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Heat Balance: Decarbonisation of heat and mitigation of renewable curtailment

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All-Energy
Heat Decarbonisation Show Floor Theatre
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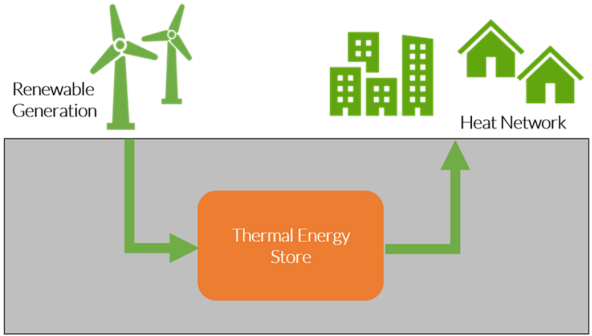
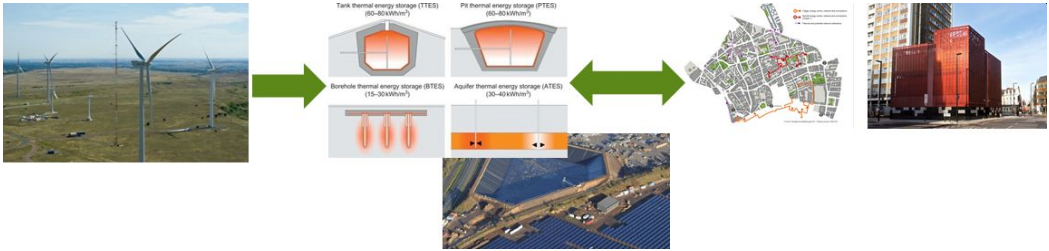
Heat Balance concept



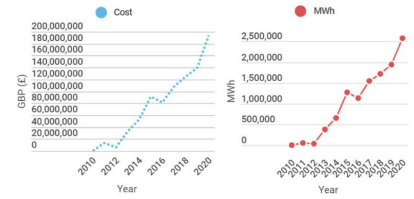
- Utilising constrained wind to generate and store heat in long-term thermal energy storage (LTES)
- LTES supplies heat networks and provides grid services
- Heat Balance project led by SPEN and funded through the Strategic Innovation Fund from Ofgem

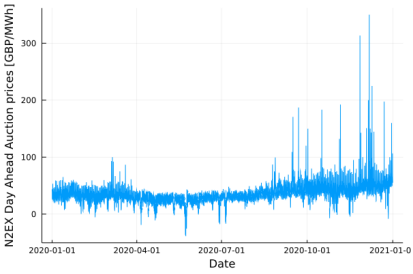
Key takeaways from the Heat Balance project

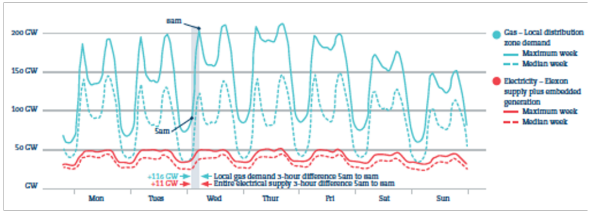


1. Thermal energy storage can and should be a vital part to provide an affordable, sustainable and reliable energy system
2. Thermal energy storage can provide reliable thermal energy for district heating at reduced running costs and with lower emissions while providing a large percentage of that energy from otherwise curtailed wind energy
3. Commercial and regulatory barriers need to be overcome to make this a reality

System flexibility and wind curtailment





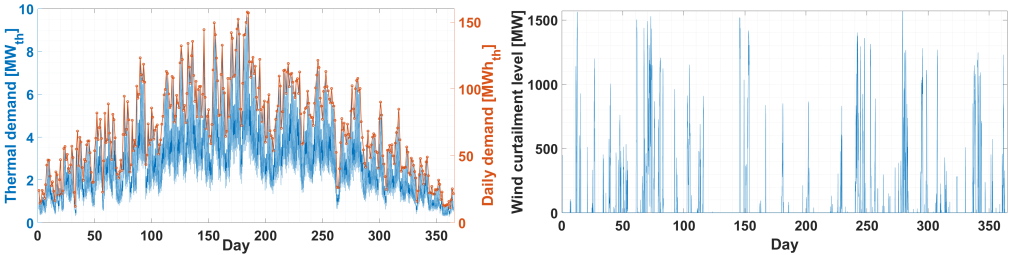


- Daily linepack in the gas grid of up to 690 GWh
- Peak daily and hourly gas demand up to four times the electricity demand
- 1 hour difference in demand over 7 times larger for gas compared to electricity
- Wind energy curtailment is increasing and predicted to reach costs of £1B

Image from the National Transmission System

Wilson et al., Challenges for the decarbonisation of heat: local gas demand vs electricity supply Winter 2017/2018
Wilson and Rowley, Flexibility in Great Britain's gas networks : analysis of linepack and linepack flexibility using hourly data, 2019

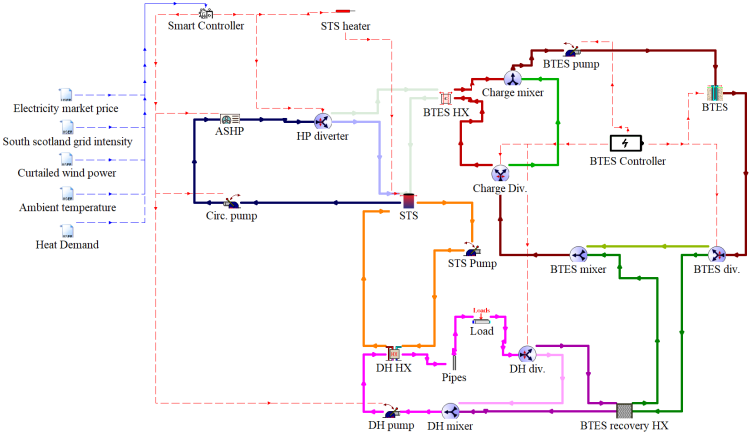
Seasonality of heating demand and wind curtailment



- Thermal energy demand for the King's Buildings campus shows strong seasonality
- Curtailment of 10 windfarms in Southern Scotland shows great variability
  - Spacing between curtailment events ranges from 30 minutes to a few weeks
- Curtailed wind energy from these 10 windfarms could provide heat to hundreds of KB sized district heating networks
- Thermal energy storage can link curtailment events with the heat demand

Desguers and Friedrich, Design of a Low-Carbon, High-Temperature Electrified District Heating Network with Thermal Storage and Curtailed Wind Integration, submitted to 18th SDEWES conference

Simulation linking curtailed wind with district heating



- Simplified schematic of the TRNSYS model of the proposed energy system for King's Buildings showing only the main loops and connections

Benefits of combining LTES with electric heating

System performance:

- Total electricity-to-heat efficiencies up to 200%
- Up to 43% of the heat energy can be provided from otherwise curtailed wind
- Provides resilience for the district heating network and the wider electricity system

District heating benefits:

- Shifts energy purchase to lower cost and lower emission periods
- Provides resilience to electricity network outages as well as high cost periods during the winter peaks

Electricity system benefits:

- Uses otherwise curtailed wind energy
- Reduces the need for grid reinforcement
- Reduced electricity demand for heating during winter peak periods
  - Reduces the need for peaking plants and balancing interventions

Insights from countries with successful LTES deployment

- Strong early-stage government intervention for high deployments of LTES
- After strong early-stage support, LTES become market-competitive
- International trend is towards large-scale (>100MWh) & long-term (10hrs +)
- Large-scale storage needed (50-70 TWh by 2050 for UK even with more interconnectors) & LTES are uniquely scalable: technically, economically & environmentally
- LTES therefore the most cost-effective & feasible energy storage (ES) at scale
- Coupling – LTES characteristics best ES for variable renewables
- Hybridity – LTES can integrate multiple heat & power sources & services

LTES provides multiple services over long timeframes and requires multiple long-term revenue streams and multiple forms of long-term market certainty or guarantees

Ways to overcome UK's commercial and regulatory barriers

Two phases to reach sustainable LTES commercialisation:

1. Phase 1 - Early-stage market development
   - Government intervention to establish technologies, reduce costs and address key regulatory issues, e.g. legal framework for the sale of stored heat
   - Establish large-scale demonstrators
2. Phase 2 – Mature market: Transition to commercial business-as-usual, creating the conditions for long-term market stability to attract diverse investors
   - LTES in National and local energy planning assessments, including in heat zoning policy and National level planning
   - Ensure there is a market for stored, renewable heat – development of heat networks is an essential component
   - Cost-reflectiveness - Financial incentives must match the social, economic, and environmental value LTES delivers
   - Reform rules on curtailment and ancillary services

Key takeaways

1. Thermal energy storage can provide flexibility to the wider system and should be a vital part to provide an affordable, sustainable and reliable energy system

2. Thermal energy storage can provide reliable thermal energy for district heating at reduced running costs and with lower emissions while, at the same time, providing a large percentage of that energy from otherwise curtailed wind energy

3. Commercial and regulatory barriers need to be overcome to make this a reality

Questions?

Acknowledgements

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- Some of the results are from the EPSRC INTEGRATE project: https://blogs.ed.ac.uk/integrate/

Thank you for your attention!