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Energy system transition challenges

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https://www.strath.ac.uk/staff/bellkeithprof/ http://www.ukerc.ac.uk/about-us/people/keith-bell.html

2nd International Conference on Energy Systems Integration, London, March 2019

The transition: can't wait to the last minute

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- The supply chain needs to be built up
  - Installation competence needed, not just manufacturing
- Capital needs to be raised
- Should avoid early asset write-off
  - Replace capital stock when it's due for replacement

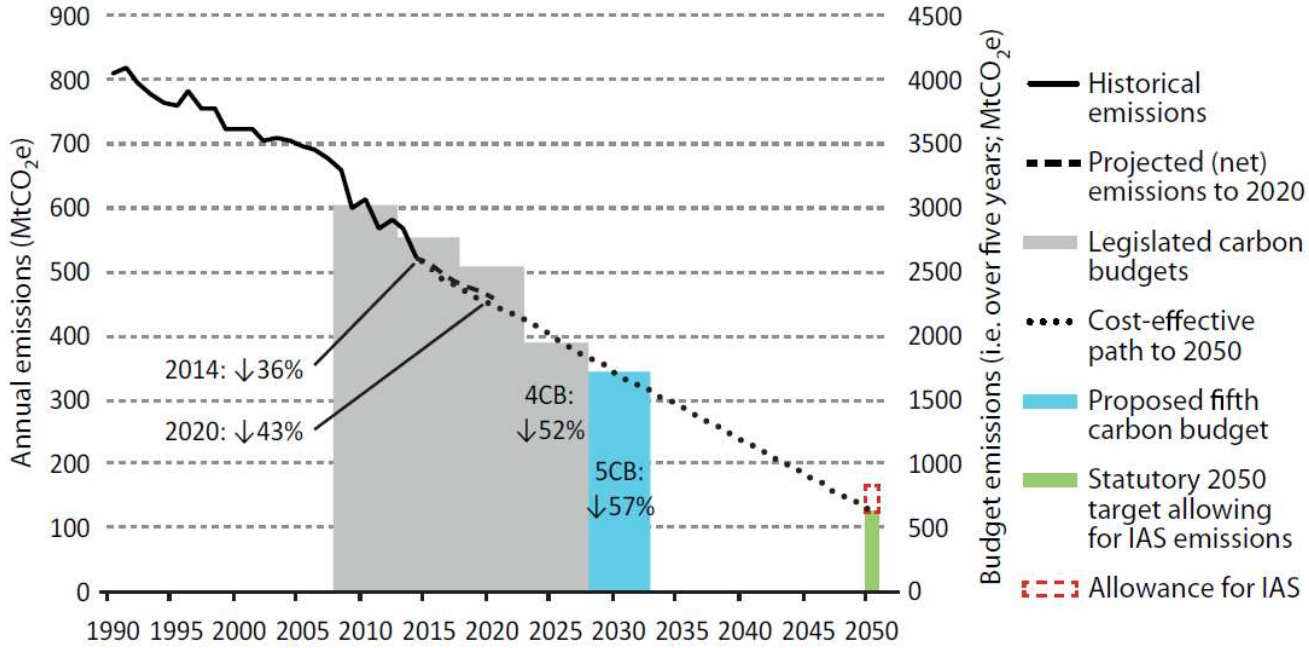
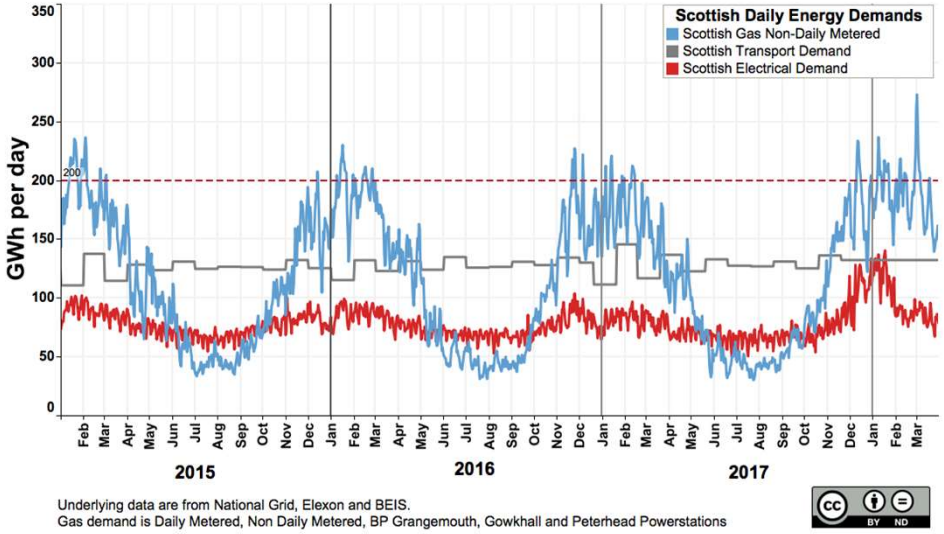
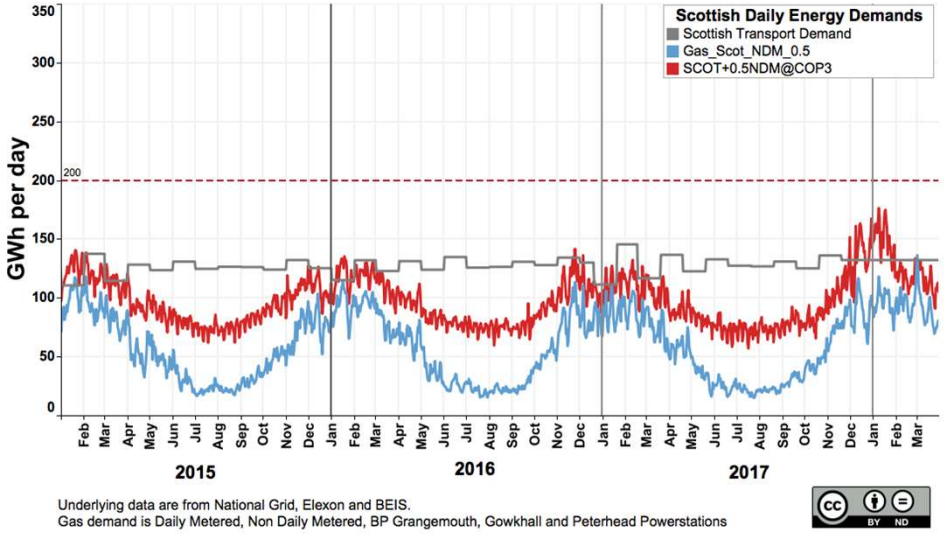


Figure: Committee on Climate Change, November 2015

Scotland's demand for energy

What if half of gas demand for heat was converted to heat pumps with a (generous) COP of 3?



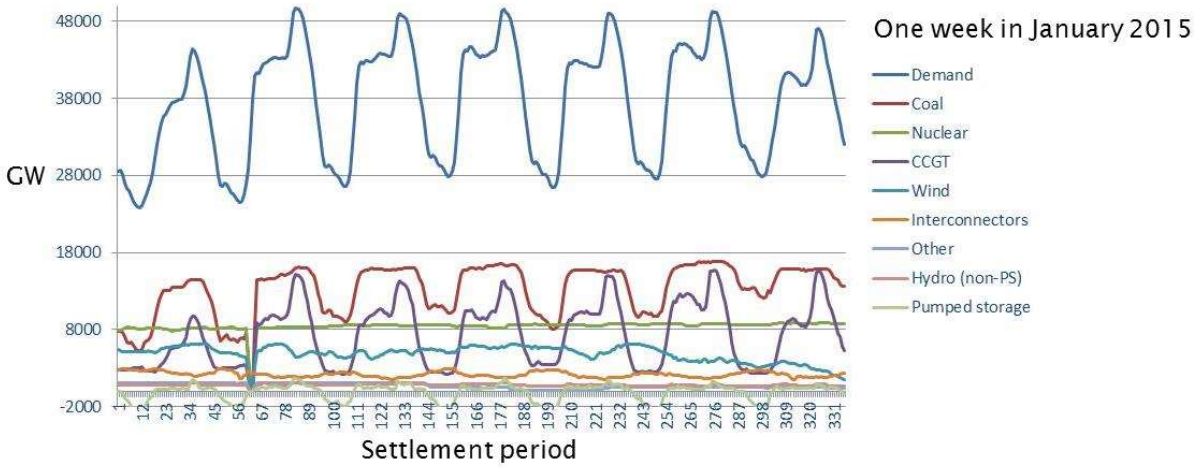


- Peak electricity demand roughly 50% bigger
- Bigger intra-annual variation of electricity
  - What extremes should the system be capable of meeting? How big and for how long?

Charts courtesy of Grant Wilson, University of Birmingham

Demand for electricity is not constant

- Balance out in time
  - Move energy to different times via storage
  - Time shiftable demand
- Balance out in space
  - Export surpluses
  - Meet deficits via imports



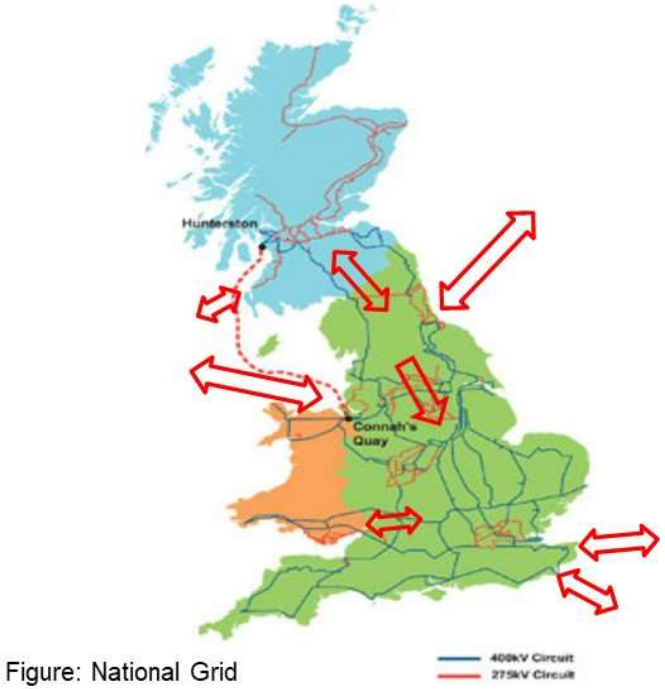


Figure: National Grid

Large scale storage

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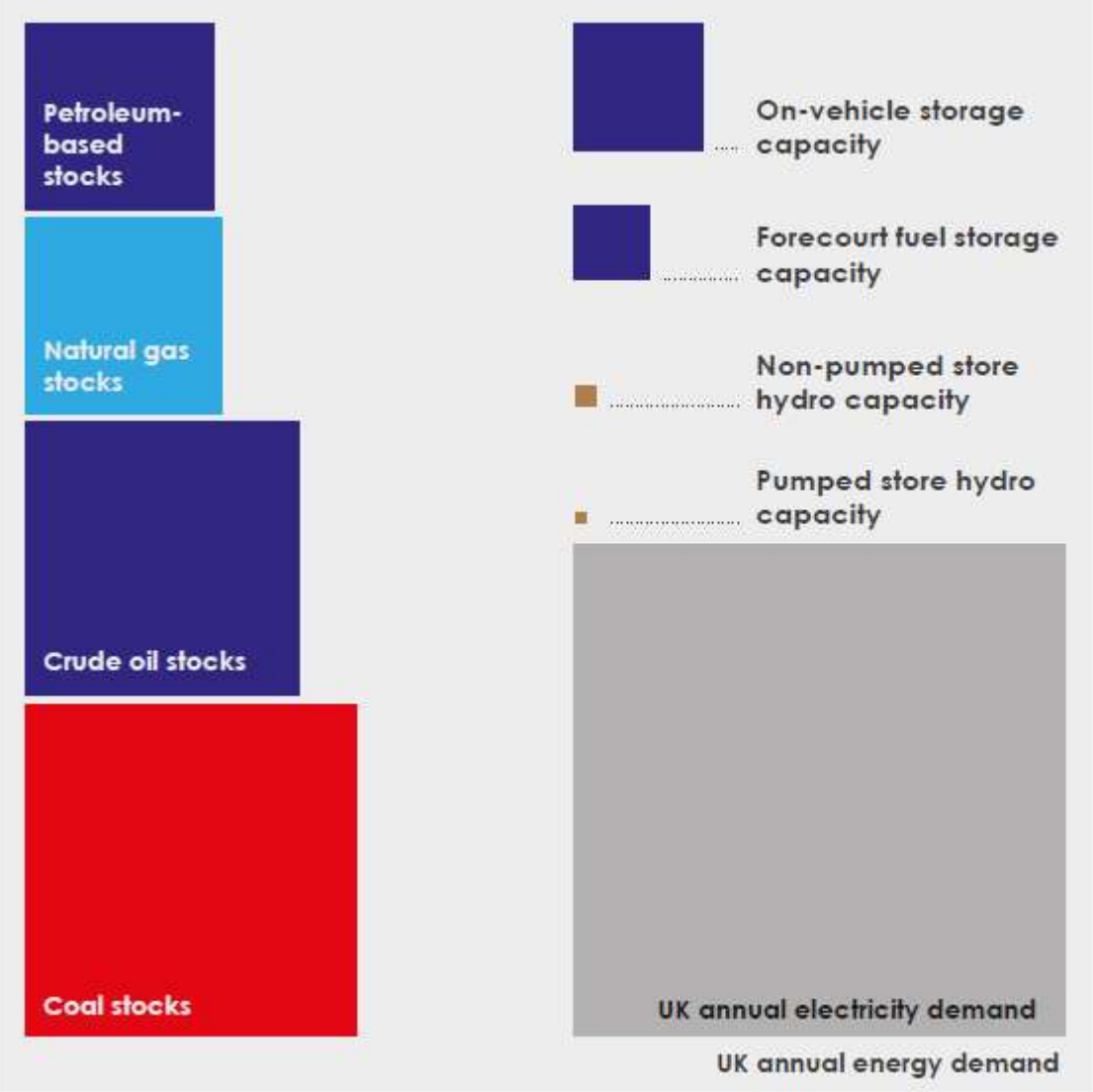
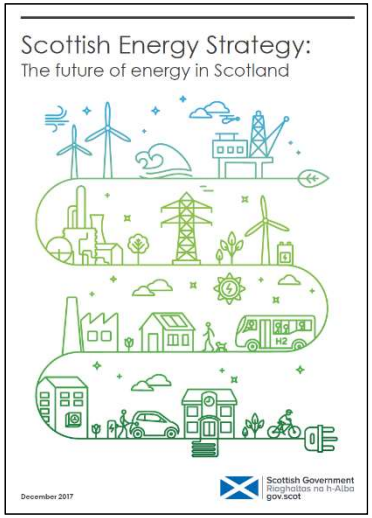
The future electricity system depends on storage…?

Storage in the UK (2014)



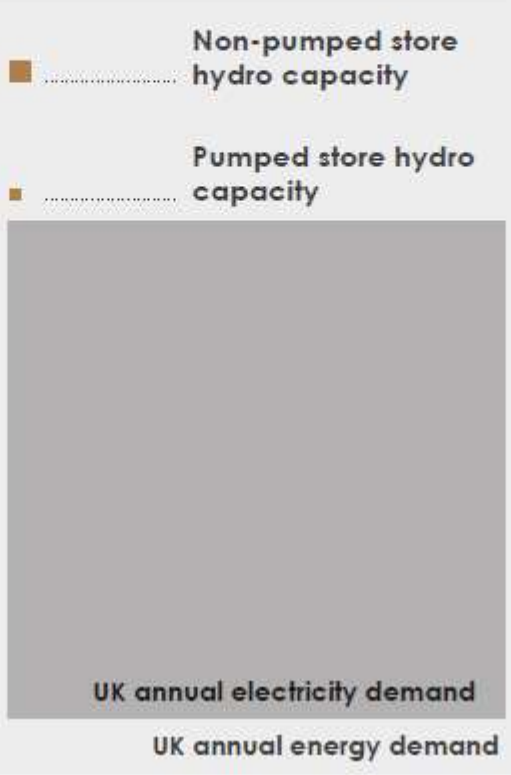
- Much of the fuel imported just in time
- Energy from renewables converted to electricity when it becomes available

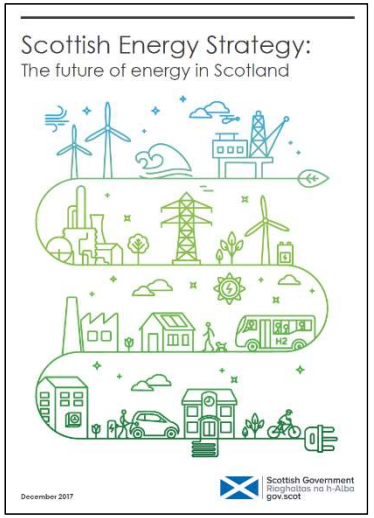


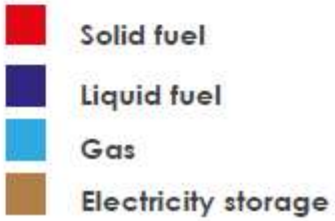
Solid fuel
Liquid fuel
Gas
Electricity storage

Storage in the UK (2014)

Decarbonised storage
(if you don't use CCS or 'green gas')







Electricity system behaviours and costs

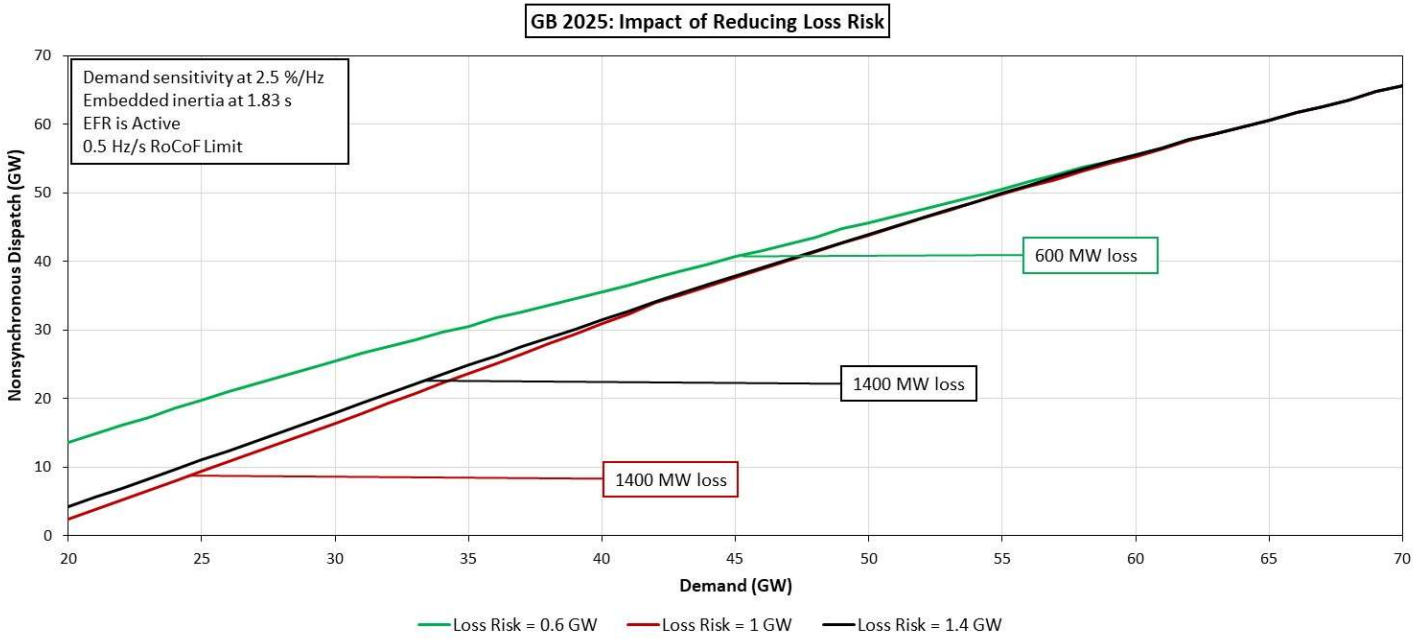


Figure: Marcel Nedd, University of Strathclyde

- Different capabilities and costs: one service buys time to access the next
- Almost all present day provision of frequency response depends on stored energy
  - Inertia, high pressure steam, hydraulic head, chemical energy
- What happens to inverters during short circuit faults?
- Need for new ancillary services or grid code requirements?

Work needed now to enable the transition:

- Engineering research
- Market development

The value of local storage: heat

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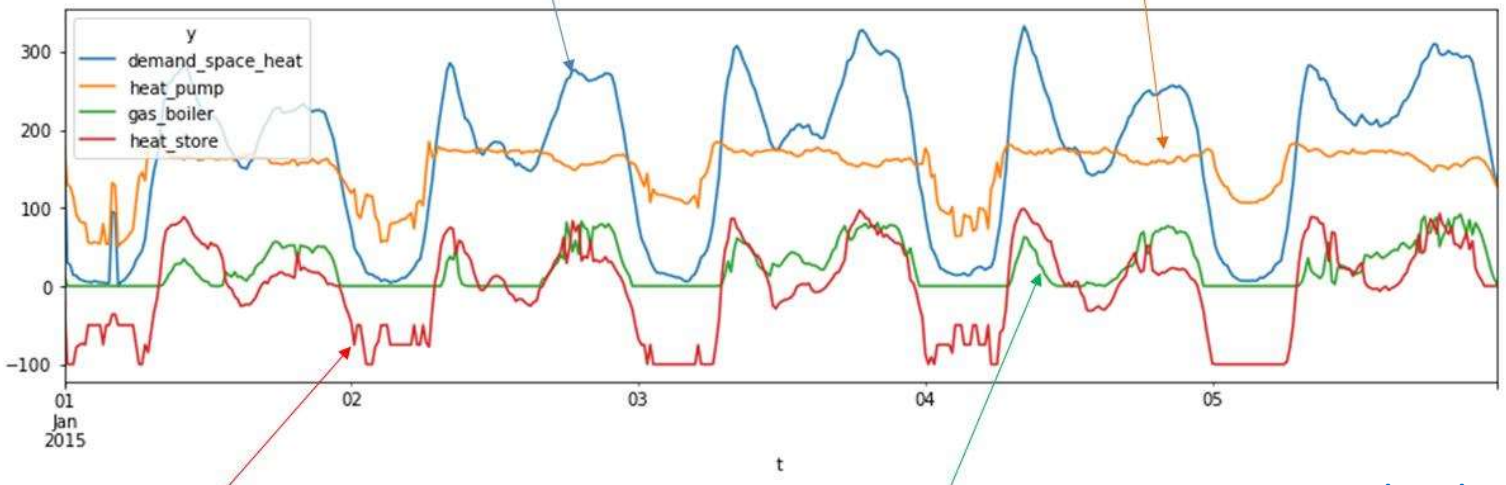
Work by Graeme Hawker
at University of Strathclyde

Net space heat demand: building efficiency reduces total energy and provides temporal buffering

Heat pumps utilise decarbonised electricity (local and grid) to limit of network capacity (minus other electrical demand)



Heat storage increases utilization of heat pump capacity

Existing gas network and boilers provide remainder of space heating

Need to legislate now to make future homes capable of storing heat?

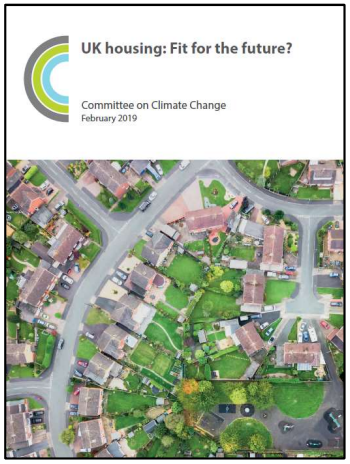
Buffering of heat reduces need for

- extra rating of electrical appliances and the distribution network
- top-ups from gas boilers

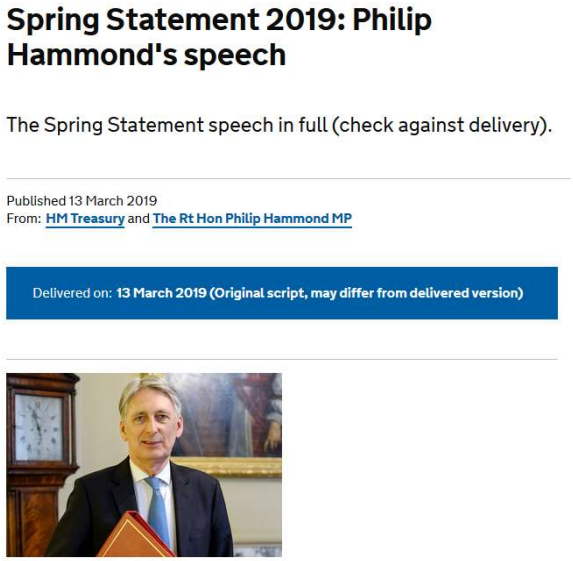
Do what you can when you can

- “Implement **tighter standards for new buildings** to ensure they are designed for a changing climate, properly ventilated, moisture-safe, are future-proofed for low-carbon heating and deliver ultra-high levels of energy efficiency.”
- “All new homes should be made low-carbon heat ready. **By 2025** at the latest, **no new homes should connect to the gas grid**, and should instead rely on low-carbon heating systems such as heat pumps.”

CCC, February 2019



- “We will publish proposals to **require an increased proportion of green gas** in the grid, advancing decarbonisation of our mains gas supply.”
- “We will introduce a **Future Homes Standard**, mandating the **end of fossil-fuel heating systems in all new houses from 2025**.”



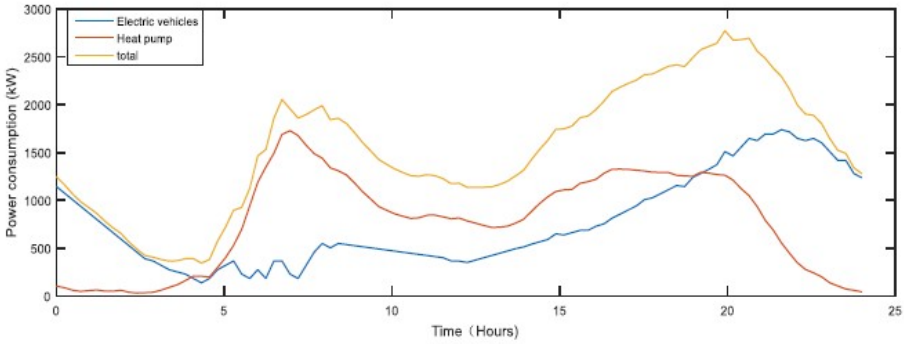
Storage for transport

- Does electric vehicle charging impose an unreasonable burden on the electricity system?
  - 43% of households don't have off-street parking at home[1]
    - They want (or need) fast charging?
  - Average travel per day[2]: 34.6km
  - 34.6km requires 5.6kWh, i.e. 49 mins charging at 7kW
  - What extremes and how much flexibility?

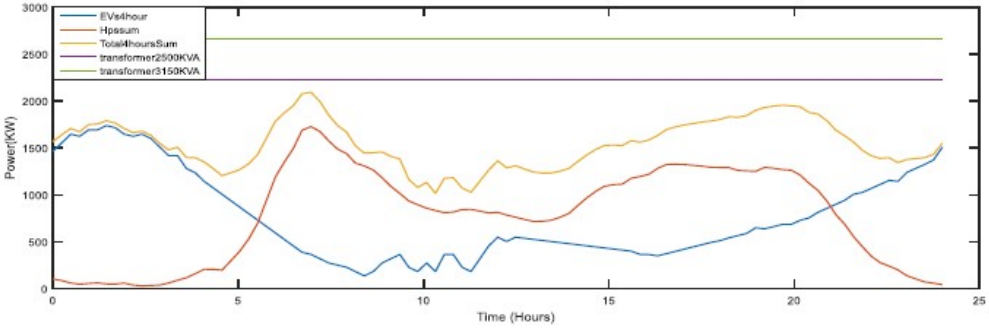
1. 2008 Dept. of Transport survey
2. Derived by James Dixon at Strathclyde from My Electric Avenue project data

LV network modelling: lots of heat pumps and electric vehicles

Unmanaged EV charging



Managed EV charging
(Heat pump load is the critical factor)



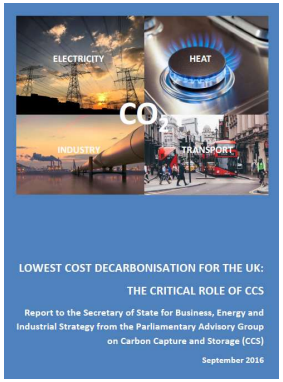
Figures by Hengqing Tian
University of Strathclyde

Incentives for 'smart charging'? Lack of charging infrastructure a barrier to EV adoption?

Enabling infrastructure

- Build the EV charging infrastructure and the EVs will follow?
- Build a hydrogen infrastructure and demand for hydrogen will follow?
  - CCC, November 2018: hydrogen
    - "is a **credible option** to help decarbonise the UK energy system but its role **depends on early Government commitment** and improved support to develop the UK's industrial capability."
    - "could replace natural gas in parts of the energy system."
  - Hydrogen depends on CCS?
    - "**Establish a CCS Delivery Company** … 'PowerCo' to deliver the power stations and 'T&Sco' to deliver the transport and storage infrastructure … will need c.£200-300m of funding over the coming 4-5 years"

Report of the Parliamentary Advisory Group on CCS , Sept. 2016



Driving the transition

- How to ensure the right infrastructure or capability of assets before there is a ‘natural’ market incentive?
  - Manufacture the market?
  - Build the infrastructure ahead of need?
  - Set standards or rules in advance, e.g. for ramping capability, banning of diesels or of gas boilers?
- Minimum regret: invest in options that can be adapted to different futures
- Regulatory mission: present day or future consumers?
  - “We [will] have a much better understanding of how to balance the interests of today’s consumers against those at different points in the future.”

Scottish Government, March 2019