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The effect of small power plants on the distribution of mains voltage and power losses

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Structure

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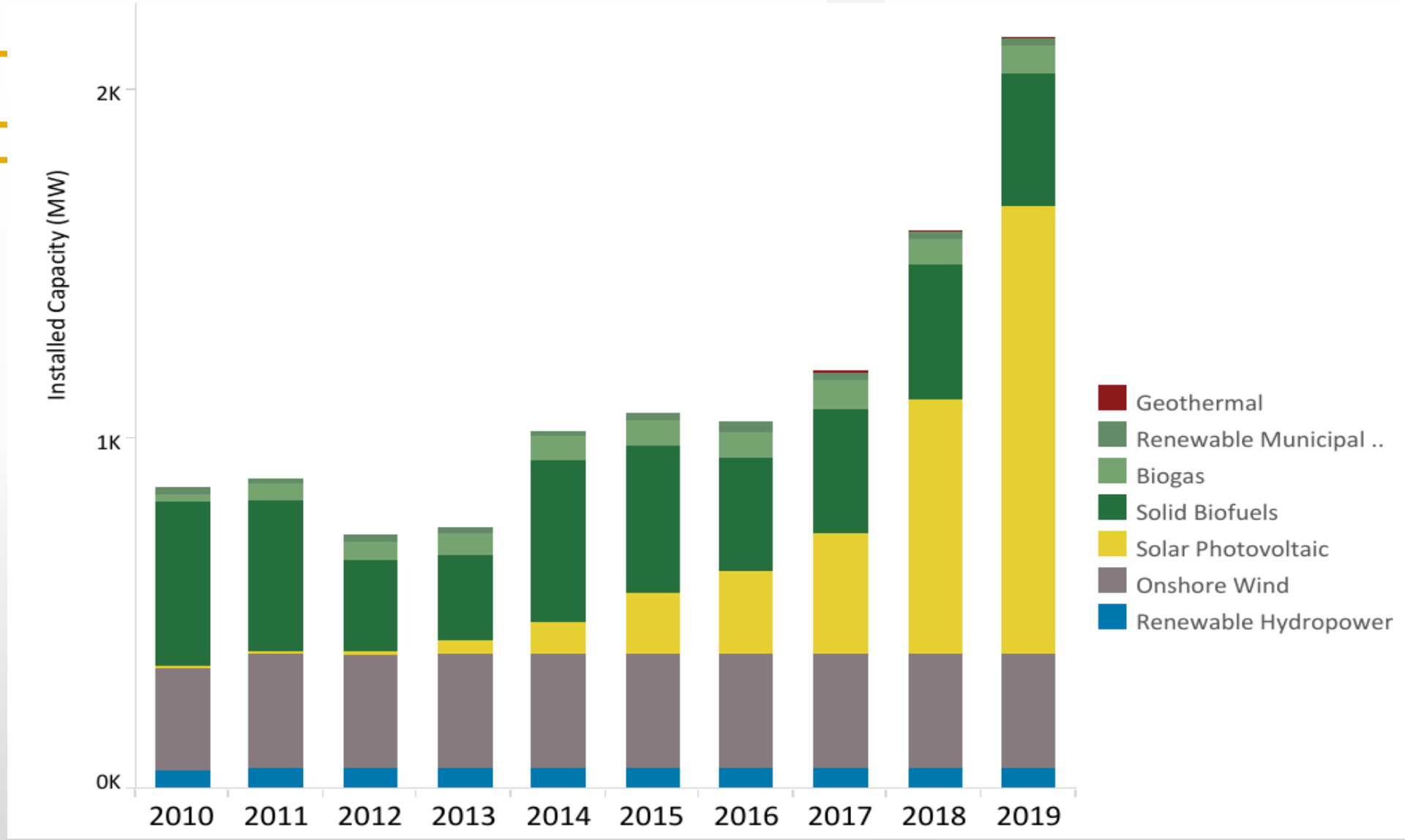
- Centralized, decentralized energy systems
- Simulated network
- Results
- Conclusion

Motivation for research

Renewable energy sources (RES) are playing an increasingly important role in energy production. The size of non-renewable sources is limited, so humans has had to look for new sources. The European Union would provide 20 % of its energy from renewable sources by 2020, which it would increase to 32 % by 2030.

The next figure shows the change trends in Hungary's installed capacity since 2010. Performance has almost tripled in 10 years. This is mainly due to solar energy and solar cells, while the amount of other energy sources has increased only slightly or not at all.

The installed capacity of solar energy increased in the country to such an extent that the peak of solar energy production in Hungary was exceeded on 16 April, 2020. It was able to provide 22 % of domestic production for a time and 8,3 % of domestic production for the whole day

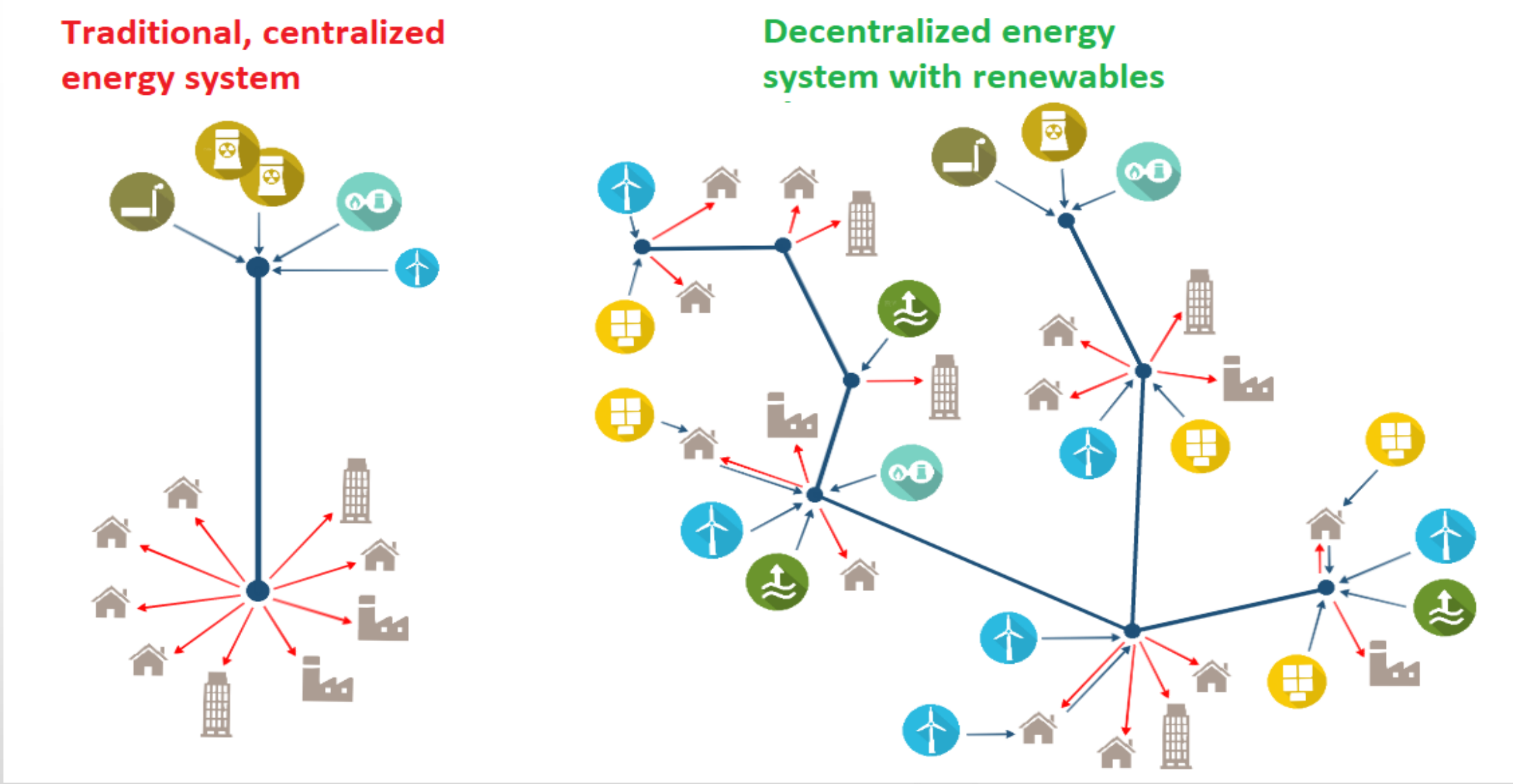


Installed capacity trends in Hungary

Centralized, decentralized energy systems

The traditional energy system is centralized. Energy is produced in large power plants, which reach consumers through different voltage lines. Transformation between these lines generate losses that need to be minimized for energy efficiency. In centralized system, there is a significant transport distance between consumers and electricity producers.

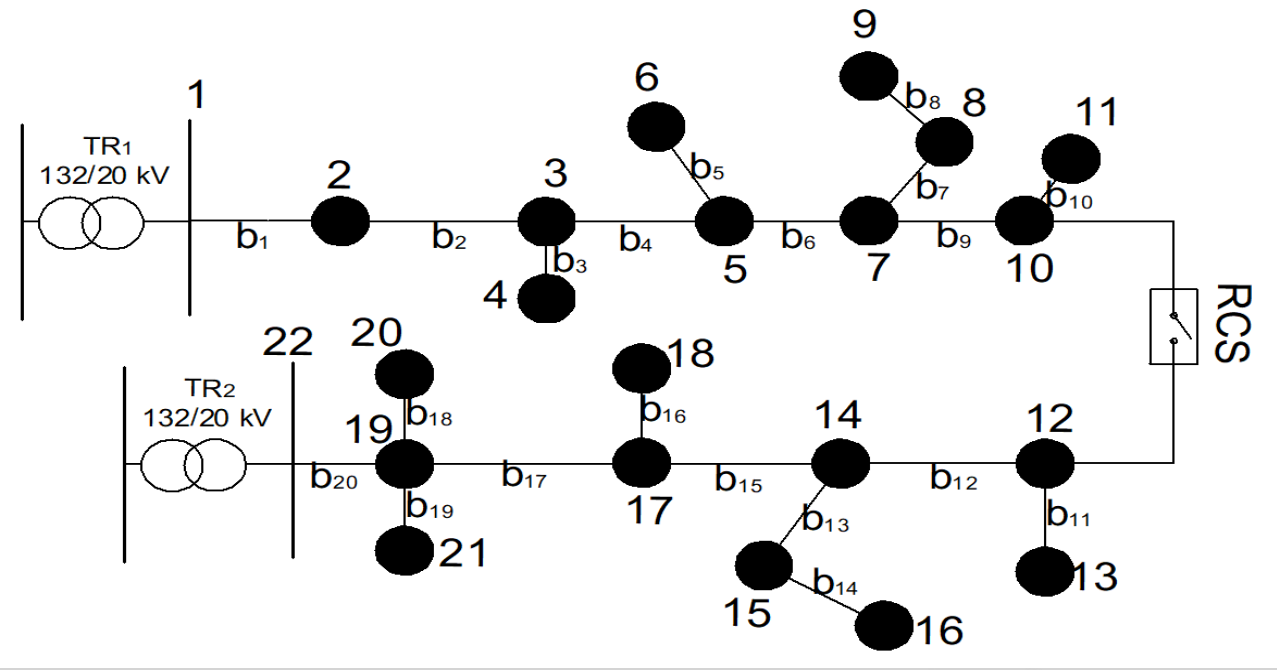
The decentralized energy system has come to the fore with the spread of renewable energy sources. There are still large power plants in this system that were also in the centralized energy system, but many smaller power plants are built into the grid. As a result, the failure of some power plants will not have as much impact on the entire energy system.



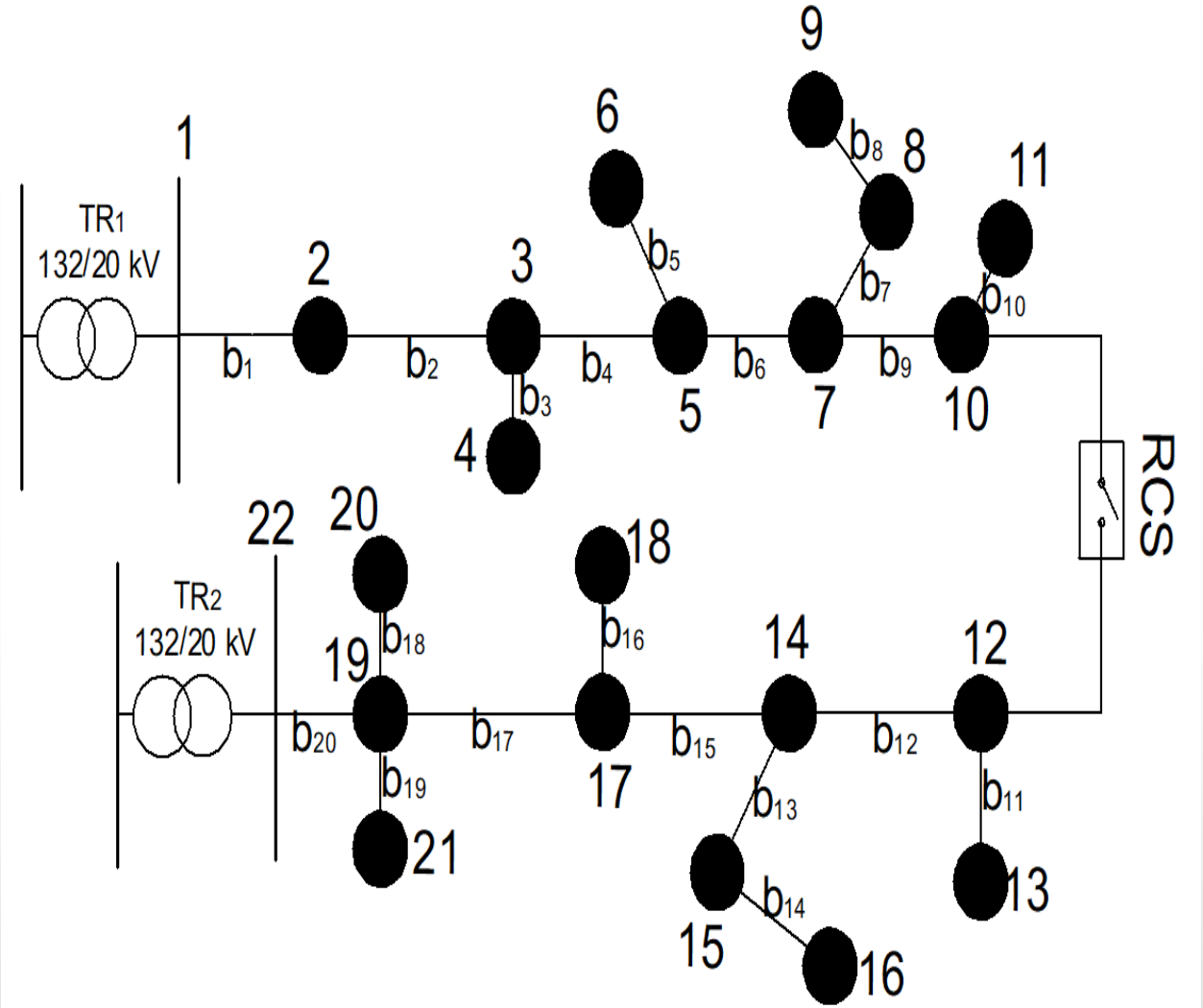
Difference between the centralized and decentralized energy system

Simulated network

The test network topology is illustrated in the figure. There are 2 feed points in the network (TR_1, TR_2). Thanks to the remote-controlled switches (RCS), which is in the position OPEN, all consumer can only receive electricity only from one direction.



Topology of the examined network



Topology of the examined network

Branch parameters

Branch	Resistance [Ω]	Inductive reactance [Ω]	Branch	Resistance [Ω]	Inductive reactance [Ω]
1	0,9	0,9	11	1,2	1,2
2	1,2	1,2	12	1,2	1,2
3	0,9	0,9	13	1,5	1,5
4	1,5	1,5	14	1,2	1,2
5	0,9	0,9	15	0,9	0,9
6	1,5	1,5	16	1,5	1,5
7	0,9	0,9	17	1,8	1,8
8	0,9	0,9	18	1,5	1,5
9	1,2	1,2	19	1,5	1,5
10	0,9	0,9	20	1,2	1,2

Nodes consumption data were as follows:

- Nodes 1 to 11 consume 700 kW from the grid.
- All nodes between 12 and 22 consume 900 kW from the grid.

Results

- **Only 1 small power plant is connected to the grid**

The first step in the simulation was to simulate the current state. We examined the voltages at the nodes without small power plants.

After that, we started to connect 500 kW small power plant to the grid. We connected to the Node 1 and after that started the simulation. After the simulation small power plant was connected to the Node 2, but we removed the previous added small power plant from the grid. In this way, we continued the simulation until we reached the last node.

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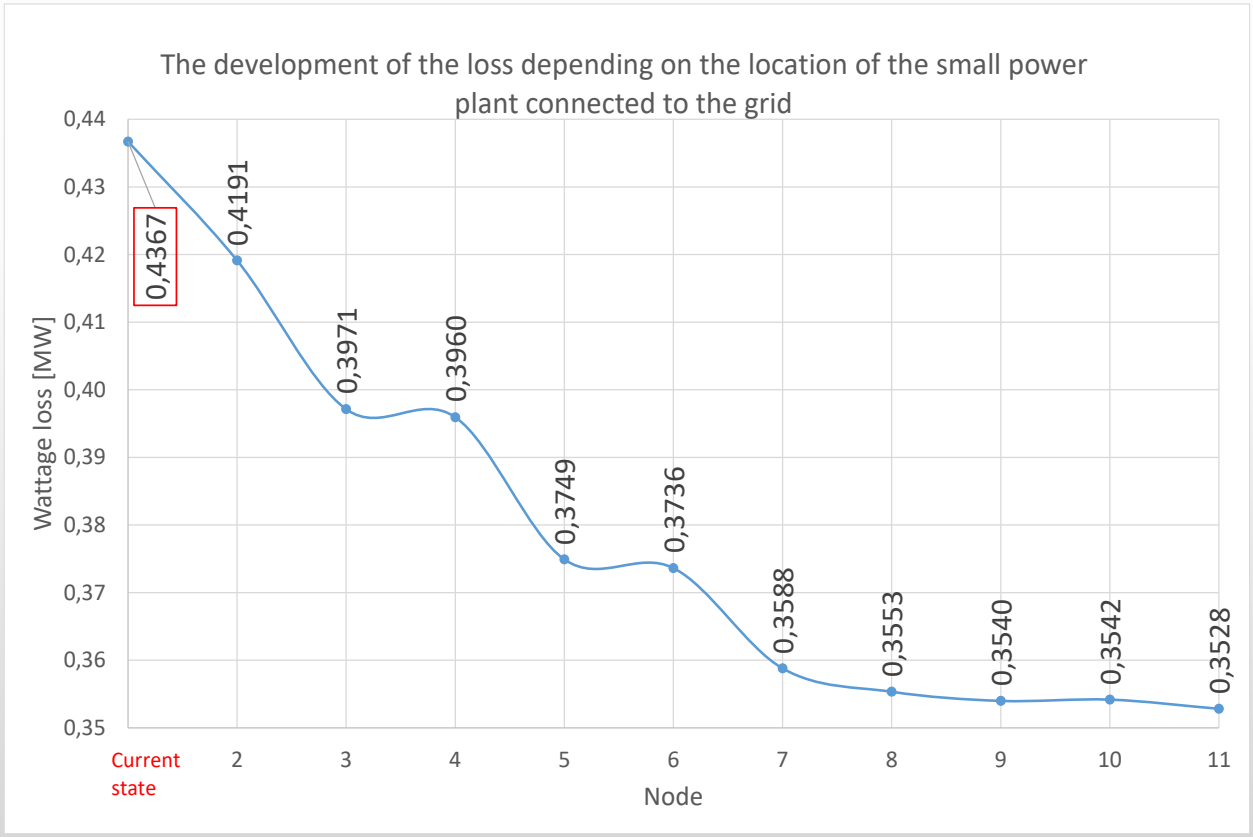
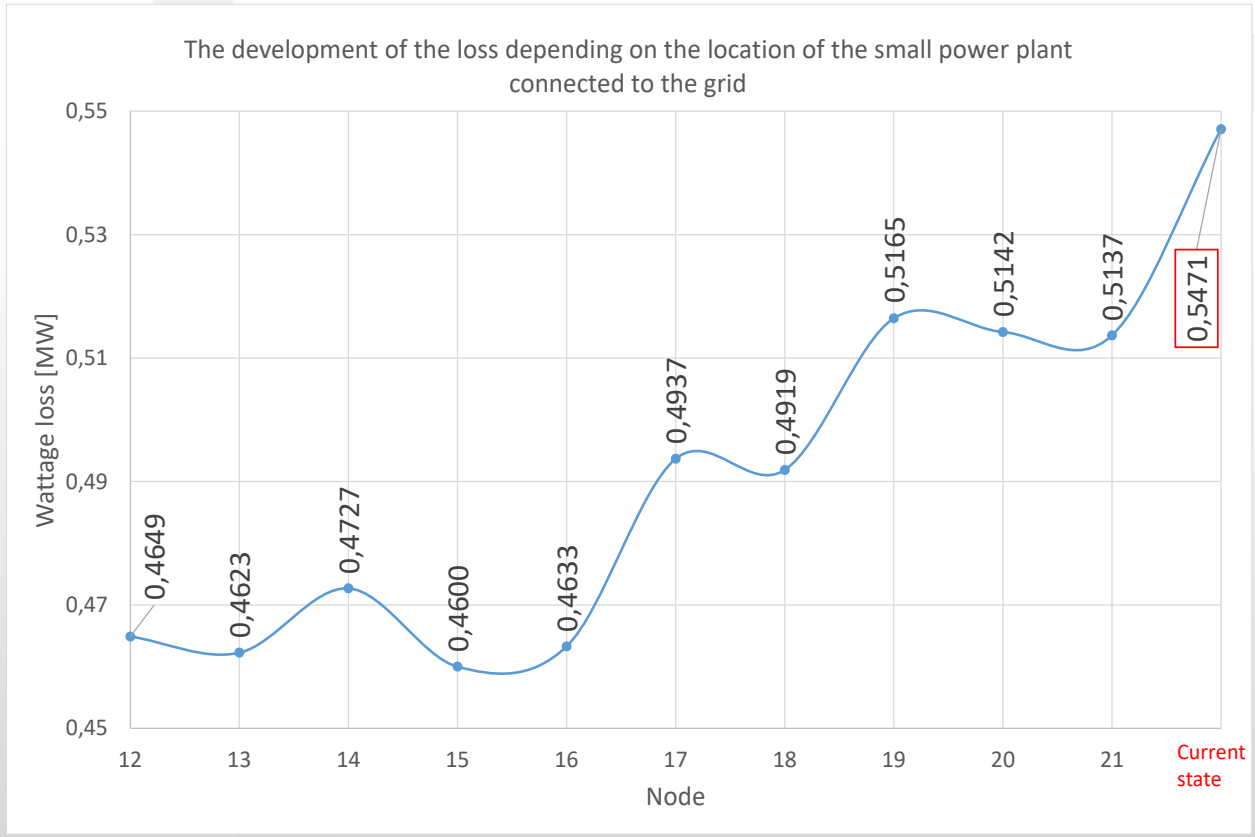
A) Investigation of power losses



The development of the wattage loss depending on the location of the small power plant connected to the grid between nodes 2 – 11



The development of the wattage loss depending on the location of the small power plant connected to the grid between nodes 12 – 21

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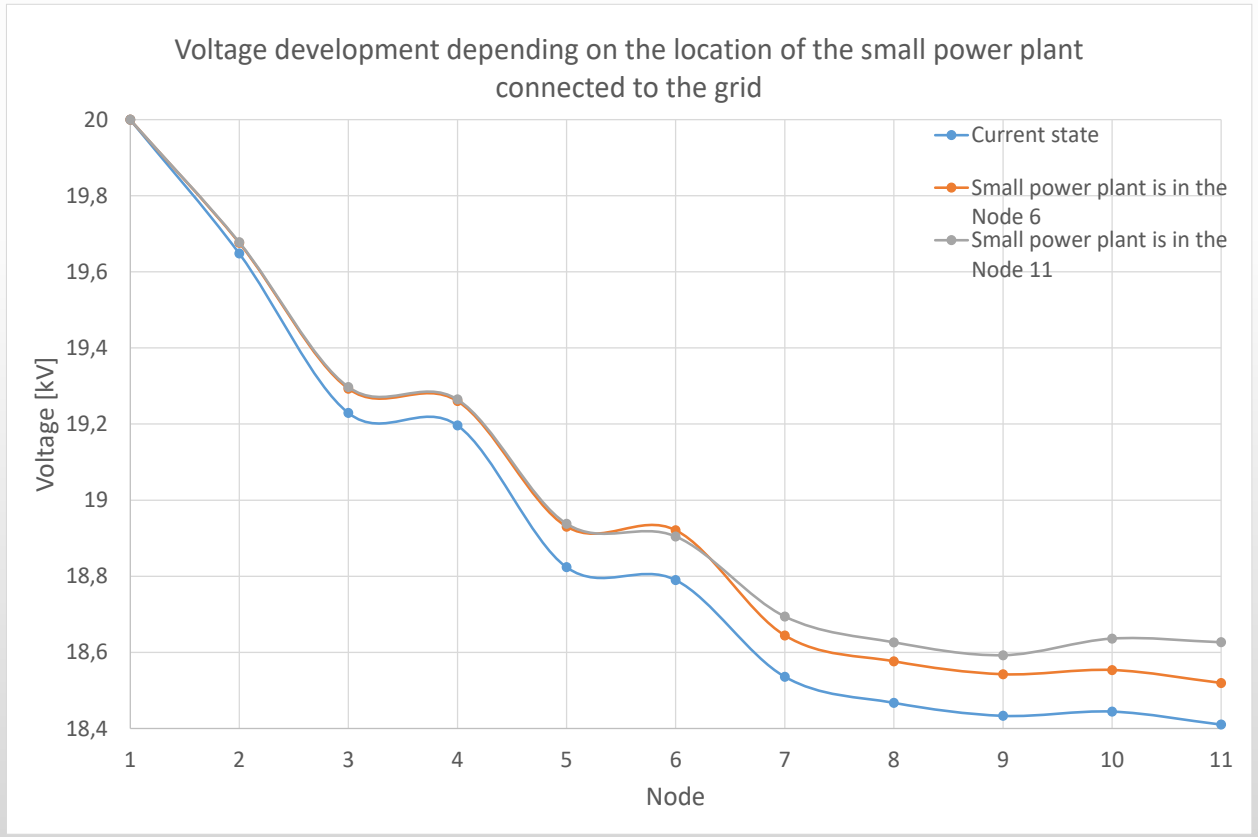
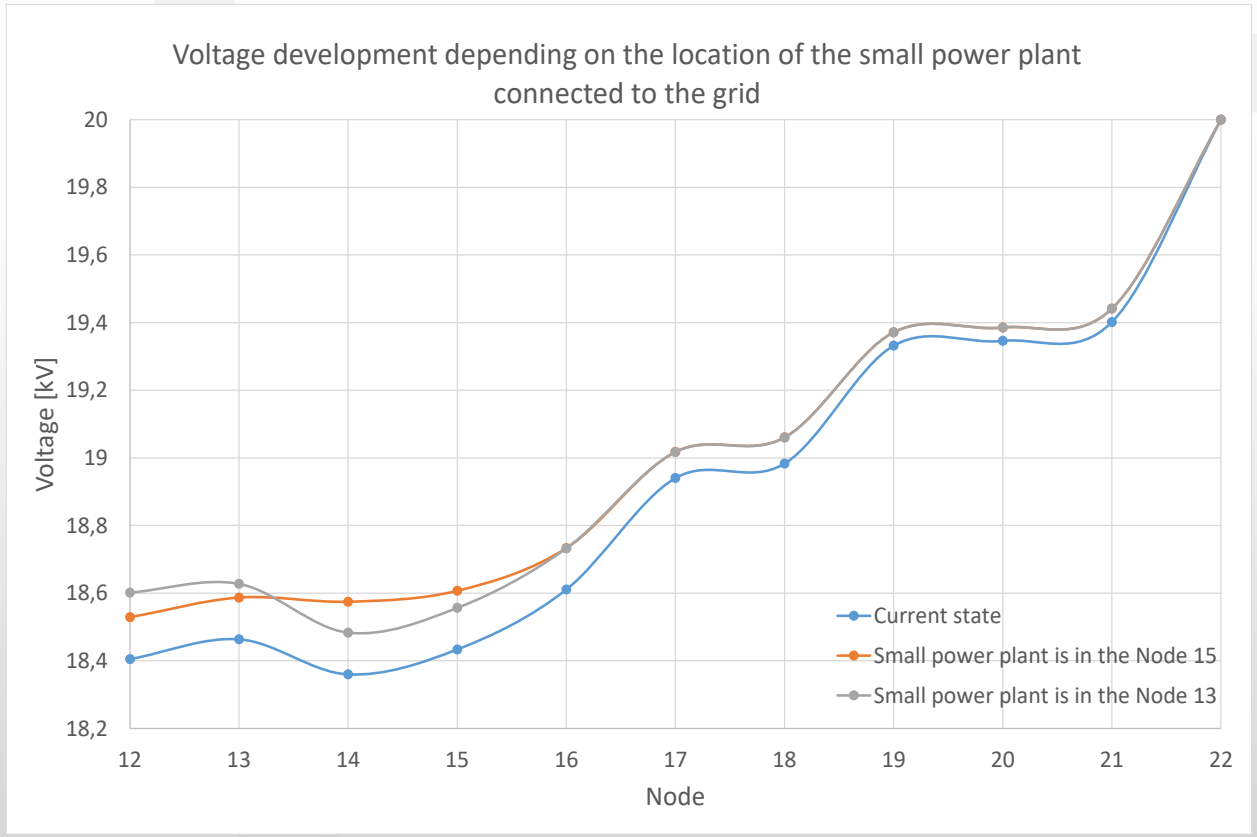
B) Voltage distribution



Voltage development depending on the location of the small power plant connected to the grid between nodes 1 – 11



Voltage development depending on the location of the small power plant connected to the grid between nodes 12 – 22

Results

- **Small power plants are connected to the grid**

The first step in this case is unchanged, the current state must be calculated. The current state is indicated by point 0 in the following figures.

After that, we started to connect 500 kW small power plants to the grid. We always started in the node, which was the closest to the remote-controlled switches and moved in the direction of the feed point. During the simulation we followed the following process:

- First power plant was placed at the node closest to the remote-controlled switch.
- After that, we placed a power plant to the next node, but the previous power plant also remained.
- In this way, we continued the simulation until we reached the last node as well.

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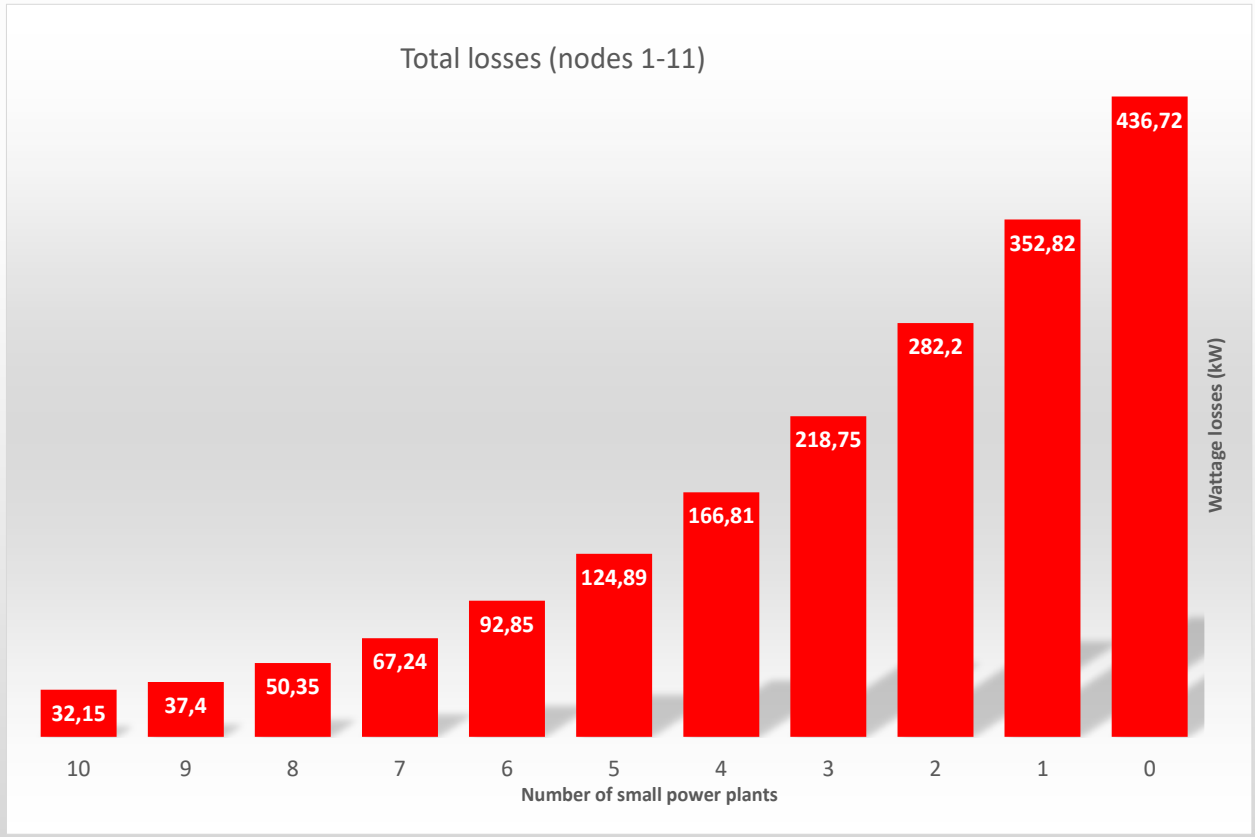
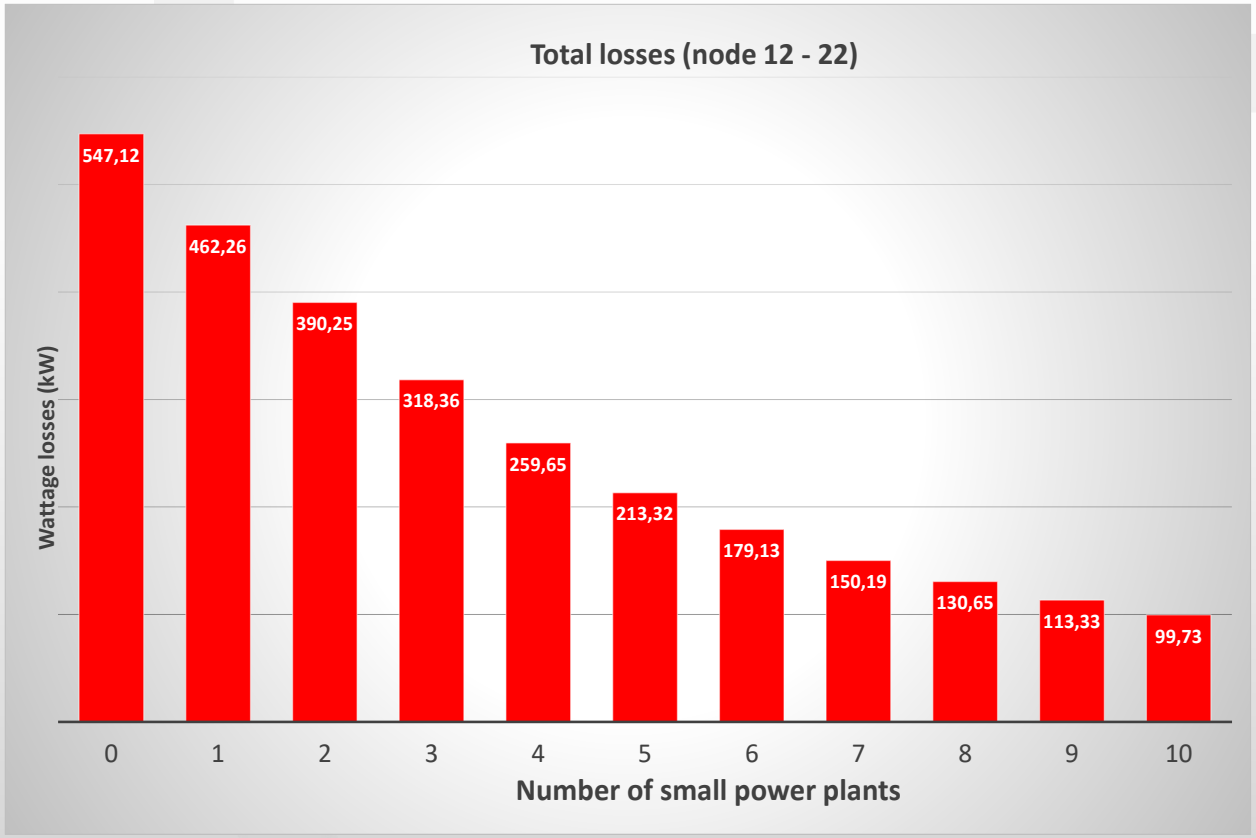
A) Investigation of power losses



Development of total loss between nodes 1 and 11 depending on the number of small power plants connected to the network



Development of total loss between nodes 12 and 22 depending on the number of small power plants connected to the network

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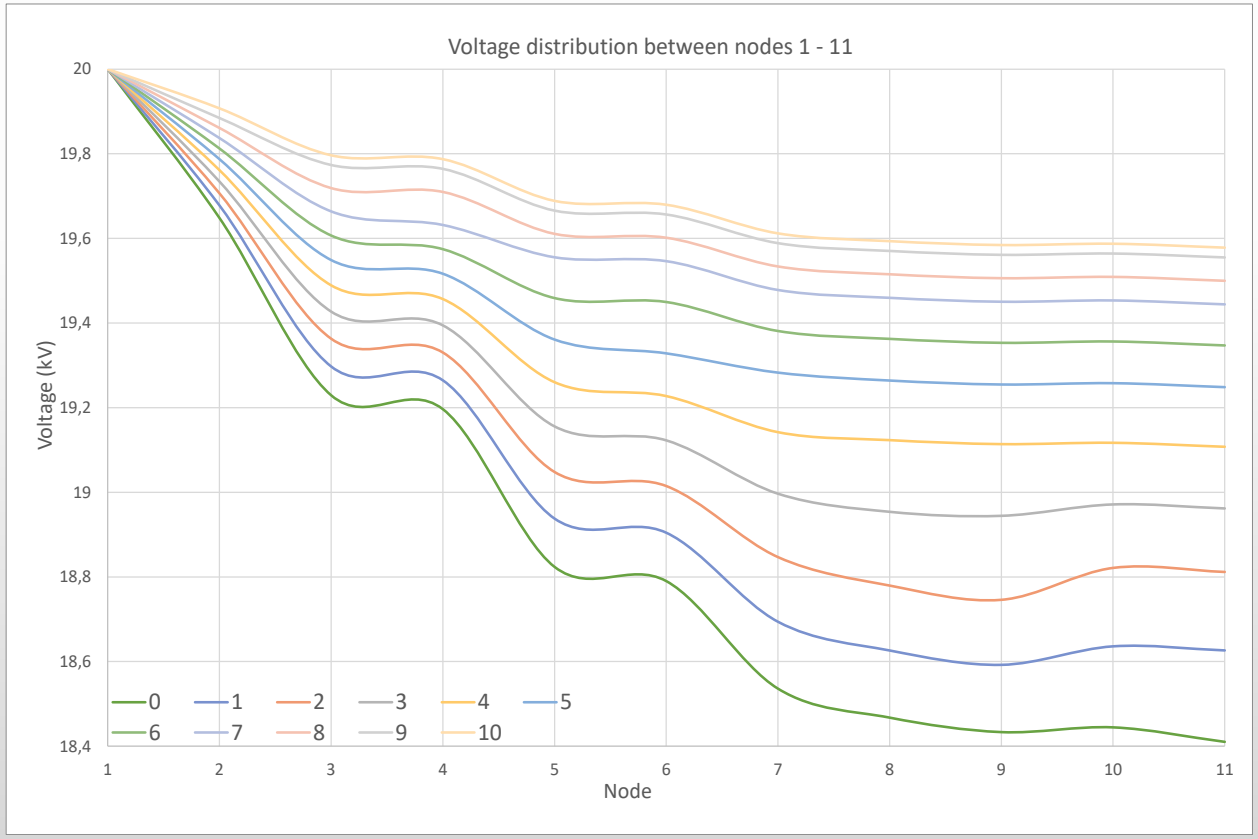
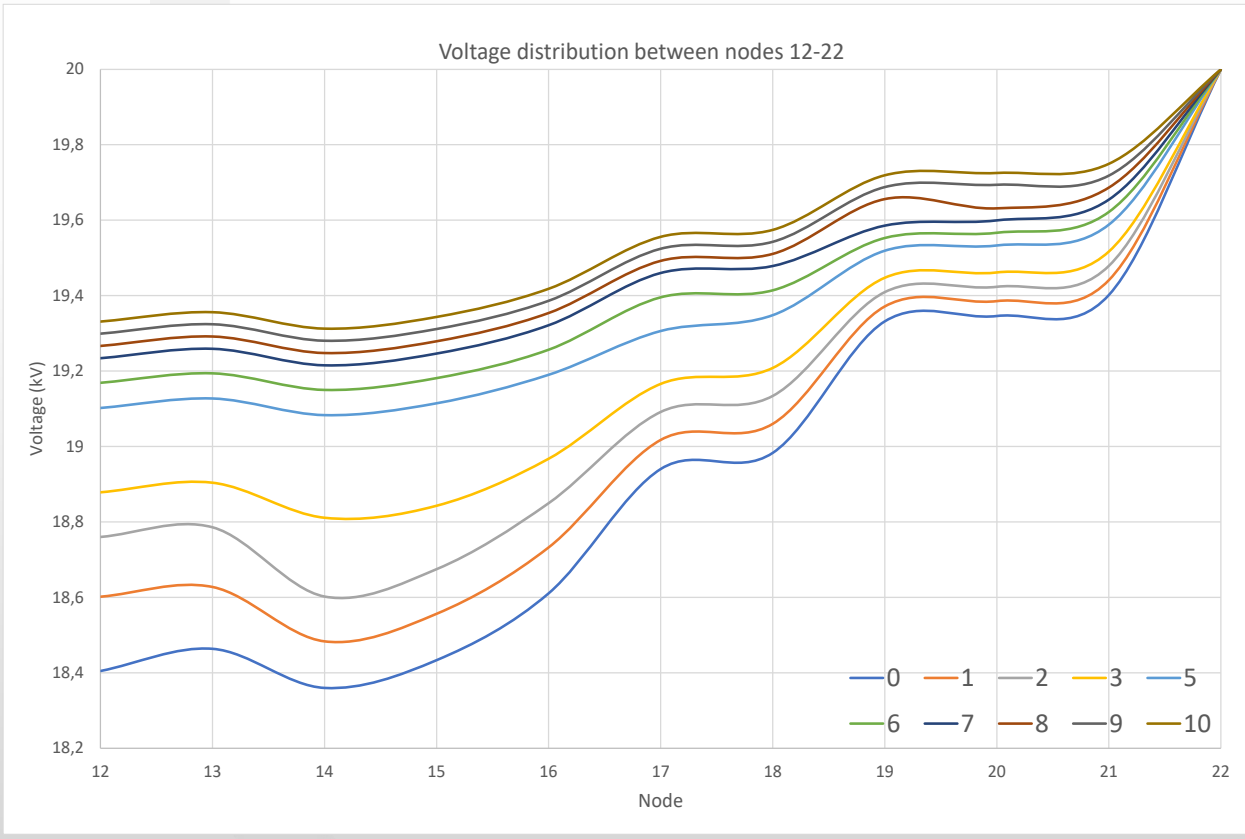
B) Voltage distribution



Voltage distribution between nodes 1 – 11



Voltage distribution between nodes 12 – 22

Conclusion

The aim of the publication was to draw attention to the possible impact of renewable energy sources on mains voltage and loss. It was seen that small power plants (usually renewables) were able to significantly increase the voltage, even above the allowable value, what to look out for. However, this has not been investigated in this publication. In this article we examined the effect of small power plant on the network when only 1 small power plant was connected to the grid, but also examined, when more small power plants are connected to the grid.

The reason for the reduction in wattage power losses was that the energy did not have to be transported from a remote point in the grid but was produced close to consumption. Based on the above, in the case study, small power plants improved the quality of supply.

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Thank you for your attention

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