
Editorial

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1 Introduction

Current patterns of global energy consumption – primarily based on fossil fuels – not only continue to increase environmental pressures, but also exacerbate energy dependency of importing nations with yet unknown socio-economic consequences. By way of contrast, the use of Renewable Energy Sources (RES) can improve economics, social development, security of supply and the environmental performance of energy consumption. The significance of Renewable Energy Technologies (RETs) are not only acknowledged in international communications such as the United Nations Kyoto Protocol and the Report of the World Summit on Sustainable Development, but also supported through a variety of domestic policies and support programmes.

However, amongst others, a major obstacle to the expansion of some of the most promising RETs, such as wind turbines, is the stochastic nature of the RES they are based on. Unlike conventional energy technologies, intermittent RETs cannot be ‘dispatched’ at will to match electricity demand. In fact, intermittent power output does not fit well with present schemes for network design, operation and electricity trading markets, as well as potentially affecting supply reliability and power quality. In most cases, intermittency imposes costs through system balancing requirements – such as the need for increased regulating and reserve power – and grid network upgrades, which both increase as the proportion of intermittent generation on the system rises.

This Special Issues aims at improving our understanding of the limits and opportunities for grid-connected intermittent RETs, as well as the direction that is taken by market actors and governments alike to further the introduction of intermittent RETs. Acknowledging the expansion boundaries of intermittent generation – which ultimately is not purely a techno-economic problem but also limited by socio-environmental considerations – can aid energy policy formulation by gaining a more realistic understanding of the contribution that intermittent RETs can make towards present and future levels of electricity supply. By the same token, early appreciation of these limits allows a more proactive and strategic approach towards achieving sustainable energy production by vigorously supporting the development of additional RETs, policies and programmes, as well as demand side management strategies.

This volume comprises of eight contributions with an overwhelming geographic focus on Europe.

Guel and Stenzel's contribution outlines how recent discussions on the 'intermittency' of wind energy can be put into the wider context of varying natural availability of resources and various 'options' that exist to manage intermittency. Similarly, *Debra Justus* focuses on the challenge of bringing significant amounts of intermittent generating sources into grids dominated by large central generating units. She also highlights present research collaboration amongst stakeholders in the field of wind power integration into electricity systems.

Niels Meyer illustrates the influence of government policy in Europe to promote wind power integration. Using Denmark as a case-in-point, he demonstrates that domestic policies can lead to both, growth and stagnation of wind power implementation. *Auer et al.* argue that legislation for the market integration of RETs is still deficient in almost all countries of the European Union (EU). To illustrate their viewpoint, the authors present the results of the recently completed EC-Project GreenNET, which addresses existing inadequacies and models dynamic time paths up to the year 2020 for a variety of least-cost RES-E grid integration cases in the EU for different degrees of unbundling and different cost allocation schemes. While government policy is clearly instrumental in providing favourable conditions for the investment in the RETs, public perception and acceptance can be equally important to provide a fertile environment for market growth. *Patrick and Hannah Devine-Wright* explore how intermittency is communicated to the public by campaign groups as part of their arguments against or in favour of wind energy, using 'social representations theory'. Their findings suggest a number of implications for future research and policy-making.

The ongoing penetration of intermittent RETs challenges the proper functioning of the physical grid network. In Germany, existing wind power capacities already have an impact on the direct costs of RES promotion, grid extensions, as well as regulating and reserve power capacities, which will all grow more severe as intermittent penetration rises. On behalf of the German Energy Agency, *Gatzen et al.* analyse the economic and technological effects of the planned extension of wind power capacities onshore and offshore in Germany until 2020. With the planned expansion of wind power in Northern Germany, existing transmission capacities between individual regions may become insufficient, leading to significant electricity price differences in the regions, as well as impeding on the stability of the network. It is supposed that the extension of transmission capacities and the use of energy storage can avoid this separation of individual regions. *Barth et al.* use a novel stochastic linear optimisation model to estimate the arising price differences between the regions in Germany, as well as systematic case studies to assess the impact of transmission lines extensions and energy storage solutions on the electricity prices in various regions.

In part, small autonomous power systems face very different challenges, especially with regard to limited geographical dispersion potential of intermittent energy technologies. *Kaldellis et al.* conclude this Special Issue and propose a wind-hydro configuration in combination with a desalination plant to address the intermittent and stochastic wind behaviour. Interestingly, only by co-producing electrical energy and clean water via an appropriate desalination plant, it is possible to achieve high wind energy penetration rates and minimise the system energy surplus.