Flexibility Connections: Explainer and Q&A

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1. Introduction

1.1. About ENA

Energy Networks Association (ENA) represents the owners and operators of licences for the transmission and/or distribution of energy in the UK and Ireland. Our members control and maintain the critical national infrastructure that delivers these vital services into customers' homes and businesses.

1.2. About Open Networks

Britain's energy landscape is changing, and new smart technologies are changing the way we interact with the energy system. Our Open Networks project is transforming the way our energy networks operate. New smart technologies are challenging the traditional way we generate, consume and manage electricity, and the energy networks are making sure that these changes benefit everyone.

ENA's Open Networks Project is key to enabling the delivery of Net Zero by:

a) opening local flexibility markets to demand response, renewable energy and new low-carbon technology and removing barriers to participation
b) providing opportunities for these flexible resources to connect to our networks faster
c) opening data to allow these flexible resources to identify the best locations to invest
d) delivering efficiencies between the network companies to plan and operate secure efficient networks

1.3. Purpose of this Document

Network Active Network Management (ANM) schemes can be used with both generation and demand customers on the transmission and distribution networks, but the most common use to date has been by Distribution Network Operators (DNOs) offering ANM facilitated Flexible Connections to generators wishing to connect to constrained parts of the network. These "Flexible Connections (ANM)" allow generators to connect more quickly and at lower cost by including provisions for curtailing their output during constrained periods to avoid the need for network reinforcement.

This guide is intended to be of use to customers that might be offered ANM facilitated Flexible Connections or to participate in ANM-enabled Demand Side Response (DSR). Its aim is to help these customers understand better these types of connections, the additional benefits and risks, and the information and advice available from the local DNO.

1.4. Background

The UK government is committed to delivering net zero terrestrial greenhouse gas emissions by 2050, which will require a major transformation of our energy system. As part of this transformation, the amount of electricity generated from renewable sources will increase. A significant proportion of this will be connected to the lower voltage distribution networks (at 132kV and below) rather than to the transmission network at 275kV or 400kV, as would be the case historically for larger generation assets. These new connections will change the traditional role of distribution networks from being passively managed to requiring more active management of power flows. Distribution Network Operators (DNOs) are planning for the effects of increasing volumes of distributed, and often intermittent, generation and demand (e.g. Electric vehicles, and heat pumps) on their networks.

Generators wanting to connect to distribution networks under the current regulatory access rules (also known as "shallow-ish" access rules) may find the connection costs too expensive. When generators connect to an (export) constrained network they can trigger reinforcement costs; currently under the "shallow-ish" access rules

generation customers are liable for the network reinforcement costs at their connection voltage plus further into the network (at one voltage level above). Similarly demand connections can find they are subject to high reinforcement costs or long timescales for connection. Many of these new demand customers have increasingly variable imports such as electric vehicle charging, heat pumps, and electric energy storage.

Finding solutions that provide faster, more cost-effective access to the distribution networks without reinforcement has been a major focus for DNOs because accommodating the growth and management of distribution connected flexible assets is a prerequisite for the GB transition to net zero carbon. This is the core principle underpinning Active Network Management (ANM): its use can speed up connections and materially reduce connection costs, primarily for the benefit of those customers who are able to operate their assets flexibly with a Flexible Connection facilitated by an ANM scheme.

2. Overview of Flexible Connections (ANM)

2.1. What is a Flexible Connection (ANM)?

In constrained areas of the electricity distribution network, the time and cost to reinforce the network can be a significant deterrent to customers wanting to connect their assets. To mitigate this, customers may be offered, or request directly, a more flexible (constrained) connection (sometimes described as a "non-firm" connection) that either limits the times in which the generator can export, or the capacity that can be exported. Similarly for demand customers with a (constrained) connection, the times in which a site can import, or the level of import may also be constrained. Where assets on flexible connections have their export or import constrained by the DNO this is commonly termed curtailment.

These (constrained) connections are often facilitated through the network control system known as Active Network Management (ANM) and are termed Flexible Connections (ANM). Whilst there are other types of flexible connections (Section 2.2) this document is focused primarily on Flexible Connections (ANM).

Flexible Connections (ANM) can be implemented as both enduring or temporary solutions. Operationally, the DNOs use Flexible Connections (ANM) to connect more customers (typically generators/storage) through active management of the network loads, often in close to real time. This automated management of network loads prevents a constrained part of the network from exceeding its firm capacity[1]. ANM schemes require the use of communications equipment and centralised control systems to limit generation for short periods. The ANM systems continually monitor all the constraints on the network in real time and allocate the maximum amount of capacity available to customers in that area based on the Principle of Access (See Section 2.6) and curtailing other assets as required to avoid exceeding the network limits.

2.2. Are there other types of Flexible Connections?

Whilst this document is primarily concerned with Flexible Connections enabled through ANM schemes, there are several different types of flexible connections that may be offered by the DNOs. The types of flexible connections available can vary depending on the DNO.

a) **Timed export/import connections:** these offer customers the possibility of connecting to the network but with limited export or import during certain periods of the day, week, month or year. Typical example could be wind generation limited to exporting during non-daylight hours in areas with significant PV generation.

[1] A network's firm capacity is the load it can carry following one or more faults (i.e. less than the total capacity). An "N-1" network operating within its firm capacity is able to continue delivering power to customers without loss of service following a single network fault.

b) **Single Generation Active Network Management (SGANM**): is similar to a full ANM scheme, except instead of managing multiple constraints and multiple generators it manages only one generator and up to two constraints.

c) **3rd party ANM connections:** some customers can also consider shared capacity and demand management, both of which are installed and managed by the customer.

d) **Export Limited Connections**: these are used where the installed generation asset has a greater export capability than that which has been agreed to be exported onto the distribution system. For example, a site which utilises the majority of energy generated within onsite processes and therefore limits the export of electricity to the network. These sites incorporate failsafe protection devices to ensure that the level of export is limited to a pre-agreed threshold.

e) **Import Limitation Connections:** these are used where the installed asset has a greater import capability than that which has been agreed to be imported from the distribution system. For example, a site which has multiple electric vehicle charge points may utilise an import limitation scheme to control smart charging of their electric vehicle fleet so as to not exceed their maximum agreed import capacity (MIC). These sites incorporate failsafe protection devices to ensure that the level of import is limited to a pre-agreed threshold.

2.3. How to apply for a Flexible Connection (ANM)?

In the first instance, customers should access the local DNO's website where more information detailing the potential flexible connection options available can be found, together with advice on how to apply.

If a customer decides to apply for an unconstrained connection (sometimes described as a "firm" connection), and there is significant reinforcement required to connect their asset, then alternative flexible connection options may be suggested by the DNO. Options will be dependent on the voltage level of connection, and the reinforcement works required.

Times and costs for connection applications for both flexible and unconstrained connections can vary by DNO and also by voltage, connection offer type and the work required. The DNO will support customers in understanding the options and the relative benefits and risks.

2.4. How often do Flexible Connections (ANM) get curtailed?

Investment in network capacity is driven largely by peak usage but where the outputs from customers' generation assets are variable, the overall network requirements can be less (due to diversity in when the different assets are running. How often an asset is curtailed depends on how often the site's annual output profile coincides with the times constraints are likely to appear on the network

To maintain safe operation of the network the worst-case scenario is used in the network modelling; i.e. coincident operation of generation is assumed in the DNOs' network capacity assessments. This may result in a conservative curtailment estimation for the customer (in other words the network capacity assessment may forecast more curtailment than is experienced in practice).

Finally, ANM systems have an integral failsafe mode to eliminate any technical or regulatory risk to the DNO of associated unsafe network operation. The DNO sets the technical parameters / triggers for the ANM scheme, but the actions are automated and not generally at the discretion of the DNO in real time. The actions are supervised by control room staff in the event that manual intervention is required to prevent an unsafe condition.

2.5. What are the factors that influence curtailment of a Flexible Connection (ANM)?

Curtailment of the generation assets will occur at varying levels based on a real-time network load assessment on the distribution system. The level of curtailment will depend on a number of factors including, but not limited to, those listed below and may increase or decrease over time:

a) Changes in operational running of the distribution system
b) Changes in the level of demand on the distribution system
c) Increases in the number of connecting small scale embedded generators
d) Reinforcement of the distribution system triggered by demand
e) Reinforcement of the distribution system triggered by unconstrained generation connections
f) Any Active Network Management system or associated communications systems outage
g) Any reduction in the normal ability of the distribution system to absorb generation export and/or supply load
h) Technology of the generation assets and their standard profile
i) In some ANM enabled distribution networks, transmission constraints at the Grid Supply Point (GSP) level also play an important part.

2.6. How is the curtailment of Flexible Connections (ANM) determined?

Currently three approaches exist for determining curtailment of Flexible Connections (ANM) to manage congestion on the distribution system, all three are deterministic and rules based: However, each DNO employs a preferred method and as such customer do not have an option to select an alternative method.

a) **Last In First Out (LIFO)** where any binding network constraint is resolved by curtailing generators in reverse order of their connection applications. In this way generators are insulated against greater curtailment caused by other generators connecting after them, as illustrated in Figure (a).

b) **Pro-rata** where curtailment in an impacted ANM zone is shared equally across all generators exporting during the constraint, as illustrated in the Figure (b). Pro-rata curtailment resolves constraints based upon each generator's proportional contribution.

c) **Curtailment Index** where customers with flexible connections are assigned a forecasted index value, and a maximum cap value of curtailment they should expect to see during the course of a year. This is used to rank the future curtailment stack in which flexible connection will be curtailed by the DNO, as illustrated in Figure (c).

If a customer applies for a formal quote for a flexible connection, the DNO will also provide a Curtailment Assessment report that gives customers an estimate of how often their connection may be curtailed over the course of one year. This estimate depends on factors such as historical network power flows, typical load, generation profiles, and the asset's position in the Last-In First-Out (LIFO) priority stack (if the DNO employs this method).

2.6.1. What does a position on Last-In First-Out (LIFO) priority stack mean?

Last-In First-Out (LIFO) is a "Principle of Access" that defines how assets that contribute to the same constraint get curtailed when that constraint materialises. Under LIFO, each generation asset is assigned a position within a priority stack based on application date. When new generators apply for a connection in the area, they are given a position at the bottom of the priority queue i.e. these assets will be curtailed first when a constraint is binding. A customers' position in the priority stack is reserved unless the connection offer expires or is withdrawn.

During a constraint event the generator at the bottom of the priority stack will be curtailed first. This means that a generator with a lower priority will always be fully curtailed before the generator one position higher in the priority

stack is curtailed. LIFO ensures that the curtailment for a given generator will not be impacted by generators with a lower position in the priority stack.

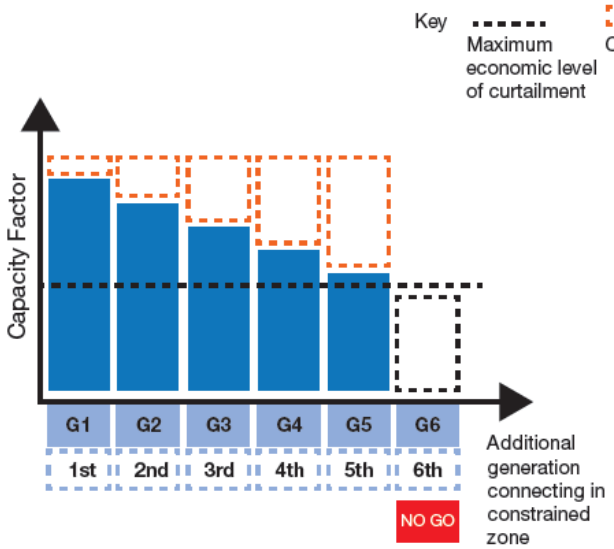

Figure (a) Last In First Out (LIFO)

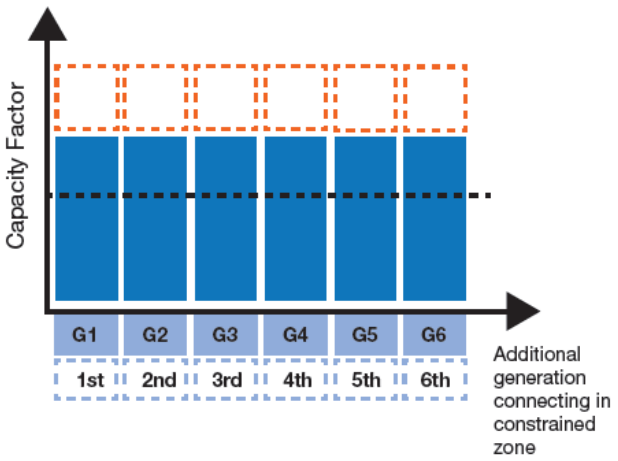

Figure (b) Pro-Rata

2.6.2. What does a position on the Curtailment Index priority stack mean?

The aim of the Curtailment Index is to provide assurance to network users that the network will be available for use for an average time per year. A Curtailment Index is presented as the percentage of time that the network is unavailable per site. To determine the Curtailment Index, DNOs consider all the scenarios when the system is abnormal and unavailable, for instance during faults, construction, and maintenance outages. The actual curtailment experienced by the customer is monitored, and if this level approaches or exceeds the index value DNOs will investigate and potentially seek to intervene. Network users with a Curtailment Index will receive an annual review letter, providing the curtailment experienced over the previous year. The 'actual' curtailment is typically calculated based on a six-year rolling average. Any new site being connected to the network which has a flexible connection will be assigned a Curtailment Index, to allow it to be incorporated into the ANM system; legacy sites already connected to the network which already have the facilities to operate flexibly will also be assigned a Curtailment Index. It is envisaged that some legacy sites may choose to sign up to flexibility bilateral trading or may wish to alter their connection agreements to make savings on their electricity bills by accepting a flexible connection agreement; these sites are also enrolled into the Curtailment Index system. The Curtailment Index system provides a safety net for customers with flexible connections to protect them from being excessively curtailed by manual and/or automated control processes.

All sites with Curtailment Indexes are entered into a stack which puts those with the lowest Curtailment Index at the top of the stack for future curtailment (higher likelihood). When a customer's import/export is curtailed as a result of a distribution network constraint the index is incremented to reflect this curtailment and the customer's position within the curtailment stack will be reassessed.

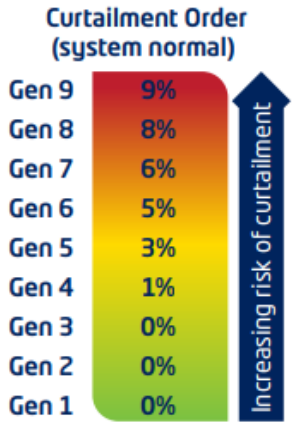

Figure (c) Curtailment Index

2.7. Can customers move from Flexible Connection (ANM) contracts to unconstrained connections?

Customers can, at any time, request changes to their connection arrangement and a formal process already exists. Customers can request additional security or additional capacity via the normal connection application process. This application (via the Engineering Recommendation G99 Form) will be subject to Assessment and Design fees and any subsequently identified charges to provide the additional requirements.

There is no planned formal review of customer contracts by DNOs, however DNOs offer Connection Surgeries and/or stakeholder events where such options can be discussed ahead of a formal request for an unconstrained connection quote. Customers are advised to raise concerns about their contracts by directly contacting their DNO in the first instance.

3. Flexible Connections (ANM) and Flexibility Services

3.1. What is the difference between Flexible Connections (ANM) and Flexibility Services?

Flexible Connections (ANM) are a connection option where:

a) In return for a faster cheaper connection, the customer accepts a contractual, requirement for their usual power flows to be changed by the DNO remotely, in real time, through automation. The amount of change, or curtailment, varies as per the connection agreement.
b) The flexible connection is curtailed (if and when required) and uncompensated as set out in the connection agreement.
c) The up-front connection charges are reduced and faster connection facilitated
d) The customer chooses to have specific, binding (curtailment) terms added to the connection agreement.
e) Usually, the connection choice is driven by the need to achieve a faster, cheaper connection
f) The key beneficiary of this scheme is the connecting customer who benefits from reduced connection costs / timescales in return for reduced network access rights.

Flexibility Services is a commercial arrangement which requires participants to deliver a change in their usual power flows where:

a) A market-led initiative, through procurement exercises, finds customers' assets located within constrained networks that are able to deliver flexibility to help manage constraints.
b) The customers can choose not to respond to the dispatch signal (albeit with commercial consequences in some areas).
c) The participation is voluntary and the flexibility services provided are rewarded as set out in the commercial contract.
d) Contracted customers are required to deliver flexibility services as defined and requested by the DNO (Market led).
e) The key beneficiaries of this scheme are the DNOs, and connected customers who pay 'Distribution Use of System (DUoS) charges due to reduced reinforcement expenditure.

The Table below compares existing uses for typical Flexible Connections (ANM) and Flexibility Services

	Flex Connections (ANM)	Flexibility Services
Used for Thermal Constraints	✓	✓
Used for Voltage Constraints	✓	✓
Used for Fault Level Constraints	×	× (1)
Controls Real Power	✓	✓
Controls Reactive Power	× (2)	✓
Export turn-down	✓	×
Export turn-up	×	✓
Import turn-down	× (3)	✓
Import turn-up	×	✓
Current Likely Utilisation Periods	Times of high renewable output and low demand	Peak demand, planned outages, network faults.

(1) Not currently used; being tested in a range of innovation trials
(2) ANM systems are usually capable of providing the signalling necessary to control reactive power
(3) Done for "Timed" and "SGANM" Flex Connections

3.2. Can assets with Flexible Connections (ANM) provide Flexibility Services?

There is no inherent reason why customers with Flexible Connections (ANM) cannot provide Flexibility Services. Assets with Flexible Connections (ANM) can provide Flexibility Services as long as they meet the minimum criteria for participation for the service they are bidding into. For example, a solar farm with a timed connection which can only export during daylight hours, may not meet the criteria for a Secure Service seeking flexibility during the winter peak of 4-8pm. Presently, Flexible Connections (ANM) and Flexibility Services are managed primarily as distinct services, so there is unlikely to be any conflict observed. Currently, ANM controlled generation is not turned down or curtailed to solve demand constraints and activating Flexibility Services such as demand turn-down does not increase the level of ANM curtailment.

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The voice of the networks