MODELLING AND FLEXIBLE LONG-TERM PLANNING INTEGRATING INNOVATIVE TECHNOLOGIES FOR THE DISTRIBUTION GRIDS OF ZURICH

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ABSTRACT

Long-term distribution grid planning for a sustainable, active and flexible energy system is challenged with many new uncertainties. In a referendum held in 2008, the population of Zurich voted in favour of achieving the 2000-Watt Society by 2050. In order to reach this goal energy efficiency, renewable energies and mobility have been identified as important fields of action. In addition to the unknown penetration of the renewable production in the future, uncertainties for the distribution system operators (DSOs) include the impact of storages, regulatory framework, technological innovations and the Internet of Things. ewz, the DSO of the city of Zurich is currently investigating the impact of these drivers on the future distribution grid.

INTRODUCTION

Due to the long life duration of assets from more than 50 years, distribution grid planning has always to be based on a prognosis for several decades. Traditionally, the main drivers for distribution grid development have been load growth and additional connections to new supply areas. Recently, the main focus has shifted to incorporating the large expected increase of renewable production. New technologies have also started changing the tasks the distribution grid operator has to fulfil. The new role of the customer as prosumer and the rollout of the Internet of Things will require more flexibility from the DSO.

PROJECT "FUTURE DISTRIBUTION GRID"

ewz, the DSO of Zurich, is currently investigating the influence and interaction of these and other drivers in the project "Future distribution grid". The objective is to have a basis for future grid concepts and strategic investments. Scenarios have been defined and a prognosis of the quantity structures and grid costs for these scenarios is made. The scenarios include a forecast of the most relevant factors until 2050 and range from conservative to extremely sustainable. Criteria for the selection of the most relevant factors are that they exert a strong influence on the supply task, are quantifiable and have a broad range of possible forms. Accordingly six key factors have been selected: extending new decentralised power production, capacity of decentralised stationary storage systems, load development, electromobility, load management and power quality.

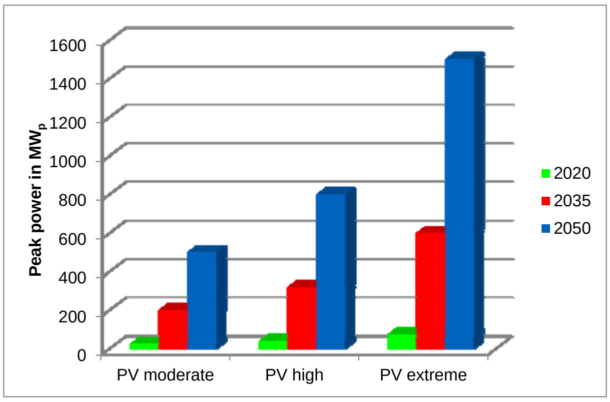

Figure 1 Forecast PV Production

The first five factors have a direct impact on the power balance in the grid. Power quality as sixth factor determines the redundancy of the system. For each key factor two to three forms have been projected for 2020, 2035 and the target year 2050.

Scenarios / Key factors	«Business as usual»	«Realistic»	«Sustainably und flexibly»	«Extremly sustainable»
Extending new decentralised power production	PV moderate (c. 500 MWp)	PV high (c. 800 MWp)	PV high (c. 800 MWp)	PV extreme (c.1500 MWp)
Decentralised stationary storage systems	None	70% of PV-peak power (i.e. 560 MW)	70% of PV-peak power (i.e. 560 MW)	70% of PV-peak power (i.e. 1050 MW)
Load development (without electromobility)	Maximum load rises through high-density construction (800 MW)	Maximum load rises through high-density construction (800 MW)	Maximum load stagnates (520 MW)	Maximum load stagnates (520 MW)
Electromobility	Portion of 10% of cars	Portion of 60% of cars	Portion of 90% of cars	Portion of 90% of cars
Load management	No additional potential	Additional potential 15 MW	Additional potential 30 MW	Additional potential 30 MW
Power Quality	Present target value ewz Stadt Zürich	Approximation to target values VSE Distribution Code	Approximation to target values VSE Distribution Code	Approximation to target values VSE Distribution Code

Table 1 Scenarios for Zurich

Changes in the general framework for example the introduction of a different regulation scheme or technological innovations as the internet of things can influence the key factors within a short time span. Therefore monitoring of the general framework is essential.

MODEL "GRID EXPANSION"

The prognosis of quantity structures is determined with a simulation model. The simulation model comprises load flow and capacity calculations, replacement due to age and statistical clustering of characteristic sub grids. Grid costs based on the Swiss grid charge regulations and the asset structure of ewz are evaluated with an economic model. The simulation model should give an assessment for the development of the distribution grid within the next 45 years and the quantity structure according to the different scenarios. It has been modularly constructed which allows combining rough top down and detailed bottom up analyses and synthesising both within a statistical analysis. The load flow is decisive for the determination of the required capacity of the grids. The present networks are designed primarily for future load increase. Therefore a rising decentralised production may lead to limit violations earlier as spatial distribution of load and production differs. Consequently models have been constructed, which evaluate the load flow for subnetworks. Lines (cables) and transformers constitute the bottlenecks for load flow in the grid and are therefore considered as key components.

The simulation model has been developed based on the existing distribution grid with regard to key components. Grid extension measures are represented in form of a statistical forecast of the quantity structure. The statistical prognosis is based on the number of key components which are overloaded or exceed voltage limits. Scenarios are transferred to load flow calculations by translating the set of key factors into load cases.

The capacity of the grid is always designed for the expected extreme load flow situations. This is because overloading of electric components results in their failure whereas underloading does not result in problems. However, electrical components increase in cost with their rating. Therefore the challenge for grid design is to estimate the maximum loading of the components as accurately as possible. An accurate prognosis permits to choose the optimal design as to cost and supply reliability.

For each of the scenarios two load cases are analysed:

- Extreme case “Load”: Maximum load with no PV generation
- Extreme case “Gen”: Maximum PV generation with minimum load (estimated at 30% of maximum load)

Based on the assumed development of load and decentralised generation in the four scenarios the overloading of the components is determined for 2020, 2035 and 2050 based on the actual grid structure.

For the grid in Zurich decentralised generation is driven by photovoltaics, as wind generation is not economically viable. The distribution grid of Zurich is completely modelled in programs for load flow calculation with the exception of the low voltage grid. Therefore a statistical approach has been chosen for the low voltage grid. Decentralised generation having been identified as the main driver for grid expansion, 15 representative low voltage subgrids have been chosen by assigning the prospective PV potential to all transformer stations for central and periphery substations respectively. Figure 2 shows the selection methodology for the representative subgrids for the central substations.

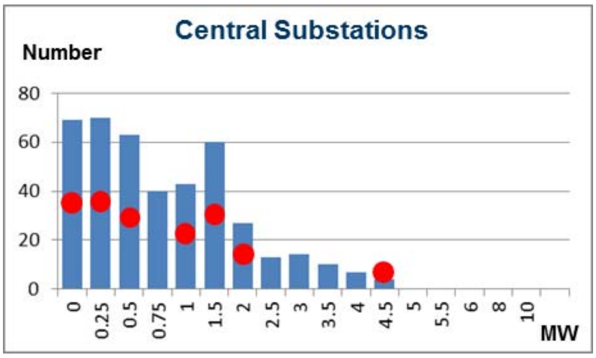

Figure 2 Histogram of photovoltaic potential

MODEL “NEW TECHNOLOGIES”

A separate parametric model is used to assess the impact of new technologies. This model applies the parameters which have been identified in the simulation model and interrelates the existing and new drivers. In a top down approach the impact of new technologies based on their potential to shave load/generation peaks is assessed. For the storages different concepts have been taken into account.

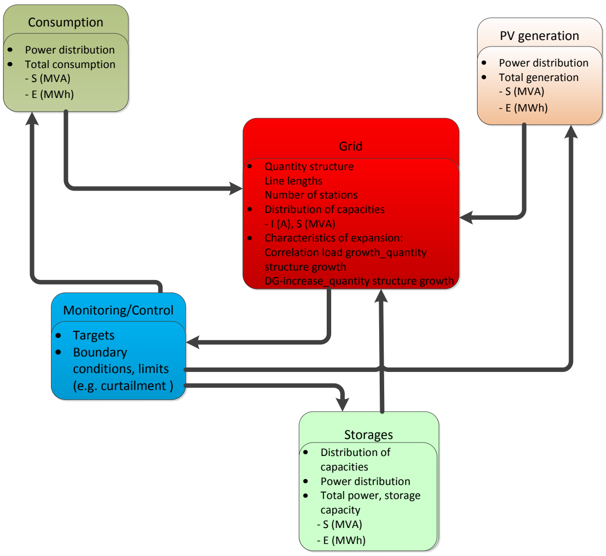

Figure 3 Parametric Model for Simulating the Impact of New Technologies

RESULTS

The method allows a solid prognosis until 2050 for different scenarios and lays the fundament for a strategic asset management. First results show that the distribution grid in Zurich is well prepared for the coming challenges and very few bottlenecks will occur until 2020. In the medium term load growth is the dominating driver for grid development for the conservative scenario, i.e. moderate growth of PV. From 2035, the grid development is driven by PV increase for all scenarios.

DISCUSSION

The fundamental infrastructure of the grid will still be planned with long investment cycles, but as external constraints can quickly change, more flexibility will be crucial for efficient distribution grid planning. Short and middle term options such as storage, network monitoring and control will have to be incorporated.

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