EPSRC
Engineering and Physical Sciences Research Council

Research Councils UK Energy For a Low Carbon Future

Energy Networks

Multi-Vector Energy Systems

- Unique and innovative modelling and optimisation tools for combined gas and electricity transmission networks operation (CGEN) and planning (CGEN+) were built.
- The CGEN and CGEN+ models help network companies and policy makers better understand the complexities and technical implications of interactions between multi-vector energy systems at the transmission level alongside the potential costs and policy strategies.
- The ideas of the original modelling concept of 'integrated network analysis' are now being widely used in academia (through new projects such as ITRC/MISTRAL) and at organisations such as the Energy Systems Catapult.

Traditionally energy carrier systems, i.e. electricity, gas, district heating and district cooling networks, have been developed and operated independently of each other. Increasingly, however, these systems are being coupled through things like combined heat and power (CHP) plant and new approaches to heating and cooling buildings. Thus there is greater interdependence, both technical and economic, in the operation and planning of the systems.

The basic concept for modelling the interaction between multiple energy vectors was initiated in 2006 through RCUK funding of UKERC. The model the was created, known as CGEN, combined operational analysis of both the gas and electricity transmission networks. This led to work exploring the impact of wind power on the gas network and the resilience of the combined energy networks. The importance of taking a multi-vector view of energy was recognised by HubNet in establishing this as one of its five themes. There are other important EPSRC projects such as ITRC and the Top & Tail Transformation that have help progress the work.

An upgraded model, CGEN+, now includes transmission network expansion planning. In the planning time frame, the model determines the reinforcement of both the gas and electricity transmission networks in parallel (e.g. new gas pipes and electricity transmission capacity) while establishing the optimal location of new generation plants in the system. A HubNet PhD student led the effort to expand the national transmission systems model to allow analysis of EU-wide gas and electricity networks. At the other extreme of scale, modelling tools for the optimal design and planning of community-scale multi-vector energy systems have been developed through HubNet and the Top & Tail project.

Case Study:

The National Needs Assessment (NNA) initiative is facilitated by the Institution of Civil Engineers (ICE) to provide a cross-sector assessment of the UK's national economic infrastructure needs to 2050 and identify options for how they can be met. The CGEN+ model is being used for analysis of the energy system and to highlight the interaction between other infrastructure sectors such as transport, communications, and water. Additionally, the CGEN+ model is being used to model and analyse multiple scenarios for the newly formed National Infrastructure Commission (NIC).

At the local level, owners of large estates and community energy groups provide opportunities to better optimised supply of services additional power capacity that the UK will require over the coming years. These systems are likely to use multiple energy vectors (e.g. hydrogen, district heating) from local energy sources (e.g. solar, wind, waste) to meet the energy demand. A tool for the optimal operation planning of a community-scale multi-vector energy system was developed. This was used to analyse and inform the operation of the integrated energy system of the University of Warwick estate.

Achievements:

• The ability of the energy system to withstand shocks was modelled. The analyses was used to inform evidence to the House of Commons 'Energy and Climate Change Select Committee' on the resilience of the main energy networks (gas and electricity) in GB.
• In conjunction with Infrastructure UK, the performance of the energy system (cost, carbon intensity, energy security) in the National Infrastructure Plan (NIP) was analysed for a range of future socio-economic and climate change scenarios.
• A model for the carbon-constrained design of community energy supply infrastructure for new build schemes was developed. The model finds the optimal mix of on-site energy supply technologies that meets emissions targets at a minimum cost to the developer. A detailed case study was carried out using data from a community redevelopment scheme in South Wales (Ebbw Vale).
• Secondments of two researchers to Poyry and Wales and West Utilities providing opportunities to apply the CGEN and CGEN+ models to address real world challenges.

EPSRC Outcomes Focus:

This case study delivers impact with industry and policy makers in the form of a new modelling and planning tools that contribute to the following outcomes:
R1, R2, and P2

Resilient
Connected
Productive
Healthy

Academic partners:
Imperial College London & University of Manchester

Industrial partners:
GTC (Independent utility and network infrastructure provider), Toshiba TRL & Wales and West Utilities

The Supergen Programme, part of the Research Councils UK Energy Programme, led by the Engineering and Physical Sciences Research Council (EPSRC), aims to contribute to the UK's environmental emissions targets through a radical improvement in the sustainability of the UK's power generation and supply.

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