Energy Policy 109 (2017) 36–48

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Spatial smoothing of onshore wind: Implications for strategic development in Scotland

Andrew N. Commin*, Magnus W.H. Davidson, Nicola Largey, Paul P.J. Gaffney, David W. Braidwood, Stuart W. Gibb, John McClatchey[1]

Environmental Research Institute, North Highland College, University of the Highlands and Islands, Ormlie Road, Thurso, Caithness, Scotland, UK

ARTICLE INFO

Keywords:
Onshore wind
Spatial smoothing
Strategic development
Energy security
Environmental impacts

ABSTRACT

High levels of wind penetration is widely accepted as presenting problems for energy security. With increasing wind deployment this issue is well recognised in Scotland. Spatial smoothing of generation is seen as one method to enhance energy security in a high wind penetration system. This requires wind farms to be developed in a way to take advantage of this smoothing; however, this is not part of the UK/Scottish government wind deployment strategy – which is instead developer led.

This research seeks to contribute to a strategic approach to wind development in Scotland, taking into account spatial smoothing – which is shown in this study to be statistically significant within Scotland. Providing quantification of which pre-existing areas of large-scale wind development in Scotland should be the focus of further development and which are of least benefit. Wind farms in southern Scotland offer least in terms of energy security, due to over-concentration of deployment in this area, further development here should be in part considered in terms of export value, rather than utilization within Scotland. The two island areas modelled are shown to have high spatial smoothing value. This work should help inform current political discourse over grid connections to these areas.

1. Introduction

Currently, onshore wind capacity in Scotland exceeds all other renewable resources combined, with over 5.6 GW being operational at the end of 2015 (DBEIS, 2017). However, onshore wind power can be highly variable (Sinden, 2007; Yang et al., 2016); this has implications for both short term security of electricity supply and system efficiency. Additionally, with increased penetration, wind curtailment can become more prevalent (Waite and Modi, 2016). These issues are well recognised; leading to many valuable UK focused studies of wind's integration into the electricity system. These studies are predominantly academic (e.g. Boehme and Wallace, 2008; Dale et al., 2004; Le and Bhattacharyya, 2011; Oswald et al., 2008; Sinden, 2007) but there are also reports commissioned by government (e.g. Boehme et al., 2006), advisory bodies (e.g. Cox, 2009) and NGOs (e.g. Milborrow, 2009). The depth and breadth of literature highlights the importance of the issue. Yet, research tends to be rather generalised, focusing on the long-term trends and theoretical wind development, rather than actual wind farms.

Large-scale renewable projects, such as wind farms, in the UK were historically supported by the Renewables Obligation (RO), which in essence paid certified renewable generators a subsidy for each unit of electricity generated. The RO is being phased out and replaced by the Contracts for Difference (CfD) scheme. This operates in a similar way but with a bidding process attached. Neither of these policy mechanisms directly assigns additional value to renewable generators if they add to system security by having a different output regime to other generators. With onshore wind increasingly dominating the Scottish renewable portfolio this could become a problem. Much of the wind power development in Scotland is focused, and set to continue to be focused, in the South, see Fig. 1. Consequently, there is limited geographic smoothing of wind generation – which can have a significant effect on wind power production (Buttler et al., 2016).

By identifying areas where wind development would be of greater benefit to the Scottish electricity system it would attach additional value to development in such areas. This could enable policy makers to either directly increase the subsidy to such developments, alternatively indirect assistance through mechanisms that encourage development

* Corresponding author.
E-mail addresses: andrew.commin@uhi.ac.uk (A.N. Commin), magnus.davidson@uhi.ac.uk (M.W.H. Davidson), nicola.largey@uhi.ac.uk (N. Largey), paul.gaffney@uhi.ac.uk (P.P.J. Gaffney), david.braidwood@uhi.ac.uk (D.W. Braidwood), stuart.gibb@uhi.ac.uk (S.W. Gibb).
[1] Deceased 30th April 2015.

http://dx.doi.org/10.1016/j.enpol.2017.06.038
Received 27 February 2017; Received in revised form 13 June 2017; Accepted 16 June 2017
0301-4215/

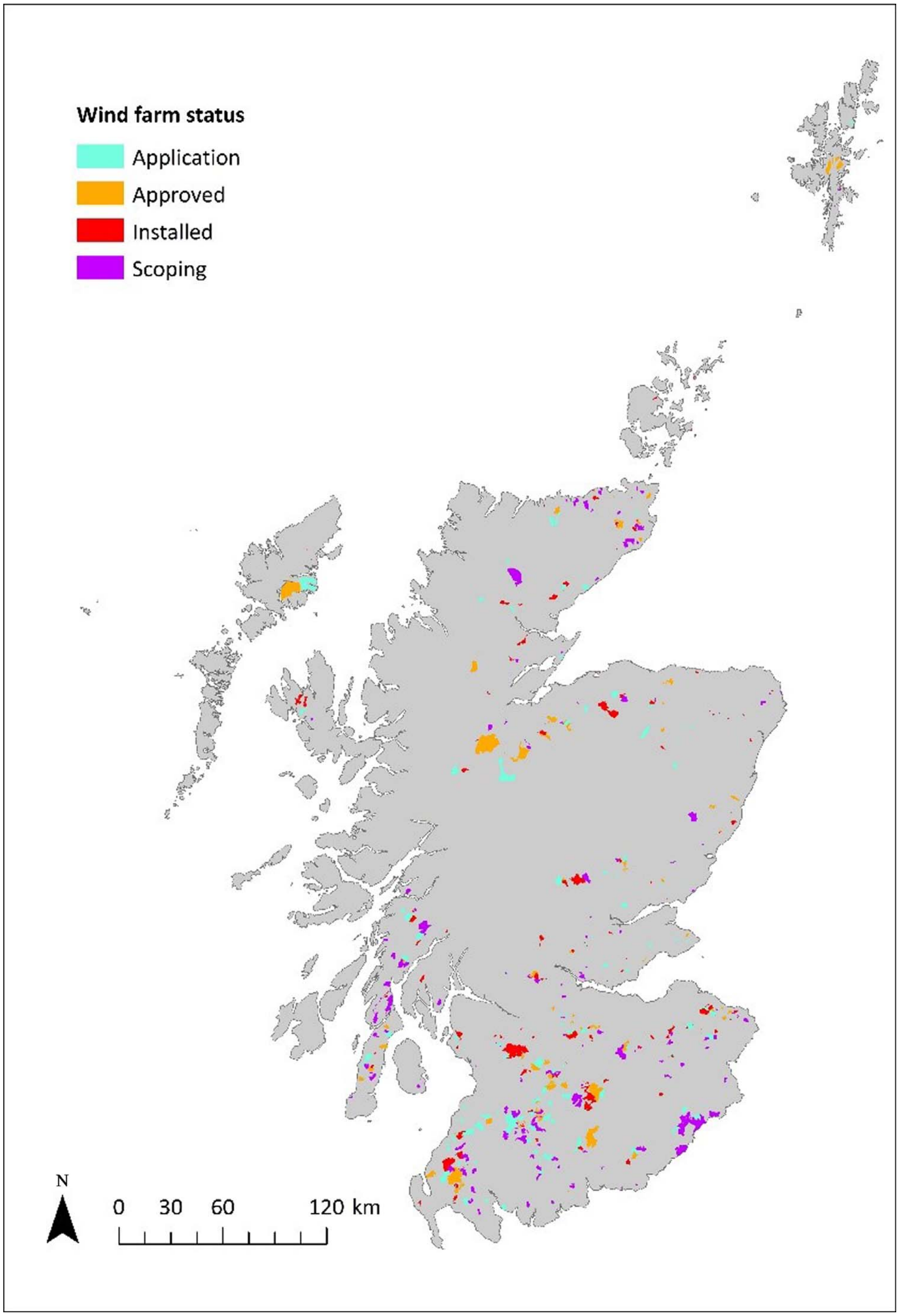

Fig. 1. Wind farms of Scotland in 2016 either in operation or within the planning system. Wind farm data is from Scottish Natural Heritage (SNH, 2017). Crown copyright ©.

such as greater grid connection to isolated areas.

This paper aims to provide initial quantification of the comparative benefits of additional onshore wind capacity in different areas of Scotland. Indicating where extra capacity would be of the greatest value for more reliable contribution of onshore wind to the Scottish electricity system; assisting with strategic development of onshore wind in Scotland.

2. Methodology

This study utilises a hindcasting methodology, taking historic wind speeds and using them to infer generation for onshore wind farms given past conditions. The longer the set of historic data, the greater the accuracy of the hindcast in its representation of how future renewable plants would have performed given historic conditions. A 30 year time series is desirable as it is classified as a climate normal period by the World Meteorological Organisation (WMO). The most recent climate normal period classified by the WMO is 1981–2010 and is the period used in this study. To hindcast onshore wind, measured wind speeds are the preferred data source for the UK; e.g. Früh (2015, 2013), Sinden (2007) and Boehme and Wallace (2008). Sharp et al. (2015) observe that these measured datasets perform better than modelled ones in high wind speed environments in the UK, such as Scotland.