An integrated multi-scale approach for low carbon energy system design

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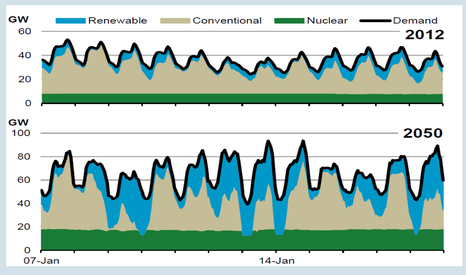
Approach and Aim of research

In the design of low carbon energy systems, decisions made at one scale markedly affect system behaviour at other length scales. This work develops an integrated, multi-scale systems design, optimisation and simulation framework wherein molecular level insight is fed up to process and subsequently whole system scales.

- On the system scale the "System Value" (SV) metric, quantifies the value of a given technology to the electricity system.
- On an process scale, we model the whole CCS chain, from power to storage using the gCCS toolkit in gPROMS.
- On the molecular scale, a process-performance index aims to design an improved new solvent, by evaluating and optimising the values of the thermophysical properties of an ideal solvent based upon monetised and non-monetised indexes.

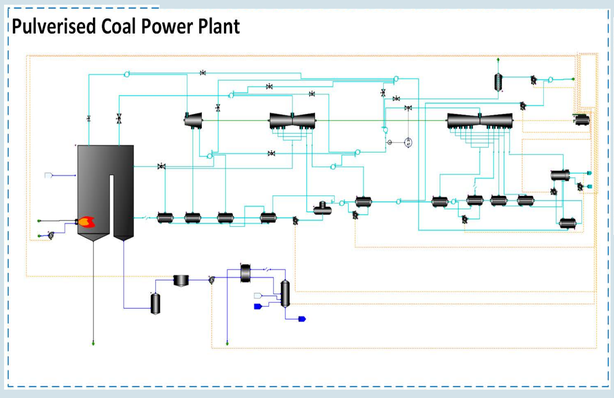
Energy systems modelling

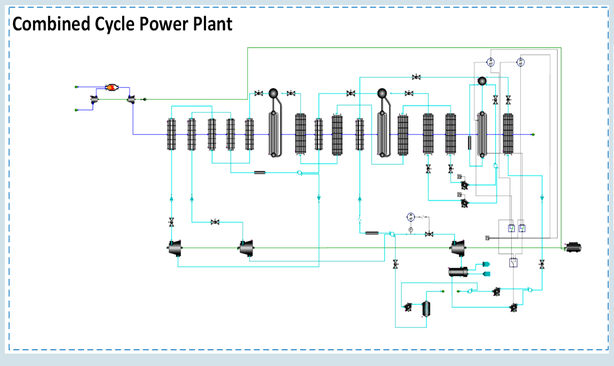


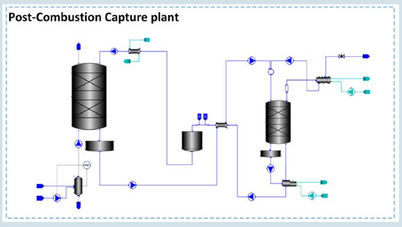
Flexibility Study

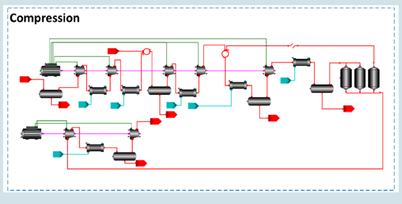
- Perform a quantitative assessment of the flexibility of the CCS chain
- Identify which links aid and limit system flexibility
- Develop a list of Key Performance Indicators (KPI's) for whole-system flexibility
- Develop a flexible CCS chain to adapt to the energy system

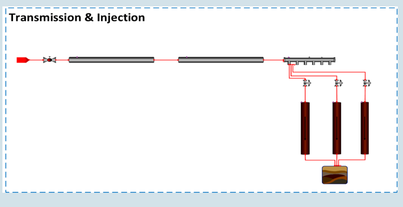
Detailed CCS chain modelling



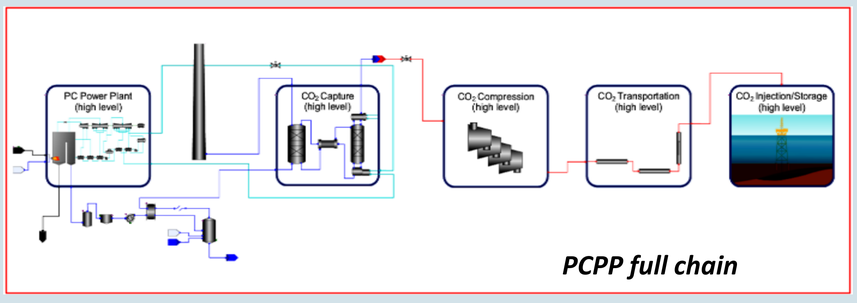


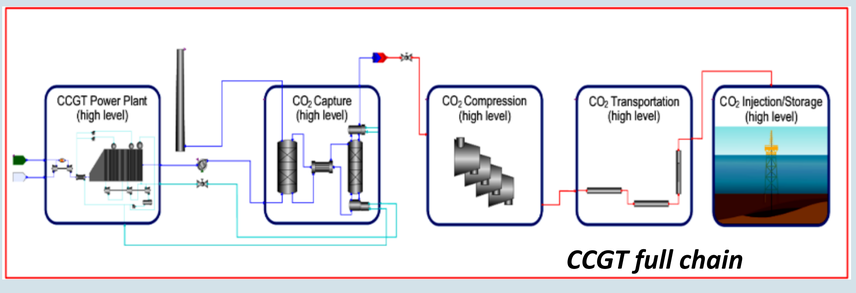




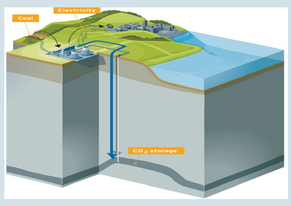


High level CCS chain modelling



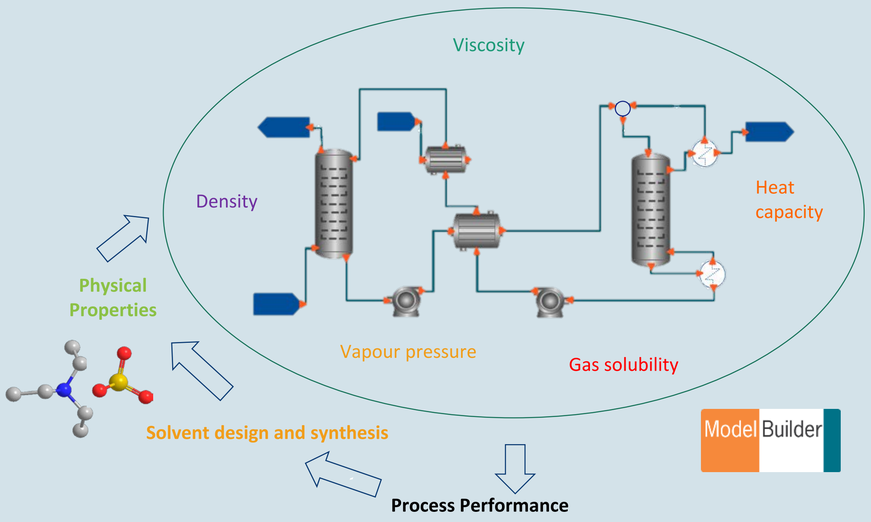


CO_2 storage

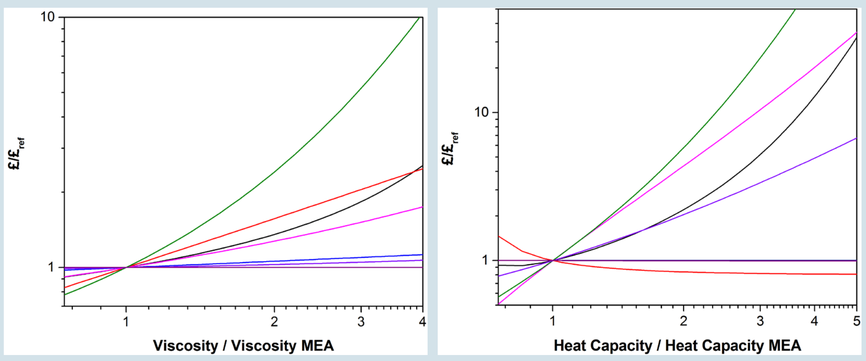


Solvent Design based on process performance

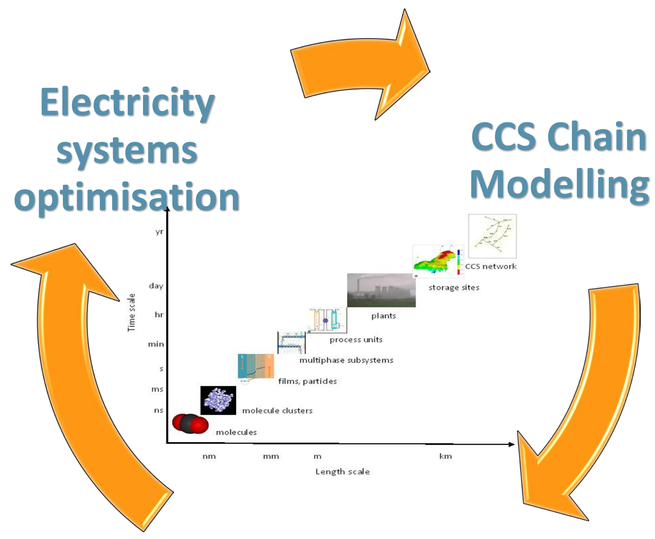
Chemical characteristics of the solvent impact the physical properties, which in turn affect the process performance and subsequently the cost of the carbon capture process.



Process-performance indexes are used to design task-specific solvents.



Physical properties of the newly design solvent should be kept within optimized ranges to reduce the cost.



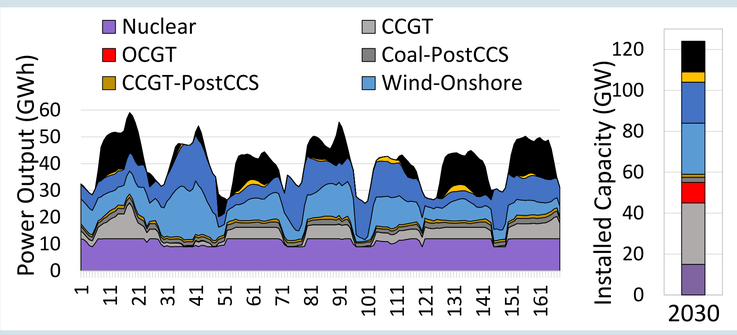
Conclusions and Future Work

- Through integrated multi-scale modelling we can develop disruptive low-carbon technology designs.
- Model integration enable us to re-design and enhance the detailed models and develop "ideal" low-carbon technologies of the future.
- This integrated approach can dictate the technical characteristics that the stand-alone or integrated power and capture model, should have in order to gain a high-value energy mix of the future.

Electricity systems optimisation

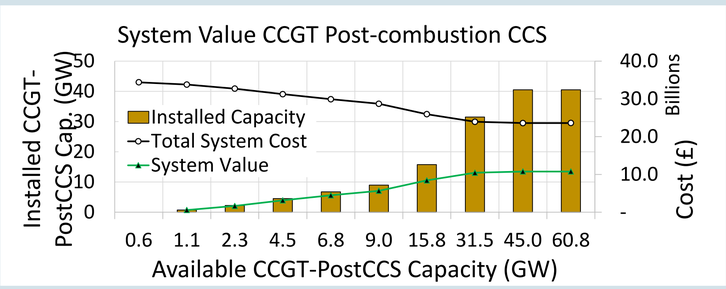
MILP for simultaneous system design and scheduling

- Technologies $i \in I; ic, ir, is \subset I$
- Operational modes $m \in M$
- Time steps $t \in T$
- Spatial zones $z \in Z$

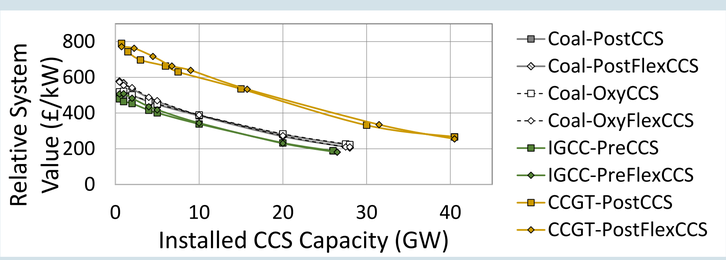


Systemic Technology Valuation

The **System Value (SV)** of a technology quantifies the incremental change in total system costs caused by deployment within the electricity system.



The SV and is a function of the technology's characteristics and the prevalent system conditions.



Acknowledgements

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