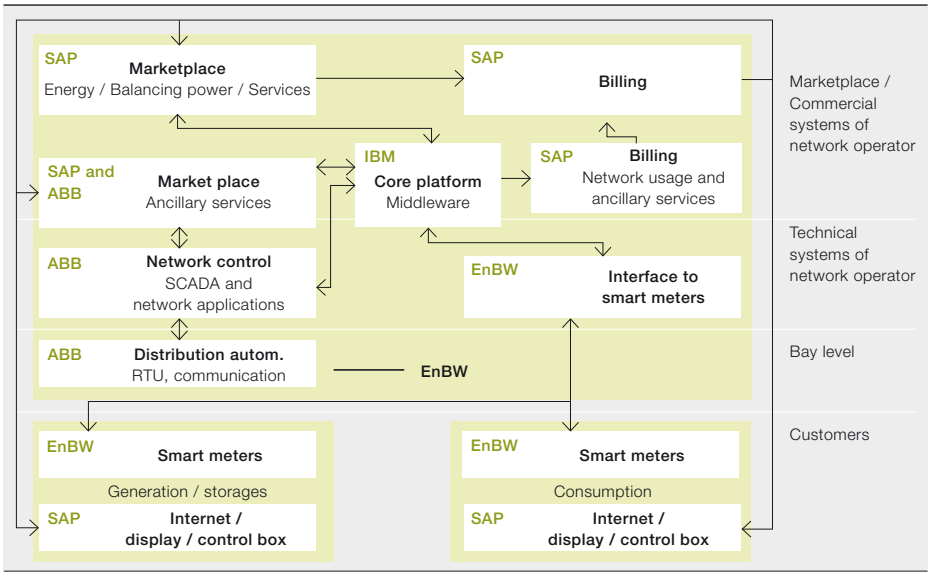
Head smart

Strengthening smart grids through real-world pilot collaboration

CARSTEN FRANKE, TATJANA KOSTIC, STEPHAN KAUTSCH, BRITTA BUCHHOLZ, ADAM SLUPINSKI – ABB has, and continues to develop, all the necessary components to enable and optimize smart grids. In order to evaluate and further improve existing solutions, ABB participates in research projects and pilot installations. One of these very successful pilot projects was the MeRegio pilot, one of six beacon E-energy projects funded by the German government. ABB's development of new information and communication technologies for smart grids, required extensive cooperation work with numerous project partners. The outcome is a solution that brings yet further strength and stability to smart grids.

1 Consortium and competency interactions in MeRegio



In 2012 ABB successfully completed its participation in the MeRegio (Minimum Emission Region) pilot project. The pilot, which started in 2008, is one of a group of E-energy projects that are funded by the German government's Federal Ministry of Economics and Technology in partnership with the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety [1].

Like all of the E-Energy projects the focus of MeRegio was on developing, implementing and testing information and communication technology (ICT) for managing future energy systems. The MeRegio project consortium comprised:

- ABB
- EnBW Energie Baden-Württemberg
- IBM Deutschland
- SAP
- Systemplan GmbH
- University of Karlsruhe (KIT)

The responsible parties and their main components are shown at → 1. ABB was mainly responsible for the network control and the distribution automation. IBM focused on the information exchange middleware to connect the various MeRegio components. SAP mainly developed the marketplace while EnBW, as the utility, developed the platform for smart meters and control box integration into their grid. Furthermore, EnBW led the overall consortium. KIT supported the consortium with specific research tasks. Systemplan helped to set up and install submeters specifically for industrial customers.

New ICTs for smart grids

Within MeRegio, ABB developed and installed new, intelligent measuring devices and techniques. However, the main focus of the ABB contribution was on developing and deploying new information and communication technologies embracing additional network control applications and mechanisms in smart grids. ABB focused specifically on four different development aspects. Subsequently aspects one, three and four have all been evaluated through intensive simulations.

> Secondary substations can almost double the amount of renewable power generation that can be integrated.

Aspect one: offline simulations

The first aspect that was investigated in detail within the MeRegio project focused on offline simulations for the pilot medium- and low-voltage network in order to identify further optimization opportunities. Therefore, ABB took into account different new technical solutions, like cos(φ) regulation, voltage regulation units and energy storage. Results from this work are, for example, that voltage regulations in the secondary substations can almost double the amount of renewable power generation that can be integrated and avoid voltage band violations in the low-voltage grids without any modification of the network topology. Furthermore, it has been ensured that all these offline simulation results can also be applied for other grids. Therefore the acquired knowledge can be reused and can help customers with similar issues. In addition these results have been used to identify scenarios where the installation of additional ICT for further investigation, monitoring, and increase in reliability of supply in the distribution grid, is meaningful.

Aspect two: development of measuring technologies

Based on this knowledge the second aspect focused on the further development of measuring technologies for secondary substations. This required the use of remote terminal units (RTUs) to automate the operation of secondary substations. For the realization, the ABB RTU560 and the Multimeter 560CVD11 were used in order to determine the voltage on the medium-voltage side of the substation by only using

Title picture
The model region of Freimat in Germany.
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measurements from the low-voltage side. This specific measuring technique was developed within the MeRegio pilot and was also intensively tested in the field network. As this approach to determine the medium side voltage has now been proven to work well, it has already been applied in subsequent ABB pilot projects.

Aspect three: integration of measurements

The third aspect that was realized within the MeRegio project focuses on the integration of all medium- and low-voltage measurements from the different substations as well as the use of the available smart meter measurements in the network management system. In this way, the network calculations can be enhanced and the network operator has better online control capabilities. Whereas the data from the substations could be integrated directly using existing communication protocols, the smart meter data import called for a newly developed mechanism. The required data exchange has been implemented via a Web-service interface with the IBM CORE platform using a data model that was highly influenced by existing standards. Specifically the Common Information Model (DCIM, including extensions for distribution, IEC 61968-11 and IEC 61970-301) has influenced the information model exchange protocol, which was developed by ABB. The integrated data from the low- and medium-voltage levels makes it possible to run power flows and to visualize network bottlenecks and voltage violations. For this, a coloring approach has been used to also show the load- and generation-dependent influences relating to the identified problems. All of these concepts and methods have been validated by executing intensive system simulations.

Aspect four: market-compliant approach

The fourth aspect of the MeRegio pilot focused on the market compliant approach to Demand Side Management applied to the medium- and low-voltage grids. Here, ABB implemented forecasts for decentralized photovoltaic and wind based generation. Furthermore, an additional interface to the IBM CORE platform was implemented to receive the forecasts from special "control boxes" installed within the given distribution grid that is operated by EnBW. Based on all these data, predictive power flows have been implemented in order to anticipate potential network bottlenecks up to six hours in advance. The results of these predictive calculations are encoded in XML and communicated to an analysis tool. This newly generated bottleneck analysis module calculates, for all loads and all generators, sensitivities to expected problems. Based on these sensitivities, the module actively suggests re-dispatch schemes involving the local generation and loads. These solutions are encoded in so called priority signals that are communicated towards the marketplace of the distribution system operator in order to be resolved. The priority signals data exchange model has been developed as an extension to standard DCIM. This ensures that similar problems in distribution grids can be solved in a very similar way using the same message payload types. The whole problem, starting from the predictive load flow, including the bottleneck analysis, the sensitivity signal's generation and communication was addressed by a team of experts from ABB.

> Network bottlenecks were simulated because of the difficulty of observing such events frequently enough in real life.

The evaluation of the effectiveness of the "priority signal" process to proactively resolve expected network bottlenecks was primarily based on online simulations of the distribution grid. This reflects the difficulties of observing such bottlenecks frequently enough in the real life system. Therefore, some loads and generation forecast data were modified in order to generate bottlenecks for different lead times. Then the algorithms and information exchange mechanisms were evaluated regarding their efficiency at identifying and resolving the predicted network problems.

Demonstrable results

The pilot evaluation itself was based not only on field measurements but also on extensive simulations. In order to demonstrate and communicate the outcome of the MeRegio pilot project to a larger audience, a sophisticated demonstrator, the ABB Smart Distribution System, has been developed that can be used to introduce and demonstrate smart grids in general and further explain the MeRegio issues and the developed solution strategies. Additionally, the demonstrator also addresses the evaluation of economic impacts of smart grid solutions to given network operation problems. Simulation was a critical part of developing the solution shown in the demonstrator, however the project could only have been successful when many parties worked together to share their expertise and ideas. Such successful collaboration is an example of how it is possible for different interest groups to work together to bring the world a solution that has benefits for everyone. Two (or more) heads really are better than one.

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Reference
[1] E-energy project of the German Federal Ministry of Economics and Technology. Retrieved from http://www.e-energy.de/en/ (2013, June 5).