Security of supply in the future, zero carbon electricity system
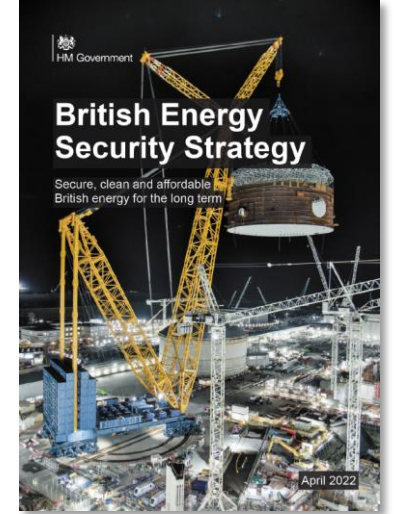
Keith Bell

Holder of the ScottishPower Chair in Future Power Systems at the University of Strathclyde and a co-Director of the UK Energy Research Centre (UKERC)
http://www.strath.ac.uk/staff/bellkeithprof/

All Energy, May 11th 2022

April 2022 "Energy Security Strategy"
Massive increase in low carbon electricity supply

	Nuclear	Offshore wind	Onshore wind	Solar	Total
Capacity (GW)	25	50	30	70	
Target date	2050	2030	Not promised	2035	
Capacity factor	90%	55%	30%	12%	
Annual energy if fully utilised (TWh)	198	241	79	73	590

- Reduce dependency on fossil fuels
  - Short term: reduce vulnerability to global gas markets
  - Medium to long term: leave (almost all?) fossil fuels in the ground
- However, little to say on
  - energy efficiency
  - the residual demand curve challenge
- To me, 3 things are important:
  - being as efficient as possible in our use of energy.
  - being able to make full use of low carbon electricity when it's available.
  - still meeting demand when it's not windy (and when it's too windy)
  all at least cost

Demand for electricity in the CCC's Balanced Pathway

Legend:
- Electrolysis
- Fuel Supply
- Manufacturing & construction
- Residential buildings
- Other
- Surface transport
- Non-residential buildings

Stuff happens

University of Strathclyde Engineering

The Guardian — UK edition
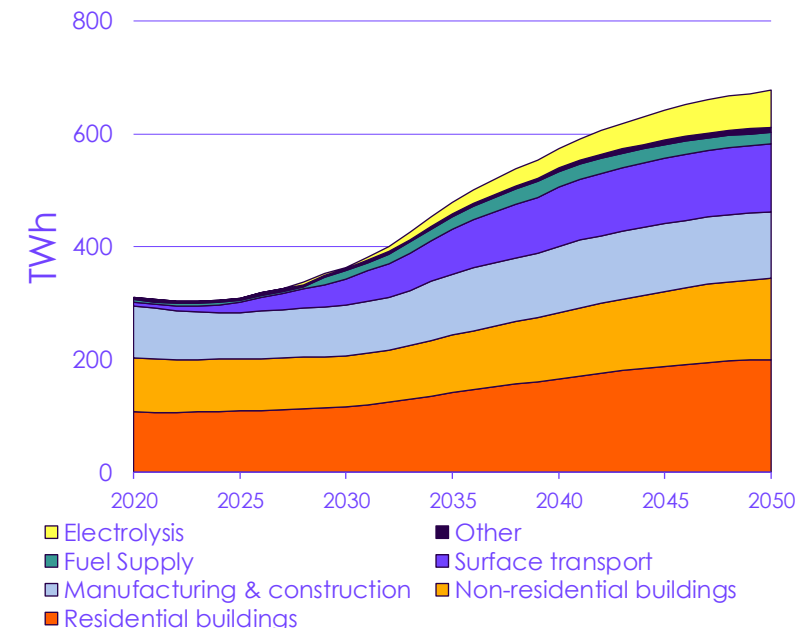
Transport chaos across England and Wales after major power cuts

Energy watchdog Ofgem warns it could take 'enforcement action' over the outage

Kevin Rawlinson and Jillian Ambrose

Fri 9 Aug 2019 23.18 BST

▶ Power cuts spark transport chaos in London - video

Large parts of England and Wales were left without electricity following a major power cut that had a serious impact on rail and road services, including city traffic lights.

Passengers were shut out of some of the country's busiest train stations during the Friday evening rush hour, while hundreds of thousands of homes were left without electricity after what the National Grid described as a problem with two generators.

The Peak of Texas's Power Outages
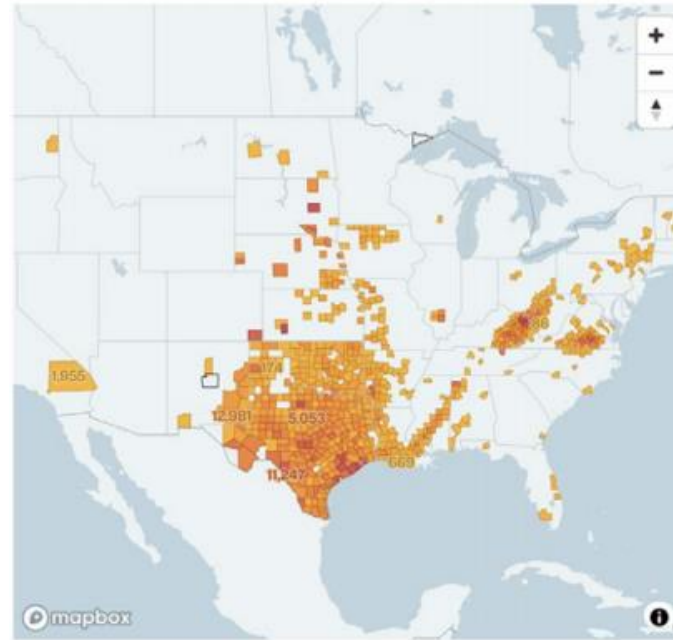
More than 4.5 million customers in Texas were without power during the peak of outages in the state this week, as freezing temperatures hit parts of the country. This map shows activity

0% —— 100%

From by Alison Silverstein – IAEE Seminar -
https://www.iaee.org/en/webinars/webinar_kiesling.aspx

Image: PA
https://inews.co.uk/news/more-than-19000-homes-still-without-power-six-days-after-storm-arwen-1331091

Times of paucity, times of plenty:
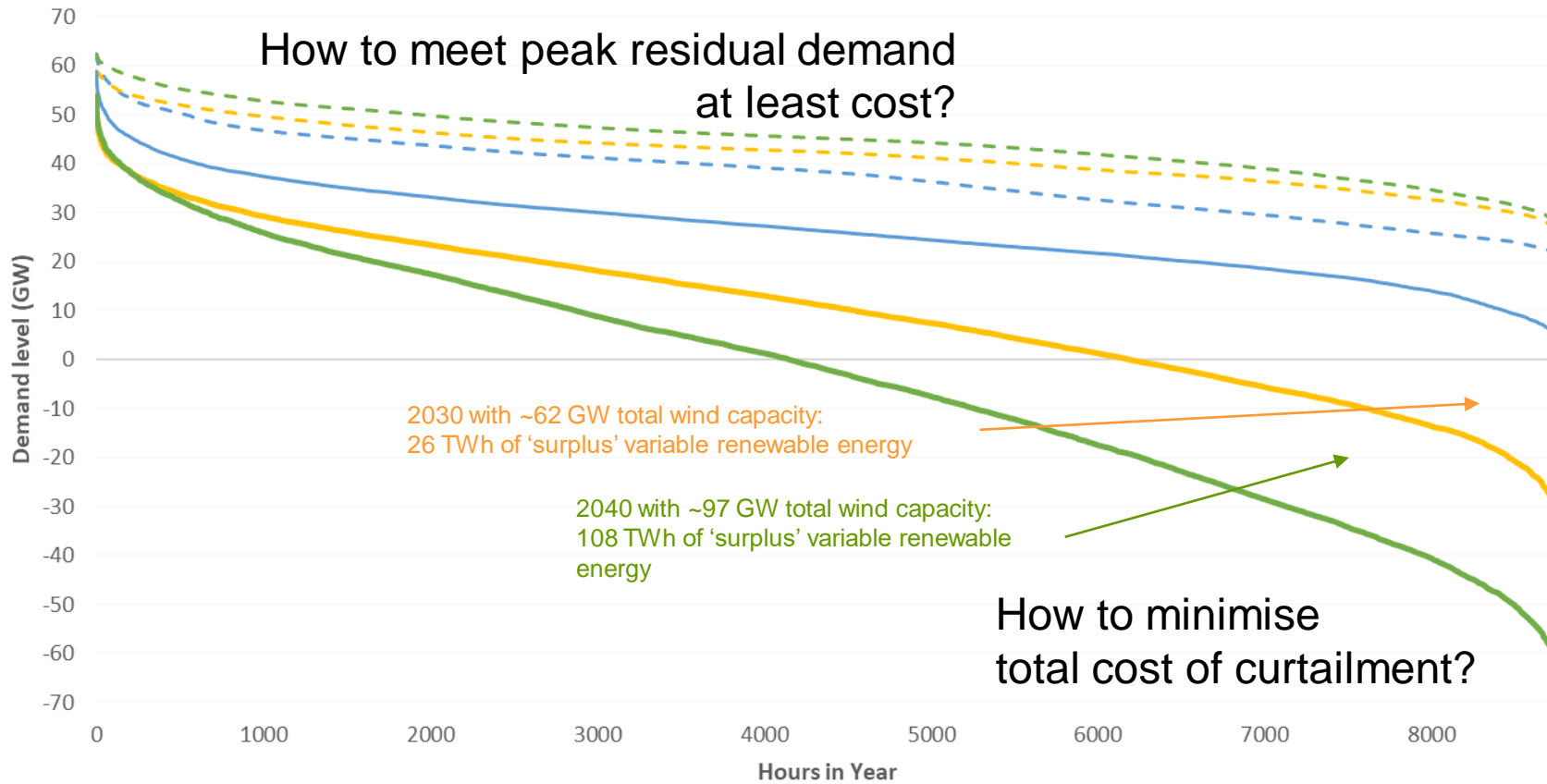# the residual demand curve challenge

University of **Strathclyde** Engineering

Demand & Residual Demand Duration Curves - 2020, 2030 and 2040 Scenarios

How to meet peak residual demand
at least cost?

2030 with ~62 GW total wind capacity:
26 TWh of 'surplus' variable renewable energy

2040 with ~97 GW total wind capacity:
108 TWh of 'surplus' variable renewable energy

How to minimise
total cost of curtailment?

Y-axis: Demand level (GW) — 70, 60, 50, 40, 30, 20, 10, 0, -10, -20, -30, -40, -50, -60, -70

X-axis: Hours in Year — 0, 1000, 2000, 3000, 4000, 5000, 6000, 7000, 8000

Legend: – – – Demand 2020 – – – Demand 2030 – – – Demand 2040 —— Residual Demand 2020 —— Residual Demand 2030 —— Residual Demand 2040

* in each hour residual demand = total demand – (wind + solar + run of river hydro)

GB Installed Wind & Solar Capacity (GW)			
	2020	2030 ST	2040 ST
Solar-PV	13.0	25.4	43.0
Wind: offshore	10.5	38.4	68.2
Wind: onshore	12.7	23.4	29.0
TOTAL	36.2	87.2	140.2
Peak residual demand	58.7	49.2	53.9
Min. residual demand	0.86	-34.4	-69.9

– Modelling at University of Strathclyde by Callum MacIver using ENTSO-E 2018 & 2020 TYNDP demand time series (2020 Best Estimate, 2030 Global Ambition, 2040 Global Ambition)
– Wind and solar output based on renewables ninja 2007 combined fleet time series scaled to FES 2021 System Transformation capacity scenarios
– Run of river Hydro modelled from historic trends
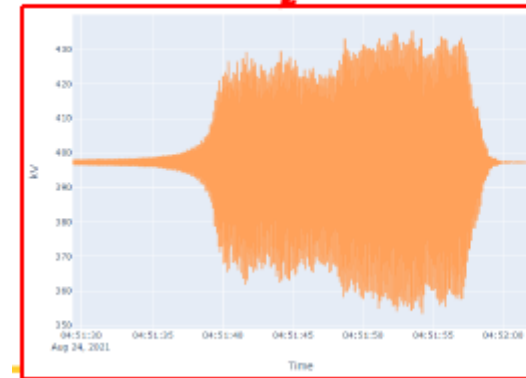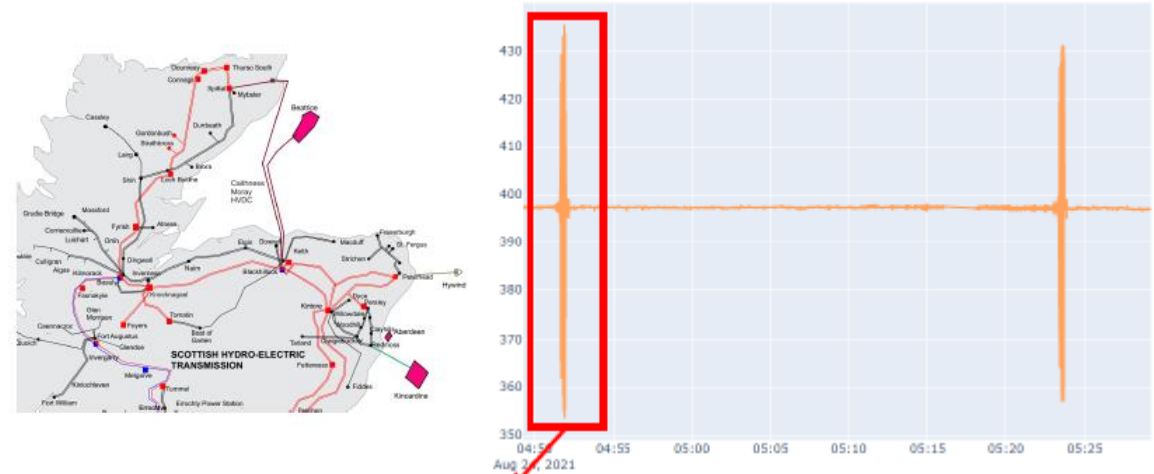
Complexities and operability

August 9th, 2019

Voltages and reactive power at Hornsea 1 wind farm oscillated after the voltage dip had been cleared
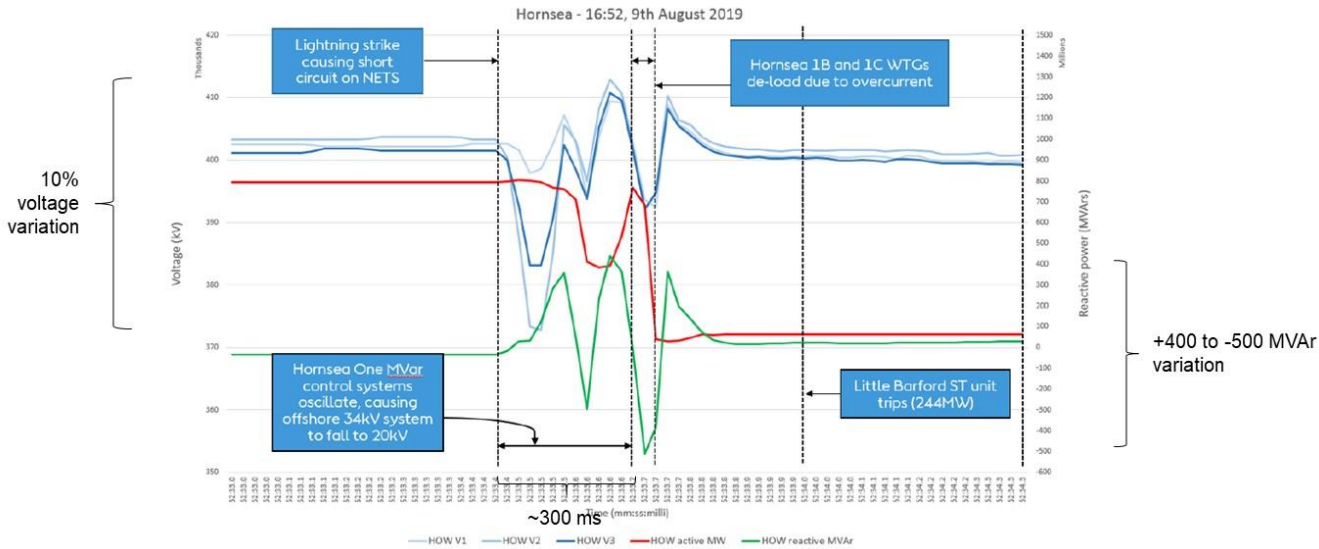
NG ESO Technical Report
on the August 9 incident,
Appendix D, Sept. 6, 2019

August 24th, 2021

Julian Leslie, "Managing Declining Inertia and
Short Circuit Levels", *G-PST/ESIG Webinar
Series: Managing Grid Stability in a High IBR
Network*, January 2022

This session

- What will be the place of electricity in the future energy system and where will the electrical energy come from?
- Will we have the right mix of generation, storage, flexible demand and interconnectors?
- Will the system be operable in a stable manner?
- Will supplies to end users be sufficiently resilient?

Panellists:
- **Dr. David Joffe**, Head of Carbon Budgets, Climate Change Committee
- **Shurooque Baloch**, Operability Product Manager, National Grid ESO
- **Scott Mathieson**, Network Planning & Regulation Director, SP Energy Networks