Study Committee C6

Distribution Systems and Dispersed Generation

Paper C6_110_2016

State estimation in MV distribution networks: experience in the Spanish smart grid project PRICE-GDI

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Motivation

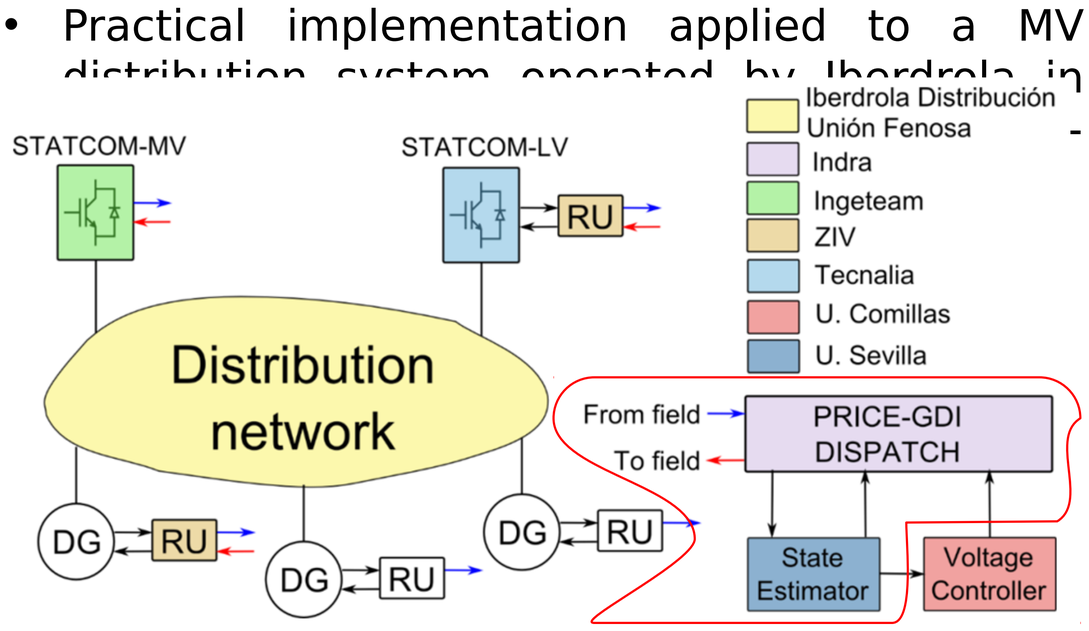
- Massive integration of distributed generation in MV / LV distribution systems (main goal of PRICE-GDI project).
- Growing tendency to improve the distribution systems observability dealing with a lack of appropriate and well-distributed measurements.
- Traditional way of modelling the load demand from Distribution Transformers (DTs), e.g. Contracted Power (CP), has proved to be inefficient.

Objects of investigation

- A more accurate estimation of the load of consumers connected to DTs taken into account the lack of real-time information for the Load Allocation (LA) module: Daily Load Curves (DLC) based.
- Practical implementation and test of the proposed DLSE methodology.

Method / Approach

- Distribution Load and State Estimation (DLSE) based on two submodules: LA and Distribution System State Estimator (DSSE) feeding each other.
- Incorporate to the LA the new information available at the concentrators allocated at the secondary side of DTs.
- Practical implementation applied to a MV distribution system operated by Iberdrola in

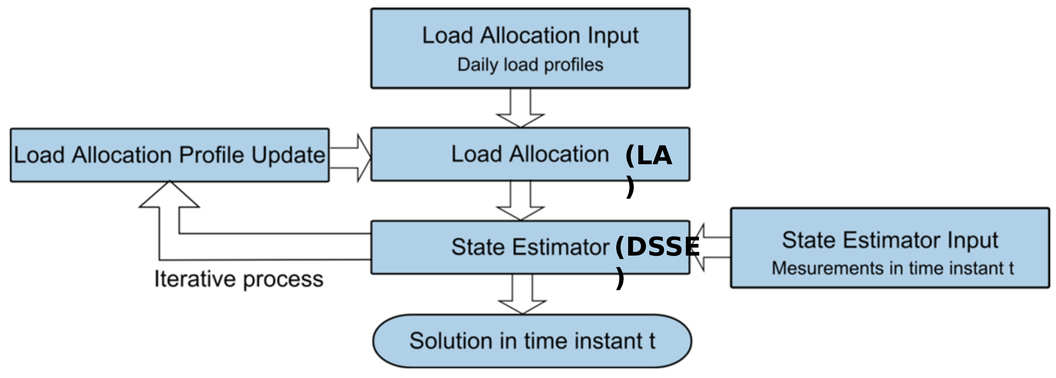


Main technologies deployed in the pilot project PRICE-GDI
(in red the integration of the DLSE system proposed)

Challenges

- State estimators for distribution systems must tackle with their specific characteristics: *large proportion of injections in the measurement set, long and short lines coming to the same bus, presence of current flow measurements to the detriment of power flows, high R/X ratios* and, *mainly, reduced number of real-time measurements.*
- The lack of real-time information causes a problem of non-observability of the system, so pseudo-measurements at MV/LV transformers have to be added previously to perform the state estimation of the whole MV system.

Experimental setup



DLSE methodology proposed, implemented and tested

- LA and DSSE blocks are solved by means of the reciprocal feeding of information in an optimal and efficient way until convergence is reached.
- The LA methodology solves the initial problem of non-observability by estimating loads demanded from DTs and also allocate losses among consumers, using:
  - ✓ DLC: deducing the most common daily load patterns of consumers per DTs (clustering techniques).
  - ✓ Information coming from previous measurements registered at feeder head: dynamic LA solution.
- The DSSE computes the best state (total active and reactive powers) that matches all real and estimated measurements, using:
  - ✓ Load estimations at DTs by the LA.
  - ✓ Other measurements if available.
- DLSE doubly optimized from computational point of view.

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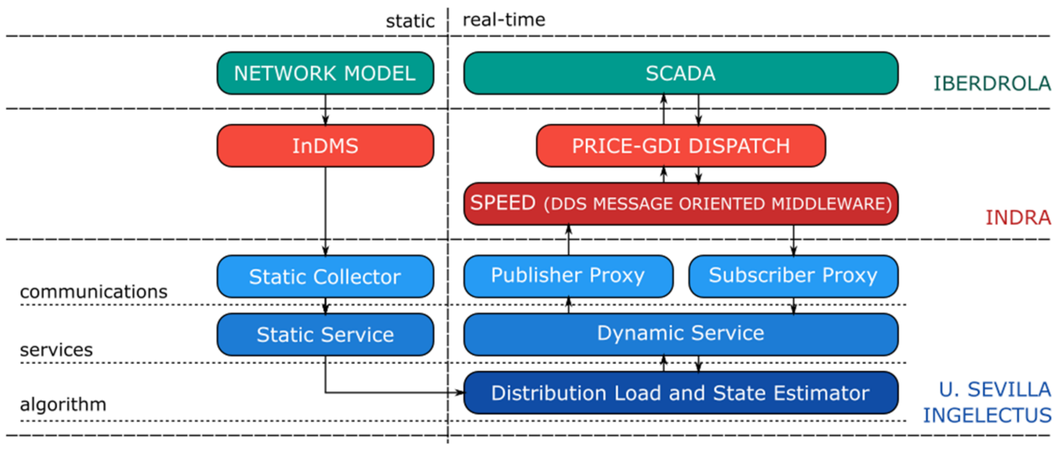
Application architecture



Architecture of the application

- All real-time field measurements collected using the current Iberdrola's SCADA.
- The DLSE is launched in a periodic base.
- In order to integrate the DLSE within the architecture a series of modules have been implemented.

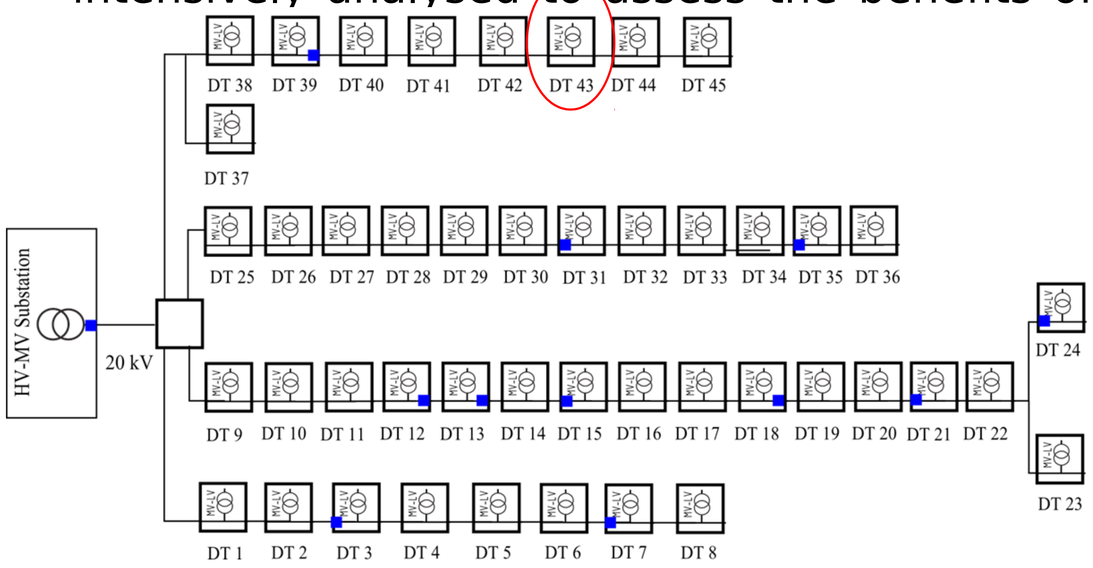
Test Case

- The application considers the whole Iberdrola distribution network within the regional area known as *"El Corredor del Henares"* (PRICE-GDI project area).

9 HV/MV substations	170.729 consumers
2.228 secondary substations (SS)	131 MV feeders

Key figures

- However, one MV distribution feeder intensively analysed to assess the benefits of



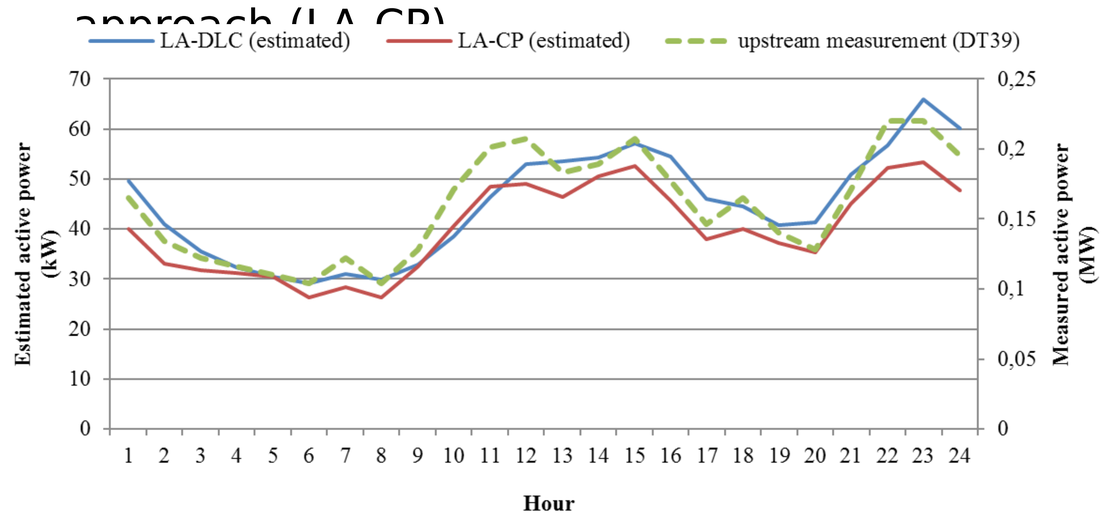
One-line diagram of the distribution feeder used in the test case. Measurements available marked up with blue squares: *V, I, P* and *Q* at the MV feeder head / *V, I, P* and *Q* in 11 MV/LV SS. In red, the DT selected for presenting results.

46 SS	26,09 MW contracted power
40,7 MVA installed power	12,57 km total length

Key figures

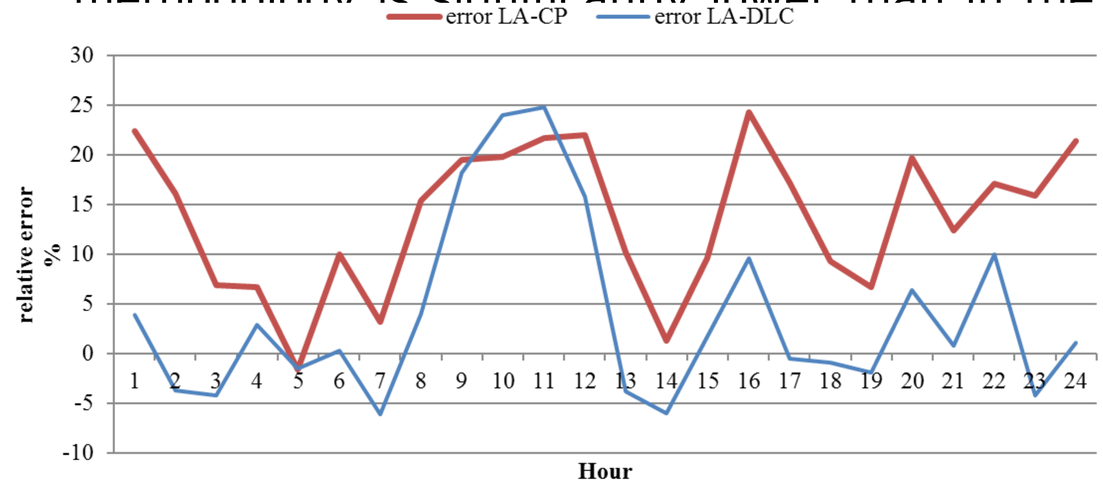
Main results

- The proposed method for Load Allocation (LA-DLC) has been compared with a traditional approach (LA-CP)



Estimation of the active power demand on DT43 (red and blue lines)

- The average absolute error for the proposed methodology is significantly lower than in the



Relative error between the estimated and the actual active power demanded by DT43

Conclusion

- The use of DLC resulting in a LA solution better fitted to the real behaviour of connected loads than classical techniques based on contracted or rated power of DTs.
- Dispatch centres involving advanced algorithm (e.g. state estimators and Volt/VAR controllers) are necessary for enabling massive integration of renewable generation.

about PRICE-GDI project

- This work has been financially supported by the Spanish Ministry of Economy and Competitiveness under projects PRICE-GDI (IPT-2011-1501-9) and AlltoGather (ENE2014-54115-R) partially granted by FEDER funds.