Customer-Led Network Revolution

CLNR Demand Side Response Trials

Application Guide

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1 Introduction

1.1 Purpose

The purpose of this document is to outline how Demand Side Response (DSR) should be procured and deployed by Northern Powergrid as part of Business as Usual (BaU) activities.

1.2 Background

DSR can offer significant advantages to the conventional "BaU solutions" currently deployed to overcome network constraints:

- The DNO only needs to purchase the capacity it actually requires, rather than having to purchase the potentially higher discrete increments that traditional reinforcement delivers;
- DSR can be contracted annually, allowing it to be discontinued if not required in future years;
- DSR can be environmentally beneficial; and
- DSR provides a financial benefit to the customers who deliver the DSR service, in the form of DSR payments, as well as to all other connected customers in the form of lower future DUoS charges due to the reduced reinforcement requirements.

Northern Powergrid's policy is that DSR should always be considered when reviewing the possible options to manage a potential future network constraint and should be selected if:

a. Sufficient DSR resource is available to provide a reliable response; and

b. It is at least cost neutral to the next most economical solution.

The approach for the use of demand side response at Northern Powergrid is as follows:

- DSR services will be procured to maintain post-fault security of supply at 132kV and EHV constraint points (for instance a highly loaded primary substation) following a fault on the network that either occurs during, or cannot be fully restored before, the onset of a network peak load. This peak could be a winter evening peak or a summer lunchtime peak, etc. and the constraint will be managed by procuring DSR from customers downstream of the constraint.
- DSR services will initially be procured from industrial and commercial (I&C) customers; and
- Research and development will continue to be undertaken to assess the potential for DSR from residential customers to support the above use case and also address different types of network constraint.

This approach will defer investment in the network, therefore providing financial benefits to the DSR providers, the DNO and customers in general. It should be noted that this approach will be subject to annual review following the implementation of DSR services as part of BaU.

1.3 Related documentation

This application guide should be read in conjunction with the related documentation as shown in Figure 1.

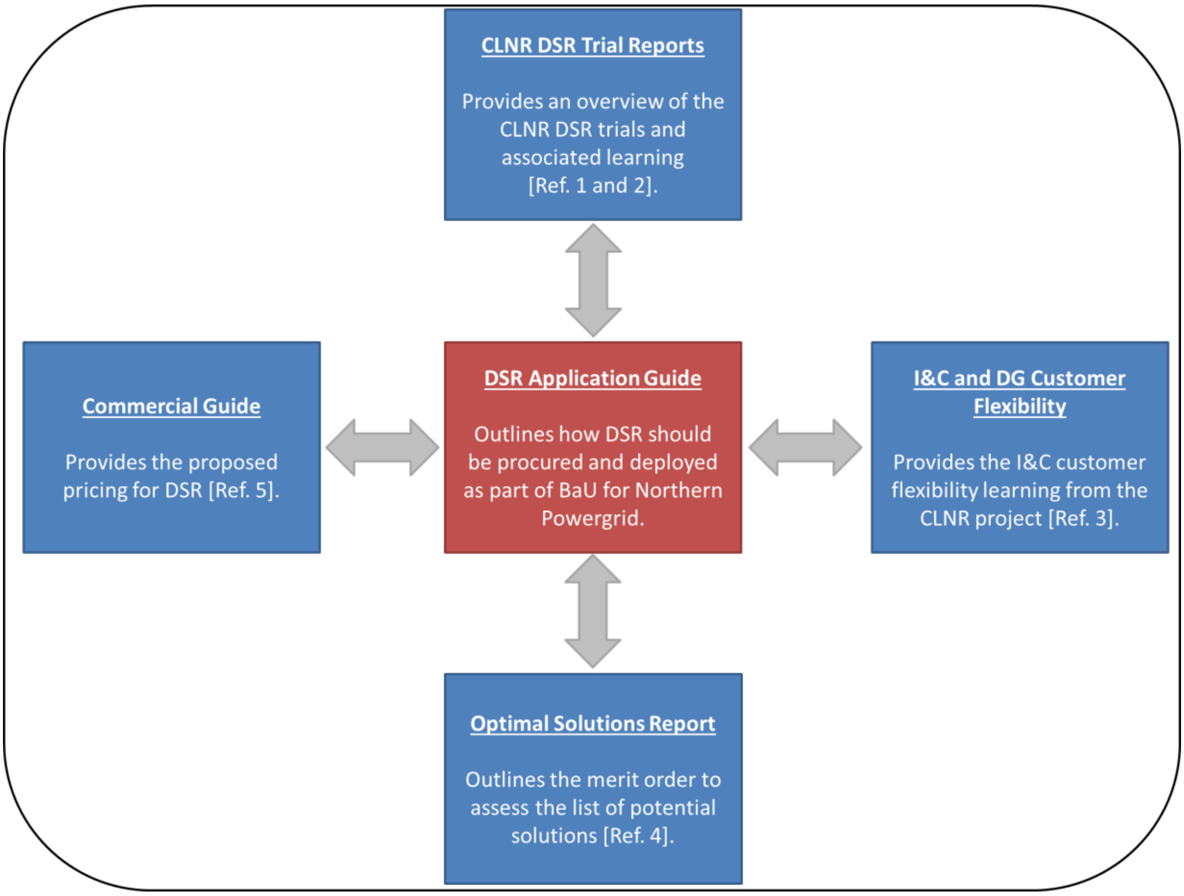


Figure 1 – Derivation

1.4 Document structure

The structure of this document is as follows:

- **Section 2:** Implementation Process;
- **Section 3:** Network Assessment;
- **Section 4:** Security of Supply;
- **Section 5:** Business Case;
- **Section 6:** Customer Engagement;
- **Section 7:** Implementation; and
- **Section 8:** Summary.

2 Implementation Process

Figure 2 shows the overall implementation process for procuring and deploying DSR. This implementation process must be followed when assessing the need for DSR services at each substation site.

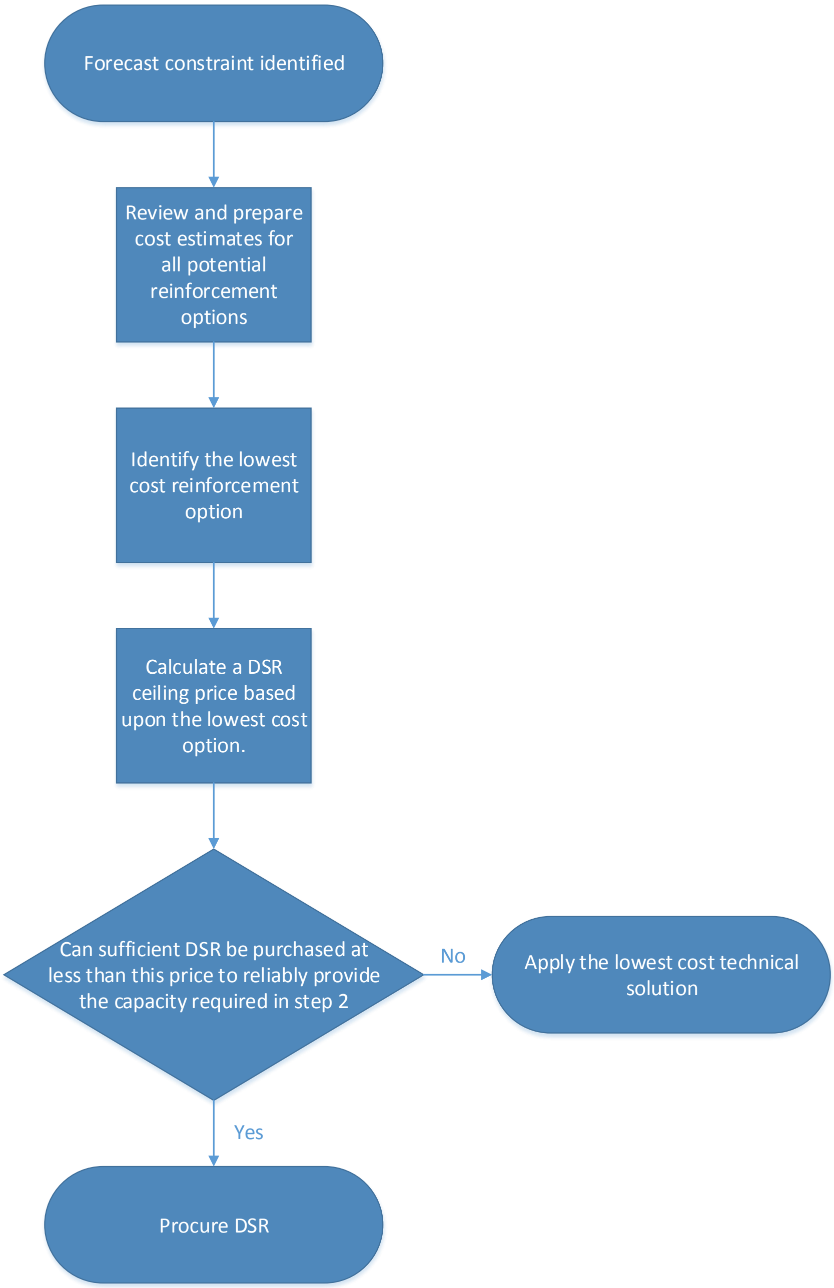


Figure 2: DSR implementation process

The merit order for assessing the list of potential solutions for the identified constraint can be found in the report CLNR-L248 Optimal Solutions for Network Businesses [Ref. 4].

3 Network Assessment

3.1 Introduction

This section outlines how a substation site can be assessed to identify whether DSR would be an appropriate solution to address a forecast potential network constraint.

3.2 Data requirements

The following data is required in order to assess the characteristics of the forecast constraint and the potential for DSR to address that constraint:

- **Network / Site configuration:** Number of transformers, rating of transformers, cable / line ratings, an overview of the network connectivity for the site and the firm capacity (summer and winter);
- **Substation / circuit demand profile:** Provides a visual representation of the substation / circuit demand on the peak days;
- **Forecast demand:** A forecast of the potential future demand along with the available transfer capacity to adjacent networks. The forecast demand will be developed from assumptions on load growth based upon the types of customers connected as well as knowledge of future major connections or disconnections;
- **Historic fault characteristics:** The fault characteristics Mean Time Between Failure (MTBF) and Mean Time To Repair (MTTR). The fault characteristics need to be taken into account as this will drive the number of times that DSR is likely to be called;
- **Class of supply:** The supply group of the substation / circuit will have an impact on the DSR response required post fault (see Section 4.3 for further information);
- **Firm capacity:** Is the maximum capacity available during a fault event (typically N-1). This value provides the threshold where the DSR requirement can be measured; and
- **Substation forecast demand profile:** The substation forecast demand profile will determine the number of times the firm capacity is breached within a given time period, how much the firm capacity is breached by and how long each breach occurs for.

3.3 Assessing the characteristics of the DSR requirement

Assessment of the variables for each potential constraint point will enable the required DSR characteristics to be determined and assessed in comparison to other potential solutions. For example:

- The demand profile will show the number of days that the demand is likely to be in excess of the firm capacity and the number of hours that this will be the case on each day, which provides the availability window and the likely call duration;
- The historic fault data provides the likely frequency of DSR requests and the number of days the service is likely to be required.

An example of two forecast substation demand profiles is provided in Figure 3 below. This shows that the challenges in recruiting customers and the associated costs for implementing DSR for ‘Substation Profile A’ will be greater than for ‘Substation Profile B’ because the duration of the service, if called, is going to be longer and level of DSR required is also greater.

DSR costs need to be offset against the reinforcement costs for each site. The costs of reinforcement will also vary significantly from one site to another and will be driven by the site characteristics, for example, the number of transformers, types of cables, network connectivity and the type of constraint.

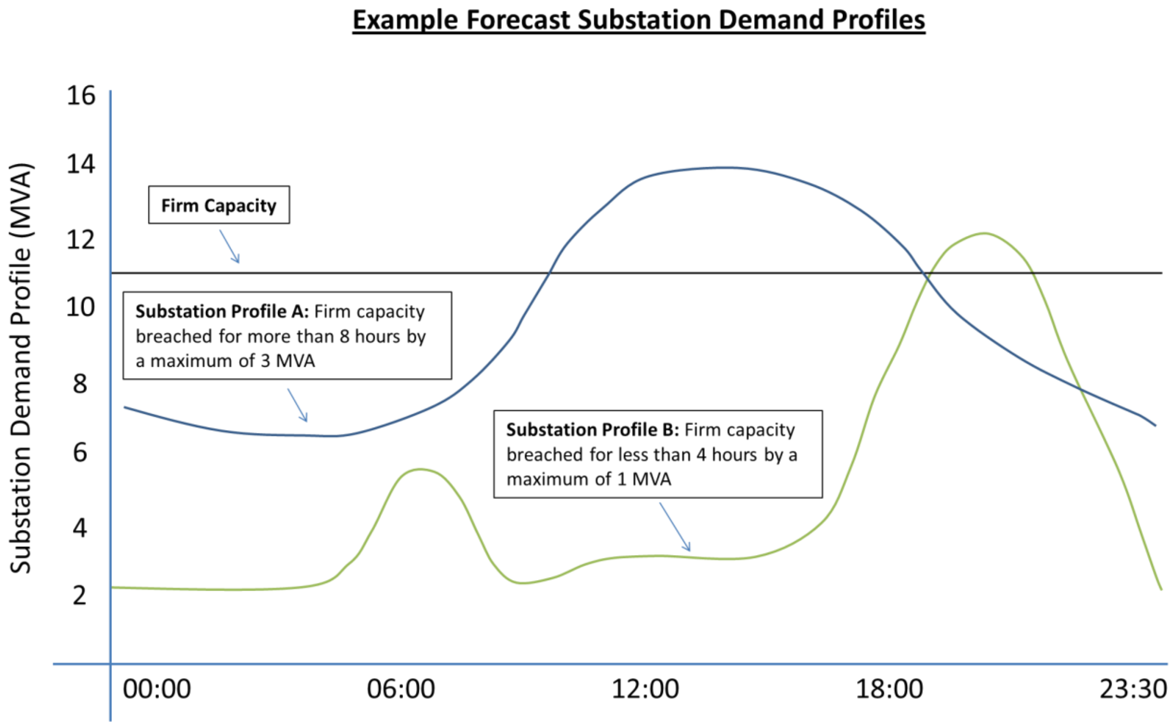


Figure 3: Example forecast substation demand profiles

3.4 Load Forecasts

Load forecasts will play an important part in forecasting DSR requirements in future years. The following points should be taken into account when determining the DSR requirements:

- The number of active load and generation connections will largely determine the overall substation demand growth in future years, together with assumptions about underlying load growth, for example, due to LCTs. This level of load growth in reality will be variable and will vary from the forecast. As a result, the business case and requirements for DSR will need to be reviewed periodically and amended accordingly. Assessments should be carried out at least annually;

- It should be noted that loads can decrease as well as increase so the DSR requirement could either reduce or not be required at all in future years; and

- The transfer capacity at a substation site must be taken into account when identifying the DSR requirements. Where it is possible to transfer capacity to manage a constraint DSR should not be procured.

Figure 4 below shows an example of a substation profile where demand is increasing. This shows the DSR requirement increasing year on year in terms of both the maximum response (MW) and duration over-firm (minutes).

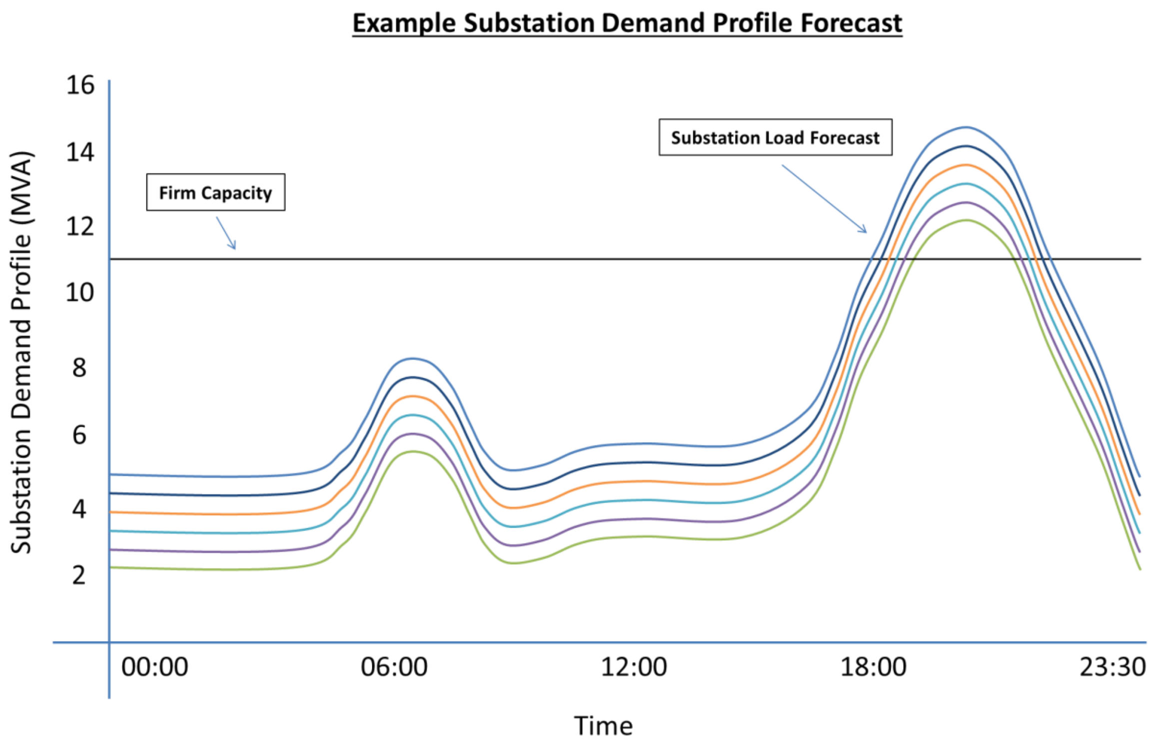


Figure 4: Example substation demand forecast

Further information on load forecasting can be found in the Northern Powergrid document INV/001/008 - Code of Practice for the production of Load Estimates [Ref. 6].

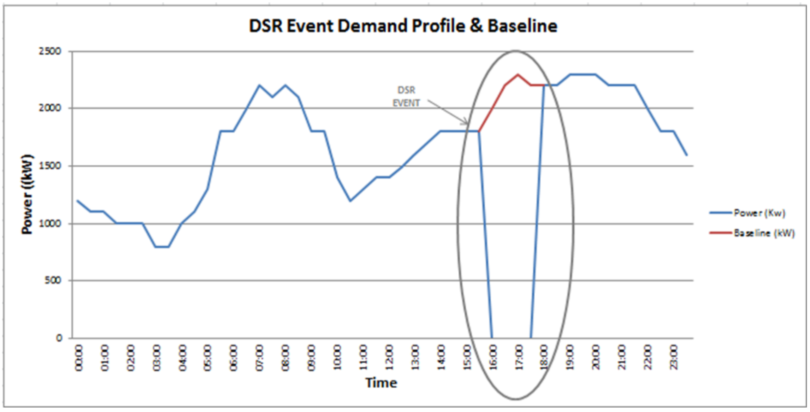
3.5 DSR procurement specification

The following characteristics are required in order to specify the DSR procurement requirements:

- The response time required i.e. how fast the load is required to be reduced (minutes);
- The total power (MW) required for each DSR event;
- The duration required (minutes) for each DSR event ;
- The number of times the DSR event will need to be called per year based on the fault characteristics for the site;
- The duration of the availability window that will be required each year (i.e. if the firm capacity is forecast to be exceeded every weekday between November and February, then the availability window is 83 days); and
- The number of years the DSR response will be required for based upon the forecast load growth (i.e. if the load is forecast to grow beyond the capacity of the DSR providers).

The DSR requirement should be assessed using the substation demand profile for the maximum demand day within the season (summer or winter).

Figure 5 shows a daily demand profile for a generation led DSR event along with a zoomed in graph showing the 30 minute DSR response time with a DSR event duration of 2 hours.



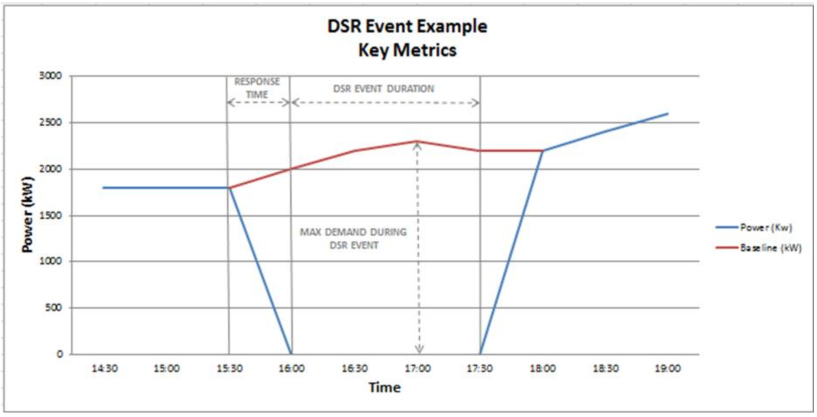


Figure 5: Example DSR event profile

4 Security of Supply

4.1 Current regulation

Compliance with Engineering Recommendation P2/6 [Ref. 7] is a distribution license condition. The current regulation does not provide specific information on how DNOs should assess the contribution of DSR to maintain 'Security of Supply'. A review of P2/6, with recommendations to update ETR130 (Ref. 8], was completed as part of the Capacity to Customers (C2C) project [Ref. 9]. These recommendations have been fed into a more structural review of P2 by the Distribution Code Review Panel which is intended to reassess the underlying basis of network security assessments and which is still ongoing. It is expected that changes will be made to P2 as part of this structural review. However, it is likely that the future revision of P2 will not be available for approximately 2 years.

4.2 Proposed changes to existing regulation

Due to the length of time it will take to update P2 the associated application guide ETR130 was reviewed as part of the C2C project and a number of changes were proposed. It is not clear from this review when or if these changes will be officially made to ETR130 [Ref. 10]. However, it is recommended that the proposed changes are taken into account when assessing the security of supply for DSR. Specifically, it is recommended that the following proposed change is adhered to:

"An appropriate allowance should be made for DSR. The effects of DSR might already be included in the Measured Demand. To the extent that this is a reasonable interpretation of future effects of DSR, no further action need be taken. Where DSR is to be deployed on a contingency basis across future system loading peaks, an assessment needs to be made of the MW of DSR that will actually be delivered at that time. This assessment, in MW, will need to be deducted from the Measured Demand. This assessment should be formally recorded as part of the overall compliance assessment".

This means that it is up to the DNO to determine the relevant reliability factors (F factors) to ensure security of supply can be maintained when DSR services are implemented as part of BaU.

4.3 Class of supply

Table 1 outlines the normal levels of security required for distribution networks classified in ranges of group demand.

Table 1: Class of supply [Ref. 7]

Supply Group	Group Size	1st Circuit Outage	2nd Circuit Outage
A	<= 1MW	In repair time: Group Demand	Nil
B	> 1MW <= 12MW	a)< 3 hours (all but 1 MW) b)In repair time: Group Demand	Nil
C	> 12MW <= 60MW	a)< 15 minutes: Group Demand - 12MW or 2/3 Group Demand b)< 3 hours: Group Demand	Nil
D	> 60MW <= 300MW	a)Immediately: Group Demand minus up to 20MW (automatically disconnected) b)< 3 hours: Group Demand	c)< 3 hours; For Group Demands > 100MW: Group Demand - 100MW or 1/3 Group Demand d)Within time to restore arranged outage: Group Demand
E	> 300MW <= 1500MW	a)Immediately: Group Demand	b)Immediately: All consumers at 2/3 Group Demand c)Within time to restore arranged outage: Group Demand

Table 1 shows that restoration times for first and secondary outages vary depending upon the class of supply. This essentially provides the maximum operational response times required for DSR services. These response times should be taken into account when assessing both the business case and the operational requirements for procuring DSR as part of BaU.

As previously outlined DSR will only be considered when there is a fault on the network. Figure 6 shows how DSR can contribute to the security of supply in accordance with ETR130.

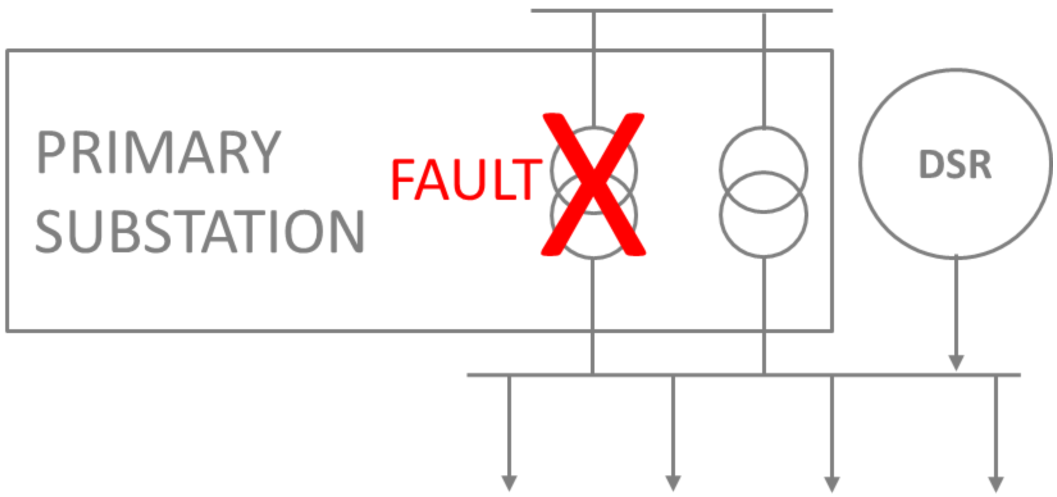


Figure 6: Distribution system DSR example

4.4 Reliability of DSR

DSR trials undertaken as part of the LCN Fund research projects have shown that the reliability of DSR services varies from one customer to another. This variability is down to a number of factors including the:

- Type of DSR response: demand-led or generation-led services;
- Ability of the customer to shed load when the DSR request is made;
- Reliability of back up generation devices to provide a response when required;
- Level of response required: total MW and duration of the event; and
- Contractual agreements, for example, penalty clauses for not providing the contracted response.

The reliability of DSR services needs to be taken into account to ensure that the security of supply is maintained.

4.5 Maintaining security of supply

The CLNR project has shown the reliability of DSR to be between 47% and 83% depending on how the sites that declared themselves unavailable for the whole of the trial are treated in the calculation. It also showed a significant difference between the reliability of load turn-down compared to generator substitution, the latter being the least reliable. However, the number of sites involved is not enough to form firm conclusions on reliability factors.

Further work has been completed on how to assess the security of supply for DSR as part of the Low Carbon London (LCL) project. The learning from this project has not been formally published, however, it is understood that the data from the LCL trials has been utilised to produce a table of 'F factors' for DSR. These F factors represent the effective capacity contribution of DSR to security of supply and show how much DSR can be relied upon to meet group demand.

It is recommended that the latest learning from industry wide DSR trials is utilised when assessing security of supply. In particular, in relation to the LCL project it is recommended that the data from the CLNR trials is utilised to validate the learning from the LCL project to assess whether:

- The F factors can be utilised in Northern Powergrid's licence area; and
- The differences in terms of implementation have an impact on security of supply. For example, whether the systems used during the trials to call DSR has an impact on the reliability of the service.

It is recognised that applying an F factor to the DSR requirement to maintain security of supply may not be sufficient. For example, if there was a requirement for 5MW of DSR at a substation applying an F factor of 50% would result in a requirement to procure 10MW of DSR (see Figure 7). However, following market assessment if a single DSR customer was to provide 5MW of DSR then an alternative approach may be required to ensure security of supply is maintained should 50% of the providers , including the 5MVA provider not be able to respond to a DSR request (see Figure 8).

The number of DSR contracts being procured, reliability of the response from each customer and the level of response from each customer needs to be taken into account when assessing the contribution of DSR services to 'Security of Supply'. Figure 9 shows that 11MW of DSR has been procured so in the event that the two providers, including the single largest customer, cannot provide a response a number of additional contracts have been placed to ensure security of supply can be maintained under this circumstance.

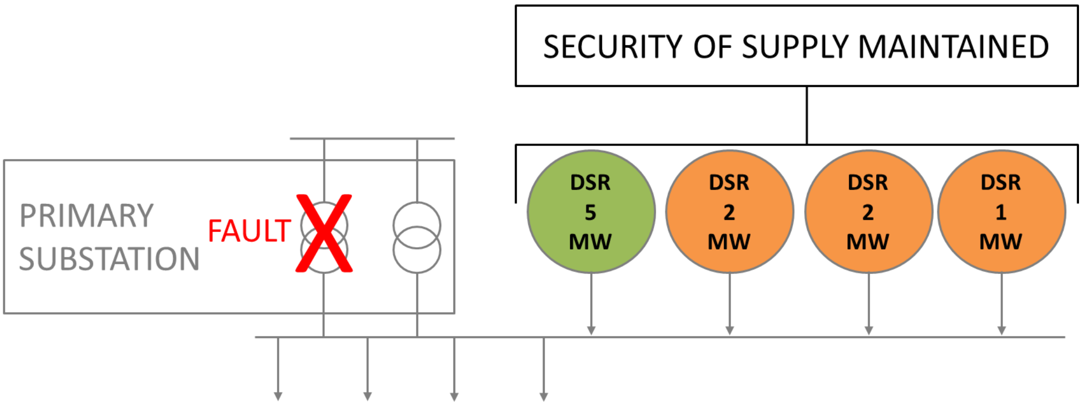


Figure 7: DSR Maintains Security of Supply

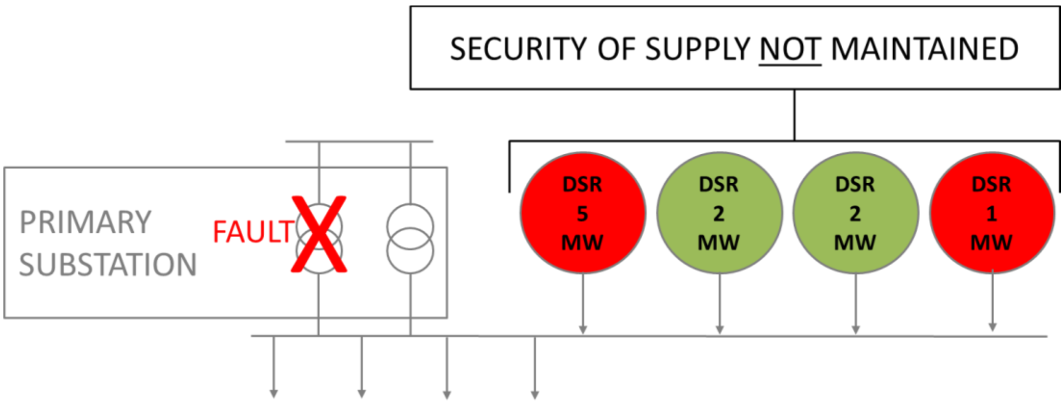


Figure 8: Security of supply not maintained (5MW response required)

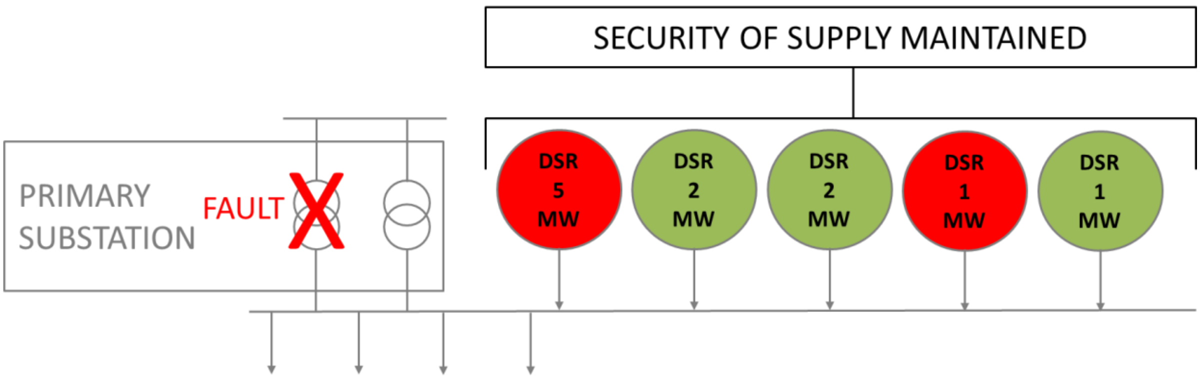


Figure 9: Security of supply maintained when single largest provider cannot respond

5 Business Case

The key driver for implementing DSR as part of BaU is the potential to defer reinforcement costs therefore providing financial benefits to the DSR provider, Northern Powergrid and ultimately all connected customers. Given the varying costs of reinforcement and the variation in both substation load profiles and characteristics the business case assessment for DSR will need to be completed on a case by case basis. The following example provides guidance on the approach to calculate the ceiling price for DSR [Ref. 11]. The steps are as follows:

Calculate the set up costs of the DSR solution and the reinforcement alternative

DSR setup costs - In this example it is estimated that the site-specific cost to set up a DSR control system, draw up contracts, set up payment arrangements are in the region of £0.1m per primary substation. This would include a controller in the substation linked to a real-time thermal ratings device to monitor the transformers. It would hold details of the DSR contracts and automatically call off the DSR requirements via signals directly to the contracted provider, which could be the end provider or an aggregator.

The cost of the alternative reinforcement option – it is assumed that lower cost options such as load transfers have been utilised and that the next lowest cost option is to replace the transformers at the substation for the next standard size at a cost of, say, £1.5m including civil and ancillaries. This would increase the firm capacity of the substation by 6MVA when, over the next 5 years, it has been forecast that only 2 MVA is required. It would therefore seem sensible to defer this investment until the trajectory of the projected load growth is more certain.

Calculate the NPV of the DSR solution relative to the reinforcement solution.

Using a regulatory discount rate of, say 4%, the annual benefit of deferral can be derived which, in this example works out to be £49,000 per annum for a 5 year deferral, as shown in Figure 10.

Calculate the MVA value of DSR contracts required based upon the reliability of response. If a reliability of 75% is assumed, then the minimum capacity needed to meet a 2MVA requirements is 2.00/0.75 = 2.67MVA.

Calculate the DSR ceiling price based upon the annual benefit of deferral, adjusted to take into account annual operating costs and reliability of response.

If an annual operating cost of 5% of the annual benefit of deferral and a reliability of 75% is assumed, then the ceiling price of DSR in this example can be calculated to be £49,000 * 0.95 * 0.75 = £34,912 per annum.

Dividing by the capacity required (i.e. 2MVA) gives a ceiling price of £17.5k per MVA per annum

Dividing by the availability window (83 days) gives a ceiling price of £211/MW-day or dividing by the typical utilisation of 8hrs/yr. gives a ceiling price of £2,190/MWh.

This is the maximum value that the DNO should pay and, at this rate, delivers all the value of the DSR to the DSR providers. However, it is still worth paying this price because of the option benefit it delivers if the future load turns out to different to the assumed forecast load. If a lower price could be achieved, then more value could be delivered to other connected customers in the form of lower future DUoS charges.

Figure 10 shows a simple spreadsheet designed to undertake the calculations.

Calculating the DSR ceiling price relative to the lowest cost investment alternative

Discount rate	4%	Regulatory discount rate
Investment to be deferred (£m)	1.5	Cost of the lowest cost alternative solution
DSR contract period (yrs)	5	Number of years that the investment can be deferred based upon forecast load growth rates
MW demand reduction required to defer investment through DSR contract period (MW)	2.00	The amount of demand reduction required to defer that investment by five years
Set-up costs (£m)	0.10	The fixed costs of providing a DSR controller at the relevant substation plus the work required to find DSR providers, draw up contracts, and set up payment arrangements.
Ongoing operating costs	5%	
Confidence	75%	Reliability of DSR (Used to calculate how much DSR would need to be purchased in order to deliver the capacity required.
DSR availabilty window (days/yr)	83	Availability window. i.e the number of weekdays during the period of peak loading (i.e. thereare 83 weekdays between November and February)

yr	0	1	2	3	4	5	6	7	8	9
Main investment (deferred) - £m	0.00	0.00	0.00	0.00	0.00	-1.50	0.00	0.00	0.00	0.00
DSR set-up costs - £m	-0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Net cashflows (exc ongoing operating costs) - £m	-0.10	0.00	0.00	0.00	0.00	-1.50	0.00	0.00	0.00	0.00
Annual value of deferred investment - £m	**0.00**	**-0.049**	**-0.049**	**-0.049**	**-0.049**	**-0.049**	**0.000**	**0.000**	**0.000**	**0.000**

Value of deferring the capex by x years after taking into account the DSR setup costs

DSR ceiling (£k/MW-year)	**£ 17.5 k**	Equals the Value of deferred investment a) reduced by 5% to allow for ongoing operating costs, b) multiplied by the reliability to reflect the overpurchase requirements and c) divided by the capacity required to give a £/MW.
DSR ceiling (£/MW-day)	**£ 211**	Divide Rate/MW/yr by the days in the availability window to give a ceiling for the rate per day
or (£k/MWh)	**£ 2.18 k**	or divide by the hours per year to give a rate per MWh contracted
MW required to be contracted	**2.67**	This is equal to the actual DSR requirement divided by the confidence factor

Figure 10: DSR cost benefit analysis

6 Customer Engagement

6.1 Target customers

I&C customers will be targeted to provide DSR services (see Figure 11) and these customers will be approached and contracted via a number of routes, including directly and via aggregators.

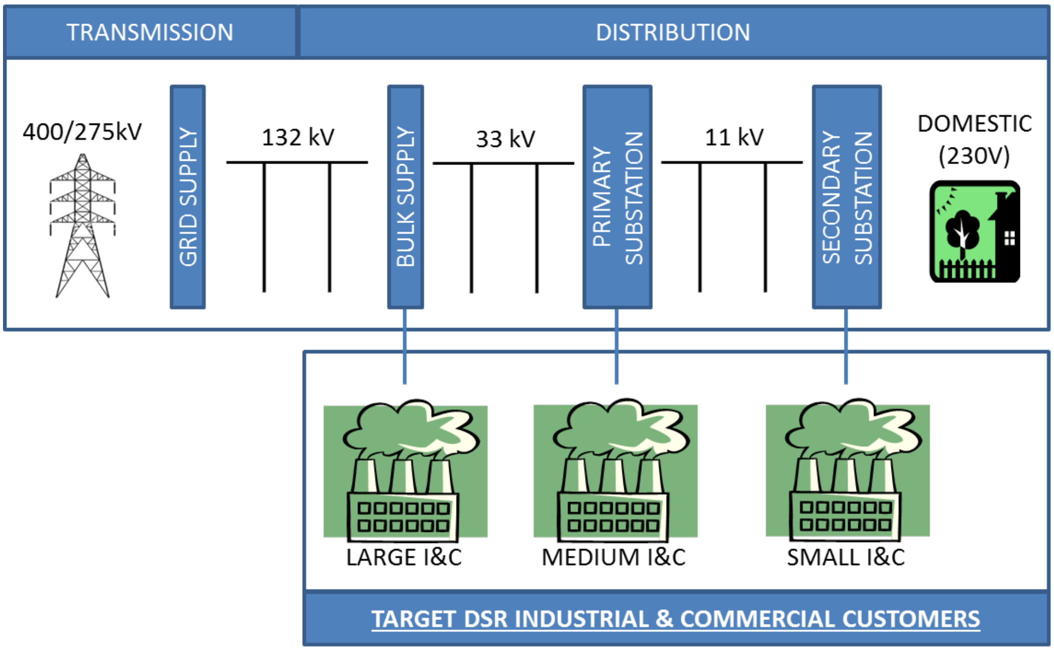


Figure 11: DSR target customers

6.2 Trigger point

The trigger point for going to the market place to seek DSR services will be the identification of a reinforcement need where the merit order calculation of all the potential solutions suggests that the best solution is DSR and the business case for implementing DSR is either positive or cost neutral.

6.3 Approaching the market

DSR is a developing market in the UK and the most efficient route to market has not yet been identified for DNOs. Until the market is fully developed Northern Powergrid will continue to explore as many options as possible. These will include, but not be restricted to, the following options investigated in CLNR, by other LCNF projects and also new routes yet to be identified and developed. These potential routes include:

- Building relationships with companies that have centralised energy management and have a widespread footprint in the region operating on multiple sites (e.g. water, telecoms, local authorities, hospital trusts, supermarkets, etc);
- Direct engagement with other significant known customers;
- Working with National Grid for sharing of STOR resource;
- Engagement via aggregators (including suppliers);

- Direct marketing using MPAN information and load profiles and inviting companies to tender into a local capacity auction;
- In partnership with local bodies such as Chambers of Commerce; and
- Advertising through local media.

6.4 Customer engagement process

The overall process to customer engagement is shown in Figure 12.

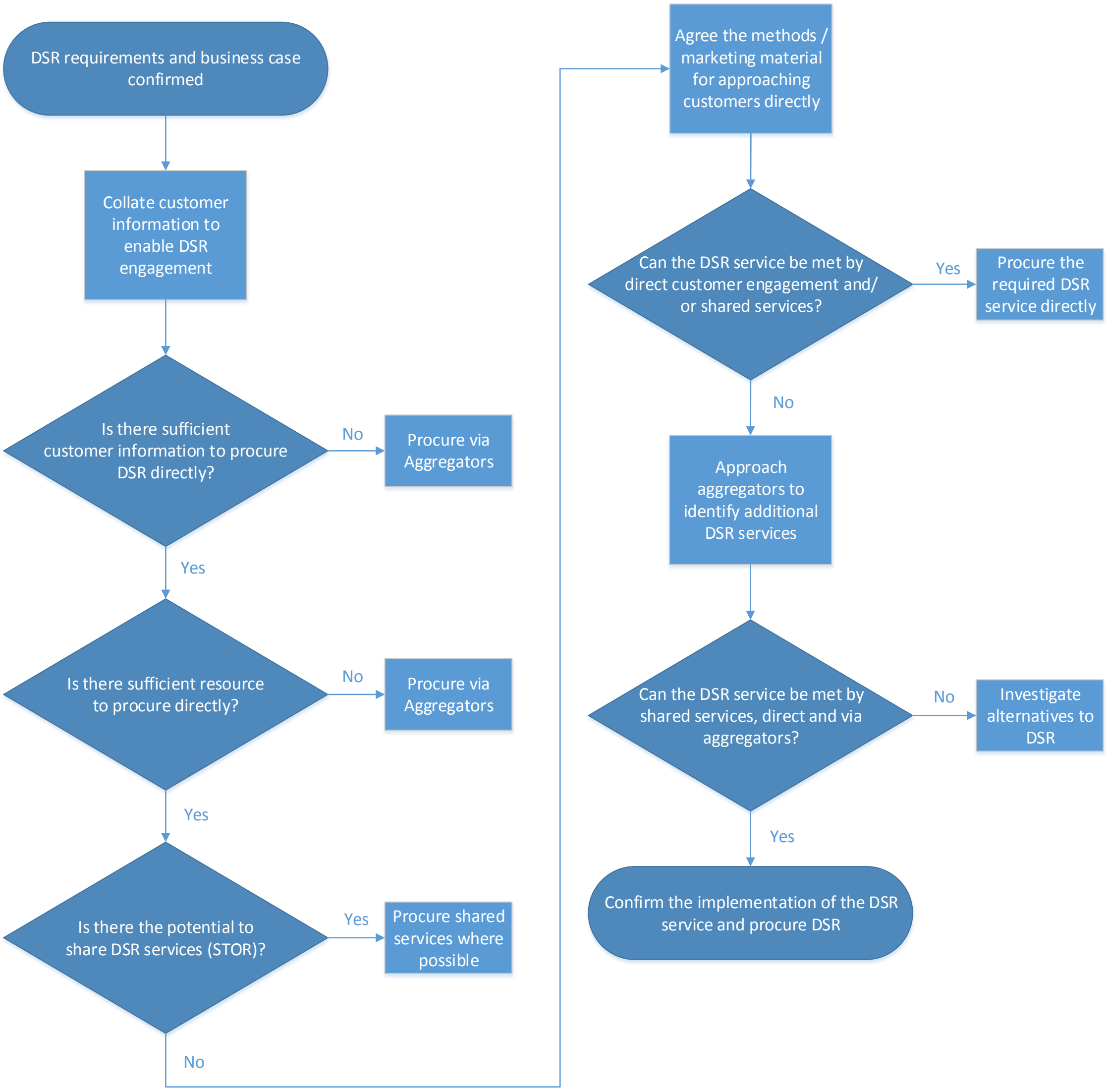


Figure 12: Customer engagement process

7 Implementation

7.1 DSR dispatch trigger

The trigger for dispatching DSR will be where there is a fault on the in-feeding network associated with a substation and the demand is forecast to exceed firm capacity.

7.2 High level ICT requirements

The DSR system has two main components: 1) DSR Dispatch System and 2) DSR Verification and Settlement System.

The DSR Dispatch System will:

- Provide the dispatch trigger required to call the DSR services;
- Identify how much DSR is required;
- Identify which DSR providers can be utilised;
- Identify the order the DSR services should be called; and
- Send an automatic signal to DSR providers to notify them that they are required to deliver DSR as contracted.

The DSR Verification and Settlement System will:

- Determine the volume of DSR that was delivered for each DSR event; and
- Calculate the payment that is due to each DSR provider.

The DSR system will be supported by the Network Management System that provides the Control Engineer with up to date information on the status of the network. The Network Management System will:

- Display alarms when fault conditions occur on the network;
- Show whether DSR services are available at the substation site;
- Display an alarm if the firm capacity is forecast to be exceeded;
- Display an alarm in the event the required volume of DSR is not available;
- Display an alarm when the number of DSR calls in a given time period is getting close to but has not breached the contractual limits;
- Alert the Control Engineer as required to show whether the DSR service will be called automatically or whether intervention is required; and
- Provide the Control Engineer with the option not to call DSR and to take alternative action to manage the constraint.

7.3 Procurement & Settlement

7.3.1 Pricing

Irrespective of the method of approach, the market will be invited to tender bids at or below the price identified by Northern Powergrid. As more experience is gained in offering contracts, opportunities may be identified to reduce the costs of DSR. On oversubscription contract award will be prioritised based on:

1) Price;

2) The ability to maintain security of supply;

3) Environmental factors; and

4) The ability to secure the contracts.

So long as the weighted average price offered is below the reserve price, discounted as necessary to reflect confidence in the service to be provided, DSR will be accepted as the most economic solution.

7.3.2 Contracts

In order to maximise the potential to procure DSR services two pricing options may be offered to potential DSR suppliers, which are as follows:

- **Benchmarking:** This methodology takes the baseline as the power consumption from the metered half hour data immediately before the despatch instruction and compares that to the post-despatch consumption levels for the minute by minute data during the DSR event. The difference between the two consumption levels is the delivered DSR. This contract type offers Availability and Utilisation payments as per the STOR methodology (see Figure 13 and Figure 14).

Benchmarking DSR Payment	=	**Availability price** (£XX/MW/h) paid for each day the response is notified as being available during the Availability window	+	**Utilisation price** (£XX/MW/h) Paid for the No. of hours each MW is delivered.

Figure 13: Benchmarking DSR payment

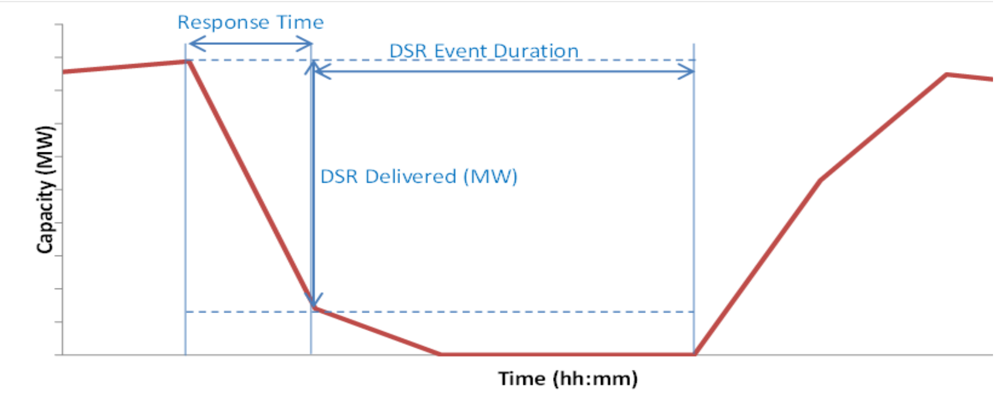


Figure 14: Benchmarking methodology Graph

- **Floor:** The floor methodology requires the site to drop consumption below a threshold level during the DSR event. A "Floor" is agreed which the site must not go over during the DSR event.

Floor DSR Payment	=	[Average demand calculated from the sites average consumption for the relevant time period(s)]	-	[Maximum demand in MW during the DSR event]

Figure 15: Floor benchmarking payment

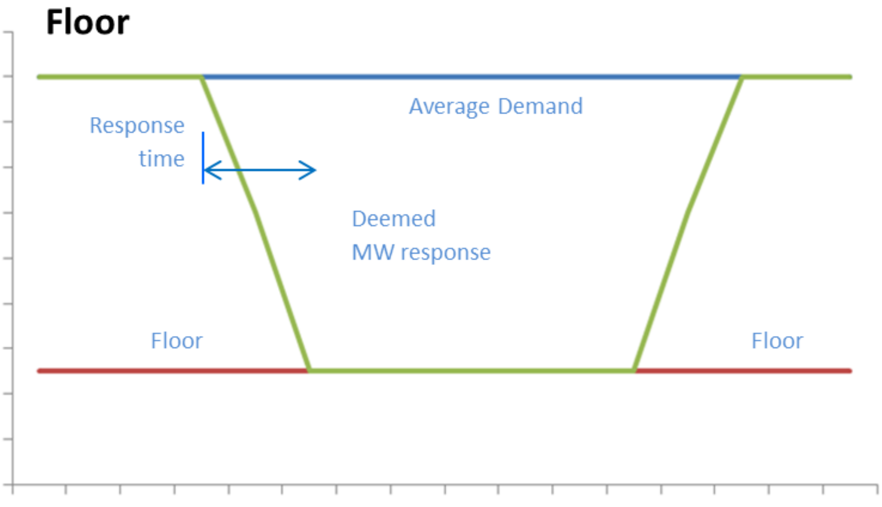


Figure 16: Floor methodology graph

The contracts utilised as part of BaU will be based on the contracts developed during the trials. Contract review will be completed annually based on operational experience and customer feedback.

7.3.3 Settlement

As shown in Figure 14 and Figure 16 the volume of DSR that is delivered is calculated by comparing the actual demand profile during a DSR event to a baseline. The payments made will be calculated as per the terms and conditions of the DSR contracts.

8 Summary

The following set up activities and ongoing responsibilities have been identified to support the transition from trials to business as usual.

FROM DSR TRIALS TO DSR AS BAU	• Identify the people, process and system requirements for DSR operation • Identify the costs for implementing & operating DSR (hardware capital costs , set up and ongoing operating costs) • Establish process for undertaking the DSR cost/benefit analysis • Establish transparent contracts and routes to market (i.e. direct, via aggregators, sharing, capacity auctions, etc) • Establish DSR hardware / software standards • Allocate responsibilities and provide training
PLANNING & DESIGN	• Include DSR as an option in all load related reinforcement schemes • Review all existing load related reinforcement schemes for DSR potential • Based upon load forecasts and fault history; calculate volume of DSR required (MW), duration of DSR event (minutes), potential frequency of DSR event calls • Assess the types of customers connected to estimate reliability factors • Calculate DSR ceiling price and undertake cost/benefit analysis • Request procurement of DSR for less than the calculated ceiling price
FAULT MANAGEMENT	• Provision of fault data required to identify the DSR requirements • Review DSR scheme proposals for operational security impact / scheme approval
COMMERCIAL / PROCUREMENT	• Identify potential DSR providers downstream of the constraint point • Invite tenders and recruit DSR providers at or below the ceiling price • Negotiate and sign off DSR schemes/contracts for implementation
CONSTRUCTION / TELECOMMS ENGINEERS	• Install, set up & commission monitoring & control systems (i.e. real-time thermal ratings, remote terminal unit, communication links, etc)
CONTROL ENGINEERS	• Review DSR schemes for operational security impact and scheme approval • Manage the network under fault conditions & respond appropriately to any alarms from the DSR schemes • Provide feedback on the operational performance of DSR events
BACK OFFICE	• Provide settlement and management of DSR contracts • Review the performance of DSR contracts

Figure 17: Responsibilities

9 References

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11) DSR Valuation Spreadsheet, Northern Powergrid.

[1] Available at http://www.networkrevolution.co.uk/resources/project-library/

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