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Economic zones for future complex power systems

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In order for society to meet its challenging CO_2 reduction targets it is essential for energy systems to be decarbonised. There are many possible trajectories that can be envisaged for this transition and all of them require radical changes to the way electric power is generated, transmitted and distributed not least due to the additional burdens presented by the electrification of heat and transport. One vision relies upon carbon capture and storage, interconnectors and large-scale nuclear power coupled with heavy reinforcement of the grid infrastructure. A competing vision favours high levels of decentralisation of both generation and control using fast intelligent network management systems for dynamically defined sub zones of the network. This latter vision relies on flexibility on the demand and generation side, as well as the network, to deliver decarbonisation and promises to require much lower levels of network reinforcement. This decentralisation leads us to consider localised markets to assist with this flexibility. These markets could be for energy and for ancillary services. One consequence of this asset light, flexibility heavy vision is that it will result in a relatively higher network asset utilisation. This means that we would expect the network to place more frequent constraints on the flow of energy between generators and loads. Therefore this paper examines the possibility of a commercial-technical approach to local markets and network management by finding efficient market arrangements that can be delivered without infringing network constraints.

This paper examines the economics of the electricity market out to 2050. We propose a flexible zoning concept, built up around economic and technical layers, in networks of the order of hundreds of thousands or millions of nodes. The Economic Layer runs auctions to determine the electricity to be delivered and prices. The Economic Layer delivers suggestions after a fixed ordering, starting with suppliers and demands that generates the lowest overall system cost, then second-lowest overall network cost etc. These suggestions are delivered to the Technical Layer that checks for feasibility in terms of technical constraints. The first match between the ranked suggestions and non-violation of technical constraints is chosen. We demonstrate why this paper should be considered for future power systems. This paper extends previous work on reactive power exchange by introducing market considerations in zoning mechanisms for active power exchanges. We also exhibit the potential for much higher price resolution in distribution networks via our concept of economic zoning.

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