Future distribution networks

- New constraints appear on MV and LV networks
  - DG connected to distribution networks → impact on voltage profiles, losses, power quality
  - Assets ageing
  - New types of loads

- New DMS functionalities to be developed
  - To optimise future network reinforcement/development capex
  - Voltage control functions, Network Reconfiguration Functions, Power Flows and losses Optimisation, etc…

Algorithms require topology and observability information
DNO’s architecture

Not enough to run DMS functionalities?

Distribution State Estimation: objectives

- Determine the current operating point of the MV network in near to real-time
  - Redundant measurements are required
  - Load models for un-measured MV/LV substations
  - Real time topology of the network
Distribution State Estimation: issues

- **MV networks have:**
  - Instrumentation issues
    - No (or only a few) sensors in the distribution networks
  - Algorithmic issues
    - Long radial feeders with heterogeneous lines and cables
      - Ill conditioned matrices
    - Large number of nodes
      - Long calculation times
  - Active and reactive power cannot be decoupled
    - Transmission State Estimation techniques cannot always be applied

Distribution State Estimation: algorithms

- **Objective function:** \[ \min \sum_i \left( \frac{z_i - h_i(x)}{\sigma_i} \right)^2 \]
  - \( z_i \): measurement vector,
  - \( h_i \): non-linear function linking measurements to the state vector,

- **DSE algorithms**
  - Constrained and un-constrained WLS DSE using Newton optimisation,
  - Specific robust DSE based on M-estimator,
  - DSE based on trust region optimisation,
  - Meta-heuristic approach,
  - ...

- **Criteria choice**
  - Robustness
    - Detect, identification and elimination of measurements, network model or parameters errors
  - Accuracy of results
  - Calculation time
  - Impact of sensors on DSE results

Depend on DMS functionalities
DNO’s architecture

Distribution State Estimation: accuracy (1/2)

- DSE accuracy will have an effect on DMS functionalities using results

Sensitivity of Automated functions to uncertain DSE results?
Distribution State Estimation: accuracy (2/2)

Impact of sensors on DSE results

<table>
<thead>
<tr>
<th>Sensor</th>
<th>Nature of sensor</th>
<th>Sensors’ precision</th>
<th>Number of additional sensors required for 0.5% max error</th>
<th>Number of additional sensors required for 1% max error</th>
</tr>
</thead>
<tbody>
<tr>
<td>MV feeder 1</td>
<td>V</td>
<td>0.5%</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>MV feeder 2</td>
<td>V</td>
<td>0%</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>PQ</td>
<td>V</td>
<td>2%</td>
<td>6</td>
<td>7</td>
</tr>
</tbody>
</table>

HiperDNO project

- High Performance Computing Technologies for Smart Distribution Network Operation
- From 1/02/2010 to 31/01/2013
- EC FP7 funding
- 11 European partners:
  - Slovenia, Germany, Israel, Spain, France, UK

www.hiperdno.eu
DSE on the HiperDNO project

- **DSE algorithms:**
  - WLS, PSO, WEM, DEA and Hachtel Augmented Matrix
- **Scalability of DSE algorithms:**
  - 2 zonal approaches: Disjoint zones and overlapping zones
  - Implementation on HPC platform
- **Impact of sensors on DSE results**
- **Connection with new DMS functionalities**
  - Voltage control function

HiperDNO Results: Zonal approach

- 2 approaches depending on available sensors:
  - Serial approach: PQV sensors only at the beginning of the feeder
  - Parallel approach: PQV sensors at all remote controlled switches
Conclusions

- DSE algorithms to enable new DMS functionalities

- DMS functionalities will define the performance required by DSE function
  - DSE results accuracy
  - Calculation time
  - Required instrumentation

- DSE algorithms have been investigated in the HiPerDNO project

Thank you for your attention