Department of Meteorology
School of Mathematical, Physical and Computational Sciences

University of Reading

Open Research
Meteorological information supporting the clean energy transition

David Brayshaw and Hannah Bloomfield

With Paula Gonzalez, Andrew Charlton-Perez, John Methven, Phil Coker
and members of the Energy-Meteorology research group (both past & present)

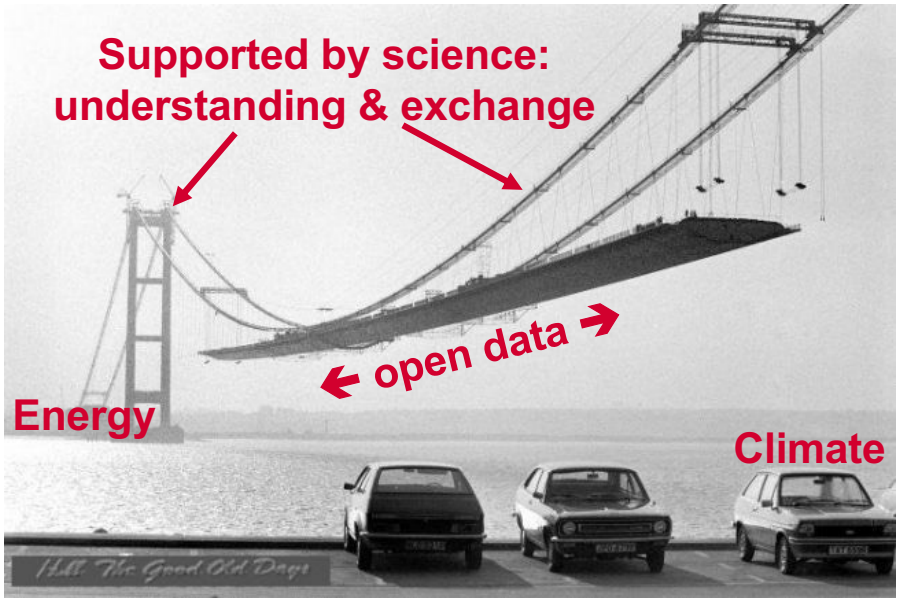
Motivation

- Climate change driving a complete transformation of the electricity sector
  - Rapid growth of renewables such as wind & solar (global investment of US$242 billion in 2020)
  - Electrification of other sectors: transport & heating

- Fundamentally changes exposure of energy-system to weather:
  - Ability of existing infrastructure to cope with *impacts of a changing climate*
  - Ensuring new infrastructure design is robust to *climate uncertainty*

- Historically weak connections between energy- and climate- research
  - Need for open research

- Energy-Meteorology group:
  - Open data, models and tools
  - Open access publications
  - Building interdisciplinary community



Humber Bridge, near Hull in Yorkshire (UK). Formerly the longest single-span suspension bridge in the world, started construction 1973, opened 1981.
Image adapted from driventowrite.com/2019/10/06/bridge-across-the-humber/#jp-carousel-55246

Timeline of major activities

2009-2013 Scoping research

- Exploration of impacts of climate information in energy
- Enabling the ***use of widely accessible met data*** in energy applications

2013-2015 UK wind power historical reconstructions

- National Grid: rapid increases in wind capacity
- ***First datasets/models released*** on CENTAUR/group webpages then RRDR

2016-2020 European renewables

- ***Multiple datasets released***, spanning many technologies and countries
- Includes both historic and weeks-ahead forecast

Summary

- 7 major datasets (~12GB); 2 OA book chapters; 10 full-OA journal publications
- Industrial use: Nat Grid, Crown Estate, Met Office for Nat Infrastructure Commission
- Research users: Norway, Russia, Austria, UK & Netherlands
- Teaching: 7 PhD/MSc/UG projects; new MSc "Climate Services" module
- Contributions to 2 major freely-available EU "climate service demonstrators"

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Selected projects/publications

Brayshaw et al (2011, 2012)
Ely et al(2013); Kubik et al (2013)

nationalgrid

Cannon et al (2015)
Drew et al (2016)

Brayshaw (2018 x2)
Drew et al (2019)

S2S4E Climate Services for Clean Energy

Bloomfield et al (2019, 2020a, 2020b)
Gonzalez et al (2020)

…

Open research in energy-meteorology

- Challenge of 2010's: demonstration-of-principle (science), enabling access (data)
- Challenge of 2020's: continues but also need for understanding, exchange and community building

- "Next Generation Challenges in Energy-Climate Modelling" workshops (June 2020 and planned for Sept 2021)
  - Free, online, interactive & open

Figure: clim2power project (clim2power.com)
Reproduced in Bloomfield et al 2021

Why do the Energy sector care about the data we are creating?

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Operational seconds – days	Grid management, plant scheduling Anticipating extreme weather	Nowcasting & short range
Trading days – 1 year	Maintenance/resource planning Longer-term wholesale energy contracts	Extended range & seasonal forecasts
Strategic year – year climate variability	Characterising demand and supply Impacts of year-year variability	Reanalysis & control runs
Planning climate change	Impacts of climate change Trade-off between climate change and energy system change	Climate model projections
Extremes disrupting weather	Risk and impact of extreme disruptive weather local vs. far afield impacts	All of the above!

Control room

System planners

Policy makers

Images sources for control room, system planners and policy makers

How open data has helped me

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- At the start of my PhD there was a lot going on (!)
- Having well documented code with good metadata from other group members really helped get me started.
- Other institutions open data archives were a great way to learn.

Image source: https://ergyork.wordpress.com/2015/01/12/starting-a-phd-here-is-some-advice-on-year-one/

Challenges in Creating open data

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- When is it ‘good enough’?
- Is my metadata complete?
- Will someone find something wrong with it?

Can we add more countries or more variables?

What are all these acronyms?

Are we using the best modelling technique?

Is this a complete set of instructions?

Is this data out of date now?

Is this the best way to package the data?

We could try a few more tests….

Image source: https://www.rightattitudes.com/2018/03/13/what-your-messy-desk-says-about-you/

Impact of Our datasets

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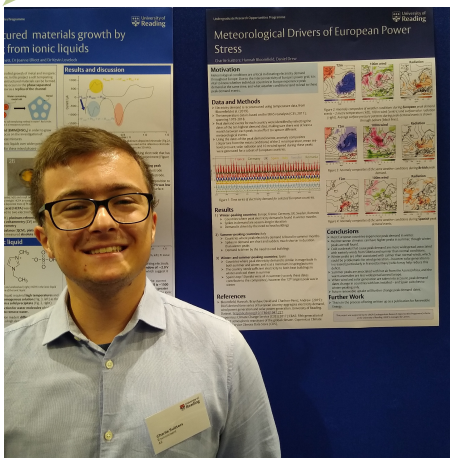
Great starting point for student projects



Fantastic opportunities to collaborate with other scientists!

Hindawi
Journal of Renewable Energy
Volume 2020, Article ID 5481010, 12 pages
https://doi.org/10.1155/2020/5481010

Hindawi

Research Article

Meteorological Drivers of European Power System Stress

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Received 13 December 2019; Revised 3 August 2020; Accepted 11 August 2020; Published 28 August 2020

Academic Editor: Pallav Purohit

A rapid decarbonisation of power systems is underway in order to limit greenhouse gas emissions and meet carbon-reduction targets. Renewable energy is a key ingredient to meet these targets; however, it is important that national power systems still maintain energy security with increasing levels of renewable penetration. The operating potential of renewable generation at times of peak demand (a critical time for power system stress) is not well understood. This study therefore uses a multidecadal dataset of national demand, wind power, and solar power generation to identify the meteorological conditions when peak demand occurs and the contribution of renewables during these events. Wintertime European peak power demand events are associated with high atmospheric pressure over Russia and Scandinavia and are accompanied by lower than average air temperatures and average wind speeds across Europe. When considering power demand extremes net of renewable power production, the associated meteorological conditions are shown to change. There is considerable spatial variability in the dates of national peak demand events and the amount of renewable generation present. Growth in renewable generation has the potential to reduce peak demands. However, these impacts are also not uniform with much larger reductions in peak demand seen in Spain than in central Europe. The reanalysis-derived energy models have allowed recent peak demand events to be put into a long-term context.

1. Introduction

In order to meet the carbon-reduction targets, such as those outlined within the Paris Agreement, a rapid decarbonisation of national energy systems is required [1]. There has been a large global uptake of renewable generation (i.e., wind power, solar power, and hydropower) in recent years [2]. However, renewable power generation is weather-dependent and therefore has variability over a range of temporal scales. For efficient operation (i.e., avoiding costly disruption and maintaining security of supply) of a power system with high penetrations of renewable generation, an understanding of the weather-driven variability and the meteorological conditions which result in power system stress is required. Of the conditions which cause system stress, a particular challenge is peak demand, which is the hour/day of the year when there is a largest demand for electricity (i.e., times which lead to high power system costs and problems with energy security).

Electricity demand is dependent on temperature and wind chill (for heating and cooling) and illumination (for lighting) [3–6]. In most central and northern European countries, peak electrical loads occur in winter, at darkness peak (e.g., the UK [6–8]; Scandinavia [9]; and Germany [4, 9]). However, in southern European countries, peak demand can be seen in summer (e.g., Greece [10, 11]; Spain [9]; and Italy [9, 10, 12]) due to increased demand for air conditioning.

The ability of renewable generation to provide a contribution to peak demand is sometimes described in the literature as the capacity credit. This is defined as the contribution that a generator makes to system adequacy, usually related to a defined reliability target [13]. In countries with a winter peak, there is no guarantee that wind power will be available at times of peak demand, although some positive correlation has been shown between times of high demand and wind power generation [14, 15]. Several studies have investigated the potential for the availability of wind generation at peak demand, with the term "low wind, cold snap" being common in the literature to describe times of potential concern for winter peaking energy systems [16]. A

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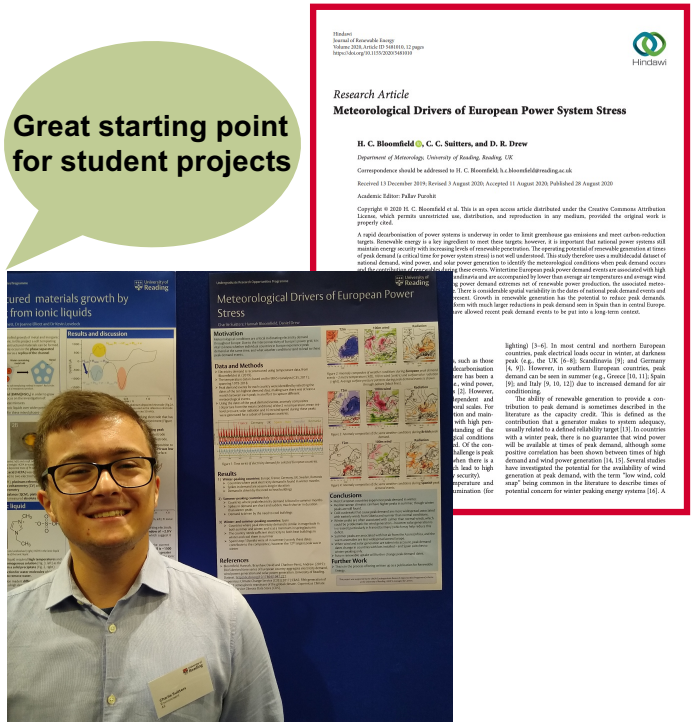

Hindawi
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Research Article

Meteorological Drivers of European Power System Stress

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Datasets are being used across Europe in collaboration with us

Fantastic opportunities to collaborate with other scientists!

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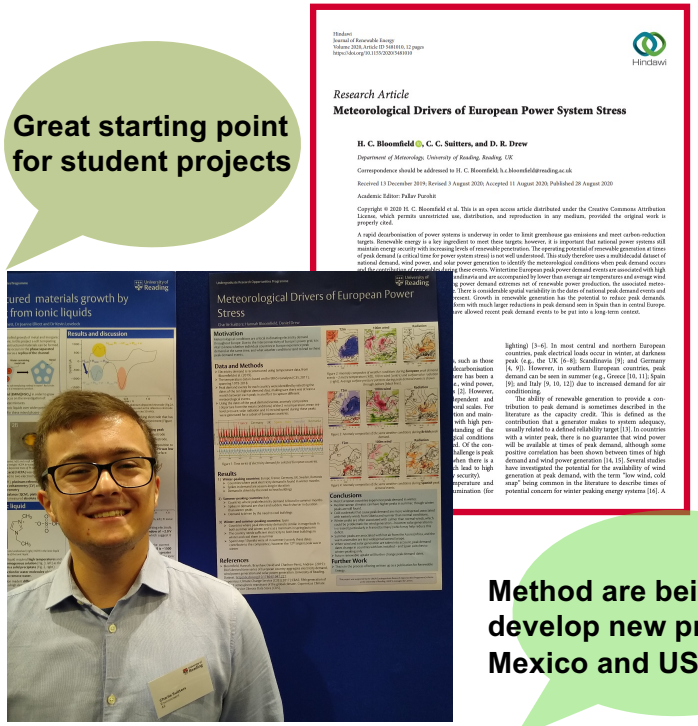

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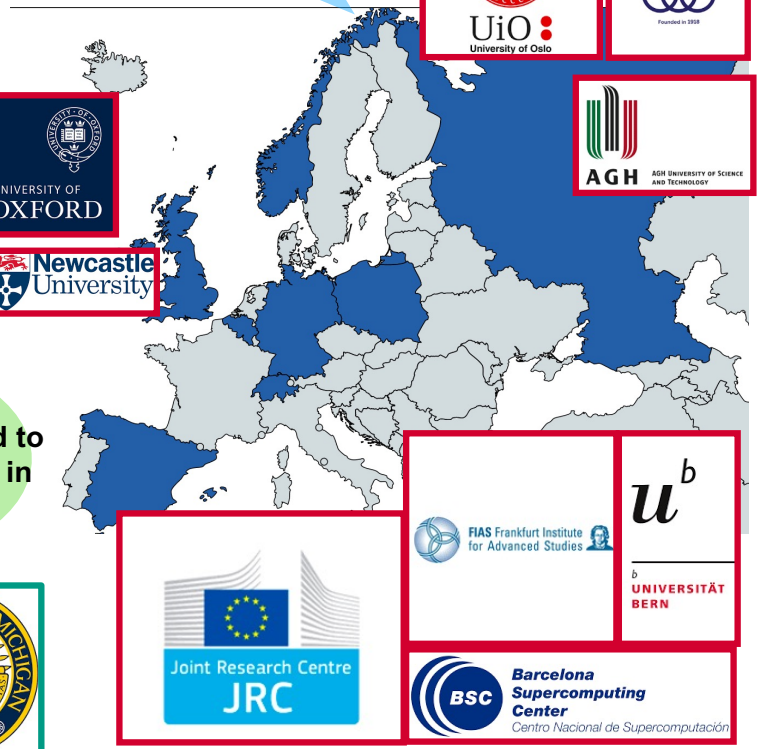
Method are being used to develop new products in Mexico and USA

Datasets are being used across Europe in collaboration with us



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Methods used by UK Met Office, providing evidence to the National Infrastructure Commission

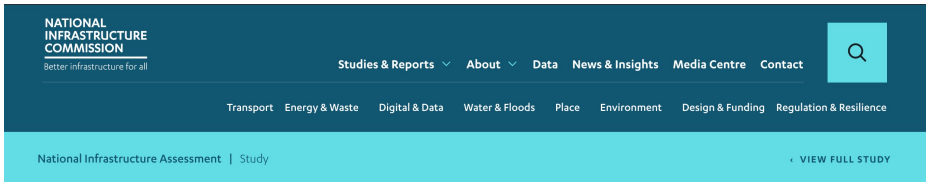
Met Office

Data is contributing to a Royal Society Report on the future of renewables

THE ROYAL SOCIETY

Ongoing discussion with National Grid

nationalgrid



EXTERNAL RESEARCH :: ENERGY & WASTE

Adverse weather scenarios for renewable energy system testing

12 Jun 2020

EXTERNAL RESEARCH :: ENERGY & WASTE

Characterising adverse weather for the UK electricity system

14 Dec 2020

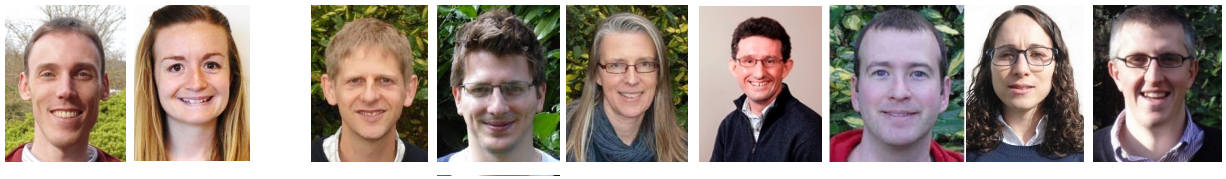
Use published scientific methods in collaboration with Bloomfield

Heavily based on/reference to work from the Reading energy-met research group

https://nic.org.uk/publication_category/supporting-evidence/

Summary

- Energy systems around the world are rapidly changing to meet climate mitigation targets.
- A key aspect of this is the transition to renewable energy – much of which is highly sensitive to weather.
- Data to quantify and understand the impact of weather and climate on the energy system has been historically sparse. Few researchers have access to sufficient expertise in both energy and meteorological science.
- For more than a decade our group has addressed this challenge, publishing 7 OA datasets 2 OA educational book chapters; 10 OA publications which have been widely used by academia and industry.



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Datasets

time

nationalgrid

Cannon et al., (2015)

Drew et al., (2016)

Drew et al., (2019)

S2S4E Climate Services for Clean Energy

Bloomfield et al., (2019)

Bloomfield et al., (2020a,2020b)

Gonzalez et al., (2020)

References

- Cannon, D.J., Brayshaw, D.J., Methven, J., Coker, P.J. and Lenaghan, D. (2015) *Using reanalysis data to quantify extreme wind power generation statistics: a 33 year case study in Great Britain.* Renewable Energy, 75. pp. 767-778. ISSN 0960-1481 doi: https://doi.org/10.1016/j.renene.2014.10.024
- *Drew, D., Cannon, D., Brayshaw, D., Barlow, J. and Coker, P. (2015) The impact of future offshore wind farms on wind power generation in Great Britain. Resources, 4 (1). pp. 155-171. ISSN 2079-9276 doi: https://doi.org/10.3390/resources4010155*
- *Bloomfield, H. C., Brayshaw, D. J., Shaffrey, L. C., Coker, P. J. and Thornton, H. E. (2016) Quantifying the increasing sensitivity of power systems to climate variability. Environmental Research Letters, 11 (12). 124025. ISSN 1748-9326 doi: https://doi.org/10.1088/1748-9326/11/12/124025*
- *Bloomfield, H., Brayshaw, D. J., Shaffrey, L., Coker, P. J. and Thornton, H. E. (2018) The changing sensitivity of power systems to meteorological drivers: a case study of Great Britain. Environmental Research Letters, 13 (5). 054028. ISSN 1748-9326 doi: https://doi.org/10.1088/1748-9326/aabff9*
- *Brayshaw, D. (2018) Weather, climate and the nature of predictability. In: Weather & Climate Services for the Energy Industry. Palgrave Pivot, Basingstoke, pp. 85-95. ISBN 9783319684178 doi: https://doi.org/10.1007/978-3-319-68418-5_6*
- *Brayshaw, D. (2018) The nature of weather and climate impacts in the energy sector. In: Weather & Climate Services for the Energy Industry. Palgrave Pivot, Basingstoke, pp. 151-160. ISBN 9783319684178 doi: https://doi.org/10.1007/978-3-319-68418-5_11*
- *Drew, D. R., Coker, P. J., Bloomfield, H. C., Brayshaw, D. J., Barlow, J. F. and Richards, A. (2019) Sunny windy Sundays. Renewable Energy, 138. pp. 870-875. ISSN 0960-1481 doi: https://doi.org/10.1016/j.renene.2019.02.029*
- Gonzalez, P. L. M., Brayshaw, D. J. and Zappa, G. (2019) *The contribution of North Atlantic atmospheric circulation shifts to future wind speed projections for wind power over Europe.* Climate Dynamics, 53 (7-8). pp. 4095-4113. ISSN 1432-0894 doi: https://doi.org/10.1007/s00382-019-04776-3
- *Coker, P. J., Bloomfield, H. C., Drew, D. R. and Brayshaw, D. J. (2020) Interannual weather variability and the challenges for Great Britain's electricity market design. Renewable Energy, 150. pp. 509-522. ISSN 0960-1481 doi: https://doi.org/10.1016/j.renene.2019.12.082*
- Bloomfield, H. C., Brayshaw, D. J. and Charlton-Perez, A. J. (2020) *Characterizing the winter meteorological drivers of the European electricity system using targeted circulation types.* Meteorological Applications, 27 (1). e1858. ISSN 1469-8080 doi: https://doi.org/10.1002/met.1858
- *Bloomfield, H. , Suitters, C. and Drew, D. (2020) Meteorological drivers of European power system stress. Journal of Renewable Energy, 2020. pp. 1-12. ISSN 2314-4394 doi: https://doi.org/10.1155/2020/5481010*
- *Bloomfield, H. C. , Brayshaw, D. J. , Gonzalez, P. L. M.* and Charlton-Perez, A. (2021) *Sub-seasonal forecasts of demand, wind power and solar power generation for 28 European Countries.* Earth System Science Data, 13 (5). ISSN 1866-3516 doi: https://doi.org/10.5194/essd-13-2259-2021

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