

# **A general spatio-temporal model of energy systems, STeMES, and its application to integrated wind-hydrogen-electricity networks in Great Britain**

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It is widely accepted that electricity and hydrogen have a role to play in decarbonising the transport sector, which still relies almost exclusively on oil. In Great Britain (GB), for example, the transport sector is a major oil user and consequently is responsible for the majority of greenhouse gas emissions: the domestic transport sector alone makes up approximately 20% of total GB carbon emissions. Indeed, decarbonising this sector is a main driver behind the development of fuel cell and electric vehicles. On a more positive note, GB has a very strong potential for wind power; in fact, it is considered as one of the best locations in the world and the best in Europe. Converting wind energy to either electricity or hydrogen that can be used in electric or fuel cell vehicles results in zero emissions (or low emissions if the emissions in manufacturing and installing the network components are considered). Since both demands and wind availability are distributed in space and vary with time, there is no guarantee that wind power will be available where and when it is needed. Therefore, a network of technologies that can deal with the mismatch between the intermittent supply and demand for energy is needed.

In this conference, we will present the design and operation of integrated wind-hydrogen-electricity networks using the general spatio-temporal modelling framework, STeMES [1], which is a mixed integer linear programming model that can be used to model any energy networks comprising conversion, storage and transport technologies.

One of the concerns of wind energy projects is the siting of wind turbines. Therefore, the suitable sites for wind turbines were identified using GIS by applying a total of 10 technical and environmental constraints (e.g. buffer distances from urban areas, rivers, roads, airports, woodland and so on). The overlay of the 10 constraint layers was used in the model as the land footprint constraint that limits the number of new wind turbines that can be installed in each location.

With an objective of minimising the total cost of the system, the model simultaneously determines:

- the optimal number, size and location of wind turbines, electrolysers, fuel cells, compressors and expanders,
- the optimal number, size and location of hydrogen storage facilities,
- whether to transmit the energy as electricity or hydrogen,
- the structure of the transmission network, and
- the hourly operation of each network component.

The number of fuelling stations and the length of the distribution network were determined from the demand density at the 1 km level.

In this presentation, we will discuss the challenges involved in developing such a large-scale optimisation model. We will also present different optimal network configurations considering different scenarios.

## **Reference:**

[1] S. Samsatli and N.J. Samsatli (2015). A general spatio-temporal model of energy systems with a detailed account of transport and storage. *Computers & Chemical Engineering*. DOI: 10.1016/j.compchemeng.2015.05.019