Local Electricity Market Development for Distributed Wind Generation

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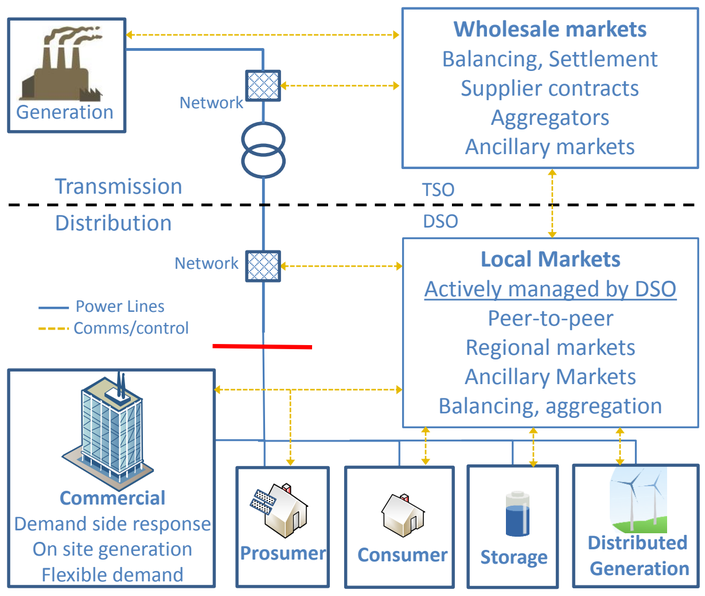
Introduction

There is strong potential for the growth of regional electricity markets (alongside existing wholesale markets) with the increase in distributed energy resources (DERs) and mass roll out of information communication technology (i.e. smart meters).



This PhD considers the potential for local electricity markets in Great Britain and the benefits they can bring in terms of increased uptake of DERs (including distributed wind generation) and reduced network upgrades requirement.

Motivation/benefits

The potential benefits of local electricity markets operating alongside wholesale electricity markets include;

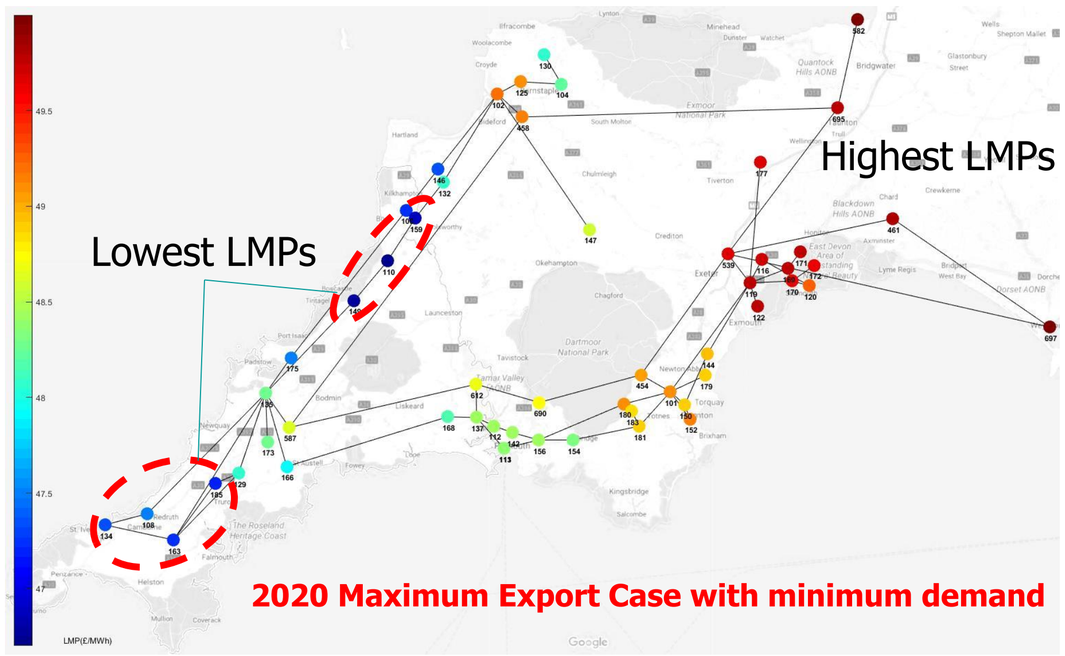
- Increased penetration of DERs ➔ Smaller DERs able to participate in providing demand response and ancillary services to local market
- Constraints at lower voltages can be reduced using flexibility
- Ancillary services including flexibility, reactive power etc can be provided by local market to wholesale market

Application of LMPs to distribution

- Locational Marginal Prices (LMPs) applied to distribution offers a method of accounting for spatial variations [2] (particularly congestion and losses) increasingly seen deep down in the network with the greater presence of distributed assets.
- LMPs allow the market operator to set clearing prices for each node and providing the bases for network investments where constraints arise.
- Challenges in the application of LMPs to distribution are;
  - Requires detailed network model/information ➔ move from passive to actively managed distribution network, increased complexity.
  - Market/network coordination ➔ most transmission LMP markets (in US) centrally cleared by transmission system operator (TSO) in a power pool. - In UK future distribution system operator (DSO) could facilitate central clearing or could supply network information to market operator.
  - ACOPF (or close approximation of) is required for accurate calculation of losses ➔ computationally demanding.
  - Uncertainty for investors ➔ potential for increased volatility in pricing and local knock-on effects of adjacent investments.
- Larger flexible loads could be exposed to LMPs as market participants however domestic demands not proposed to be exposed to LMPs.

Case Study - South West England Network

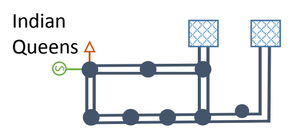
- Area with high DG penetration including ~1 GW PV and 230 MW wind capacity. ➔ Many areas at limit of DG connection capacity.
- Constraints including thermal and voltage experienced by DNO.
- LMP variation studied at 400 kV, 132 kV and 33 kV.
- In case of maximum DG output constraints result in **0 £/MWh** LMPs
  ⇒ Opportunity for local markets to promote flexible demand turn up
- Losses result in LMPs varying up to 30% between maximum import and export at 33 kV ➔ this variation would be greater at 11 kV and LV.



Aggregation study - Time series

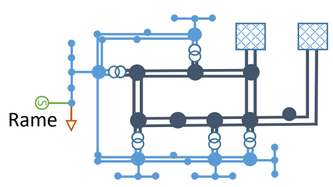
- Study on DER response and DG penetration with levels of aggregation and connection agreements.
- Initial results ➔ Aggregation beyond constraints reduces DERs ability to respond to LMP signals and turn-up demand during curtailment

Aggregated to 400 kV GSPs

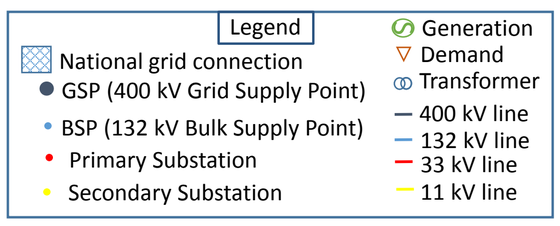


- Connection arrangement ➔ Firm
- Limit to DG connections set by transformer capacity + min demand (30% of max demand).

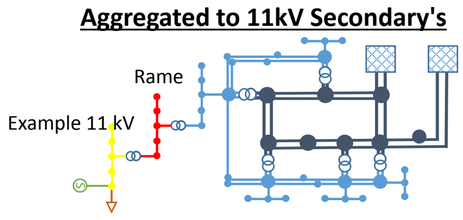
Aggregated to 132 kV BSPs



- Connection arrangement ➔ Active Network Management (real-time curtailment).
- Limit to DG generation set by transformer capacity + real time demand at BSPs



Aggregated to 11kV Secondary's



- Connection arrangement ➔ central optimal dispatch with nodal pricing
- DG generation set by network capacity and generation cost minimisation (optimal power flow).

Future research areas

Further work to be carried out to answer research questions include;

- What level of network detail is optimal for informing a local market?
- What local market structure will be favourable, i.e. exchange, power pool?
- Under what circumstances is it cost effective to promote local markets for distributed wind generation rather than carry out network upgrades?

References

1. C. Edmunds, S. Galloway and S. Gill, "Distributed electricity markets and distribution locational marginal prices: A review" *2017 52nd International Universities Power Engineering Conference (UPEC)*, Heraklion, Crete, Greece, 2017, pp. 1-6.
2. Massachusetts Institute of Technology, "Utility of the future, An MIT Energy Initiative response to an industry in transition" 2016.