# Synergistic Water-Energy Systems to Minimise Carbon Emissions

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# Contents

- Context
- Model Framework
- Results
- Conclusion

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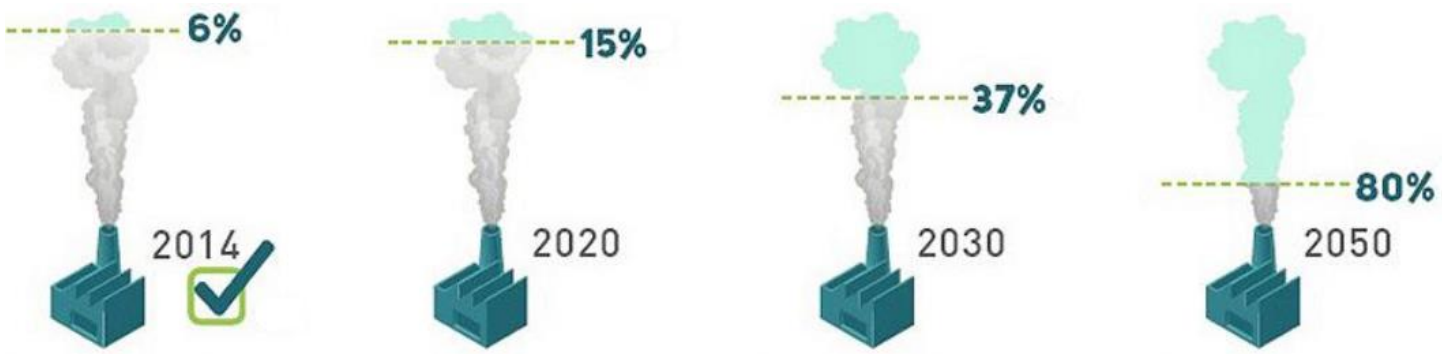


- UK has a legally binding 2050 carbon reduction target of **80%** on a 1990 baseline.
- UK is **not on track** to meet its carbon target for 2030 and 2050.
- Ban gas cookers and boilers in new home within 6 years (The Times, Feb 2019).

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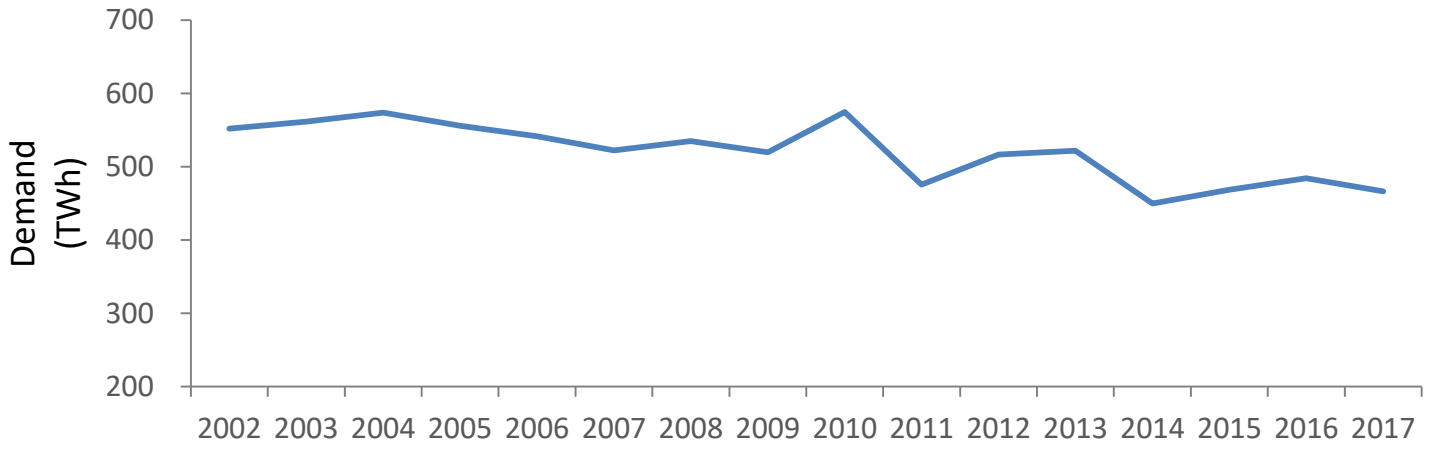


- Domestic heat demand
  - **28%** of the total UK energy demand,
  - **17%** of UK's carbon emission.

- This usage is currently **static**.

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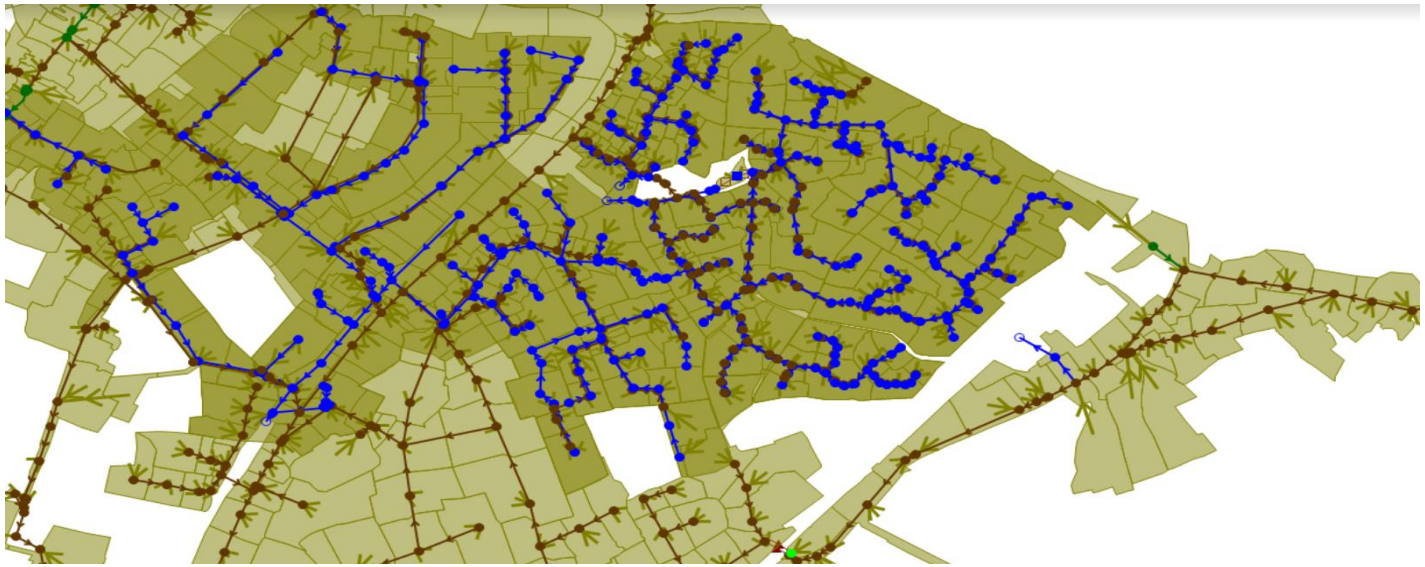
- We explore whether assets from water utilities could be linked intelligently with renewable generation sources to deliver further carbon emission reductions to the overall UK emission target.



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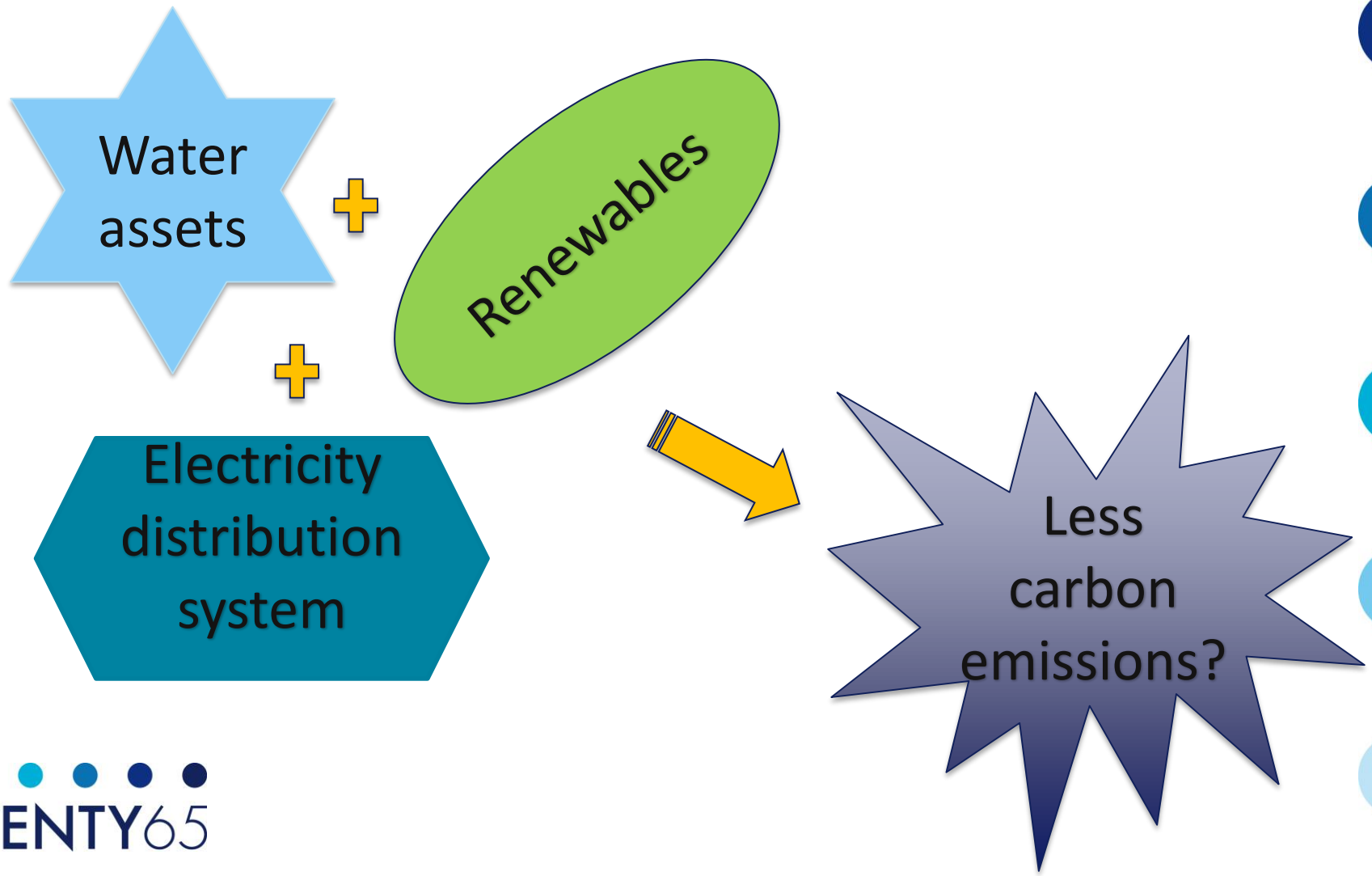
# Research Question

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# Model Framework

- A **simulation tool** has been developed that uniquely integrates:

- To find the **optimal energy generation mix** to minimise the annual total carbon emissions while meeting residential gas demand.

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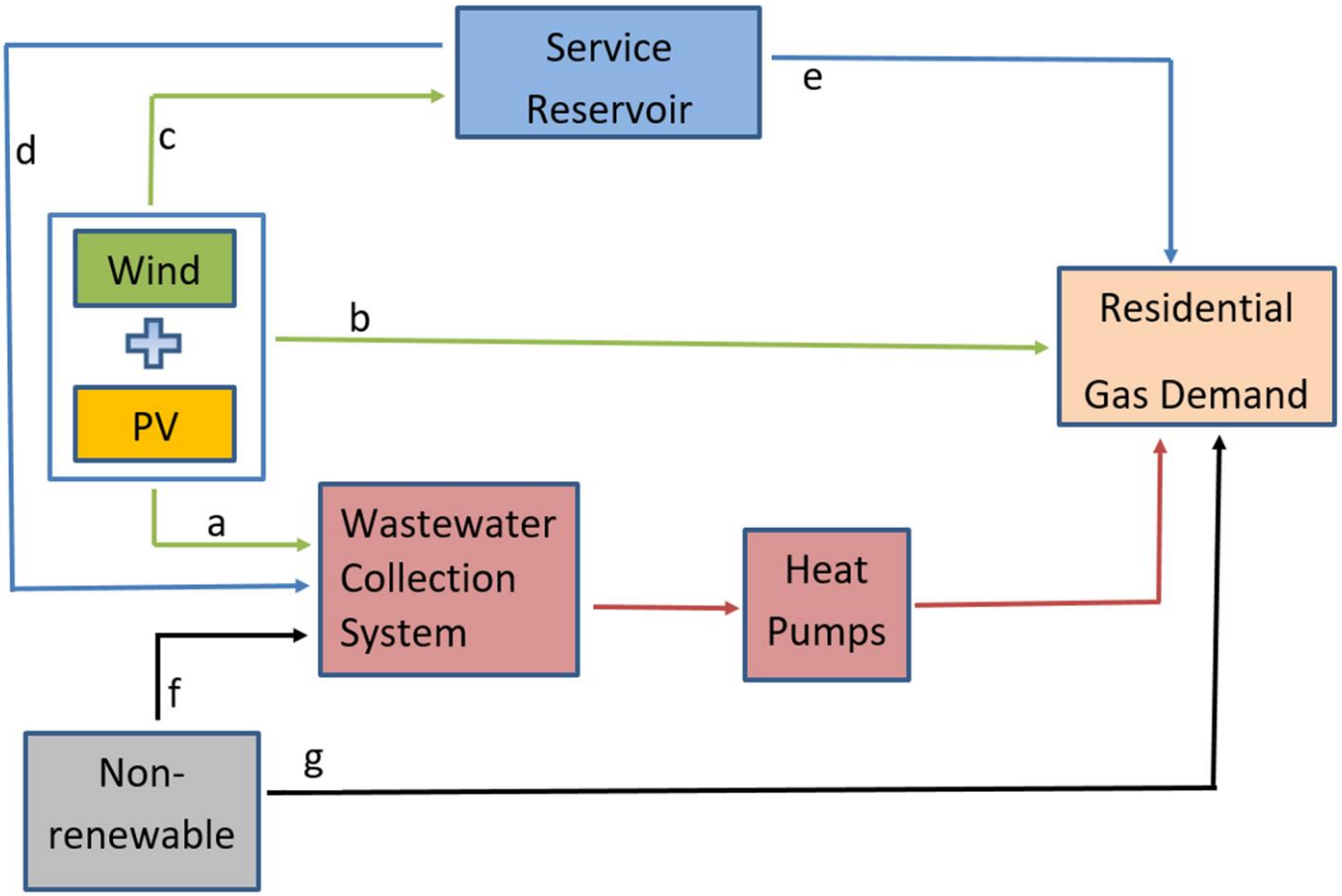
# Synergistic Water-Energy System

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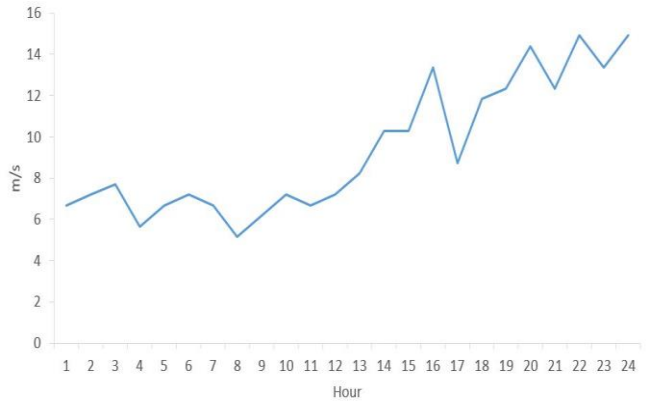
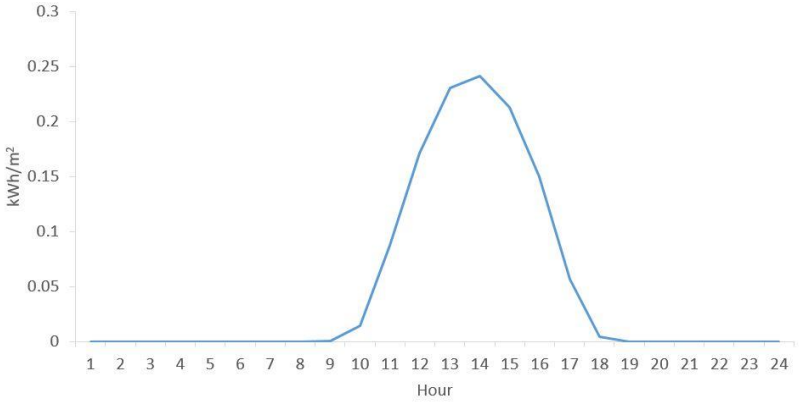
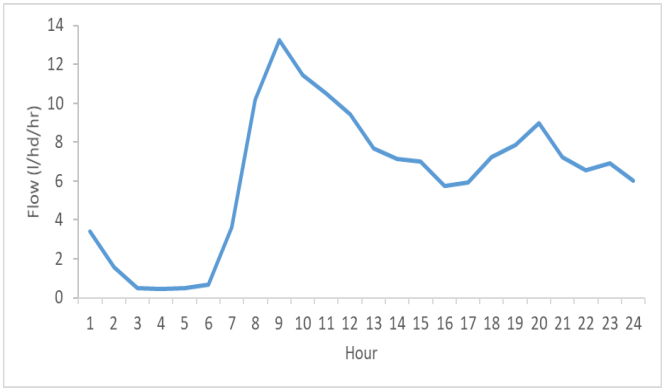
## Wind speed



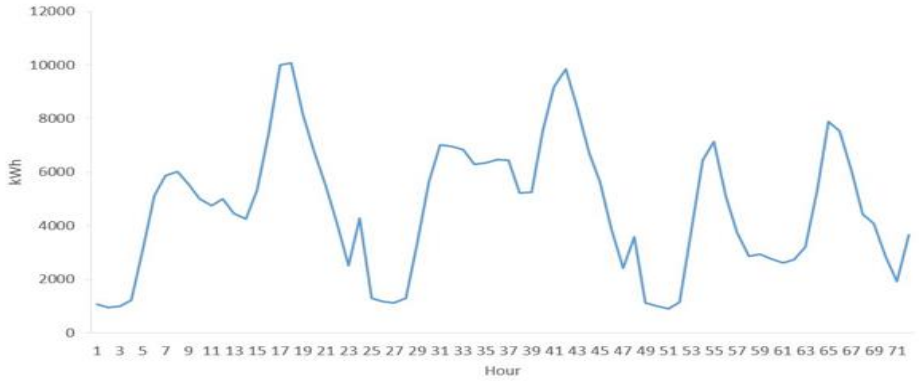

## Solar radiation




## Waste water flow




## Gas demand

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# Case Study Approach

| Location | Strathclyde Wind, Solar $(m/s)$, $(kWh/m^2)$ | Lincoln Wind, Solar $(m/s)$, $(kWh/m^2)$ | Gloucestershire Wind, Solar $(m/s)$, $(kWh/m^2)$ |
|---|---|---|---|
| Min | 0; 0 | 0.51; 0 | 0; 0 |
| Mean | 7.33; 0.10 | 5.60; 0.13 | 5.31; 0.12 |
| Max | 24.69; 0.98 | 20.06; 0.96 | 18; 0.92 |

- 1000 households
- 3 different locations in the UK

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# Data

- Half-hourly gas consumption data at residential level was obtained from UK Data Service, then converted to hourly consumption.
- Sum up 1000 randomised households to get a stable demand for a community.
- Hourly wind speed and solar radiation for the year 2009 was obtained from CEDA (Centre for Environmental Data Analysis).

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# Results

- Fixed service reservoir capacity (1200 $m^3$)

| | **Solar panel ($m^2$)** | **Wind (kWh)** |
|---|---|---|
| Strathclyde | 10998 | 12465 |
| Lincoln | 6933 | 9997 |
| Gloucestershire | 8403 | 9758 |

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## Total carbon emission

| | |
|---|---|
| Strathclyde | 1539 $tCO_2$ |
| Lincoln | 1512 $tCO_2$ |
| Gloucestershire | 1507 $tCO_2$ |

- Non-optimised system: 3519.78 $tCO_2$ (natural gas)
- Optimised System: **56-57%** ↓ of the17% of UK's $CO_2$ emission associated with domestic heating


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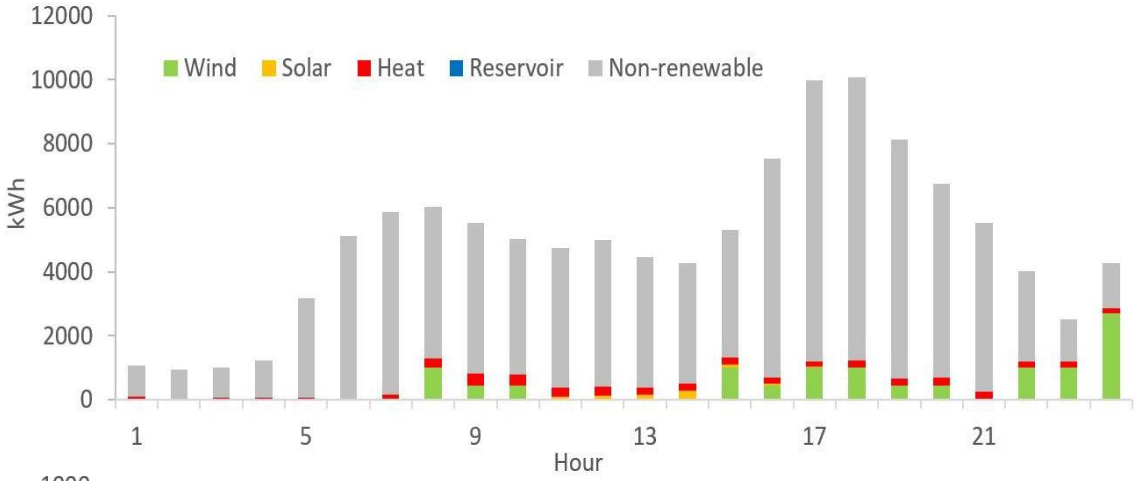
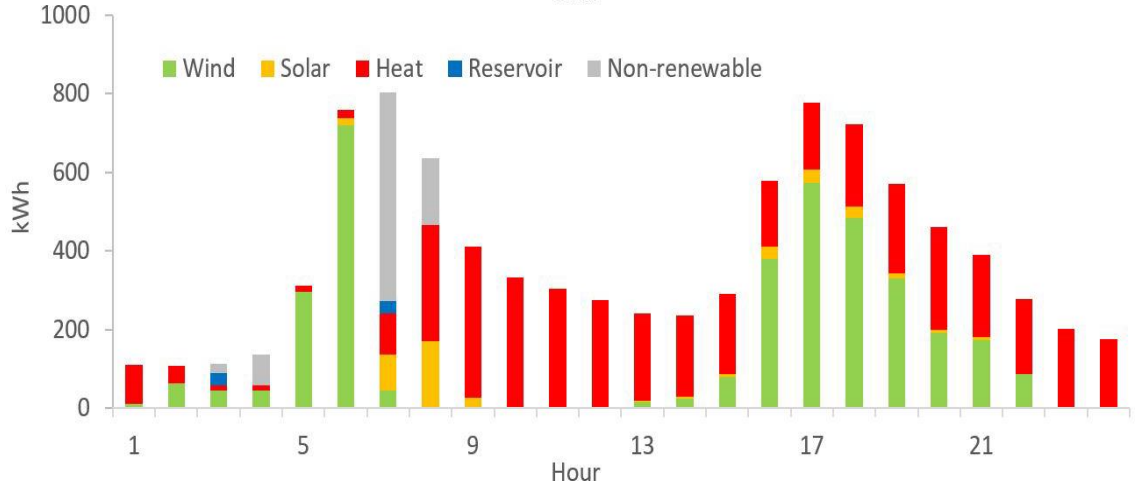
# Interesting Seasonal Effects




Winter:

Dominated by non-renewables, wind and heat recovery

Summer:

Dominated by heat recovery, wind, solar, still some non-renewables to achieve daily peaks

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# Concluding Remarks

- Linking water assets, existing renewable technologies and energy distribution at a local scale can give up to

  **56-57%** annual $CO_2$ reduction.

- Domestic heating estimated to be **17%** of UK's annual emissions.

- Developing inter-seasonal storage could obtain a further **60%** reduction – if the technology could be delivered.

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# Future Work

- Model assumptions need to be tested in real urban areas, to study the influence of spatial layout of the urban water systems and existing electricity distribution network.

- We are looking for case study models of water supply systems, urban drainage systems and electricity distribution models!!

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# White Paper

- Energy use in the UK and within water sector.
- Domestic energy and water consumption.
- Future use of energy and water.

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# Thank you!

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