Distribution system planning, operations & technological applications, integrating high wind penetration

Ellen Diskin (ellen.diskin@esb.ie), **Andrew Keane** (andrew.keane@ucd.ie)
UCD School of Electrical, Electronic and Communications Engineering

electricity research centre

Background

Research combined with role in ESB Networks Smart Networks – design, development, trial & implementation of network management innovation. Close collaboration with the Electric Power Research Institute (EPRI), Eurelectric & DSO experts across Europe.

Developing solutions for RES integration, local control, preservation of distribution level integrity & managing TSO-DSO interface including wind operational modes, non-firm access, dynamic network management, voltage & reactive power management.

Objectives:

- **Analytical & planning tool development**
- **Economic & technical appraisal of operational policies**
- **Investigation of operational implications – protection & asset interaction**

Current Work: Voltage & Reactive Power Management

- TSO-DSO interface conditions
- Economic allocation of resources
- Assessment of technical & commercial feasibility of different solutions
  - Networks based approach
  - Distributed services approach
- Developing technical aspects
  - Control architecture
  - Resourcing needs
  - Optimal installation levels

Approach

- Analysis & application of ESBN field trials
- OpenDSS (EPRI) – time series power flow
- ACOPF in AIMMS Optimisation Environment

Acknowledgement

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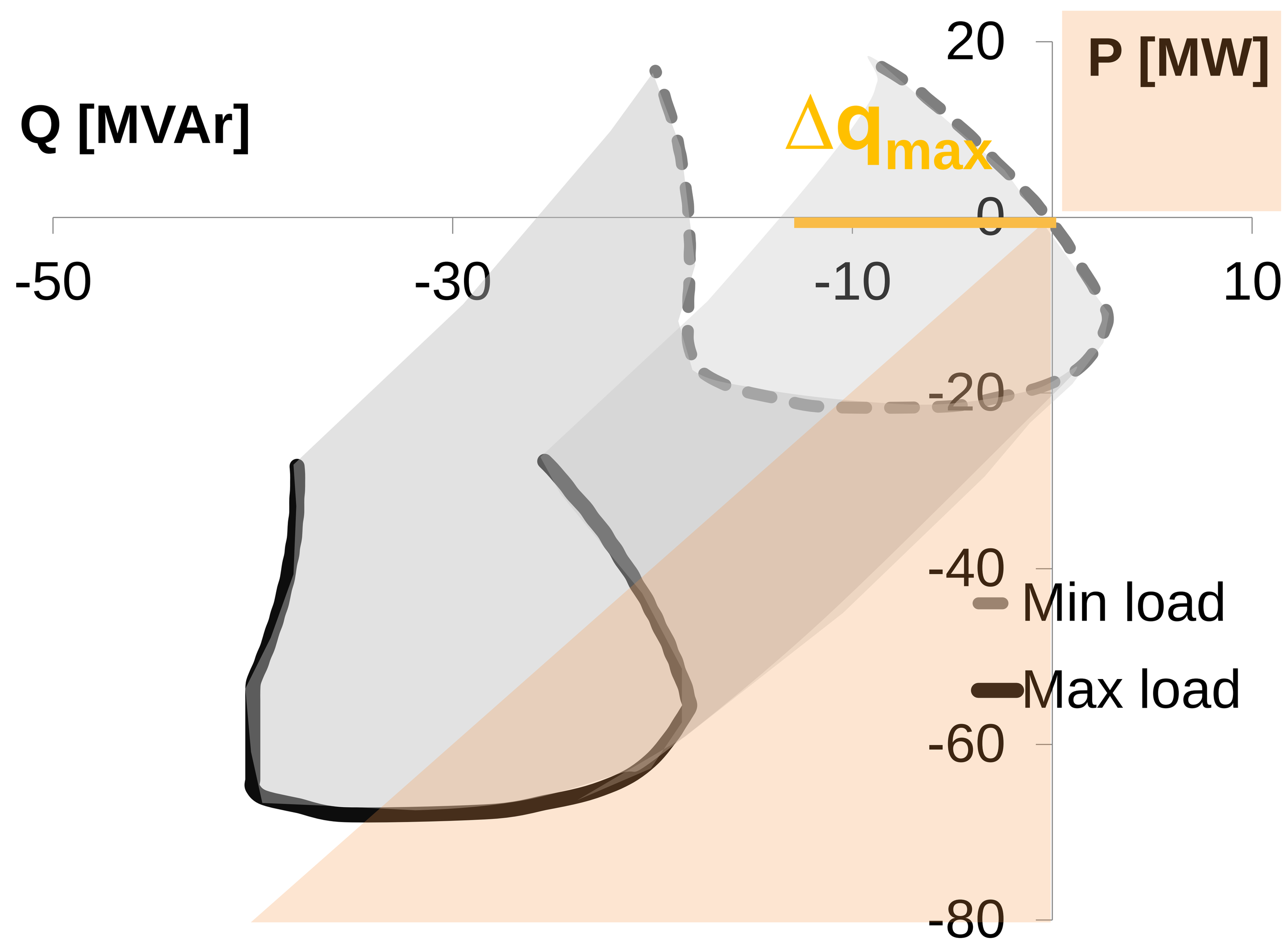
Ellen Diskin is an employee of ESB Networks.

ESB Networks

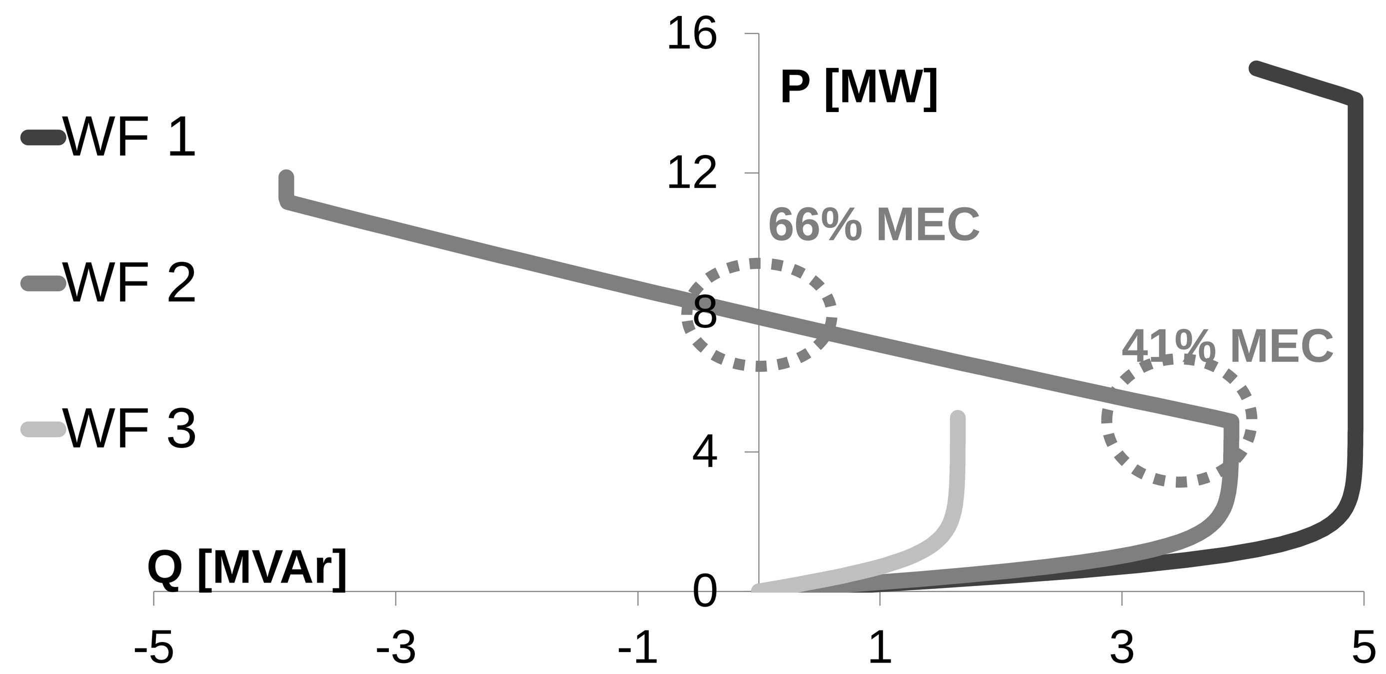
Reactive power at TSO-DSO interface



Coloured region indicates hybrid of Grid Code demand power factor (below x-axis) and unity power factor, or delivering MVAr, when distribution node is delivering generation to transmission system. Grey region is achievable characteristic with full wind farm voltage / reactive power control, as a function of demand load. Indicates a potential deficit of Δq_{max}

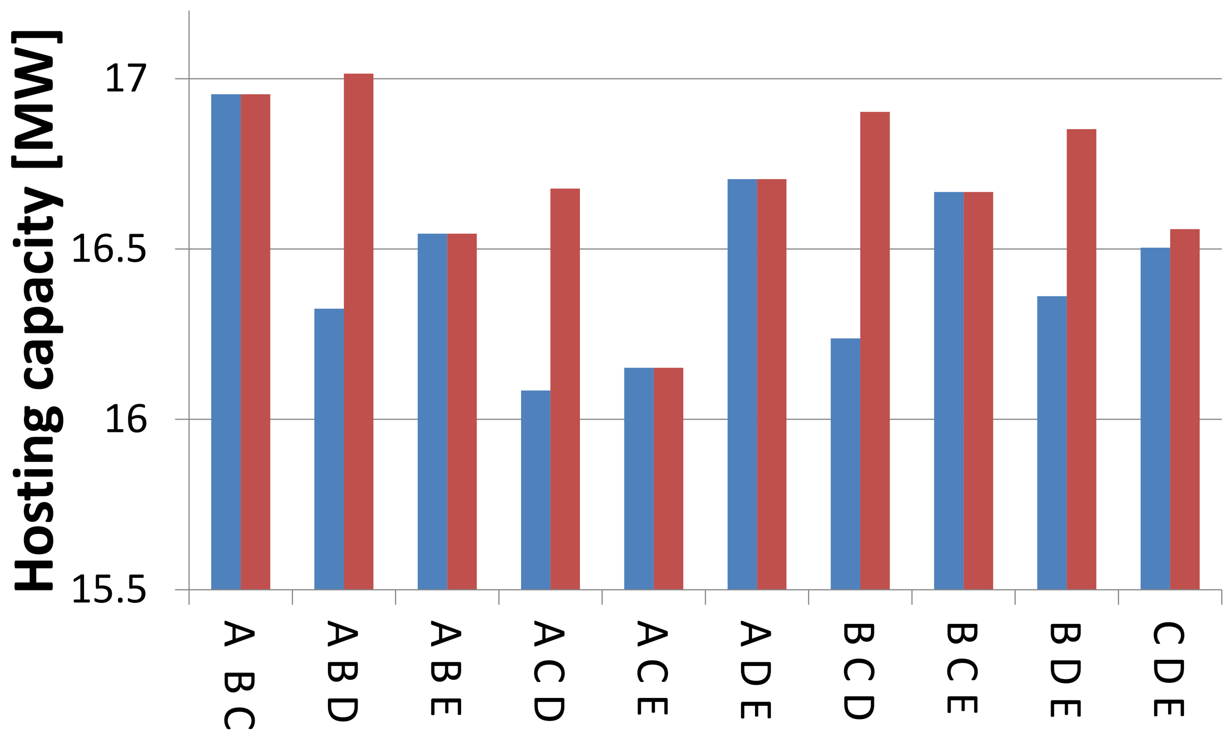
Capability of wind farms to deliver reactive power

Due to network factors including reduced demand and interaction between wind farms, the reactive power any WF can offer is limited. Even at max load, the reactive capability of WF2 is limited above 41% export & when export is >66%, reactive power cannot be delivered.



Reactive compensation installation: achieving max efficiency

System wide MVAr requirements are reduced if installations are on distribution system, reducing network losses and bulk supply point losses. Location & distribution of installed compensation impacts total investment required, hosting capacity increase & losses.

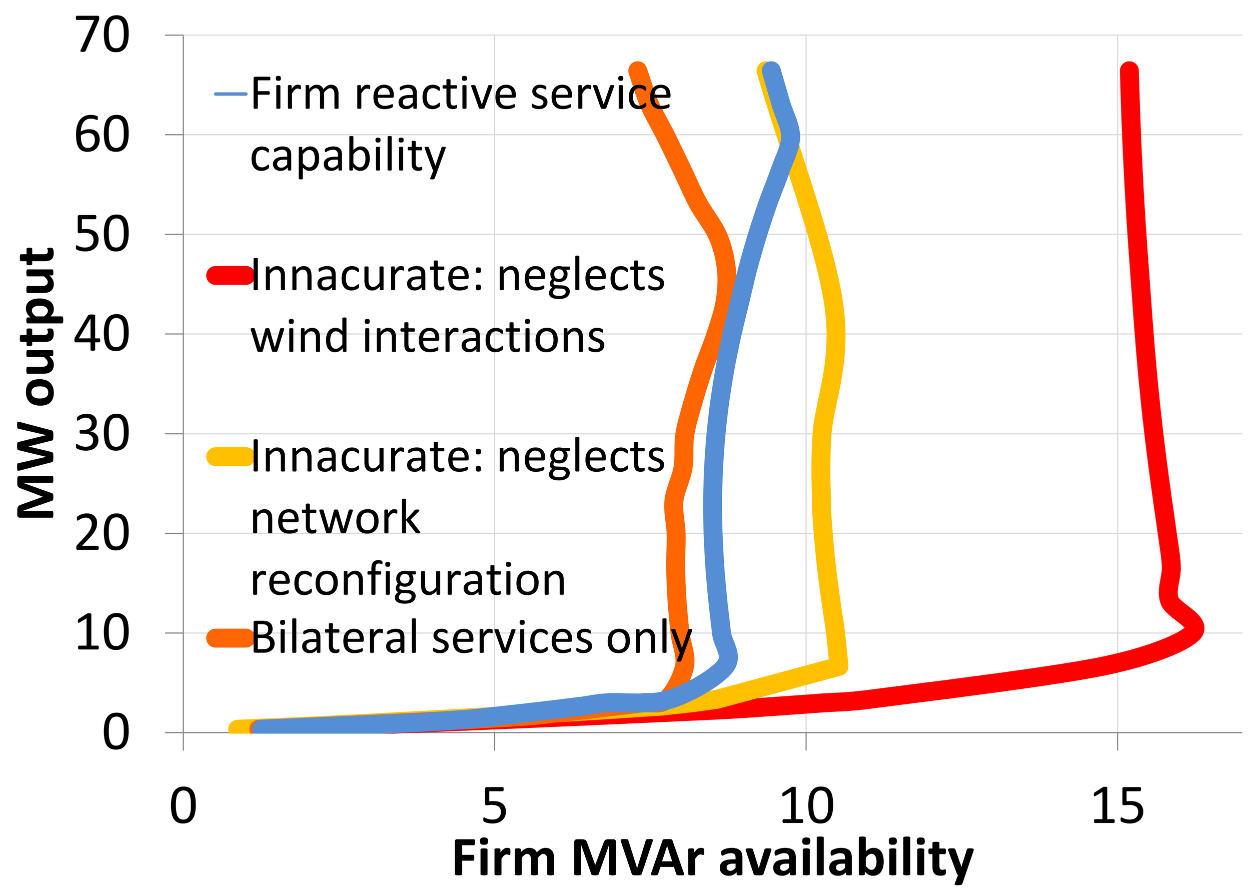


Installed reactive power on the distribution network can increase hosting capacity. Figure below illustrates the hosting capacity increase with reactive power installed at combinations of stations A, B, C, D, E. The distribution of MVAr is balanced…

- **Blue** – to minimise losses
- **Red** – to maximise hosting capacity

Impact of network configuration on reactive power service feasibility

This figure shows the firm combined reactive power capability of six existing distribution connected wind farms accounting for the impact of likely network reconfiguration (blue), two inaccurate capabilities calculated without regard for network configuration or the interaction between wind farms and the further limited capability where only bilateral contracts exist between the system operator and wind farms.



Ongoing work in technical and commercial evaluation of reactive power services from wind generation and developing practical control methods to optimize reactive power services, integrating DSO assets and operational capabilities.