Establishing DSOso-specific scenarios for future electrical distribution grids

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ESTABLISHING DSO-SPECIFIC SCENARIOS FOR FUTURE ELECTRICAL DISTRIBUTION GRIDS

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Keywords: SMART GRIDS, DISTRIBUTION SYSTEM OPERATORS, FUTURE DISTRIBUTION GRID, SCENARIOS

Abstract

The evolution of electrical distribution grids requires the Distribution System Operators to be ready for a more complex and flexible grid. This paper explores the use of scenario analysis as a useful tool that the operators can use to foresee and hedge against any upcoming challenges. However, available energy transition scenarios in literature predominantly focus on a large scale in their projections and hence may not be the best fit for this task. This paper proposes an approach to break down the projections of these scenarios to the level of a specific distribution grid, taking into account the current state of the system and its specificities. A study case with a distribution system operator and the electricity system in France is also presented. The work demonstrates how applying scenario analysis to an individual distribution system operator can be beneficial in exploring multiple possible futures and determining future challenges and requirements.

1. Introduction

Transitions in the energy sector and the evolution towards electrification and digitalization impose new challenges on electrical distribution grids. Distribution System Operators (DSO) have to be ready for a more complex and flexible grid and a change in consumption and generation of electricity. Scenario analysis is a method for projection that encourages thinking about upcoming possibilities and results in different views of the future, or 'future possibilities'. This represents a different approach than forecasting, which includes constructing a detailed model of the system and predicting the future by assigning probabilistic values to future events [1]. The concept of scenario analysis can help DSOs in understanding future challenges and prepare them for the impact of these scenarios on distribution grids. However, available energy transition scenarios in literature and industry are on a scale of countries or larger. Their projections present an aggregated view of possible futures, which is more relevant to actors of the electrical system on a bigger scale than a DSO. Their projections are difficult to break down and translate to the level of local or small DSOs. This is because distribution grids and DSOs in Europe greatly vary between countries and within the same country in some cases [2] with more than 2000 DSOs are operating in Europe [3]. The variance is the result of many factors, including the number, type and density of customers, geographical location, operating voltage levels, historical factors and any applicable regulations determining DSO responsibilities and activities.

This multitude of factors and the variety of DSOs present a big challenge in translating the impact of scenarios on each DSO and distribution network individually. However, understanding various possible future trends related to the specific situation of a distribution grid helps a DSO in making investment decisions and long term planning of the grid they operate. Because of the usefulness of more accurate scenarios for a DSO, the rest of this work focuses on establishing an individual assessment of the impact of scenarios on any individual DSO. The second part of the paper proposes an approach to establish DSO-specific scenarios; the third part presents a study case applying the approach and a conclusion of the work is provided.

2. Approach

Figure 1 shows the proposed approach to establish scenarios specific to a DSO by analysing relevant existing projections. A baseline of the DSO is required in this evaluation that is based on a framework previously presented in [4]. The following sections elaborate the three steps of the process.

2.1. Identification of scenarios

Most common available scenarios pertaining to the power grid come from: 1) energy transition scenarios developed on the national level or bigger, 2) scenarios for the electrical system usually developed by national entities e.g., energy agencies or Transmission System Operators (TSOs), or 3) specific technology scenarios or projections e.g., photovoltaics (PV) installed capacity and Electric Vehicles (EV) adoption rate. The approach uses national scenarios extracts the relevant projections for the DSO.

2.2. Extracting relevant projections

After identifying multiple scenarios, common projections between the scenarios that are relevant to the future development of power grids are extracted. The relevant projections are related to the technical, market and regulatory aspects of the grid operation. By having numerous projections of the same indicators from a variety of studies,

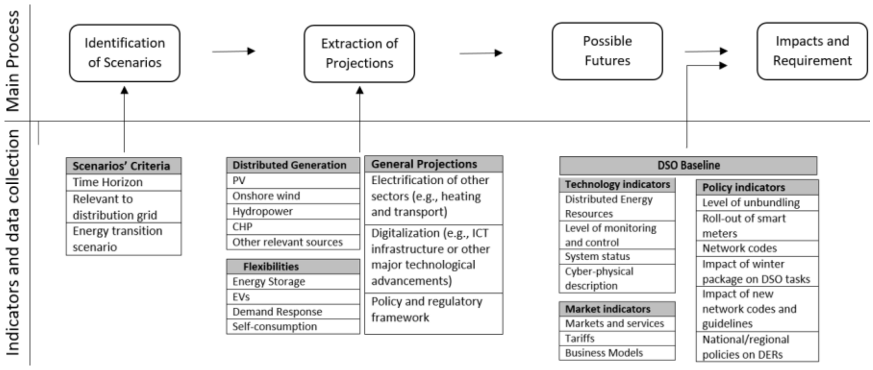

Fig. 1 Proposed approach

an outline of future possibilities for a specific DSO is achieved. Each set of projections extracted from a scenario represent a 'possible future' for the DSO. The gap between this possible future and the baseline of the DSO is studied in the next step of the approach.

2.3. Impact and requirements

Studying the impact of the extracted projections by analysing the gap with the baseline of the DSOs. The same projection can have varying impacts on different grids. From this, the challenges and requirements for the DSOs to be prepared for future active distribution grids are reached.

3. Study Case: French scenarios

A study case using the approach was conducted on a French DSO, SOREA. They operate a small distribution grid in, southeast of France, with 15000 customers, 300 kms of distribution lines and 100 GWh of annual electricity demand. Due to their geographical location, the grid hosts both hydropower plants and PV production.

3.1. Identification of scenarios

Four studies and eleven scenarios relevant to distribution grids in France on the time horizon of 5 to 15 years were identified and are presented in Table 1.

Table 1 Identified Scenarios

Scenario	RES*	Source and time horizon
OHM	34%	Time Horizon: 2025 – 2035
AMPERE	50%	RTE generation adequacy of
HERTZ	45%	electricity report (2017) [5]
VOLT	40%	
WATT	71%	
50% nuclear	44%	Time Horizon: 2035 – 2050
80% RES	80%	ADEME Energy-Climate
90% RES	90%	Visions 2035-2050 (2017) [6]
100% Renewable	100%	Time Horizon: 2050
80% Renewable	80%	ADEME Renewable Electricity Mix (2016) [7]
Scenario 2017-2050	100%	Time Horizon: 2017 – 2050 négaWatt (2017) [8]

*Renewable Energy Sources (RES) share of annual production

The RTE scenarios are those of the only French national TSO based on the generation adequacy of electricity supply-demand balance. It has five variant of projections related to the decommissioning of nuclear reactors, rate of RES deployment and consumption evolution. The scenarios also take into consideration new energy technologies (e.g., demand management, storage and electrification) and effect of new national policies and regulations. The French energy agency ADEME (Agence de l'Environnement et de la Maîtrise de l'Énergie) Visions scenarios are the agency's vision to achieve the energy commitments set on the global scale (Paris agreement), the European level (Energy-Climate 2030) and the national level with the National Low Carbon Strategy (SNBC) and the Multiyear Energy Programme (Programmations pluriannuelles de l'énergie). While Renewale Electricity Mix scenarios of ADEME consider optimising the energy mix to reach a certain RES penetration with balance of supply and demand for each hour of the year taking into consideration the national potential of each technology without considering the current state of the power system. The NGO négaWatt advocates for renewables and their scenario presents a future that relies on energy efficiency and sustainable practices for reduction in energy consumption and a 100% renewable and carbon neutral France by 2050.

3.2. Extracting relevant projections

The identified scenarios were analysed individually to extract projections pertaining to the DSO (e.g., distributed generation, RES, storage, digitalization and electrification of the distribution network). The data from all of the scenarios and their variants was collected and as a demonstration of the overview achieved by this exercise, two indicators are highlighted. The annual total consumption of electricity in France, shown in Figure 2, demonstrated how the majority of scenarios project the decrease of consumption on a country level. This, however, is due to energy efficiency measures and the DSO has to consider the projected increase of Electric Vehicles that are mostly connected to the distribution grid. Figure 3 shows the projected annual share of renewables in the French electricity system and the DSO expect to see a similar increase on the distribution grid to the national scenarios and in technologies that fit its geographical locations (PV and hydropower for SOREA).

Table 2 SOREA's baseline and evaluation under two scenarios

Indicator	SOREA Baseline	Evaluation under Scenario 'WATT'	Evaluation under Scenario '50% nuclear'
Distributed Energy Resources (DERs)	Today the distribution system has a limited amount of solar PV and hydropower production. There are a few EVs in the network while the system has high heating demand. However, it is currently not used for flexibility provision. Currently, the network does not have any energy storages, but it is expected soon to be installed. Solutions for PV very short-term PV production forecasting has been recently installed at demo-site	Large decommissioning of nuclear power in France and RES accounting for 71% of total production. For SOREA, an increase of distributed generation in the form of PV and hydropower is to be expected. High penetration of RES can affect the reliability of supply and the grid will have to adapt. Big increase of EVs with multiple charging modes available, so the grid needs to be ready to host the EVs and manage the charging infrastructure. Demand Response is essential and energy storage (intra-day, weekly and accompanying self-consumption) is on the increase. Favourable legislation and improved ICT will push for increase of DERs. DSO needs new solutions to deal with flexibilities on the grid	France keeps a 50% share of electricity produced from nuclear power plants. RES at 44% of total production on the national level so the impacts of renewables on the distribution grids is less pronounced. Minimal increases of weekly and intra-day storage are needed when a high share of nuclear is present. No inter-seasonal storage (e.g., power-to-gas) is required
Level Of Monitoring And Control	The DSO is presently not equipped with the AMIs (advanced measurement infrastructure), but they are expected to be installed soon. However, some substations are equipped with automation systems	High increase of DERs and new solutions necessary on the distribution grid will require an advanced level of monitoring and control to deal with the added complexity on the grid	Low amount of flexibilities and DERs on the grid will demand less evolution for the levels of monitoring and control
System Status	The system has both underground and overhead cables for the distribution purposes, but underground cables are the majority. The distribution network is designed as meshed network. The network has a high level of reliability of supply	High increase of DERs and new solutions necessary on the distribution grid will require an advanced level of monitoring and control to deal with the added complexity on the grid	With less DERs on the distribution grid and dominating nuclear power plants, new solutions for flexibilities, peaks and ancillary services in general might not be profitable or needed on the distribution grid
Cyber-security Description	No information available.	In future active distribution grids, need to take into consideration the risks of cyberattacks on the grid with the spread of ICT	Level of ICT is lower and thus there will be lower risk and security concerns for the DSO
Services And Markets	Limited information provided. Wholesale electricity supply is open to competition.	Including different sides of the distribution grid in the electricity market will require new enabling market mechanisms	Centralised generation and lower opportunity for open markets based on DERs
Tariffs	Grid tariffs are based on fixed cost based on subscribed power and energy charge	Tariff schemes have to accommodate the remuneration of flexible demand and distributed generation	Less DERs might not require a big overhaul of the tariffs schemes
Business Models	Feed in tariffs for PV and hydro	New business models are needed to accommodate DERs	No changes for current Business Model

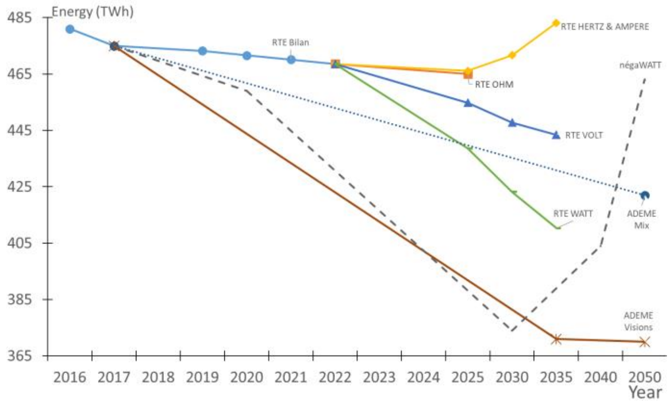

Fig. 2 Annual consumption projections in France

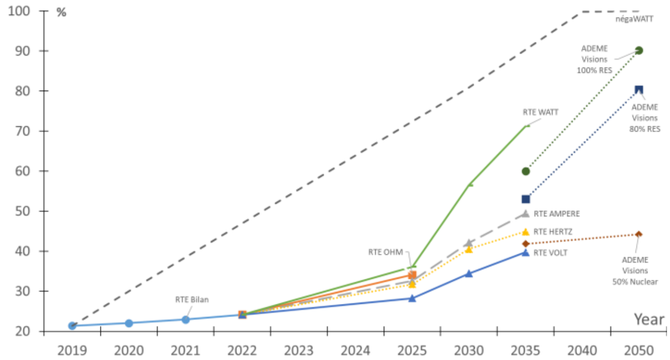

Fig. 3 Renewables share of annual electricity production in France

3.3. *Impacts and requirements*

The identified scenarios were elaborated by different sources: two from the national energy agency, one study from the national TSO and another developed by an NGO. This variance in sources represents an overview of available possible futures for the electricity system in France. An evaluation of all the scenarios could be made, but for this study case, SOREA was evaluated under two scenarios with opposing views of the future. RTE's WATT is a scenario with a decentralized view of the future and high share of renewables in the system. While ADEME's '50% nuclear' vision is a more centralized view of the future electrical system where France keeps a high share of its nuclear power operating. When using scenario analysis, the focus is on a specific time range depending on the intended application. For this study case, the interest was the challenges that DSO will face in the near future and the evaluation is for the data points of year 2035 in the scenarios. The impact of the two scenarios on the DSO's baseline and the general requirements to face future challenges are summarized in Table 2. The table 2 also shows the baseline of SOREA that was previously established in [4]. The column of evaluation in the table describes the gap between the DSO's baseline and each scenario's extracted projections. It also includes a general requirement of what SOREA would need to prepare for each of these two possible futures. It is shown that SOREA's distribution grid requires new technical and non-technical solutions to accommodate the changes in the electricity system and the high increase of DERs in a scenario that emphasises DERs like 'WATT'. While in a scenario with more of a centralised view of the electricity system would, like the 50% nuclear of ADEME, less changes and evolution would be required from the DSO.

4. Conclusion

This paper presented a process that breaks down energy transition scenarios to the level of distribution network. The process establishes DSO-specific scenarios and consists of a baseline of DSO that describes current technological, regulatory and market environment it is operating in; extraction of relevant projections, and finally, determining the impacts of the scenarios on DSO and any required changes it need to face the future challenges. A study case where applying the proposed approach was presented. This shows how applying scenario analysis to an individual DSO helps in planning the future of its grid. A DSO can apply this approach to help in different investment and design decision to ensure a good operation of its future electrical system.

5. Acknowledgements

The work presented in this paper was part of the results from the UNITED-GRID project which has been funded by the European Community's Horizon 2020 Framework Programme under grant agreement no. 773717.

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