Value Web Model: a powerful optimisation-based framework for integrated spatio-temporal multi-vector energy networks and value chains

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The Value Web Model [1] is a multi-objective spatio-temporal optimisation model, based on mixed integer linear programming, that can simultaneously determine the design and operation of any integrated multi-vector energy networks. It can answer variants of the following questions: "What is the most effective way, in terms of cost, value/profit and/or emissions, of designing and operating the integrated multi-vector energy networks that utilise a variety of primary energy sources to deliver different energy services, such as heat, electricity and mobility, given the availability of primary resources and the levels of demands and their distribution across space and time? When to invest in technologies, where to locate them; what resources should be used, where, when and how to convert them to the energy services required; how to transport the resources and manage storage inventory?"

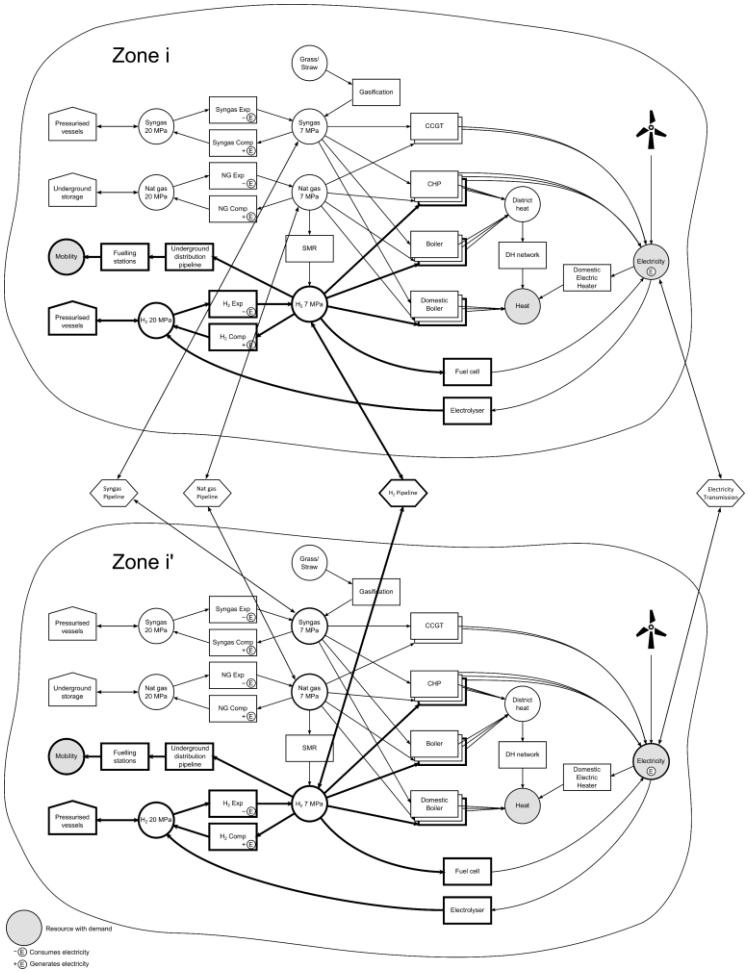

Figure 1. Hydrogen is a versatile energy vector that can facilitate integration of different energy networks. The Value Web Model can optimise the design and operation of these integrated energy networks.

The model was used to optimise strategic design and tactical operation [2-3] of integrated networks, shown in Figure 1, in which hydrogen plays a central role in integrating the different networks for a variety of energy carriers. Scenarios for Great Britain were examined involving different primary energy sources, such as natural gas, biomass and wind power, in order to satisfy demands for heat, electricity and mobility via various energy vectors such as electricity, natural gas, hydrogen and syngas. Different objectives were considered, such as minimising cost, maximising profit, minimising emissions and maximising renewable energy production, subject to the availability of suitable land for growing biomass and siting wind turbines as well as the maximum local production and import rates for natural gas.

Results suggest that if significant mobility demands are met by hydrogen-powered fuel cell vehicles, then hydrogen is the preferred energy vector, over natural gas, for satisfying heat demands. If natural gas is not used and energy can only be generated from wind power and biomass, electricity and syngas are the preferred energy carriers for satisfying electricity and heat demands.

References:

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