sensei

Smart Energy Services to Improve the Energy Efficiency of the European Building Stock

Advancements and lessons learned from the first Horizon 2020 project to support the introduction of energy efficiency Pay-for-Performance programmes in Europe

The SENSEI Project Final Report

The SENSEI project has received funding from the European Union's Horizon 2020 Research and Innovation programme under Grant Agreement No 847066.

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ABOUT THE SENSEI PROJECT

The SENSEI project (full title: **Smart Energy Services Integrating the Multiple Benefits from Improving the Energy Efficiency of the European Building Stock**) was a HORIZON2020 project funded by the European Union, which ran from 2019 to 2023. It comprised of 14 partners from 8 EU countries: Belgium, Denmark, Germany, Greece, Italy, Norway, the Netherlands, and Spain.

The purpose of SENSEI has been to prepare the ground for programmes that compensate energy efficiency as a grid resource, while turning its value into an investable asset for private financing. The SENSEI project has been investigating how to estimate the value of energy efficiency, quantify its benefits for the power grid, and help set the framework that could help attract additional investments into energy efficiency retrofits, based on the rules of project finance.

The key concept behind SENSEI is **Pay-for-Performance (P4P)**, where payments are made for energy savings estimated ex-post. P4P programmes exist in many configurations, but in essence it is a multi-actor arrangement in which financial compensation is rewarded based on metered energy savings. SENSEI has been based on the success of the Energy Performance Contracting (EPC) model, and it has aimed to further expand its scope by integrating payment mechanisms based on metered energy savings, and proposing business models and institutional arrangements that promote a performance-based market for energy efficiency.

P4P programmes have been applied in **the US** for many years and based on the lessons learned, SENSEI was the first project to investigate P4P in the EU. **SENSEI analysed 11 P4P programmes** across the US, developing knowledge and insights into how P4P can benefit EU market players such as ESCO's, building owners and energy providers. This is being explored in the context of **aiming to improve energy efficiency renovation rates so that the corresponding energy demand reductions contribute to the EU climate goals.** This could eventually **lead society to avoid the construction of new power plants, reduce grid infrastructure costs and mitigate the energy crisis**. Adopting P4P programmes holds promise for increased investments and returns for energy efficiency infrastructure projects.

More information on the project deliverables is available on:

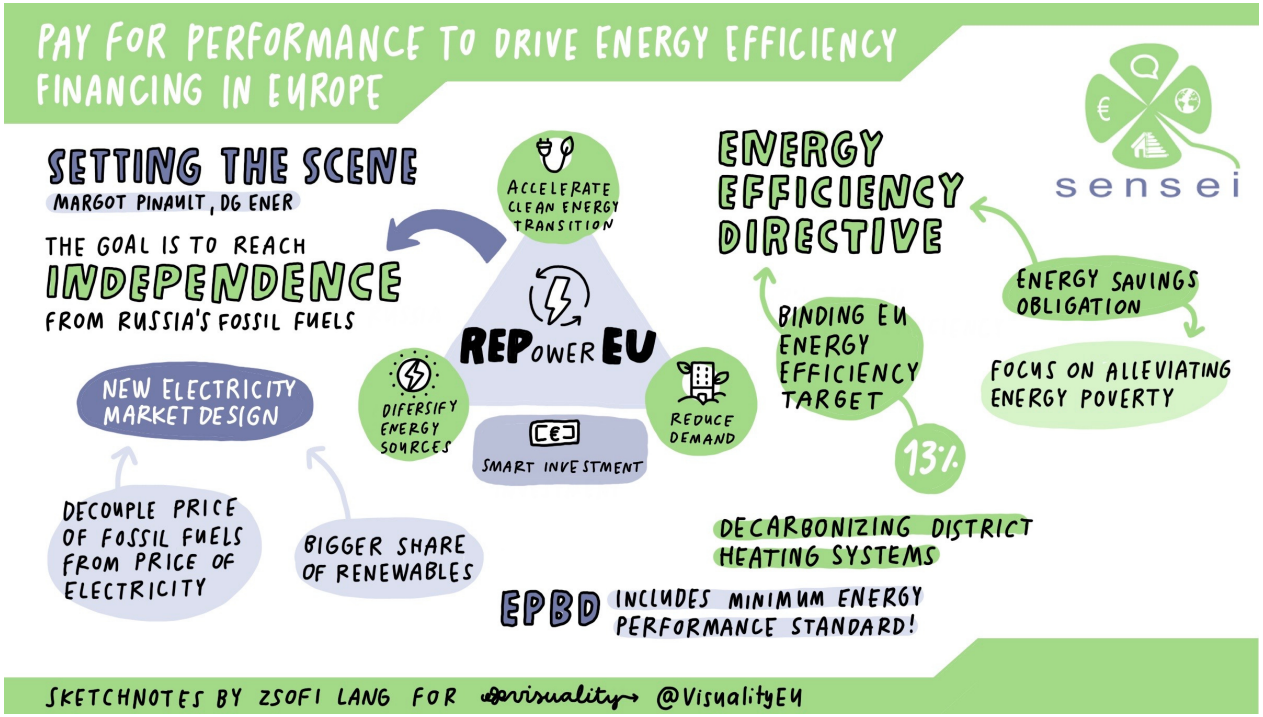
The SENSEI project website

The Community for Pay-for-performance on Zenodo

INTRODUCTION

Buildings account for 40% of the European Union's (EU) final energy consumption, and the EU has set the target to decrease greenhouse gas emissions by at least 55% by 2030 compared to 1990 levels, with a goal of reaching carbon-neutrality by 2050. Reaching the new climate goals would require the building sector to cut its greenhouse gas (GHG) emissions by approximately 60% before 2030. This means that the annual energy renovation rate should at least double in less than 10 years.

Significant progress has been achieved using the **Energy Performance Contracting (EPC) model**, which has been successful for large-scale energy efficiency projects in the Municipalities, Universities, Schools and Hospitals (MUSH market). However, the typical approach to energy efficiency programmes – based on rebates and incentives – lacks accountability and hinders innovation.



As a result, **energy efficiency (EE)** in the building stock presents a major opportunity for the EU to reduce GHG emissions, decrease energy imports, create jobs, and enhance building comfort and health. Despite this potential, energy efficiency ranks at the lower end of realised sustainable energy investment opportunities, with building renovation rates in the EU ranging between 0.4-1.2% per year.

To make energy efficiency attractive to investors, it must be associated with **consistent returns and stable long-term cash flows.**

Pay-for-performance (P4P) programmes offer a solution to this issue, **linking financial flows to actual energy savings produced by retrofit projects.** Instead of providing subsidies for installing equipment, these programs offer **rewards to building owners or third-party contractors for achieving energy savings after implementing energy efficiency measures**. In the United States (US), pilot programs have shown potential in decreasing system costs, deferring investments and lowering emissions. Almost all have been conducted in the context of regulatory-led energy efficiency obligation programmes and have mostly targeted non-residential buildings. The successful P4P pilots conducted in the US suggest that P4P programmes can be an effective way to engage energy providers and third-party investors in energy efficiency.

Following the footprint of the US case studies, SENSEI has designed concepts and business models based on P4P **to generate new sources of benefits, turn the project's value into an investable asset, and aggregate energy savings into portfolios that can be offered to energy providers and third-party investors**. SENSEI has made progress that will be essential to support public and private actors in developing P4P programmes for financing energy efficiency projects that can be implemented throughout the European Union.

1. THE CORE CONCEPTS OF SENSEI

Pay for Performance

Pay-for-Performance (P4P) is the principle underpinning financial incentive schemes that provide payments to energy efficiency service providers by linking payments to the value of metered energy savings achieved through retrofits or efficiency upgrades, rather than the predicted or estimated savings. P4P programs incentivize energy efficiency service providers to deliver energy savings beyond business as usual, by only paying for the actual performance outcomes of energy efficiency measures.

P4P programs differ from traditional energy efficiency programs, that are based on tax deductions or grants, which provide upfront incentives based on the estimated savings of a project. P4P programs **shift the risk of performance from the building owner to the energy efficiency service provider**, who is responsible for delivering the guaranteed energy savings.

P4P programs can also be designed to **reward energy efficiency measures that provide additional grid benefits**, such as load shaping, that can help to address grid reliability challenges.

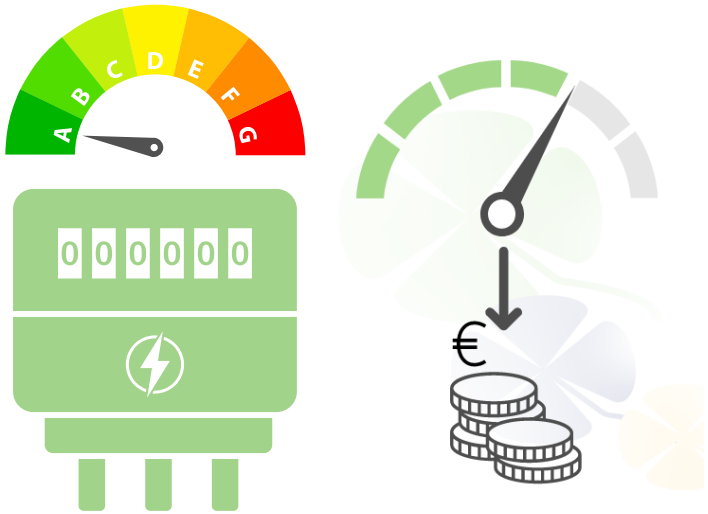
The most important benefits of P4P programmes are the following:

- Improving current subsidy programmes for energy efficiency by **replacing one-off payments for installed measures with periodic payments that reflect the actual energy savings achieved**. These are estimated using advanced Measurement and Verification (M&V) techniques agreed upon by all programme participants.

- **Aggregation of individual retrofit projects into portfolios** to attract investments from private funds seeking bigger projects with better risk management strategies. Periodic payments for metered energy savings offer a minimum guaranteed return and allow energy efficiency investments through P4P programmes to be treated as project finance.

- **Evaluating and quantifying the various benefits** of energy efficiency projects for the power system, the programme participants, and society as a whole, and **generating cash flows from the parties who benefit**.

The **technological innovation** that has enabled P4P programs is the emergence of advanced measurement and verification (M&V) methods for metered energy savings. This represents a significant departure from traditional approaches, which rely on estimated savings or other less precise methods of measurement and verification. **P4P programmes are essentially reliant on an energy efficiency meter.**



The value of Pay-for-Performance programmes

The P4P approach applies to many levels of established policies and measures as a transformative enabler for the financing of energy efficiency projects. P4P allows to improve current subsidy programmes, aggregate buildings into larger portfolios to access financing, and make use of demand side resources as a service to the power grid. By shifting the performance risk to the private sector responsible for implementing energy efficiency measures, P4P programmes enable a wide range of demand-side options for energy savings and act as an energy resource to the grid. Unlike traditional programmes, P4P incentivizes participants to ensure quality installation and maintenance of equipment to drive energy savings.

1 Primarily, P4P improves **existing energy efficiency programmes that follow the deemed (pre-assumed) energy savings approach, which remunerates contractors based on installed energy efficiency measures**, but not on their performance. Public entities funding retrofit programmes have very little control over the quality of work and are unable to track real energy savings. With the P4P approach, the risk of underperformance is on the private sector who is responsible for implementing appropriate measures, while public authorities can have access to accurate energy saving data. Under this approach, one-off payments are replaced with periodic payments that are proportional to the metered energy savings.

2

Secondly, **aggregation enables large scale investments and novel business models to access diverse building types**, including smaller residential properties, and tap into their potential for energy savings. P4P and advanced M&V allows to aggregate individual projects into larger portfolios to enable large scale investments in energy efficiency projects with an improved risk management strategy. The PG&E residential P4P program in California offers a good example. Following a competitive procedure, PG&E selects several aggregators, which engage with residential homes to deliver EE upgrades. Using advanced M&V of a third party (Recurve), the energy savings from these portfolios of buildings are estimated on an ongoing basis to calculate their performance, according to which, PG&E rewards aggregators based on their bid of $/kWh saved.

3

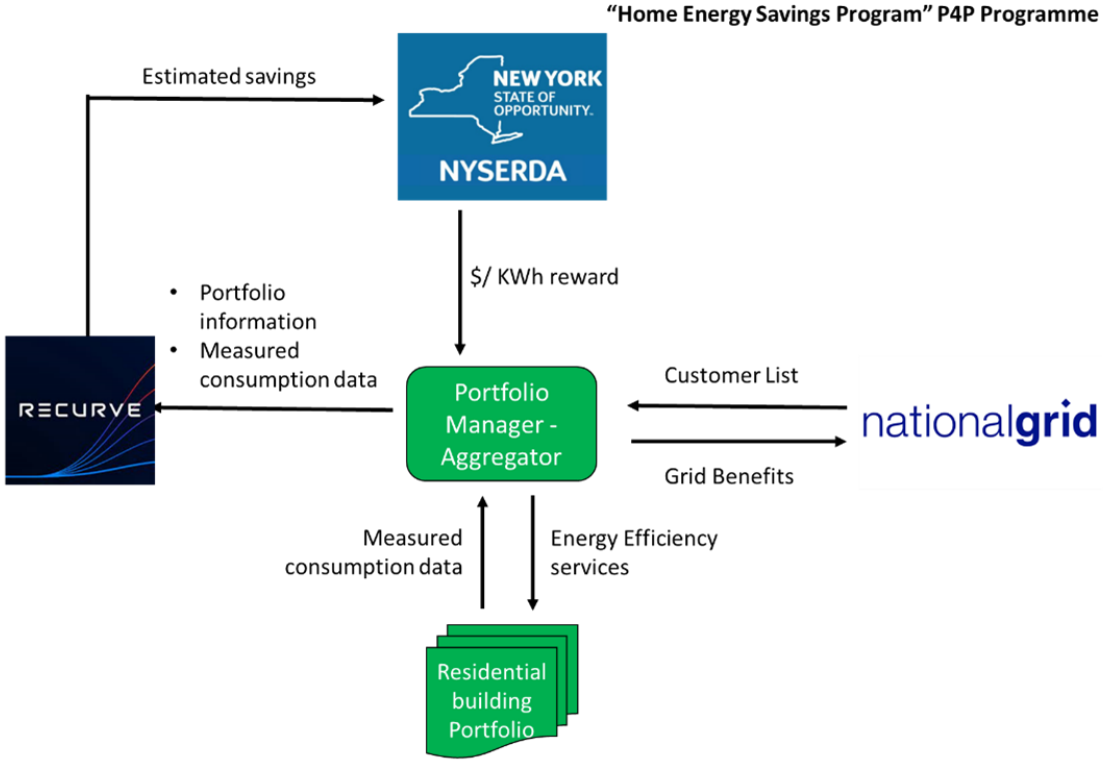
Thirdly, P4P enables the **power system to recognize energy efficiency as a demand-side energy resource by quantifying and rewarding energy demand reductions**, instead of extending capacity to meet demand, an option often termed "non-wires alternatives". *To quantify the value of building energy efficiency projects as a power grid resource*, the SENSEI project has proposed a methodology using the same process and the same tools that power system operators use for capacity adequacy studies. An example of using energy efficiency measures for their benefits to the power grid is the Home Energy Savings Program, a residential P4P programme administered by NYSERDA and the National Grid in the state of New York. It targets large portfolios of one-to-four-family homes that is described in the following page.

Example of Pay-for-Performance: the NYSERDA Home Energy Savings Programme

The Home Energy Savings Program is an innovative Pay for Performance (P4P) programme that was launched in mid-2021 and is administered by the New York State Energy Research and Development Authority (NYSERDA) and National Grid, the utility provider. The programme aims to enhance the use of energy efficiency as a grid resource, achieve large-scale energy savings, attract new energy efficiency investments, and provide space for innovative business models and technologies to emerge. The utility makes use of the energy demand reduction resulting from the implemented measures as a demand-side grid resource, and a deferral of investments for grid upgrades.

Under this programme, NYSERDA and National Grid choose one or more aggregators to implement energy efficiency services, either themselves and/or with subcontractors. Participating customers, who undergo EE upgrades, are part of large portfolios of one-to-four-family homes. Their energy savings are measured and aggregated on an ongoing basis, over a period of three years after the interventions, to calculate aggregators' compensation.

The chosen Portfolio manager(s), implementers and aggregators will be awarded a five-year contract with National Grid, comprising of a two-year implementation period during which PMs can enroll customers and implement interventions at customer sites, and three years for the completion of project performance periods during which payments will be made for metered energy savings.



To learn more about, please visit the *Home Energy Savings Program page of NYSERDA.*

Advanced Measurement and Verification

Measurement and verification (M&V) is a critical aspect of energy efficiency interventions, providing insight into the effectiveness of implemented measures. Creating customized models tailored to specific buildings can be expensive and time-consuming, particularly when dealing with large portfolios of buildings. Therefore, new methods must rely on data-driven models that can be easily adapted to different building types and sizes.

Fundamentally, M&V is an impact assessment problem that aims to **estimate the counterfactual energy consumption of a building in a scenario where the energy efficiency interventions had not been implemented**. Different M&V methods and tools are already being used to support energy efficiency interventions, particularly through Energy Performance Contracting (EPC). However, for EPC to be scaled up to cover more and diverse buildings, new M&V methods are required that are fully data-driven and require minimal human involvement.

Automated M&V methods have the potential to revolutionize the way we approach energy efficiency interventions in buildings. By combining real-time data with predictive modelling methods, M&V can produce tools to understand the characteristics of a building's energy consumption and provide continuous feedback on the most probable impact of an energy efficiency intervention.

SENSEI has contributed significantly to the advancement of automated M&V methods and has delivered a coherent understanding of the main aspects of an M&V process, including data requirements, metrics for evaluating baseline energy consumption models, and methods for quantifying uncertainty. The project has reviewed the state-of-play in terms of M&V methods and the existing models for predictive modelling of energy consumption. The review showed that only a limited number of M&V frameworks are ready to be tested and adopted by practitioners. Although the literature on M&V methods is extensive, there is often a significant gap between presenting a methodology and its results and offering the tools for practitioners to experiment with the methodology.

Furthermore, SENSEI has developed new methods and tools to better understand the characteristics of a building's energy consumption and estimate the energy savings from an intervention. The **EENSIGHT** methods and tools are available as a reproducible open-source project for practitioners to experiment with and test on different datasets. The relevant functionality can be found in the GitHub repository at *https://github.com/hebes-io/eensight*.

The Energy Efficiency Aggregator

The Energy Efficiency Aggregator (EE Aggregator) is a fundamental player that enables the development of innovative pay-for-performance (P4P) programmes. An Energy Efficiency Aggregator can have different functions and roles, including **marketing activities, identifying funds, aggregating buildings into portfolios to manage performance risk and capture the multiple additional benefits of EE projects into new revenue streams**. Experience from the US shows that P4P programmes that make payments to aggregators appear to be effective in promoting innovation in energy efficiency service delivery. **The EE Aggregator and P4P programmes are being examined as part of the EU's ambitions to meet energy efficiency targets through novel financing and business models**.

The EE aggregator is a new concept that rests on experience of aggregation approaches in the energy sector. Energy aggregators are entities that **bundle and manage the consumption and/or generation of different agents in a power system to optimize electricity service market participation. They offer value to both downstream and upstream market players,** such as Balance Responsible Parties (BRPs), Distribution System Operators (DSOs), Transmission System Operators (TSOs), and energy suppliers.

Two aggregation approaches, **Demand Response (DR)** and **Virtual Power Plants (VPPs)**, are beneficial for system operators, as they contribute to the short-term and medium-term balancing of the energy system. These types of aggregators have been set up due to the need for flexibility in power systems to accommodate the expansion of Distributed Energy Resources (DERs), intermittent power generation by renewables, and new load peaks from the electrification of transport and heating. Aggregators help overcome scale issues by grouping assets and trading their services in power markets on their behalf.

The Energy Efficiency Aggregator has a flexible business model that can adapt to ambitious energy efficiency programs. It can **offer flexibility and balancing services to Distribution System Operators (DSOs) and Transmission System Operators (TSOs), expand the services of Energy Service Companies (ESCOs) while minimizing performance risks, help utilities comply with energy efficiency obligations, exploit energy efficiency as a resource, achieve large-scale energy savings for public authorities, and enable energy communities to sell energy savings just like self-produced energy.**

The value of energy efficiency for the power grid

The growing need to decarbonize the power system is driving an increase in renewable energy capacity, posing new challenges for grid operators. One of these challenges is to **ensure the reliability and stability of the grid while accommodating the variability of renewable energy sources**.

Energy efficiency can bring numerous benefits to energy systems, such as **reducing energy costs, lowering carbon emissions, avoiding expensive capacity and network upgrades, and increasing flexibility in heating and cooling systems**. However, energy efficiency providers are often not rewarded for the benefits that energy efficiency measures provide to the energy system. This results in fewer energy efficiency measures being taken, higher energy system maintenance costs, and adverse effects on bill payers and society. To address this, mechanisms such as **dedicated energy efficiency markets, capacity markets, and regulatory incentives can be implemented to reward energy efficiency**. Additionally, the adoption of the Energy Efficiency First principle in the EU challenges the energy efficiency industry to prove its value, which requires **high-quality measurement and verification to ensure reliability and accuracy**. By implementing these mechanisms, energy efficiency can be recognized and rewarded for the valuable contributions it brings to energy systems.

The SENSEI project has proposed a methodology that quantifies the value of energy efficiency improvement projects as a grid resource. The idea is that retrofit projects can help phase out old, polluting power plants or reduce curtailment of renewable-based power generation, thereby improving the grid's hosting capacity for renewables.

The **EEVALUE** methodology developed in SENSEI considers how energy efficiency improvements in buildings can affect power consumption in two ways: by decreasing power consumption through equipment upgrades or increasing power consumption through fuel substitution. It then identifies which retrofit projects persistently modify the power system's load shape in ways that align with the system operator's goals and quantifies and rewards this value as a grid resource. The proposed methodology uses the same process and tools that power system operators use for capacity adequacy studies, which means that compensating energy efficiency for its contribution to the grid does not require a radically new toolset. Instead, it requires a different way to treat energy efficiency, recognizing that it has seasonal/temporal characteristics that may decrease or increase the total cost of the power system's operation. The methodology has been open-sourced and can be accessed at *https://github.com/hebes-io/eevalue*.

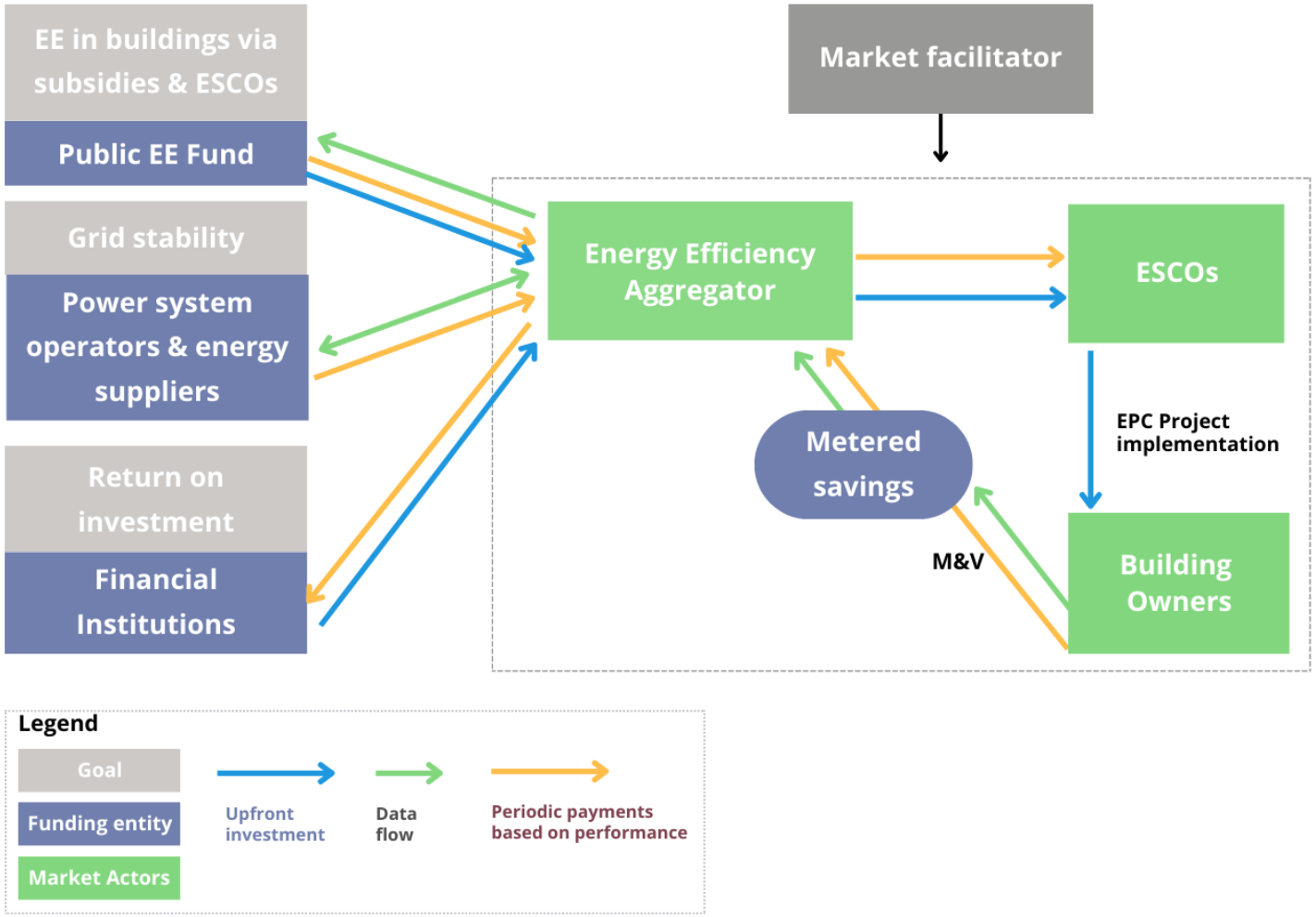
2. THE SENSEI FRAMEWORK FOR ESTABLISHING PAY-FOR-PERFORMANCE PROGRAMMES IN EUROPE

The SENSEI project has delivered a simplified understanding of the structure of P4P programmes. The scheme indicates (on the left of the diagram below) the various sources of finance, and (on the right) the system for exploiting the energy efficiency potential of the building sector. The EE Aggregator has a central role bundling individual energy efficiency projects into portfolios, linking them to ESCOs, and securing financing through public and private entities aiming to invest in energy efficiency projects.

Financial flows originate from public authorities subsidising EE programmes, TSOs & DSOs interested in using demand side resources for their grid benefits, and financial institutions that expect long-term returns on investment. Financing is channelled to ESCOs, which have the technical expertise for implementing energy efficiency measures in buildings. Savings are estimated using advanced M&V techniques. Periodic payments across this system are based on performance, and are collected from beneficiaries of EE measures (e.g., building owners, or TSOs & DSOs), and redistributed to ESCOs and Financial Institutions by the EE Aggregator.

An enabling energy market and legal framework needs to be set in place by a public authority, and a market facilitator is required to drive the development of the programme by analysing market conditions, proposing adaptations to the regulatory framework, and by setting enabling rules (e.g. for procurements) and the right infrastructure.

The presented theoretical model constitutes a framework for **conceptualising how to build a P4P programme, and the key roles of the EE Aggregator within it**. The concrete specifications of each programme need to be decided in consultation with the involved stakeholders of the market in which the programme is to be carried out, and adjustments would need to be made to the regulatory environment.



Energy Efficiency Financing

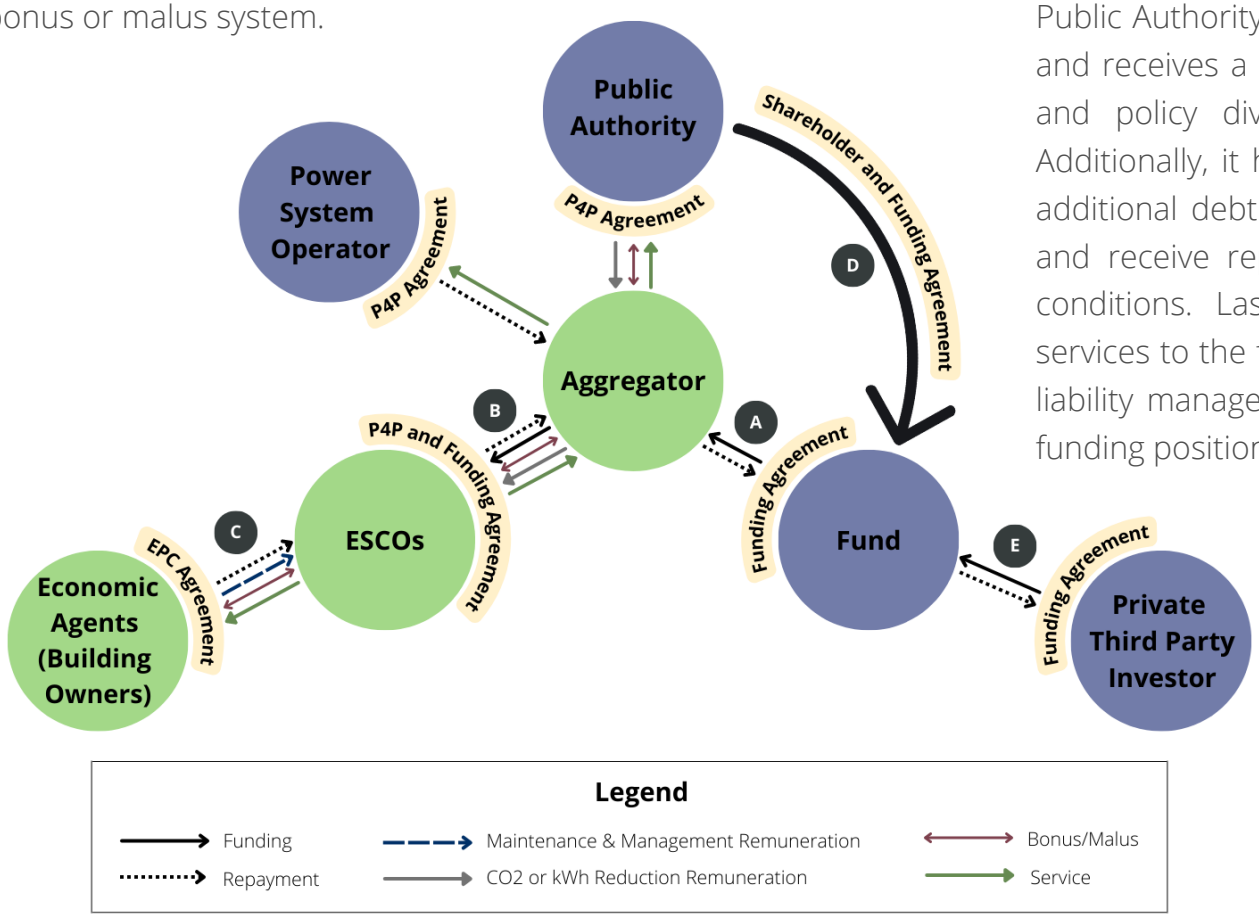
In the EU, we mostly see energy retrofits financed through credit financing, leasing financing, project financing, cession and/or forfaiting on a project-by-project basis. More EE finance projects become 'bankable' through aggregation. This is due to (i) the de-risking of investments through guarantees of financial payback of EE measures for investors or public subsidy providers at the programme level and (ii) the generation of income from providing benefits to the power system. This improves the business case of energy retrofits in buildings. Innovative energy efficiency contracting and financing options such as P4P may prove effective.

To understand the basic European P4P model suggested by the SENSEI project, one must become familiarised with the main actors involved, including Aggregators, ESCOs, Economic Agents, the Public Authority, the System Operator, the Fund and the Private Third-Party Investors. The configuration of actors proposed by the project foresees Aggregators at the center of the model, coordinating the realization of renovation projects in different sectors, for which they receive an agreed remuneration (e.g., EUR/kWh or EUR/tCO2) from the Public Authority based on the Aggregator's offer and dependent of metered reduction.

Within a P4P programme, there is a certain degree of **flexibility in terms of funding opportunities**, such as **direct funding of Aggregators by Private Third-Party Investors**, of **ESCOs by the Fund**, or of **Economic Agents by the Fund**. The feasibility of a particular financing programme often depends on a combination of factors, from project size and anticipated payback period to utility incentives/rebates and security features.

The following diagram covers the financial flows and relationships between the various market actors involved in the P4P model for energy efficiency projects. It outlines the various components of the model, including the roles of the Aggregator, ESCO, Public Authority, Private Third-Party Investors, and Fund managers. It is important to highlight the flexibility of the P4P model in terms of funding opportunities and its potential to reward energy retrofits that benefit the grid's operation.

As the **Aggregators** receive public money (A), a public procurement and tendering procedure must take place. The Aggregator with the best offer for a sector will implement the P4P programme. With this, the aggregator (co-)funds an **ESCO**'s investment in energy efficiency projects (B), and thus should conclude a funding agreement with the ESCO. The ESCO in turn concludes an energy performance contracting agreement with an **Economic Agent** (e.g. a building management company or the building owner) for the specific project (C). This lays out the minimum energy cost savings that the ESCO guarantees, via a bonus or malus system.



The **building owner** does not have to fund the investments of the energy efficiency project and only pays the ESCO a yearly remuneration, composed of repayment, maintenance and management fees and a bonus/malus fee.

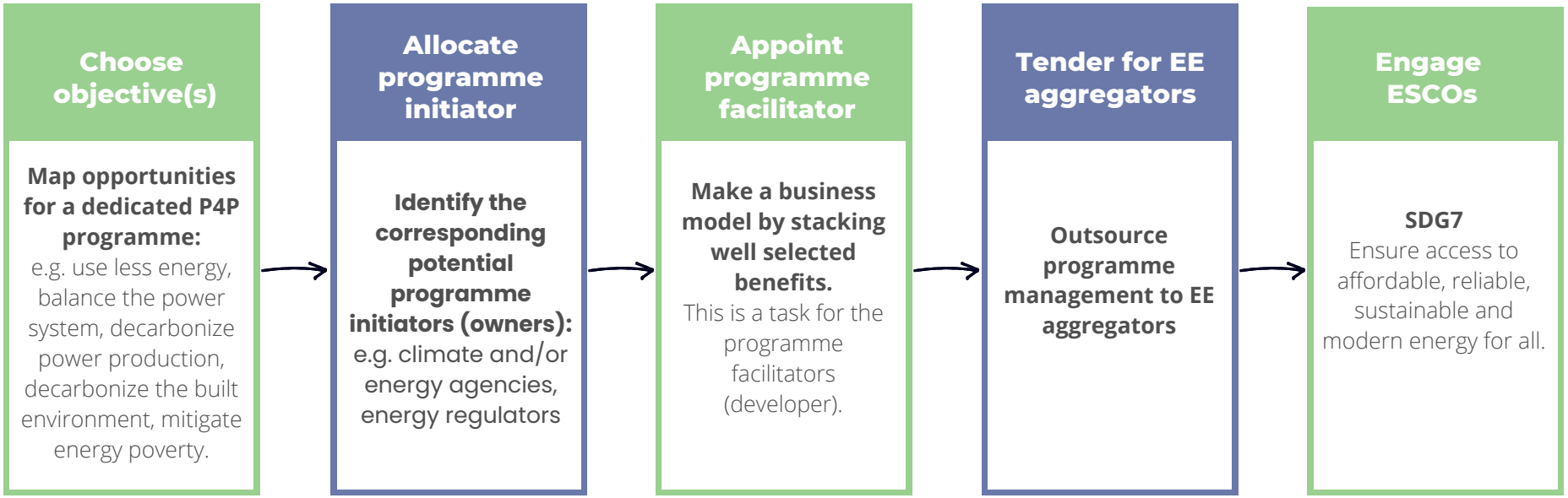
The **Public Authority** capitalizes the Fund at the required equity level, especially at the start of the Fund in order to attract Private **Third-Party Investors** and **financial institutions** at senior or subordinated debt levels. The Fund can be part of the Public Authority or can be an autonomous public entity founded by the Public Authority. The Public authority acts as primary shareholder and receives a double dividend (D), namely the financial dividend and policy dividend via energy demand or CO2 reduction. Additionally, it holds the starting equity of the fund and possible additional debt.Private Third-Party Investors finance the Fund (E) and receive repayment according to the risk level and market conditions. Lastly, Fund managers provide general corporate services to the fund such as accounting, taxes, auditing, asset and liability management, as well as tasks related to the EE projects' funding position.

Designing a Pay-for-Performance programme

To design a P4P programme, e.g., for the purposes of improving the quality of public subsidies, for attracting private investments, or for offering value to the power grid, it is important to **examine existing experience and adapt to national circumstances.**

Creating a P4P programme is unlikely to happen organically and will require an **enabling energy market and legal framework.** This means that a top-down program initiator will need to take charge.

When considering the design of a P4P program, it's important to **determine its scope and objectives**. In each Member State or region, one or more objectives should be selected, such as achieving climate goals by decarbonizing society and the built environment, improving building performance for greater comfort and energy efficiency, enhancing power system efficiency by avoiding investments in production and distribution capacity, and advancing socioeconomic goals, such as boosting the green economy, creating jobs, and mitigating energy poverty.



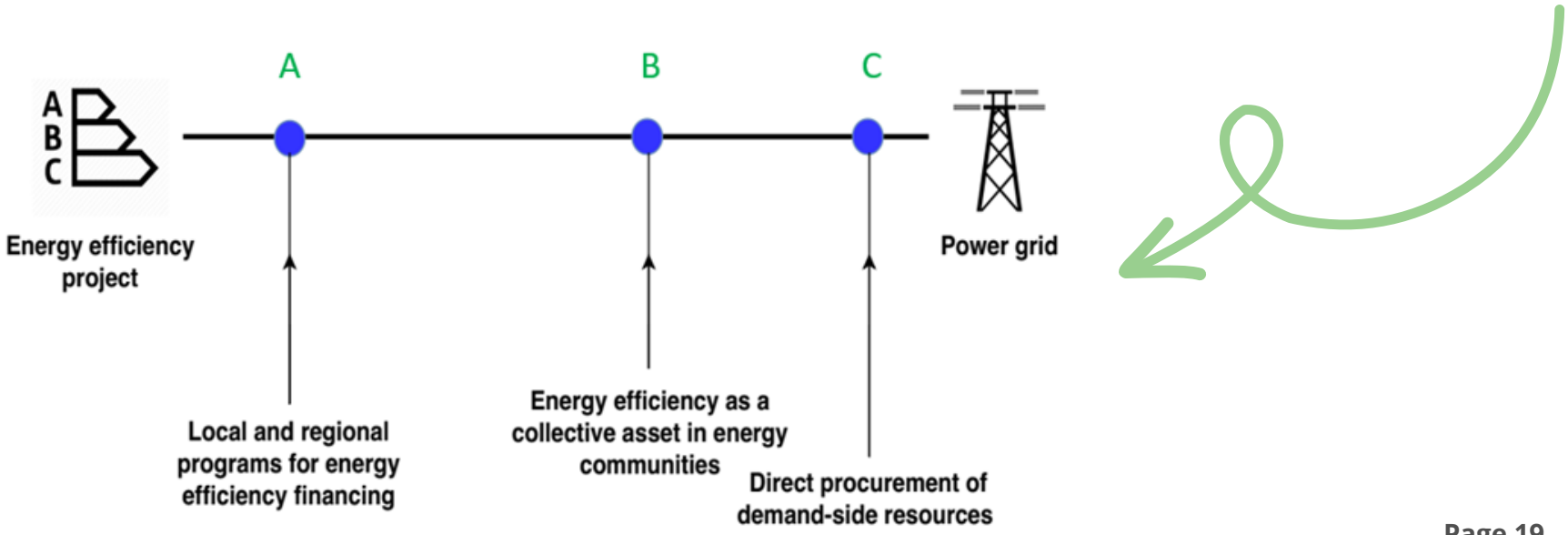
Positioning of a Pay-for-Performance programme

P4P programmes can be implemented to meet specific policy objectives, and thus positioned accordingly within the energy system. They can range from a small-scale improvement of existing public renovation programmes and reach the status of strategic infrastructure for energy planning objectives. In the first case P4P is used as an advanced way of regulating payments. Yet, when foreseeing interaction with the power grid, questions must be raised about whether the program would aim for a permanent load reduction, load shifting (passive/implicit or active/responsive), or a combination of both.

SENSEI explored various options for increasing energy efficiency in buildings and their potential benefits for the power grid.

The figure below illustrates a range of positioning options, depending on whether the program prioritizes structural energy efficiency in buildings (Option A) or supports the power system (Option C).

- **Option A** involves energy retrofits in buildings as a means of improving energy efficiency, which can have positive spillover effects on the grid.
- **Option B** involves energy communities, which can play a significant role in a P4P system as aggregators.
- **Option C** involves the procurement of energy efficiency as a resource for the power system, creating a level playing field between energy production and energy saved.



Structure of a typical Pay-for-Performance programme

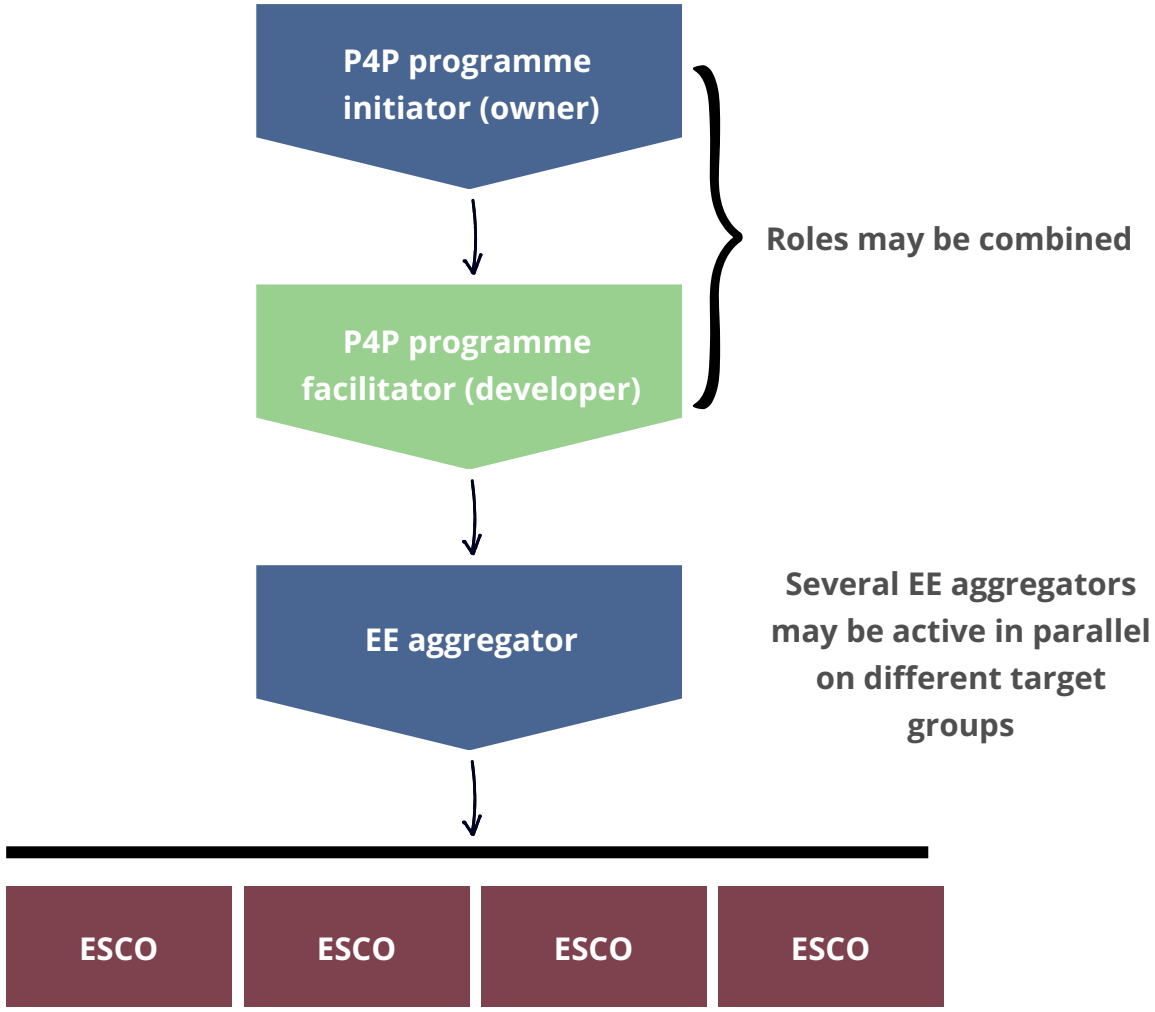
P4P programmes require the aggregation of many individual energy efficiency projects, and their success depends on a **high-level policy initiative**. This means that a program initiator is needed to conceive and create legal conditions for running the programme. Policymaking entities are typically responsible for creating P4P programmes, and this role would be taken up by specific departments **within national climate and energy ministries, national energy regulators or energy agencies**.

The SENSEI project has published guidelines for the design of P4P schemes and recognizes the **main elements that need to be considered in the incentive structure of a P4P programme** to foster the adoption of energy efficiency measures:

- **The scope of the P4P programme** must define the type of energy efficiency and flexibility measures to be implemented and rewarded, in accordance with specific strategies for each country or region.

- **The Aggregator or Portfolio Manager** must have tools (e.g., advanced M&V) and indicators (e.g., Smart Readiness Indicator) to group together different kinds of buildings according to energy efficiency measures needs and qualification, in order to construct an Energy Efficiency Plan and apply Energy Savings and Compensation Rates.

- **Additional factors related to building activities** must be considered that are not directly linked with energy efficiency measures, such as energy purchase contracts, legislative restrictions or incompatibilities.



When a P4P programme is launched, a **P4P programme facilitator** should be appointed to manage the development and market facilitation of the programme. This individual or organization is selected by the programme initiator to practically implement the programme. The main responsibility of the P4P programme facilitator is to bundle a relevant selection of benefits into a comprehensive package, thereby supporting a business model for the ultimate energy efficiency aggregator. Following this, the P4P programme facilitator must issue a tender to identify potential EE aggregators. These aggregators will establish and manage portfolios of buildings where energy service companies (ESCOs) will implement measures to improve energy efficiency. Large ESCOs could also evolve to take on the role of an energy efficiency aggregator.

Supporting material for stakeholders interested to set up a Pay-for-Performance programme

To support the establishment of P4P programmes, the SENSEI project provides valuable resources and tools to assist professionals in effectively designing and implementing such initiatives, including by offering tools for accurately measuring the benefits of energy efficiency interventions.

The SENSEI **e-learning platform** has been created as a self-paced environment to aid stakeholders in designing a P4P programme. The platform is based on the online engagement tool, EngageSuite, which offers various features that cater to asynchronous self-paced learning activities. Interested professionals can access the relevant material by visiting *www.senseih2020.eu/p4p-elearning-tool*.

The online book **Rethinking Measurement and Verification of Energy Savings** is available on the dedicated website created by SENSEI at *www.hebes-io.github.io/rethinking*. This material has been produced to aid understanding of the project's approach to measuring and verifying energy savings. It is presented in the form of a combination of text, software code, and plots, ensuring that every argument and result is transparent and replicable.

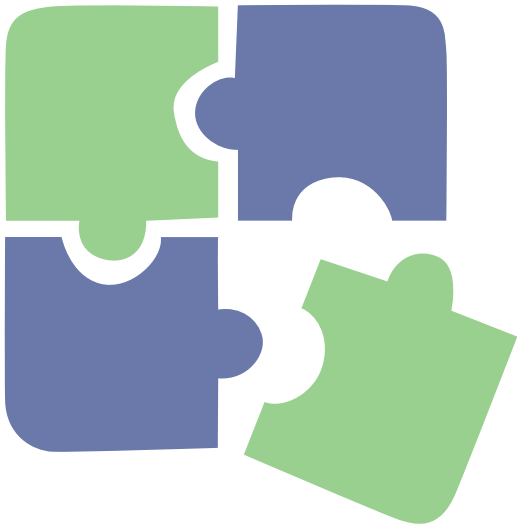
EENSIGHT is an open-source tool developed by SENSEI project to improve advanced Measurement and Verification (M&V) methods for energy efficiency projects. It offers new ways to frame the M&V task and its fundamental calculations, providing insights necessary for all parties involved in up-scaling energy efficiency to quantify and share benefits based on metered savings. EENSIGHT is designed to better understand a building's energy consumption and estimate energy savings from interventions and can thus help professionals accurately estimate the benefits of energy efficiency interventions and support energy efficiency programs. EENSIGHT is available as a reproducible open-source project at *www.github.com/hebes-io/eensight*.

EEVALUE is an open-source methodology that quantifies the value of energy efficiency projects as a grid resource. The methodology helps identify retrofit projects that persistently modify the power system's load shape in ways that align with the system operator's goals, quantifying and rewarding this value as a grid resource. The methodology uses the same process and tools that power system operators use for capacity adequacy studies, recognizing energy efficiency's seasonal/temporal characteristics that may decrease or increase the total cost of the power system's operation. EEVALUE is a useful tool for professionals exploring the importance of energy efficiency for the power system and can be accessed at *www.github.com/hebes-io/eevalue*.

Challenges to overcome in setting up Pay-for-Performance programmes

Throughout the stakeholder engagement activities conducted during the project, it was observed that some stakeholders found the P4P program concepts clear and easy to understand, while others faced **difficulties in grasping its applicability in their specific regional and national contexts**. Project partners identified several challenges to the practical implementation of the P4P concept, including **financial, technical, data quality, market, regulatory,** and **behavioural challenges**. The interaction around the P4P concept was also found to be a major barrier during stakeholder engagement activities, with stakeholders struggling to understand how it relates to the existing energy system and actors involved in Energy Performance Contracting (EPC). It was further observed that there is a **need for a clear and context-specific project definition** that takes into account actual figures, stakeholder needs (including non-technical and general public), reliability and security of existing power systems and other infrastructure, national regulatory and financial incentives, availability of skilled personnel, and upskilling training opportunities.

Addressing these challenges will be important in future efforts to set up an energy efficiency programme based on metered energy savings.



Main barriers and challenges identified by SENSEI consortium partners in their specific operational context

Category	Challenge	Context
Understanding the P4P concept	The general impression for some stakeholders was that the P4P concept is difficulty to fully grasp practically, and in terms of monitoring and implementation opportunities. Stakeholders confuse P4P with the current EPC contracts provided by ESCOs. Some of them also asked about the specifications of new contracts, and how they could be articulated.	
	Market participants have had difficulties comprehending the definition and concept of P4P. ESCOs do not understand the difference between their current role and that of the Energy Efficiency Aggregator, which can be an opportunity as some major ESCOs could eventually take up that role.	
	The relatively modest awareness of and knowledge about P4P was a clear barrier for stakeholders that were initially reluctant to engage with new concepts.	
	Financial stakeholders, especially the more conservative ones like big banks, pension funds and insurance companies see P4P as interesting but mainly as a new (EE financing) market mechanism. Innovation is not feared, but requires a few years to be proven. Participation of these stakeholders without public backing of some kind is unrealistic, although the mechanism of P4P as a boost for EE financing is clearly recognised.	
Regulatory context	The regulatory context and the ideological background are currently distant from the concepts of the P4P programme for market actors that are closely linked to the traditional programmes for financing energy efficiency interventions (via EPC in particular) that reply on deemed savings.	
	P4P programmes may face regulatory barriers, such as restrictions on how energy savings can be measured or limitations on the types of organizations that can participate in the programme.	
	While stakeholders were mostly enthusiastic about the P4P model promoted by the SENSEI project, many stressed that the current EU legislation on energy efficiency does not mandate the use of metered savings methods. This creates a lack of alignment among the EU, its Member States and energy efficiency programme managers. SENSEI and its partners highlighted this issue during the Fit for 55 package preparations, but unfortunately the legislation was not improved on this point.	
	A significant barrier has been the conflation of P4P with traditional ESCO projects, which meant that recipients of communication had pre-conceived ideas about P4P, often shaped by negative experiences with ESCO style projects.	
	While in theory, demand response and Energy Performance Contracts (EPC) are well defined concepts, a lot of confusion arose in stakeholders when P4P was presented as it combines parts of a DR program and a classic EPC.	
	The majority of stakeholders agree that the first responsible to start a P4P program should be Public Administrations. The difficulty is to define how to articulate it to improve the traditional Grants and how manage the justifications of the participants regarding the energy savings verifications.	

Infrastructural (incl. system reliability, security)	A P4P programme that includes the power system is only feasible with the involvement of public entities and public funding, given the different electricity market and grid congestion problems in Europe (and Italy) compared to the United States where such P4P programmes were first implemented. It is important to have increased interactions with TSOs, DSOs, ESCOs and national research agencies. A strong interest comes from the last two, while TSOs were not so interested in adopting Energy efficiency as a resource for ensuring power system reliability and security.	
	System operators on their side see non-wired alternatives P4P and DR/Flex as an interesting small part in the energy infrastructure adequacy puzzle, not as a breakthrough solution. Some, certainly not all, even don't think the mechanisms will play an important role, saying that congestion is not probably going to happen at large scale given the over dimensioning of the networks today. Whatever the situation might evolve towards, it will take some more time to convince some system operators.	
Financial (incl. upfront costs and existing national incentives programmes)	Presence of incentives (Ecobonus, Superbonus 110, etc.) currently place the application of a P4P programme in the background, as they are more economically advantageous and more easily admissible by the subjects to whom they are addressed, in particular, the end-users.	
	Stakeholders stressed that network companies were not yet ready to pay for EE resources in the EU.	
	The benefits for the energy system after an EE intervention have not been easy to be measure and understandable for national stakeholders (TSO, DSO, Energy Agency) that would pay for the effects of EE measures.	
	There are currently no rules to dictate system operators to establish a P4P programme and pay the resulting rates, although they are obligated to pay to the Energy Fund as an EED Article 8 Obligated Party. The same happens with Financial Institutions, because they want to recover the initial investments, hence the key is to define the actual savings achieved and the value of the P4P rate (€/Kwh saved). Progress with energy efficiency auctions may be a way forward.	
Behavioural	Energy efficiency measures often require changes in behaviour or routines, which can be challenging to achieve and sustain over time. This can impact the effectiveness of P4P programmes, as they rely on sustained energy savings to generate payments.	
	The development of the EENSIGHT tool for the monitoring and verification of energy savings has shown promising potential in differentiating the impact from energy efficiency improvements, from the effect of behavioural changes of occupants.	
Data availability and quality	P4P programmes require accurate and reliable data to measure energy savings and determine payment amounts. However, many energy efficiency projects lack adequate data tracking and monitoring systems, which can make it difficult to accurately calculate savings and determine appropriate payments.	
Technical – M&V	Measuring and verifying energy savings can be complex and time-consuming, requiring the use of specialized equipment and expertise. This can make it difficult and costly to accurately determine the savings achieved by energy efficiency measures, which in turn can impact the effectiveness of P4P programmes.	
Technical – upskilling	The implementation of energy efficiency measures may require specialized technical knowledge and expertise, which can be a barrier for some organizations or individuals that lack the necessary skills.	
Market – successful pilot demonstration	It is necessary to aggregate energy efficiency interventions, in order to obtain their financial sustainability. A pilot project is necessary to test the business model, M&V system and practical arrangements between market actors.	
	There is a clear need to set up a physical demonstration project in order to include all practical matters such as the needs of market actors, financing and other regulations, behaviour of occupants, testing of the M&V systems, etc.	

3. THE ROLE OF POLICY MAKERS IN ESTABLISHING PAY-FOR-PERFORMANCE PROGRAMMES

Europe's buildings have the potential to play a key role in our future energy systems. Making buildings more efficient reduces the need for expensive power plant capacity, defers the costly upgrading of network infrastructure, and enables this infrastructure to be used with more flexibility. However, the fact that **energy efficiency is not adequately compensated for its benefits** acts as a missed opportunity for promoting its deployment. This deprives it of valuable funding and means that we all pay more to ensure the adequacy, reliability and security of our energy systems.

To address this issue, the SENSEI project has looked towards Pay-for-Performance (P4P) programmes that have been developed in the US. These programmes have been mostly set up in the context of **Energy Efficiency Obligations (EEOSs)** for power system actors and target largely commercial buildings, while residential buildings have also appeared as promising.

P4P models in the US have been designed to monetize two main benefits of energy efficiency, namely, using it as a **demand-side grid resource to avoid technical upgrades** and extension planning of network infrastructure due to congestion, and using it as a **demand-side energy resource to participate in capacity auctions** by offering a reduction of demand for targeted periods in a year. This has led to the creation of business models based on periodic payments from load serving entities interested in using energy efficiency as a demand-side grid or energy resource, due to favorable regulation and grid characteristics.

In Europe, the SENSEI project has found that system operators and utilities have currently **limited interest in paying for energy efficiency as agrid resource**, owing to the absence of well-developed regulation and incentives that allow load serving entities to sell energy efficiency as a demand-side resource. Yet, the power grid, especially at the DSO level, will be facing challenges under pressure from the increased penetration of renewable energy sources, the shift to electrification of heating, and increase in the share of electric vehicles.

It is expected that P4P programmes will have an important role to play to **moderate the overall energy demand of the building stock,** and **to support efforts for electrification and flexibility**.

While P4P is not meant to replace energy efficiency grants and subsidies, these programmes can be utilized to reward energy retrofits that lead to load shape changes that are beneficial for the grid's operation. By compensating energy efficiency on an equal basis with other alternatives for ensuring the power grid's reliability, such as capacity reserves and demand response, energy efficiency is rewarded based on actual rather than deemed impacts. P4P can therefore offer a premium to **energy efficiency retrofit projects that can be regarded as valuable grid resources**.

THE ROLE OF POLICY MAKERS IN ESTABLISHING PAY-FOR-PERFORMANCE PROGRAMMES

To reach the objectives set by the European Union, it is necessary to establish new, more flexible and efficient financing models, and regulators are essential in setting up energy efficiency programmes that are based on accurately measured energy savings. The European Commission, being aware of the potential of P4P programmes, stated in its 2020 ***Renovation Wave communication*** that "Member States can [...] scale up market incentives such as [...], pay-per-performance public support schemes [...] to attract private intermediaries and aggregators".

This commitment was re-iterated in May 2022 in the context of REpowerEU, at the ***EU Save Energy communication***, stating that "the Commission will examine possible additional measures to trigger further private investments, e.g. through [...] pay-for-performance schemes".

Recommendations for pioneering a Pay-for-Performance programme pilots

Programme Set-up:

First, ensure that the P4P programme has a sufficient critical mass to cover all transaction costs. This requires a sizeable portfolio of buildings, including a decent share of large commercial and public buildings. Secondly, standardize energy retrofit contracts, in analogy with power purchase agreements for renewable energy installations, to develop a large pipeline of green assets that can be bundled together cost-efficiently. A detailed regulatory risk analysis should be conducted, and the risks of a changing regulatory framework should be assigned to a willing and able party. Unambiguous clauses should be drafted that establish a clear stakeholder allocation of the risks of non-fulfilment of obligations. State of the art monitoring tools ("M&V 2.0") should be utilized to enable transparent and trustworthy programme management.

Financing a P4P Programme:

To finance a P4P programme, well-targeted investors with matching risk aversion profiles should be engaged for each market development phase. In the start-up phase, earmark government guarantees to enable the "bankability" of the programme, with a pool of public buildings integrated into the building portfolio to give the start-up phase a boost. When designing the programme, ensure that the revenue streams of the foreseen energy efficiency measures are predictable enough to attract external financiers. Adopt a valuation approach in line with an investor's valuation standards and set up the financing structure of the programme between investors and the aggregator. Double-check that EU Solvency ratio requirements are not a stumbling block for investors to venture into large-scale energy efficiency programme investments like P4P. Make use of the current momentum of ESG and SRI funds when financing a P4P programme.

Role and Competence of the Aggregator:

A standardized assessment procedure must be used when deciding whether to include an energy efficiency project into the aggregator portfolio. Aggregators should bring together pooled energy efficiency projects by building types, geographic origins, industry sectors, etc. and source a combination of public and private financing from several types of investors to provide funding to designated energy efficiency projects via an investment platform. Adopt a comprehensive approach to retrofitting buildings that goes beyond energy efficiency and encompasses other non-financial benefits.

Involvement of Power System Operators:

Even if power system operators are (currently) not interested in participating in a P4P programme, they should be involved as a programme partner for the mere fact that they are an indispensable key data provider. In particular, during the pilot phase, P4P programmes should seek the involvement of a power system operator as an entry point or preferred channeling partner for investors, given the data they possess, participating end consumers and because they are seen as a financially stable party.

The EU Member States can enable new business models for energy efficiency based on P4P supported by the provisions in *REPowerEU* and the *Recovery and Resilience Facility*. What is now needed is national pilots, following inclusive stakeholder dialogues and partnerships between regulatory bodies, power system operators, manufacturers, ESCOs, digitalization solution providers and consumers.

Energy efficiency in a market-driven, performance-based system

Complementary to the establishment of P4P programmes, EU MSs can embrace a **market-driven, performance-based system** that identifies the value of energy efficiency and includes all system actors. The following policy recommendations aim to incentivize property owners, building managers, and ESCOs to invest in energy efficiency measures and establish market structures that reward market actors based on the achieved energy savings.

It is of utmost importance to **recognize Energy Efficiency as a valuable resource** by utilities and Distribution System Operators that are tasked with providing services to the energy system. The "metered savings" methodology of the Energy Efficiency Directive (EED) should also be required, at least partially, to support performance-based programmes.

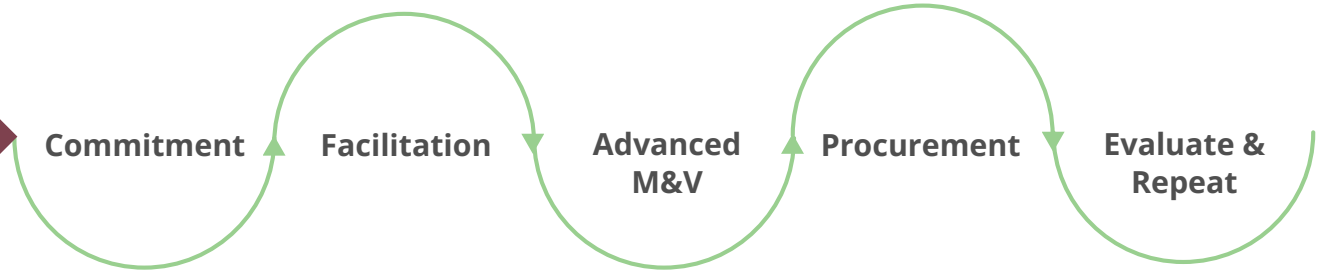
Economic stimulus packages can be leveraged to encourage the development of innovative business models that prioritize metered performance, such as P4P programmes. This can help enhance the Energy Performance Contracting (EPC) model through the presence of aggregators covering hard-to-reach sectors, such as the residential and small to medium commercial building sector.

Minimum energy performance requirements should be established for all parts of the building stock, with specific compliance deadlines, and training and capacity building activities should be promoted to encourage the adaptation and implementation of P4P programmes, along with establishing standards, template contracts, and procedures. The rules for monitoring, reporting, and verifying energy savings outlined in Article 8 of the Energy Efficiency Directive (EED) should be further strengthened to improve transparency and accountability by promoting the use of advanced monitoring and verification methods.

For **public buildings and small to medium enterprises**, additional requirements should be established to encourage renovations and metered savings, along with increased involvement from energy efficiency service providers. This could include mandatory energy audits, implementation of energy-saving recommendations, and increased requirements for metered savings. Energy efficiency market players, stakeholders, and citizens should be enabled to participate in building renovations and the residential sector, while stakeholders should be involved in the design process of P4P programmes to drive investments in energy efficiency. Finally, **raising awareness and promoting the concept of energy efficiency aggregators** can empower citizens to understand and benefit from P4P programmes.

Finally, to ensure the success of P4P programmes, it is important that they are incorporated as part of a **regulated program guided by government policies and regulations**. This is because some market players may not be motivated to participate if left to their own devices. To attract ESCOs and end-users, changes need to be made to the existing energy market elements. The main challenge is not a technical issue, but rather a market failure resulting from a significant information gap between the buyer and the seller. The solution to this lies in treating energy efficiency in a similar manner to power generation, where payment is only received upon the achievement of the desired results.

A stepwise approach for piloting Pay-for-Performance programmes



To achieve the right market configurations, policy makers in consultation with key national stakeholders could design a P4P programme from the beginning, or adjust existing mechanisms (such as EE auctions), in a stepwise approach:

1 **Commitment:** Recognize energy efficiency as an energy resource at a high level (regulatory, legislative, TSO/DSO, Utilities) and secure commitments to pilot energy efficiency programmes based on P4P and metered savings.

2 **Facilitation:** Designate a competent managing authority (energy agency or a government entity) to oversee and support the co-design and execution of pilots, to define minimum energy performance standards, and to set enabling rules and the right infrastructure.

3 **Advanced M&V:** Develop an open and transparent methodology for metered savings to increase accuracy and trust. This would require collaboration of ESCOs and M&V expects to define test protocols for evaluating M&V tools and defining the scope of their applicability. The EENSIGHT tool produced by SENSEI has been a first step towards improving accuracy and broadening the applicability of M&V.

4 **Procurement:** Issue tenders for energy efficiency projects that adopt the pay-for-performance approach and a compensation structure based on metered savings. Provide favorable conditions to secure involvement, including by ensuring predictability through guarantees.

5 **Evaluate and Repeat:** Gather insights and know-how from the first pilots, conduct capacity building activities to strengthen the role of market actors, and repeat piloting with improved approaches and refinements (e.g., on payment structures).

For a successful replication of the P4P approach in the EU, it is important to begin with piloting P4P programs, starting small and building upon experience, focusing on clear, precise and detailed measurement rules. It is crucial to involve stakeholders in program development and communicate clearly to target audiences in the market. It will be essential to continue adapting payment structures to fit market conditions and the needs of stakeholders. To support policy objectives, attention should be placed on P4P programs to integrate well with broader climate and energy objectives, be supported from relevant policies (e.g. accelerating the smart meter rollout), and foresee the publishing of evaluation results and the sharing of knowledge to support a positive reinforcing cycle of improvements in implementation.

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