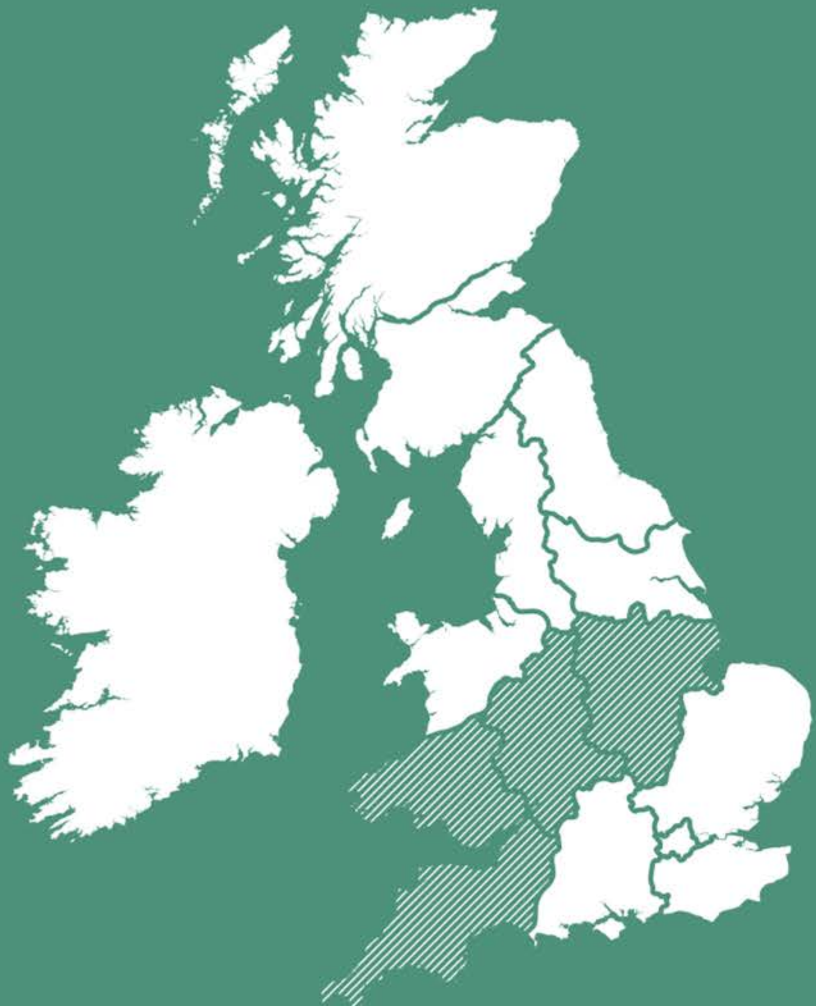
WESTERN POWER DISTRIBUTION

INNOVATION

NEXT GENERATION NETWORKS

SYNC Technique 2
Load Matching



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Contents

Glossary

Term	Definition
ANM	Active Network Management
CHP	Combine Heat and Power
DNO	Distribution Network Operator
DSR	Demand Side Response
DTU	Demand Turn Up
I&C	Industrial & Commercial
LIFO	Last In First Out
PV	Photo-Voltaic
R&D	Research and Development
SPEN	Scottish Power Energy Networks
SYNC	Solar Yields Network Constraint
ToU	Time of Use
WPD	Western Power Distribution

1. Executive summary

Technique 2 of the SYNC project investigated the commercial feasibility of matching customer load and demand through ANM systems. Building on the technical feasibility investigated by SPEN as part of the ARC project, SYNC aimed to investigate the commercial mechanisms required to apply such a scheme.

The investigation highlighted the many challenges of such a scheme, including the potential to detriment existing customers, the changes to principles of access as well as the difficult balance needed between matching technical requirements and deriving workable commercial products. Whilst a matching scheme could be implemented, the customer protections required would impact on the values that can flow through the service

Due to the limited existing curtailment on WPD ANM schemes, no suitable trial locations could be found. However further commercial investigations will proceed under WPD's NIA funded Plugs and Socket project and the WPD funded Virtual Private Wires R&D project.

2. Project Overview

WPD has connected significant amounts of embedded generation to its distribution network in recent years. This includes a large variety of different technologies, dominated at first by wind and more recently by solar PV.

With so much generation already connected, and significant quantities in the pipeline, most of the latent capacity within the network has now been utilised. As such WPD is looking at ways of releasing extra capacity in the most economically efficient manner. Alongside the use of traditional reinforcement, the roll out of alternative connections has been one of innovative manners this has been done, building on the flexibility of generators. These give the option of trading off capital expenditure and time delays against potential curtailment. This moves from a passively operated network to a more active one.

Whilst the inherent flexibility of generation is now being used, the flexibility of the demand side is as yet untapped.

As part of the SYNC project we looked to test a range of Demand Side Response (DSR) techniques to help address many of the different challenges being posed by PV generation. By engaging with industrial and commercial (I&C) customers we could release additional capacity or even improve power quality.

There are 4 techniques that project SYNC will look to investigate:

(T1) - Automated demand increase / generation limiting in line with variation in solar yields.

(T2) - Directly matching flexible load with flexible generation

(T3) - Manually dispatched response signals from a WPD control facility (DSR)

(T4) - Creation of suitable ToU (Time of Use) tariffs to encourage appropriate demand

The project required significant engagement and involvement of third parties including demand customers, generators, storage operators and National Grid. WPD built on the learning gained in the FALCON project and directly manage a full service program directly. By doing so WPD attempted to demonstrate how to maximize value to the industry and minimize the cost to customers.

3. Background: ANM and Customer load matching

As part of project SYNC, WPD investigated the use of the demand side to help improve network functionality and efficiency during times of high solar PV generation. Whilst other techniques look into the value to a DNO of controlling load during the summer, technique 2 investigates the potential benefit to other customers, specifically generators with Active Network Management (ANM) connections.

Under an ANM connection, a generator can avoid network reinforcement by accepting curtailment under network constraints. This is operated through an autonomous monitoring and control system. With an ANM connection, generation customers effectively trade off capital expenditure for potential loss of revenue.

All WPD ANM capacity is distributed under a Last In First Off (LIFO) principle, ensuring that the arrival of subsequent generators does not penalise the existing customers. As a constraint is being approached the system will begin curtailing generators from the bottom of the queue, often referred to as the LIFO stack.

Whilst this minimises the effect of subsequent generation connections on the level of curtailment seen, there will inherently be some level of variability due to changes of demand behind the constraint. Should demand decrease, customer curtailment may increase, however should demand increase, the curtailment may decrease. As such there is a direct value to customers for controlling or increasing local load.

The concept of a virtual customer load matching is to link demand shifting to specific generation customers and allow for the appropriate values to flow between the parties.

Interestingly this could already happen externally to the DNO, with generators directly contracting with demand to change their profile. However the effect will only benefit the marginal generator in the LIFO stack. Going through the DNO would allow for this contractual position to be translated through the ANM system.

This is shown in the following Figures. Curtailed generation is shown in red.

Time		1	2	3	4	5
LIFO Stack	Generator 1					
	Generator 2					
	Generator 3					
Demand		4	1	0	1	3

Figure 1: base case ANM Scheme (curtailment in red)

Figure 1 shows the base case. Over 5 time periods the local demand varies significantly. Where demand is high, in periods 1 and 5, there is no curtailment. As this drops, the generators at the bottom of the stack get curtailed (periods 2 and 4). At the time of minimum load all ANM generators are curtailed.

Time		1	2	3	4	5
LIFO Stack	Generator 1					
	Generator 2					
	Generator 3					
Demand		4	1	+1	1	3

Figure 2: Effect of demand turn-up purchased through a bilateral. A turn-up of 1 is purchased in period 3. This only benefits generator 1, limiting the access of customers lower in the LIFO stack

Figure 2 shows the effect of any generator buying an increase in demand in period 3. This reduces the level of curtailment and benefits Generator 1. If the demand increase had been in purchased in periods 2 or 4, it would have benefited generator 2.

Time		1	2	3	4	5
LIFO Stack	Generator 1					
	Generator 2					
	Generator 3					
Demand		4	1	+1	1	3

Figure 3: Effect of demand turn-up purchased through WPD. A turn-up of 1 is purchased by generator 2 in period 3; WPD modifies the ANM system to attribute it accordingly

Figure 3 represents the implementation of customer load matching; a turn up in demand has been purchased by generator 2 and has been transferred to him by the ANM system.

This is a very simplistic representation; however it can help show the principle of customer load matching. This enables more directed transaction between generator and demand, representing value to all constrained generators rather than just the marginal one.

It should be noted that any reference to flexible demand may also involve flexible generation. Whilst a demand turn up may occur through the addition of new processes, it may also happen through the deferral of embedded generation such as biomass or CHP.

4. Technical feasibility

The SYNC project did not investigate the technical feasibility of such load matching as such a scheme was being investigated concurrently by Scottish Power Energy Networks (SPEN) as part of the ARC project. The details can be found in the associated learning reports.

5. Commercial feasibility

Whilst the ARC project has shown the technical feasibility of a customer load matching, this leads to many questions around the commercial implications and frameworks of such a system.

These must equally be developed to understand the full implications of the technical capability.

Conceptually it is simply a case of creating a market framework around the system to connect, and appropriately recompense, generation and demand.

However there are significant challenges and questions that must be addressed when looking to design these market structures.

5.1 Determining a baseline and predicting curtailment

Potentially the biggest challenge to such market is accurately predicting the baseline condition. This means determining the state of the network before any market actions.

Whilst many methodologies exist to predict the starting position, the granularity required for doing so on an ANM system would make it highly challenging.

An idealised system would provide accurate second by second predictions of base demand, in line with the measurement frequency of the ANM system. In practice this would not be possible and much wider predictions would be required. As per many other DSR services as baselining methodology may be implemented. Where the turn up is implemented through new, additional load, this is relatively simple as the baseline is zero, however it is far more complex for marginal increases on existing loads. Existing methodologies such as “low five of ten” or a weather corrected output from the previous year could be used, each method with its own strength and limitation. For all the methods however, thought must be taken for the timescale considered. Many of these methods are designed for longer, more stable values such as half hourly measurements; second by second data will be far more variable. As such the accuracies of such baselines would be questionable.

A simpler set of half-hourly profiles could be used to allow a market to function, but this would be a significant step away from the real time principles of ANM.

Whichever method is chosen, it must be acknowledged that if a baseline demand is used, DNO’s will be affecting curtailment to other customers. As no prediction is ever right, utilising one to determine your baseline will change the principles of the system. To prevent detriment to existing customers, as a conservative baselining approach would be required. This would however lower the available flexible demand and reduce the value to the participants. The level of conservatism required would be related to the variability in load at the required granularity.

In addition to baselining demand, similar considerations would be required for generator curtailment. If the curtailment to be passed thought the ANM system is in the form of “Curtailment-Demand increase” then it is important to consider what curtailment should be. Again the similar issues arise with both developing accurate enough predictions as well as impacting curtailment. Indeed they are made more difficult by the number of factors and customers affecting general levels of curtailment. Levels of load on the network as well as other generation would need to be modelled to understand when curtailment is likely.

An alternative method for baselining demand would be to always assume a base level of zero. This is a significant departure from traditional network panning but acknowledges that DNOs have no powers to prevent reductions in demand. This is a large simplification of the baselining but would prevent any gaming of baselines; it also prevents the creation of different classes of load and the issues identifying one from the other. This would allow customers to sell their demand to generators and operate like a more conventional behind the meter private wire system. This would however have a significant impact on other customers. This would in fact change the rules of access for an ANM system, pushing contracting capability as the means of access rather than the LIFO stack. It would also create issues for DNOs which have connected generation assuming some base load. It should also be noted that introducing such a scheme may not deliver additional load onto the ANM scheme but may just reallocate value.

5.2 Purchase of change in demand, fixed demand or minimum demand

Another key element is specifying exactly what is being offered and purchased.

The value driving the load matching is the provision of a decrease in curtailment. However this is not the commodity directly on offer from demand customers who can only offer flexibility in their demand. Flexible demand could be sold as the ability to provide a fixed pre-determined load, or an increase in load.

The latter more closely reflects the value stream, but may be hard to achieve. This would be intrinsically linked to the baselining method as discussed in the previous section and may prove challenging if implemented on a highly granular level.

A fixed demand would be easier to achieve, however the value of the service would be dependent on the underlying demand baseline. This may bring uncertainty around the value of the service, especially if it is procured ahead of the baseline setting.

A minor variant on the fixed demand would be guaranteeing a minimum level of demand. This allows the demand customer sufficient flexibility to operate effectively, however it limits the value to the agreed minimum.

With all these options a balance must be struck between the value of the service and the ease of delivery.

5.3 Potential for customer detriment

Another key issue with load matching is the potential for detriment to existing customers.

In the examples so far, the response has been provided by an increase in demand, rather than a shift. This could be provided in practice by an additional processes or shifting demand from a different energy vector. This additional load is attributed to the paying customers and the base case is not altered.

However this may not always be the case. In some scenarios, the response will be provided by a shift in demand. This could be provided by shifting a process.

Time		1	2	3	4	5
LIFO Stack	Generator 1					
	Generator 2					
	Generator 3					
Demand		3	1	1	1	3

Figure 4: A demand shift of 1 from period 1 to 3, paid for by generator 2

As shown in figure 4, if the demand is shifted from a time period with no constraints, where there is an abundance of demand, there is little effect on generators. There is still sufficient local load to prevent any increases in curtailment. However this won't always be the case, as shown by figure 5.

Time		1	2	3	4	5
LIFO Stack	Generator 1					
	Generator 2					
	Generator 3					
Demand		4	0	1	1	3

Figure 5: A demand shift of 1 from period 2 to 3, paid for by generator 2

Here demand is shifted from period 2 to period 3. This allows generator 2 to reduce its curtailment, however the reduction in load in period 2, requires the curtailment of generator 1.

By encouraging customers to manipulate demand, the load matching mechanism can allow other generators to affect the curtailment of their peers and reduce their revenues.

As noted earlier, this could already be done to a certain extent; however the provision of the services increases the value flow of the service and makes it a more attractive proposition. Introducing such a market would significantly alter the DNO treatment of demand in an ANM system. As such retrospective applications of load matching schemes may be seen as changing the principles of access of the scheme.

Rules could be introduced to try and prevent detriment; however this could be very challenging. Providing sufficient protection whilst guaranteeing enough flexibility and granularity of response to operate a functioning market would be a difficult balancing act.

Such protections may also create a difference in value between "new" load and existing load, as the impacts to other customers are different. This would move away from principles of equal treatment. In addition the ability to enforce such a vision as the distinction between existing and new load is by no means clear.

5.4 Market structure

Market rules could be structured as a forward or reverse auction depending on which side has excess. If there is more flexible demand than generation, demand customers could set their offers and be selected by the generators. The opposite could be true is there is more generation than demand.

It should be noted however that a DNO constraint adds significantly more complexity than a simple energy matching.

First each constraint area must be treated separately, generation and demand must sit below the same constraint. In addition, it must be acknowledged that some pairings will be of more value than others. In a simple radial network with a thermally constrained in-feed, then all demand is as valuable to the generator. However, if the constraint is voltage related, then the respective locations of demand and generations have a significant influence. Where networks are run in rings, or meshed this is also the case for thermal issues. As such the location of demand will affect its value. This is made more complex through network re-configuration, as might happen following a fault. These differences are accounted in ANM systems by sensitivity factors. Whilst in simple systems these are relatively static, in complex systems they are calculated and amended in real time.

The manner of contracting and dispatching response is also non trivial. Purchasing a long term change in behaviour will make it easier for demands to be shifted; however generators may have to pay for shifts where it provides no direct benefit.

On the other hand, generators could enter contracts similar in structure to the DTU service, contracting for availability and utilisation. This would mean paying for fewer hours but probably paying more for them.

All of this depends on the predictability of constraints. Where these are highly predictable, such as during an outage, the former may be more desirable, where constraints are due to subtle changes in weather then allowing for last minute changes is preferential.

5.5 Coordination with existing DSR schemes

As with any DSR scheme, the coordination with other schemes must be thought through. Developing an uncompetitive service has no value to either DNO or customer

The main competitor for this service would be the DTU scheme which offers values around £60-75MWh. As many generation revenues include subsidies such as FITs or ROCs, they should be able to commit in terms of value. A key decider will be on the frequency of calls as total value depends on the value of each call and the number of them. Here it really depends on the amount of curtailment expected.

Finally it should be noted that additional demand in this form would not be able to benefit from both this market and DTU at the same time as the point of this service is the release of additional generation, leaving no net effect at the GSP. However the stacking of both services with different availability windows may be possible (depending on the generator requirements).

5.6 Market winners and losers

As with any market, it should be acknowledged that there will be winners and losers. Generators operated by commercially savvy entities may benefit significantly from reducing curtailment. In addition, customers with flexible load will benefit. On the other hand some generators may lose out during the auction phases and may have additional curtailment.

5.7 Doing Nothing

As with any optioneering, the case for doing nothing should always be considered.

It should be recognised that customers could already manipulate ANM schemes through bilateral with demand customers, however there are no known examples of such schemes to date (although there is currently very little curtailment seen on ANM schemes).

These dealings would not be the most economically efficient as there is no direct tie in to the ANM systems; however this ensures that no changes are made to curtailment methodology. Whilst customers may see detriment, this would be seen as a change to embedded load rather than an explicit DNO signal.

Additionally customers may move toward private wire solutions, connecting generation behind load to guarantee the ability to generate, avoid supply costs and appear on the network as a reduction in demand.

6. Conclusion

As discussed above, the implementation of a load matching scheme poses many difficult commercial questions. These predominantly look into the treatment of existing customers and the difficulties that would surround changing the rules of access to ANM schemes. This would most probably limit load matching to future schemes.

In addition, to make such a scheme work, simplifications would be needed to translate the technical requirements into a service that can be sold on a market. This simplification inherently reduces the value of the service and reduces the attractiveness.

Also levels of curtailment on existing WPD ANM schemes are very low, as such no viable trial location was found. As such the work on T2 has been limited to this investigation.

However, WPD is progressing other commercial innovation in projects like the Plugs and Socket, where a local energy market is being investigated, and the investigation into Virtual Private wires. These projects seek to investigate alternative options to make the most of local flexibility.