Presented at 2012 3rd IEEE PES ISGT Europe, Berlin, Germany, October 14 -17, 2012

Development of Distribution State Estimation Algorithms and Application

IEEE PES ISGT Europe 2012 (Berlin)

Panel : Novel State Estimation for Smart Distribution and Transmission Network Operation

17th of October 2012

Leticia De Alvaro
EDF R&D

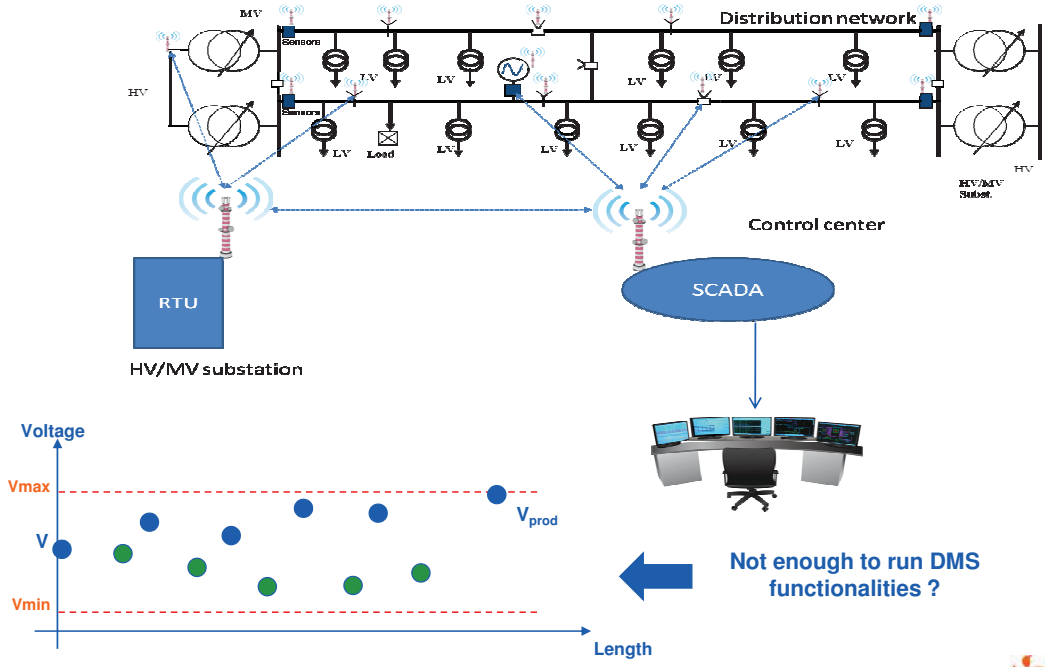
EDF
LEADING THE ENERGY CHANGE

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…

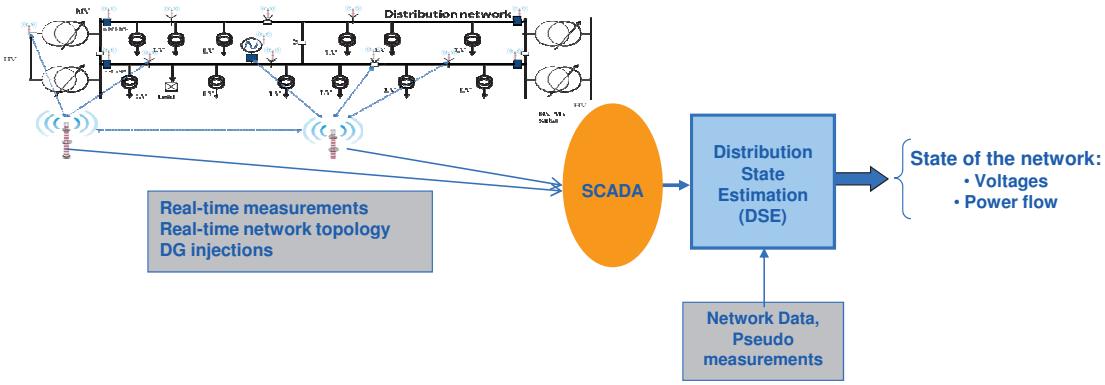
Algorithms require topology and observability information

DNO's architecture



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

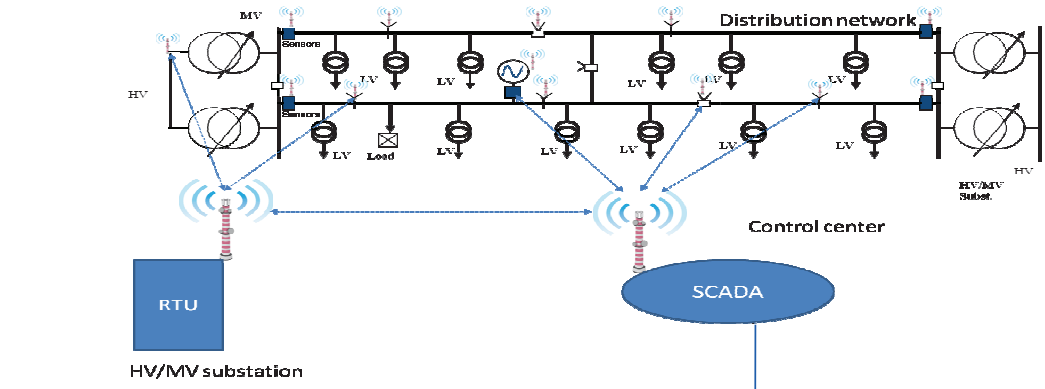
- MV networks have:
  - Instrumentation issues
    - No (or only a few) sensors in the distribution networks
  - Algorithmic issues
    - Long radial feeders with heterogeneous lines and cables
      → Ill conditioned matrices
    - Large number of nodes
      → Long calculation times
    - Active and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

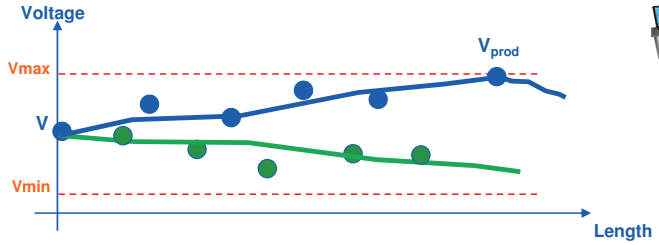
Distribution State Estimation: algorithms

- Objective function: $\min \sum_i \left(\frac{z_i - h_i(x)}{\sigma_i} \right)^2$
  - z: measurement vector,
  - h: 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

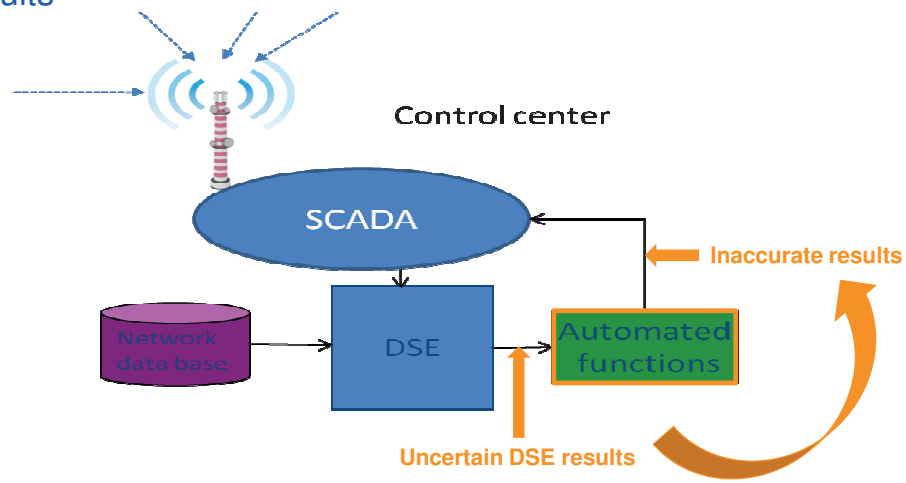
DNO's architecture





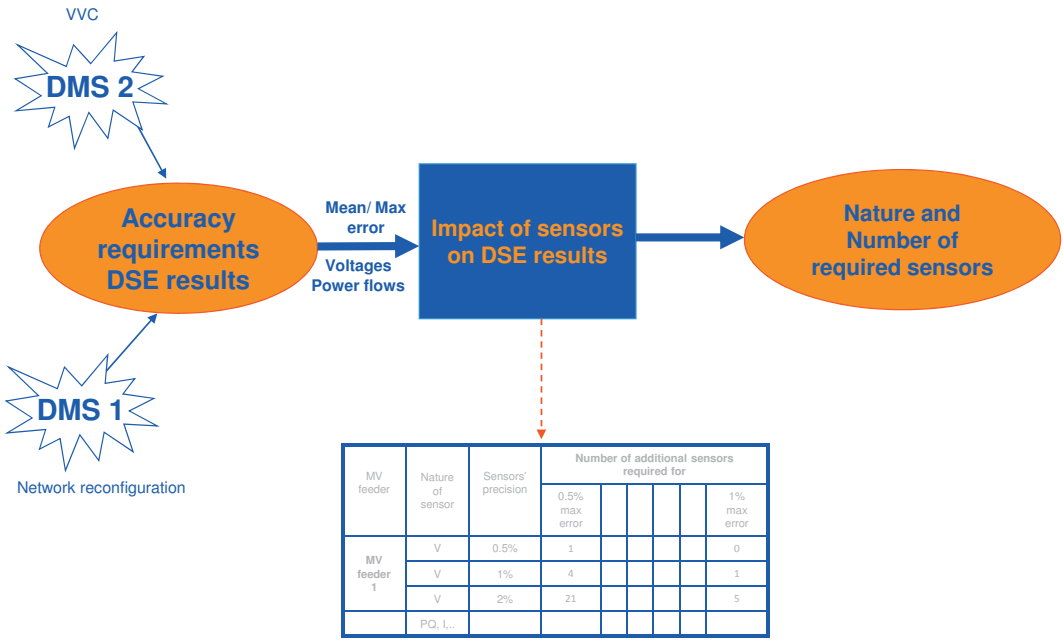
Distribution State Estimation: accuracy (1/2)

- 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)

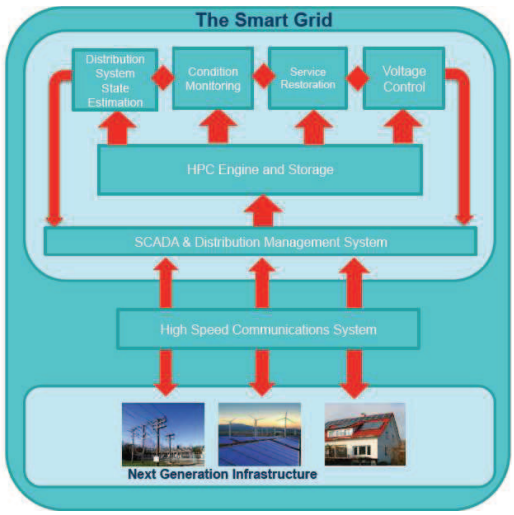


MV feeder	Nature of sensor	Sensors' precision	Number of additional sensors required for 0.5% max error					1% max error
MV feeder 1	V	0.5%	1					0
	V	1%	4					1
	V	2%	21					5
	PQ, I...							

HiperDNO project

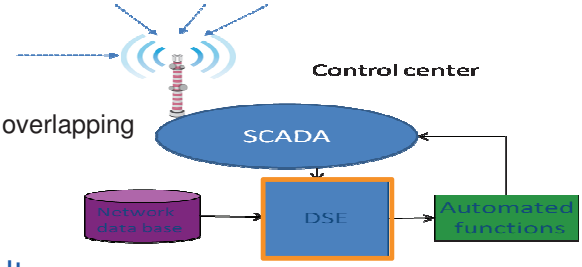
- High Performance Computing Technologies for Smart Distribution Network Operation
- From 1/02/2010 to 31/01/2013
- EC FP7 funding
- 11 European partners:
  - Slovenia, Germany, Israel, Spain, France, UK

www.hiperdno.eu

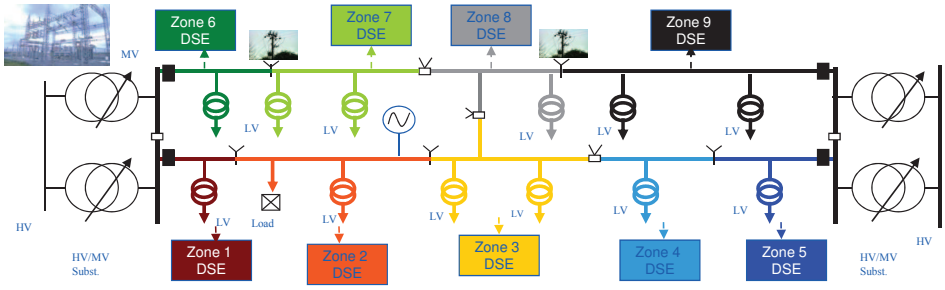


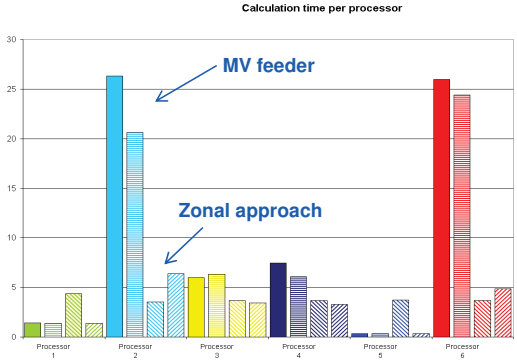
DSE on the HiperDNO project

- 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