# The Electric Power System

## - Serbia -

## DEVELOPMENT OF THE ELECTRICITY ENERGY SECTOR IN SERBIA

* with Kosovo

| POWER INDUSTY OF SERBIA | | 1951 | 1958 | 2007 | 2019 |
|---|---|---|---|---|---|
| Capacity of the Power plants | MVA | 188 | 511,0 | 8.355,0 | 7.664,90<br>8.931,90* |
| Produced electrical energy | GWh | 581 | 1.685,0 | 38.897,0 | 39.639,86 |
| Consumed electrical energy | GWh | 491 | 1.463,0 | 37.785,0 | 33.607,00 |
| Electrification of settlements | % | 29,6 | 55,8 | 100,0 | 100,0 |
| Joint Stock Company „Elektromreza Srbije“ Belgrade - the Serbian TSO (Transmission System and Market Oparator) | | 1951 | 1958 | 2007 | 2019 |
| Length of transmission line | km | 498,0 | 1.880,0 | 9.899,6 | 9.811,07<br>10.866,07* |
| Installed capacity of power transformes | MVA | 35,0 | 393,0 | 17.385,1 | 16.041,00<br>17.624,00* |
| Transmission of electricity | GWh | 511,0 | 1.484,0 | 46.606,0 | 38.834,00<br>38.834,00* |

Exchange of electric power of the electric power system of Serbia with systems of other republics was carried out in the period 1960-1990, in the following ratios of delivered and received electric power.

| Exchange of electric power | 1960 | 1970 | 1979 | 1990 |
|---|---|---|---|---|
| Delivers (GWh) | 95 | 252 | 4.381,0 | 5.422,0 |
| Receives (GWh) | 228 | 573 | 1.757,0 | 926,0 |

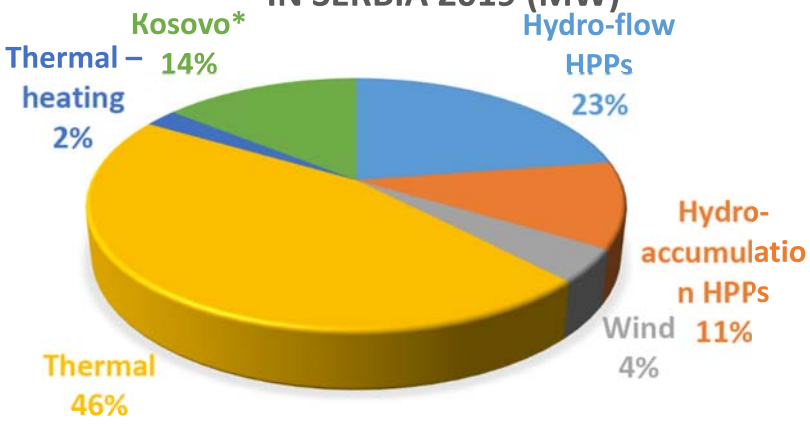
## DISTRIBUTION NETWORK IN SERBIA DURING HISTORY

| Year | Network length (km) | | | Transformer capacity (MVA) | |
|---|---|---|---|---|---|
| | 35 kV | 20 (10 kV) | 0,4 kV | 35/10 kV | 20 (10)/0,4 kV |
| 1946. | 478 | 2.123 | 5.419 | 92 | 190 |
| 1955. | 2.627 | 4.603 | 10.557 | 237 | 305 |
| 1960. | 4.234 | 9.140 | 25.915 | 589 | 732 |
| 1965. | 4.944 | 12.429 | 39.216 | 1.014 | 1.027 |
| 1970. | 5.025 | 16.912 | 51.545 | 1.997 | 2.553 |
| 1975. | 5.963 | 23.227 | 61.063 | 3.481 | 3.782 |
| 1980. | 6.295 | 26.209 | 68.500 | 4.500 | 5.769 |
| 1985. | 6.276 | 31.211 | 72.899 | 5.278 | 7.792 |
| 1990. | 6.548 | 33.425 | 90.450 | 5.845 | 9.785 |

## PRODUCED CAPACITY AND PRODUCTION OF ELECTRICAL ENERGY IN SERBIA DURING HISTORY

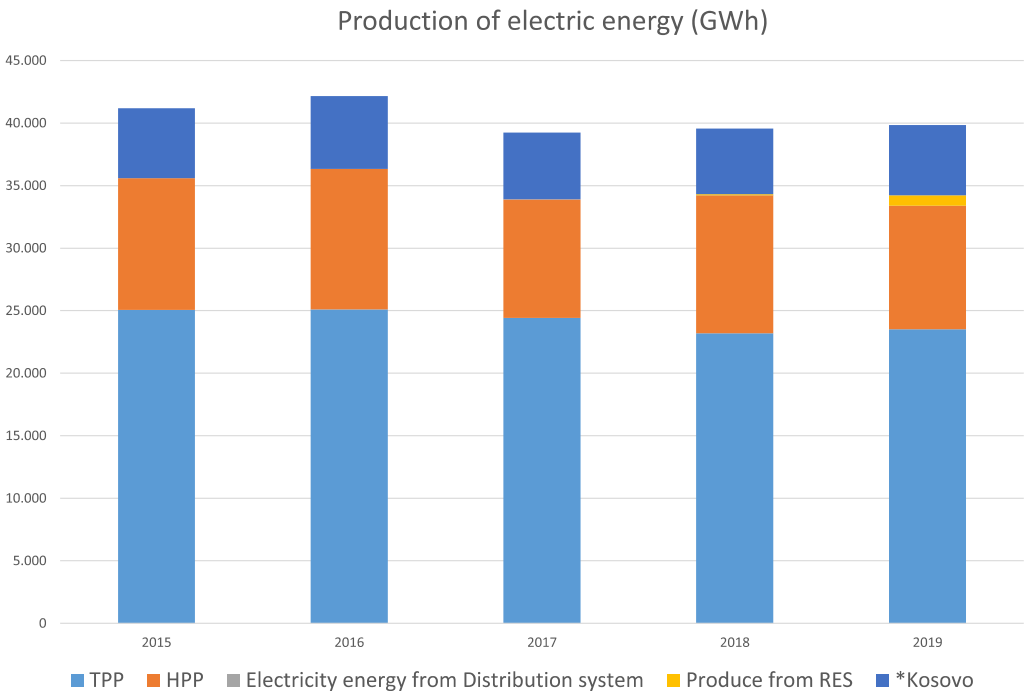
| Year | 1950 | 1960 | 1970 | 1980 | 1990 | 2000 |
|---|---|---|---|---|---|---|
| | Installed capacity (MW) | | | | | |
| HPP | 7 | 298 | 1.067 | 1.855 | 2.812 | 2.812 |
| TPP | 168 | 404 | 1.397 | 2.828 | 5.080 | 5.608 |
| Total | 175 | 702 | 2.464 | 4.737 | 7.892 | 8.420 |
| | Generation of the threshold (GWh) | | | | | |
| HPP | 16 | 1.006 | 3.201 | 10.850 | 8.337 | 10.337 |
| TPP | 586 | 1.024 | 4.191 | 13.645 | 28.256 | 21.227 |
| Total | 602 | 2.030 | 7.392 | 24.495 | 36.593 | 31.564 |

## CAPACITY OF THE POWER PLANTS IN SERBIA 2019 (MW)



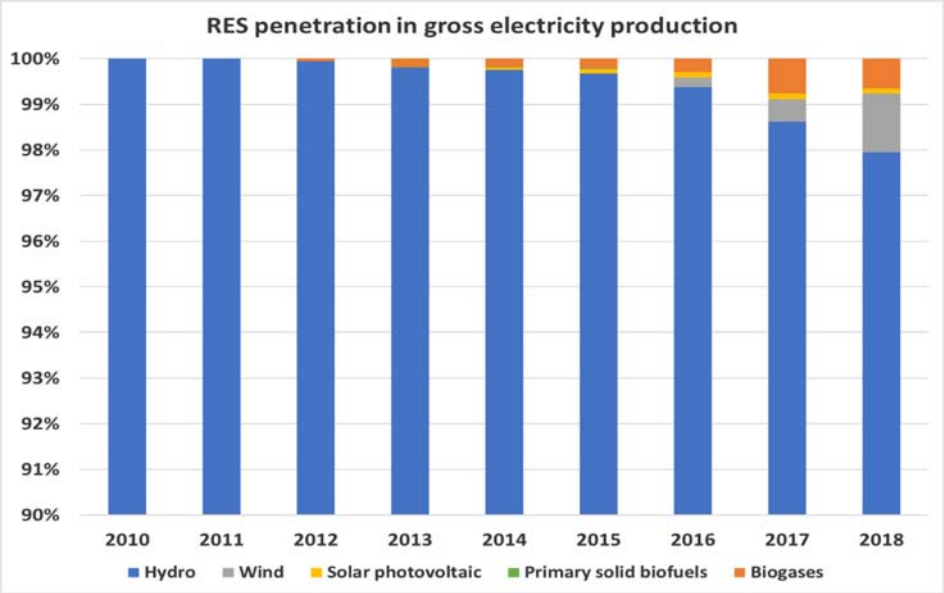

| Capacity of the Power Plants in Serbia 2019 (MW) | |
|---|---|
| Hydro-flow HPPs | 2.015,8 |
| Hydro-accumulation HPPs | 986,1 |
| Wind | 373,0 |
| Thermal | 4.082,00 |
| Thermal – heating | 208,00 |
| Kosovo* | 1.267,00 |

Thermal power plants produced 23,506 GWh, which is 313 GWh more than in 2018 and participated in the total production with 68.69%. Hydropower plants produced 9,884 GWh, or 1,147 GWh less than in the previous year. Electricity pushed from the distribution system is 5 GWh. Produced electricity from renewable energy sources delivered to the transmission system is 830 GWh. The realized production of electricity in Kosovo and Metohija delivered to the transmission system amounted to 5,619 GWh, which is 7.11% (373 GWh) more than the realized production in 2018.



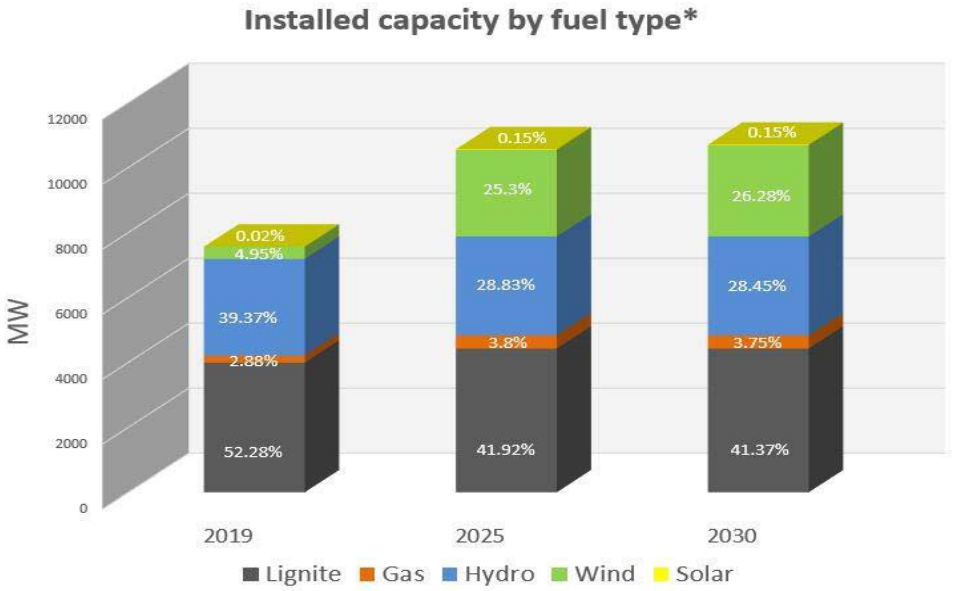
# RES (Renewable sources) goals

- Objective: RES share in the gross final energy consumption in 2020 of 27%
- Production of electricity from RES reduced by 8% in the period from 2010-2018
- Revised RES Directive by EC shall be transposed via EnC to Serbia
- National Energy and Climate Plan still to be prepared (covering the period from 2021 to 2030)
- TSO goal: secure the stability of the transmission system with high RES generation



# Installed capacities development

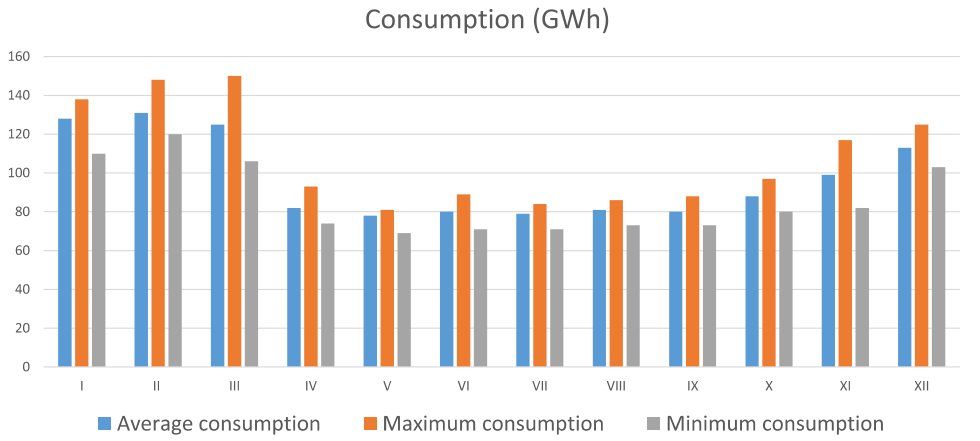
- Significant increase of wind capacities by 2025 (2650 MW)
- Moderate increase of lignite TPP by 2025 (new units are more environmentaly friendly)
- No large PV projects planned
- Flue gas desulphurisation projects (PE EPS)
- Potential balancing issues due to large penetration of RES



**Monthly electricity consumption in the Republic of Serbia (excluding Kosovo and Metohija) in 2019 in MWh**

| Month | Distribution system | Customers in the electricity market | Consumption for the needs of electricity production |
|---|---|---|---|
| January | 3.181.424 | 226.770 | 113.287 |
| February | 2.692.140 | 206.213 | 86.769 |
| March | 2.582.711 | 234.602 | 170.476 |
| April | 2.258.559 | 216.166 | 134.697 |
| May | 2.243.886 | 231.526 | 153.912 |
| June | 2.110.079 | 225.930 | 116.541 |
| July | 2.175.228 | 233.460 | 108.358 |
| August | 2.201.410 | 224.060 | 138.389 |
| September | 2.055.010 | 245.140 | 137.048 |
| October | 2.317.293 | 252.166 | 137.364 |
| November | 2.469.755 | 242.548 | 128.646 |
| December | 2.967.092 | 244.474 | 143.258 |
| **Total** | 29.254.587 | 2.783.055 | 1.568.745 |

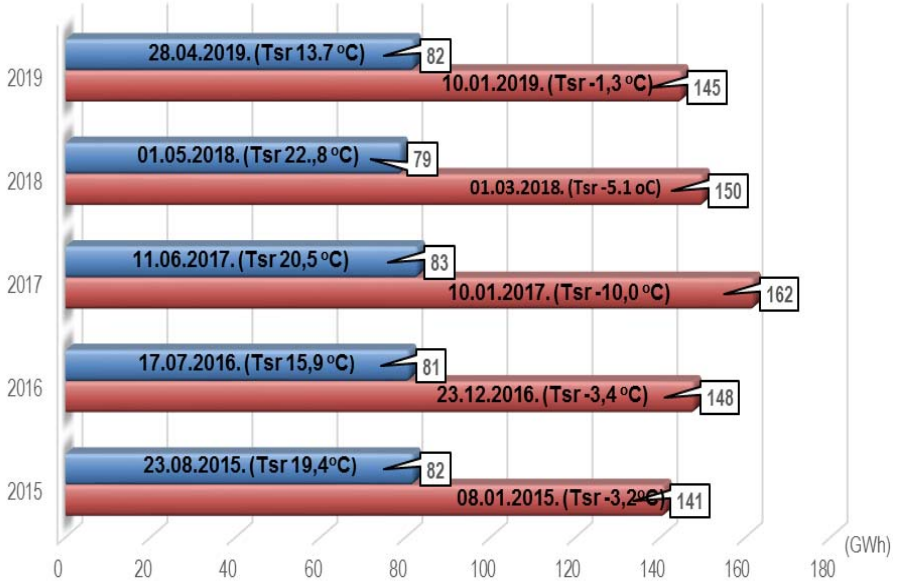
Gross consumption (net consumption plus transmission losses) without Kosovo and Metohija in 2019 amounted to 34,413 GWh, which is 0.66% (225 GWh) more than planned (34,188 GWh) and at the same time 0.42% (146 GWh) ) less than gross consumption in the previous year. The following diagram shows the change in consumption (from Kosovo and Metohija) by months during 2019.




| GWh | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average consumption | 128 | 131 | 125 | 82 | 78 | 80 | 79 | 81 | 80 | 88 | 99 | 113 |
| Maximum consumption | 138 | 148 | 150 | 93 | 81 | 89 | 84 | 86 | 88 | 97 | 117 | 125 |
| Minimum consumption | 110 | 120 | 106 | 74 | 69 | 71 | 71 | 73 | 73 | 80 | 82 | 103 |

# The Maximum gross consumption (from Kosovo and Metohija) by years

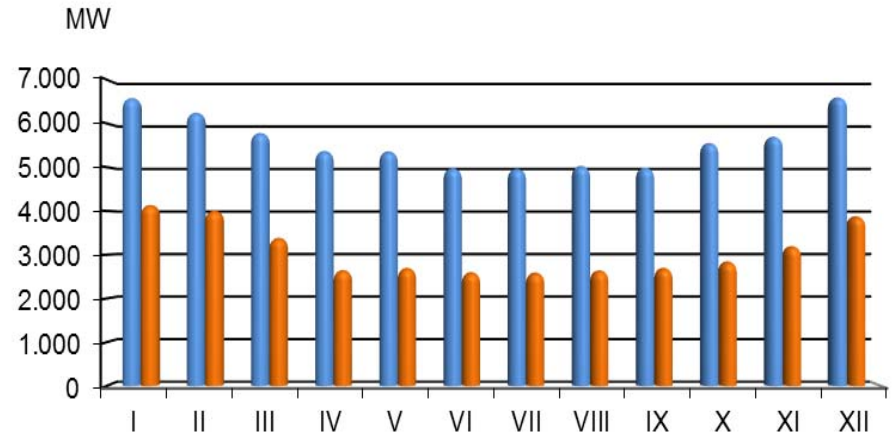
The maximum daily gross consumption (from Kosovo and Metohija) was achieved on January 10, 2019, and amounted to 145,308 MWh, at an average daily temperature of -1.3 ºC. The minimum daily gross consumption (from Kosovo and Metohija) was achieved on April 28, 2019, and amounted to 81,893 MWh, at an average daily temperature of 13.7 ºC.



# The maximum daily gross consumption in 2019

The largest gross consumption realized so far in the power system (with Kosovo and Metohija) was 162,671 MWh, and it was realized on February 8, 2012, due to the ice wave that hit central and southeastern Europe in mid-February 2012.

Average hourly forces (from Kosovo and Metohija) by months




| | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MAX | 6.604 | 6.269 | 5.801 | 5.387 | 5.380 | 4.993 | 4.980 | 5.046 | 5.005 | 5.572 | 5.716 | 6.621 |
| MIN | 4.145 | 4.014 | 3.389 | 2.648 | 2.698 | 2.601 | 2.592 | 2.644 | 2.700 | 2.850 | 3.200 | 3.887 |

Electricity received in the transmission system in 2019 is lower compared to electricity received in the transmission system in 2018 by 1,075 GWh or 2.64%, and electricity delivered from the transmission system in 2019 it is lower than the delivered energy in 2018 by 1,012 GWh or 2.54%.
The following table gives an overview of the transmitted electricity in 2019 in relation to the balance of the planned amount for 2019 and the transferred quantities of electricity in the previous 2018.
The realized transit of electricity in 2019, calculated as the lower value of electricity that entered or left the transmission system via interconnection transmission lines, amounts to 4,281 GWh.

| | Balance | | Realized | | | | Index (%) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2019 | 2019.* | 2019 | 2019.* | 2018 | 2018.* | Realized 2019 / Balance 2019 | Realized 2019 / Realized 2018 | Realized. 2019* / Realized. 2018* |
| Input (GWh) | 41.179 | 47.304* | 39.640 | 45.985* | 40.715 | 46.866* | 96,26 | 97,36 | 98,12* |
| Losses (GWh) | 900 | 900** | 806 | 806** | 868 | 868** | 89,55 | 92,86 | 92,86** |
| Losses (%) | 2,19 | - | 2,03 | - | 2,13 | - | 92,69 | 95,31 | - |
| Output (GWh) | 40.279 | 46.404* | 38.834 | 45.179* | 39.846 | 45.998* | 96,41 | 97,46 | 98,22* |

* Data with Kosovo and Metohija
** In the energy balance for 2019 and 2018, no losses in transmission to Kosovo and Metohija are planned

**Liberalisation of electricity market in the Republic of Serbia implemented on the basis of the Energy Law and Treaty on Establishment of Energy in the South-East Europe Community**

**Electricity market organisation, administration and development**

- Bilateral (OTC) and Balancing markets
- Accounting and settlement of electricity and services
- Procurement of electric energy to cover network losses
- Guarantee of Origin administration and issuance
- Transparency
- Developing, implementing, administrating and maintaining the software system for electricity market
- Organised market (power exchange) – SEEPEX

## Overview capacity of the substations and switchyards of the Joint Stock Company „Elektromreza Srbije“ Belgrade

## Overview capacity of the substations and switchyards of the Serbian TSO (Transmission System and Market Oparator) Belgrade

| Substations and Switchyards EMC JSC | | 31.12.2019 | Difference 2019-2018 | 2018 | 2017 | 2016 | 2015 |
|---|---|---|---|---|---|---|---|
| 400/x kV/kV | Number of substations | 20 | 1 | 19 | 18 | 18 | 18 |
| | Number of transformers | 30 | 1 | 29 | 29 | 29 | 29 |
| | Installed capacity (MVA) | 9.750 | 300 | 9.450 | 9.450 | 9.450 | 9.450 |
| 220/x kV/kV | Number of substations | 14 | -1 | 15 | 14 | 14 | 14 |
| | Number of transformers | 30 | 0 | 30 | 30 | 30 | 30 |
| | Installed capacity (MVA) | 5.631,5 | 0 | 5.631,5 | 5.631,5 | 5.431,5 | 5.331,5 |
| 110/x kV/kV | Number of substations | 8 | 1 | 7 | 6 | 6 | 6 |
| | Number of transformers | 14 | 0 | 14 | 14 | 14 | 14 |
| | Installed capacity (MVA) | 659,5 | 0 | 659,5 | 625 | 625 | 625 |
| TOTAL | Number of substations | 42 | 1 | 41 | 38 | 38 | 38 |
| | Number of transformers | 74 | 1 | 73 | 73 | 73 | 73 |
| | Installed capacity (MVA) | 16.041 | 300 | 15.741 | 15.706,5 | 15.506,5 | 15.406,5 |
| IN TOTAL WITH KandM* | Number of substations | 46 | KandM* according to currently available data | | | | |
| | Number of transformers | 86 | | | | | |
| | Installed capacity (MVA) | 17.624 | | | | | |

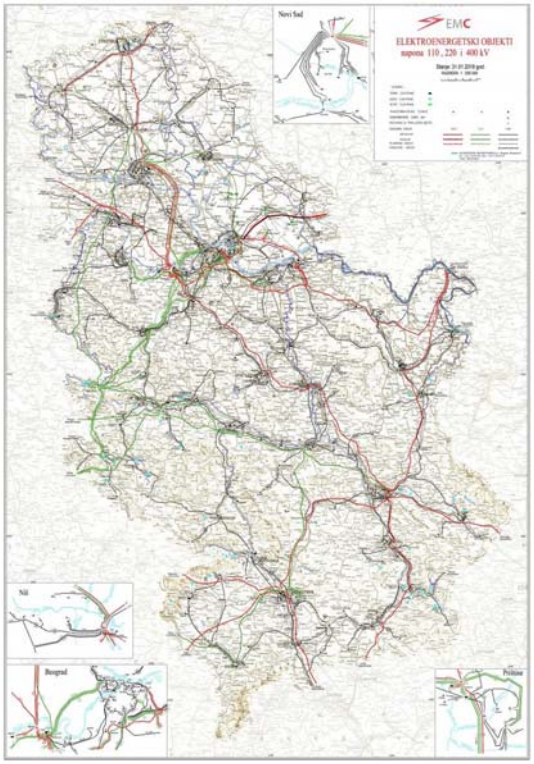
## Overview capacity of the transmission line of the Joint Stock Company „Elektromreza Srbije“
## Overview capacity of the transmission line of the Serbian TSO
## (Transmission System and Market Oparator)

| Transmission lines EMS JSC | | 31.12.2019. | Difference 2019-2018 | 2018 | 2017 | 2016 | 2015 |
|---|---|---|---|---|---|---|---|
| 400 kV | Number of transmission lines | 38 | 1 | 37 | 36 | 34 | 34 |
| | Length of transmission lines (km) | 1798,14 | 10,45 | 1787,69 | 1766,06 | 1629,4 | 1.630,04 |
| 220 kV | Number of transmission lines | 48 | 1 | 47 | 46 | 46 | 46 |
| | Length of transmission lines (km) | 1847,14 | -0,54 | 1847,68 | 1844,59 | 1844,59 | 1.845,51 |
| 110 kV | Number of transmission lines | 370 | 3 | 367 | 358 | 359 | 353 |
| | Length of transmission lines (km) | 5902,17 | 2,76 | 5899,41 | 5805,23 | 5821,29 | 5.785,78 |
| 110 kV | Number of cables | 11 | 2 | 9 | 9 | 0 | 0 |
| | Length of cables (km)) | 42,99 | 6,41 | 36,58 | 36,58 | 0 | 0 |
| <110 kV | Number of transmission lines | 10 | 0 | 10 | 10 | 11 | 12 |
| | Length of transmission lines (km) | 220,63 | 0 | 220,63 | 220,63 | 220,63 | 231,85 |
| TOTAL | Number of transmission lines | 477 | 7 | 470 | 459 | 450 | 445 |
| | Length of transmission lines (km) | 9811,07 | 19,08 | 9791,99 | 9673,09 | 9.493,18 | 9.493,18 |
| IN TOTAL WITH Kosovo* | Number of transmission lines | 527 | Kosovo* according to currently available data | | | | |
| | Length of transmission lines (km) | 10866,07 | | | | | |

| Capacity of the substations and switchyards of users of the transmission system | | 31.12.2019. | 31.12.2018. | Difference 2019.-2018. |
|---|---|---|---|---|
| Production | Number of substations | 20 | 19 | 1 |
| | Number of transformers | 40 | 38 | 2 |
| | Installed capacity (MVA) | 1.159,5 | 1.127,5 | 32 |
| Distribution system operator | Number of substations | 193 | 189 | 4 |
| | Number of transformers | 348 | 341 | 7 |
| | Installed capacity (MVA) | 10.751,5 | 10.508,5 | 243,0 |
| Others | Number of substations | 42 | 42 | 0 |
| | Number of transformers | 92 | 92 | 0 |
| | Installed capacity (MVA) | 2.295,0 | 2.295,0 | 0 |
| TOTAL | Number of substations | 259 | 254 | 5 |

| Transmission lines of users of the transmission system | | 31.12.2019. | 31.12.2018. | Difference 2019.-2018. |
|---|---|---|---|---|
| Production | Number of transmission lines | 12 | 10 | 2 |
| | Length of transmission lines (km) | 58,6 | 54,4 | 4,2 |
| Distribution system operator | Number of transmission lines | 3 | 3 | 0 |
| | Length of transmission lines (km) | 44,3 | 44,3 | 0 |
| | Number of cables | 2 | 2 | 0 |
| | Length of transmission lines (km) | 5,8 | 5,8 | 0 |
| Others | Number of transmission lines | 22 | 22 | 0 |
| | Length of transmission lines (km) | 73.2 | 73,2 | 0 |
| УКУПНО | Number of lines | 39 | 37 | 2 |
| | Length of transmission line (km) | 181,9 | 177,7 | 4,2 |
| NOTE: In the transmission lines of others , OHL no. 199/2 which is the property of R. Croatia. | | | | |

## Map of The Electric Power System of Serbia

- Secure and quality transmission of electric energy
- Network operations
- Maintenance of overhead high-voltage power lines
- Maintenance of high-voltage underground power lines (e.g. cables)
- Maintenance of high-voltage equipment, units and protection, measurement and local control systems in substations and switchgear stations
- Power facility protection against the impact of other facilities located nearby
- Functional tests, internal technical inspections and commissioning of power facilities
- Covering and implementing new accomplishments in the field of development and engineering for improvement of power transmission

# TRANSMISSION SYSTEM CONTROL

Transmission system control includes short term planning activities and real time activities.
The most important planning activities are as follows:

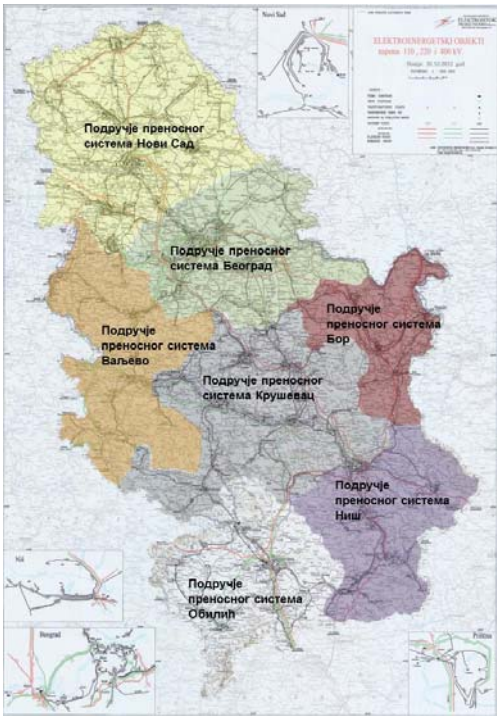
- Contracting system services;
- Planned outage scheduling;
- Developing operation plans;
- Developing security models and analysis;
- Cross-border capacity estimation;
- Demand and loss forecasting.

Real-time system control encompasses the following main activities:

- Intraday modifications of operation plans;
- Supervising transmission system operation;
- Load frequency control by means of activation of generating capacities via balancing mechanism;
- Voltage control;
- Taking primary measures for securing the place of work on transmission system elements and for issuing work orders and papers;
- Remedying disturbances.

The acitivities of transmission system maintenance and operation are done by respective Regional Maintenance Centres (RMC):

- **RMC Beograd – Transmission System Area of Beograd and Transmission System Area of Valjevo**
- **RMC Kruševac - Transmission System Area of Kruševac, Transmission System Area of Niš, Transmission System Area of Bor, and Transmission System Area of Obilić**
- **RMC Novi Sad - Transmission System Area of Novi Sad**



# TRANSMISSION SYSTEM CONTROL


Real-time control is performed from the EMS control centres organised in two tiers:

- National Control Centre (NCC) department operates the elements of 400-kV and 220-kV networks, as well as 110-kV interconnectors,
- Regional Dispatch Centre (RDC) departments operate 110-kV transmission network and a part of the 110-kV distribution network.

Presently, there are 5 regional dispatch centres: RDC Beograd, RDC Bor, RDC Valjevo, RDC Kruševac and RDC Novi Sad.

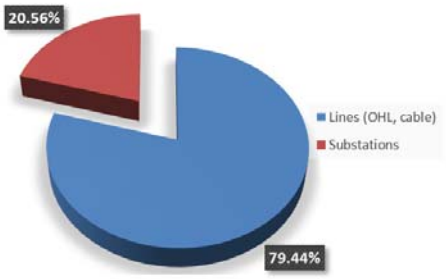
Transmission system control is carried out via information system exchanging and processing data coming from the facilities of:

- Transmission system;
- 110-kV distribution system;
- Power generation, connected to the transmission system;
- Customers, connected to the transmission system;
- European transmission system.

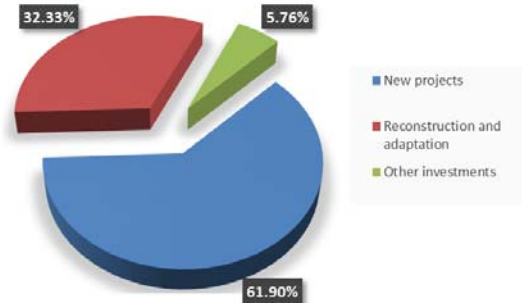
- Pan-European Ten-year network development plans (TYNDP2012, TYNDP2014, TYNDP2016, TYNDP2018); a new TYNDP2020 is underway
- Regional investment plan (RgIP2012, RgIP2014, RgIP2015, RgIP2017); a new RgIP2019 is underway
- Ten-year network development plan of the Republic of Serbia, under the auspecies of ENTSO-E, was published in 2011, 2012, 2013, 2014,2015, 2016, 2017, 2018 and 2019, a new 2020 is underway

## DEVELOPMENT - STRATEGY - INVESTMENTS
## European and regional aspect

- Planned investments for the period 2020 - 2022 in overhead lines, or HV facilities




- Investment per type of activities for the period 2020 - 2022



# TRANSBALKAN CORRIDOR
# - OVERVIEW -

- Total length 321 km
- Total investment: 157 MEUR
- **Section I** – Construction completed from Serbian side and energized in December 2017.
- **Section II** – Construction Work is expected to start in the first half of 2020.
- **Section III** – Work on technical documentation (Design for Building Permit and Project execution plan) started in May 2019.
- **Section IV** – Kick off meeting for work on technical documentation (Design for Building Permit and Project execution plan) was held on 27.09.2019. Update of Techno-economical and financial analyses for Section III and IV is included in the ToR.

# TRANSBALKAN CORRIDOR

Project of the highest **national and regional interest,** enabling at the same time the transnational power transmission, for coupling the markets of eastern and western Europe:

- Primarely designed to provide for **national energy security** of the Republic of Serbia and to replace a part of the obsolete 220-kV network with the network operating at 400-kV voltage level.
- **2017 –** Completed construction works for OHL 400-kV SS Pančevo – SS Resita (Romania) (EMS finance)
- **2020 –** Start of works on the route of new OHL 400-kV SS Kragujevac – SS Kraljevo (funds provided by EU, KfW and EMS)
- **In 2021** – if the grant contract will be signined during 2020, works on the route of new OHL 400-kV SS Obrenovac – SS Bajina Bašta should start.
- Ministry of Mining and Energy drafted and RS National Assembly adopted a special **Law establishing the public interest and the special procedures for the expropriation and documents for the realization of construction of electricity transmission system "Trans-Balkan corridor-first phase".**

# Strategic projects in the investment phase

- Reconstruction of the existing 220 kV substations with upgrade to 400 kV in SS Srbobran (total capacity will be 300 MVA, commissioning in 2021) and SS Smederevo (300 MVA in the first phase, completed in 2019, at the moment in probation period)
- Reconstruction of the existing substations and switchyard stations in Obrenovac (to be finished in 2020), Krusevac ((2x250 + 2x31,5) MVA, to be finished in 2020), Djerdap (expected in 2023), Kragujevac 2 (expected in 2025) and Bor (expected in 2025)
- Construction of new SS 220/110 kV Bistrica with corresponding overhead lines (150 MVA, expected in 2020/21)
- In 2019, two cable lines were laid down (length 6 km), connection lines to SS Beograd 23 and SS Krusevac 3
- Constraction of two new cables in Belgrade (length 7.4 km, expected in 2020)
- Constraction of new cable in Novi Sad (length 3.9 km, expected in 2021)

# Connection projects for electricity producers and consumers – till 2030

- Connection of the following 19 Wind Power Plants with about 2598 MW of total installed capacity is anticipated by the end of 2027:
- WPP Alibunar 1 (99 MW), WPP Alibunar 2 (75 MW), WPP Plandiste (102 MW), WPP Pupin (100 MW), WPP Krivaca (103MW), WPP Nikine Vode (45 MW), WPP Kostolac (75 MW), WPP Bela Anta (118 MW), WPP Crni Vrh Omanje (70 MW), WPP Elicio Wind 01 (50 MW) , WPP Banat (186 MW), WPP Banat 2 (140 MW), WPP Bela Anta 2 (80 MW), WPP Basaid (85 MW), WPP Crni Vrh (100 MW), WPP Elicio Ali 2 (150 MW), WPP Maestrale Ring (600 MW), WPP Torak (120 MW), WPP Vetrozelena (300 MW).

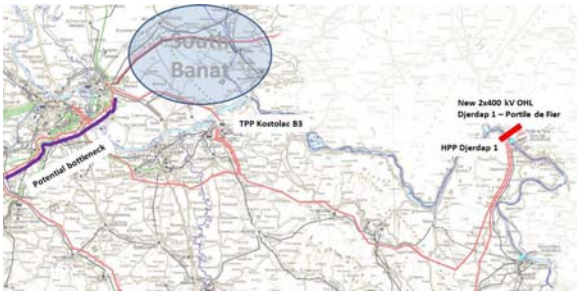
- In next three years, the following thermal power plant and CHP plants are expected to be connected to the grid:
- Unit 3 in TPP Kostolac B (350 MW), CHP Pancevo (189 MW), CHP Vinca (30 MW)

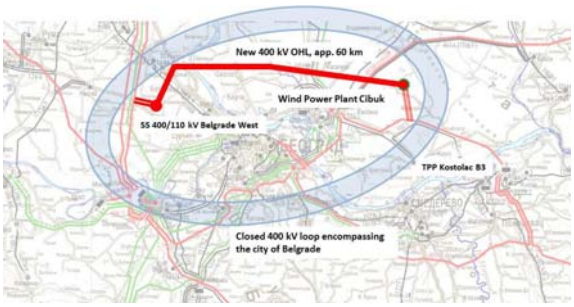
- In the next three years, the following consumers are expected to be in operation:
- Mine Jadar near Loznica (63 MW), Mine Cukaru Peki near Bor (43 MW), Mine complex YiJin Bor (164 MW), Mine complex YiJin Majdanpek (50 MW), Ling Long factory (40 MW), Mei Ta Factory (31 MW)

- In addition to participating in the implementation of connection projects, EMS AD is obliged to strengthen the existing transmission network by its own resources, as foreseen by the investment and development plans.

# Strategic projects in the development phase
# - North CSE CORRIDOR -

- North Continental South East (CSE) Corridor project consists of the following subprojects:
  - ✓ SS 400/110 kV Belgrade West (2x300 MVA)
  - ✓ OHL 400 kV SS Belgrade West – WPP Cibuk (60 km 400kV and 20 km 110 kV lines)
  - ✓ Upgrade of existing OHL 400 kV Serbia (HPP Djerdap 1) – Romania (Portile de Fier) to double circuit OHL (2 km)




- Purpose:
  - ✓ enable energy evacuation from new generation plants (future TPP Kostolac B3 (350 MW) and wind farms in the area of South Banat)
  - ✓ Increase NTC (facilitate energy transits from the Romanian power system)
  - ✓ Increase security of electricity supply in the region of Belgrade

# Strategic projects in the development phase

- Because of intensive reidustrialization there is a need for increasing transmission capacity in substations for amount around 10%: SS Belgrade West, SS Konatice, SS Valjevo 3, SS Bor 2, SS Smederevo 3.

- There is a need for increasing amount of investment for reconstruction of exsisting OHLs 110 kV