MARKET MODELS FOR LOCAL FLEXIBILITY PROCUREMENT: INTERFLEX' EXPERIENCE AND MAIN CHALLENGES

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ABSTRACT

The use of flexibilities by DSOs to optimize the grid raises new questions related to the regulatory and market framework. This paper presents the different approaches taken within the InterFlex project to mobilise flexibilities. It tackles some of the major issues regarding the use of flexibilities in distribution grids. It identifies the challenges the project stakeholders are facing and presents a series of highly innovative mechanisms put in place in four of the project's demonstrators to foster the local use of flexibilities and contribute to the energy transition.

INTRODUCTION: THE USE OF LOCAL FLEXIBILITY FOR DSO NEEDS WITHIN INTERFLEX

The development of flexibilities at a local level to empower distribution systems

Europe's journey towards a low carbon and digital economy is inducing major changes in the way electricity is generated, transported and consumed. Distributed renewable energy sources such as wind or solar power have reached significant shares. New uses of electricity have emerged, and there is still much to come such as the ongoing development of e-mobility and its millions of electric vehicle charging stations. In the near future, power quality could be compromised in terms of voltage limit violations and overloaded lines. Distribution System Operators (DSOs) could reinforce grids, but demand response and storage could constitute an economically more profitable solution to solve network congestions.

Flexibilities will be essential to ensure cost-effective, secure, and sustainable energy systems. While they are already being traded on the national balancing markets, their use at the local scale opens up new pathways for DSOs. The latter will play a major role in exploring the various benefits of flexibilities for their own needs (Table 1) and for service provisions to TSOs. Accenture's Digitally Enabled Grid research [1] shows that a majority (70 percent) of utility executives see growth opportunities in platforms providing flexibility services, allowing service suppliers and consumers to participate in demand response and ancillary service markets.

Within InterFlex, flexibilities bring different solutions to DSOs

InterFlex is a DSO-coordinated demonstration project supported by the European Commission within the framework of the Research and Innovation Program Horizon 2020. The trade of flexibilities for distribution grid purposes, in 4 European countries, is operated through different tools and platforms (Figure 1).

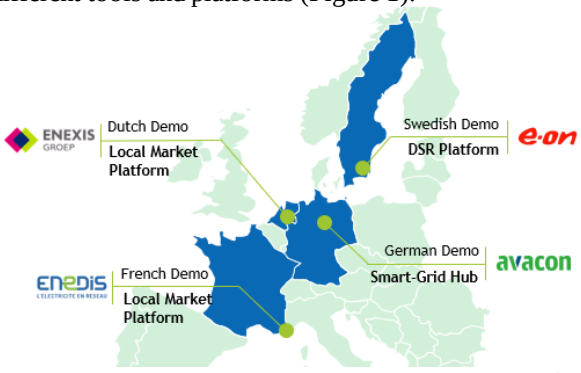

Figure 1: InterFlex demonstrators, stakeholders and platforms

The InterFlex consortium members aim to explore how the active use of flexibilities in local electric systems can help to optimise them.
Flexibilities can arise from a wide range of distributed solutions (Figure 2).

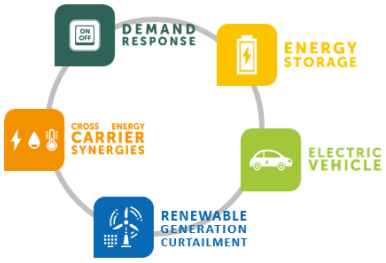

Figure 2 : Flexibility sources

The project explores the interest and limits for the DSOs to procure and use flexibilities, in relation with the Clean Energy Package discussions. The DSOs use flexibilities to address the new challenges they face on distribution networks (Table 1).

DSO need	InterFlex Use Cases
Grid operation Constraint due to extreme conditions	Enexis can buy flex to avoid congestions Flexible loads are used to relieve congestion Enedis can buy flex to avoid congestions
Grid operation Situation of incident	Enedis uses flexibilities in case of a network incident
Grid operation Planned maintenance	Enedis avoids back-up solutions for maintenance
Grid development Flexibility to avoid grid reinforcement	Enexis buys flex to avoid or postpone reinforcement Avacon Smart Grid Hub increases hosting capacity
System operation Balancing	E.ON manages balancing in **islanding mode** Flexibility to optimise the DSO balancing circle

Table 1 : DSO needs and uses of flexibility

DIFFERENT APPROACHES TO MOBILISE FLEXIBILITIES

Integrated and market approaches are tested within the InterFlex project.

Flexibility activations are triggered by identified needs (requests). Offers can either be market driven (market approach) or directly controlled (integrated). To mobilise different flexibility sources, InterFlex is testing:

- an integrated approach where the DSO is the flexibility operator or aggregator. No external aggregator or other third party is involved.
- a market approach where the DSO procures flexibility from market stakeholders (aggregators, consumers, generators, etc.).

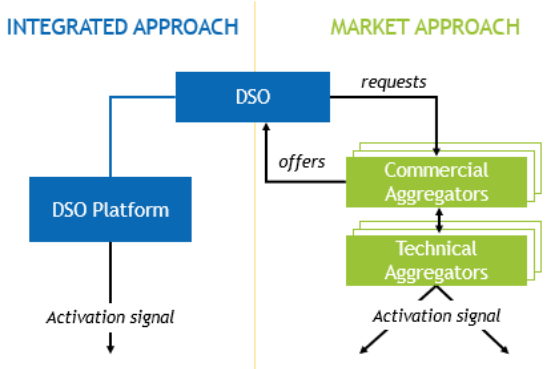

Figure 3: Integrated vs Market approach

The integrated approach is tested in 2 different InterFlex demonstrators. In the German demo, Avacon directly manages residential and generation assets through its platform called Smart Grid Hub (SGH). In the Swedish demo, E.ON directly controls residential assets through its Demand Side Response (DSR) platform to activate local flexibilities.

The market approach is tested in the Dutch and French demonstrators. The Dutch DSO Enexis requests activation of flexibilities through "commercial" aggregators (Jedlix, TNO, and Sympower). The latter can be contractually linked to one or several "technical" aggregators (Elaad and CroonWolter&Dros) which operate several assets with their own platform (optimisation of asset portfolio). Within the French demonstrator, Enedis mobilises its flexibilities through two commercial aggregators (ENGIE and EDF) following the same principle, whereas they also play the role of the technical aggregator. The gas DSO (GRDF) acts as a pure technical aggregator as it is connecting flexible hybrid assets to the gas distribution grid accessible to commercial aggregators. Together, all partners developed an aggregation platform, control chains and bid algorithms.

Both approaches present limits as well as business opportunities

Today, the integrated approach is relatively limited by the regulatory framework.

In most European countries, unbundling rules prevent the DSOs from directly controlling behind-the-meter assets as this is considered a market (unregulated) activity.

In Germany, the Renewable Energy Act enables the DSOs to directly curtail Distributed Energy Resource (DER) production in critical grid situations. The Smart Grid Hub developed within InterFlex enables Avacon to perform curtailment actions on the low voltage grid with precision and effectiveness. In addition, flexible loads, such as heat pumps or storage heaters, qualify for a reduced grid charge if flexibility management is accepted. The DSO indirectly controls these assets via the definition of peak and off-peak windows. However, the extent to which DSOs can leverage the peak / off-peak scheme for optimisation of grid operations and the increase of DER hosting capacity is currently unclear. Regulation needs to clarify the role of the DSOs.

In Sweden, DSOs can cover unregulated activities as long as they stick to the existing unbundling rules. As such, new types of customer services are under development within E.ON. Still, the DSO is never allowed to trade energy. To directly control the customers' assets, a bilateral contract is always needed.

InterFlex is building the foundations of future viable and replicable flexibility markets.

Flexibility markets at a local scale are not yet industrialised in Europe. InterFlex is conducting several experiments to demonstrate the value of this approach and to propose new frameworks between market stakeholders.

Discussions towards a market-based approach in Germany are underway, in particular a revision of the Energy Markets Law EnWG §14a, regarding controllable loads and curtailment mechanisms. The SGH developed in InterFlex would be the tool to enable these yet-to-be-defined use cases and mechanisms.

The market model developed in the Dutch and in the French demonstrators can be considered as a long-term and viable approach on a large scale. The aim of the stakeholders is to prepare DSOs and future market participants to the evolution of flexibility markets at local levels and to simulate such a market with actual customers and aggregators. Market processes as well as the aggregation platform will be consolidated thanks to ongoing field experiments to achieve replicability. The platform architecture and communication between commercial and technical aggregators is based on standard protocols and interfaces. It can be reused and implemented by other stakeholders. Development of a mature DSO flexibility market is highly dependent on involvement from local technical aggregators and commercial aggregators at a national scale.

Both approaches are necessary to answer all of the DSO's needs and unlock maximum flexibility potential

Neither approach can meet the DSOs' needs alone

A flexibility product is characterised by several parameters: period of the day, maximum duration, capacity of power curtailment/increase and notice delay. The DSOs' needs introduce different time scales at different levels. Notice delays can impact which need can be addressed. There is a duality between constraints that can be managed by market flexibilities and others that cannot. Facing this difficulty, InterFlex is testing network incident management with flexibilities, a case that requires particularly high reactivity. Enexis investigates the integrated approach with a "flexible capacity" contract for customers to solve unforeseen constraints. The DSO has the possibility to administratively reduce the network connection capacity during a certain time. Consumers benefit in return from a grid tariff reduction.

A combination of both approaches to foster the development of flexibilities.

The major benefit of the integrated approach is that the DSO has direct access to full capacity of flexibilities when required. However, the DSO has no access to existing capacity that cannot be operated directly for regulatory reasons, such as consumer asset flexibilities.

The major challenge of the market approach is to ensure that all flexibilities identified on the network are available when needed. This approach usually requires a minimum entry capacity for the stakeholders to join the market platform. Locally, the market approach has to respect two constraints: avoid a dominant position of one of the market stakeholders and have sufficient quantity and liquidity of flexibilities in the area.

Besides, the availability of flexibilities depends on the given local context. When a flexibility is requested by the DSO, the flexibility provider may only provide a portion of the requirements depending on what is locally available.

One of the main challenges of the market design is that the flexibility type is bound to the flexibility provider and its flexible asset. A diversification of approaches would bring out different types of flexibilities (duration, notice delay, etc.) allowing to meet varying DSOs' needs.

FLEXIBILITY ACTIVATION AND INCIDENT PLANNING

InterFlex differentiates three types of mechanisms to activate flexibilities for the DSO

Within InterFlex, different activation mechanisms are used depending on the purposes of the flexibility.

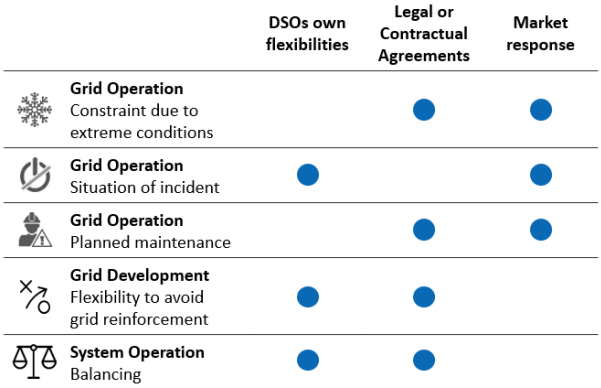

Figure 4: Activation mechanisms for DSO needs in InterFlex

DSOs' own flexibilities

DSOs own and directly control assets in this mechanism. They can decide to activate flexibilities without involving any third parties.

In Sweden, a centralised battery provides flexibilities to manage islanding of a microgrid, including frequency control. A storage system installed in the French demo delivers complementary service to the DSO. Enedis explores the operation and direct control of a battery which can provide flexibility on short notice to relieve grid constraints if necessary. It is used as an alternative to traditional copper reinforcement solutions for outages or maintenance.

DSO	Examples of DSOs' own flexibilities
Enedis	Flexibilities provided by batteries.
E.ON	Flexibilities provided by a central battery and a back-up generator (microgrid)

Legal or Contractual Agreements

The Contractual Agreement is a mechanism with a bilateral contract between the DSO and the flexibility provider (consumer, producer, aggregator) which defines the conditions of flexibility activation.

In some countries such as Germany, stakeholders have a legal obligation to provide flexibility to the DSO. In the terms defined by law and in case of grid congestion in Germany, renewable energy producers (mainly solar) can

temporarily be curtailed. The DSO sends a signal to the flexibility owners which are required to respond by a servitude mechanism. Besides, customers with flexible loads have control boxes on their premises, according to the terms and conditions of the contractual agreement. Avacon relies on SCADA to determine its need for flexibility. The Smart Grid Hub collects data from smart meters, monitors the grid situation, qualifies the flexibility availability and sends activation signals to control boxes.
In Sweden, E.ON has contractual agreements with customers and manage residential assets (water boilers, heat pumps, batteries) by sending a signal from its control system. Depending on the terms of the contract, flexibility activation is either directly controlled by the DSO (E.ON, Avacon) or depends on the respect of the contract by the consumer or the aggregator (Enexis' variable contracts).

DSO	Examples of Contractual Agreement
E.ON	Flexibilities provided by wind and PV curtailment, controllable residential assets (water boilers, heat pumps, batteries).
Avacon	Flexibilities provided by heating devices, batteries, and EV (smart charging).
Enexis	Flexibilities provided by variable capacity.

Market response

The market mechanism is where the flexibility provider bids in response to a DSO market demand and activates its flexibility according to market rules and results.
In the Dutch and French demos, the DSOs send their flexibility requests to aggregators through their respective market platforms. The aggregators have a contractual agreement with the flexibility providers and in certain cases can control their assets through their own platform.
In France, aggregators have contractual agreements with different consumers to test behaviour-based flexibility (consumption curtailment after receiving text messages) or steered flexibility (electrical assets curtailment with dedicated box or Linky smart meter). Flexibility forecasts appears to be a major challenge to industrialise the approach: the DSO shall publish opportunities for the use of flexibility to have aggregators make relevant market offers, and the aggregators shall forecast flexibility availabilities to meet upcoming DSO requests.

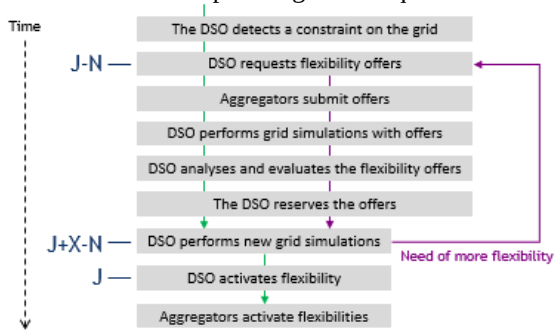

Figure 5: Market process for French demonstrator

DSO	Examples of Market Response
Enedis	Flexibilities provided by B2B and B2C Demand Response, Smart EV, Batteries, Dual energy heaters and CHP.
Enexis	Flexibilities provided by PV curtailment, batteries, and EV (smart charging).

Today, the DSOs manage most of the risk of incident. Tomorrow, a risk management process should be defined and set up.

During the setup phase of most balancing and capacity markets, TSOs have faced instances of failure or unavailability of demand reductions. This is also a major risk for DSOs in local flexibility markets, which is amplified by the need to source flexibilities in a geographically restrained area. Stakeholder engagement rates on local flexibility markets should be measured. Market actors should cover the risk of the flexibility inactivation. Today, with the small volume of flexibilities used in the distribution networks, the risk for mismatch or lack of offers is high. The risk of incidents is mainly covered by the DSO.

In one of Avacon's use cases, flexible loads are activated via direct control. In another one, PV producers are responsible to respond to DSO signals otherwise they have penalties including loss of feed-in tariff. Hence the risk for flexibility to be unavailable or unresponsive is low. For a seamless transition to more powerful and effective flexibility mechanisms, the DSO-wide installation of control boxes must be secured under the regulatory framework of DSO and metering service provider in Germany. With the roll-out of smart meters, the activation of flexibility can be carried out via the smart meter framework as demonstrated in InterFlex.

E.ON, as system operator of a local microgrid in Sweden, manages the risk of imbalance due to lack of flexibility in islanding mode. Customers are not obligated to participate actively, nor to grant E.ON control of their assets. Hence, taking the customer's perspective into account is fundamental. The project is an opportunity to measure customers' willingness to provide flexibilities.

In the Netherlands, the risks of incident due to unavailable flexibility rest entirely with the DSO. In extreme conditions, if the network segment is overloaded and shut down due to congestion, Enexis is subject to penalties depending on the amount of disruption.

The French demo explores the possibility of sharing the risk among several stakeholders through a contractual approach. In order to deal with the constraints uncertainty on the grid, a process of flexibility reservation with related penalties for both parties in case of retraction is being introduced (Figure 5). Then, as soon as a flexibility offer

is confirmed, the risk is supported by the aggregator and the customer. Risk value is still to be addressed.
When flexibilities will be used at a large scale in the distribution network, particularly to avoid grid reinforcement, it will be necessary to develop risk management processes.

THE VALUE OF FLEXIBILITIES AND ITS DISTRIBUTION AMONG STAKEHOLDERS

Stakeholders must set a flexibility value that benefits the entire community while using incentives to stimulate the market

DSOs have to choose the most profitable solutions for social welfare. Hence flexibilities shall be used in situations where it can provide a solution that maximises profit for the whole community. Its value will depend on its use by the DSOs and the avoided cost as a result. In some demonstrators, DSOs have set up kick-starter approaches where the cost of flexibility is equal or greater than the cost of traditional solutions. Specific incentives are given to market players who provide the flexibility. Within InterFlex, the flexibility is evaluated based on different factors such as cost reduction of back-up solutions, reduced penalties for undistributed or injected energy, grid investment deferral, reduced losses on the network.

In Germany, renewable energy producers are being fully compensated for the loss of production at the price of the feed-in tariff. Consumers with flexible loads (heaters, wall boxes) benefit from a flat rate discount of grid charge (approximately 57% reduction). The current curtailment mechanism requires the DSO to carry out fair curtailments and distribute the amount of curtailed energy evenly across all relevant assets. Contrary to a merit order approach, this can lead to higher than necessary costs for congestion-induced curtailments.

A kick-starter approach has been set up in the Swedish demonstrator to show that a local electricity system can be 100 % powered by renewable energy sources. The flexibility value can be determined as follows:

- in case of overproduction, maximum value is the electricity price when curtailing wind or PV
- in case of overconsumption, maximum value is the cost of running up the back-up generator (HVO diesel)

Customers are paid a monthly compensation for their participation (100 SEK/month) and a variable portion based on the kWh provided (discount on original electricity grid invoice). The purpose is primarily to give the customers some compensation for the new equipment installed. It cannot be seen as a valuation of the flexibility.

In the Dutch demonstrator, there is no exchange of money: flex coins are used as virtual money (convertible in euros) to analyse money flows. In the Netherlands, DSOs are subject to pay relatively low penalties in case of outages for households. The flexibility price must preferably be compared to the investment in network to prevent outages in the future. Flexibility in a business case perspective will be mainly for congestion management in peak hours and so to postpone investments on this network segment.

In France, one major purpose of the demonstrator is to evaluate a possible economic match between offer and demand. On the one hand, the maximum DSO value of flexibility can be estimated to be equivalent to the penalties of the undistributed energy, i.e. 9200€/MWh for network incidents and 2500€/MWh for planned maintenance (see the Economic assessment report of smart grid solutions, [2]). The DSO's willingness to pay arises from the optimisation of both grid operation (Opex) and grid planning (Capex) using flexibilities. This value is bound to local grid specificities, and difficult to extrapolate. On the other hand, the flexibility service's minimum value is set by aggregators' costs (hardware, customer involvement, direct costs to participate in the markets) and their margins. A profitable market model is possible whenever costs & margins remain below the flexibility value for the DSO and for social welfare. The large-scale development of flexibilities is thus driven by two factors. Firstly, the flexibility value outpasses the minimum price, or occurrence probability that raises the aggregator's interest. Secondly, if there is no natural economically driven flexibility offer, financial incentives are necessary to aggregate relevant amount of flexibilities capabilities on specific localisation such as secondary substation or MV feeder scale.

CONCLUSION

InterFlex project sets up and manages local flexibility mechanisms in the field. Experiments demonstrate that both integrated and market-based flexibility solutions are necessary, in combination, to achieve the full potential of grid optimisation. Among the major identified challenges are the definition of a common market design, the industrialisation of local flexibility markets, as well as measures to create liquid markets and secure quality of supply by flexibility incident planning. InterFlex shows that current regulations lack definitions that would allow the marketing and sales of flexibility services. Furthermore, roles and business models for different actors should be defined to overcome financial hurdles to create the market.

REFERENCES

[1] Accenture research programs, 2018, "Digitally Enabled Grid", Accenture
[2] DSO analysis, 2017, "Economic assessment of smart grids solutions", Enedis and ADEeF

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