1. SCOPE

This document defines the Policy for **Flexible Connection Solutions** and their **Principles Of Access** to be adopted throughout SP Energy Networks from 28th February 2017. The purpose of this document is to ensure that network access for **Users** makes full use of the existing network and maximises its utilisation before the requirement for network reinforcement.

2. ISSUE RECORD

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Author	Owner	Issue Authority
David Neilson Distribution Network Manager, SPD	Steve Withell Distribution Network Manager, SPM David Neilson Distribution Network Manager, SPD	Jim McOmish Head of Distribution Network pp.. Date: ....23/10/2020..................

4. REVIEW

This is a Controlled document and shall be reviewed as dictated by business / legislative change but as a period of no greater than 3 years from the last issue date.

5. DISTRIBUTION

This document is not part of a Manual maintained by Document Control and does not have a maintained distribution list.

6. CONTENTS

7. TERMINOLOGY EXPLAINED

7.1 Definitions

Terms using the definitions outlined in this section have been emboldened throughout this document.

Active Network Management	a **Flexible Connection Solution** where distributed control systems continually monitor the limits on the network and allocate capacity to customers.
ANM Customer Substation	an **ANM** controller to send **Curtailment** signals based only on the voltage and current measurements at a single substation.
ANM Circuit Schemes	an **ANM** system to send **Curtailment** signals to a limited number of customers and managed at an HV circuit or Secondary Substation level.
ANM Zones	an **ANM** system which manages an area of network supplied at Primary or Grid substation level and may encompass multiple substations and many customers.
Applicant	means a potential **User** who requesting a formal connection **Offer** from SP Energy Networks.
Connection Agreement	means a form of agreement based upon acceptance of a Connection **Offer**, stating the terms under which a **User** (or customer) shall be and shall remain connected to the distribution system.
Curtailment	means to limit, from time to time, the maximum export/import capacity of a **Non-Firm** connection**.** This limits the access into the Distribution (and or Transmission) system at the Point of Connection to avoid breaching network operational limits based on thermal, voltage or fault level constraints. The term **"Curtail"** shall be construed accordingly.
Curtailment Analysis	refers to a suite of calculations used to estimate the expected frequency, duration and MWh of restricted capacity a **User** under a **Flexible Connection** may expect.
Demand	means the electrical load in MW or MVA (or kW or KVA) being consumed by a customer or **User** or group of customers or **Users** as the context requires.
Demand Side Response	means an arrangement whereby customers agree to reduce or shift their electricity **Demand** upon request. This could be for Total System or distribution network management reasons.
Embedded	means connected to the Distribution System .
Embedded Generation	means any means any source of producing electricity (other than an energy storage unit) connected to the distribution system; and **Embedded Generator** shall be construed accordingly.
Export Limiting Device	A **Flexible Connection Solution** where automated equipment at the **User's** substation ensures that the **User's** Agreed Export Capacity is not exceeded.
Firm	means a connection provided by more than one circuit without capacity constraints for the outage of any single item of plant, circuit or its associated equipment.
First Circuit Outage	refers to operational states of the network where a single item of equipment is out-of-service due to a fault, or due to a planned outage/reconfiguration to enable repairs or maintenance activities.

Flexible Connection	means a **Non-Firm** connection (or scheme) whereby network access is managed (often through real-time control) and made available based upon contracted and agreed **Principles Of Access**.
Flexible Connection Solution	means a commercial and technical design solution with defined **Principles Of Access** which limit a **User's** network access to enable a **Non-Firm** connection by means other than a full traditional network solution.
Last In First Off (**LIFO**) **Network Access Principle**	means of allocating network capacity where a network constraint is resolved by **Curtailing** all participating **Users** in the order in which they applied for connection to the network. The term **LIFO Stack** refers to the ordered list of participating **Users**.
Local Management Scheme	a **Flexible Connection Solution** where network feeder monitoring at the User's site is used to trip the site under prescribed conditions.
Network Access Queue	a queue of customers requesting connection to the network, ordered as first come first served but may be stalled / terminated if development milestones are not met.
Non-Firm	means a connection which does not fulfil the requirements for a **Firm** connection. This includes a connection provided by a single circuit and/or a connection with capacity constraints.
Offer (Connection Offer)	has the meaning set down within the Paragraph 12.3 of the Electricity Distribution Licence.
Principles Of Access	means definition of a methodology or rules by which network access shall be granted and governs when a **Curtailment** instruction is issued or network capacity released to a **User** under a **Flexible Connection**.
Registered Capacity	has the meaning set down in the GB Distribution Code.
Remote Intertrip Schemes	a **Flexible Connection Solution** where capacity is temporarily reduced to a pre-defined level (which may be zero) for prescribed system abnormal network conditions. These may be distant from the customer's site and are monitored in real-time.
Second Circuit Outage	refers to operational states of the network where two items of equipment are out-of-service simultaneously. This is usually due to the occurrence of a fault at the same time as a planned outage.
Sensitivity Factors	represent the degree to which an **ANM** customer is able to influence a particular network constraint under a particular network outage. These factors are used to optimise the available real-time network capacity by minimising the overall level of **Curtailment** required to resolve a network constraint.
System Intact	refers to the "authorised" operational state of the network, that is the normal running arrangement with no outages or reconfigurations applied.
Timed Capacity Connection	a **Flexible Connection Solution** where the **User** manages their import/export level within a prescribed operating schedule agreed within their **Connection Agreement**.
User	has the meaning attributed to it in the Distribution Code refers to the customers using the Distribution System.

7.2 Abbreviations

ANM	refers to **Active Network Management**
DSR	refers to **Demand Side Response**
FCO	refers to **First Circuit Outage**
ICT	refers to Information and Communications Technology
LIFO	refers to **Last In First Out** Network Access principle
N	refers to the **System Intact** network condition
N-1	refers to a condition with a **First Circuit Outage**
NMS	refers to Network Management System
SCADA	refers to a Supervisory Control And Data Acquisition system
SCO	refers to **Second Circuit Outage**
SPEN	refers to Scottish Power Energy Networks

8. EXTERNAL STANDARDS AND RECOMMENDATIONS

Distribution Code of Licensed Distribution Network Operators of Great Britain. The Code covers technical parameters and considerations relating to the use of and connection to public distribution systems. Information about the distribution code can be obtained on the distribution code website[1].

Electricity Act 1989. This legislation sets out the regulatory framework and licensing regime for the UK Electricity Supply Industry.

Electricity Safety, Quality and Continuity Regulation 2002. The purpose of these regulations is to secure the safety of the public and ensure a proper and efficient supply of electrical energy. The Electricity Safety, Quality and Continuity Regulation 2002 supersede the Electricity Supply Regulations 1988. Copies of the regulations can be obtained from HMSO[2].

GB Grid Code. The Code covers all technical aspects relating to the planning, operation and use of the interconnected transmission system and the operation of electrical apparatus connected to that system. It is a requirement of the Electricity Distribution Licence that the SP Manweb and SP Distribution systems comply with the provisions of the GB Grid Code. This document is available on the National Grid website[3].

Utilities Act 2000. This legislation sets out a series of reforms for the system of regulation of the utility industries. The act established a single Gas and Electricity Markets Authority (the Authority) in place of the twin posts of Director-General of Electricity Supply and Director-General of Gas Supply.

ENA Engineering Recommendation P2/7. P2/7 sets out the minimum standard to be applied in the planning of the distribution system.

System Security and Quality of Supply Standards. The National Electricity Transmission System Security and Quality of Supply Standards (NETS SQSS) establish a coordinated set of criteria and methodologies that Transmission Licensees use in the planning and operation of the National Electricity Transmission System.

[1] Distribution Code website: www.dcode.org.uk

[2] HMSO: www.hmso.gov.uk/si/si2002/20022665.htm

[3] National Grid website: http://www.nationalgrid.com/uk/Electricity/Codes/gridcode/gridcodedocs

9. SUMMARY OF POLICY

In some areas of the network it is not possible to connect further amounts of generation, or energy storage, without the risk of breaching network limits. These areas would require significant network modifications or upstream reinforcements to be able to accommodate the new connections in an unconstrained manner.

Applicants can apply for either a **Firm** or a **Non-Firm** connection. This policy explains why the scope of **Non-Firm** connections is extended to include **Flexible Connection Solutions**. It indicates the type of application for which a **Flexible Connection Solution** is suitable:

- Embedded Generation;
- Demand Side Response;
- Virtual Private Wire; and
- Energy Storage.

This policy states the commercial principles / arrangements (Section 13) and outlines the techniques used to achieve a **Flexible Connection Solution** (Section 15)**:**

- **Timed Capacity Connections**;
- **Export Limiting Devices**;
- **Local Management Schemes**;
- **Remote Intertrip Schemes**; and
- **Active Network Management** (Zones, Circuits and Local Schemes).

The above techniques are arranged in order of increasing complexity (and network optimisation), although it is envisaged that, over time, much of the network will progress towards **Flexible Connection** zones involving **ANM.**

The commercial section of this policy describes the **Principles Of Access** for each **Flexible Connection Solution** and the process and principles of making a **Flexible Connection Offer**. These **Principles Of Access** and the expected amount of **Curtailment** are important to **Users** in assessing the viability of their projects. This policy draws attention to the need to fully engage in stakeholder discussions with affected **Users** in order that they have no ambiguity as to what a **Flexible Connection** means for their projects and to share information.

Each **Flexible Connection Solution** is then outlined in more detail (Section 15), including the commercial **Principles of Access** for each, in summary:

- For a **Timed Capacity Connection**, the **User** manages their import/export level within a prescribed operating schedule agreed within their **Connection Agreement**.
- For all other **Flexible Connection Solutions** apart from **ANM**, localised constraints and associated control actions are specifically identi**fied within the Connection Agreement**.
- In summary of the **Principles of Access** for **Active Network Management**, this policy states that the **LIFO** principle applies for any **Curtailment** under **System Intact** conditions. Where a **Flexible Connection** is used to constrain capacity under **First Circuit Outage** conditions, the **ANM** will, where efficient and technically practicable, use **LIFO** in conjunction with **Sensitivity Factors**. These seek to make efficient use of the network whilst having due regard of the **LIFO Stack**. In general, once a **Principle Of Access** is established for an **ANM** zone, that **Principle Of Access** needs to apply to all future **Non-Firm** connections within the zone to ensure equity and transparency for **Users**. As far as possible, across the network, solution systems should be based upon standardised technical and commercial principles.

Because adopting **Flexible Connection Solutions** involves communication interfaces with **Users**, this policy highlights acceptable approaches to technical communication and cyber security.

It is important that standardised designs are developed and adopted consistently network wide. Where solution requirements differ from the established designs, the Design Authority within SPEN should be consulted.

10. NEED FOR FLEXIBLE CONNECTIONS / NON-FIRM ACCESS

10.1 Need For Flexible Connections

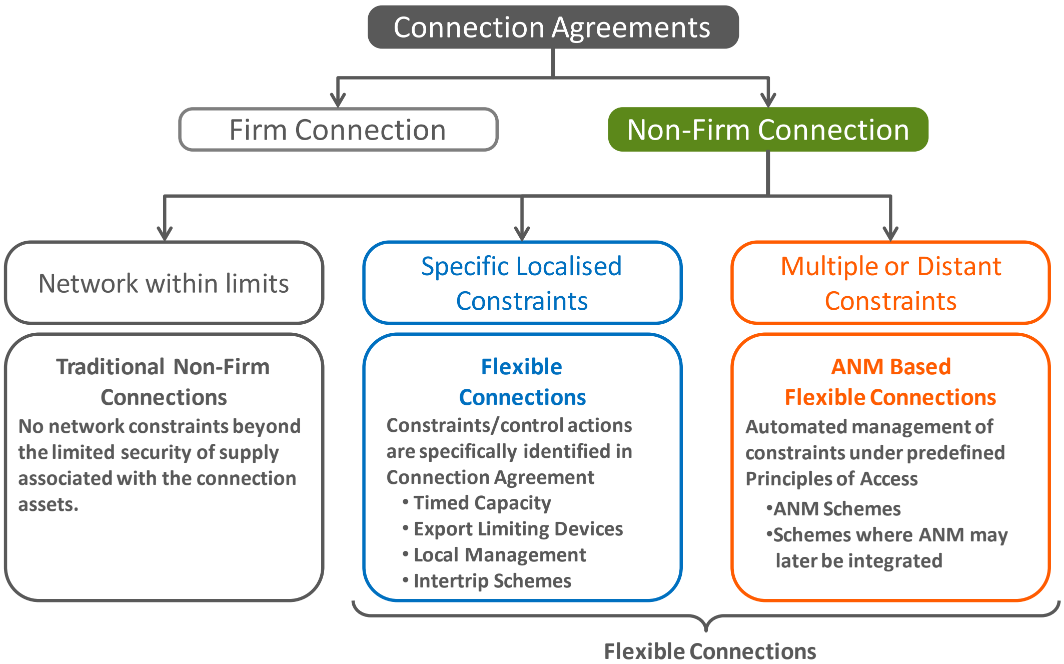
Embedded Generation flows on the distribution system have increased and will continue to increase across all **SPEN** network areas. **Embedded Generation**, Energy Storage, Heating and Electric Vehicle charging will increase as the UK transitions towards a Low Carbon Economy. This increased connection activity, coupled with the changing usage patterns of the network leads to an increasing requirement for network operators to optimise their existing network utilisation through greater autonomous control in real-time.

10.2 Firm And Non-Firm Access

Following an application for connection from a **User**, **SPEN** must make an offer in accordance with Licence Condition 12 and Clause 16 of the Electricity Act 1989. To ensure equity, all **Users** may apply for a **Firm** connection to the network. This implies that the **User** will be able to access their **Registered Capacity** even during the outage of one distribution network component. **Firm** connections need alternative paths to the **User's Connection Point** and thus often have high cost and delivery time. Many **Users** therefore initially opt for a **Non-Firm** connection.

In order to ensure equity, transparency and adequacy of information, **Users** are offered a **Non-Firm** connection with associated **Principles Of Access**. The main principles which have been used in **Offers** and **Connection Agreements** in constrained areas of the network up to this point are generally to manage localised constraints. Intelligent systems to actively manage the network and control new connections in real-time are required to utilise the maximum network capacity. Therefore less restrictive approaches are required, based upon real-time network information across zones of the network and some limited freedom to take the necessary control actions.

The following highlights how **Flexible Connection Solutions** facilitate low cost and timely connections into constrained areas of the network with differing levels of constraint complexity:



For **Non-Firm** connections, the historic approach of explicitly specifying all constraints and arrangements at initial offer stage may no longer be workable for complex **ANM** schemes. A slightly modified offer process is outlined in Section 15.5.

The contractual position of existing **Users** must form part of the background for new **Offers**. Existing **Users** could agree to take advantage of additional benefits arising from being part of a **Flexible Connection,** in which case a modified **Connection Agreement** is required. Any existing **User** will have the choice to form part of a **Flexible Connection** scheme or not.

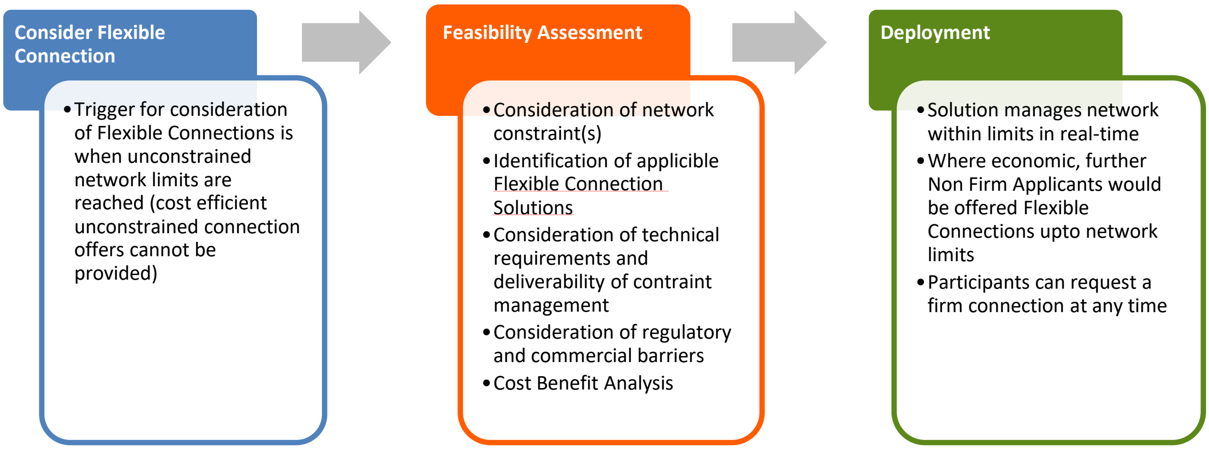
Any **User** may, at any time, request a **Firm Connection Offer** whether that **User** already has a **Non-Firm connection** or not.

11. USING FLEXIBLE CONNECTION SOLUTIONS

11.1 When To Use A Flexible Connection Offer

Flexible Connections can be used to facilitate new generation and demand onto the distribution network in areas where conventional **Non-Firm** unconstrained connections would either be slow or prohibitively expensive.

The process for triggering a **Flexible Connection Offer** is shown below:



Considerations in deciding the suitability of a **Flexible Connection Offer**:

- Is the request for a **Non-Firm** connection?
- Is conventional reinforcement either time or economically prohibitive for **Applicants**?
- Is the network at or approaching capacity?
- Is a **Flexible Connection** likely to be an acceptable alternative?
- Are there any technical, regulatory or commercial barriers to using a **Flexible Connection** e.g. that it could have an adverse impact upon the rest of the network?

A **Flexible Connection Offer** is not considered for any **Applications** requesting a **Firm** connection.

A **Flexible Connection Offer** should be considered for any **Non-Firm** generation connection **Applications** where studies identify only **FCO** constraints in areas already (or scheduled to become) an **ANM** Zone.

A traditional **Non-Firm Offer** involving reinforcement should be issued if an **Application** is made for a **Non-Firm** connection, and studies identify that management of constraints is required under **System Intact** conditions. Where conventional reinforcement is likely to be either time or economically prohibitive for **Applicants**, consideration should be given to whether a **Flexible Connection Offer** could be used to allow periods of access despite **System Intact** constraints. Guidance should be provided to the customer on how to apply for a **Flexible Connection**.

11.2 Customer Groups For Whom A Flexible Connection Offer Is Applicable

11.2.1 Embedded Generators

The nature of Embedded Generation
Embedded Generation ranges from facilities with many MW of traditional or renewable plant to kW sized installations within domestic and commercial customers' facilities. Some customers come "off-Grid" with some or all of their load, at certain times, to avoid peak charges. Whilst these peak reducing generators do not contribute overtly to export, the net effect is that by reducing local load they limit the amount of **Embedded Generation** which can be operated at that time. **Embedded Generation** can disturb network voltage profiles, especially at times with low Demand, so that parts of the network approach Licence standards or thermal limits, or create reverse power flows. Network loading and topology dictate the maximum available export capacity in real-time. A **Flexible Connection Solution**, and in particular an **ANM** solution, is therefore very suitable in many situations because it allows **Embedded Generation** output to track the available real-time capacity which will usually be higher that the capacity estimated at times of minimum network loading.

Principles Of Access
If not carefully managed, a commercial risk in applying **ANM** systems could lead to a reduction in the level of network access that is available to each participant when subsequent participants join the **ANM** scheme. To protect **Embedded Generation** against this, **LIFO** principles have been used as this curtails the subsequent participants first and maintains the level of access to the earlier applicants.

Within a complex interconnected network, a wide variety of factors can affect network constraints, and the amount of influence a particular **ANM** customer can have on a constraint is sensitive to both the network and its topology. For this reason, where efficient and technically practicable, the **Principle of Access** under **FCO** conditions is based on a hybrid of **LIFO** and **Sensitivity Factors**. This applies **LIFO** amongst only those **ANM** customers assessed to influence the critical network parameters.

11.2.2 Energy Storage Providers

The nature of Energy Storage
Embedded Energy Storage can be based upon a range of technologies. The key characteristics are: the maximum amount of stored energy (MWh); and the charging and discharging rates (MW). For example, a system based upon compressed air storage could maintain the same compressor /motor-generator but could increase their stored energy capacity by adding a further compressed air storage vessels.

This Policy is Energy Storage technology agnostic.

Embedded Energy Storage is at times an increased **Demand** and at other times an **Embedded Generator** connected to the distribution system. Sections on **Embedded Generation** and **DSR** together apply to the applicability of its role within a **Flexible Connections Solution**. However, to enable an **ANM** solution to effectively manage this type of **Embedded Distributed Energy Resource** an **ANM** controller will need to receive real-time information about the state of charge of the Energy Storage device, and have information about the limits / time profile of import and export power. The Energy Storage device will likely have an on-board controller with **User** defined commercial objectives. There will be a need to define the circumstances when network priorities as set by **ANM** overrule the on-board controller and signals will need to facilitate this.

Rapid transitioning of the energy storage state from say generating mode to **Demand** mode may be very useful to manage network parameters (e.g. under immediate post-fault outage conditions). It may be that ramp rate limitations are needed within **ANM** action to manage voltage step limitations.

Analyses to determine the network value of Energy Storage may be complex and heavily dependent on the intended operation of the scheme.

Principles Of Access

The **Principles Of Access** for constrained networks may be complex even for system normal conditions. There may be times when this **Embedded Distributed Energy Resource** may be **Curtailed** in **Embedded Generating** mode and other times when it is **Curtailed** in **Demand** mode. The device can, depending upon its state of charge, offer significant advantage at times of depleted network real-time import or export capacity and **ANM** can facilitate access to this support. As far as possible, the **Principles Of Access** for managing connections within an **ANM Zone** should be applied. As with many of the **Applications**, conflicts between distribution network priorities and Total System requirements (as incentivised by the Balancing Market) will need to be carefully managed if the network benefits are not to be overstated.

11.2.3 **Demand Side Response** Providers

The nature of DSR

Demand Side Response is an application of customer automation and control to defer or avoid general network reinforcement. The solution can be used stand-alone or as part of a larger **Active Network Management** scheme to allow access for **Applicants**. Broadly, as the local **Embedded Generation** increases output, it is helpful to have a commensurate rise in local **Demand** and vice versa. Also additional **Demand** (which is secured to Licence standards) can be accommodated if some of the **Demand** is contracted to reduce under certain conditions (or on request). Conventional reinforcement can be mitigated through use of **Demand Side Response** to reduce the expected peak export/import. In principle, **Demand Side Response** can offer the same security of supply that would have been delivered through traditional reinforcement.

Principles Of Access

Demand Side Response is delivered via a commercial arrangement with individual **Users** or customers. In all cases, contractual arrangements must make provision for periodic testing of **DSR** to ensure that the **User's** facility will achieve the required response when called upon to do so.

A range of network related and Total System related commercial arrangements is possible (outside the scope of this Policy). Total System arrangements are likely to be managed through the Balancing Market. It is important to establish boundaries / priorities and contractual arrangements so that reliance for distribution system performance is not defeated by the Total System Balancing Market prices. Consideration should be given to the period of contract and required notice for withdrawal of service for **DSR** services. If reliance, for a time, is to be placed on **DSR** to avoid network development, the notice should be at least the time needed to make alternative arrangements for securing the distribution system.

Who can participate?

In principle, any **User** could be eligible for use of **Demand Side Response.** However in order to fully understand the benefit to both the **User** and wider SP Energy Networks network a number of factors should be considered.

- Will the proposed **Demand Side Response** solution be a temporary or enduring solution?
- How will any **Demand Side Response** request be instructed?
- What level of visibility and control (real-time) is required of the **User**?

Checklist for suitability of Demand Side Response to mitigate need for network reinforcement

Standalone **DSR**

- Is a reinforcement planned at a given network location?
- Is the level, location and response time of **Demand Side Response** available to provide sufficient reduction or increase in **Demand** to mitigate the network constraints?
- Can the required number of **DSR** Customers be recruited?
- How enduring would a **DSR** solution be – Would reinforcement be deferred or avoided?

DSR integrated within an **ANM** Scheme

- Can the **Demand Side Response** contribute to a reduction in **Curtailment** instructions issued to Distributed Generation by actively controlling the **Demand** of participating **Demand** or storage customers?

<u>Response time</u>
Speed of demand response is an important factor in determining whether **DSR** is an appropriate arrangement. For example, demand reduction may need to be rapid (e.g. < 500ms) to avoid the risk of back-up protection operating which could cascade trip areas of network.

Consideration should also be given to the mechanism of the response, for example switching off a refrigeration load for an agreed period may later cause a period of higher demand when the **DSR** signal is lifted and the refrigerator seeks to regulate the temperature again.

<u>Engagement Requirements</u>
Having identified suitable **Demand Side Response** opportunities, a detailed technical and commercial assessment must be undertaken. Different participating customers will contribute differently to **Demand Side Response** instructions. Key considerations are listed below:

- Number, size of customers participating in a **DSR** scheme (by geographical location i.e. Linked to Grid Supply Point, Primary and Secondary Substation)
- Information about participating customer type (e.g. Generation, Storage or **Demand**, Response Times, whether “true” **Demand Side Response** or “Behind-the-Meter” generation)
- Whether any of the participating customers are part of an **Active Network Management** scheme
- Estimation of potential change in import/export under **Demand Side Response** and a model of how participating customers would respond individually and viewed as a portfolio

11.2.4 Virtual Private Wire Users

<u>Nature of Virtual Private Wire</u>
Where one embedded demand or generation customer has linkage, through ownership or contractual arrangements, with another embedded demand or generation customer, a connection to the distribution network can be considered using a commercial system called **Virtual Private Wire.** This option is only available if the two customers' facilities are being operated together according to **SPEN** rules to manage the same network constraint or lie within the same **Active Network Management** zone.

The control methodology follows a similar process to that described in the **Active Network Management** and **Demand Side Response** sections detailed above.

<u>Principles Of Access</u>
This is a simple **Flexible Connection Solution** where the **Principle Of Access** is that when a relevant generator is subject to **Curtailment**, a corresponding action or instruction can be taken with an affiliated **Demand** to increase import thus absorbing the export from the generation and maintaining the system within a defined operating limit. Similarly if more than one **Embedded Generation** source is involved, the contracted parties will together manage their net export according to rules set down in their **Connection Agreements**.

In the event that such schemes are to be part of a wider **ANM** scheme, then the overall **ANM** scheme **Principles Of Access** should be applied to the group of internally contracted parties. Where network real-time optimisation is to be applied and parts of the group have different effects on network performance, then the guiding principle should be that the network optimisation rules apply as if the parties were not a group.

12. STAKEHOLDER ENGAGEMENT

It is likely that **Flexible Connections** will involve greater technical or commercial complexity than a traditional unconstrained connection. For this reason, **Flexible Connection Solutions** are expected to require a greater degree of stakeholder engagement and liaison. The interaction is particularly important during the transition to **Offers** based upon **Flexible Connection Solutions**. Within this context, it is important to develop standardised designs, and to be as consistent as possible. The **Principles Of Access** of each **Flexible Connection Solution** need to avoid ambiguity and should be publicly available to external stakeholders.

<u>Initial Interaction with External Stakeholders</u>
Typically **Applicants** will need greater interaction with **SPEN** to:

- enable them to undertake income forecast projections and risk assessments, for example **Applicants** may require information to estimate the annualised level of **Curtailment** associated with their scheme;
- provide them with technical and commercial information beyond that currently provided for unconstrained **Non-Firm** connections; and
- discuss the technical requirements for interface with their equipment and associated communications.

Typically **SPEN** will need greater interaction with **Applicants** to:

- assess the characteristics, response and intractability of the **Applicant's** equipment; and
- enable **SPEN** to conduct accurate modelling, and thereby assess and design complex **Flexible Connection Solutions**.

<u>On-going interaction with External Stakeholders</u>
Some schemes may require the installation, commissioning and ongoing support of equipment that operates "behind-the-meter" and interfaces directly and autonomously with the control infrastructure of **Users** in real-time.

<u>**SPEN** Internal Stakeholders</u>
Where solution requirements differ from the established designs for a **Flexible Connection Solution**, the Design Authority within **SPEN** should be consulted prior to a **Flexible Connection Offer** being issued. This may include, but is not limited to discussion / assessment of:

- commercial **Principles Of Access**;
- equipment design or control settings;
- communications/protections protocols or infrastructure;
- **ICT** systems or third party dependencies;
- inspection, maintenance or operational requirements.

13. COMMERCIAL ARRANGEMENTS

13.1 Offers And Connection Agreements

Offers and **Connection Agreements** for an **Non-Firm** Connection must clearly state that these are for a **Non-Firm** connection and must show the **Principles Of Access** which will apply under **System Intact**, and **First Circuit Outage** conditions. In addition, as part of the **Offer** a **User** must be given sufficient information to enable them to determine the commercial impact of the **Principles Of Access** on the operation or income earning potential of their connection.

13.2 Principles Of Access

The **Principles of Access** may differ with different types of **Flexible Connection** solutions. More detail is provided for each solution in subsequent sections, however the commercial **Principles of Access** for any **Flexible Connection Offer** must:

1. Comply with all GB Grid Code requirements;
2. Support a safe, secure, and reliable power system;
3. Support efficient network operation;
4. Be clear and commercially and technically transparent;
5. Be flexible to suit future network scenarios;
6. Be consistently applied across the network;
7. Allow generators to be able to reasonably estimate future annual outputs in order to secure investment from financial backers.

13.3 Transparency And Records

Principles Of Access for each type of **Flexible Connection Solution** need to avoid ambiguity and complexity and should (where possible) be consistent network wide. These general **Principles Of Access** for each **Flexible Connection Solution** should be readily published and communicated with stakeholders.

For **ANM** systems, the day-by-day constraint decisions resulting from the automated application of the rules should be logged and audited so that there is confidence in the fair application of the rules and to enable disputes to be averted or resolved.

13.4 Managing The Network Access Queue

Management of contracted capacity is a key issue faced by DNOs. A **Network Access Queue** is established because of the lack of available capacity on the distribution network, the impact on the upstream transmission network and requirements for Statement of Works. The principle of the **Network Access Queue** is first come first served. However, projects are often not ready within the agreed timescales. This can be for various reasons including delays in planning, finance, equipment, land rights, TSO process etc. Capacity is tied up that could be productively used by others.

The governing principles of the queue are:

- Initial queue position determined by offer acceptance date
- Projects must advance in accordance with progression milestones
- Planning decision refusal (including appeal) may result in loss of queue position
- Where possible consented projects should be given the opportunity to advance

- Queue positions reassigned based on date of consent and ability to progress
- Ability to recover capacity where contracted MW differs from planning MW

Flexible Connections may extend the available capacity subject to application of **Principles Of Access** within **Connection Agreements**. For **ANM** solutions, the **Applicant's** position in a **LIFO** Stack is governed by their position in the **Network Access Queue**.

The ENA have consulted the industry and consider the following 7 milestones for project progression:

	Detail	Evidence
Milestone 1	Initiated Planning Permission	Submission of planning application / commissioning of EIA
Milestone 2	Secured Planning Permission	Permission Granted / Appeal lodged / Judicial Review launched
Milestone 3	Land Rights	Proof provided to demonstrate that land right obtained
Milestone 4	TSO Interface	Be progressing appropriate TSO process, SoW, BEGA, BELLA, etc.
Milestone 5	Progress Adoption Agreement	Design submission / adoption agreement being progressed.
Milestone 6	Commence Works	Agreed construction plan being followed
Milestone 7	Construction of Generating Activity	Completion of generation facility

Building on the ENA progression milestones, we consider the following guidelines for when to terminate, to be flexible or to treat as stalled. In summary:

<u>When to Terminate:</u>

- Early milestones (Milestones 1, 3, 4 and 5) not achieved in agreed timescales.

<u>When to be flexible:</u>

- Milestone 2 not achieved. Project in appeal.
- Milestones 1 to 6 achieved but completion of customer works delayed (for reasons beyond customer's control)
- Milestones 1 to 5 achieved but commencement of customer's works delayed

<u>When to Treat as Stalled:</u>

- Milestone 2 achieved but subject to conditions to be resolved.
- Milestones 1 to 5 achieved but commencement of DNO works delayed (at request of customer)
- Milestones 1 to 5 achieved but commencement of customer's works delayed
- Milestones 1 to 6 achieved but completion of customer's works (milestone 7) delayed beyond an agreed time period (for reasons beyond customer's control)
- Milestones 1 to 7 achieved but completion of DNO works delayed beyond an agreed time period (at customer's request)

An **Applicant's** position in a **LIFO Stack** is governed by their position in the **Network Access Queue**. The **Applicant** is removed from the **LIFO** queue if a connection is Terminated. An **Applicant's LIFO** position may be overtaken if their connection is considered to be Stalled.

14. TECHNICAL ARRANGEMENTS

The communications infrastructure requirements differ with different types of **Flexible Connection** solutions. Solutions which consider a wider area of network enable a greater degree of network optimisation. However, this in turn also increases the complexity and often the communications requirements. For more complex systems (particularly **ANM**), communications and **ICT** requirements will be part of the design process following acceptance of a Stage 1 offer (see Section 15.5.2).

14.1 Communications Infrastructure

Specific communication requirements for any **Flexible Connection Solution** will depend on the architecture of the particular scheme.

Flexible Connection Solutions can be either centralised or decentralised. More information on each is provided in Appendix 1. Centralised **Flexible Connection Solutions** are likely to utilise existing communications links where possible. For decentralised schemes it is unlikely that existing network communication assets are available to achieve communication between remote devices. Where new assets are deployed the protocols are likely to be more modern and advanced than existing assets.

The communications requirements should be detailed in the **Connection Offer** and **Connection Agreement**. Any schemes where the communications requirements differ from established designs must be agreed by the Design Authority. The **Connection Offer** should include a clause limiting SPEN's liability for the consequences of loss of communication routes or devices. This should outline any actions required to be undertaken in the event of communications failure. For example, a generator may be required to ramp down or tripped off.

14.2 Cyber Security

"Cyber security" aims to ensure that a system remains secure with regard to all Information and Communications Technology (**ICT**) components and sub-systems, including third parties, connecting to a communications and **SCADA** system.

A fundamental requirement for cyber security is to establish suitable electronic and physical security perimeters and the associated access points.

SPEN do not allow linkage of customer **ICT** systems with **SPEN** systems as this linkage would pose a significant cyber security risk.

With the connection of **ANM** schemes and control devices located in remote areas, the physical security of **ICT** equipment becomes an increasing concern. Remote **ANM** scheme control devices may potentially have links into the central real-time systems of a network where the **NMS** resides. The physical location of remote interfaces must be carefully considered and appropriate security provided to mitigate such "cyber security" risks.

A cyber security assessment should:

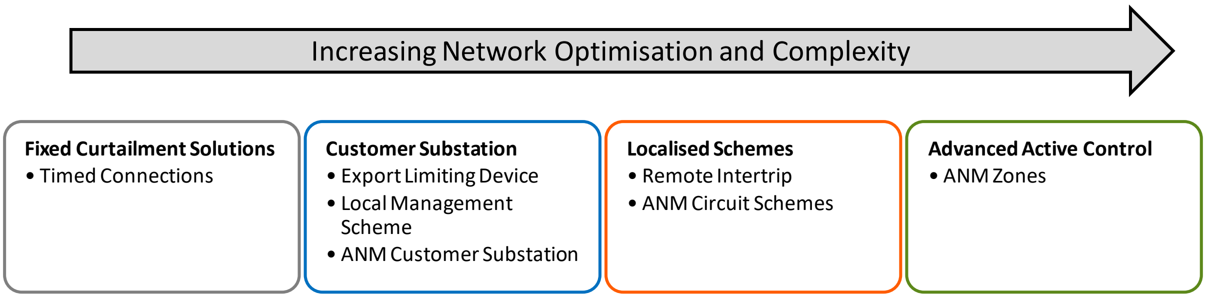
- take account of risks and vulnerabilities, and
- set out methods of prevention and response to all identified issues

The overall aim is to minimise threats. This is achieved by enhancement of existing policies, processes and practices.

Connection Agreements with **ANM Users** should oblige the **User** to comply with such reasonable instructions as SPEN may issue from time to time to protect its systems from cyber threats.

15. TECHNIQUES TO ACHIEVE FLEXIBLE CONNECTIONS

The diagram below shows how both complexity and network optimisation increase as the span of a solution widens.



The feasibility and suitability of a **Flexible Connection Solution** should consider:

- suitability of **Flexible Connection Solutions** to address the network constraint(s);
- generation / demand profiles;
- the mix of customers behind a constrained point on the network and the ability of their technical characteristics/response times to alleviate the constraint;
- the risks of a **Flexible Connection Solution** introducing network issues (e.g. transient voltage instabilities, protection mal-operations etc);
- communications, protection, **SCADA** and infrastructure requirements, costs and feasibility;
- cost / benefit of a **Flexible Connection Solution**.

In principle, connections and planning engineers should approach the solution by asking, is a less complex solution adequate, before seeking to deploy the more complex / costly alternatives. There may be situations where the wider strategy exercises significant influence on the **Flexible Connection** option to be adopted.

The subsequent sections outline the following **Flexible Connection Solutions** in order of increasing complexity:

Timed Capacity Connections	This solution offers a connection with a fixed level of **Curtailment**. The **User** manages their import/export level within a prescribed operating schedule agreed within their **Connection Agreement**.
Export Limiting Devices	Automated equipment at the **User's** substation controls the customer's demand / generation to ensure that the **User's** Agreed Export Capacity is not exceeded.
Local Management Schemes	Network feeder monitoring is taken from the protection panels located at the **User's** site. Capacity is temporarily reduced for prescribed feeder outages or monitored voltages / currents exceeding the limits prescribed in the **Connection Agreement**.
Remote Intertrip Schemes	Capacity is temporarily reduced to a pre-defined level (which may be zero) for prescribed system abnormal network conditions. These may be distant from the customer's site and are monitored in real-time.
Active Network Management	In areas where there are multiple or complex constraints affecting one or more customers, full **ANM** systems will be implemented. These distributed control systems continually monitor the limits on the network and then allocate the maximum amount of capacity to customers in that area.

15.1 Timed Capacity Connections

This solution offers a connection with a fixed level of **Curtailment**.

Some areas of the network have predictable load and generation profiles which enables adequate determination of when limitations will occur at design time. Connections will be given an operating schedule which will define the times and levels of capacity available to them.

This connection is suitable for connection capacities under 0.5 MVA and connecting at 11 kV or less. It provides a reasonable balance between facilitating connections and reserving network capacity for individual customers. More optimal usage should be made of network capacity at higher voltage levels and therefore **Timed Capacity Connections** at 33kV and above should be avoided.

In general, this constraint management is not expected to require communications. Ongoing enforcement of the **Curtailment** will be undertaken from the standard metering flows. Any breaches will result in the connection offer being withdrawn or further remote control being installed at the customer's cost.

15.1.1 **Principles Of Access**

The **User** manages their import/export level within a prescribed operating schedule agreed within their **Connection Agreement**. The DNO monitors the **User's** network usage through their metering flows.

In principle, where more than one User in an area of the network is subject to such constraints, the operating schedule of later applicants should be so arranged as to not disturb the arrangements for earlier applicants.

15.1.2 Making a **Flexible Connection Offer**

The **Demand** and generation patterns must be considered and then an appropriate operating schedule established.

An illustrative example of a timed constraint for generation in a PV dominant area is shown below:

Period	10am to 4pm	4pm to 10am
October to March	No Constraint	No Constraint
April to September	30% of full output	No Constraint
May to August	0% of full output	No Constraint

In summary, because the circumstances of constraint are specified, this remains a traditional **Flexible Connection Offer** and the connection is **Non-Firm**.

15.2 Export Limiting Devices

Customers who are seeking to increase the amount of generation installed to offset their import requirements, in circumstances where an increase in generation export capacity would require costly or time-bound upstream reinforcement, may choose to restrict the net export of their connection rather than wait for or contribute to the reinforcement.

An **Export Limiting Device** measures the Apparent Power at the exit point of the installation and uses this information to either restrict generation output and/or balance the customer **Demand** in order to prevent the Agreed Export Capacity from being exceeded.

The risk to the security of supply for existing customers is managed by ensuring compliance with technical requirements and by placing limits on the generation capacity installed, which reduces both the likelihood and effect of equipment failure.

Export Limiting Devices are suitable for all capacities and voltage levels to reduce an **Embedded Generator's** contribution to thermal or voltage infringements on the distribution network.

15.2.1 **Principles Of Access**

Automated equipment ensures that the **User's** Agreed Export Capacity is not exceeded.

15.2.2 Technical Requirements

Export Limiting Devices must adhere to the relevant power quality standards, and ENA ER G100 "Technical Requirements for Customer Export Limiting Schemes"

- The scheme has hard wired communication links (not Bluetooth, Wi-Fi etc.) between the various component parts of the export limiter scheme (e.g. the sensors, the export limiter and the inverters).
- When the export limitations scheme operates it will reduce the exported Apparent Power to a value that is equal to, or less than, the Maximum Export Capacity within 5 seconds.
- Granular monitoring data (instantaneously, 1 minute or 10 minute averages) can be made available to **SPEN** upon request.
- The scheme is fail-safe and limits export if any of the discrete units and signalling systems that comprise the export limitation scheme fail or lose their source of power.
- The maximum export from the connection should not cause SPEN back-up protection to operate, nor have the potential to cause damage to SPEN equipment.

LV connections will require a reverse power relay if the system cannot be demonstrated to be fail-safe. To prove this, during witness testing, the device must turn down or disconnect the generation if any of the discrete components lose communications or lose power.

The installer must carry out a battery of tests under **SPEN** supervision to prove the system is fail-safe. This should be identified in the **Connection Agreement**.

HV **Export Limiting Devices** must also include a separate reverse power relay set to trip upon exceedance of agreed limits.

15.3 Local Management Schemes

Some networks are constrained due to local issues which can be identified and managed by low-cost monitoring from the protection panel at the **User's** site.

By monitoring the feeder voltages and power flows at the **User's** site, or possibly the Point of Common Coupling, the constraint can be monitored and appropriate control actions taken.

Capacity can be released when these limits or assets are within normal operating parameters. When there is no capacity available, the generation output will be reduced (possibly to zero) until the network is operating within limits.

15.3.1 **Principles Of Access**

Network feeder monitoring equipment is located at the **User's** site (or possibly the Point of Common Coupling). Capacity is temporarily reduced for prescribed feeder outages or monitored voltages / currents exceed limits prescribed in the **Connection Agreement**.

If studies identify that management of constraints is required under **System Intact** conditions, the traditional **Non-Firm** form of **Offer** should be issued for the **System Intact** constraints, unless otherwise agreed with the **Applicant**.

15.3.2 Technical Considerations

This solution is generally used to manage simple network constraints and can manage single generators. It cannot be used to manage multiple nested constraints.

This connection may not be suitable in areas of heavily interconnected network, or in areas of network where **SPEN** will be undertaking **Active Network Management** within the near future.

Where appropriate, the system can be used to monitor:

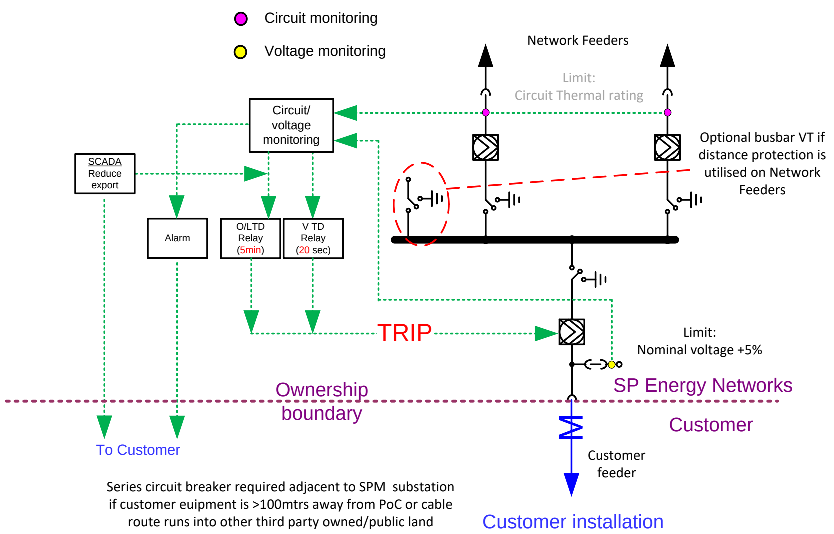
- (Transformer Reverse Power);
- (**N-1**) Constraints;
- Voltage Constraints;
- Thermal Constraints.

Local management schemes can be used for:

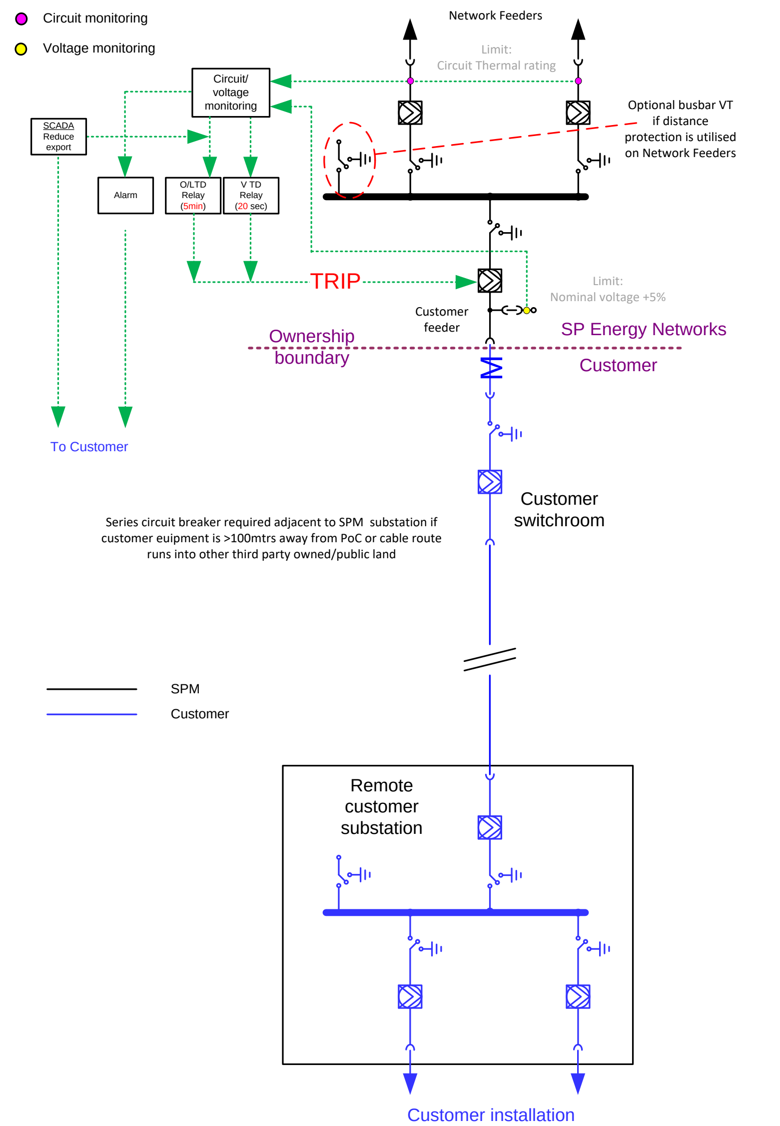
- single 33kV Metered Customer Feeder into a radially supplied substation;
- single 33kV Metered Customer Feeder into a substation supplied by two network feeders;
- dual 33kV Metered Customer Feeders into a substation supplied by two network feeders;
- dual 33kV Metered Customer Feeders into a substation with bus section;
- an HV generator connected to a Primary substation, by monitoring feeder voltage/flow at 33kV.

A series circuit breaker is required adjacent to **SPEN** substation if customer equipment is >100 meters away from PoC or cable route runs into other third party owned/public land.

An example of a 33kV scheme is shown below. Time delays indicated are ‘generic standards’ and apply to all sites unless site specific requirements dictate different settings. These ‘bespoke’ settings will be determined by the system design engineer in collaboration with a protection & control engineer.



33kV Local Management Scheme



33kV Local Management Scheme with Series Circuit Breaker

15.4 Remote Intertrip Schemes

Some networks are constrained due to a single upstream asset (i.e. a single limit being infringed under certain conditions). Through monitoring these conditions, capacity can be released when these limits or assets are within normal operating parameters. When there is no capacity available, the connection will be curtailed to a predefined limit, which may be zero.

<u>For interconnected networks, Remote Intertrip schemes should generally be avoided as they can become complex to implement and introduce difficulties in the future development of the network.</u>

15.4.1 **Principles Of Access**

Capacity is temporarily reduced to a pre-defined level (which may be zero) for prescribed system abnormal network conditions.

15.4.2 Making a **Flexible Connection Offer**

The **Flexible Connection Offer** must be explicit on the **Principles Of Access** and detail those network conditions where capacity may temporarily be suspended.

A **Connection Offer** must, in addition to the normal arrangements, contain details of any communication (including the communications security level) and control requirements in sufficient detail to allow the **Applicant** to understand whether these can be met.

The **Offer** shall also contain an example of arrangements to be put in place to deal with events where normal control is not available. The **Connection Agreement** shall incorporate the agreed arrangements and shall list the measurements, signals, actions and consequences of inaction.

15.4.3 Technical Considerations

Where appropriate the system can be used to monitor:

- Transformer Reverse Power
- (**N-1**) Constraints
- Voltage Constraints
- Thermal Constraints

This solution can be used to manage single network constraints and simple pinch points, and can manage single generators or small clusters. It cannot be used to manage multiple nested constraints. Unless the **Offer** is amended as above and the arrangements are identified as temporary this connection may not be suitable in areas where **SPEN** plans to undertake **Active Network Management**.

A traditional **Non-Firm** offer involving reinforcement should be issued if studies identify that management of constraints is required under **System Intact** conditions (unless an **Applicant** has requested a **Flexible Connection**).

This solution is suitable for generator applications connecting at HV and above. Although due to the coarse method of **Curtailment**, there will be a maximum number of participants per area.

15.5 Active Network Management

In areas where there are multiple or complex constraints affecting one or more customers, full **Active Network Management** systems will be implemented. These distributed control systems continually monitor the limits on the network and then allocate the maximum amount of capacity to customers in that area.

ANM Customer Substation: These are schemes which use an **ANM** controller to send **Curtailment** signals based only on the voltage and current measurements at a single substation

ANM Circuit Schemes: These are **ANM** schemes which manage a limited number of customers and are managed at an HV circuit or Secondary Substation level

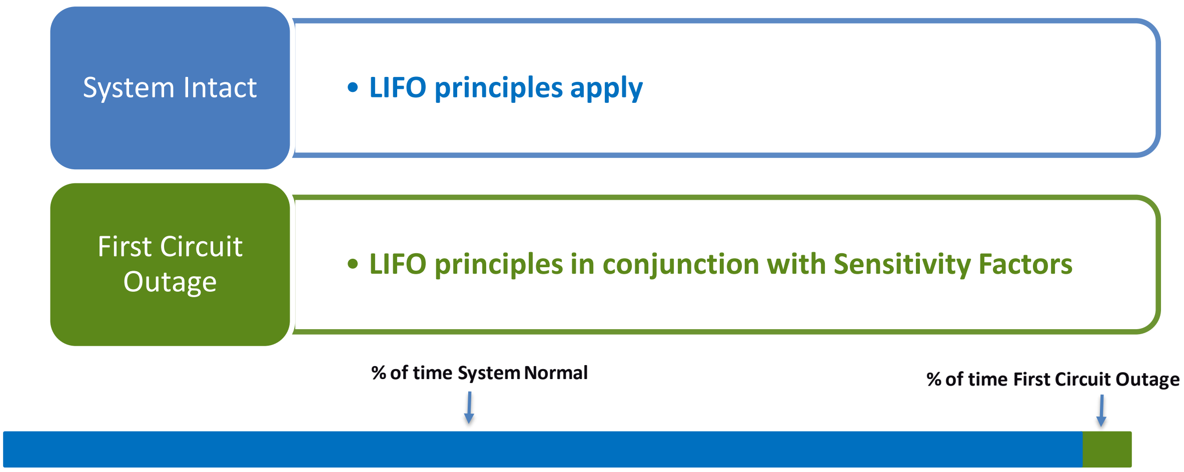
ANM Zones: These are more complex **ANM** systems which manage areas of network supplied at Primary or Grid substation level and may encompass multiple substations.

Active Network Management schemes operate in real-time and monitor inputs, outputs, network flows and voltages at key points within the controlled zone. If the network is approaching limits, the **ANM** controller instructs actions to be taken. These could be changes in network topology or changes in the power into or out of the network, depending upon the characteristics of the particular system.

ANM schemes to maintain fault energy within equipment limits are presently under consideration / development.

15.5.1 **Principles Of Access**

The following **Principles Of Access** apply, where efficient and technically practicable.



<u>Constraints under System Intact Conditions</u>
Where a **Flexible Connection** is used to constrain capacity under **System Intact** conditions, the level of capacity is allocated based on the date when the customer's connection was accepted. There are modifiers to this stack for cancelled and stalled projects. The **Last In, First Off (LIFO)** hierarchy prioritises the oldest connections when issuing capacity, but is extensible so that new entrants will get access to the capacity as it becomes available. This **Principle Of Access** aims to offer developers certainty in their investment decision making processes for a high percentage of the plant lifespan.

Constraints under **First Circuit Outage**
Where a **Flexible Connection** is used to constrain capacity under **First Circuit Outage** conditions, the **ANM** scheme will, where efficient and technically practicable, use **LIFO Principles** in conjunction with **Sensitivity Factors**. This approach seeks to make efficient use of the network whilst having due regard of the **LIFO Stack**. In complex interconnected networks, a wide variety of factors can affect a network constraint. The amount of influence an **ANM** customer can have on a particular constraint is sensitive to both the topology and the characteristics of the network. **Sensitivity Factors** represent the degree to which an **ANM** customer is able to influence a particular network constraint under a particular network outage. These factors can be used to optimise the available real-time network capacity by minimising the overall level of **Curtailment** required to resolve a network constraint. The **Principle of Access** under **FCO** conditions are based on a hybrid of **LIFO** and **Sensitivity Factors**. It applies **LIFO** amongst only those **ANM** customers assessed to influence the critical network parameters.

In networks with radial topologies that do not have alternative supplies, the need for **Sensitivity Factors** is reduced as all generators are expected to have a similar influence on the critical upstream network parameters, meaning there may be little difference in efficiency between **LIFO** and minimum **Curtailment** based on **Sensitivity Factors**.

ANM Access Principles based upon "pro-rata" **Curtailment** are not generally used. This method of **Curtailment** would resolve constraints based upon the proportional contribution from each generator. **Curtailment** is shared equally amongst all generators in the **ANM Zone**. This method cannot insulate against greater **Curtailment** caused by the connection of later generation. Any new schemes using pro-rata based **Curtailment** algorithms must be agreed by the Design Authority.

ANM Access Principles based upon "rota" **Curtailment** are not generally used. This approach would alter the **Curtailment** stack on a rota basis changing daily, weekly or monthly. It is thought that generators could be unfairly curtailed due to seasonal variations in **Demand**. Any new schemes using rota based **Curtailment** algorithms must be agreed by the Design Authority.

Curtailment under **SCO** conditions
ANM Customers will be managed in such a way as to maintain safe and efficient operation of the network.

In general, once a **Principle Of Access** is established for an **ANM Zone**, that **Principle Of Access** needs to apply to all future **Non-Firm** connections within the zone to ensure equity and transparency for **Users**. As far as possible, across the network, solutions should be based upon standardised technical and commercial principles.

15.5.2 Modified **Offer** Process

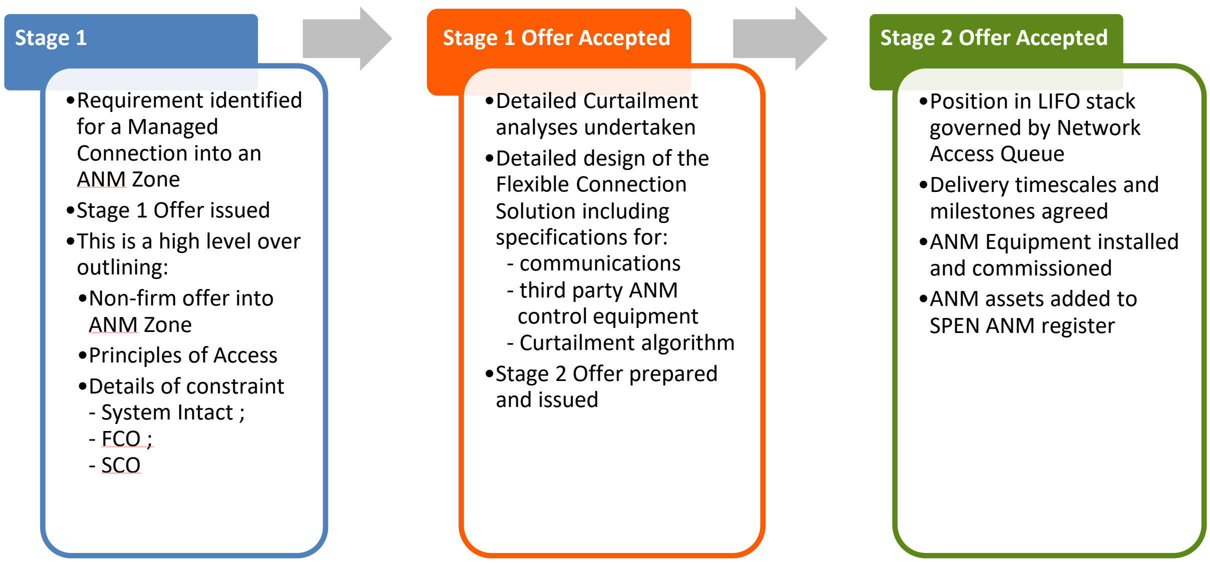
All offers must enable prospective customers to understand the commercial proposition and the manner in which their connection will be managed. It is important that **Applicants** have both the technical and commercial information to forecast income projection and analyse their financial risk.

The feasibility and practicality of providing a **Flexible Connection Offer** should be considered for any **Non-Firm** generation connection applications where studies identify only **FCO** constraints occur in areas already (or scheduled to become) an **ANM Zone**.

A traditional **Non-Firm** offer involving reinforcement should be issued if an application is made for a **Non-Firm** connection, and studies identify constraints under **System Intact** conditions. Where conventional reinforcement is likely to be either time or economically prohibitive for applicants, consideration should be given to whether a **Flexible Connection Offer** could be used to manage these **System Intact** constraints and guidance should be provided to the customer on how to apply for a **Flexible Connection**.

The **ANM Flexible Connection Offer** process is as follows:

- Initially, a Stage 1 **Flexible Connection Offer** will be issued. This high level offer outlines the **ANM** solution, and must be explicit on the **Principles Of Access** and detail those network conditions where capacity may temporarily be suspended, including whether these are **System Intact** constraints, or under **FCO** conditions. This Stage 1 offer does not provide any estimate on likely levels of **Curtailment**.
- Once an **Applicant** has accepted a Stage 1 **Offer**, detailed **Curtailment Analysis** can be undertaken, along with detailed design and specification of the **ANM** scheme and associated communications. The detailed designs form the basis of a Stage 2 **Offer**.
- The position in the **LIFO Stack** is governed by the **Applicant's** position in the **Network Access Queue**. Detailed **Curtailment Analysis** may be reassessed upon any changes to the **Applicant's** position in the **LIFO Stack**.



A **Connection Offer** must contain details of any communication (including the communications security level) and control requirements in sufficient detail to allow the **Applicant** to understand the level of risk associated with loss of communications. The **Offer** shall also contain an example of arrangements to be put in place to deal with events where normal control is not available. The **Connection Agreement** shall incorporate the agreed arrangements and shall list the measurements, signals, formats and destinations.

Any **User** subject to a **Flexible Connection** may request a **Firm** connection at any time and follow the existing network connection process whereby they may be liable for any network reinforcement costs incurred.

15.5.3 Changes in System Capacity

Access patterns of existing and new **Users** change over time. These changes together with power system hardware and software developments may impact on available system capacity in future. **Flexible Connections** are **Non-Firm** and therefore by accepting the **Flexible Connection Offer** the **User** is deeming the level of associated risk as appropriate. The **Applicant** is strongly encouraged to conduct their own assessment of potential revenue risk.

Two outcomes are possible for customers with **Flexible Connections**:

- if the side of effect of change in **Demand** patterns, small scale generation increase or system development in one part of the system results in a reduction in capacity, this may lead to greater than expected **Curtailment**.

SPEN does not guarantee any level of duration or frequency of **Curtailment** or constraints. The **Connection Agreement** states **Non-Firm** access with a **Flexible Connection**. The **User** is, at any time, able to request a **Firm** connection.

- if new capacity becomes available then unless that capacity has been paid for by other specific **Users**, it can be used to benefit the access of existing **Users** according to the **Principles Of Access** within their **Connection Agreements**.

When **Connection Agreements** become time expired and renewal is requested they should be modernised in line with new access standards and other improved drafting.

15.5.4 Functional Specifications

It is the responsibility of **SPEN** to provide a set of functional specifications to which an **Active Network Management** scheme must adhere. These functional specifications must also be provided to the **Applicant** being offered an **Active Network Management** connection solution.

Functional Specifications fall into four distinct categories;

- System configuration and algorithms
- Measurements and data exchanges
- Communications and interfacing
- Forecasting

15.5.5 **ANM** Rollout Philosophy

The driver for making a network zone **ANM** enabled ultimately comes from the requirement to facilitate the connection of new customers in areas where conventional connections would either be slow or prohibitively expensive. The trigger for considering when to establish a new **ANM Zone** is when network limits are reached in that area of the network and there are requests for **Non-Firm** connections.

ANM Platform Deployment: Once an area of EHV network has reached capacity limits, the feasibility and practicality of establishing a centralised **ANM Zone** should be assessed. Where practical and efficient, a new centralised **ANM Zone** would be established.

ANM Applicants: Applicants connecting into an **ANM** system would pay a capitalised licence fee. This shall be included in the **Connection Offer**. Any significant OpEx costs, particularly those associated with communications, should be avoided or capitalised. The **Connection Agreement** expiry date shall be based on the expected life of the **ANM** system and licence.

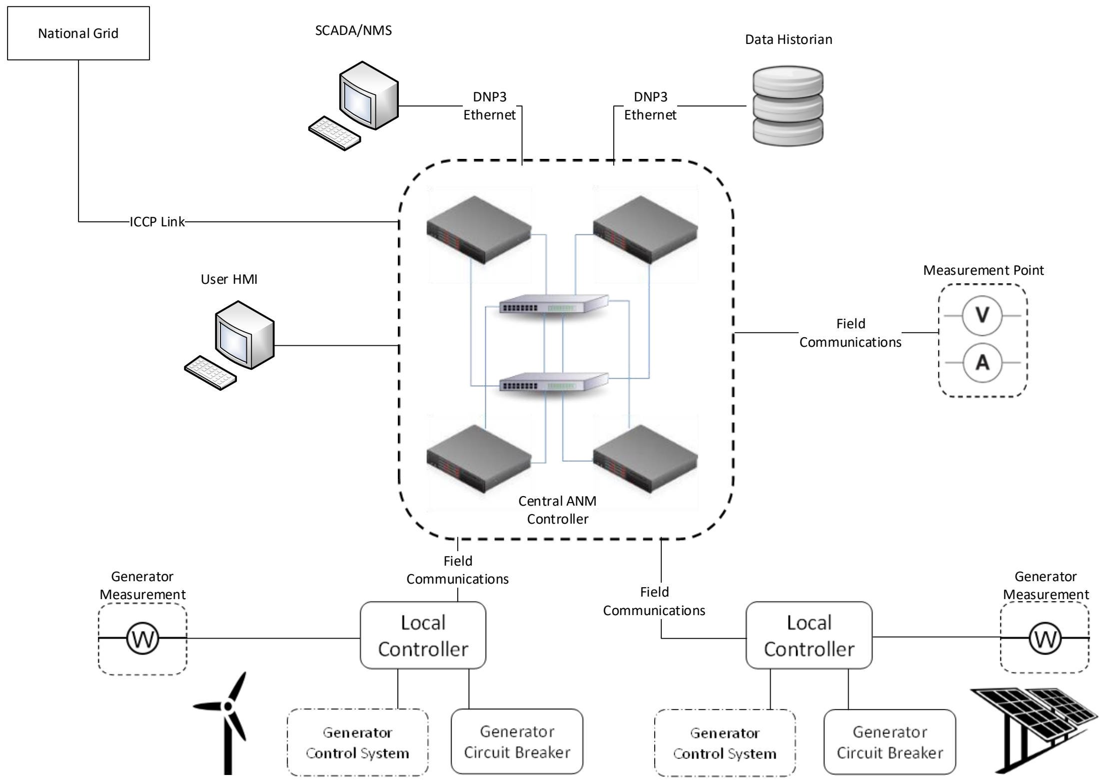
15.5.6 **ANM** Technical Considerations

The technical integration of **Active Network Management** involves physically embedding a scheme into **SPEN**'s existing electrical and communications infrastructure, as well as into its network operations and management practices.

The system architecture of an **Active Network Management** scheme will define to a large extent how it is integrated with existing network systems, and more detailed functionality requirements will inform hardware, software, **SCADA** and communications specifications. Furthermore control room visibility and network safety considerations are critical to the operation and management of the network and will determine the interfacing requirements with the **User**.

The technical architecture of an **Active Network Management** scheme can be categorised as either decentralised or centralised. The distinction between the two is found in the integration method with remote devices performing algorithms in decentralised schemes and centralised schemes being more **Embedded** within a central network control infrastructure. More information on centralised / decentralised systems is listed in Appendix 1.

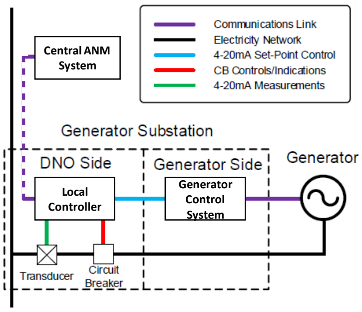
ANM Zones:



A centralised architecture is preferred to manage wider network constraints particularly **ANM Zones** or when the constraint location relates to an existing Grid Supply Point or interface with the transmission system. These typically have redundant **ANM** controllers, link with the Human Machine Interface in the Control Room and link to the Data Historian system.

<u>**ANM** Circuit or Customer Substation Schemes:</u>

An **ANM** circuit scheme controlling an HV feeder or secondary substation is generally decentralised and usually favours a low-cost solution. This architecture is favoured for localised schemes which manage a limited number of customers at HV feeder or below.



A "hybrid" approach can improve the overall **Active Network Management** scheme reliability, by having improved communications redundancy, compared to decentralised architectures. The approach also removes the "single point of failure" risk of centralised architectures.

15.5.7 Position of last resort

Connection Offers should state that SPEN reserve the right to disconnect all flexible connections participating in an **ANM** scheme if, for any reason, the automated systems do not adequately serve to safeguard the operation of network.

15.5.8 Constraint Analysis

When considering a **Flexible Connection** solution, the long term impact of **Curtailment** is of significant importance to the development of a robust and financeable commercial proposal. Therefore, **Constraint Analysis** (either provided by **SPEN** or undertaken by the **Applicant**) is of importance to the **Applicant** to forecast MWh of output that the plant can expect to transit on an annualised basis.

Constraint Analysis requires:

- data to enable modelling of the technical characteristics of the network relevant to a constraint location and
- knowledge of the specified **Principles Of Access** to enable simulation of the level of **Curtailment** and/or network access that would be experienced by the **Applicant**.

The analysis should consider:

- 8760h/year for a representative period;
- profile assumptions relating to the **Applicant's** plant, agreed with the **Applicant** prior **to Constraint Analysis** being undertaken;
- the generation and **Demand** profiles of existing customers (historically measured where possible);
- profile data related to future plant (generic or historical output from similar plant may be used);
- the **Principles Of Access** for the particular **Applicant**, in particular the **LIFO** Stack;
- **Curtailment** quantification which should reflect the expected operation of the **ANM** scheme (this should reflect as closely as possible the operation of the **ANM Curtailment** Algorithms);

- the network operation which should reflect reality as closely as possible (for example, the model should include appropriate models for any AVC, load transfers, intertrips or special protection schemes or pertinent network responses);
- failure rates assumptions (which should be agreed and visible);
- planned outage schedules and network reinforcement plans (where these can be identified);

The analysis report should:

- present detail on the frequency and duration of events as well as the overall MWh **Curtailment**

Some sensitivity impacts may be required, (for example, an agreed reduction in background **Demand**, or heavier than average generation profiles for entrants higher in the **LIFO** stack, or increased failure rates).

16. APPENDIX 1: CENTRALISED / DECENTRALISED ANM

A **Flexible Connection Solution**, and in particular **ANM** can be either centralised or decentralised. In centralised systems, the control algorithms are performed on server grade computers located in the Operational Control Centre. The **ANM** system is closely linked to, or embedded within central network control. In decentralised systems, the **ANM** control is performed within remote substations. Control algorithms are deployed on ruggedized substation computers and can operate autonomously.
There are ownership, skills and cost implications for both types of deployment.

	Decentralised	Centralised
Scheme Location	Suited to remote locations where communications with central network control may not be reliable and/or robust enough	Locations served well by existing **SCADA** and also in areas where it is not ideal to install a software based scheme out in the network within SP Energy Networks estate
Constraint Type	More suitable for localised Constraints or for one-off single circuit grid constraint management	A centralised approach is well suited to management of a wider grid constraint due to increased visibility and controllability requirements
Response Time	A decentralised architecture can be specified to provide a response that is required at a local constraint and in a timeframe that is more rapid than **SCADA**	The required response time should be considered as an initial and first line of control to manage network assets that can operate in a timeframe consistent with **SCADA**
Controllability & Visibility	Can be lower visibility and controllability if communications with central network control is unreliable and/or robust (see scheme location)	Provides robust visibility and controllability of the scheme
Reliability	Multiple hardware devices lead to a greater risk of one or more equipment faults at any time. A decentralised system reduces risk of a catastrophic failure and must be balanced with the consequences of a failure which has the probability of being a low risk.	Dual **SCADA** communications structure provides redundancy. However a centralised **Active Network Management** scheme provides a single point of failure for all devices and customers connected under it!
Costs	'Plug and Play' on existing hardware reduces overall scheme costs however may lead to a greater penetration and number of hardware devices (although some of these may be customer owned	Costs fully integrated within the **Active Network Management** scheme (or stand-alone equivalent)
Security	Easily segregated from existing network management systems so connection of customer assets and control systems should not affect overall network cyber security	Where existing network management systems are used, integration of customer assets and control systems into those existing systems is required. However the security of a single **ANM** solution interfacing directly with multiple customers can be more easily managed and controlled centrally behind the corporate firewall as compared to decentralised management of devices in remote multiple locations – however must balance costs with actual and not perceived risk of security breach and weigh this up with probability and result of failure