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Britain's gas system, a case for reducing flexibility to increase wider system resilience?



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Dr Grant Wilson is a Lecturer in Chemical Engineering at the University of Birmingham and board member of the IMechE's Energy, Environment and Sustainability Group. His research activities focus on energy system flexibility, and multi-vector, multi-scale data analytics. He recently led a work-package from the UK Energy Research Centre's FlexiNET project that is delivering new insights into sub-daily demand, demand variability and intra-day flexibility of local gas networks in Great Britain. He also leads the TeachEnergy project that aims to encourage interdisciplinarity and diversity in energy teaching in Higher Education. Additional research includes modelling the use of thermal energy stores for the UK's Active Building Centre project.

- The talk will present analysis from the UK Energy Research Centre's FlexiNET project on flexibility of GB energy systems, with a particular focus on natural gas supplies and demands
- □ In 20 minutes:
  - A quick overview of Britain's primary energy swings using daily data
  - Comparison of local gas demand and national electrical demand (link to 1 minute video)
  - Pose the hypothesis that Britain's future energy system will be more resilient if it has less need for within-day flexibility

### GB daily primary energy - coal





# GB daily primary energy – low-carbon elec. UKERCFlexiNET





## GB daily primary energy – primary energy UKERCFlexiNET



- Natural gas is the biggest source of interseasonal daily demand swing
- This is driven by the interseasonal swing in local gas demand, rather than power stations or industry
- This is underpinned by the interseasonal swing in demand for space heating, itself dependent on the weather
- Natural gas storage helps to provide resilience but Britain's only interseasonal gas storage facility was shut in January 2018. Now only circa 27 TWh of natural gas storage in total comprised of 14 TWh of medium term gas storage and 13 TWh of LNG storage

### Britain's monthly natural gas demands

#### Great Britain's Monthly Natural Gas Data in GWh 120,000 GWh 100,000 GWh **3Wh per month** 80,000 GWh 60,000 GWh 40,000 GWh 20,000 GWh GWh 0 1999 2001 2003 2011 1997 2005 2007 2009 2013 2015 2017 Year

Grey Line = Production + Imports - Exports; Blue Line = Production; Red Shaded Line = Imports; Dark Purple Line = Exports

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### Britain's monthly gas indigenous production UKERCFlexiNET



Grey Line = Production + Imports - Exports; Blue Line = Production; Red Shaded Line = Imports; Dark Purple Line = Exports

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### Britain's monthly gas imports



Grey Line = Production + Imports - Exports; Blue Line = Production; Red Shaded Line = Imports; Dark Purple Line = Exports

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- These slides show that the flexibility for interseasonal variation in natural gas demand has been offshored. Varying imports and exports over the year provides flexibility, although system resilience (with the reduction in gas storage) has been subject to ongoing debate
- There is a strong argument to say that the market mechanisms worked last March during the cold weather event, as there was no supply interruption
- However, there was a marked increase in price for natural gas during and after a gas deficit warning day on the 1st of March

#### Storage needs are driven by demand

The UKERC FlexiNET project looked at the national electrical demand and the local gas demand at a sub-daily level (the hourly local gas data was not previously available)

- Domestic heating, cooking and hot water connected to the gas grid is part of the local gas demand, as well as smaller industry, commercial and service sector too. Embedded Combined Heat and Power plants will also be contained in this timeseries
- However, the local gas demand does not include gas demands directly connected to the high pressure gas transmission grid *e.g.* interconnectors, powerstations, storage and industry
- The electricity timeseries is transmission connected large power plants (metered) plus embedded generation (estimated)



# Peak demand week for Britain's Local Gas Demand UKERCFlexiNET



https://www.youtube.com/watch?v=LPx9rXM0zhg



#### Gas pipeline storage - Linepack

- **UKERC**FlexiNET
- The gas system copes with this level of within-day demand swing by utilising the inherent storage capacity within the pipelines themselves – linepack flexibility
- Linepack is the amount of gas contained within the higherpressure pipelines (>7bar) of the transmission and distribution gas infrastructure. It is calculated by combining measurements of pressure, temperature, compressibility, and specific gravity of the gas contained within the pipelines, with the knowledge of pipelines' internal volume
- As the pipeline pressure can be changed, the linepack can be flexed over a range within safe operating pressures
- This provides a large capacity for within-day flexibility, and is an inherent part of the gas delivery system. The electrical system has no intrinsic equivalent

### Current levels of within-day flexibility?

 Analysis shows that local gas linepack was flexed more than 183 GWh for 75% of the days from October to March over 63 months of data between 2013-01-01 to 2018-03-07
In comparison, the 4 pumped storage schemes in Britain have a total capacity of 28 GWh

- Why does Britain have a system that requires these levels of within day flexibility? A likely reason is the use of gas combination boilers that are a just-in-time technology to turn natural gas primary energy into space-heating or hot water. They do not have hot water storage cylinders
- Chicken and egg? the aggregate number of these boilers are only able to connect to the local gas system because it can cope with these increased demand ramp rates, if it could not, then the issue of managing within-day flexibility would have been raised previously

#### A future without fuels?

- Natural gas currently provides a significant level of stored energy and flexibility over different timescales to Britain's energy system.
  Liquid fuels and nuclear fuels offer larger stores of energy, and could perhaps be used for seasonal flex, but are not typically used for this purpose
- Unabated combustion of natural gas or other fossil liquid fuels have a highly limited or no role in Britain's net-zero future
- If we are moving from the flexibility currently provided by a gaseous energy vector, how much do we need to replace, what do we need to replace this with, where, and at what cost?
- What does this mean for resilience and what value do we place on this?

### Thoughts on research questions

- Lowering the need for within-day flexibility provides greater amounts of flexibility 'headroom' for system resilience, without having to increase the provision of flexibility
- The costs for additional within-day flexibility will become obvious when providing this through the electrical system rather than through the natural gas system using linepack flexibility
- As we shift away from fossil fuels, perhaps we need less overall flexibility rather than presuming that we need more? We certainly need more low-carbon flexibility, but do we need as much withinday flexibility as we have previously enjoyed with fossil fuels?
- Research and innovation should consider an additional focus on how much within-day flexibility we need, and how can it be reduced by differing methods *e.g.* behavioural change, thermal storage, demand reduction and time-shifting of demands

- □ We need more low-carbon flexibility, but do we need as much within-day flexibility as we have previously enjoyed with fossil fuels?
- Natural gas networks contain linepack, which can be flexed to provide significant amounts of within-day storage
- Research and innovation should consider an additional focus on how much within-day flexibility is needed, and how it could be reduced by differing methods

