCe, 2020)

It can be seen that "more energy savings" is considered a driver by most actors, followed by "more cost savings", confirming that EPC is used as a common model. More "Emission savings" and "improved comfort" are still quite important but seem to be more boundary conditions to be maintained when saving energy, rather than a parameter to be improved.

To assess the potential for AEPC, it is important to understand to which technologies stakeholders already apply active control, because this provides an indication of the flexibility potential associated to different technologies. Figure 26 below provides an overview of the frequency by which stakeholders apply active/automated control on various common technologies.

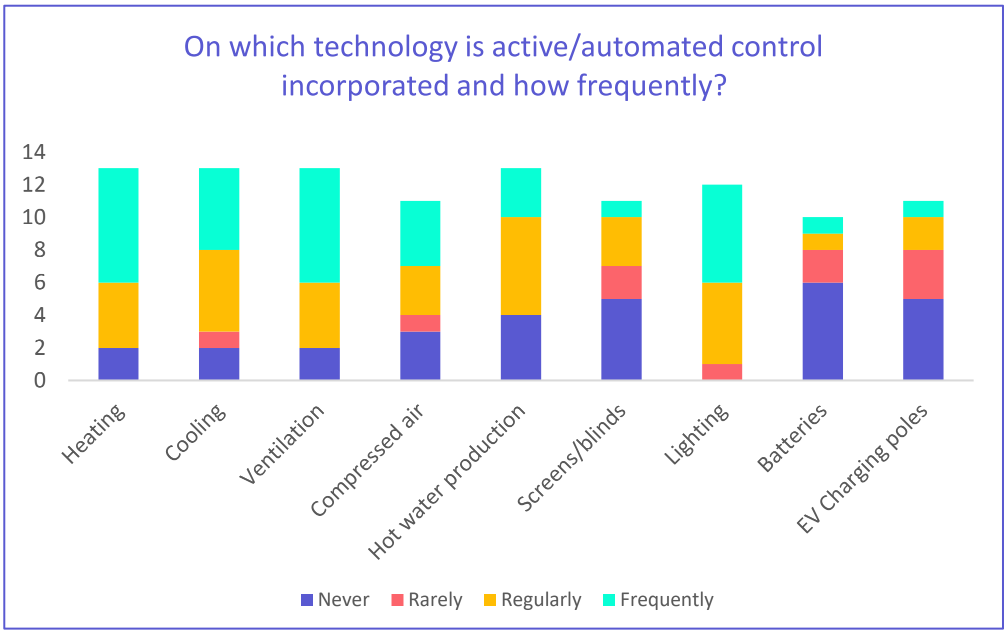


Figure 26 – Stakeholder survey – frequency of use of active/automated control of various common technologies in projects (AmBIENCe, 2020)

Heating, cooling, ventilation and lighting are clearly the most common applications in current projects, on which active control is being used most frequently. One could expect those also to deliver the most potential for DR. However, batteries which are rarely used or actively controlled are an exception as they are potentially an important DR facilitating technology.

Active/automated control is less used on the other technologies, whereas batteries and EV charging poles are much less being managed by active control. These findings may be probably ascribed to the fact that the diffusion level of these technologies is still not sufficiently high. Opposite results are found concerning the business cases and the under-laying tariff structures that the stakeholders consider possible for their building projects and currently leverage.

		Which positive business cases are possible according to you?	Are you making use of this business case?	Could this business case be possible in 3 to 5 years?		Is it a Pilot or Commercial
Implicit DR (tariff structure based)						
Dynamic tariffs (Day/Night, more complex)	Yes	9	2	12	Pilot	2
	No	3	11	2	Commercial	3
Different Injection/Consumption tariffs	Yes	7	2	10	Pilot	2
	No	5	11	3	Commercial	2
Capacity tariffs	Yes	7	1	8	Pilot	2
	No	4	11	4	Commercial	2
Explicit DR (on-request services)						
	Yes	6	1	9	Pilot	2
	No	4	9	2	Commercial	2

Figure 27 – Stakeholder survey – frequency of use of active/automated control of various common technologies in projects (AmBIENCe, 2020)

In fact, a majority of potential Flex providers sees a potential for the various implicit DR programs, with a small preference for dynamic tariffs, as is shown in Figure 27. However, a large majority of the interviewed stakeholders (> 80%) is not using them today. It is to be highlighted that a significant majority of stakeholders (>75%) believes that these business cases may become possible in 3 to 5 years, thus conforming the potential for different AEPC models.

(2) QUALITATIVE ANALYSIS

In addition to the quantitative analysis that was carried out of the information obtained by the answers to closed and multiple-choice questions, a qualitative analysis was also performed of the additional comments and of the information gathered through open questions included in the questionnaire.

Active Control Measures

One of the areas of interest investigated in the survey was the **type of active/automated control measures** that was already being used. In detail, the main automated control measures reported by the participants in the survey were:

Time based controls, consisting out of relatively common techniques such as the ones listed below:

- Temperature and lighting control
- Clock timers on heating, cooling and ventilation, in combination with outside temperature control
- Alignment of working hours of systems with occupancy

Trigger/Event/Measurement based controls, also quite common and often integrated into a Building Management System (BMS) or Energy Management System (EMS):

- Occupancy, presence/absence and daylight detection (on/off) for lighting
- CO_2 detection/measurement for ventilation
- Thermostatic valves for heating
- Solar intensity for sun screens
- Outside temperature for heating

A few respondents mentioned some ***more advanced control methods***:

- Automated control based on external air and carried fluid temperature for the optimization of thermal plants consumption
- Auto-dimmer for lighting, I.e. a photocell connected to the electronic ballast/driver that transmits an instantaneous reading of the contribution of natural light to the illumination of the interior. This information enables the electronic ballast/driver to correctly gauge the amount of power to be supplied to the light source in order to maintain constant lighting on work surfaces

Smart control methods, furthermore, a minor number of flexibility providers use even smarter controls:

- Weather forecast
- Optimiser for heating and cooling start-up
- Control based on prediction models and controlled by their monitoring system

Today's Barriers for Demand Response

As mentioned in the quantitative analysis, today only a limited number of ESCOs deliver DR services, either explicit or implicit DR.

The main reasons given by the interviewed stakeholders for not offering DR services are related to the following perceived obstacles:

- difficulty in clearly identifying positive business cases;
- lack of demand for DR from the customers/the market. Currently there are not always dynamic tariffs available in all member states;
- need to drastically redesign the Capacity auctions in order to let DR or EE play a role in it. This task is expected to take a long time to be accomplished due to its technical complexity;
- current focus of DR on industrial applications (and production process in particular), rather than on buildings, which consequently need to change the regulatory scheme and the incentives/tariffs in the future (e.g.: energy communities, etc.). Several ESCOs still consider the regulatory and market conditions insufficiently mature to start offering demand-response services;
- technical inadequacy of Building systems' design for implicit DR, because of the current focus on EE. This is obviously the result of the previously described conditions and creates somewhat of a chicken-and-egg situation.

However, it is worth highlighting that an interviewed ESCO conceived the following approach to use DR in buildings:

- For Explicit DR in buildings equipped with (large) electrical batteries.

  The electrical batteries are in principle used for temporarily storing excess electricity that is generated by building integrated PV. However, in case of power shortage, this electricity may be fed into the grid.
- For Explicit DR in buildings equipped with thermal buffers for heating or cooling

  The thermal buffers may be used to absorb excess electricity from the grid.

As hardly any ESCOs are providing DR services in combination with EPC, we could not extract any useful information on the current business models that apply to them. The regulatory environment and tariffs/incentives do not allow for real business models, with positive business cases yet. It confirms the results from chapter 5.

6.1.2 FLEX REQUESTER SURVEY

(1) QUANTITATIVE ANALYSIS

The first relevant element that stands out in the quantitative analysis consists in the unanimous and affirmative answer for all participants in the flexibility requester survey to the question whether the stakeholders are using or would be interested in using "ready-to-use" flexibility provided by buildings. This clearly demonstrates that they are waiting for business models as AEPCs to be developed.

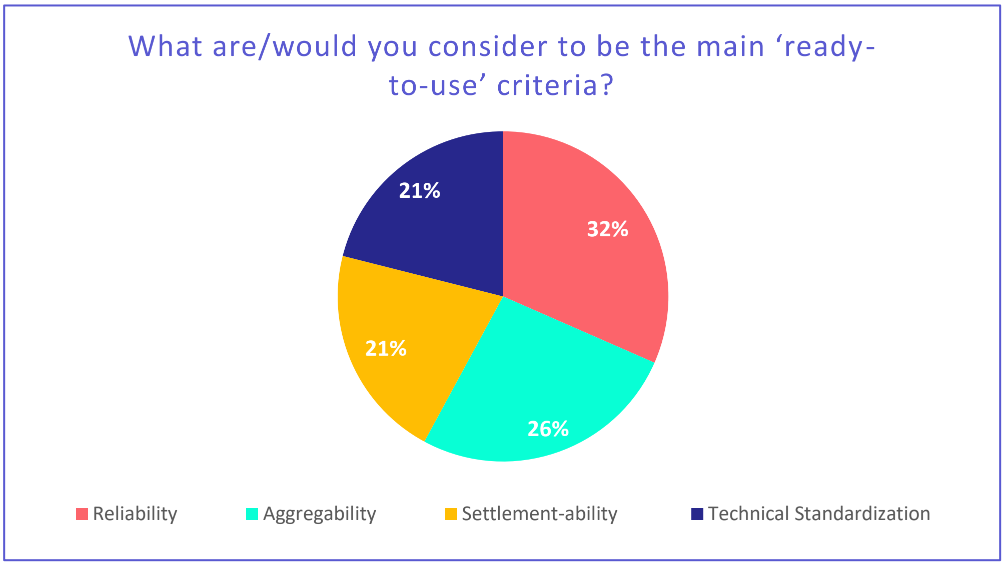


Figure 28 – Stakeholder survey – main ready-to-use criteria for flexibility for flex requesters (AmBIENCe, 2020)

As for the main ready-to-use criteria, across the board there is overall no real strong preference for any of the four proposed criteria, as is shown in Figure 28. Specifically, it can be noticed that reliability and aggregability scores are slightly higher than Settlement-ability and Technical Standardization ones. This could indicate that all these criteria are required for flex requesters before they join EPC programs with active building control. However, when analysing the responses, it turns out that most Flex requesters only indicate 2 or 3 criteria. Only one respondent, from Finland, indicated all 4 criteria. A more in-depth analysis shows that many interviewees mention different criteria. Thus, even though all criteria appear in a similar proportion overall, it should be noted that actually they are not the same for all stakeholders

When asked about the frequency, at which they would need flexibility (as shown in Figure 29), almost 62% of respondents confirmed that they would need it on a daily basis. 13% (also) would need it weekly, whereas 25% would only need it occasionally. This shows that if ESCOs can design services and customers can expect flexibility with a daily frequency, there could be added value and thus higher business potential to satisfy Flex requesters.

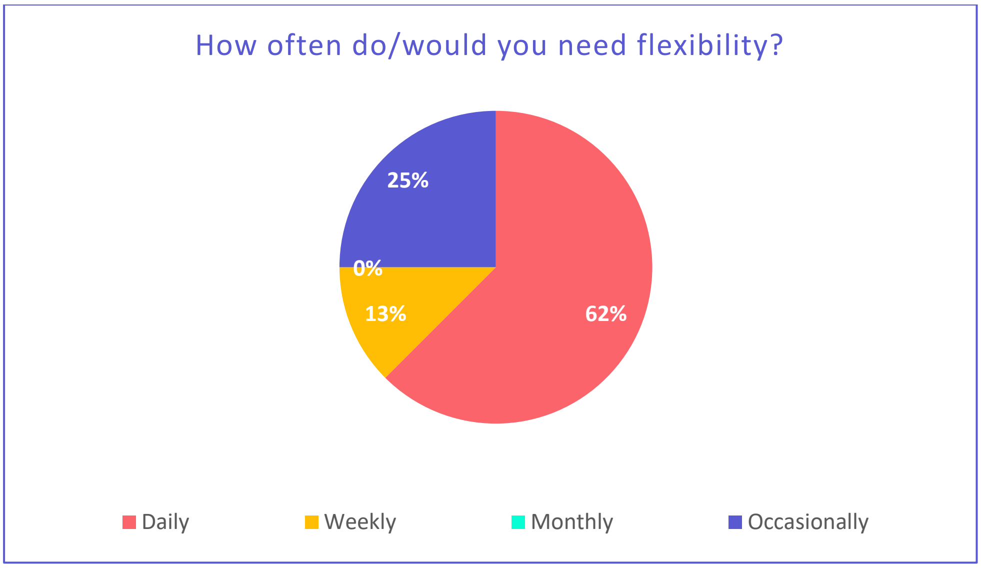


Figure 29 – Stakeholder survey – frequency of request for flexibility (AmBIENCe, 2020)

As shown in Figure 30, in terms of the underlaying DR-driven reward/incentive scheme, a combination of reservation and activation payments is considered an interesting scheme by 57% of the flex requesters, which resulted the most attractive one. A lower but still appreciable 29% of the flexibility requesters would prefer a scheme with no reservation and only pay for activation modality. Then, a smaller amount, i.e. 14%, would like to be able to do reservations, followed by payments in case of activation. Pay for capacity/availability did not turn out to be an interesting option.

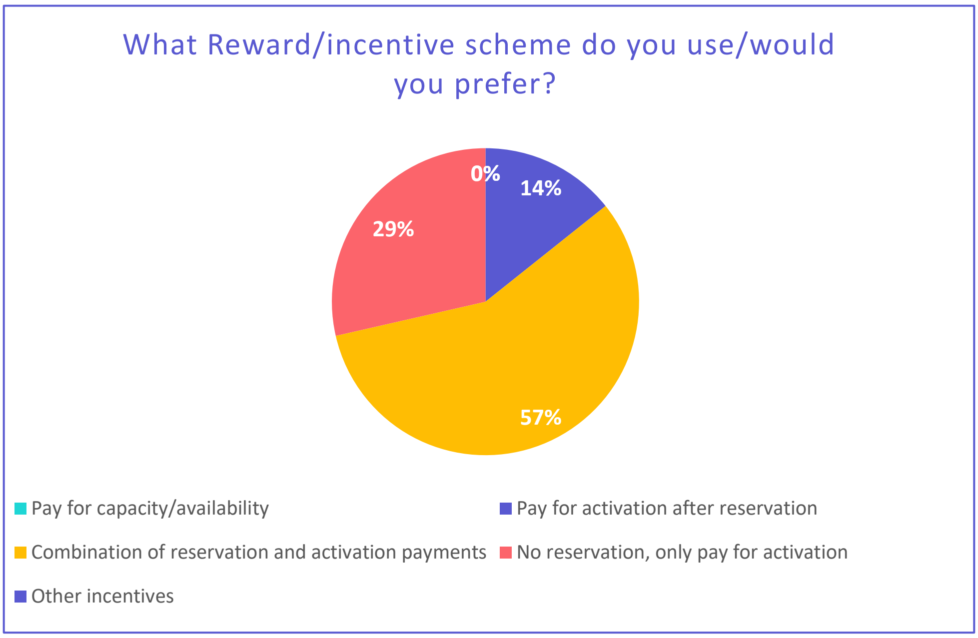


Figure 30 – Stakeholder survey – used/preferred reward/incentive scheme for flex requesters (AmBIENCe, 2020)

As to the question whether it would help if buildings themselves provide information on their planned flexibility, rather than building managers, to facilitate the decisions of the flex requesters, a positive answer was provided by all stakeholders.

It was also interesting to learn that 33% of the flex requesters are already using some kind of flexibility in buildings in a commercial manner, whereas 67% is still working at pilot level, thus indicating that there is still room for development in this area at European level

As for those stakeholders that are adopting flexibility yet, the survey revealed that the totality of them assume to consider or plan to start at pilot level in a preliminary phase. This further confirms that the market is still in its early development stage.

However, an encouraging element lies in the fact that 33% of the flexibility requesters is planning to use flexibility within the next 12 months, and the remaining 67% within 3 years. This is a positive signal for the development of the AEPC model.

(2) QUALITATIVE ANALYSIS

Several aspects were the subject of the quantitative analysis for the flexibility requesters. In particular, in terms of **ready-to-use criteria**, the stakeholders identify the following important metrics for.

Reliability:

The tolerable deviation in terms of power profile in order to minimize voltage deviations, enhance power quality and enable larger amount of renewables integration.

- Congestion management of the transmission grid
- Voltage control
- Grid investment optimization
- Power quality management
- Power system balancing in real time
- power system reserves

As for the provision of flexibility service to the TSO, it is to be pointed out that one of them would prefer to see this implemented via interruptability contracts or a regulating reserve. That means, if the TSO requests to increase or decrease the power levels, the consumer must respond to the request (immediately). When the request is fulfilled, the consumer has a right to the compensation, when it is not fulfilled there would be a penalization.

Aggregability:

- The ability of the DSO to provide ancillary services to the TSO, so the volume should be high enough to have an impact from the TSO's perspective.
- Local flexibility, i.e. solving distribution grid issues locally. The minimum volume depends on demand and production feeder profiles, but it should be in the order of at least 1MW. This number was also mentioned by other Flex requesters.
- Good aggregation management tools to aggregate households up to such levels.

Moreover, it is worth mentioning that the flexibility requesters that completed the survey suggested several **benefits** from flexibility which they would be interested in (in other words what the **drivers** are), they are listed below:

- Reduction of infrastructure costs, although many stakeholders insisted on the reliability that should be guaranteed in that case.
- Reduction of voltage fluctuations
- Increase of the Distributed Generation (DG) penetration level.
- Better local grid congestion management, decreasing the need for capacity upgrades
- Possibility to avoid costly balancing on the overall TSO level thanks to local balancing can (this implies the split of networks tariff between the TSO and DSO)
- Enabling Ancillary Service Markets to decrease the dispatching cost, helping the progressive integration of renewable sources within the grid.
- Need of new services provided by both loads and DER - that today are mainly inflexible - in order to enable a cost-effective grid management. Flexibility can be used to adjust the demand profiles to the supply peaks in renewable generation, or to the available capacity in the distribution grids.
- Possibility to differ in time the necessary investments in network upgrades

Concerning the parameters to characterize flexibility, stakeholders indicated the following elements:

- The amount of power modulation
- Generation forecasts,
- The duration
- The rate of change
- The response time and the location

Furthermore, DSOs see 4 different levels in the drivers, from different perspectives:

- Consumer perspective – They receive the compensation from the TSO when the request is fulfilled (or are obliged to pay a penalty if the request is not fulfilled); This also offers them the possibility to reduce their energy bill;
- Aggregator – They get a possibility of making profits making via aggregation of multiple consumers that would provide the ancillary service to the TSO (thus, an aggregator will charge a %-based the service fee);

- TSO – They can contribute to the energy grid stability and will have reduced need to invest in new grid infrastructure; They have a lower need to use the carbon-based generation units during the peak consumption.

Society – In terms of carbon emission criteria the flexibility use would lead to a greener sustainable energy society.

One of the reasons why some DSOs/TSOs only occasionally need flexibility, rather than on a regular or permanent basis, is that there is currently no significant need to decongest the network. Effectively, the energy network axes are still evolving and few bottlenecks are present. The frequency will always depend on the price of flexibility and it will be hard to compete with typical grid investment. Thus, the possible main use will be occasional and related to unplanned congestion management.

Conversely, for those stakeholders that need flexibility weekly or even daily, this is motivated by the willingness of reducing the infrastructure investments. In this case the flexibility should be available at short notice depending on the season – for the time being. In the future, with an increase in electric vehicles, the flexibility would become more important, but it would be used probably on a daily basis in absence of long-term investment reductions. For one DSO a key parameter is represented by the cost of such distributed flexibility, but they suggest to keep in mind that the main goal is to have such resources available to provide flexibility, especially during the hours when there are a lot of wind and sun and the other flexibility sources (mainly thermal plants) are not available.

When flexibility will be fully adopted and procured through dedicated markets it is expected that the DSO will leave the traditional approach of "fit and forget" planning, by switching to a new way to plan the grid. In this new way, expected low-probability violation of appropriate operating parameters (e.g. voltage level limits) or expected temporary (a few hour-year) violation, could be solved by using flexibility services.

As for the reasons that DSOs/TSOs prefer a certain incentive scheme, they can be summarized as in Table 10.

Table 10 – Preferred incentive schemes for Flexibility Requesters

Preferred incentive scheme	Explanations
Combination of reservation and activation payments	Should be a mix in case of DSO as most of flexibility needs will be calculated based on forecast. Activation could be or not be necessary (or with some minor changes in the quantity) when the forecasted contingency time comes.
Pay for activation after reservation	It is a simpler way for the DSO to manage the procurement process. The second-best option could be the “combination of reservation and activation” that could favour the growth of the market.
No reservation, only pay for activation	Lowers the ability to speculate and paying for reservation could ultimately result in more cost for DSO. The consumer has access to the compensation only when the TSO program is fulfilled: Reduced/increase energy consumption. If not: no payment; but if yes: penalization.

7. CONCLUSION

Delivering services to buildings based on an Active building Energy Performance Contracting (AEPC) model provides an interesting new opportunity to Energy Service Companies (ESCOs and Grid operators), aiming to generate new business or improve existing ones, while lowering GHG emissions. The literature study shows that sufficient potential exists for flexibility/DR services and that some are already being used. Their large-scale adoption, however, depends on the availability of dynamic tariffs in various member states and the underlaying infrastructure (e.g. smart metering) to deploy them. This is the case for both energy tariffs (e.g. driven by customer demand or CO_2 prices) and network tariffs (driven by network congestion, balancing, etc.). The existing EPC model, declined into different types, is sufficiently flexible to allow for the integration of DR, both explicit and implicit one. Nevertheless, challenges arise as to the combination of short time Time-of-Use flexibility behaviour in DR services and longer time (typically annual) evaluation of energy savings in EPC contracts. This will require specific attention to the M&V in an AEPC model, in particular since the aim is to guarantee the overall kWh, GHH and/or cost savings within the project.

Electrification, in combination with active control, based on demand response to variable pricing, seems to be the key to a successful business case. The survey of flexibility providers, in particular ESCOs has confirmed that they are already using electrification to some extent (e.g. heat pumps) but that they are not so likely to be chosen with shallow energetic renovations. Deeper energy renovations provide the conditions for optimizing their use, so in combination with active control they can be the backbone of the AEPC model. As ESCOs already frequently use regulation and control as part of EPC to optimize energy efficiency measures in buildings, it is expected that extending this to a more active flexibility driven control should not pose important problems. Flexibility requesters are to a limited extend already using building flexibility, and most are interested to increase it. Sufficient volume (typically at least 1MW) and reliability are key for flexibility requesters. This makes the case for a model were the ESCO acts as a technical aggregator of flexibility, which is well suited to the current practice of some of the larger ESCOs who typically pool many buildings (sometimes up to 25 and even 50 or more) into one project and manage hundreds of buildings in their overall customer portfolio.

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9. ABBREVIATIONS AND ACRONYMS

aaS	as a Service
AEPC	Active Building Energy Performance Contracting
aFRR	Automated Frequency Restoration Reserves
BMS	Building Management Systems
BRP	Balancing responsible party
BT-I	Baseline Type-I
BT-II	Baseline Type-II
CAPEX	Capital Expenditure
CHP	Combined heat & power
COP	Coefficient Of Performance
CPP	Critical Peak pricing
CR	Comprehensive Refurbishment
CR-EPC	Comprehensive Refurbishment - Energy Performance Contract(ing)
DAM	Day ahead markets
DER	Distributed Energy Resources
DR	Demand Response
DSO	Distribution System Operators
EC	European Commission
ECM	Energy Conservation Measures
EE	Energy Efficiency
EPC	Energy Performance Contract(ing)
ESC	Energy Supply Contract(ing)
ESCO	Energy Service Company
EU	European Union
EV	Electricle Vehicles
FCR	Frequency Containment Reserves
FiT	Feed-in tariff
GC CR-EPC	General Contractor CR-EPC
GP CR-EPC	General Planner CR-EPC
HVAC	Heating, Ventilation and AirConditioning
ICT	Information and Communication Technologies
IEA	International Energy Agency
IEC	Integrated Energy Contracting
IM	intraday markets
IPMVP	International Performance Measurement and Verification Protocol
IPR	Intellectual Property Rights
IRR	Internal Rate of Return
KPI	Key Performance Indicator
MBL	Maximum Base Load
MBMA	Meter Before / Meter after
M-EPC	Maintenance and Energy Performance Contract
mFRR	Manual Frequency Restoration Reserves
MGO	Metering Generator Output (MGO)

M&V	Measurement and Verification
NEM	Net metering
NPV	Net Present Value
OPEX	Operating Expenses
P2P	Peer to Peer
PBT	pay-back time
PPA	Power Purchase Agreement
PV	Photovoltaic
QAI	Quality Assurance Instruments
RES	Renewable energy sources
RR	Replacement Reserves
ROI	Return On Investment
TCO	Total Cost of Ownership
TOU	Time of Use
TSO	Transmission System Operators