COMMERCIAL ARRANGEMENTS TO FACILITATE ACTIVE NETWORK MANAGEMENT

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ABSTRACT

Active Network Management (ANM) is concerned with the real-time control of energy producing and consuming devices to maintain electricity networks within acceptable operating parameters. ANM is being deployed in the UK to facilitate increased connection of renewable generators to the existing grid and avoid or defer associated network reinforcement. ANM also provides a means of maximising the use of network infrastructure and can be an economically preferable connection solution for users of the network.

This paper will build upon the state of the art in terms of deployed ANM schemes, academic literature and industry reports, to identify the range of Principles Of Access (POA) that could be implemented in an ANM scheme. The key stakeholders in an ANM deployment will be identified and used to inform a set of criteria for assessing POA options. A simplified multi-criteria assessment of each POA option is then presented from the perspective of the stakeholders. The assessment is subjective based on engineering judgement with a view to promoting discussion. Recommendations are presented, based on the assessment undertaken and discussions with industry partners, which are relevant to Governments, regulators, network operators and users of the network.

INTRODUCTION

Generator or demand participants in an ANM scheme accept that they will be controlled by the ANM scheme when network constraints are breached. There are a number of different ANM schemes emerging that manage thermal, voltage and fault level constraints. Central Networks has deployed dynamic line ratings in the Skegness Registered Power Zone (RPZ) [1] and Scottish Hydro Electric Power Distribution and Smarter Grid Solutions have deployed ANM technology in the Orkney RPZ [2]. However, there are few examples of deployed ANM schemes elsewhere at the present time. When more than one device is being controlled to manage one or more network constraints, POA must be considered. POA are the commercial rules that govern the operation of an ANM scheme.

POA define the relationships between generators, demand customers and the constraints that are managed on the network (either transmission or distribution) within the terms of interruptible contracts. For example, POA define the relationship or connection priority of generators connected to the same grid zone, contributing to one or more network constraints. In this case, POA essentially specify the manner in which to curtail generators and define the operational rules applied by the ANM scheme to maintain the network within safe operating limits.

STAKEHOLDERS & ASSESSMENT CRITERIA

The implementation of a POA approach has the potential to impact on all parts of the electricity supply chain. The key stakeholders in the electricity supply chain include:

- Regulators (e.g. Ofgem in the UK)
- Transmission System Operators
- Distribution Network Operators
- Generator Developers
- Load Customers
- Investors

Any POA assessment criteria must consider the technical, commercial and regulatory strengths of each approach. A relevant range of assessment criteria has been identified by ESB National Grid in Ireland [3]. It has been considered that an ANM scheme and the accompanying POA employed must:

- Contribute to a Safe, Secure and Reliable Power Network
- Be Equitable and Transparent
- Support Efficient Network Operation
- Be Sustainable and Future Proof
- Not Impact On Existing Connection Agreements
- Apply to all Network Operating States
- Comply with Relevant Laws, Standards and Codes

PRINCIPLES OF ACCESS

The University of Durham has undertaken an assessment of POA options in a recent publication [4] and ESB National Grid in discuss these issues in light of operational rules to curtail wind generation [3]. The POA options are summarised below.

Last In First Out

This POA curtails the last generator added to the ANM scheme first. Adding a new generator connection to the Last In First Out priority list (in the position of least priority) does not alter the priority position of existing generator units with interruptible contracts.

Generator Size

This POA curtails the largest generator that is contributing to a constraint first. The total amount of curtailment required to alleviate a constraint is allocated in order of size. Generator Size may refer to the installed rated capacity of the generator unit or the power output at any given time when constraints arise.

Greatest Carbon Benefit

This POA aims to minimise the carbon emissions associated with actively managed generation by curtailing the largest carbon emitting generators first. Based on a carbon metric such as CO2/MWh per generator the network operator could prioritise generation.

Shared Percentage

The Shared Percentage POA divides the required curtailment equally between all generators contributing to the constraint. The total amount of curtailment would be shared by each of the generators based on the ratio of rated or actual generator output to total required curtailment.

Market Based

Under a Market Based POA, generators with interruptible contracts could pay for access to the network for a period and capacity allocated to those offering the highest payment. Alternatively, generators may offer a price to be curtailed with a market mechanism to proportion curtailment accordingly.

Technical Best

A Technical Best POA aims to curtail the generators in order of contribution to the prevailing constraint or based on which generator(s) response characteristics are deemed best for meeting the prevailing constraint. This may vary for different types of constraints and network configurations.

Most Convenient

The POA based on Most Convenient allows system operators to curtail the generator they know to be the most convenient for responding to network constraints. This assessment may be influenced by system operator (or control room engineer) preference.

INITIAL ASSESSMENT

Table 1 documents the initial assessment of the POA options against the criteria. From Table 1 it can be seen that all POA meet the following criteria:

- Contribute to a Safe, Secure and Reliable Power
- Network
- Comply with Relevant Laws, Standards and Codes
- Apply to all Network Operating States

Based on an initial pass/fail assessment, Table 1 presents three POA options that are not considered feasible: Most Convenient, Technical Best and Generator Size. These POA do not meet the Equitable and Transparent Criteria set out previously.

	Last In First Out	Generator Size	Greatest Carbon Benefit	Market Based	Shared Percentage	Technical Best	Most Convenient
Be Equitable and Transparent	PASS	FAIL	FAIL	PASS	PASS	FAIL	FAIL
Be Sustainable and Future Proof	PASS	FAIL	PASS	PASS	FAIL	FAIL	FAIL
Contribute to a Safe, Secure and Reliable Power Network	PASS	PASS	PASS	PASS	PASS	PASS	PASS
Support Efficient Network Operation	FAIL	FAIL	FAIL	FAIL	FAIL	PASS	PASS
Impact On Existing Connection Agreements	PASS	FAIL	FAIL	PASS	FAIL	FAIL	FAIL
Apply to all Network Operating States	PASS	PASS	PASS	PASS	PASS	PASS	PASS
Comply with Relevant Laws, Standards and Codes	PASS	PASS	PASS	PASS	PASS	PASS	PASS/FAIL
PASS Count	6	4	4	6	4	4	4
FAIL Count	1	4	4	1	3	3	3

Table 1: POA Options Vs Assessment Criteria

Transparency is required at all levels of the electricity industry to ensure no individual or company is receiving unfair competitive advantage or disadvantage [5]. It is judged that the three POA options identified above may unfairly discriminate against certain types of generators based on their location, control room preference and the size of the generator.
It is clear from Table 1 that the top two POA options are Last In First Out and Market Based. Although Shared Percentage scores lowly, it is recommended that this POA is explored further as in theory it could be combined with other POA options to add flexibility. For example, to consider multiple generator units to be equal in terms of access to available network capacity. The fairness of this approach meets the criteria of regulator making it worthy of further consideration.
Greatest Carbon Benefit is inherently discriminatory against high carbon emitting generators. However, this approach promotes current government and European energy policy [6, 7] and therefore has been included for further assessment.
The careful design of the implementation strategy for this POA could address some of the areas in which this POA failed. For this reason, Greatest Carbon Benefit will be considered further.

FURTHER ANALYSIS

Each of the POA options which passed the initial assessment has been subject to further analysis which aims to identify any barriers to implementation (commercial or technical) and the potential risks to stakeholders.

Last In First Out

The simplicity of the Last In First Out POA philosophy ensures it is transparent to all network stakeholders and achieves consistency for both existing generation units and new generation units by not impacting on their connection agreements. This de-risks the interruptible contract for the investor as the long-term impact of curtailment can be modelled based on a fixed position in a priority stack for access to capacity.
There are no foreseeable problems in the short-term with either regulation or legal compliance. An ANM scheme operating a 'Last In First Out' POA methodology is currently in operation in the UK as part of the Orkney RPZ.
A 'Last In First Out' POA philosophy does not differentiate between low carbon sources and carbon intensive sources; therefore, energy produced by renewable sources could be curtailed ahead of non-renewable sources. This POA could also limit the technical utilisation of the distribution network.

Shared Percentage

A 'Shared Percentage' POA philosophy is favourable from the perspective of the majority of the stakeholders identified and does not require regulatory change to implement. The simplistic rule of dividing curtailment evenly between all constraint contributing generators ensures fair access to available network capacity for multiple generators, satisfying the fairness and competition goals of the regulators.
The main issue with the implementation of this POA is that it is difficult for investors to assess the long-term impact of the interruptible contract on the business proposition. Under Shared Percentage, the generator that is the first unit to connect would experience increasing curtailment as additional interruptible generator units connect. The extent of potential further units wishing to connect to an area of constrained network cannot be forecast and therefore could introduce a potentially significant barrier to raising project finance. This could be addressed by some form of constraint payment, but such a mechanism does not typically exist at the distribution level at the present time.

Market Based

A Market Based solution meets the assessment criteria in that it will not impact on existing connections and is sustainable and future proof providing a suitable market can be established. A Market Based POA philosophy would require the development of a market (or regularly agreed bi-lateral contracts) for implementation. Significant effort would be required to deploy this POA, including the implementation of a market clearing and settlement system.
One significant advantage of this approach is the potential to extend the market to incumbent connectees satisfying the fairness and competition goals of regulators. However, due to the localised nature of constraints this approach is probably more suited to wider transmission system constraints than distribution networks.

Greatest Carbon Benifit

Adopting the Greatest Carbon Benefit POA could essentially result in the implementation of a CO2/MWh priority stack for individual generator units (as in Last In First Out) or shared access rights for a number of generators utilising the same primary fuel source (whether renewable or not - as in Shared Percentage). Therefore, Greatest Carbon Benefit is not expected to be complex to implement from a technical perspective but significant thought will need to be given to the commercial implications of implementing such an approach. Determining the real carbon footprint of each generation technology in a clear, open and fair manner is not a simple task. However, a simple approach could involve banding of generator types, similar to the approach adopted in the Renewables Obligation in the UK.
Regulatory intervention would be required to implement Greatest Carbon Benefit on its own or in conjunction with another POA option; therefore it cannot be considered as a short or medium-term POA option.

RECOMMENDATIONS FOR PRINCIPLES OF ACCESS

In order to support the rollout of ANM technology and facilitate the role of the network operator in the transition to the Low Carbon Economy, SGS and Central Networks recommend taking a phased approach to implementing the best PoA options identified in this paper. These recommendations are broken down across the short-term (0-5 years), medium-term (5-10 years) and long-term horizons (10+ years), as shown in Figure 1.

In the short-term, Shared Percentage and Last In First Off can be implemented separately or together in a combined approach without significant regulatory or industry change. These PoA options may facilitate a significant increase in the capacity for new connections to existing distribution networks in the next five years. Further work and industry discussion is required to determine the specifics of implementing standard business processes to enable such arrangements, while providing flexibility for the DNO and certainty for the generator developer. However, this is not expected to present a significant barrier to the short-term implementation of these PoA. Indeed, Last In First Out has already been implemented in the Orkney RPZ by SGS and SHEPD.

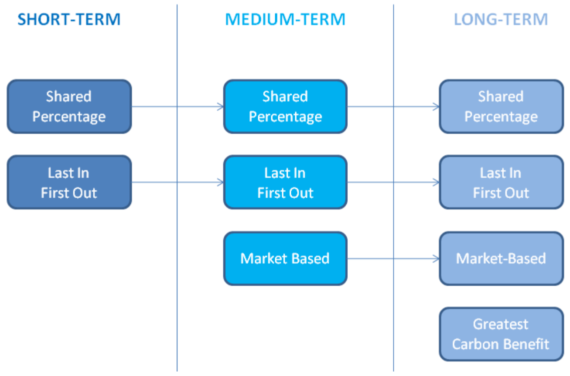

Figure 1: Principles of Access Recommendations

In the medium-term, it is recommended that a Market-Based PoA approach is considered. Significant development work is required to define the scope and operation of such a localised market. Trials of such an approach would represent a significant development in the global power sector. Lessons learned from such trials could be applied to create local markets to facilitate the increased connection of other low carbon technologies, such as electric vehicles.

In the long-term, if the goal is to maximise the use of renewable energy sources and other low carbon technologies across the supply chain then Greatest Carbon Benefit should ultimately be pursued. This will require significant regulatory and market reform, the discussion of which falls out with the scope of this paper.

CONCLUSIONS

Interruptible contracts will form the basis for the deployment of ANM technology to facilitate the increased connection of low carbon technologies.

The adoption of the Last In First Out and Shared Percentage POA is recommended in the short-term. These POA options are implementable today and do not require new technology or changes to the existing regulatory environment. It is expected that these two POA options will be implemented together and separately and will remain valid over the medium and long-term.

A Market Based approach to POA will require a significant effort to deploy, but is perhaps most suitable for transmission system constraints where a larger number of customers can participate. Trials of such an approach in the short-term will provide significant learning to the industry and inform the debate regarding the access of other low carbon technologies to the network. Such advances will require significant regulatory change.

In the long-term, the Greatest Carbon Benefit POA will deliver increased decarbonisation of the electricity sector. Trials of such an approach are complex, impacting all across the supply chain and at different levels in the electricity networks. Such an approach will require end-to-end thinking, considering the needs of all network users, technologies and the wider system impacts of low carbon technology adoption, including system balancing and security of supply.

To conclude, this report has provided a concise overview of this complex and emerging area. Further exploration and debate is required to validate the observations made and take recommendations forward.

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