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Combined Effort Opportunities of Aggregated Demand Response Flexibility and Energy Savings in Households

[1] Statements expressed in the paper are author's own opinions, they are not binding for the company/institution in which author is employed nor they necessarily coincide with the official company/institution's positions.

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SUMMARY

This paper analyses possible synergies between demand response flexibility programmes and energy savings delivered by households. In the framework of the energy transition, European Union (EU) directives are endorsing energy consumers to become full-fledged participants of the energy market, mostly via independent aggregator intermediaries. The flexibility aggregators have a very arduous role in collecting, optimising and settling aggregated flexibility delivered from heterogenous sources on the energy market. Novel business models incorporating both flexibility and energy savings opportunities from household consumers could deliver revenue diversification for flexibility aggregators and support them in overcoming technical and motivational challenges for activating consumers in the energy market. This paper discusses the main pillars for a sustainable flexibility aggregator business model which sums up the potential for flexibility placement on energy, ancillary services and energy savings markets. The main challenge identified in this work are the requirements for programme establishment, allowing the recognition and proper interpretation of energy savings triggered by short-term events and obtained by an aggregator via explicit demand response actions. This paper proposes possible solutions for a joint venture of a flexibility and energy savings aggregator, thus alleviating possible data collection problems. Collaborative efforts have been recognised in the establishment and maintenance of information and communication technologies and infrastructure, therefore facilitating continuous monitoring and verification of flexibility programmes which are able to deliver energy savings.

KEYWORDS

flexibility, energy savings, demand response, ESCO, P4P, monitoring, verification

1. INTRODUCTION

In order to set in motion EU long-term carbon neutrality, the Clean Energy Package [1] is launching ambitious energy and climate targets for 2030. The integration of renewable energy sources in the transmission and distribution energy grids are changing the landscape of the energy system. Flexibility aggregation opportunities are particularly interesting for soothing the effects of volatile production in real-time system balancing, although they could be valuable tools for network operators in long-term grid planning, as well as demand and supply balancing.

Energy consumers, which could be led by various motivational factors [2], should become enablers of energy system democratisation [3] with their capabilities to produce, store and consume energy. The technological changes which are increasing the smart readiness level [4] of buildings are occurring rapidly and the introduction of such solutions is becoming more affordable for consumers. Along with the empowerment of flexibility opportunities in the energy market, the Clean Energy Package [1] endorses energy efficiency as a priority through "energy efficiency first" principle [5]. At the EU level, buildings account for 43% of final consumption[6], therefore obvious emphasis is dedicated to the building sector and improvement of its energy performance: the target is to increase the efficiency of EU energy use by almost one-third (at least 32.5%) by 2030.

The Energy Efficiency Directive [7] defines aggregators as "demand service providers that combine multiple short-duration consumer loads for sale or auction in organized energy markets"; while the Electricity Market Directive [8] defines independent aggregator as " a market participant engaged in aggregation who is not affiliated to the customer's supplier".

Energy consumers are on one hand expected to become active participants on the energy market [8], and on the other hand to improve their energy consumption efficiency [7] via interventions in performance of their buildings, purchasing energy efficient products [9], improving energy consumption management, etc. Obviously, for achieving such ambitious targets, consumers should be provided with adequate tools, incentives and know-how. Business models which allow aggregation of such scattered

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potential trapped in households have a unique opportunity to perceive their potential in both energy market through flexibility provision and energy savings market by delivering energy savings. Offering energy savings programmes through aggregators, as a part of flexibility service, creates more awareness of their benefits as consumers become more aware of the energy costs and impacts of energy use [10].

This article provides an overview of possible solutions and limiting factors enabling this particular cohesion.

2. METHODOLOGY AND APPROACH

The first step in the research is the analysis of existing business models which are based on flexibility aggregation, energy performance contracting, and their possible synergies. In a second step, revenue creation opportunities derived from energy savings obligation schemes have been analysed. In a third step, possible synergies in monitoring and verification techniques for a programme settlement and continuous alignments used in both flexibility and energy savings programmes have been elaborated.

2.1. Analysis of business models and possible synergies

In the following section, an overview of possible business models for an independent aggregator where flexibility provisions are dissociated from the supply contract are elaborated. Models for energy savings and flexibility aggregation are analysed, and a model is proposed to integrate both flexibilities and savings opportunities of household consumers.

2.1.1. The independent flexibility aggregator

The Electricity Market Directive [8], published with the Clean Energy Package, states that independent aggregators should be introduced in European electricity markets [11]. Independent aggregators are market participants performing demand-side aggregation and are not affiliated with the consumer's retail suppliers. More precisely, the role of the independent aggregator is to operate in the opposite direction of the energy supplier. The independent aggregator purchases the flexibility from the end users (or consumers) and offers its aggregated value to a Balance Responsible Party (BRP) on the energy market or to the system operators on the ancillary service markets. In order to regulate imbalances between energy purchased for supply and actual consumed, caused by flexibility activations from the independent aggregator, several market models could exist [12]. If flexibility provisions are dissociated from the supply contract - which is the case for the independent aggregator – ENTSO-E proposes three types of market models:

1. bilateral agreement model;
2. supplier settlement model and
3. central settlement model.

The bilateral model allows the independent aggregator to operate with a low degree of complexity on the energy market, ensuring fairness as there is a consent between involved stakeholders (supplier and aggregator). However, in this model, the participation of the independent aggregator on the energy market is highly dependent on the willingness of BRPs and suppliers, thus the economic efficiency of such model depends on the contracted conditions. Market design without bilateral contracts provides a higher degree of confidentiality for consumers and allows independent aggregators to operate without the consent of the BRP or the supplier. As stated in [12], economic efficiency is ensured if the prices to settle the transfer of energy with suppliers are cost-reflective. Such market design requires a higher degree of complexity which could take time to develop. In a supplier settlement model, the energy sold on the market by the independent aggregator is invoiced to the consumer by the supplier as if it had been consumed, which is not desirable in terms of consumer motivation. In the central model, the settlement of the transferred energy is performed by a neutral entity, which could be a system operator or a third party. Such model would allow consumers to receive a single bill, exposing the amount of consumed energy minus the transferred as flexibility via an independent aggregator. This model might be one of the most advantageous for consumers because the benefits for participation in flexibility programmes would be directly reflected in the energy bill.

Apart from supplier/BRP imbalance settlements, the independent aggregator could deliver ancillary services to the system operator under contracted conditions [13]flexibility can be provided to operators using home-appliances with the ability to modify their consumption profiles. These actions are part of demand response programs and can be utilized to avoid problems, such as balancing/congestion, in distribution networks. In this paper, we propose a model for aggregators flexibility provision in distribution networks. The model takes advantage of load flexibility resources allowing the re-schedule of shifting/real-time home-appliances to provision a request from a distribution system operator (DSO , which could add more complexity to the business model (Figure 1).

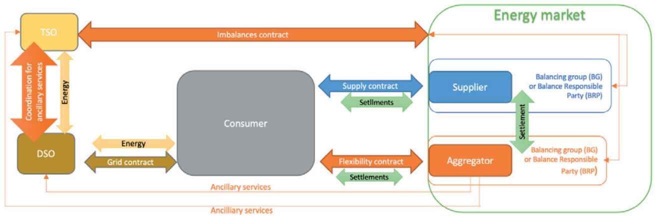

Figure 1 Independent aggregator business model

An important backbone for the introduction of independent aggregators as ancillary service providers to system operators is the introduction of a coordination platform to exchange flexibility activation information between transmission system operators (TSOs) and distribution system operators (DSOs). More precisely, the DSO should timely receive the insights of the flexibility activation schedule planned for distribution network users and purchased by the TSO. The creation of a common platform for the trading of ancillary services would increase the coordination between purchased services and would probably improve the network management efficiency.

Therefore, even if the regulatory framework eases the introduction of the independent aggregator to the energy market, its existence is highly dependent of the level of maturity of the market and willingness to establish novel contracting relationships between traditional market participants.

2.1.2. Energy saving models

Citizen or renewable energy communities offer consumers the possibility for participation in production, consumption and local energy sharing [14] to fully unleash their potential, they require a coordinated operation and design that the community itself may be ill-equipped to manage. Aggregators and Energy Service COmpanies (ESCOs. Such initiatives facilitate the integration of new technologies, advance energy efficiency at household level and support the mitigation of energy poverty through reduced consumption and lower supply tariffs [15]. The same applies for independent aggregators, oriented toward local household consumers, because they can contribute to the same goals. Business models enabling synergistic action to ensure energy savings and activation of demand side flexibility in households are interesting to observe in this context.

Through an Energy Performance Contract (EPC), which is based on achieving client's or consumer's energy savings, an energy service company (ESCO) implements a project to improve energy efficiency or integrate renewable energy sources, by using financial savings obtained from energy savings (as income) to cover investment costs. The ESCO company finances and implements energy efficiency measures for its clients and guarantees them energy savings. If the implemented project does not result in the planned energy savings, the ESCO company does not achieve the planned income [16]. The approach is based on the transfer of technical risks from the client (who concludes the EPC) to the ESCO company that guarantees energy savings, while procedures for assessing and verifying energy savings are based on the standardized procedures for monitoring and verification of energy savings. One of the most important characteristics of the EPC is that it dispenses the client (electricity consumer or network user) with permanent savings even after the contract expires, which is when the ESCO company exits the EPC financing model.

Contracts on energy performance mostly find their application in renovation projects of industrial plants, commercial or public buildings [17]. The progressive digitalization of the energy sector with the integration of automation and management systems in buildings will provide the means to ESCO companies for better data collection and analysis opportunities of their customer's portfolio. This also contributes to a better assessment of energy savings through the application of information and communication technologies as well as adequate protocols for measurement and verification [18].

In this context of combined effort opportunities between flexibility and energy savings in a real-time environment, the Pay for Performance (P4P) financial scheme is interesting for monitoring energy savings in direct consumption through actual measured data. The amount of cash payments made by the company that offers the P4P service depends on the measured consumption data, i.e., the normalization values of energy consumption for the associated weather conditions [19].

The P4P scheme can facilitate investments in the energy efficiency of buildings by continuously verifying energy savings through smart metering and transparently calculating the investment return period. One of the more important, but not key, prerequisites for the introduction of P4P schemes is the integration of smart (interval) meters. Smart meters would facilitate the collection of data of the desired granularity through standardized protocols and could enable simpler monitoring of consumption. Given that consumption is observed in relation to, for example, climatic parameters, the P4P model needs to be adapted to local conditions and characteristics of consumption [19]. Choosing an appropriate method for monitoring and verifying energy savings that can be dynamically calibrated according to the collected input data is also crucial. The basic difference between classic schemes for co-financing energy efficiency projects and P4P schemes is shown in Figure 2. In classic subsidy schemes, the payment of the subsidy for achieving savings by means of energy efficiency measures occurs at the beginning of the project, usually in one payment. The P4P scheme could ensure greater and more persistent energy savings by continuously financially compensating energy efficiency resources through a comparative analysis of actual and baseline consumption (which would occur without energy efficiency interventions). Energy savings are used as the main indicator for the performance of the energy efficiency project, and payments are made continuously based on the calculated savings [20].

The P4P schemes used for financing energy efficiency projects do not necessarily imply the stipulation of EPC. If energy savings are linked to payment, it gives more certainty to investors that energy efficiency measures will really improve the performance of a building or a system, therefore reducing their investment risk [21]. The P4P schemes require a more dynamic system for calculating savings then the usual ESCO schemes. Methods applied for monitoring and verification of energy savings should grant continuous calibration of the calculated savings, minimising errors in assessments.

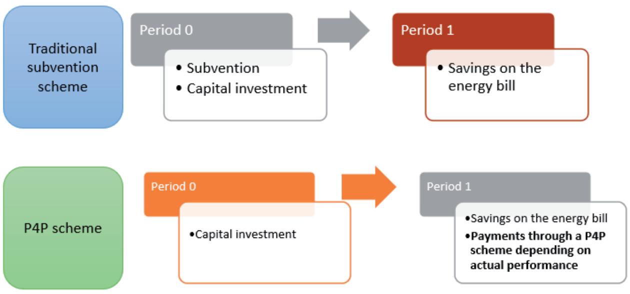

Figure 2 Difference between traditional energy efficiency and P4P subsidy schemes

The business model of the energy savings aggregator, which uses P4P schemes, is based on periodic payments which are calculated according to the obtained savings in the observed time interval. Moreover, it is not necessary that all stakeholders participating in the value-chain are part of the P4P scheme: if the scheme is more comprehensive, the complexity of the P4P programme increases.

2.1.3. Possible synergies

Figure 3 represents energy savings and flexibility aggregator combined business model, based on the model developed in the framework of the research project and adapted to European conditions [22].

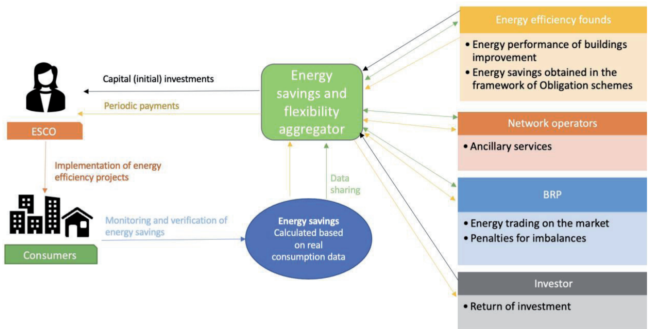

Figure 3 Energy savings and flexibility aggregator combined business model

Network operators could, for example, take part in the P4P scheme, by co-financing energy efficiency projects for network users, via energy savings aggregators for long-term congestion management in distribution networks. The aggregator of energy savings could also be included into ancillary services provision, in the same fashion as the independent aggregator, but should take special attention to the short-term activations (e.g., for peak-shaving) that could deliver permanent savings. One of the main goals of a combined business model (flexibility and savings aggregator) should be to ensure permanent savings of short-term flexibility activations. With continuous consumption monitoring, it is possible to valorise savings through short-term activation with proper monitoring and verification techniques. Additionally, special attention should be given to the imbalances that consumers could cause to the suppliers by participating in such schemes.

The combined effort of a flexibility aggregator that actively monitors, analyses consumption data of its users, and optimizes the derived flexibility on the market, along with an entity that must provide savings to those same users, opens the spot for the creation of new business models.

2.2. Revenue opportunities on the energy savings market for flexibility aggregators

Apart from traditional revenue creation opportunities for an independent aggregator on the energy market as ancillary services provider, this chapter analyses additional opportunities for a combined energy savings-flexibility aggregator business model.

According to the Energy Efficiency Directive [7], mainly Article 7, Member States shall achieve cumulative end-use energy savings. Member States shall achieve the amount of energy savings by establishing an energy efficiency obligation scheme or by adopting alternative policy measures. Energy efficiency obligation schemes (EEOS) are schemes setting an obligation on energy companies to achieve energy savings targets. By year 2020, new energy savings were set as 1.5% of annual energy sales to final customers by volume, averaged over the most recent three-year period prior to 1 January 2013, while for the 2021-2030 period, the amount has been set to 0.8% of annual final energy consumption. The obliged parties under EEOS are energy suppliers or/and energy distributors. Several Member States have implemented or are considering the introduction of an energy efficiency obligation scheme [23]. For example, in the Republic of Croatia, according to the current Energy Efficiency Law [24], the obliged parties are energy suppliers of electricity, natural gas, heat and oil products. The obliged parties could fulfil their obligations by:

- investing in energy efficiency improvements and encouraging energy efficiency in final consumption, in such a way that investments are realized as new energy savings in accordance with the Ordinance on the System for Monitoring, Measuring and Verifying Energy Savings [25], not excluding investments in electricity production equipment and self-supply, small and micro-cogeneration, smart meters for customers, i.e. energy consumers and all other investments and incentives for which the obliged party proves new savings;
- purchase of energy savings from third parties;
- payment of a prescribed fee to the Environmental Protection and Energy Efficiency Fund in case of non-compliance with the annual target; the Fund is obliged to use the gathered financial means to co-finance alternative measures and the fee is calculated annually, based on costs encountered by the Fund to achieve savings with alternative measures.

The possibility to purchase energy savings from third parties could trigger the energy savings market, thus allowing energy suppliers to purchase verified savings from an energy savings aggregator. Energy service providers (ESCO) or savings aggregators could achieve energy savings in final consumption through the implementation of energy efficiency projects, and obliged parties could purchase these savings. In the Republic of Croatia, a bottom-up method prescribed in the Ordinance on the System for Monitoring, Measuring and Verifying Energy Savings [25] is used to prove savings. If a measure is not covered by the Ordinance, the obliged party within the report on realised savings can make a proposal for verifying new savings with the submission of appropriate evidence.

The bottom-up method consists of mathematical formulas for the calculation of unit final energy savings (UFES), which are expressed per unit relevant to the considered energy efficiency measure. Total energy savings in final consumption (FES) are calculated by multiplying the value of UFES with the value of the relevant influencing factor in the considered period and adding up all individual projects that were realized as part of a measure (e.g., a programme to encourage the renovation of the building envelope of family houses). The UFES calculation is based on the difference in specific energy consumption 'before' and 'after' the implementation of energy efficiency measures. If the value of energy consumption 'before' cannot be determined for a specific project, reference values are used [26].

The method used for monitoring and verifying energy savings within the EEOS is very often based on the calculation according to reference values, and the achieved savings are calculated for each observed year. The selection of a method for calculating savings achieved through a P4P scheme require the establishment of customized parameters for measurement and verification in a dynamic environment, which are regulated within the EU. If the energy service provider in its portfolio also offers the activation of flexibility for its users, this should be considered as a separate measure to achieve savings. In such case, it is necessary to demonstrate that the activation of demand side flexibility in a short-term event activation leads to a permanent reduction of energy consumption.

In order to include demand side flexibility as a measure for achieving energy savings, it is necessary to define an applicable methodology for monitoring and verifying the achieved savings. Additionally, special attention should be given to the calculation of energy savings to avoid double counting if the flexibility aggregator is also an energy savings aggregator.

The establishment of a trading system for energy savings would allow new stakeholders in the energy market, such as flexibility aggregators or energy communities, the possibility of income diversification. Income diversification could make it easier for aggregators to solve the problem of business sustainability in the electricity market [27]. The combined effort to sell flexibility and energy savings could certainly increase the degree of complexity of the business model for the aggregator. In practice, as an example, the requirements for flexibility activation by the distribution system operator may be in price collision with the achievement of energy savings. Likewise, it is necessary to regulate relations between different entities, i.e. suppliers and aggregators, or/and electricity consumers. If the supplier and the aggregator have a contract with the same electricity customers, and the supplier buys savings from the aggregator in order to fulfil the obligation in the framework of the EEOS, such relations must be regulated to avoid deviations and penalisation of the supplier on the electricity market. For the aforementioned reasons, there is a need to create a sustainable business model that would enable the valorisation of the flexibility in the form of energy savings.

2.3. Monitoring and verification of achieved savings in flexibility programmes

Monitoring and verification procedures (M&V) are used to evaluate the effect of certain energy efficiency measures [28] and the achievement of national energy efficiency goals [25]. They allow appropriate understanding, management and distribution of risks in energy efficiency projects [29]. Monitoring and verification procedures include programme planning, data collection and analyses, working toward reducing uncertainty energy savings estimations. ESCO usually use standardised monitoring and verification procedures to define savings within the EPC.

The first attempts to establish a protocol for monitoring and verification of energy savings have been initiated by the Department of Energy of the United States in 1994 [30], and resulted in the release of the first North American Energy Measurement and Verification Protocol (NEMVP) [31] in 1996. Considering its great international interests, a new version was issued in 1997, and the NEMVP was renamed in the International Performance Measurement and Verification Protocol (IPMVP) [32]. The application of the IPMVP is still recommended to ESCO companies [29]. The IPMVP defines guidelines, common practice in measuring, calculating and reporting of savings achieved in energy efficiency projects. It is intended to be used by experts as a base for the preparation of reports on the achieved savings. The IPMVP sets the framework for the implementation and evaluation of energy efficiency and energy management measures.

As stated in the protocol, the basic characteristic of energy savings is that they cannot be directly measured. Energy savings represent the elimination of consumption that would have occurred in the absence of a certain measure. The IPMVP gives indications about the assessment period, the reporting period and the methodology for calibrating or correcting calculations. Baseline consumption values need to be continuously calibrated and adjusted according to developing conditions (climatic conditions, number of people in the household, etc.) in order to be comparable with measured consumption values. Special attention should be given to the needs for input measurement data, e.g. the total consumption of the entire facility or a part of the facility, and the granularity of the data required to determine savings.

If demand response flexibility needs to be valorised as energy savings, adequate monitoring and verification procedures should be selected. The parameters used for the purpose of monitoring and verification of short-term flexibility are crucial for determining the effects of the flexibility programme and quantifying the achieved savings. The example is given in Figure 4.

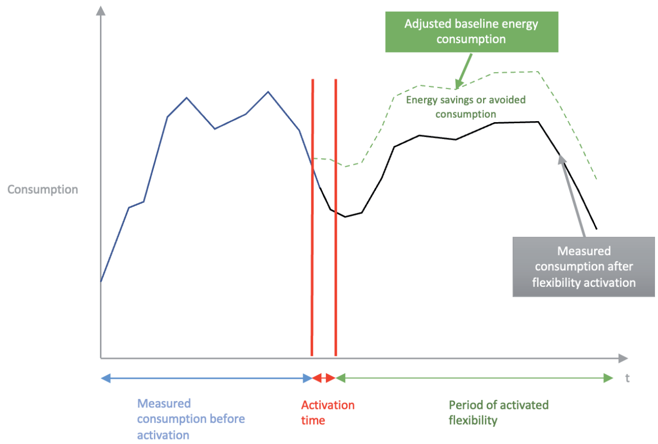

Figure 4 Example of the energy savings estimates in flexibility programmes

The methods used to quantify the estimated consumption should consider the type of user or consumer, the dependence of the observed load on variables (weather and seasonal conditions) and must be continuously adapted to changes. The result of mutual cooperation between the Department of Energy of the United States of America and the Federal Energy Regulatory Commission (FERC) is a document published in 2011 on measurement in the verification of consumption response [33], as part of the National Implementation Action Plan for Demand Response (NAPDR). The NAPDR is the product of the working group efforts and pragmatically describes the procedures which need to be followed for the establishment of a flexibility programme and continuous monitoring of its effect.

Measurement and verification of demand response flexibility defines the determination of demand reduction quantities in two broad contexts [33]:

1. Settlement – determination of demand reductions achieved by individual programme or market participants, and the corresponding rewards or penalties allocated to or from each participant.
2. Impact estimation – determination of programme level demand reduction that has been obtained or it is projected to be achieved, used for programme evaluation and planning.

It is envisioned that the measured reductions should be recognised in both contexts to ensure proper flexibility programme design and its continuous verification during operation. Settlements should be considered in programme planning, design and operation, while impact estimation should examine the appropriateness and evaluate the programme effects. M&V should ensure continuous programme calibration and impact estimation.

It is important for M&V purposes to understand the difference between ex-ante and ex-post impact estimates. The ex-ante impact estimation assesses and approximately forecasts future load reduction capabilities, while ex-post impact estimation retrospectively assesses demand reductions [34]aggregators of flexibility are expected to deliver flexibility programs rules (notification prior to a flexibility event, eligibility, rewards, penalties.

Achieved energy savings resulting as short-term flexibility activations should be observed in both contexts. Settlements should be arranged through the processes of design, planning and implementation of a flexibility programme, while performance evaluation is a continuous process through which the applied programme is examined and evaluated.

The results of M&V of consumption response are used to determine the suitability or ability of resources engaged in flexibility programmes, determining retail and wholesale settlements, predicting the effects of individual resources based on their historical performance, assessing the effect of the established flexibility programme, forecasting and planning [33]. Wholesale settlements refer to settlements between aggregators and system operators or customers on the wholesale market, while retail settlements refer to settlements between aggregators and electricity buyers or consumers.

For iterative calibration of the consumption flexibility programme, it is necessary to determine the effect of the flexibility programme in advance (lat. ex-ante) and continuously monitor the effect of the programme in retrospect (lat. ex-post). Ex-post performance analyses can be a good basis for adjusting the projections of the applied flexibility programme, but it is imperative to have the appropriate information and communication infrastructure and the correct semantic data interpretation [34]aggregators of flexibility are expected to deliver flexibility programs rules (notification prior to a flexibility event, eligibility, rewards, penalties.

The key quantities obtained from a flexibility M&V are calculated baseline load (based on historical data), calculated reduction (difference between the calculated baseline load and observed load) and financial settlement amounts (payments or penalties based on the calculated reduction). Besides the observed load, none of the mentioned quantities can be directly measured when direct load control is applied. In order to minimize the errors, both estimates and communication technologies should be properly selected and applied. For the establishment of a P4P model, which combines both short-term flexibility activations and energy savings, suitable M&V methods should be developed. Such methods should be adaptable to dynamic baseline changes and measurements with higher data granularity. Bottom-up M&V methods are not suitable for P4P model purposes.

2.3.1. Identified requirements for setting-up a programme for energy savings achieved by short-term flexibility activations

Considering the identified M&V requirements for programme settlements and their continuous calibration, authors have identified the following requirements to set-up a flexibility programme which could allow achievement of verified energy savings through a flexibility programme (Table 1).

Table 1 Identified requirements

	Requirements	Description
Initial requirements	Information and communication technologies	Set-up of a functional architecture enabling explicit demand response as well as the physical infrastructure
Ex-ante estimations	Data availability	Availability of interval metering or smart metering data
	Calculation methods for baseline assessment	Load disaggregation methods Regression analysis of key parameters influencing the consumption of flexibility assets Baseline assessment and calibration methods
	Settlement	Applying adequate strategies for consumer engagement and determination of adequate compensations
Ex-post estimations	Data availability	Smart metering data
	Calculation methods	Calibration methods of ex-ante estimates
	Information and communication technologies	Semantic data interpretation

For explicit demand response and enabling proper monitoring and verification of achieved savings, proper information and communication infrastructure should be established and installed in consumer premises.

Various techniques could be used for baseline assessment, but they are mostly dependent on the data granularity. Regression analysis on key parameters influencing the consumption of flexibility assets should be performed. Based on the assessed market potential, proper settlements should be determined for consumer compensation.

Besides data availability and the selection of proper adjustment/calibration methods, to ensure the quality of an ex-post estimate, proper semantic data interpretation should be available. Communication protocols and data models with proper message payloads should enable a comparative analysis of ex-ante impact estimates and ex-post analysis as an iterative process with continuous programme adaptation [34]aggregators of flexibility are expected to deliver flexibility programs rules (notification prior to a flexibility event, eligibility, rewards, penalties.

As an example, the OpenADR standard [35], adopted in the EU as IEC 62746 [36], specifies the data semantics only to a limited extent. The message payload interpretation does not go beyond generic types of events. However, its open specification facilitates any user to implement the two-way signalling systems, providing the servers that publish information to the automated clients subscribing to the information. Such information can serve as an immediate verification of curtailment and identification of failed or over-ridden signals. For monitoring and verification of demand response purposes, OpenADR is applicable, but needs to be enhanced with additional data semantics alignments. When the customer is paid based on the participation metrics, OpenADR is suitable for verification of such events. However, Event and Report services are not enough for impact estimation, nor are payload messages describing the assets involved in direct load control events and the interrelationship between them.

OpenADR is applicable for programme settlement purposes as part of the functional architecture for short-term flexibility activation and the related communication between the aggregator and the consumer. However, for a proper ex-post estimate and verification of achieved savings, additional semantic information for involved flexibility assets is needed. Existing data models such as Smart Appliances REFerence (SAREF) [37] offer such solutions, but a certain semantic interoperability between communication standards and ontological data models should be developed [34]aggregators of flexibility are expected to deliver flexibility programs rules (notification prior to a flexibility event, eligibility, rewards, penalties.

3. CONCLUSION

The constitution of a sustainable business model should be one of the principal goals of an independent aggregator. An independent flexibility aggregator, who optimizes the flexibility of households and therefore sells its aggregated value on the market, must either set up its own metering infrastructure for data collection and analysis or purchase the costs of a metering service.

The main challenge in identifying savings achieved through flexibility activations is the lack of proper data semantic interpretation. Interoperability must work at the technical and semantic level. Consistent and non-equivocal data interpretation is an absolute requirement for ensuring proper M&V ex-post analysis and programme impact assessment.

In a joint venture with a company that offers energy services to household consumers for improving their energy performance, the independent aggregator could overcome technological and cost challenges that this requirement implies. For a business model where an aggregator bids into the market, there is a significant risk of not reaching scale and ending up in the so-called technological valley of death [27], where costs overburden the business model. In this context, the combined effort of an energy savings and flexibility aggregator model should become a viable option, as the revenue is primarily focused on the avoided energy costs derived from savings.

Moreover, this opens up possibilities for the flexibility aggregator to participate in the energy savings market, which could become more attractive if savings purchase market would be established on the national level. Additionally, if suppliers would be able to purchase verified energy savings from a flexibility aggregator, this could also solve the risk of imbalance between the two involved parties on the energy market.

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