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A review and analysis of renewable energy curtailment schemes and Principles of Access: Transitioning towards business as usual

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HIGHLIGHTS

- Literature review of Principles of Access.
- Detailed case study analysis of Principles of Access in ANM projects.
- Quantitative analysis of different Principles of Access.
- Proposed business models for ANM as business as usual.

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ABSTRACT

In the last decade, the EU has driven forward the development and connection of renewable power sources across Europe. This has changed the way in which distribution networks operate, moving from a passive system, to a more active system where generation and demand are located closer together with system states being more complex and variable. Increased penetration of renewable generation into distribution networks is presenting a number of challenges to Distribution Network Operators (DNOs) including the provision of network access in capacity constrained networks. The introduction of Active Network Management (ANM) is enabling an increase in renewable generation connections through enhanced network access in otherwise 'full' networks.

This paper presents a way in which DNOs might move towards Business as Usual (BAU) arrangements for ANM schemes. It is necessary to determine the curtailment arrangements, or Principles of Access (PoA), and from this estimate generation access under ANM and the flow of services and money for different scenarios. In this paper, a comprehensive literature review, detailed case study evaluation on early ANM schemes, quantitative curtailment assessment for different PoA and a qualitative analysis of business models for different ANM PoA is presented in turn with conclusions drawn from these three approaches.

1. Introduction

The European Union (EU) is currently in the process of moving towards 'greener' technologies with a drive to encourage the adoption of renewable energy technologies. The threat of climate change is a global concern and the EU governs a significant degree of energy policy in the United Kingdom through directives which are applicable to all EU member states.

EU Directive 2009/28/EC (The European Parliament and the Council of the European Parliament, 2009) sets renewable energy targets for all member states to achieve by 2020 in overall energy production and transport. The targets state that 20% of energy generated in the EU and 10% of energy used in transport should be from renewable means. The directive requires member states to set their own personal targets; these must however be consistent with 2009/28/EC.

UK Government targets outlined in the UK Government Low Carbon Transition Plan (HM Government, 2009) state that around 30% of electricity will be generated from renewable energy sources by 2020. The Scottish Government has also set its own ambitious targets, aiming for 100% of electrical demand to be met from renewable energy by 2020 (Scottish Government, 2011).

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To encourage the connection of renewables, a number of incentives were introduced by the UK Government including the Feed-in Tariffs (FITs) (Ofgem, 2013b) and Renewable Obligation (RO) (Ofgem, 2013c).

The RO is the most significant incentive for renewable generation development in the UK, where generators are rewarded Renewable Obligation Certificates (ROCs) for each MWh of energy produced by renewable energy sources.

The value of ROC has an important impact on the price paid to the renewable generator for electricity produced. The ROC price is set at a fixed rate for each year, while the market price of electricity fluctuates, and the long term value of the PPA is typically lower than the average market rate (Cornwall and Littlechild, 2008)

The number of ROCs awarded varies depending on the technology, namely to encourage investment in less developed technologies (Department of Energy and Climate Change and Ofgem, 2013). The value of ROCs is set by Ofgem each year and will change over the years in line with the Retail Price Index (RPI). An example of ROC prices can be found online at the e-ROC website (e-ROC, 2013). The current Electricity Market Reform (EMR) (Department of Energy and Climate Change, 2011) will introduce Contracts for Difference (CfDs) and these will replace ROCs by 2017. The aim of CfDs is to remove the long term exposure of low carbon technologies to volatile electricity prices. CfDs ensure that generators receive payments for energy produced at a fixed price, known as the ‘strike price’. If the electricity price is lower than the strike price, low carbon generators will receive a top-up payment to make up the difference from suppliers. However, if the electricity price is higher than the strike price, then low carbon generators must pay back the difference.

Feed in Tariffs (FITs) apply to any generators smaller than 5 MW and the rates vary depending on the size of installation and the technology used. FIT prices are set by Ofgem each year. Prices for the 2013/2014 period are available on the Ofgem website (Ofgem, 2013d).

At transmission level, Connect and Manage was introduced by National Grid (2009) with the aim of facilitating the connection of new renewable generation to the transmission system. Connect and Manage allows all new generators, regardless of size or type, to connect to the network by simply carrying out the required local upgrades (around the point of connection) without waiting for any wider transmission network upgrades that might be required. Connect and Manage also applies to large embedded generation (greater than 50 MW) on the distribution network. Through the introduction of Connect and Manage, applications from renewable generators for connection to transmission and distribution networks have increased (National Grid, 2011).

At distribution level, the increase in Distributed Generation (DG) connecting led to a change in the behaviour of the distribution network (CIGRE Working Group C6.09, 2011). Traditionally, distribution networks were designed to transport electricity from transmission grid connection point down through to lower voltages and eventually to demand customers. However, with the connection of DG the location of generation is now closer to demand, and in some cases the direction of power flow may be reversed i.e. more electricity is generated in the distribution network than is required by demand and will therefore flow up to transmission level.

Legislation at EU and UK levels has provided the stimulus and incentive to develop renewables, but there are three sets of issues which can sometimes restrict the connection of renewable generation to the power system. These include:

1. Network issues which focus on local issues such as lack of capacity on the network to enable new connections, and also control of voltage and reactive power levels on the network.
2. System issues which can include security of supply, back up reserve and system balancing. Systems which are overloaded with new generation may have difficulty in balancing generation and demand.
3. Market issues such as the subsidies, compensation for curtailment, use of system charging, and electricity pricing.

Currently, solutions are being developed to these three issues, and ANM is emerging as a serious contender for solutions to the first of these problems i.e. better control of network and enabling additional generation to connect.

A number of definitions for ANM were defined by a CIGRE working group report (CIGRE Working Group C6.11, 2011). The authors define ANM as the control of power, voltage and frequency within a network through the use of remote control and communication technologies.

ANM schemes allow the increased connection of renewable generation (Currie et al., 2007) to the distribution network. In order to do so, there may be some curtailment of renewable generators required. For the purpose of this paper, curtailment can be defined as the reduction of output of wind generation to an output level lower than current availability of the generators.

While this suggests curtailment has a negative effect on wind, it is in fact a positive result for wind farms connecting to constrained networks. Without ANM and the curtailment of wind generation during certain time periods, the generators would not have been able to connect to the network without costly and time consuming upgrades. (Currie et al., 2010)

This paper is structured as follows. In Section 2, examples of curtailment practices are presented and Principles of Access (PoA) which have been collected as part of a literature review and are assessed against a list of criteria, and the advantages and disadvantages discussed. Section 2.2 presents case studies of ANM schemes which have applied PoA and the cost of the ANM scheme is compared with traditional reinforcement costs. In Section 3, a quantitative analysis of different PoA is carried out using constraint management techniques. Section 4 goes on to discuss the ‘Business as Usual’ (BAU) case for ANM schemes and demonstrates how a DNO might recover the costs associated with the ANM installation when they are no longer funded through innovation funds such as the Low Carbon Network Fund. Finally, Section 5 contains concluding remarks on how DNOs might move towards BAU with ANM schemes that apply PoA to curtail generation.

2. Materials and methods

2.1. Principles of Access

PoA for wind generators in ANM systems is a relatively new field of research. In order to gain an understanding of PoA, it is appropriate to look to transmission systems to build on previous learning. At transmission level, short-term access trading (Shaaban and Bell, 2009) is a method identified as a possible short-term solution to the problem of transmission access rights to integrate renewable generation. The principle works by trading generation capacity between renewable generation and conventional generation in particular transmission network zones to make efficient use of renewable generation whenever possible. For example, when wind conditions are good then access rights can be traded from a conventional generator who has firm access rights to the wind generator with non-firm rights. Trading could also take place during planned outages of the conventional generator or during periods when wind conditions are poor. DC power flow analysis is used to determine which generators can trade access rights