EVOLVDSO: NEW AND EVOLVING DSO ROLE FOR EFFICIENT DRES INTEGRATION IN DISTRIBUTION NETWORKS

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ABSTRACT

evolvDSO is a 40 months R&D project launched in September 2013 receiving funding from the European Community's Seventh Framework Program (FP7/2007-2013), Call for Proposals FP7-Energy-2013.7.1.1 under grant agreement n° 608732.
evolvDSO addresses a number of research and technology gaps that need to be solved for Distribution System Operators (DSO) to efficiently fulfill their emerging roles in the future European electricity system. *evolvDSO* will explore a future set of scenarios with corresponding DSO roles, from which needs and requirements for new tools will be defined and developed. The project moves beyond the state of the art by leveraging current research findings and technological solutions, complementing these efforts where needed and integrating results in order to deliver a system on the basis of which DSOs can operate. The developed tools will take into account both the current environments as well as a future system where a market for services could be in place.
The transition of distribution networks towards a smart system which supports the successful integration of distributed renewable energy sources (DRES) and demand participation in the electricity system, requires an evolution of the role of DSOs with respect to the operation and management of the grid, as well as new tools to support these potential new roles.
The added value that *evolvDSO* brings to consumers, energy producers, DSOs, Transmission System Operators (TSOs) and other stakeholders in the electricity market is its holistic, aggregate, systemic approach of the research and demonstration activities. While several research projects have addressed technical questions in various specific realms (e.g. Ecogrid, GRID4EU, ADVANCED, S3C), *evolvDSO* aims to leverage and integrate the existing solutions, and using a selected number of defined scenarios from which future roles of DSOs are defined, develop new necessary tools for these DSO roles to be feasible.

INTRODUCTION

The goal of reducing the emission of CO_2 in Europe to address the climate change and resource scarcity issues poses a number of technical and operational challenges to all actors along the electricity value chain. In particular, the target of a 20% share of renewable energy resources in the EU energy consumption mix as one of the EU 20-20-20 goals requires new technical, regulatory as well as market-related approaches to the way electricity networks are managed today. In 2010, the share of renewable energy sources in the EU energy production mix was almost 12%, but less than 10% in the consumption mix. With transport and heating not being very likely to meet the 20% target, EU electricity generation is expected to fill this deficit with a 30% share of renewable in the total production mix. Furthermore, it is envisaged that this new renewable generation will involve large new wind/photovoltaic (PV) farms connected to high Voltage / Medium Voltage (HV/MV) grids in rural areas, as well as smaller units next to customers, like through PV rooftops and as is the case for the majority of PV systems in Germany. With an increasing share of renewable sources in combination with an increasingly active consumer, challenges related to both the supply and demand-side are foreseen.

Electricity generation – challenges on the supply-side

In the future, volatile sources such as wind and solar energy will assume a crucial role for energy generation in Europe. However, this volatility poses major challenges to the electricity networks that can be clustered in three areas:

- Variability and intermittency: Both solar and wind energy generation display a volatile supply pattern. While some of the volatility can be predicted (day/night, seasonality), the degree of unpredictable volatility poses a serious challenge for DSO to keep their networks within the necessary operating limits and avoid local network congestions.
- Bidirectional flows: While the traditional electricity distribution systems were based on centralised energy generation from large plants, the increasing integration of solar and wind energy changes the "established" unidirectional character of the distribution grid. Decentralised generation requires operators to have the capacity to manage these bidirectional flows in both the Low voltage (LV) and medium voltage (MV) grids, avoiding possible local network congestions that may arise, and to keep the voltage in the permitted range.
- The presence of renewable generation in rural environments in comparison to urban areas: As the number of PV rooftops and micro-wind installations continues to grow in rural and suburban environments (the growth in urban areas is expected to be lower due to limited space), new challenges for the distribution grid emerge such as the possibility of sections of the

distribution network entering in uncontrolled islanding modes of operation.
New solutions and corresponding DSO roles must evolve to address these new situations, and thus support the smart cities concept where local generation becomes more and more present.

From consumers to prosumers – challenges on the demand side

Driven by the changing political and regulatory framework, variable prices for fossil energy sources and evolving customer preferences, the challenges for energy generation are being mirrored by new developments on the demand side, such as:

- In numerous EU countries the large-scale roll-out of smart meters and other in-home devices/displays enables consumers to evolve from passive market participants to active consumers shaping their electricity demand in response to market signals.
- Consumers' ability to satisfy significant parts of their own electricity demand through their own generation (solar and wind micro-generation) and to feed the production surpluses into the grid.
- Challenges arising from implementing smart cities and communities which will require an increased convergence of energy, ICT and transport sectors.
- The expected introduction of electric vehicles which can require (Grid to Vehicle) /inject (Vehicle to Grid) electrical energy from/into the grid.
- Consumers participation may increase either through direct incentives or smart tariffs, providing balancing services whereby smaller consumers reduce their consumption or increase their injection to help balance supply against demand on the local grid, flexibility and a thrifty contribution to resource adequacy.

CURRENT, EMERGING AND NEW ROLES FOR DSO

This changing environment is creating the need for power systems and their operation to evolve.
A consortium composed of major European DSOs, TSOs, scientific institutions active in the field of energy research, new market players and an association of European DSO under the leadership of ENEL have been formed to combine excellent expertise to tackle the aforementioned challenges and to seize the opportunities.
evolvDSO will define future roles of DSO on the basis of a set of different future scenarios. Selected tools and methods to enable these roles will be developed and validated through computer simulations based on real grid data and existing real-life test beds. The new tools and methods will enable DSO in collaboration with TSOs and market players to support the transition of the distribution networks towards a smart system that supports a successful integration of DRES. To facilitate the uptake of the new tools and methods, *evolvDSO* will provide recommendations for the regulatory framework and market architectures, and elaborate proposals on new interactions among key stakeholders.

Today, responsibilities and roles of the DSO involve:

- Ensuring the reliability of the distribution network, and an appropriate quality of electricity supply.
- Provisioning of network capacity including DRES connection.
- Supporting TSO to ensure total system stability.
- Metering (in most European countries).

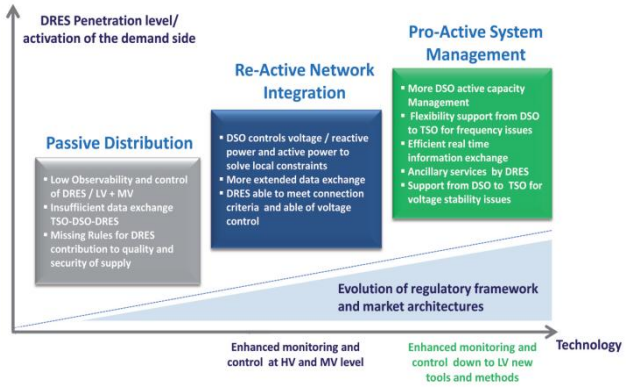

Figure 1: Evolution of the electricity networks. Source: Based on Eurelectric, "Active Network Management", DSO Workshop, May 2012.

The DSO's present evolution from a passive mode to a pro-active system management creates a urgent need for new and improved tools and methods to make this change happen. Relevant past and ongoing research projects, according to their specific scope, have generally addressed in depth individual issues that arise from these challenges and often investigated specific technology gaps. Nevertheless, the technical implications of future roles for DSO have therefore not been explored in a holistic way.
The challenges addressed in *evolvDSO* have been clustered into four broad groups of activities, related to different time domains: Planning, Forecasting, Operational Scheduling & Grid Optimisation, and Maintenance of MV and LV grids.
Furthermore, to sufficiently address the increasing complexity of the electricity systems, along with the development of the technology solutions, regulatory frameworks as well market architectures also need to be systematically revised.

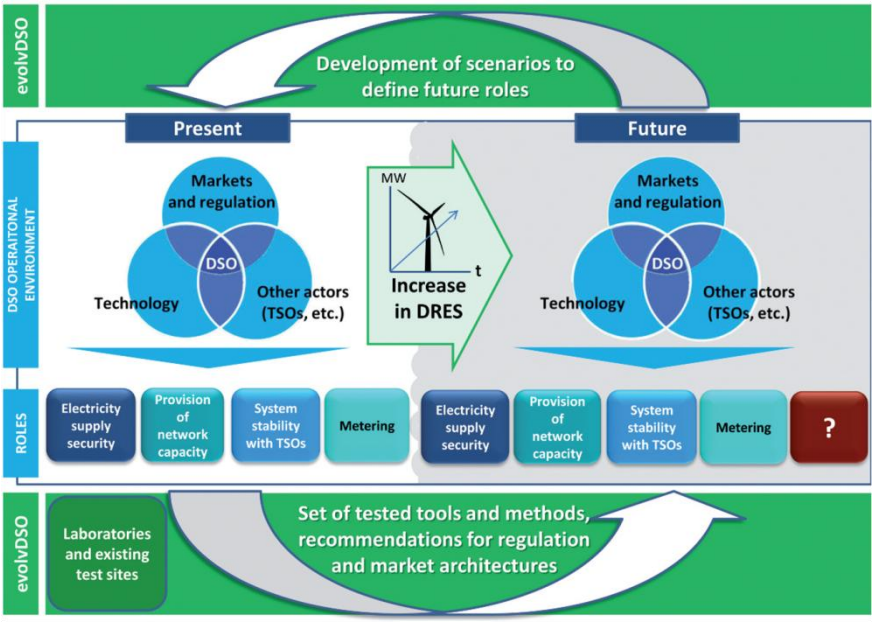

Figure 2: The *evolvDSO* approach.
Source: *evolvDSO* consortium.

TOOLS, METHODS, REGULATION AND MARKET ARCHITECTURE

evolvDSO aims to take a holistic approach in the development of required tools related to a wide spectrum of DSO's activities. The project will begin by defining a set of possible future scenarios and define the necessary future roles DSO should take to fulfill their responsibilities to make these envisaged scenarios feasible. Interactions with stakeholders of the electricity system such as TSO, DRES generators, aggregators and possible new players are a key parameter of the analysis.

The tools and methods developed within the project have been clustered into four broad areas and will investigate the following issues:

- **Planning:** Definition of planning guidelines and methodologies for distribution network development, bearing in mind the new behavior of the distribution network, namely by proposing novel approaches to select expansion plans that are flexible given uncertainties of generation expansion, system load and other market variables.

- **Forecasting, Operational Scheduling and Grid Optimization**: Scheduling tools providing optimum grid configuration based on information provided by advanced forecasting tools and network data. These grid reconfiguration actions should be aimed at avoiding possible network congestions as well as allow to resume safe interconnected operation as soon as possible.

- **Operation and Maintenance:** Operational procedures to provide enhanced controllability of distributed generation (i.e. dispatching) and active demand addressing current and expected limitations of operating procedures. A closer interaction between TSO and DSO is expected, ensuring that the distribution system is providing as well as requiring services to the transmission system (i.e. acting as a "Good Citizen"), by managing the resources connected to the distribution grid. In this context tools that provide an optimum "disconnection" as a function of various parameters are envisaged.

- **Regulation and market architectures:** New approaches for collaboration with new market players such as small-loads, distributed generation and aggregators.

The developed tools will facilitate a secure and efficient operation of the whole systems taking into account the continuously increasing DRES connections and a more active role for customers. To facilitate the uptake of the developed tools and methods, the project will include recommendations for adjustments to current regulatory frameworks, as well as new market architectures. Furthermore, new interactions among the key actors of the electricity systems will be proposed.
In summary, *evolvDSO* aims to deliver the following main outcomes:

1. A limited set of possible future scenarios describing the evolution of electricity systems including the anticipation of future challenges related to the distribution system and the future DSO roles;

2. Set of validated tools and methods with a high replicability potential focused on where the main gaps are with respect to the identified DSO challenges. These tools should address both current and possible upcoming challenges of the distribution system;

3. Methodologies to evaluate the performances of the developed tools and methods considering the requirements defined by the key stakeholders (aligned with the EEGI requirements);

4. Recommendations for the modification of the regulatory framework and market architectures (new roles, responsibilities and interactions in the system) that take into account current technical requirements with the aim to facilitate an efficient DRES integration, more active customers as well as a market participation of new stakeholders (e.g. aggregators , BRPs);

5. A pragmatic roadmap for the deployment of the developed tools and methods.

CONCLUSIONS

evolvDSO will bring a holistic and systematic approach to required technological developments for new envisaged DSO roles and associated services, delivering value to consumers, energy producers, DSO and other stakeholders in the electricity market. While numerous research projects have addressed specific technical questions in various specific realms (smart cities, e-mobility etc.), *evolvDSO* aims to leverage and integrate the existing solutions, and make use of a selected number of scenarios from which future roles of DSO are defined.

evolvDSO wants to develop a wide range of tools aimed at facilitating an uptake of DRES in MV and LV networks, while ensuring the secure and efficient operation of grids. It is expected that the tools and methods developed by the project will help to improve collaboration with TSO which will become ever more important due to increased reverse power flows caused by decentralised generation.

To facilitate the uptake of the DSO potential new roles, *evolvDSO* will provide recommendations for changes required in the regulatory framework and market architectures and elaborate proposals of new interaction mechanisms among key stakeholders.

Finally, *evolvDSO* will provide the building blocks to help DSO to evolve from their current roles and associated set of tasks and responsibilities to future roles that will enable an increased penetration of DRES.

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