Dynamic Investments in Flexibility Services for Electricity Distribution with Multi-Utility Synergies

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Overview

Selecting the optimal pathway for electricity network upgrading together with investments in flexibility services to cope with greater demand side engagement and local intermittent energy production is causing a radical change to the business models of distribution utilities and their economic value in the supply chain. Distribution Network Operators (DNOs) are seeking more active alternatives to conventional reinforcement in order to reduce network operation costs while increasing security of supply in the face of greater uncertainty in the patterns of future load flows. The transition from DNOs to Distribution System Operators (DSOs) will be accompanied by a change in the modelling paradigm, moving from top-down models to detailed local buttom-up data driven ones. This research develops and applies a new methodology, to evaluate the contribution of four alternatives to conventional reinforcements, namelysmart contracts, aggregation, demand response and peer-to-peer. The application is to large scale British distribution utlitity using a detailed network topology, national scenarios for the power system and a computationally- intensive, multi-stage stochastic optimisation methodology.

Methods

The innovation in Smart grid technologies is riddled with uncertainty regarding which technologies to choose, which investments to support and how the choices and possible regret would evolve in the long term. With many alternatives to conventional network reinforcement available and being developed, e.g., distributed generation, energy storage, demand side response, mesh networks or dynamic asset rating, it becomes increasingly difficult for the distribution network operators (DNOs), regulators and policy-makers to devise an optimal network investment roadmap, and and thereby forecast the service costs.

In collaboration with Western Power Distribution, one the largest DNOs in the UK, we have used a large scale, detailed nodal network load flow model to find optimal network evolution scenarios in the presence of changing production and demand conditions at the local level. In particular by considering multiple smart interventions to resolve network issues and constraints, we evaluate their benefits compared to traditional network reinforcement. nodal network modelling to capture the emerging behaviour and create localised network development plans. The SIM Scenario Investment Model (SIM) of the FALCON (Flexible Approaches for Low Carbon Networks) project is a scenario-dependent, optimal-seeking feedforward heuristic. For each exogenously defined scenario, each year is specified as a network state. Empirical data from the simulations are then subject to a real options evaluation of the four alternatives to traditional reinforcement. Figure 1 displays to overall structure of the modelling process.

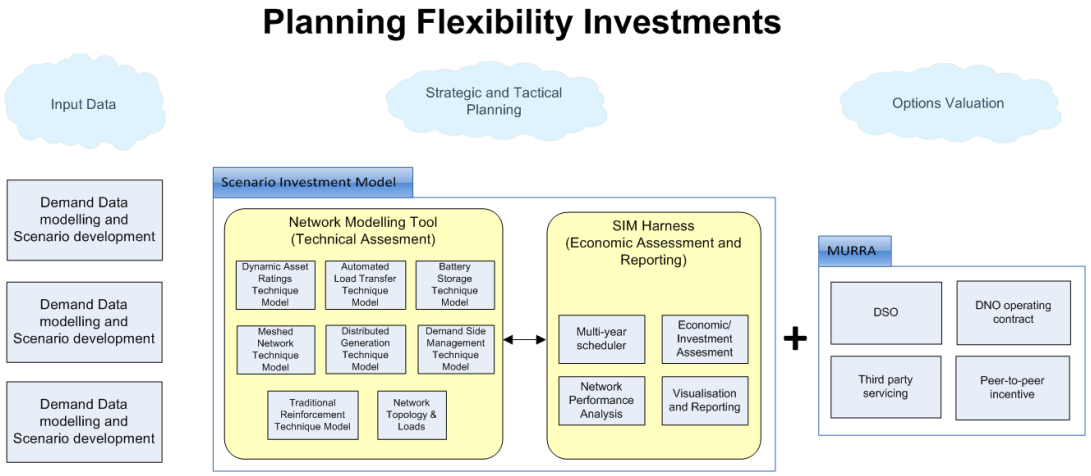

Figure 1. Domain representation of the Planning Flexibility Investment approach

Results

Four business Options with different discount periods and contracts length are compared: (a) *DSO*, the DNO building and having full operational control of flexibility assets; (b) *Out*, the DNO outsources the commercial control of their assets to a third party during contracted window periods (c) *Agg*, the aggregator servicing as the third party is responsible for building, owning and operating the asset, offering them new additional revenue streams; (d) *P2P*, Peer-to-peer trading option reacts to DNO's use of system signals for peak shaving.

Apart from identifying the relative attractiveness of the alternative business models, the analysis offers important insignts into the potential economic inefficiency of incentive based regulation for distribution utilities. The key issue is the effects of incentives to perform over finite regulatory review periods. Myopic short-term planning where the decision-maker optimises only over the next regulatiory period (RIIO-1) of incentives eg 2015-2023 in Britain, leads to a suboptimal (more expensive) investment path when compared with long-term planning scenario modelled from 2015 to 2047 (RIIO1 to RIIO4). We evaluate the regret that such a suboptimal investment path, may provide when compared to an unconstrainted 2015-2047 scenario evaluation. Short-term myopic evaluation planning periods have been proving more expensive in the long-term for the system. Forcing long-term planning (2015-2047) to adopt during the first years (2015-2023) a sub-optimal investment strategy leading to:

- In the short term, an over-investment in flexibility will be of 24\%, being defined as the value of regret.
- Adopting this sub-optimal business as usual look-ahead investment strategy, would lead to over-paying 19% for flexibility services compared to unconstrained portfolio investment strategy for the 2015-2047 period.
- By comparing long-term investment strategies, short-term myopic and unconstrained, it can be concluded that with an over-invested grid during the first regulatory period, less capacity investment is required in subsequent years.
- Competition among flexibility options is enhanced in the sub-optimal path due to the excess of investment early years, always traditional reinforcements, which will permit that with promoting policies, flexibility options such as peer-to-peer or demand aggregation will become marginal more often and therefore, the option selected.

Conclusions

In this paper is presented a two-stage service valuation methodology that can be used for assessing a portfolio of flexibility services for distribution power networks. A network state selector is presented in the form of heuristic algorithms embedded within the SIM software, selecting those network states which outperform their peers and therefore advancing with a long-term investment strategy using traditional reinforcements and smart grid techniques.

Providing a multichannel transparent methodology as presented by this research, value propositions for flexibility services can be evaluated, regardless of whether they are operating in a rate of return or incentive-based regulatory framework. In particular, our research emphasises the need for regulators to encourage the use of a long-term flexibility perspective in network investment and to be wary of the welfare losses that short-term incentives may create.

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