SHAPING THE FUTURE CROATIAN DISTRIBUTION NETWORK WITH THE TEN-YEAR NETWORK DEVELOPMENT PLAN

Sandra HUTTER
Croatian Energy Regulatory Agency – Croatia
shutter@hera.hr

Lahorko WAGMANN
Croatian Energy Regulatory Agency – Croatia
lwagmann@hera.hr

ABSTRACT

The Distribution system operator adopts and publishes an annual update to the ten-year distribution network development plan (TYNDP), which provides budgetary and economic analyses for the projected capital investments and establishes a list of priority areas in need of infrastructure upgrades.

INTRODUCTION

Croatia's economic growth of the past decade has been mainly due to the development of tourism as the slogan of the Croatian tourist agency „A small country for a great holiday!" accurately points out. Croatia is experiencing a tourism boom in the coastal regions while inland rural areas mostly in Slavonia are being drastically depopulated.

The crescent shaped territory of Croatia is characterized by a diversity of geographic landscapes including lowlands in the northeastern region of Slavonia, and mountainous regions of centrally located forest rich Gorski Kotar, and Lika, and the mountain range of the Dinaric Alps that runs parallel to the Adriatic coastline comprising 48 inhabited islands. It is difficult to justify the investment in areas of low population density, such as Lika and Gorski Kotar with 10 inhabitants/km2. The lack of infrastructure investments in those areas will on the other hand probably precipitate their depopulation and reduce living standards. Investment in these areas should therefore be carefully planned and also take into account the specificities of the local climate such as harsh snow laden winters with sub-zero temperatures typical of Croatia's mountainous regions.

The implementation of the TYNDP is necessary to preserve the safety and reliability of the energy supply, which requires investments for the renewal of the grid infrastructure. The three main goals of the TYNDP should be the improvement in supply quality, an increase in grid capacity and creation of the solid foundations for sustainable growth in the next decade.

Croatian Distribution System Operator

In Croatia, HEP-ODS – Croatian Distribution System Operator, provides the public service of electricity distribution, and is responsible for the operation, management, maintenance, development, and construction

Fig. 1. Distribution area divisions in Croatia [1]

of the distribution network, as well as for ensuring the long-term capability of the network to satisfy reasonable requirements for the distribution of electricity.

HEP-ODS serves approximately 2,445,000 residential, commercial, and industrial customers. The company's service area includes approximately 56,594 km^2, and is divided in 21 distribution area, shown in Fig. 1. [1]

HEP-ODS delivery system with overall length of approximately 140 400 km comprises 68 842 km of overhead distribution lines, 35 000 km of underground or submarine cables, and 26 259 substations.

The total electricity consumption of the Croatian distribution power network in 2017 was 16 695 TWh. The peak load of the Croatian electric power system in 2017 was 3 079 MW. The peak load of the Croatian electric power system was recorded during the summer months for the last three years. [1]

Figure 2. shows basic information on the number of transformer substations and the installed power of the transformer fleet, length of lines, installed power of connected power plants, and the number of billing metering points in the distribution system.

The Croatian distribution grid has two transformation schemes: 110/35(30) kV together with 35(30)/10 kV and direct transformation 110/10(20) kV, and two medium voltage network levels of 35(30) kV, and 20 kV or 10 kV.

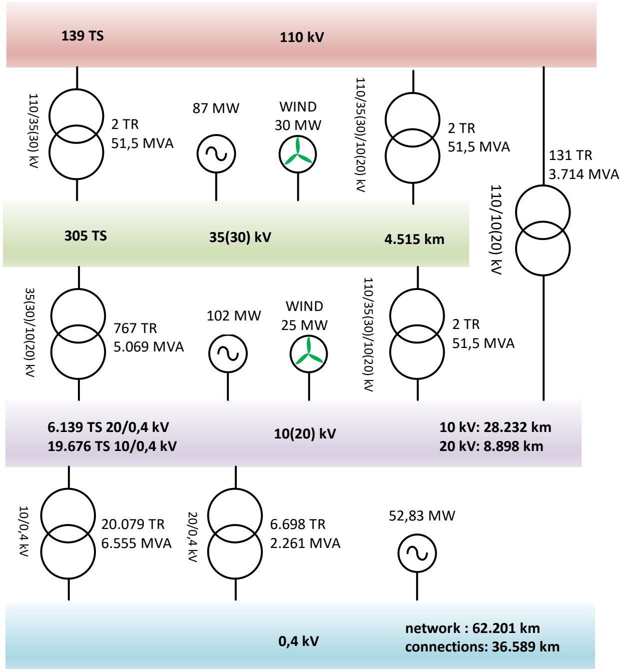


Fig. 2. Basic information about the distribution system as of 31 December 2016 [2]

The long term goal of the Croatian Distribution System Operator as projected in the Ten-Year Network Development Plan (TYNDP) [1], is to create a distribution network with only one medium voltage network level of 20 kV and one direct transformation of 110/20 kV.

The transition will be executed as follows:
1. Introduction of 110/10(20) kV direct transformation
2. Gradual elimination of the 35(30) kV medium voltage grid
3. Replacement of the 10 kV grid with the 20 kV grid.

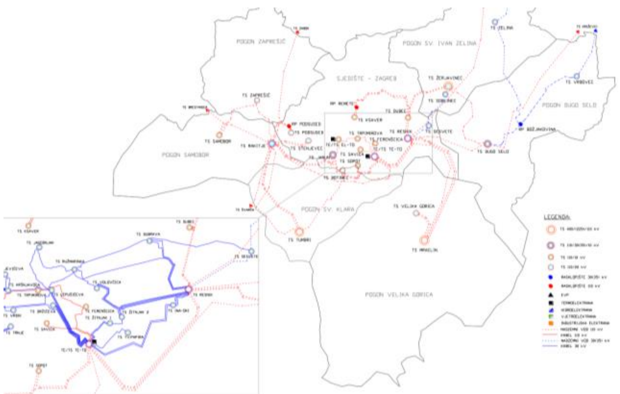
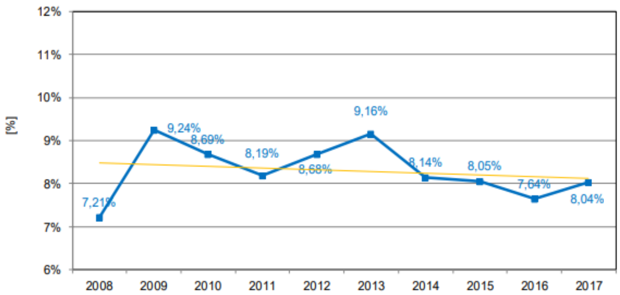


Fig. 2. Simplified topological schematic of the 110 kV and 35kV Zagreb distribution area [1]

The introduction of a unique 110/20 kV direct transformation system, will reduce the size of the 35 kV grid and the existing 35 kV corridors and cables will be repurposed for 110 kV overhead lines and 20(10) kV cables, respectively.

Losses in the distribution network

Losses of electricity in the distribution network amounted to 1.34 GWh in 2017 or 8,04 % of the procured electricity. Fig. 3. shows the amounts and percentage of losses in the distribution network from 2010 to 2017.



Source: HEP-ODS

Fig. 3. Losses of electricity in the distribution network from 2010 to 2017 [1]

HEP-ODS concentrated on measures for reducing losses in the distribution grid as a part of measures for increasing energy efficiency. HEP-ODS's goal is to reduce total electricity losses (technical and non-technical) down to 7.75 % (± 0.25 %) of the total annual electricity supply of the distribution network by the end of 2019. [1] In our opinion a reachable long-term objective for the next ten-year period should be reduction of total electricity losses in the distribution network of under 6%.

Upgrades in MV and LV grids, which include an increase in the cables' cross-section, aim to improve the voltage profile of the distribution network and reduce the technical losses that occur during electricity distribution across the grid. The transition from a 10kV to a 20kV MV grid complemented with infrastructure upgrades and the optimization of the LV conductor network should greatly reduce the above mentioned technical losses. In the next ten years this program will comprise around 8500 substations MV/LV and 14 000 km MV network. The share of technical losses is estimated to be 51% of the total energy losses (TL), while non-technical losses account for the remaining 49%. Non-technical losses can be reduced by the implementation of the following measures: a better identification of high net losses areas, careful monitoring of household consumption measurements to avoid errors and fraud and the optimization of load flows and connections.

PLANING CRITERIA

Planning criteria allow the identification of developing problems and ensure that plans adequately address service requirements. The purpose of planning criteria is to create a safe, secure, reliable, and high quality electricity supply and minimize the cost of the provided service. At the same time, environmental and social considerations have to also be taken into account in the planning process [3], [4], [5].

Distribution planning criteria

Planning criteria for the distribution network are addressed through following main requirements:
- Voltage limits should be maintained
- (N-1) Contingency Planning
- need to provide a reliable electricity supply
- need to provide a secure electricity supply.

In the planning stage it should also be insured that the following criteria are fulfilled:
- normal rating capacity limits of the distribution equipment should be respected,
- voltage drops as well as voltage fluctuations should be within permitted thresholds,
- contingency and routine replacement plans of old/damaged equipment have to be included.

Reliability Analysis

The two commonly used reliability indices system average interruption frequency index (SAIFI) and system average interruption duration index (SAIDI) were adopted by the Croatian Energy Regulatory Agency in the bylaw “Rules on the Quality of Electricity Supply” in March 2017.

The SAIFI index represents the average number of sustained interruptions per customer in a predefined area. It is the total number of interruptions for all customers divided by the total numbers of served customers. The SAIDI index represents the average outage duration for each served customer. These two indices serve as a reliability indicator of the distribution system operator and are annually reported to the regulatory agency. [3]

The distribution system operator reports annually about interruptions for each 10(20) kV feeder in the format defined in the Rules on the Quality of Electricity Supply. Starting from the January 1st, 2020 customers will be entitled to receive, upon request, a compensation fee if the reliability criteria are not met. Distribution substations with poor voltage profiles are recorded annually together with the restoration plan. Implementing automation schemes will help decrease the number of customers affected by single outage events.

The adoption of the Rules on the Quality of Electricity Supply is the first step towards the regulation of the quality of electricity supply. The goal of these regulatory measures is a gradual decrease in the number of electricity supply interruptions and shortening of their duration as well as the minimization of the repair time. A possible introduction of a penalty/reward scheme in the distribution tariff determination may further reinforce that goal. We therefore hope that the years to come will be years of improved SAIFI and SAIDI.

Table 1. Reliability criteria in the MV network (for the planning purposes)

Network type	SAIDI (min./year)	SAIFI (inter./year)
Urban, mainly cable network	120	2
Suburban areas and larger settlements	240	4
Rural networks	360	8

TYNDP 2019-2028

According to the provisions of the Electricity Market Act, the distribution system operator adopts and publishes annually an updated ten-year distribution network development plan and delivers it to the regulatory agency for approval. The transmission system operator and the distribution system operator are obliged to harmonize development plans regarding construction progress and the funding of common assets (mainly 110/x kV substations).

In the next TYNDP [1], HEP-ODS anticipates an annual budget of approximately 1 billion HRK (Croatian Kuna) to realize all the projected investments from 2019 to 2028.

During the relevant ten-year period, HEP-ODS plans to invest 63,6% of assets into energy facilities (comprising HV, MV and LV), 21,3% of assets into secondary systems, metering devices and projects for development of advanced network and new technologies, 9,8% into business infrastructure and 3,5% into Smart grid pilot projects. Table 2. shows the estimated total investment in the development of the distribution network for the ten-year period (2019 – 2028). [1] The ratio between funds allocated to new construction and the renovation of existing infrastructure is approximately 1:2.

Table 2. Estimated investment in the development of the distribution network for the ten-year period *(2019 – 2028)*

Investment category	Amount [Thousands HRK]
Transformation 110/x kV and MV network 35 kV	1.830.082
Medium-voltage network 10(20) kV	1.771.766
Low-voltage network 0,4 kV	656.895
SCADA, DMS, automation of MV network, smart meters and investments into new technologies	1.549.200
Business infrastructure	654.500
Smart grid pilot project	233.745
Network reinforcement requirements (for new connections) and electric power connections	3.500.000
Total	**10.196.197**

Source: *HEP-ODS* [1]

Smart grid pilot project [6]

The smart grid pilot project comprises the partial computerization of the Croatian electricity distribution network. The installation of advanced measuring equipment will enable a more precise loss calculation and will also localize areas with increased losses in the distribution network, while monitoring electricity consumption and active consumption management by end customers. For that purpose summative meters will be installed in 6 125 substations, and 24 000 existing end customers' meters will be replaced by smart meters. 449 currently used transformers will also be replaced by energy efficient transformers.

The medium-voltage network will be automated with the introduction of remotely controlled line switches and 10(20) kV substations, thus increasing the reliability of supply by reducing the duration of unplanned outages and creating technical preconditions for a wider integration of renewable resources into the electricity distribution network. The pilot system of smart grids will be introduced into five out of the total of 21 HEP ODS distribution areas (Zagreb, Split, Osijek, Zadar and Dubrovnik) in the period between 2018 and 2022.

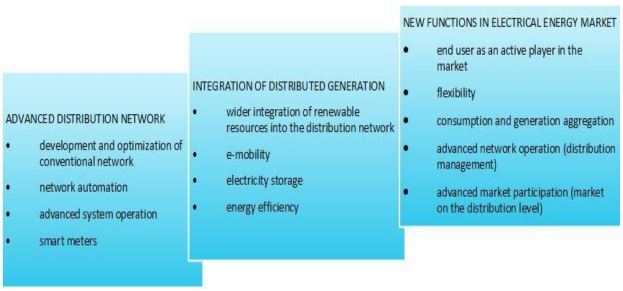


Fig. Different stages of implementation of advanced network

The distribution system operator projects further improvements following the introduction of modern technologies and the optimization of network operation.[4]

Energy efficiency

A study has been conducted to assess the potential for increasing the energy efficiency of the electricity infrastructure.

The study analyzed implemented actions that had an impact on technical losses (decreases and increases) during the ten-year development plans for the transmission and distribution systems for the period from 2016 to 2025.

Based on the study, the average annual gain in energy efficiency could amount to 25GWh for the distribution network for the period from 2016 to 2025. If the guidelines of the ten-year development plans for the period from 2016 to 2025 are followed. [2]

CONCLUSION

TYNDP will enable timely infrastructure investments resulting in the standardization of the grid equipment (substations, lines, etc.), prepare the construction of capital objects, and establish long term plans for connecting transmission and distribution networks, for efficient infrastructure building and for the spatial evolution of the distribution grid.

REFERENCES

[1] HEP-ODS, 2018, "*Ten-Year Development Plan for the HEP-ODS Distribution Network from 2019 to 2028, with a Detailed Elaboration of the Initial Three and One-Year Periods*", HEP-ODS, Zagreb, Croatia.

[2] Croatian Energy Regulatory Agency, 2017, "*Annual Report 2016*", HERA, Zagreb, Croatia.

[3] Technical Manual Iberdrola USA, 2012, "*Distribution Planning Criteria*", USA.

[4] Viktoria Neimane, 2001, Doctoral Dissertation "*On Development Planning of Electricity Distribution Network*", KTH, Department of Electrical Engineering, Electric Power Systems, Stockholm, Sweden.

[5] PowerWater, 2003, "*Power Networks - Network Planning Criteria*", Australia.

[6] https://www.hep.hr/hrk-230-million-to-be-invested-into-smart-grids-by-2022/3356