A Machine Learning Approach to Determining Viable Energy Future Scenarios

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Future Energy Systems and Quantitative Scenarios
With increased national and international pressures to reduce greenhouse gas emissions and our reliance on energy imports [1, 2] the UK energy sector will need to change. Possible energy futures vary widely with a complex and diverse mixture of fuels, technologies, build rates and objectives. The UK Department for Energy and Climate Change (DECC) [3-5] have completed extensive work on a range of energy futures alongside academic consortia such as the Realising Transition Pathways (RTP) consortium [6, 7].

The RTP consortium put forward three alternative energy futures, the 'Transition Pathways': 'Market Rules' a 'business as usual' case, 'Central co-ordination' where a government agency takes control and 'Thousand Flowers' a society led system in which 50% of generation is decentralised. However, as with all prediction based scenarios, departures from an anticipated course may occur when shocks, technology advancements and/or climatic or social shifts cause a pathway to deviate to a range of possible futures within one set of logics.

Selection: The Machine Learning Approach
Temporal data in high dimensions can exhibit a complexity that otherwise obscures potentially important detail prohibiting comparison, anomaly detection and recurring feature identification among other analysis tasks. This is a particular problem with near-optimum models such as EXPANSE [8] where large numbers of scenario paths are projected (in the case of EXPANSE, 1000 such paths). Approaching the problem using machine learning tools allows the raw data to be reduced to a manageable set of unknowns that permit human interpretation. Such tools may employ reduction of dimensionality to just the most informative variables, formation of abstractions from repeated patterns or extract generalisations from temporal or pairwise occurrences. In this way a range of possible pathways that result from say, branching points, may be refined and subsequently grouped to reveal underlying trends.

Promising Initial Results Utilising an EXPANSE simulation run, 1000 potential generation scenario pathways were produced. Working on the basis that many of these would exhibit some forms of similarity at various points in the pathways, the generation capacity probability density for various fuel types was modelled as a mixture of Gaussians [9] with the optimal number of mixtures determined by formal model selection procedures. Figure 1 shows the outcomes from the analysis, notably:

- Most are represented by one Gaussian
- Coal, Gas and Wave go under changes in the 40 year period
- Nuclear has a range of possible outcomes all the way to 2050 but with a tendency for increase

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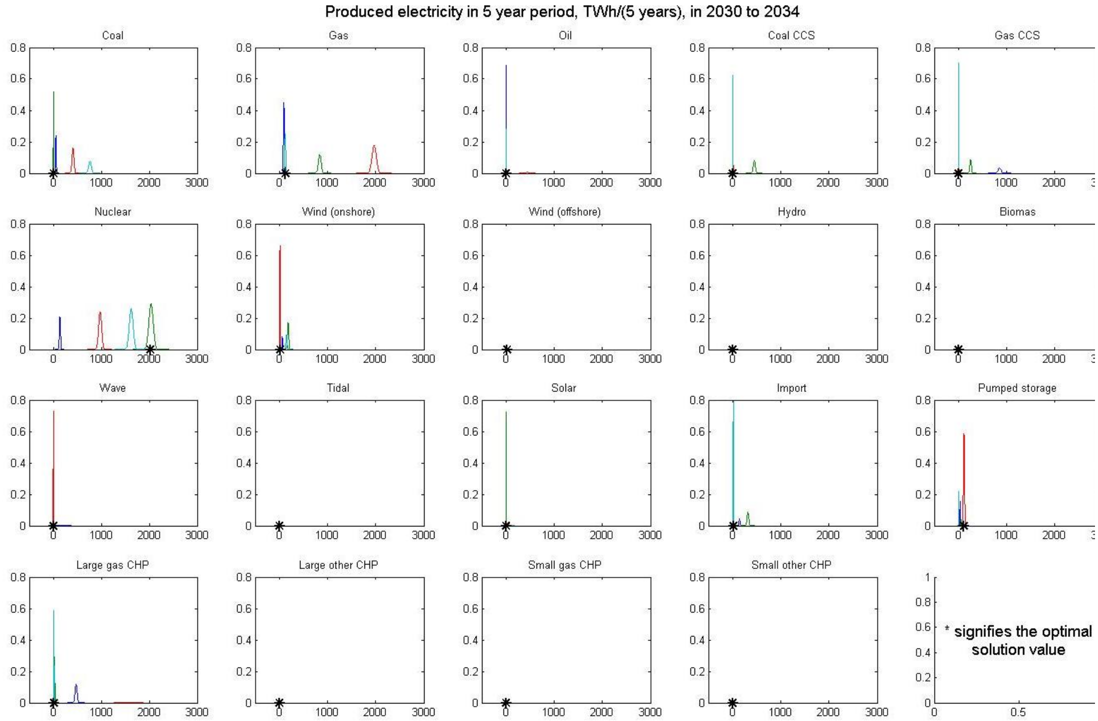

Figure 1 - Profiles of Gaussian Mixtures of total electricity generated (TWh/5 years)

Particular underlying routes are identified by individual mixture components which can be perceived as abstractions of an installed generation capacity stemming from a particular policy decision. Transitions between these abstractions can therefore be construed as a general policy path being followed. This allows the large number of potential scenarios generated by EXPANSE to be reduced to a small number of representative cases. This work will report on promising results that see large numbers of potential pathways refined and a robust selection criteria demonstrated.

References

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