
# 0237 - AN ASSESSMENT OF PRINCIPLES OF ACCESS FOR WIND GENERATION CURTAILMENT IN ACTIVE NETWORK MANAGEMENT SCHEMES

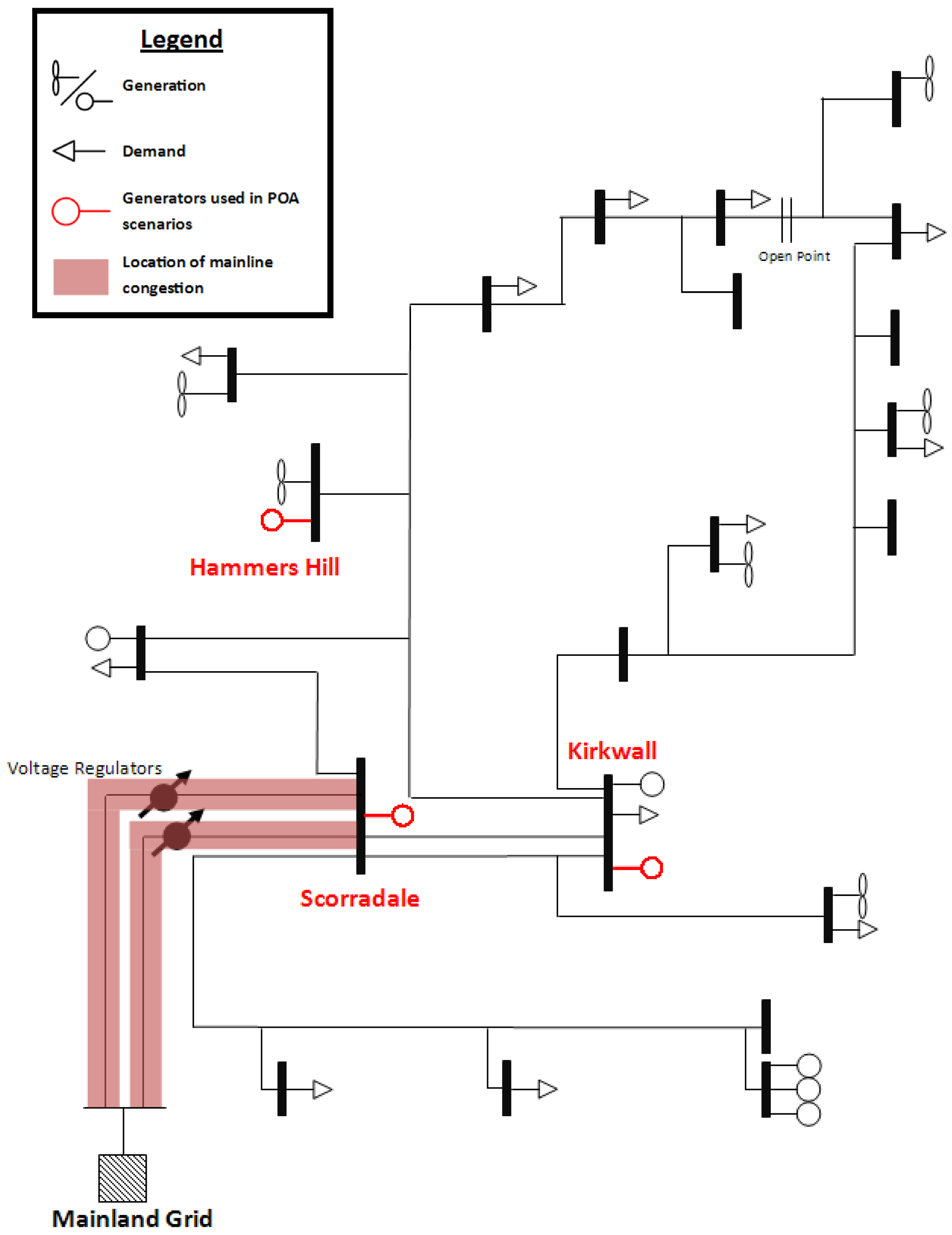
Laura Kane Prof. Graham Ault Simon Gill
Wind Energy Systems Doctoral Training Centre, Department of Electronic and Electrical Engineering, University of Strathclyde, Glasgow

## Introduction

The growth of wind generation on the distribution networks is leading to the development of Active Network Management (ANM) strategies. These aim to increase the capacity of Distributed Generation (DG) that can connect to a network. One such strategy is generation curtailment where DG is given a non-firm connection under which the network can force the generator to reduce its output under specified conditions. Currently in the UK the Orkney distribution network operates a curtailment scheme for wind and other renewable generation and a scheme is planned for the Shetland Islands.

The main purpose of this research is to explore the options for Principles of Access (POA) for curtailment of wind generation on distribution networks which employ ANM.

The scenarios are based on the Orkney distribution network which is a Registered Power Zone. The current POA is 'Last In First Out' (LIFO) which sees the last generator connected to the network as the first generator to be curtailed regardless of technical specification. MatPower – a MATLAB package, will be used to run power flow analysis of different POA methods for a number of generation levels at selected sites. The results of each power flow analysis will be collated and the capacity factor of each wind farm compared.




## Principles of Access

**LAST IN FIRST OFF (LIFO)**
LIFO is an easy method to administer, but it does not provide the optimal use of resources and in some cases can lead to generators being needlessly curtailed. In the LIFO scenario the newest farm will be curtailed first.

**SHARED PERCENTAGE**
The Shared Percentage method curtails each farm by a fraction of the curtailment required based on the maximum capacity of each farm. All farms are curtailed simultaneously.

**TECHNICAL BEST**
This method determines which farm should be curtailed based on power flow analysis of the network. The wind farm which can minimise the network losses by being curtailed will be selected.

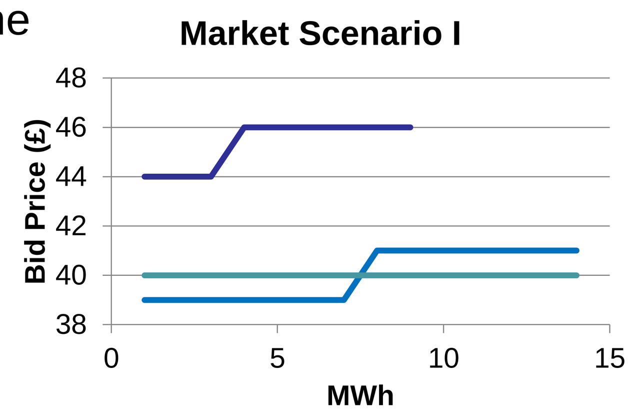
**MARKET BASED**
Generators offer a bid price in order to be allowed to remain connected. The DNO will curtail the farm which offers the lowest bid price for each 0.1MW of generation curtailed. The price remaining farms pay to remain connected is determined by the cost at which congestion is cleared– the 'curtailment market clearing price'

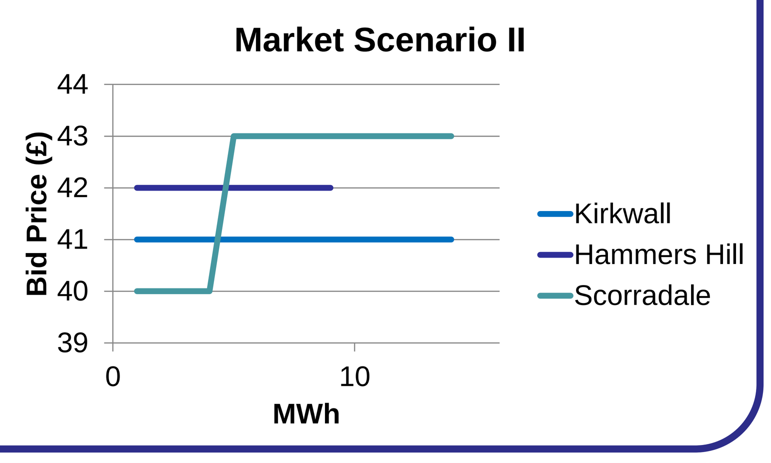
## Method

The curtailment scenario focuses on the issue of 'mainline' congestion i.e. the only congested section is in the line between the mainland grid bus and the first major bus at Scorradale. To create mainline congestion, two further generators are added at Scorradale and Kirkwall and the local generators set at a level to ensure zero local congestion. The base model has 8MW at Hammers Hill, 10MW at Scorradale and 10MW at Kirkwall. There are 4 rounds for simulations, with the value of generation at Scorradale and Kirkwall increasing by 1MW each time. The Newton–Raphson iterative method for power flow analysis is used to identify congestion on the network. The generation of the selected farm (determined by POA method discussed above) will decrease by 0.1MW each power flow analysis until congestion on the network is cleared.

There are two Market scenarios considered based on different subsidiary payments (which vary with size of generators). They are shown in the graphs on the right.

The market clearing price is set by the point at Which the constraint is cleared e.g. for Scenario I, and 10MW of congestion, the Market Clearing Price would be £40/MWh. This price is paid to the curtailed generators, and paid by the those allowed to remain connected.




## Results

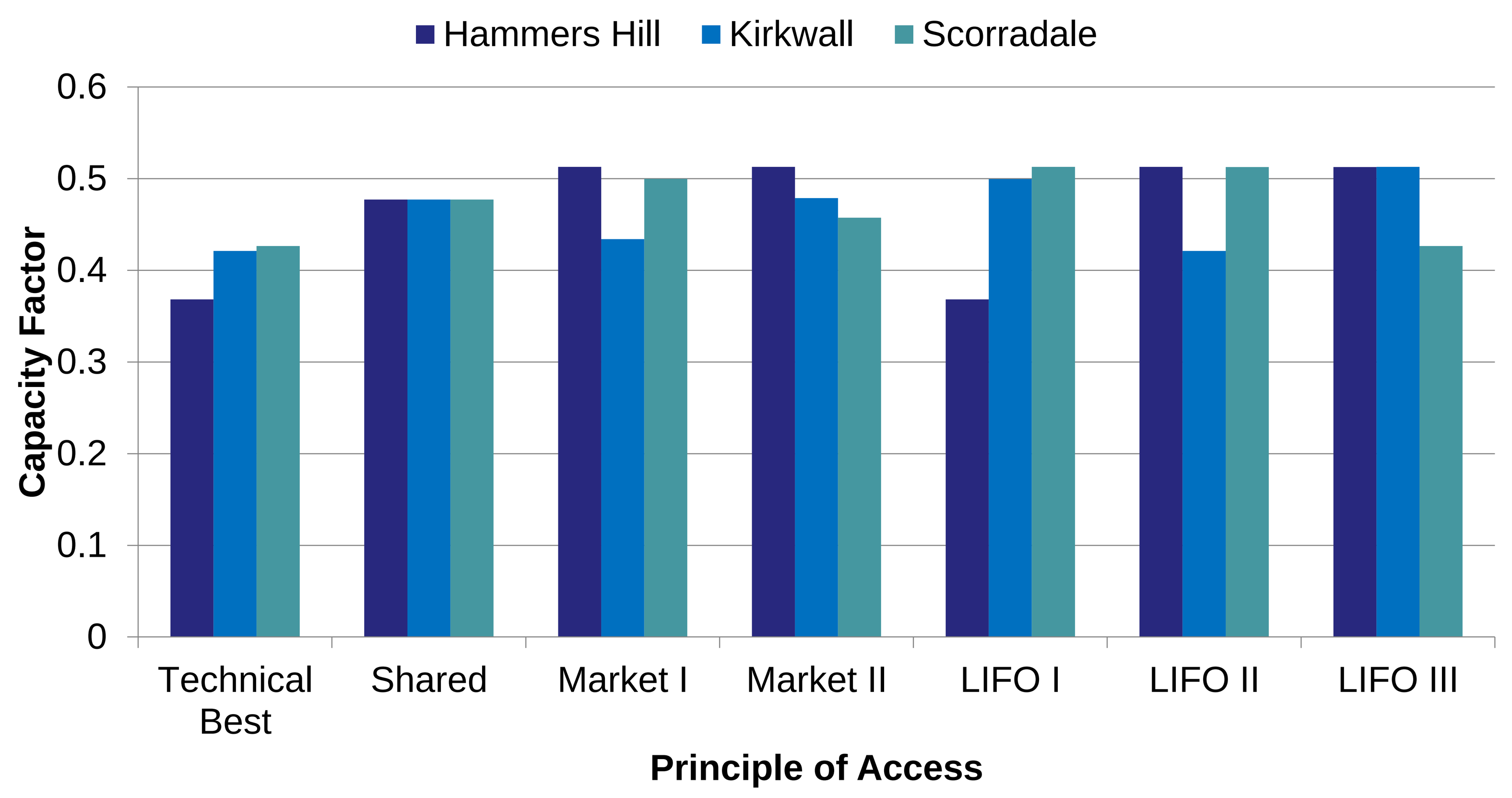
The graph on the right shows the results from the 4th round of simulations, with 8MW at Hammers Hill and 13MW at both Kirkwall and Scorradale.

In all instances of the **LIFO** method (with the generator position changing each time), the last farm to be curtailed experienced no curtailment. The volume of curtailment depends on the size of other farms in the priority stacks.

The '**Technical Best**' method demonstrates the importance of the location of congestion. Looking at capacity factor values, Hammers Hill is as low as 0.37, down from a maximum value of 0.51 because it is located furthest away from the constraint and therefore will give the biggest reduction in loses by being curtailed.

The '**Shared Percentage**' method ensures all three farms achieve the same capacity factor. It does not favour or discriminate farms based on location or size.

The '**Market**' method is dependant on bid prices. For example, in 'Market I', Kirkwall offers the lowest bid price and is first to be curtailed, followed by Scorradale in some instances. In order to prevent curtailment, Kirkwall will have to increase its bid price to be competitive with other farms.




## Conclusion

Using the above case study of the Orkney distribution network, it is possible to highlight the advantages and disadvantages of a number of POA.

The '**LIFO**' POA is simple to implement and the rules of curtailment are clear for all developers wishing to connect to the network. However, adopting this POA across the UK could discourage the increase of DG in certain networks. Changing the POA would be beneficial to both the network and wind farm developers.

The '**Shared Percentage**' POA allows a fair share of available generation to all new generators connecting to the network, however as more generators connect this share will decrease. The difficulty in assuring long term capacity factors may discourage developers past a certain point unless the DNO can provide a maximum limit for connected generators up front.

The '**Technical Best**' POA is highly dependent on location of congestion. If there are problem areas on the network which see congestion frequently (as simulated in the case study scenarios) then it is likely that the same farm(s) will experience curtailment on a regular basis. This has the advantage of sending a message to developers about the best location in which to connect a new wind farm.

The '**Market Based**' POA is suggested as the most promising POA in terms of appeal to generators and DNO. By implementing a market with a bid system, it allows generators to offer a price to generate during congested time periods. This gives control to the generators in terms of capacity factor of the farm and bids could be tailored to suit peak periods of demand on the network or available wind.

The implementation of a **Market Based** POA would require further research in terms of establishing the market rules, time scales and the establishment of the required communication systems to enforce curtailment.