

# Croatian transmission network development and possibilities of new interconnection lines building

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**Abstract**—Croatian transmission network has been developed as a part of former Yugoslavian transmission network, so it was adjusted to the shape and characteristics of the former state. New circumstances in economy and energy usage appeared after the Republic of Croatia and other former Yugoslav republics became independent. Croatian transmission network has to be strengthened and redesigned according to the country shape. Because of the specific country shape and process of electrical energy market liberalisation we expect that stronger connection with neighbourhood countries and building of new 400 kV interconnected lines will be very interesting as a part of transmission network and power system development. This paper presents actual state of Croatian transmission network, deals with possible ways of network development. Possibilities of new interconnection lines building are estimated.

**Index terms**—transmission network, 400 kV interconnection lines, network development, possibilities of new interconnection lines building

## I. INTRODUCTION

Transmission network is very important part of electric power system, which determines its characteristics and quality together with production facilities and distribution network. Transmission network main task is connection of the power plants and large groups of consumers, which are located on larger and smaller distances. Transmission network makes possible the most economical and most favourable combination of power plants production in single moment, and safely consumers supply depending on network strength and design.

Additional benefits that make electric power system more efficient and safe could be achieved with the building of interconnection lines between neighbouring power systems. Power system interconnection causes more economical production facilities usage. Differences and particularities of separated systems are decreased compared to the connected systems, which is especially significant in a case of large share of hydro production. The needs for new power plants construction are less in connected power systems.

Croatian electric power system is connected to the electric power systems of Slovenia, Hungary, Bosnia and Herzegovina and Yugoslavia through six overhead 400 kV lines, nine 220 kV lines, and twenty one 110 kV lines. All

interconnection lines to Yugoslavia, as well as interconnection lines between northern Croatia and Bosnia and Herzegovina except 220 kV line Đakovo-Tuzla, are out of operation due to the war damages, especially due to the destruction of the transformer station 400/110 kV Ernestinovo in 1991. 400 kV line Konjsko-Mostar is in operation under 220 kV voltage level due to the unavailability of the 400 kV facility in Mostar.

Electric power systems of Croatia and Slovenia are connected through two 400 kV lines (one of them is double circuit line), two 220 kV lines and three 110 kV lines. These lines connect Croatian power system to the UCTE, and allow us to import / export electrical energy from / to western countries. Poor connection with the electric power system of Hungary through two 110 kV lines Nedeljanec-Sojtor and D. Miholjac-Siklos has been improved with new double circuit 400 kV line Tumbri-Heviz, built at the end of 1999. With the building of that line, possibilities for electrical energy exchanges between Croatia and other UCTE countries have become much better. This line is in operation with only one circuit today, since the decision of Slovenian transmission company ELES about the building of the 400 kV line Maribor-Heviz, which is more interesting for Hungarian transmission company MVM, is not known yet.

In the middle term time horizon one more 400 kV interconnection line for Hungary (Ernestinovo-Pecs) has a building prospective. For a long term time horizon new 400 kV interconnections between Croatia and Bosnia and Herzegovina (Tumbri-Sisak-Bihać, Obrovac-Bihać), between Croatia and Yugoslavia (Ernestinovo-Obrovac), and between Croatia and Italy (Savudrija-Monfalcone/Planais) are especially interesting for researches.

## II. CROATIAN TRANSMISSION NETWORK DEVELOPMENT

Croatian electric power supply company (HEP) has prescribed that transmission network of Croatia should be constructed according to the N-1 criteria. In the case of unavailability of one transmission network branch (overhead line, cable, transformer, interconnection line) following events should not happen:

- permanent disturbance of operational variable limits (voltages, short-circuit power) and equipment loading

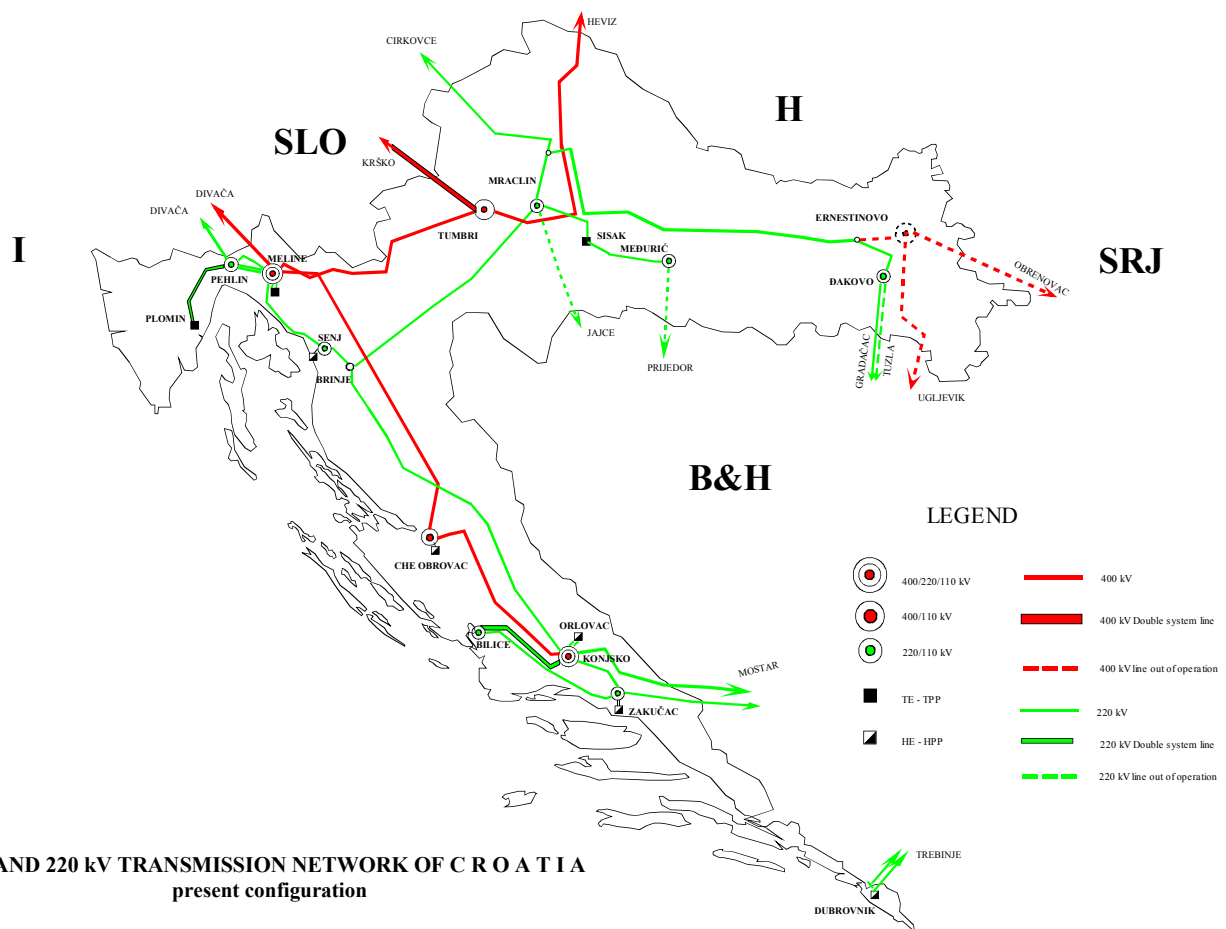
(maximum permitted current), which could be dangerous for safely operation of power system,

- electrical energy supply interruption,
- loss of stability of some power plants,
- necessary change or interruption of long term contracted electrical energy transmission (import, export, transit).

HEP has also prescribed some basic principles of transmission network planning that should be included into planning process:

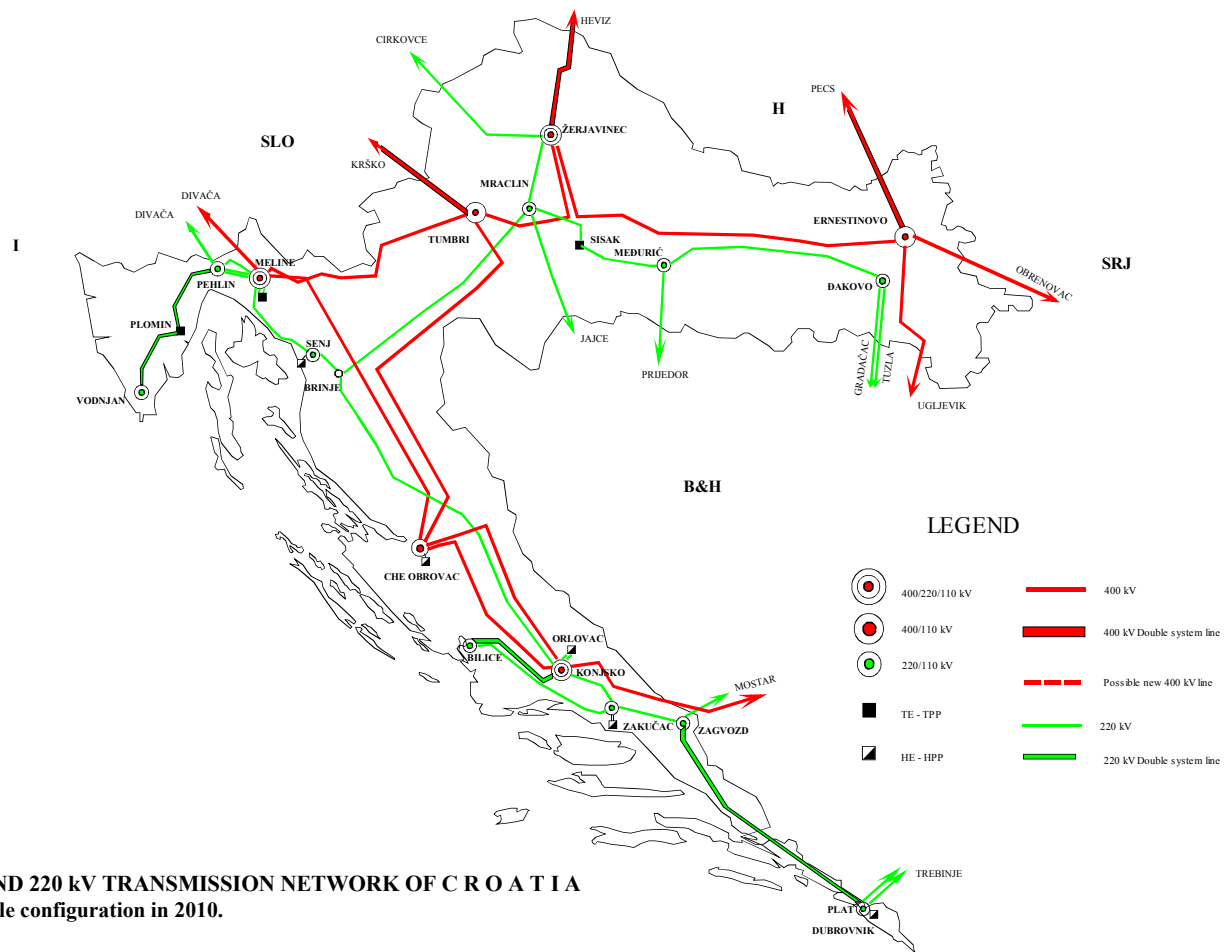
- Croatian transmission network should be constructed as independent and self-sufficient network according to the N-1 criteria.

- Transmission network should be connected with neighbouring power systems (FRJ, B&H, Hungary, Slovenia, Italy) if that connections are in common interests. Electrical energy transits for third parties are permitted if safely operation of Croatian power system is not imperilled with such transits.
- More intensive development of 400 kV network and less intensive development of 220 kV network is expected. Temporary usage of 400 kV lines under the 220 kV operational voltage is permitted.
- Concerning the problems with transmission network corridors and routes and environmental protection, new lines should be in general constructed as double system circuits.



During the last ten years several studies about transmission network development have been made. The last one is "Croatian power system development till 2030" made by Energy Institute "Hrvoje Požar" in 1998. Croatian transmission network in that study has been planned according to the already mentioned N-1 criteria and basic principles mentioned above, but together with economical approach based on *Mexico* model. *Mexico* is probabilistic model based on DC power flows, *Monte Carlo* method and linear programming. Main assumptions for that study were following:

- peak load in studied period  $\Rightarrow$  2758 MW (2000.)  
4840 MW (2030.)
- unsupplied electrical energy cost  $\Rightarrow$  5 DEM/kWh
- rebuilding of all transmission facilities destroyed during the war till 2000
- building of new power plants according to the referent generation plan made in the study
- assumed (not defined) locations of new power plants
- 220 kV network remains in operation until the end of studied period



**400 AND 220 kV TRANSMISSION NETWORK OF CROATIA possible configuration in 2010.**

The main results of that study were following:

- 400 kV network between southern part and northern part of Croatia has to be strengthened (new 400 kV line Obrovac-Tumbri)
- new 400/110 kV transformer station Žerjavinec in the Zagreb area has to be built
- connection of eastern part of Croatia has to be strengthened with new 400 kV line Međurić-Đakovo which will be in operation under 220 kV voltage level at the beginning of its operation
- feeding of some regional areas (Istra and Dubrovnik area) has to be assured with new 220/110 kV transformer stations and 220 kV lines (constructed for 400 kV voltage level)
- total investments in transmission network development and revitalisation will be about 910 millions of USD till 2010, or about 1.8 billion of USD till 2030.

### III. POSSIBILITIES OF NEW INTERCONNECTION LINES BUILDING

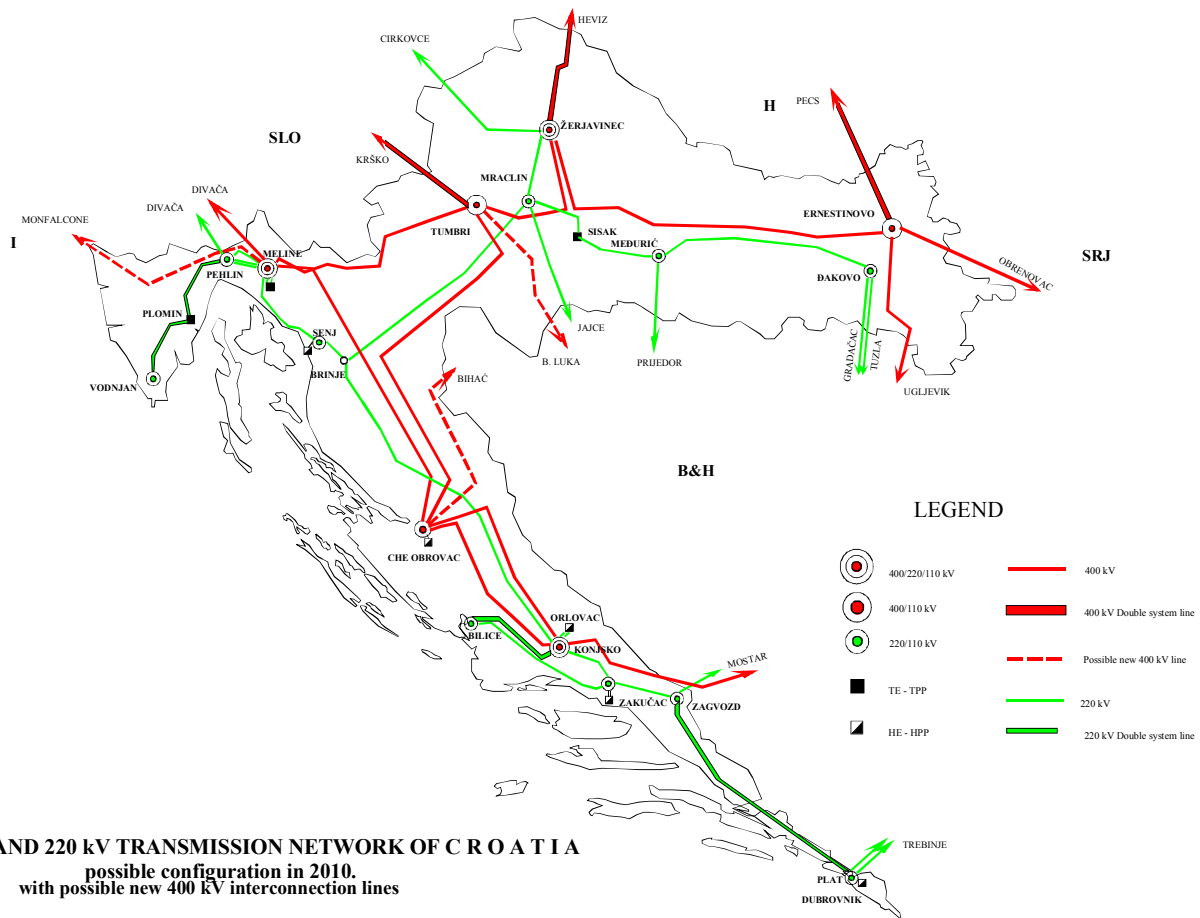
Building of new interconnection lines (mainly 400 kV lines) with neighbouring countries is a reasonable option for Croatian power system because of its position and shape. Country shape is not adequate for construction of well-meshed transmission network without large investments. Position of Croatia between the western and eastern part of UCTE allows us to predict that Croatian transmission network will have significant role in future transits between UCTE countries. Establishing of 400 kV interconnection lines that were destroyed during the war has the absolute priority in short term activities. That comprises following:

- rebuilding of 400/110 kV transformer station Ernestinovo at the eastern part of Croatian electric power system, together with 400 kV lines to Obrenovac (Serbia) and Ugljevik (Bosnia),
- operation of 400 kV line Tumbri (Žerjavinec)-Ernestinovo under rated voltage (today in operation under 220 kV),

- rebuilding of 400/220/110 kV transformer station Mostar in Bosnia and Herzegovina and reparation of complete 400 kV network in Bosnia.

New 400 kV interconnection lines Croatia – Hungary (Ernestinovo – Pecs) and Croatia – Italy (Savudria – Monfalcone / Planais) have been analysed in recent studies [2]. According to those studies, interconnection Ernestinovo – Pecs is very interesting for further analysis in middle-term and long-term period, while interconnection Savudria – Planais / Monfalcone is very expensive (100 mil. \$) and it's not perspective in middle-term period (till. 2010). Advantages of new interconnection Ernestinovo – Pecs are:

- internal Croatian transmission system reinforcement using the parallel 400 kV connection through Hungary,
- additional power corridor for feeding of eastern part of Croatian system,
- higher transit possibilities between north-west to south-east Europe, that is especially economically interesting after electricity market globalisation and UCTE connection to south-east Europe, eastern countries and Africa,
- higher possibilities of electricity import, that provides more economical Croatian power system control.



#### IV. CONCLUSION

Croatian power system has been developed as independent, self-sufficient system, which accepts and uses its position in this part of Europe. After rebuilding of all war damages in transmission system, it will be necessary to reinforce the existing network. That includes reinforcement of south-north-east connection of the Croatian system (south part is characterised by high generation, while northern and eastern parts of the system are characterised by high consumption). Stronger connection to the neighbouring countries should be built if this gives economical interest to both sides concerning electricity transit and exchange. Croatian

development strategy should improve regional electricity market establishing and development.

#### V. REFERENCES

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