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Impact of the distributed resources on the power quality indicators of the distribution network: A Case Study in Korça.

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Presentation Agenda

- Why this topic?
- Background
- An overview of Albanian Distribution System
- Korça area
- Methodology of the Study
- Performance indexes
- Case study
- Results and discussions
- Conclusions and recommendations

Why this topic?

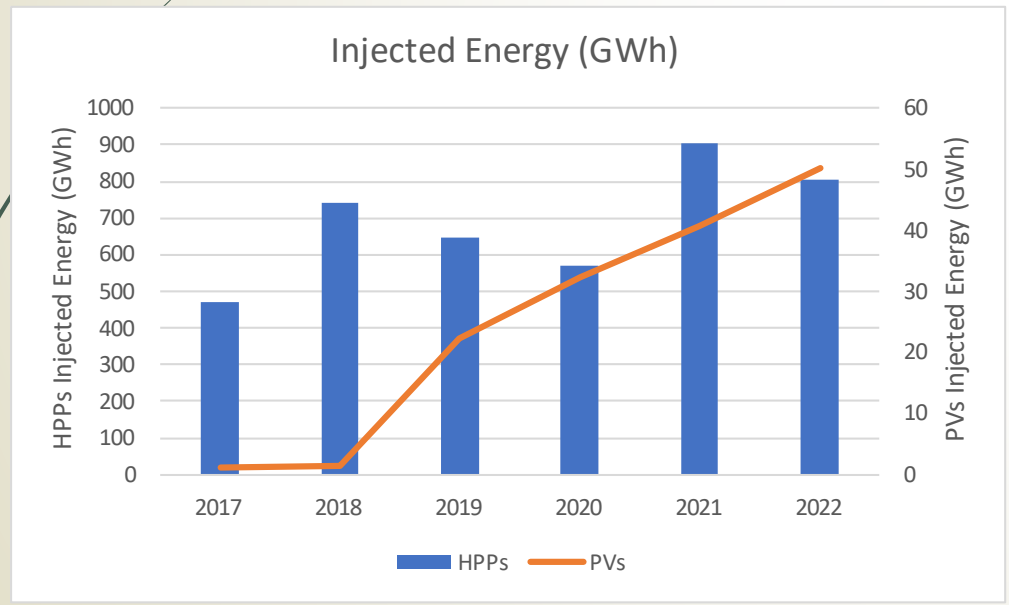
- The energy crisis and the growth of the global population have **increased the demand for electricity** everywhere.
- In this context, for 2030, the **EU** set a target of **45% of the renewable energy** sources (RESs) share.
- In addition, EU established legal **obligations** on the installation **of solar roofs** for certain categories of buildings (on residential, commercial, public and industrial roofs).
- In the same vein, **energy policies in Albania promote the use of RESs**, increasing the generating capacities.
- Most of these new capacities are **connected to the distribution system**, transforming it into an active network.
- **Except to the advantages**, the promotion of investments in RESs brings the **necessity of more detailed analyses** of each area of the distribution system.

Backround

- Motivated by these facts, this paper:
  - Deals with **the impact of the DG in the distribution system of the Korça area** in order to identify the problems that appear and the benefits of the distribution system.
  - Gives important **suggestions** for the future work of the distribution system, for example to decide about the replacement of equipment.
  - Provides **an overview** of Albanian Distribution System.
  - Is **helpful to different stakeholders**, including the RESs industry, the Albanian government, the Energy Regulator Authority (ERA), the distribution system operator (DSO), as well as for further studies in aid of scientific researchers.

An overview of Albanian Distribution System

- Electric Distribution System Operator (**EDSO**) in the Republic of Albania is managed and operated by the OSHEE Group sha. (a company with 100% of state shares) and **it is organized in 11 distribution areas and 42 agencies**.
- EDSO **includes all network elements at voltage levels of 35, 20, 10, 6, 0.4 kV** as well as substations that make transformations from 110 kV to them.

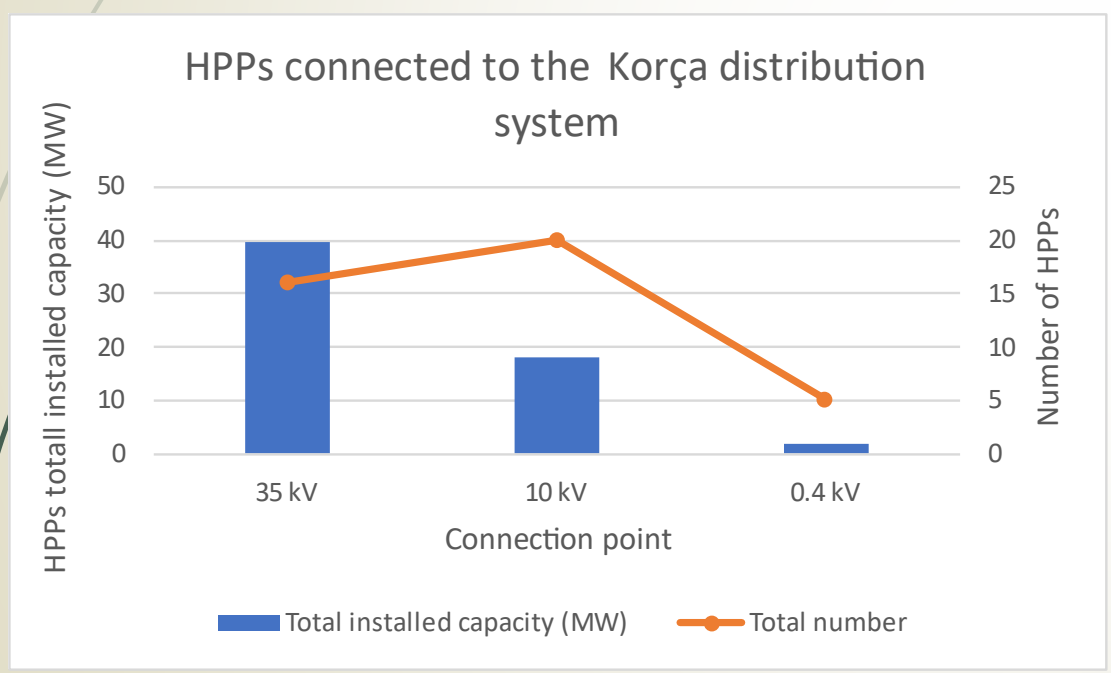


The injected energy from HPPs and PVs into the distribution system, from 2017 to 2022 (ERA Reports, 2017-2022)

- Actually, total installed capacity in the distribution system consists of:
  - **325 MW at HPPs** (depends on rainfall);
  - **29 MW in solar PVs** (promoted by government legislation/regulation).

Korça area

- Korça is one of **the largest DSO areas**.
- The entire zone is known for **large water sources** and mountainous reliefs.
- **12 HPPs** are connected to the Korça **transmission system**.



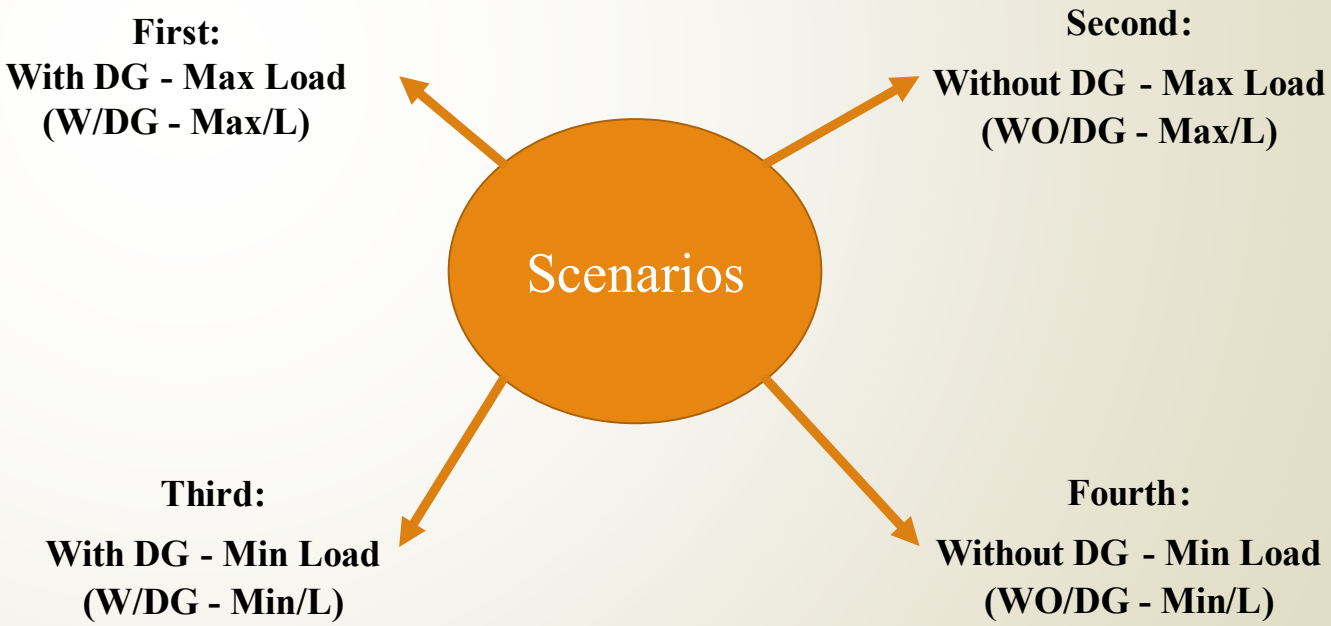
Statistical data of HPPs connected to the Korça distribution system (DSO report, 2022)

- **41 HPPs** connected to the **Korça distribution system** (**60MW** overall).
- **4 solar PV** plants (with **8 MW** total installed capacity) are connected to the Korça distribution system.
- On the other hand, **the hosting capacities of the network are almost at their limits.**

Methodology of the Study

- The distribution system of the Korça area is **modelled and simulated using Dlg Silent PowerFactory software**.
- To obtain and compare the results, **4 different with DG (or without DG) /load (max/min) scenarios are considered:**

- The maximum capacity is considered for the case "with DG".
- Using simulation results, the **performance indexes** for the main lines are calculated.



4 different scenarios

Performance indexes

- The DG benefits can be analysed using:
  - **Voltage Profile Improvement Index (VPII)**

$$VPII = \frac{VP_{W/DG}}{VP_{WO/DG}}$$

where: $VP_{W/DG}$, $VP_{WO/DG}$ are the voltage profiles of the system with DG and without DG respectively.

    - VPII<1, DG has no benefit,
    - VPII = 1, DG has no impact on the system voltage profile,
    - VPII > 1, DG has improved the voltage profile of the system.
  - **Line Loss Reduction Index (LLRI)**

$$LLRI = \frac{LL_{W/DG}}{LL_{WO/DG}}$$

where: LL are the total line losses.

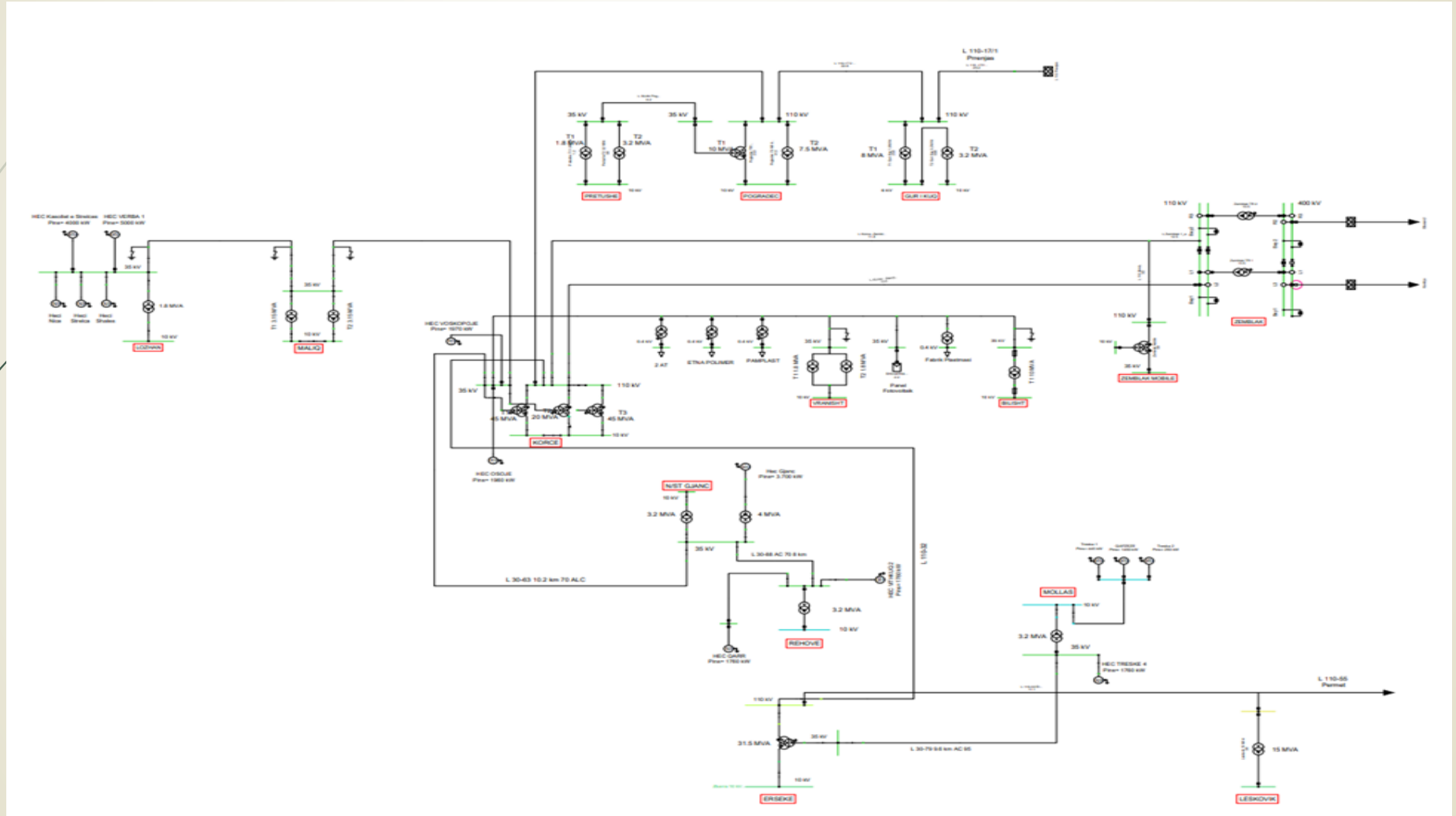
    - LLRI < 1, DG has reduced electrical line losses,
    - LLRI = 1, DG has no impact on system line losses,
    - LLRI > 1, DG has influenced the increase of losses in the system.
  - **Transformer Loss Reduction Index (TLRI)**

$$\mathrm{TLRI} = \frac{\mathrm{TL_{W/DG}}}{\mathrm{TL_{WO/DG}}}$$

Where: TL are the total transformer losses.

    - The interpretation of the results is the same as in the above index.

Case study



The main scheme of the Korça distribution system

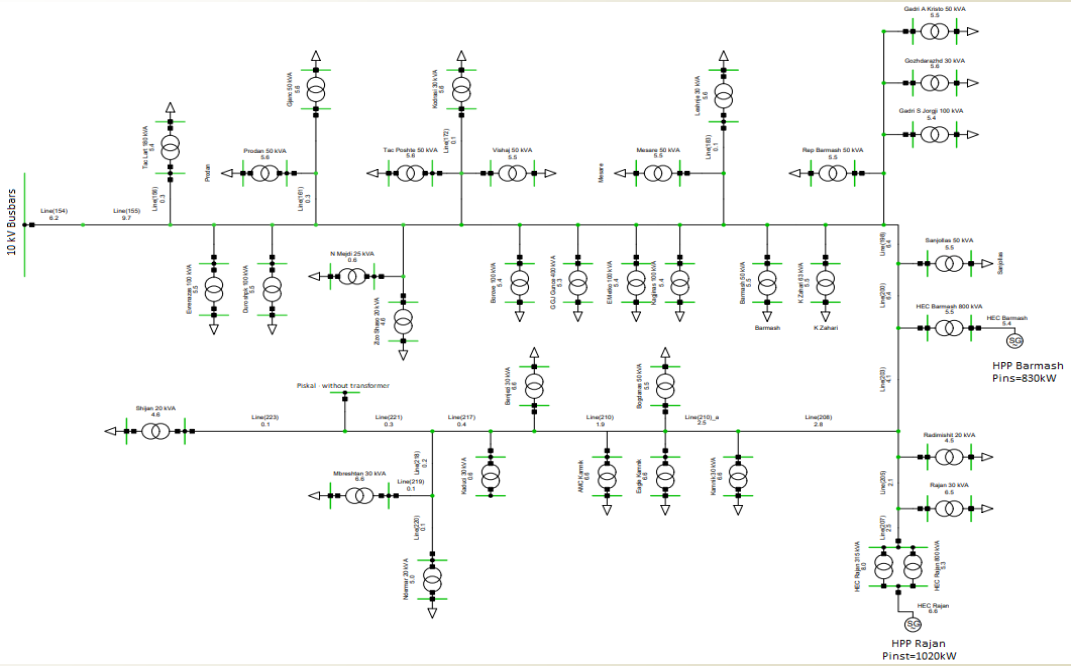
Case study

Name	In Folder	Losses related to Infeed %	Input Curren... A	Infeed, Active Power kW	Max. Voltage Drop %	Max. Voltage Rise %	Maximum Length	Total Load, Active Power kW	Line Losses kW	Transformer Losses kW	Generation, Active Power kW
Fideri Fshat Turan Nst Korce	Feeders	3.84	5	80	0.48	0.00	4.55	77	0.24	2.82	0.00
Fideri 1 Leskovik	Feeders	35.58	27	26	0.00	1.27	28.58	76	30.63	11.44	92.50
Fideri Cervenaka Guri i Kuq	Feeders	18.82	8	19	0.00	0.12	11.08	16	0.23	3.38	0.00
Fideri Fabrika 2 Guri i Kuq	Feeders	7.38	2	17	0.18	0.00	0.22	16	0.00	1.25	0.00
Fideri Fabrika Guri i Kuq	Feeders	6.54	1	9	0.16	0.00	0.20	8	0.00	0.57	0.00
Fideri Fajanca Nst Korce	Feeders	5.29	7	124	0.22	0.00	2.13	118	0.05	6.52	0.00
Fideri Fonderia Guri i Kuq	Feeders	3.85	6	89	0.19	0.00	0.27	86	0.01	3.43	0.00
Fideri Frigoriferi Nst Gjanc	Feeders	8.76	7	128	1.06	0.00	7.92	117	0.87	10.36	0.00
Fideri Fshati 1 Guri i Kuq	Feeders	13.84	6	89	0.57	0.00	11.23	76	0.50	11.76	0.00
Fideri Fshati Nst Gjanc	Feeders	10.62	7	127	0.39	0.00	4.02	128	0.20	15.03	16.00
Fideri Fshati Nst Rehove	Feeders	13.10	0	4	0.25	0.12	5.20	17	0.01	2.54	15.00
Fideri Gurore Nst Gjanc	Feeders	8.84	1	17	0.25	0.00	3.33	16	0.01	1.51	0.00
Fideri Komunal 1 Maliq	Feeders	6.92	5	81	0.20	0.00	1.93	76	0.04	5.58	0.00
Fideri Komunal 4 Maliq	Feeders	7.32	3	49	0.22	0.00	1.15	45	0.02	3.53	0.00
Fideri Nr 3 Nst Mollas	Feeders	22.54	6	-39	0.07	0.33	6.24	20	0.21	5.68	65.00
Fideri Nr 4 Nst Mollas	Feeders	19.36	4	-5	0.21	0.31	12.84	16	0.15	3.81	25.00
Fideri Nr 6 Nst Mollas	Feeders	19.08	13	-5	0.00	0.66	25.91	55	4.54	8.40	72.50
Fideri Nr 8 Bilisht	Feeders	21.36	20	101	0.29	0.16	36.89	79	8.85	12.69	0.00
Fideri Pogradeci Guri Kuq	Feeders	11.62	2	3	0.18	0.00	2.60	2	0.00	0.29	0.00
Fideri Potkozhani Nst guri Kuq	Feeders	25.12	25	110	0.00	0.83	31.91	98	13.96	18.80	20.00
Fideri Vithkuq Nst Rehove	Feeders	19.69	17	-6	0.00	0.94	34.40	75	6.77	11.55	99.00
Fideri nr 1 E Erseke	Feeders	7.70	6	73	0.34	0.00	9.22	67	0.16	5.43	0.00
Fideri nr 10 E Erseke	Feeders	6.30	8	129	0.19	0.00	0.72	121	0.02	8.14	0.00
Fideri nr 12 Lozhan	Feeders	6.59	1	23	0.20	0.00	1.30	21	0.01	1.49	0.00
Fideri nr 2 E Erseke	Feeders	9.15	8	50	0.34	0.00	14.75	62	0.41	5.87	19.00
Fideri nr 20 Nst Korce	Feeders	11.89	5	55	0.08	0.00	5.00	48	0.02	6.51	0.00
Fideri nr 21 Fshat Nst Korce	Feeders	8.96	22	389	1.85	0.00	12.06	363	3.95	31.80	10.00
Fideri nr 23 Nst Korce	Feeders	7.18	16	287	0.73	0.00	6.64	266	0.93	19.63	0.00
Fideri nr 3 E Erseke	Feeders	19.71	15	21	0.09	1.62	31.99	93	8.45	14.32	94.00
Fideri nr 4 E Erseke	Feeders	6.49	8	138	0.32	0.00	2.00	129	0.16	8.82	0.00
Fideri nr 4 Lozhan	Feeders	19.50	16	23	0.55	0.32	33.31	67	8.80	7.33	60.00
Fideri nr 8 E Erseke	Feeders	8.04	3	15	0.21	0.00	7.58	14	0.02	1.20	0.00
Fideri nr 9 E Erseke	Feeders	63.45	18	-78	0.00	1.52	27.83	8	4.83	9.23	100.00
Fideri nr 9 Lozhan	Feeders	10.40	2	29	0.38	0.02	8.01	31	0.04	3.51	5.00

The main feeders of the Korça distribution system.

The feeders are built inside the scheme.
The main feeders are those with power plants connected.

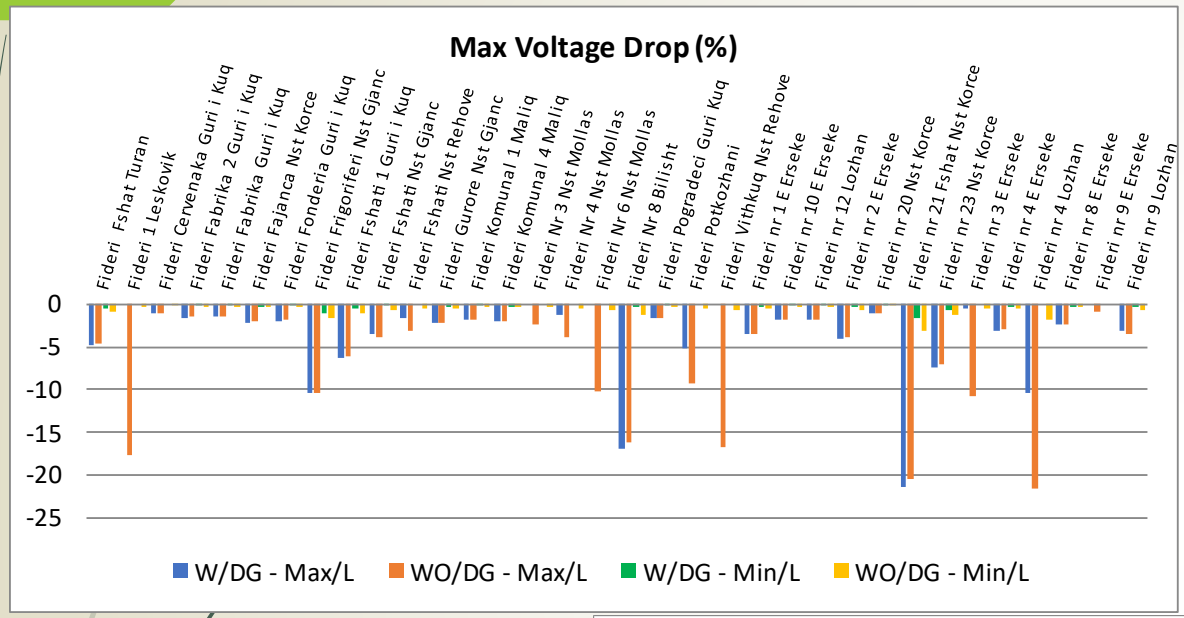
In the end of the 10 kV **Feeder Nr.3**, **there are 2 HPPs units (Barmash & Rajan), with 1.85 MW total installed capacity.**
Considering the length of this feeder, approximately 32 km, the installation of these **HPPs has significantly improved the level of voltage at the final consumers**.

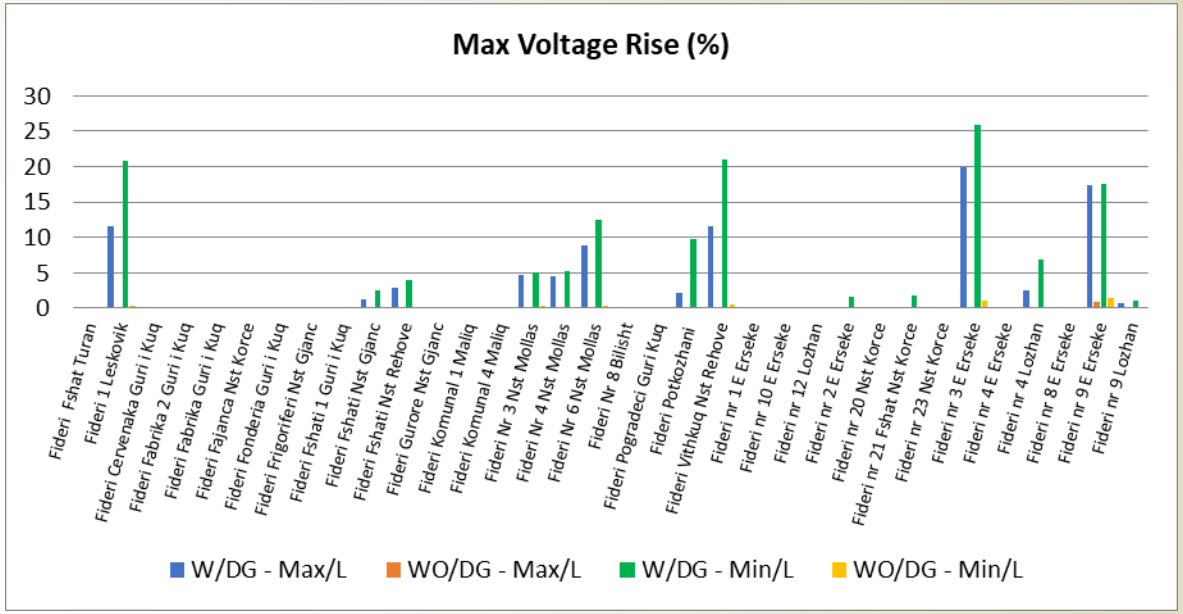


Feeder Nr. 3

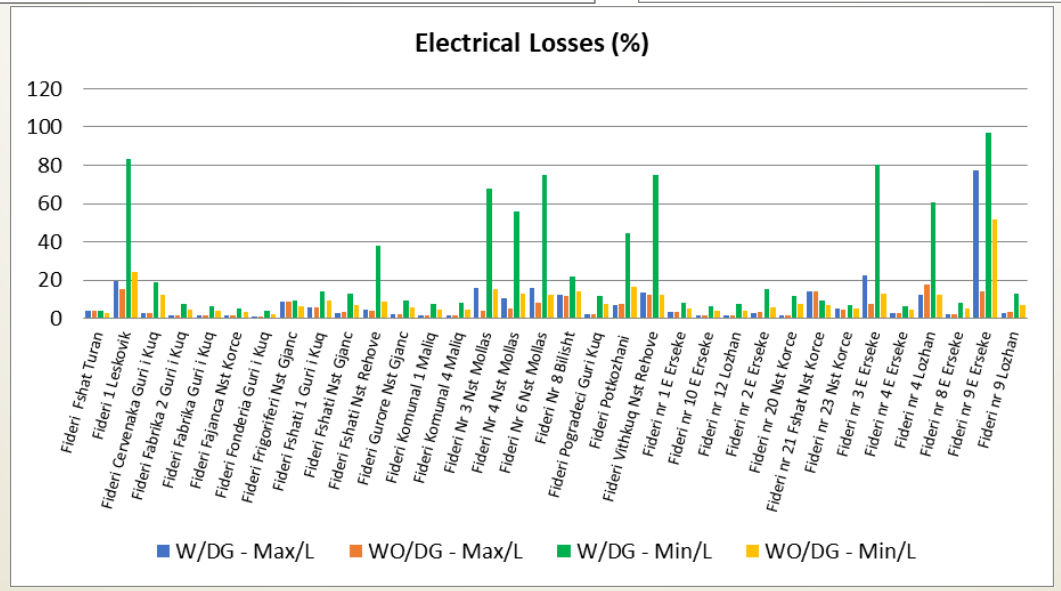
Results and discussions

The main feeders of the Korça distribution system.





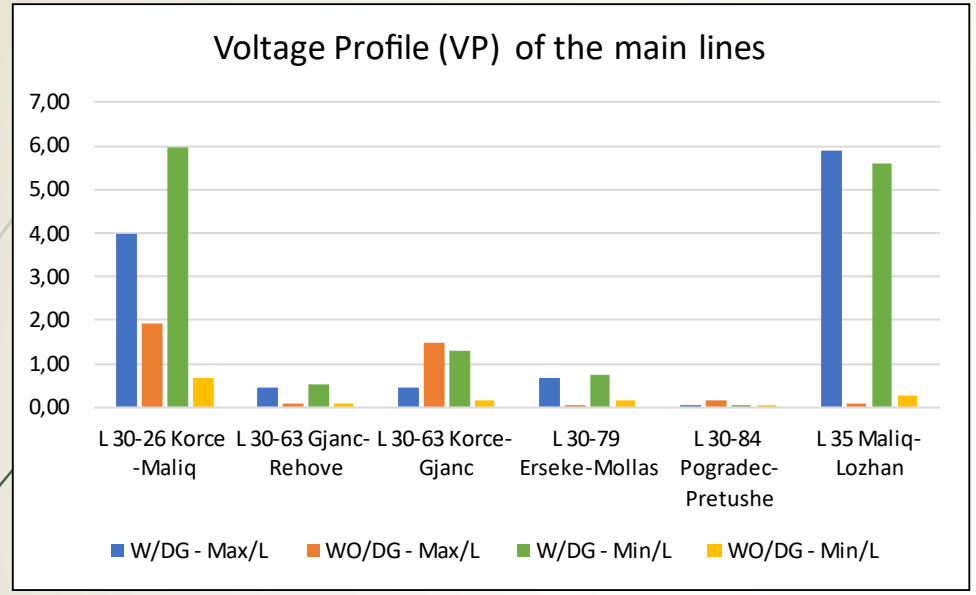
The maximum voltage drop appears only for the max load.

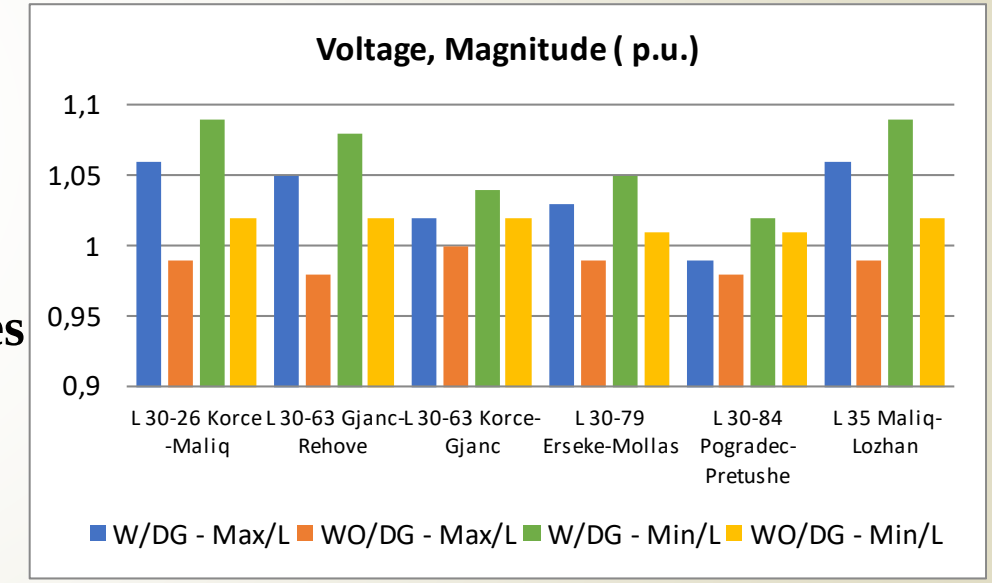


The maximum voltage rise appears only for the "with DG" case.

The maximum electrical loses appears only for the "with DG/Max load" case.

Results and discussions

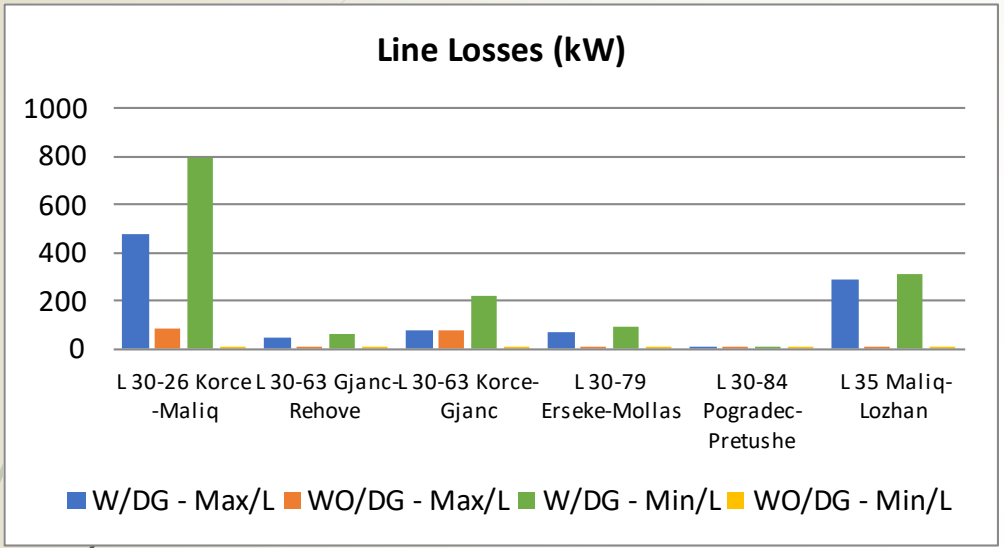


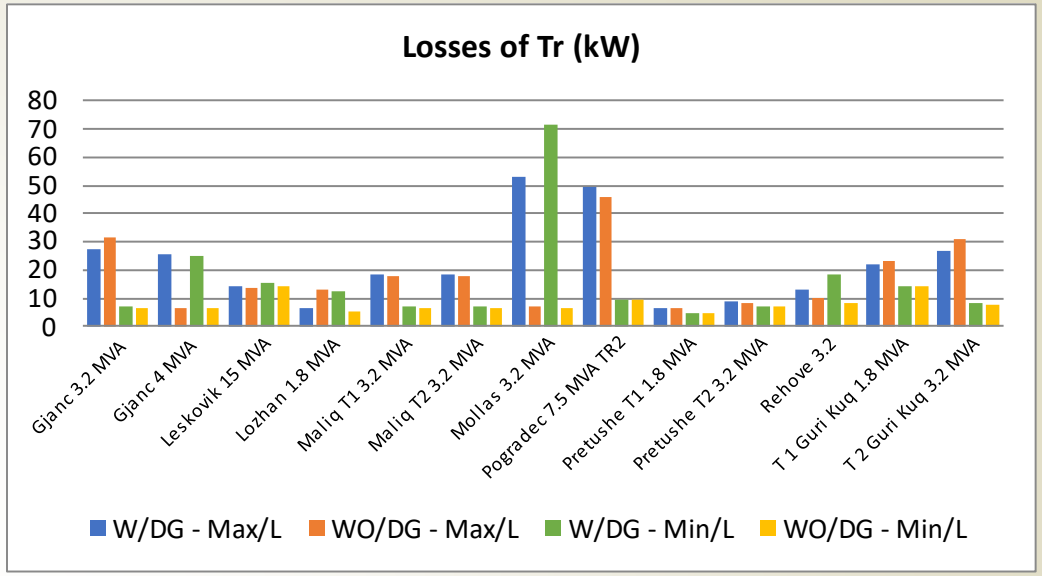


Voltage Profile Improvement Index (VPII) for the main lines

Line	Max/L	Min/L
L 30-26 Korçe-Maliq	2,07	8,67
L 30-63 Gjanc-Rehove	4,38	5,30
L 30-63 Korce-Gjanc	0,32	8,38
L 30-79 Erseke-Mollas	10,18	4,80
L 30-84 Pogradec- Pretushe	0,30	0,14
L 35 Maliq-Lozhan	58,47	21,37

Results and discussions





Line Loss Reduction Index (LLRI) for the main lines

Line	Max/L	Min/L
L 30-26 Korçë-Maliq	2,37	8,06
L 30-63 Gjanç-Rehovë	3,37	6,22
L 30-63 Korçë-Gjanç	1,07	6,11
L 30-79 Ersekë-Mollas	5,38	5,95
L 30-84 Pogradec- Pretushë	0,85	1,03
L 35 Maliq-Lozhan	12,72	10,97

Transformer Loss Reduction Index (TLRI)

Transformer	Max/L	Min/L
Gjanc 3.2 MVA	0,86	1,05
Gjanc 4 MVA	4,02	3,78
Leskovik 15 MVA	1,03	1,07
Lozhan 1.8 MVA	0,50	2,41
Maliq T1 3.2 MVA	1,02	1,13
Maliq T2 3.2 MVA	1,02	1,13
Mollas 3.2 MVA	7,44	11,29
Pogradec 7.5 MVA TR2	1,07	1,01
Pretushe T1 1.8 MVA	1,03	1,00
Pretushe T2 3.2 MVA	1,02	1,00
Rehove 3.2	1,28	2,18
T 1 Guri Kuq 1.8 MVA	0,94	1,02
T 2 Guri Kuq 3.2 MVA	0,87	1,11

Conclusions and recommendations

- This paper shows the impact of the DG in the distribution system of the Korça area, considering 4 different scenarios.
- It resulted:
  - **Increase of voltage** values for the "with DG" scenarios.
  - **Overloading of 35 kV lines** up to critical levels.
  - High active **energy losses in feeders where small HPPs are connected**.
  - **Overloading** of some **transformers**.
  - Large amount of electricity, **injected to the TSO network** (110 kV).
  - **DG** cause a **negative impact on the electrical losses**.

Conclusions and recommendations

- Recomandation for Albanian DSO:
  - **Repair of 35 kV lines**, installation of conductors with a larger section **or the uprated to 110 kV**.
  - **Replacing the old** substation **transformers** and increasing the nominal power of some of them.
  - **Replacement** of aluminium-steel **conductors**, with sections below 35 mm^2, in all feeders where we have connected power plants.
  - **The transition** of areas with higher consumption (such as the 110/10 kV Korça and Pogradec Substations) **to the 110/20 kV levels**.

THANK YOU FOR YOUR ATTENTION!!!