# Long-term planning of energy systems with higher shares of VRE

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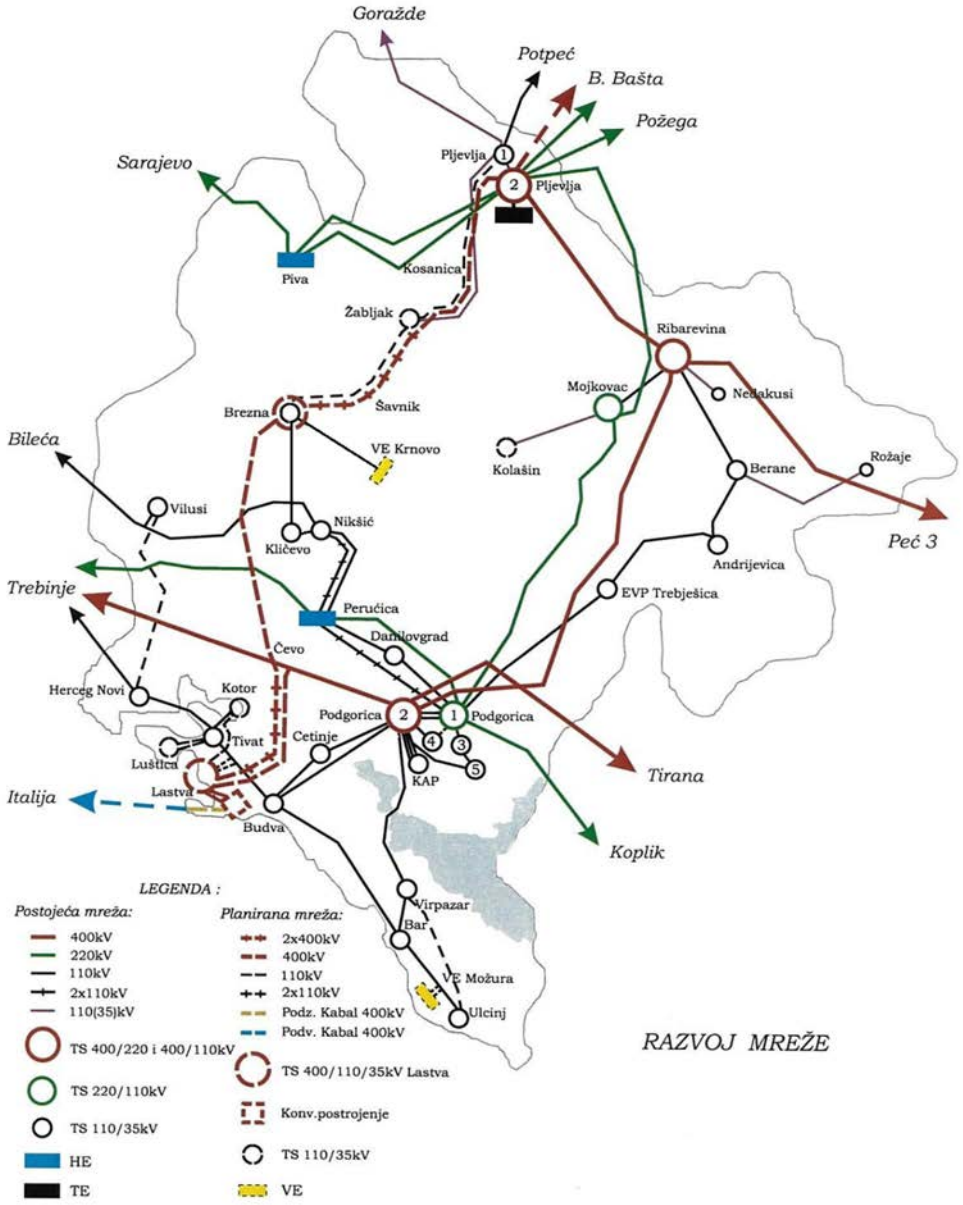
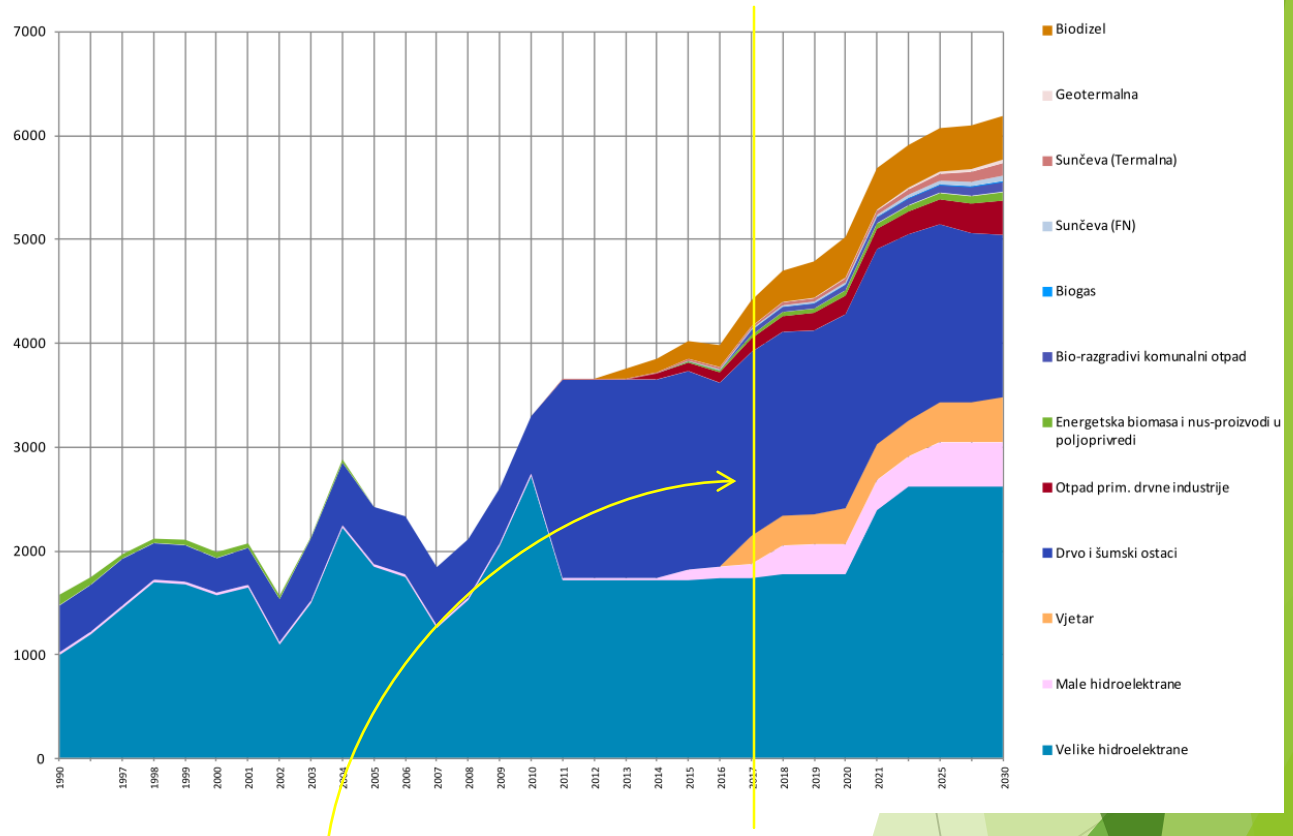
# General energy planning framework




| OIE (GWh) | 2016/2017 | 2018 (implemented and plan) | 2030 |
|---|---|---|---|
| Small HPP | 0/54.2 | 70 | 425 |
| Wind | 0/0 | 180 | 436 |
| Solar | 0/0 | 0 | 52 |
| Biomass | 0/0 | 0 | 188 |

https://www.energetska-efikasnost.me/uploads/file/Dokumenta/Strategija%20razvoja%20energetike%20CG%20do%202030.%20godine%20-%20Bijela%20knjiga_10072014.pdf

# Power sector planning

Power demand forecast

- for forecast the consumption tools software usually used are MAED but we do not use that or any other kind of tools

Generation capacity

Software tools that we are using for planning production for capacity development: dynamic (WASP IV) or simulation (ANTARES).

- Dynamically determine the optimal plan for the development of production capacities on the basis of the list of candidate plants.

- Simulation - simulate the operation of the electric power system, and based on the difference in the cost of operating the system with and without the object being considered, determine the benefits that the object brings.
  By comparing the benefits for different power plants, candidates can be rated ranking

# Representation of renewable energy in generation capacity expansion planning tools

Elektroenergetski Koordinacioni Centar

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EKC and CGES does not have a specialized tool for determining the potential for the production of renewable energy based on wind speed or solar.

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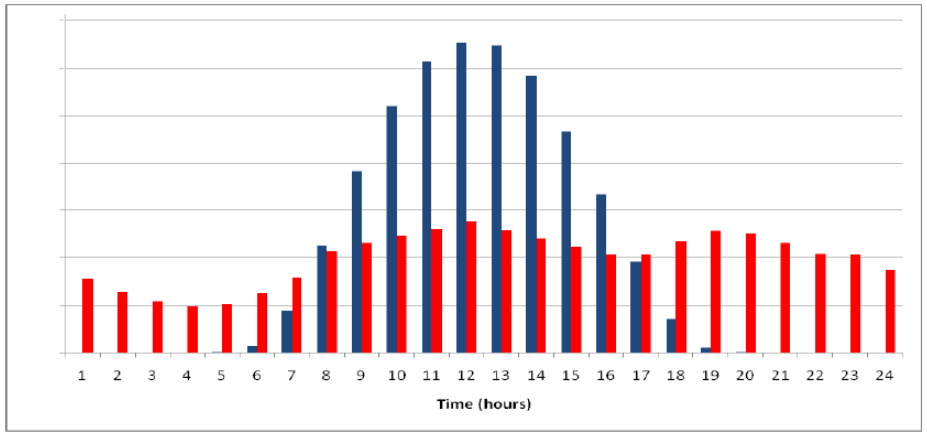
We use PSS/E or DigSilent to analyze the impact of renewable (or any other) sources on the operation of the transmission network from a static and dynamic aspect. In these analyzes, the input power and its location as well as the specific technical parameters, depending on the technology, are used as input data.

# Generation scheduling with high share of variable renewable energy

For the timetable of production capacities we use Antares as a tool for simulating the operation of the electric power system on the principles of a day-ahead market.

The result of the simulations is the hourly engagement of all power plants (also could be by blocks) for the entire year.

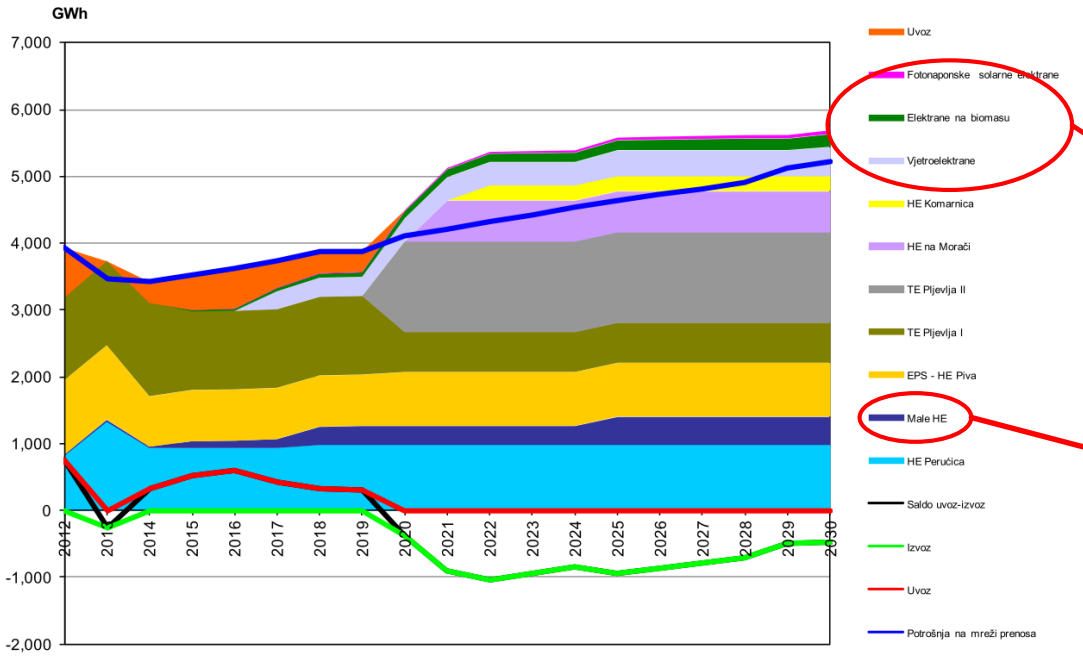



Hourly consumption values are input data. In recent years, several time series are in use in order to cover the effects of different temperature events.

Hourly production of renewable sources is also given as an input. Within the ENTSO-E association there is a PECDB (Pan-European climate database) with data on hourly power factors for more climatic years (now it is 34, for the period 1982-2015) for wind, solar and load. This data exists for Montenegro as well.
Antares can also model the operation of the battery, but nowadays we do not have them in our system.

# Network analysis

Plans related to the construction of renewables is defined in Strategy of energy supply white book




| Godina | TE Pljevlja I | TE Pljevlja II (225 MW) | HE Piva | HE Perućica | HE na Morači | HE Komarnica | Male HE | Vjetro-elektrane | Fotonaponske solarne | Biomasa | Proizvodnja svih elektrana | Potrošnja na mreži prenosa | Saldo uvoz - izvoz |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | GWh | GWh | GWh | GWh | GWh | GWh | GWh | GWh | GWh | GWh | GWh | | GWh |
| 2012 | 1246 | | 1110 | 809 | | | 22 | | | | 3187 | 3932 | 745 |
| 2013 | 1267 | | 1107 | 1330 | | | 28 | | | | 3732 | 3465 | -267 |
| 2014 | 1407 | | 749 | 932 | | | 21 | | | | 3109 | 3424 | 315 |
| 2015 | 1179 | | 762 | 932 | | | 102 | | 5 | 23 | 3003 | 3518 | 515 |
| 2016 | 1179 | | 762 | 932 | | | 110 | | 10 | 31 | 3024 | 3627 | 603 |
| 2017 | 1179 | | 762 | 932 | | | 134 | 271 | 12 | 47 | 3337 | 3749 | 412 |
| 2018 | 1179 | | 762 | 978 | | | 274 | 289 | 13 | 59 | 3554 | 3873 | 319 |
| 2019 | 1179 | | 762 | 978 | | | 287 | 289 | 15 | 65 | 3575 | 3881 | 307 |
| 2020 | 600 | 1360 | 800 | 978 | | | 287 | 348 | 17 | 101 | 4490 | 4105 | -385 |
| 2021 | 600 | 1360 | 800 | 978 | 616 | | 287 | 348 | 19 | 113 | 5121 | 4212 | -909 |
| 2022 | 600 | 1360 | 800 | 978 | 616 | 227 | 287 | 348 | 23 | 121 | 5360 | 4325 | -1035 |
| 2023 | 600 | 1360 | 800 | 978 | 616 | 227 | 287 | 348 | 27 | 129 | 5372 | 4431 | -941 |
| 2024 | 600 | 1360 | 800 | 978 | 616 | 227 | 287 | 348 | 31 | 136 | 5383 | 4538 | -845 |
| 2025 | 600 | 1360 | 800 | 978 | 616 | 227 | 425 | 387 | 36 | 144 | 5573 | 4634 | -939 |
| 2026 | 600 | 1360 | 800 | 978 | 616 | 227 | 425 | 387 | 41 | 153 | 5587 | 4729 | -858 |
| 2027 | 600 | 1360 | 800 | 978 | 616 | 227 | 425 | 387 | 44 | 162 | 5599 | 4811 | -788 |
| 2028 | 600 | 1360 | 800 | 978 | 616 | 227 | 425 | 387 | 47 | 170 | 5610 | 4908 | -702 |
| 2029 | 600 | 1360 | 800 | 978 | 616 | 227 | 425 | 387 | 49 | 178 | 5612 | 5117 | -495 |
| 2030 | 600 | 1360 | 800 | 978 | 616 | 227 | 425 | 436 | 52 | 188 | 5682 | 5214 | -468 |

Renewable sources affects the electricity system in different ways, and not only on the transmission network:

1. Higher level of construction of OI leads to the suppression of conventional sources, so their profitability is called into question. For this reason, Europe introduces a "capacity market"

2. Higher level of construction of OI requires higher level of reserve, strategic (tertiary)

3. Higher level of construction of OI requires a higher level of system flexibility (hourly changes in OI production and impact on hourly change of residual load), higher level of secondary reserve

4. Higher level of construction of the OI requires reinforcement in the network

For each of these aspects, different tools are used. 1 and 2 - Antares, 3 - statistical analysis and expert assessments, 4 - PSS / E