MERLIN

Modelling the Economic Reactions Linking Individual Networks

Milestone 2

A Review of International Experience in the use of smart electricity platforms for the procurement of flexibility services (Part 2 – Main Findings)

By **Karim L. Anaya** and **Michael G. Pollitt**

13/05/2020

UNIVERSITY OF CAMBRIDGE | Energy Policy Research Group

This is the Milestone 2 Report created by the University of Cambridge Energy Policy Research Group. The report analyses and evaluates the deployment of smart platforms that facilitate the trading of flexibility services and provides use cases from across the globe. The report is split into two parts, this being part 2, with the purpose of identifying key lessons that can be used for the MERLIN project.

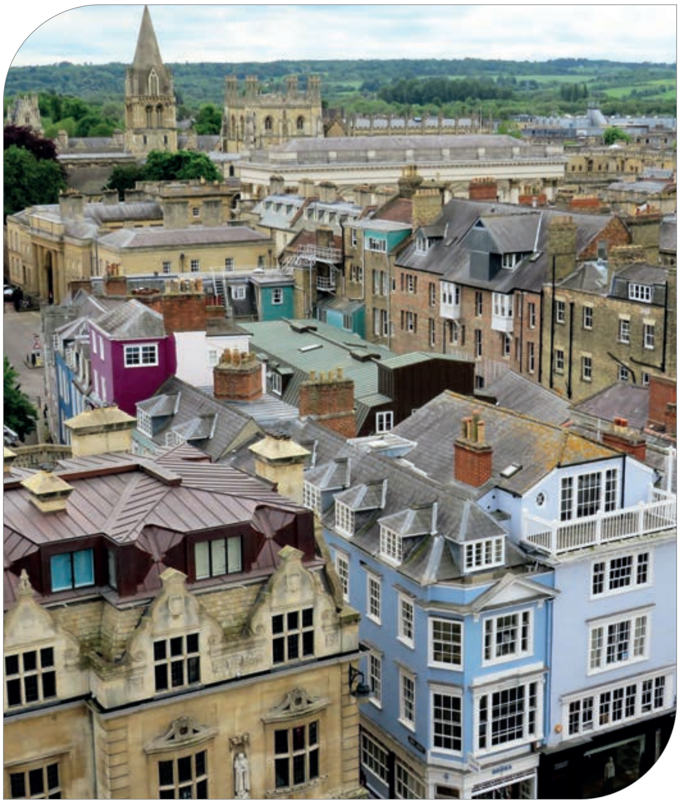
Contents

Section 1: Background

Project MERLIN[1] (Modelling the Economic Reactions Linking Individual Networks) aims to develop a transactive energy management system that optimises economic network investment, maximises the business case of industry investors (i.e. owners of distributed energy resources – DER) and delivers cost efficient energy to wider consumers. MERLIN will test new tools and capabilities for the distribution utility (SSEN) that will contribute to more efficient operation and investment planning and to better management and integration of DER, taking advantage of the flexibility services that these can offer. In Great Britain the transition from Distribution Network Operators (DNOs) to Distribution System Operators (DSOs) is being evaluated via different projects. MERLIN will contribute to the learning on this transition.

MERLIN will be implemented in the county of Oxfordshire (SSEN's Southern Network licence) and will benefit from a strong base of active customers, especially those that are already participating in other projects with SSEN such as Local Energy Oxfordshire (LEO)[2] and Transition[3]. A customised solution will be tested first in Fort William (SSEN's North of Scotland licence). LEO is the industry-first local energy system in Great Britain. A set of 'plug in projects' (covering different flexibility and energy services) are expected to be developed in order to test new market structures enabling network optimisation and flexibility, and to facilitate peer-to-peer trading. The Transition project is one of the workstreams to be delivered as part of LEO (Workstream 5). Transition aims to trial several models including 'price flexibility' (parties modify their demand/generation in response to price signal, network use at specific time/location) and 'contracted flexibility' (parties trade and contract flexibility services among them directly).

This report identifies the main findings of the 13 Use Cases in 7 jurisdictions evaluated in Milestone 1 Report[4]. The summary of the Use Cases is shown in Table 1.



1 The authors would like to acknowledge input from Alliander, Ausgrid, Avacon, ENA Australia, ENA UK, Enedis, Forschungsstelle für Energiewirtschaft e. V., National Grid ESO, NY State Department of Public Service, SSEN, Silicon Grid, Stedin, TenneT, Tepco, and UK Power Networks. They each provided valuable inputs to the report. The authors also acknowledge the financial support of SSEN via BEIS funded Power Forward Challenge – Pilot Scale Demonstration scheme. Any errors are the responsibility of the authors.

2 https://project-leo.co.uk

3 https://ssen-transition.com

4 https://project-merlin.co.uk

Table 1: Summary of Use Cases

Country	project/ initiative name	project leader(s)	type	start date	status
Australia	Battery Virtual Power Plant (VPP)	Ausgrid (DSO)	demonstrator	Jun-18	ongoing (Phase 1 completed)
France	Nice Smart Valley	Enedis (DSO)	demonstrator	Jan-17	end Dec. 2019
Germany	Avacon	Avacon (DSO)	demonstrator	Jan-17	end Dec. 2019
	The Altdorfer Flexmarkt (ALF)	FfE e.V.	demonstrator (proof of concept)	2017	ongoing (end in 2020)
GB	Power Potential	NGESO (TSO)	demonstrator	2017	ongoing (end in March 2021)
	Flexible Power	WPD (DNO)	BAU	Mar-19	ongoing
	Flexibility Services	UKPN (DNO)	BAU	Mar-19	ongoing
	Piclo Flex	Piclo	BAU	Mar-19	ongoing
	Cornwall Local Energy Market (CLEM)	Centrica	trial	May-19	ongoing (Phases 1 and 2 completed)
Japan	V2G Demonstrator Project Using EVs as Virtual Power Plant Resource	Tepco (integrated utility: DSO/TSO)	demonstrator (proof of concept)	Jun-18	ongoing (end in 2020)
Netherlands	Dynamo	Liander (DSO)	BAU	Q4 2017	ongoing
	GOPACS	TenneT (TSO) and 6 DSOs	BAU	Jan-19	ongoing (potential extension to first DSOs: Liander, Stedin)
Norway	Nodes	Nodes	BAU	2018	ongoing (different European countries)

Section 2: About the report

The aim of this report is to provide an expanded evaluation of the Use Cases described in Milestone 1 Report (Part 1), listed in Table 1, and to identify the main lessons for MERLIN. Most of the recommendations identified can be implemented or tested within the MERLIN trial. However, some limitations may exist for some of them (i.e. auction design) due to the trial implementation time. In any case, some recommendations can be potentially extended to other similar initiatives from SSEN (i.e. LEO, Transition).

The evaluation addresses six points that relate to: the use of smart architecture and solutions; market design for flexibility markets; the requirement for new business models; the value of flexibility; the most and least common trends; and the role of regulation. The questions are the following:

1. What are the recent developments in smart architectures and solutions for the procurement of flexibility services?
2. What are the different proposals for market design for the procurement of flexibility services?
3. Why are new business models required to capture the value of flexibility?
4. How do network operators value flexibility?
5. What are the most and least common trends in the acquisition of flexibility services and what is still missing?
6. Can regulation help to unlock the value of flexibility for a more efficient grid management and service provision?

The structure of the report is as follows. **Section 2** discusses briefly the smart architecture and solutions that have been developed in the Use Cases for the procurement of flexibility services. **Section 3** discusses different options for market designs across the Use Cases for contracting flexibility services, with a focus on their procurement methods and pricing rules, remuneration schemes, products (services) to be procured, flexibility providers and penalties. **Section 4** explains the new business models adopted across the Use Cases for contracting flexibility services with a focus on the cooperation with aggregators and independent platforms. **Section 5** discusses the value of flexibility and identifies a set of factors to be taken into account when defining the cost of counterfactuals. **Section 6** identifies the most and least common trends across the Use Cases and suggests a new auction mechanism approach. **Section 7** identifies key regulatory issues that can help to unlock the value of flexibility.

Section 3: Smart architecture and solutions

Most of the Use Cases acknowledge the development of smart architectures and solutions for the procurement of flexibility services in order to facilitate the communication, control of and access to different types of flexibility (flexible loads, generators, storage, others), data processing, activation of bids, optimal selection of bids, etc. Some of these developments are integrated within the Distribution System Operator (DSO), others within independent platforms and others are developed by aggregators. For instance, in the Nice Smart Valley Use Case, Enedis has developed the E-FLEX tool that allows the communication with aggregators via the Extensible Messaging and Presence Protocol (XMPP) channels, to receive bids and to call bids from them, to activate the most appropriate ones (suggested by Enedis), among others. Their respective aggregators (EdF, Engie) have also developed new tools to connect with E-FLEX. In the Avacon Use Case, the Smart Grid Hub (SGH) was developed to access and control generators of any type directly at low voltage level via digital switching. SGH is considered a single use of the Distributed Energy Resources Management System (DERMS). Power Potential has implemented a DERMS solution and also a new Platform for Ancillary Services (PAS) – a control and monitoring solution, which is the main interface between the system operator (NGESO) and DERMS. The Altdorfer Fleximart (ALF) platform proposes the development of the Smart Meter Gateway (SMGW) along with a control box for connecting, measuring and controlling different types of flexibilities. While in the Cornwall Local Energy Market (LCEM) and Western Power Distribution (WPD) Phase 2 Use Cases a new optimal clearing solution with identification of constraints has been developed by N-SIDE.

Lessons for MERLIN

MERLIN proposes the development of two systems within the Scottish and Southern Electricity Networks (SSEN)-owned distribution network: Open Grid Systems' Cimphony Concert and Opus One Solutions' GridOS systems (one for distribution planning and the other for transactive energy). The key thing for a successful smart architecture is that it is easy for participants to understand and access. Making it as easy as possible to participate in a local flexibility market is key. A proof of concept exercise is recommended to test the capabilities of both platforms and their interoperability with existing systems (at both SSEN's premises and those of the flexibility providers). A simulation of flexibility markets is also suggested to test optimisation algorithms, market rules etc. We would also recommend extensive stakeholder engagement to encourage market participation and feedback on the design of the smart interface.

Section 4: Market designs for flexibility services

Procurement method and pricing rule

With some exceptions (i.e. Avacon, Dynamo[5]), most of the network operators in the Use Cases use a market-based approach (i.e. tenders) for the procurement of flexibility services, including those procured via independent platforms and aggregators. In terms of pricing rules, we distinguish three types: pay-as-bid, regulated prices and pay-as-clear. The price formation of these three categories also varies across the Use Cases. Some of them use pay-as-bid or pay-as-clear with free prices, while others use pay-as-bid with some indication of regulated prices (i.e. in the form of maximum prices or ranges with lower/upper values per site), and still others pay regulated prices only, usually with fixed amounts or ceilings depending on the type of service to be procured. For instance, the use of free prices via pay-as-bid usually applies when flexibility services are contracted via platforms that are integrated within existing markets (i.e. Nodes, Gopacs with Energy Trading Platform Amsterdam – ETPA) or when services are contracted for balancing the system together with ancillary services (i.e. Power Potential, Vehicle to Grid (V2G) Virtual Power Plant (VPP) in Japan). Pay-as-clear with free prices is only used by WPD (Phase 2 project with CLEM).

In Great Britain (GB), most Distribution Network Operators (DNOs) involved with the procurement of flexibility services are within the second category (i.e. pay-as-bid, with some indication of regulated prices). Many of them provide an indication of maximum prices or lower and upper values at each substation.

This is the case for UK Power Networks (UKPN) in their procurement of flexibility services at HV (high voltage) sites. In France, even though the demonstrator project proposes a competitive mechanism using pay-as-bid to remunerate aggregators, the size of compensation appears to be limited to the value of flexibility that Enedis has estimated (up to 24€/kW/year). Results from this experiment suggest that the value is relatively low, which may discourage participation. Regulated prices (e.g. fixed amounts such as yearly lump-sum payments, vouchers, fixed prices per activation, prices in line with the loss of production, or in the form of discounts for grid charges regardless of utilisation) are mainly paid to small-scale customers such as residential customers (with flexible loads and small generating/storage units)[6].

These payments are in many cases made by aggregators (which are compensated by network operators for flexibility services), with some exceptions (such as the case of Avacon where the DSO compensates the residential customers). The size of this remuneration is sometimes agreed via a non-disclosure agreement (NDA) (e.g. Dynamo). This means that figures are not in the public domain or are only provided in the form of a range of values (e.g. Australia). The applicability of regulated prices to small-scale customers shows that in contrast to medium or large-scale customers (i.e. industrial, commercial, generators), residential customers are offered longer term contracts and then are exposed to lower levels of uncertainty. This may also imply lower levels of remuneration in comparison with the industrial/commercial customers – see for example the ALF Use Case in Germany.

5 Dynamo pays a regulated price to the aggregator for flexibility services; however, the selection of the aggregator was based via competition.

6 An exception to this rule is Dynamo, where a regulated price is paid by the DSO to the aggregator, due to the limited number of aggregators that can provide flexibility services in the MV substation when it is required.

Remuneration Scheme

Depending on the type of service, network operators compensate flexibility providers using different types of payments: utilisation (or dispatch, or in the form of spread payment), reserve (e.g. availability, arming) or other types (e.g. activations, service fee, etc.). We observe that the type of payment set in many of the Use Cases is in line with the way similar services are already being compensated in related national markets for constraint management, reserves, reactive power (e.g. flexibility services procured by DNOs in GB, Dynamo, V2G VPP in Japan[7], Power Potential, ALF for short-term products and the services procured via Gopacs and Nodes).

There would appear to be some standardisation (at least within the same jurisdiction) in the remuneration schemes for flexibility services. However, there is less agreement in terms of the value that network operators provide to each payment component, especially for schemes where prices are not set "free" but are exposed to regulated elements. For instance, while WPD allocates a percentage value to each component (i.e. utilisation, availability) regardless of the site with an average value of £300/MWh (excluding Restore service), UKPN indicates lower and upper values related to the total payment to be made at each HV site. Other Use Cases such as Nice Smart Valley in France are exposed to a lower value of flexibility due to the fixed amount estimated by Enedis, while in Dynamo, Liander values utilisation and availability similarly. Section 5 discusses further how network operators value flexibility.

Products/services

Most of the services identified in the Use Cases are for managing network constraints mainly via demand response (i.e. increase/reduction in demand, generation, storage) and also in a few cases ancillary services (i.e. reactive power, voltage management). Most of them are procured by DSOs (DNOs in GB), some of them can be procured by both distribution and transmission network operators simultaneously (Nodes, Gopacs, CLEM with WPD Phase 2 project), and only one by the system operator in GB (Power Potential). The name of the services varies across Use Cases with some level of standardisation noticed in those under Business as Usual (BAU) operation such as in Japan (RR-FIT) and in GB (flexibility services offered by DNOs).

However, in the case of GB, even though DNOs may refer to the same service specifications, the names of some services still vary across DNOs. DNOs are in the process of standardising the naming of flexibility services based on Energy Networks Association (ENA) recommendations[8]. Depending on the type of service, we notice two kinds of trading period: short term (i.e. day-ahead, intra-day) or medium/long term (e.g. weeks/months/years ahead). We observe that most distribution utilities are offering a short-term trading period (except for flexibility services procured by UKPN and WPD but including the case of the Cornwall Local Energy Market with WPD phase 2). For some Use Cases, the trading period is in line with the current rules for the procurement of similar services in other markets (i.e. V2G VPP in Japan, Dynamo, Nice Smart Valley, ALF).

7 In this case, Replacement Reserve will be procured in 2021, however rules regarding remuneration have already been established.

8 There are four proposed branding names: sustain, secure, dynamic and restore, for details see: https://www.energynetworks.org/assets/files/ON-WS1A-Product%20Definitions%20Updated-PUBLISHED.pdf

Flexibility providers

We identify a large range of flexibility providers using diverse technologies including flexible loads (e.g. heat pumps, hybrid systems, cooling systems), generation and storage units (including EV batteries). Flexibility providers can benefit from revenue stacking only if it does not compromise the contracted capacity (i.e. avoidance of double activation) and in some cases their participation is subject to a minimum capacity on an aggregated or individual basis (i.e. Power Potential, UKPN and other DNOs).

In contrast with the typical flexibility providers represented by larger customers (e.g. business, commercial) and medium-large sized generators/storage systems[9], the participation of residential customers in the provision of flexibility is permitted in many of the Use Cases. The participation of residential customers in flexibility markets is expected to grow in importance. However due to the limited size of their flexibility, a third party (i.e. aggregator or supplier) is required to facilitate residential trading, making the whole flexibility package more attractive for network operators. In addition, smart meters can also help to understand and better forecast the flexibility performance of residential customers[10], which can be translated into a more cost-reflective compensation scheme.

Penalties

Penalties seem superficially attractive, but in practice they appear to be expensive to impose because of flexibility providers' risk aversion. Non-payment for utilisation can be a large penalty in itself. However, there is an issue over availability payments needing some punishment to encourage actual availability. From the Use Cases, we observe how penalties are currently applied. Penalties for non-delivery are in the form of loss of revenues instead (sometimes with specific rules per type of payment and service). Some of them are supported by DSO and Feed-in Tariff (FIT) regulation (e.g. Avacon in Germany)[11] and others with specific methodologies that recall business as usual (BAU) operation rules (e.g. WPD and UK Power Networks from GB in the procurement of flexibility services via demand response[12], V2G VPP Japan in line with balancing services, in Gopacs based on ETPA terms and conditions, etc.). There are also a group of Use Cases where penalty schemes have not been defined yet or are not imposed.

9 These are the types of customers that usually participate in the provision of balancing services procured by system operators (i.e. demand response schemes).

10 This opens an interesting debate about the management of and access to customers' data. Are independent aggregators or DSOs allowed to get this data? Is the access restricted to suppliers/retailers? Rules vary across jurisdictions with some of them already offering "one stop shop" for data (i.e. Norway with Elhub which was put into operation in November 2019), https://www.statnett.no/en/about-statnett/news-and-press-releases/news-archive-2019/elhub-is-now-operational/

11 Loss of the network charge discount (Section 15aEnWG) for flexible loads and loss of compensation (FIT) for DER.

12 WPD proposes a more sophisticated methodology in comparison with UKPN. For instance, both define a threshold (of delivery performance: DP) where flexibility providers can be compensated fully if DP$\geq$ 90% or 95% respectively, however for lower values UKPN applies a linear relationship between the ratio of payment and DP, if DP< 60% no payment is made (UKPN, 2020). On the other hand, WPD applies a non-linear approach. According to WPD and based on its previous experience a linear relationship between utilisation payments and delivery does not incentivise the accurate declaration of capacity by flexibility providers (WPD, 2019a).

Lessons for MERLIN

Clear rules regarding the market design to be adopted with specific specifications according to the type of service to be procured are required. Similar to most of the Use Cases, MERLIN is evaluating a variety of services to be procured not only for grid management but also for peer-to-peer transactions (subject to approval of initial arrangement for network security purposes)[13]. Some of the services are currently offered in demand side markets (i.e. DSO constraint management) but some others are new proposals for distribution utilities (e.g. offsetting, authorised supply capacity trading). For more established services we would recommend similar rules to the current ones applied by the DNO (with respect to names, type of compensation, and penalty schemes) in order to ensure consistency, standardisation and stakeholder buy-in.

In terms of penalties, non-payment for non-delivery is a significant penalty. It is a good idea to have some penalty in the case of non-delivery during a specific event where flexibility was requested but not delivered by a contracted party. This penalty would vary from non-payment of utilisation payment if the contract was 100% on utilisation payment only, to some fraction of the availability payment if the payment were 100% on availability only. For the UK capacity market non-delivery penalties for an individual unit are capped at 200% of monthly capacity payments.[14]

13 The proposed services are: (1) DSO Constraint Management (2) Offsetting, (3) Voltage Management, (4) Authorised Supply Capacity Trading, and (5) Peak Reactive Service. The selection of services is based on the ones identified in the Transition and LEO projects (SSEN, 2020).

14 https://www.emrdeliverybody.com/CM/Delivery.aspx

Section 5: The need for new business models

Network operators are using different ways to procure flexibility services. Some of them are testing more than one channel, such as WPD (via its own platform, Piclo Flex and CLEM), Liander (with Dynamo and very soon via Gopacs too), Ausgrid with Battery VPP and additional demand response programmes (part of Power2U Program). Except for Avacon, the participation of aggregators (which can be compulsory or optional) is acknowledged across all the Use Cases. According to IRENA (2019), aggregators provide services that help to operate the power system such as: local flexibility (to DSOs subject to the existence of a local market), load shifting (in the form of demand side response to grid operators) and balancing services (such as ancillary services). Some network operators allow the procurement of flexibility services via a single aggregator (i.e. Battery VPP in Australia, Dynamo). Sometimes the decision of having one aggregator only is due to a lack of participation in congested areas at specific sites (i.e. HV/MV substations).

This is the situation in the case of Dynamo. For this reason, the remuneration scheme agreed between the network operator and aggregator is via regulated prices. Others require the participation of at least two aggregators to incentivise competition (i.e. Nice Smart Valley). The advantage of contracting with aggregators is that it mitigates the risks of non-delivery (aggregators compile and manage bulk capacity from a portfolio of flexibility providers). Aggregators also facilitate the participation of residential customers in the provision of flexibility services to network operators (by aggregating flexibility including flexible loads and small-scale generation and storage). However, the rules regarding the role of "independent aggregators[15]" are not clear across the jurisdictions. For instance, France and Belgium are among the few European countries with specific rules for independent aggregators (IEA, 2019)[16]. Independent aggregators may be discouraged from participating in specific markets (e.g. wholesale, ancillary services).

Independent platforms are also evolving and bringing new options for procuring flexibility services. Procuring flexibility services via independent platforms, especially those integrated within existing markets (e.g. Gopacs, Nodes), increases the chance of matching supply and demand. These platforms allow the participation of DSOs and the TSO and are examples of coordination platforms (i.e. DSO-TSO), preventing any conflicts as a result of congestion-related action by the DSOs or TSO. ALF is the other independent platform operated by Forschungsstelle für Energiewirtschaft e. V.(FfE), that in common with the two previous ones allows the matching of supply and demand orders; however it is still under proof of concept. According to FfE, it is not clear whether ALF will continue as an independent platform or will be integrated into the DSO. This is an ongoing discussion where the role of "platform operator" has not been defined and its operation by DSO is an option.

Lessons for MERLIN

New business models that work depend on there being underlying sources of value to society that can be monetised. It is the role of the DSO in projects like MERLIN to identify what those sources of value are and to market test them. It may be that new business models can be facilitated by actively encouraging DER and aggregator participation and potentially by signing exclusive contracts with a single aggregator, to whom encouraging participation is then delegated.

15 Those that do not act as electricity suppliers. Suppliers can also act as aggregators.

16 For further discussion about independent aggregators and their participation in flexibility markets (i.e. demand response) see Bray and Woodman (2019).

Section 6: The value of flexibility

The value of flexibility depends on where, when and for what it is needed. Based on their frequency of use (among other factors) it can be remunerated with a single payment or via a combination of utilisation, availability, and other types of payment. Different weights can be allocated to each type of payment (i.e. the case of WPD with a combination of ratios per type of payment). From the Use Cases, only a few of them provide some indication about how the value of flexibility has been estimated (i.e. in the form of maximum/minimum payments). The decision to provide an indication of the value of flexibility depends also on the maturity of the flexibility market and whether this is integrated into an existing market (e.g. intra-day, day-ahead wholesale)[17].

The procurement of flexibility services by DNOs in GB is relatively new (starting in 2019 as BAU). This means that potential flexibility providers may still need an indication of the size of their payments. However, in the case of Gopacs, Nodes and also V2G VPP in Japan (all these are integrated or are due to be integrated in existing markets), a pay-as-bid approach is used with free prices and without any indication of potential gains. This makes sense because the number of flexibility providers is potentially larger, increasing participation and liquidity.

From the Use Cases we observe WPD uses a maximum value irrespective of the site (set at £300/MWh)[18], UKPN provides a range of minimum and maximum values associated to each HV site as a result of cost benefit analysis and Enedis proposes a maximum value irrespective of the site[19]. However, none of them provide details of the methodology used[20]. In the case of WPD the value is just an indication from a previous project.

The value of flexibility can be estimated based on the cost of counterfactual solutions to solve the problem. For instance, if there is a need to reinforce the network, the value of flexibility is associated with the cost of deferred capital[21]. This can be estimated as an annual figure in order to compare the maximum amount the distribution utility would spend in flexibility per year at a specific point of the network. The value of flexibility services should also consider regulatory incentives and total costs (totex). In GB, the RIIO-ED1 totex allowance provides financial incentives to DNOs to optimally trade off capital and operating costs in order to minimise total costs. Financial incentives (or penalties) also apply to (1) quality of service measures such as Customer Minute Lost – CML and Customer Interruptions – CI[22]; (2) connections (time to connect incentive); (3) customer services (related to social obligations output) and (4) losses (a discretionary reward scheme).

17 It also may depend on the type of auction mechanism that is used. For instance, reverse auctions require a starting reference price provided by the buyer (i.e. it could be the costs of the conventional solution to solve the problem: network reinforcement, diesel generation costs etc.).

18 WPD has suggested the use of a pay-as-clear approach (with free prices) when there is enough competition, however results from the experiment (CLEM with WPD Phase 2), suggest that flexibility providers have continued bidding at prices close to this value.

19 The other Use Case is Avacon, however the value is established via regulation (i.e. network grid discounts offered by the DSO).

20 A brief explanation is provided by Enedis (see Enedis-ADEeF (2017)), however this is a general value that is not associated with the problem to be solved in Nice Smart Valley Use Case.

21 Flexibility can be an alternative to network reinforcement, however, in practice different potential options need to be evaluated by distribution utilities such as reconfiguration of the existing network with appropriate switching in and out of equipment and the use of utility only assets (i.e. a voltage tap changer), or the use of assets that can be run hotter for longer with better maintenance etc.

22 The largest incentives come from the Interruptions Incentive Scheme – IIS (composed of CML and CI). For instance, for the period 2017-2018 IIS incentives represented around 70% of the total incentives (Ofgem, 2019).

The case for the inclusion of option value is less clear. This requires a probabilistic view of the future. It is quite difficult to provide a comprehensive and passably accurate set of all the relevant future scenarios in which the participation of an asset or DER solution might appear. As Damodaran (2015) makes clear in chapter 5 (on Real Option Valuation)[23] of his text book, the problem with real options is that they are a qualitative and somewhat subjective way of departing from normal investment appraisal. They are particularly popular and useful in natural resource sectors, or sectors with exclusive rights (e.g. investment in a patent protected technology).

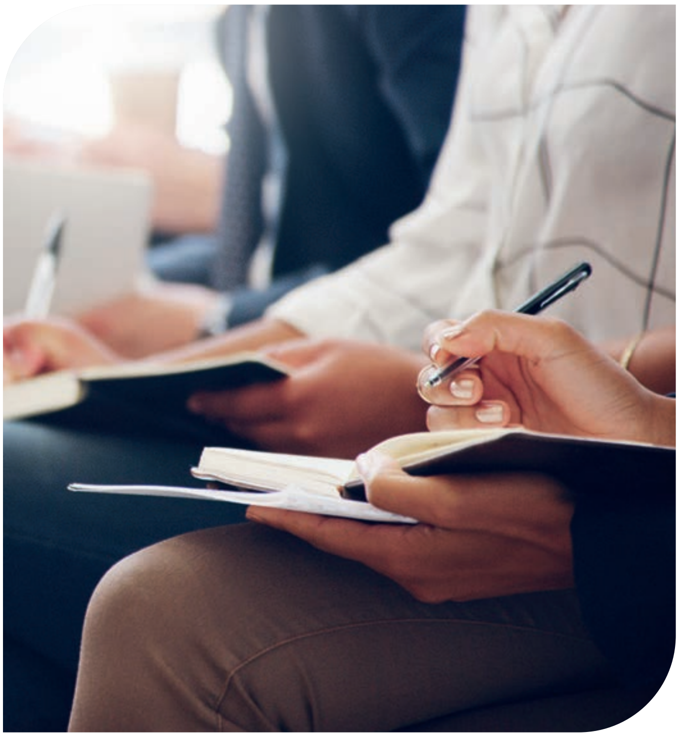
They should be treated with caution under the following circumstances: first, when the initial investment is not a pre-requisite to subsequent investments; second, when the firm does not have the exclusive right to make subsequent investments; and third, when, the option investment does not give sustained advantage. These criticisms apply in a world of uncertainty about the future path of technology for flexibility within the electricity sector. Another problem, as Damodaran (2015) notes, with non-tradeable options is that they will inevitably not be fully reflected in the valuation of a private firm. For a regulated firm this translates to the risk that the regulator might not fully recognise the cost of a real option in its regulatory asset base.

23 Available at: http://people.stern.nyu.edu/adamodar/pdfiles/DSV2/Ch5.pdf

If option value is to recognised at all in a regulatory setting, there has to be a cap on it, as there is in every other sphere of economic activity. This is because if there is not one can end up justifying large amounts to be spent on contingencies most of which will never be realised and which will therefore be difficult to justify ex post[24]. So the bottom line is that society is only willing to pay a small additional cost only to avoid very large but low probability events in the future.[25]

Some jurisdictions such as New York have suggested a common methodology for valuing flexibility with a focus on those provided by DER. Each of the six distribution utilities in New York State (known as Investor-owned utilities – IOUs)[26] has produced its own document on how to do cost benefit analysis of DER[27]. The documents are careful to point out the dangers of double counting and the need to carefully work out whether a category of benefit is additional to others already included. The methodology identifies four pots of benefits (e.g. bulk system, distribution system, reliability/resiliency and external) and costs (including incentives to participate). An interesting approach is the credit given to community generation (at 2.25c/kWh) (NYPSC, 2019). This raises the issue of an additional value to be put on community DER, not captured elsewhere.

After selecting and estimating the respective values for each factor, the next step is to estimate the total costs of the counterfactual which reflects the willingness to pay for flexibility. Depending on the type of service and estimations of its use, the total value can then be expressed in single components (i.e. maximum annual availability and utilisation prices.



Lessons for MERLIN

MERLIN needs to publish the principles on which it will evaluate the value of flexibility at a given network node and hence its willingness to pay for flexibility (in line with the different services to be procured). This would involve building on the benefit-cost of DER methodologies outlined by the New York utilities (IOUs), suitably adapted for the UK context by making use of values in line with HM Treasury guidance on social cost benefit analysis. Our recommendation is in line with the recent proposal of ENA Open Networks Project (Workstream 1A – Flexibility Services) regarding the need to account for a common methodology across DNOs for Active Network Management (ANM) vs Flexibility vs Reinforcement vs other options (ENA, 2020).

24 For option value in transmission planning, see van der Weijde and Hobbs (2010). For a good discussion of the role of option value in investments more generally, see Copeland and Keenan (1998). See: https://faculty.fuqua.duke.edu/~charvey/Teaching/BA456_2006/McK98_2.pdf

25 Ten percent of the value of an asset might seem a reasonable cap on the additional cost to build in some option value – this is because this is a reasonable contingency which is built into the normal build cost over-run risk. However, any amount of option value expenditure must be carefully justified.

26 ConEdison, National Grid, Central Hudson Gas & Electric, New York State Electric and Gas Corp, Rochester Gas & Electric, Orange & Rockland Utilities.

27 The conEdison Benefit Cost Analysis Handbook can be found at: https://www.coned.com/-/media/files/coned/documents/our-energy-future/our-energy-projects/coned-bcah.pdf?la=en

MERLIN

Section 7: Most and least common trends and what is still missing

Most common trends

Many of the Use Cases involve the procurement of a set of flexibility services (i.e. multiple products provided by a diverse range of technologies) which aim to solve different types of grid constraints, with a focus on congestion at the distribution level. Among the most common technologies are solar PV, storage systems (including domestic batteries), wind turbines, flexible loads (such as heat pumps or CHP). There is also a combination of different remuneration schemes, with utilisation and availability payments, with pay-as-bid (including those with regulated components) being the most common approach. The participation of third parties such as aggregators is also allowed in most of the Use Cases. In some cases their participation can be compulsory (e.g. Battery VPP, V2G VPP Japan, Nice Smart Valley, Dynamo), in others optional (e.g. ALF, WPD with Flexible Power, UKPN, Power Potential). Independent platforms are also evolving, and many DSOs are using them (or planning to) as an alternative way to procure flexibility services.

Least common trends

Only a few of the Use Cases specify the procurement of ancillary services, especially in the form of reactive power/voltage management. In terms of flexibility services, Nice Smart Valley is the only one where flexibility is also provided by customers with hybrid systems (i.e. by switching from gas and electricity to only gas in case of network constraints)[28]. The matching of supply and demand orders are only observed in platforms that are integrated within existing markets, with the exception of ALF which also offers this matching (still in "proof of concept"). Gopacs is the only one where the "intraday congestion spread" is paid instead by the network operator (TSO or DSO) that requires the flexibility service (estimated by the price difference between the seller and buy orders)[29]. In comparison with other distribution utilities, several DNOs from GB are already procuring flexibility services via Piclo Flex as BAU. Gopacs is still in the process of being adopted by DSOs, having already been adopted by the TSO (TenneT) as BAU. In terms of the pricing rule, CLEM with WPD (Phase 2) is the only Use Case with a pay-as-clear proposal[30]. This approach is in line with the new pricing strategy proposed by WPD[31].

28 A hybrid system produces both heating and domestic hot water using gas or electricity. The selection of the most efficient generator is managed by an intelligent control system. This is the first time in France that a remote control was built in order to manage gas appliances (InterFLEX-Enedis, 2019).

29 According to Stedin, the probability of having no matching orders is very low, due to the interaction of Gopacs with the existing market with sufficient liquidity. However, if this happens the market model changes to the mandatory regime, where bidding is required.

30 WPD performs a N-2 test to determine whether or not to proceed with the pay-as-clear approach. The test provides information about the zones with enough participation to be applicable for clearing, otherwise the maximum price approach (i.e. £300/MWh) applies instead (WPD, 2019b).

31 Composed of three phases: Phase 1 fixed (current situation with a maximum value of £300/MWh), Phase 2 Pay-as-clear (when there is enough competition) and Phase 3 Full Market (a progression toward close to real-time market operation), WPD (2019c).

What is still missing

In general, most of the Use Cases propose standard procurement methods[32] to contract for flexibility services. Given that flexibility services are contracted by the DSOs (with operations subject to regulatory oversight), what is missing is a clear and standard methodology (at the country-level) that supports the selection of the most cost-efficient approach (i.e. baseline versus flexibility options). This is an important step that will help to define the maximum and minimum values that DSOs are willing to accept at each site (i.e. substations). Other auction mechanisms need to be tested in the light of the increase of DER. There should also be a move towards uniform (pay-as-clear) pricing rather than discriminatory (pay-as-bid) settlement rules[33]. This is because pay-as-bid rules encourage inefficient bidding and are out of line with wholesale energy market pricing.

Considering the case of MERLIN, a reverse auction[34] for DER response might make sense, rather than a fixed price. The starting price cap could be the cost of the conventional solution (i.e. baseline costs). This reverse auction could specify a minimum benefit for customers to be achieved in the auction before it would be completed. This minimum benefit would cover the costs of the auction, plus some target revenue benefit for the customers. This benefit would arise as a combination of the price and quantity of flexibility, hence the auction would trade off lower prices and lower quantities of flexibility. The reverse auction should be a descending clock with an activity rule[35] and deferred acceptance[36] to make sure that all bidders participate fully and bid truthfully. The activity rule means that bidders need to participate in each round of the auction, indicating their willingness to accept the current price, in order to stay in the auction.

Withdrawal at a given price therefore means bidders cannot re-enter the auction when the price falls. Bids could be made competitive across multiple constrained locations with some sort of bid scoring mechanism to handle the value of different locations. There may be rough and ready ways to clear a multi-locational auction, which provide a reasonable degree of efficiency[37]. Deferred acceptance allows the DNO to check whether there are any network reconfigurations, in the light of all bid quantities and prices, which add consumer value, and this could be specifically made part of the auction. There would be room for experimentation as to the bid increments, the number of constraints to be included and the target revenue benefit from the auction to be set etc.

32 To some extent many of the services procured are already being contracted by system operators (TSOs); the difference here is the application of these services (i.e. for distribution grid management).

33 For a clear discussion of the need for both capacity-based bid selection and uniform pricing see Musgens et al. (2014).

34 It is a common method to auction diamonds, radio spectrum, electricity, gas, and other products (Cramton, et al., 2012).

35 An activity rule ensures that each bidder remains active and only reveals its hand at the end of the auction (which is what happens in an Ebay auction).

36 This means that if bidders reject an offer price this is irreversible (i.e. bidders cannot re-enter at a lower price in the reverse auction) and no bid is firmly accepted until the final reconciliation.

37 In line with Milgrom (2017).

Lessons for MERLIN

We recommend ideally experimenting with a reverse clock auction and a revenue benefit target. This would involve starting the bidding at the willingness to pay for flexibility and reducing the price to increase the benefit to customers. The auction would be concluded when the target benefit had been achieved. The payment rule would be pay as clear – i.e. at the closing price all remaining offers in the market would be accepted and paid the closing price. The large number of potential flexibility providers (i.e. from other projects such as LEO, Transition)[38] reinforces our preference for pay-as-clear rather than pay-as-bid. Due to the interaction between the Oxfordshire projects (Transition, LEO and MERLIN), it may be that this is trialled in Transition and LEO instead of MERLIN.

38 The units are connected at 11 or 33kV. There is also lot of diversity in technologies (SSEN, 2020).

Section 8: The role of regulation

From the Use Cases, we observe different ways in which regulation can help to integrate flexibility solutions (and all the advantages that this can provide) within the BAU network operation. These can be through funding innovation projects, adapting the price control schemes to promote more flexible networks and cost reflective tariffs, enabling and democratising digitalisation, and setting clear roles among the different parties (DSOs, aggregators) etc.

Regulation encourages network operators to experiment (via innovation funds or regulatory sandboxes) in order to gain knowledge that supports future regulation. Many of the Use Cases analysed in this report have been partially funded by governments under specific competitive schemes such as Network Innovation Competition in GB, Schaufenster intelligente Energie (Sinteg) in Germany, Minister for Economy, Transport and Infrastructure (METI) in Japan, Australian Energy Regulator (AER), some of them with specific concentrations on VPP and demand response programmes. The aim of the demonstrator projects is not limited to testing the role of distribution utilities as neutral market facilitators for DER, new market participants (i.e. DER) and new business models for trading flexibility services. It also aims to identify current limitations and future developments in the regulatory arena that promote flexibility.

Regulation can help to provide the right incentives for network operators to opt for flexibility and hence more efficient operation. One way is via totex regulation. Totex regulation is adopted in Great Britain, Germany, Netherlands and Norway (CEER, 2019).[39] A different approach is found in Australia, where the Regulatory Investment Test for Distribution (RIT-D) scheme promotes efficient investment in the distribution network by requiring network projects valued over $6m[40] to look for non-network options (i.e. flexibility services from DER) AER (2018).

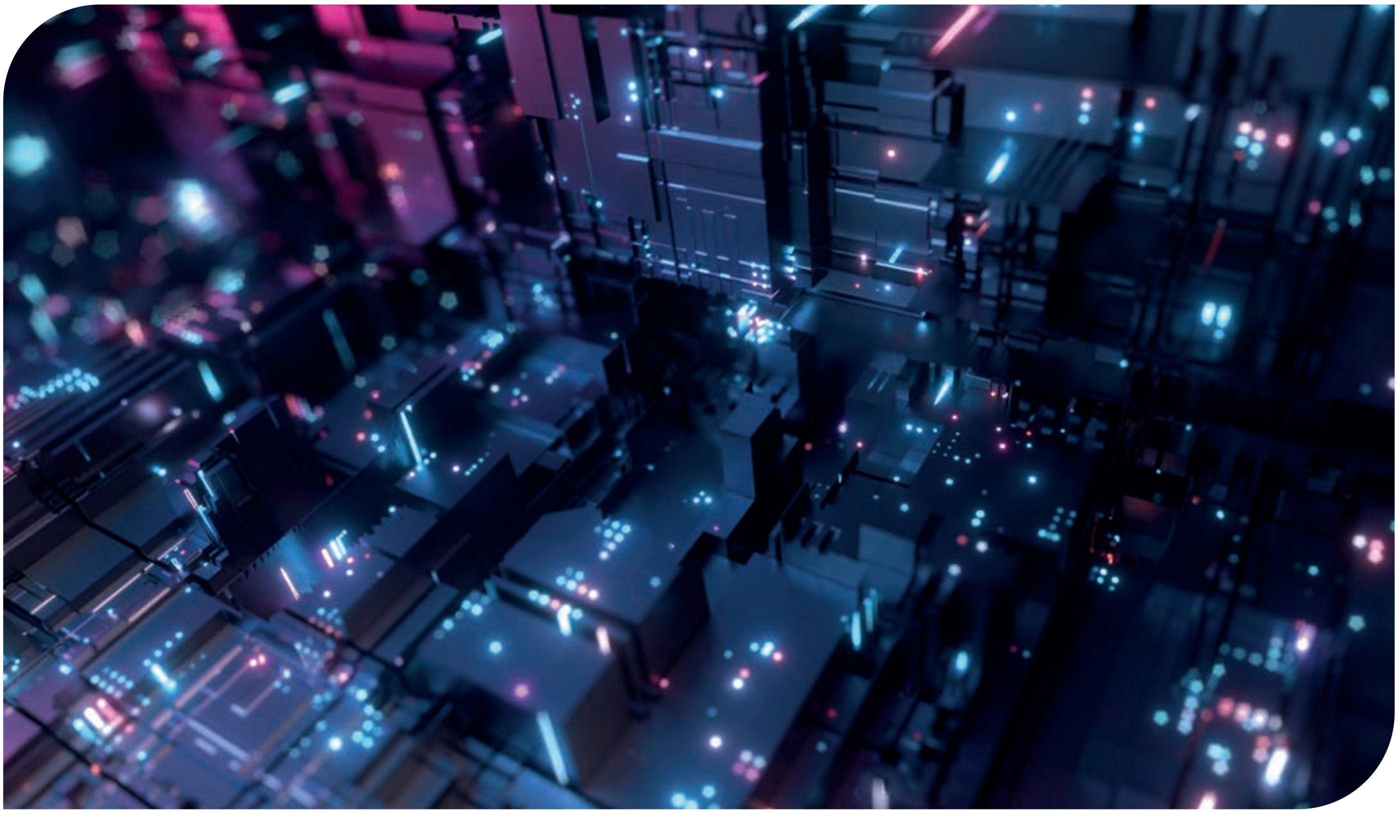
Setting more cost-reflective tariffs is something that can also help, for instance through the introduction of dynamic pricing to be facilitated via smart meters subject to minimum requirements (Eurelectric, 2017). Looking forward, some studies acknowledge the benefits of distribution local marginal pricing (DLMP) to manage congestion using DER (Bai et al., 2018). Even through nodal prices for transmission pricing (estimated as a result of an economic optimisation) have been applied by many system operators (e.g. USA, Australia, New Zealand, Singapore), their full implementation at distribution is arguable and will depend on the level of granularity where local marginal pricing is required to be implemented. According to Batstone et al. (2017), full DLMP based on economic optimisation at distribution level is still impractical due to lack of reliable optimisation methods.

39 Due to its sophistication, the pace of its development (in time and specification) differs across countries. Great Britain implemented the first Totex regulation in DPCR5 (period 2010-2015). Totex regulation goes beyond the energy sector with applications in the water sector (e.g. Ofwat in GB).

40 The amount has been initially set at $5m. The threshold is revised every three years. The scheme is also applicable to transmission operators (RIT-T).

Regulation also encourages digitalisation, especially in the adoption of smart meters and associated data management. The efficient management and integration of small-scale flexibilities needs to be supported by smart meters, especially in the residential sector. This is important, considering that in most of the Use Cases the participation of the residential sector has been acknowledged. All the jurisdictions of the Use Cases evaluated in this report are committed to supporting their implementation (partially or nationwide). However, implementation varies. Norway completed their nationwide smart meter rollout in early 2019, followed by the Netherlands in 2020, while Germany will require until 2032. In Germany the rollout is mandatory only for customers with a consumption over 6MWh (however those with lower consumption can voluntarily opt for it).

Regulation can also help set the rules for accessing and managing behind the meter flexibility assets. Flexibility assets behind the meter need to be visible and tradable. In the case of Germany, we observed that there are limitations in the participation of domestic battery systems. The current rules encourage behind-the-meter applications only, ignoring the potential to provide flexibility services in-front-of the meter.



Regulation can help to define the role of independent aggregators (also known as VPP operators) in the flexibility value chain. Aggregators are instrumental for explicit demand-side flexibility (which involves a financial reward from network operators to flexibility providers). Regulation regarding the role of independent aggregators varies across jurisdictions, especially in relation to their participation in retail[41], wholesale and ancillary markets. France is among the first movers – since 2003 – in opening its different markets to the participation of independent aggregators (focussing on demand side response – see RTE, 2019). In GB, their participation in the provision of balancing services to NGESO in the form of a "Virtual Lead Party" has been recently approved (NGESO, 2020).

Regulators, along with industry stakeholders, will help to shape the future utility by defining clear functions and new roles for distribution utilities (i.e. neutral market facilitator), including the extent of their interactions with other parties (e.g. TSOs, aggregators). Most of the Use Cases that are part of this study are testing new capabilities to manage the grid using flexibility services provided by third parties. No jurisdictions have yet decided on a framework that reaffirms distribution utilities as neutral market facilitators for DER or the creation of an independent party to manage this. The interaction between DSO-TSO is being evaluated in some jurisdictions of the Use Cases such as Australia, Great Britain and Netherlands.

Lessons for MERLIN

Having a supportive regulatory environment around flexibility is crucial. It is also a key role of innovation projects to identify the limitations of the current regulatory regime in supporting socially desirable innovation. Unlocking the value of flexibility depends on allowing the benefits to society to be monetised via the regulatory regime. It will be very important for MERLIN to identify sources of value which cannot be monetised under the current regime and to suggest how they might be monetised with appropriate changes to regulation.

41 For instance, in the European market the participation of independent aggregators is mainly with industrial and commercial customers (BEUC, 2018).

References

AER (2018), Application guidelines. Regulatory investment test for distribution. Australian Energy Regulatory, Dec. 2018.

Bai, L., Wang, J., Wang, Ch., Chen, Ch., Li, F. (2018), Distribution Locational Marginal Pricing (DLMP) for Congestion Management and Voltage Support. *IEEE Transitions of Power Systems* 33(4):4061-4073.

Batstone, S., Reeve, D., Stevenson, T. (2017), An exploration of locational marginal pricing at the distribution level in the New Zealand context. Report prepared for the Electricity Authority, June 2017.

BEUC (2018), Electricity Aggregators: Starting off on the Right Foot with Consumers. The European Consumer Organisation, Feb. 2018.

Bray, R., Woodman, B. (2019), Barriers to Independent Aggregators in Europe. EPG Working Paper No. 1901. University of Exeter, Jan. 2019.

CEER (2019), Incentive Regulation and Benchmarking Work Stream. Report on Regulatory Frameworks for European Energy Networks. CEER Report, Ref. C18-IRB-38-03. Council of European Energy Regulators, Jan. 2019.

Copeland, T.E. and Kennan, P.T. (1998), 'What is the value of flexibility?', *The McKinsey Quarterly* 1998, Number 2, pp.38-49.

Cramton, P., Filiz-Ozbay, E., Ozbay, E.Y. and Sujarittanonta, P. (2012), 'Discrete clock auctions: an experimental study', *Experimental Economics, 15*(2): 309-322.

Damodaran, A. (2015), The Dark Side of Valuation, 2nd Edition, Financial Times/Prentice Hall.

ENA (2020), Open Networks Project Phase 4 2020 Project Initiation Document. Energy Networks Association, Jan. 2020.

Enedis – ADEeF (2017), Valorisation economique des Smart Grids. Contribution des gestionnaires de réseau public de distribution. Enedis and Association des Distributeurs d'Électricité en France.

Eurelectric (2017), Dynamic pricing in electricity supply. A Eurelectric Position Paper, Feb. 2017.

IEA (2019), Tracking Energy Transition, International Energy Association, Paris, May 2019.

InterFLEX – Enedis (2019), Demonstration results based on the KPI measurements and lessons learnt from the demonstrations. V1.0. Deliverable D9.3. Dec. 2019.

IRENA (2019), Aggregators Innovation Landscape Brief. International Renewable Energy Agency.

Milgrom, P.R. (2017), Discovering Prices: Auction Design in Markets with Complex Constraints, New York: Columbia University Press.

Musgens, F., Ockenfels, A. and Peek, M .(2014), 'Economics and design of balancing power markets in Germany', *International Journal of Electrical Power and Energy Systems:* 55: 392-401.

NGESO (2020), Guidance Document Use of System – Virtual Lead Party (VLP). Version 1.1. National Grid ESO, Feb. 2020.

NYPSC (2019), CASE 15-E-0751 – In the Matter of the Value of Distributed Energy Resources, State Of New York Public Service Commission.

Ofgem (2019), RIIO-ED1 Annual Report 2017-2018. Office for Gas and Electricity Markets, March 2019.

RTE (2019), RTE Electricity Report 2018. Le réseau de transport d'électricité, Feb. 2019.

SSEN (2020), Technical Report Deliverable Project TWP6 Phase 1. Scottish&Southern Electricity Networks, Jan. 2020.

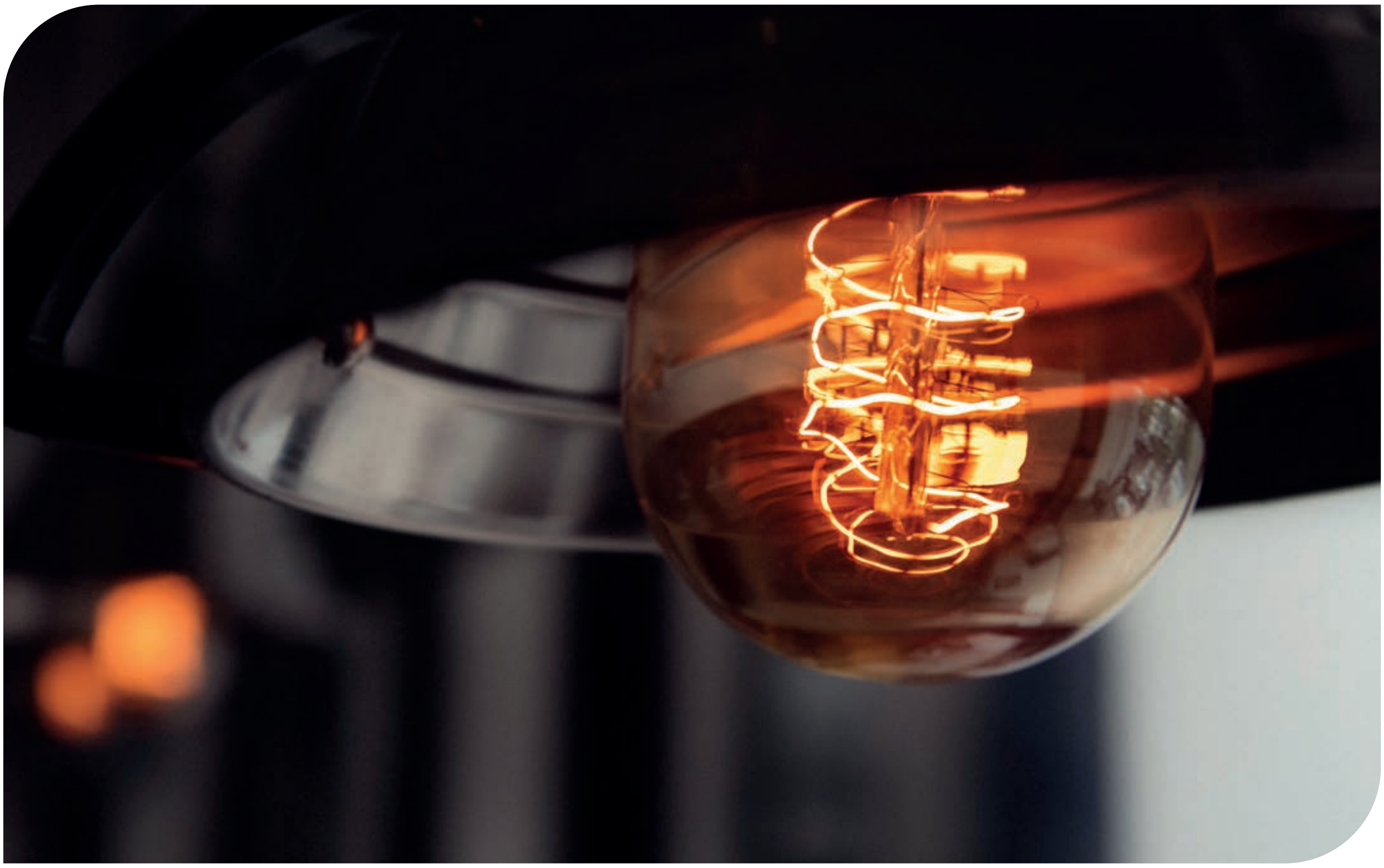
UKPN (2020), Invitation to Tender (ITT). Flexibility Services Tender Apr-20 High Voltage Zones. UK Power Networks Limited, Feb. 2020.

Van der Weijde, A.H., Hobbs, B. F. (2010), "Transmission planning under uncertainty: A two-stage stochastic modelling approach," *2010 7th International Conference on the European Energy Market*, Madrid, 2010, pp. 1-6.

WPD (2019a), Project Entire Closedown Report, Western Power Distribution, June 2019.

WPD (2019b), Webinar – Routes to Participation WPD 2019 Procurement Cycle 2. Western Power Distribution, July 2019.

WPD (2019c), Delivering A Flexibility First Approach, Consultation. Western Power Distribution, Sep. 2019.



Glossary

AER	Australian Energy Regulator
ALF	The Altdorfer Fleximart
ANM	Active Network Management
DER	Distributed Energy Resources
DERMS	Distributed Energy Resources Management System
DNO	Distribution Network Operator
DSO	Distribution System Operator
ETPA	Energy Trading Platform Amsterdam
FfE	Forschungsstelle für Energiewirtschaft e. V.
Fit	Feed-in Tariff
Gopacs	Grid Operators Platform for Congestion Solutions
HV	High voltage
LV	Low voltage
MV	Medium voltage
CLEM	Cornwall Local Energy Market
MERLIN	Modelling the Economic Reactions Linking Individual Networks
METI	Minister for Economy, Transport and Infrastructure – Japan
NGESO	National Grid Electricity System Operator
SGH	Smart Grid Hub
SINTEG	Schaufenster intelligente Energie – Digitale Agenda für die Energiewende (Smart energy showcases – Digital agenda for the energy transition)
SMGW	Smart Meter Gateway
PAS	Platform for Ancillary Services
RIT-D	Regulatory Investment Test for Distribution
RIT-T	Regulatory Investment Test for Transmission
RR-FIT	Replacement Reserve for Feed-in Tariff
SPEN	Scottish Power Energy Networks
SSEN	Scottish and Southern Electricity Networks
TSO	Transmission System Operator
UKPN	UK Power Networks
V2G	Vehicle to Grid
VPP	Virtual Power Plant
WPD	Western Power Distribution
XMPP	Extensible Messaging and Presence Protocol

Notes

Contact us:

futurenetworks@sse.com
www.ssen.co.uk/Innovation
@ssen_fn

MERLIN
Modelling the Economic Reactions Linking Individual Networks

Scottish & Southern Electricity Networks