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Energy Efficiency and Renewable Energy Project. Support for Grid Integrated Renewable Energy Generation

FINAL GRID INTEGRATION STUDY

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ABBREVIATIONS

BAU	Business as Usual
DG	Distributed Generation
DSO	Distribution System Operator
HPP	Hydro Power Plants
HV	High Voltage
JV	Joint Venture
MV	Medium Voltage
NREAP	National Renewable Energy Action Plan
LV	Low Voltage
PV	Photovoltaic
RES	Renewable Energy Sources
sHPP	Small Hydro Power Plant
TPP	Thermal Power Plant
TSO	Transmission System Operator
WB	World Bank

MANAGEMENT SUMMARY

The overall objective of this project is "*to support ERO and MED to assess the least cost options for RES in Kosovo and to assess grid integration needs at the distribution level*". This report focuses on the determination of optimal investment needs for the distribution network of Kosovo, in order to accommodate the target RES capacity up to 2030.

The analysis is conducted for a reference distribution-level RES scenario, consisting of 200 MW PV and 20 MW Biomass to be accommodated in the MV network up until 2030 and includes the following two main steps:

- First, a methodology to achieve a random but realistic spatial distribution of RES is applied, in order to take into account the effect of location and sizing of stations on the needed network projects.
- Having determined the spatial distribution of RES stations, the analysis then proceeds to distribution network planning, adopting a least cost perspective. This is based on maximum exploitation of the available hosting capacity of existing feeders, aiming to accommodate as much RES capacity as possible in the existing network, then planning extensions as needed to host additional RES capacity.

To determine the effect that RES capacity variations will have on the investment plan, a sensitivity analysis is also conducted, while the study is concluded with the evaluation of two potential planning alternatives (Integration of DG through dedicated MV feeders and deployment of new HV/MV substations to host excess RES capacity).

The key conclusions of this study are:

- The total connection cost of distribution level RES resources, for the defined target capacity up to 2030, is estimated at ca. 7.5 million EURO, with an average connection cost of 39,810 €/MW. The majority of RES stations can be connected to the existing MV network, without any need for network reinforcements or new feeders.
- In general, a new RES capacity of up to 100-150 MW can be integrated in the distribution network of Kosovo at a minimum connection cost of 35,000 €/MW, exploiting only the available hosting capacity of the existing network.
- Higher RES capacities (up to 200-250 MW) can be accommodated in the distribution network with limited reinforcements and new facilities, leading to an entirely reasonable average cost of ca. 40,000-45,000 €/MW.
- Distribution level capacities around 300 MW represent a borderline for the capacity that can easily and at minimum cost be integrated in the existing network. Beyond that level, it would make economic sense to consider deployment of large-scale RES projects that will be connected directly to the transmission system, rather than

initiate an expansion policy of the public distribution network driven solely by the integration needs of distributed generation, in order to avoid further escalation of the network integration costs (additional MV and HV facilities).

- With regard to the utilization of dedicated feeders, costs in order to host the same target RES capacity become notably higher (+53%), due to the deployment of new network facilities, while existing assets are not exploited to their full potential.
- The current technical standardization of MV service equipment (metal-enclosed MV service solution) is optimal from a technical point of view; still it constitutes a relatively costly solution for small capacity stations. A more case-specific practice, considering also the connection of new RES srtations to the network via an overhead MV network solution is adopted in various countries and is totally rational in terms of cost minimization, especially regarding small size RES stations.
- The exploitation of the existing network, as dictated by the adopted least cost planning perspective, leads to an average PV station capacity of ca. 1.4 MW. This indicates that the 3 MW typical PV station size, arising from the current FiT support scheme, is suboptimal from a hosting capacity perspective of the Kosovo distribution network, imposing the need for dedicated feeders to connect to the network.

In summary, the integration of any reasonably anticipated new RES capacity in the distribution network of Kosovo can be achieved at an entirely rational cost, as long as least cost planning principles are applied, promoting moderate RES station capacities and an optimized dispersion of new RES stations. This can be achieved through the adoption of suitable regulatory policies and incentives, such as the following:

- **Incentivization of moderate RES station capacities.**
  According to the results of the current study, the project team proposes for the regulatory framework to primarily target RES station capacities around 1 MW (e.g. between 0.8 MW and 1.2 MW), representing a reasonable compromise between small size to exploit the hosting margin of existing feeders and large capacity to avoid overburdening the per MW (and eventually per MWh) connection cost.
- **Restrictions to exclude unreasonable concentrations of RES capacity in specific geographical areas,** such as the occupancy rate limit (25%-limit), proposed in the current Draft Connection Charging Methodology of KEDS.
- **Cost-reflective network connection charges and proper information conveyed by ERO/KEDS at an early stage in the application process that will provide the required signal to investors, in order to seek sites with ample electrical space available.**
  To this end, the calculation and public availability of fundamental guiding figures as regards network hosting capacity by KEDS would also facilitate and guide investor interest. ERO could for example consider establishing a requirement for KEDS to make information on RES hosting capacity per HV/MV substation or even per geographical area within the supply area of each HV/MV substation publicly available to investors, e.g. via a web application in their site. This would direct new RES capacity towards areas where sufficient electrical space is still available.

1 INTRODUCTION

This report is the Draft Grid Integration Study of the project ***“Support for Grid Integrated Renewable Energy Generation”*** and follows the proposal originally submitted by the joint venture of EXERGIA S.A. (GR) with EIHP (HR), and subcontractor Alb-Architect (XK). The main Beneficiaries of the project are the Ministry of Economic Development (MED) and the Energy Regulatory Office (ERO) of Kosovo. The project is financed from the proceedings of a World Bank loan and is implemented in the framework of the Kosovo Energy Efficiency and Renewable Energy Project.

1.1 Project Aim and Objectives

As per the ToR, the overall objective of this project is “*to support ERO and MED to assess the least cost options for RES in Kosovo and to assess grid integration needs at the distribution level.*”

The specific objectives of the project are:

- Determine the least cost RES mix to meet RES targets based on least cost planning (**Task 1**).
- Distribution level RES grid integration study to assess the network’s capacity to absorb DER and determine optimal investments needs to accommodate the target RES capacity (**Task 2**).

Task 2 of the project includes the following subtasks:

- *Subtask 2.1 and 2.2*: Data collection, documentary review and preparation of the study framework. These subtasks were completed in the inception phase of the project and the results were incorporated in the inception report delivered on April 9, 2020. Feedback received by the Beneficiaries was incorporated in the revised version of the inception report submitted on May 19, 2020.
- *Subtask 2.3*: Assessment of the impact of distributed RES on the technical parameters of the distribution network in Kosovo. This subtask was completed, as part of the main analysis phase and the respective Grid Analysis Report was delivered on July 8, 2020.
- Subtask 2.4: Identification of distribution network projects, necessary to host the targeted RES capacity to year 2030, along with the respective investment plan.
- *Subtask 2.5*: Revision and update of the investment planning performed in Subtask 2.4, including final recommendations for the Beneficiaries.

The current report (Final Grid Integration Study) presents the results of subtask 2.5.

2 GENERAL ASSUMPTIONS AND CONNECTION CRITERIA

2.1 General Assumptions

General assumptions, which are considered in the context of this study and have already been approved by the Beneficiaries are provided in the following sections:

- A planning horizon of 10 years (up to 2030) is considered in the context of this study.
- Network planning only addresses needs for integration of distribution level RES generation. Upgrades necessary to meet the increasing load demand until 2030 are not in the scope of this study. Nevertheless, the study takes into consideration planned substation upgrades. For the downstream secondary MV distribution, the network planning is conducted based on the available PowerFactory models. Since such models are not available for year 2030, the analysis is based on the current network situation (actually, the state of the network corresponding to the PowerFactory models provided). This may provide a conservative estimate of hosting capacity and safe-side assumptions regarding the cost of integration, if secondary network upgrades are planned to take place. Nevertheless, given the modest DG capacities anticipated to be hosted by the distribution network, this is not deemed to be a serious concern.
- According to the Distribution Code[1], the capacity ceiling for connection to the distribution network is 10 MW, thus all RES plants with capacity greater than 10 MW will be connected to the transmission network. Based on wind turbine technology and size evolution and market availability today and in the near future, it is expected that all wind generation will be connected to the transmission system. All other technologies (sHPP, PV and biomass) are assumed to be connected mainly to the distribution system (individual station capacity < 10 MW).
- The current version of the Energy Strategy[2] has defined a target of 240 MW for new sHPP. The government of Kosovo, however, has recently put a moratorium on new

[1] Distribution Code, KEDS, March 2014

[2] Energy Strategy of the Republic of Kosovo 2017 – 2026, Ministry of economic development, March 2017

applications, due to potential environmental concerns and the lack of feasible potential to reach the hydro quota. In the context of this study, it will be assumed that already authorized or in application stage sHPP will be constructed as planned, exploiting the feasible potential for new sHPP.

- Given the fact that hydro potential resources are located at very specific geographical regions, identified by operating, licensed or in application stage HPP projects, it makes sense to assume that for the limited number of HV/MV substations serving those regions, sHPP will take precedence over PV in getting access to the available hosting capacity. In other areas, PV is the dominant distribution level generation technology, determining grid reinforcement.
- The current version of the Energy Strategy has defined a target of 20 MW for new biomass plants. The limited interest for biomass plants so far (1 application for a new plant with an installed capacity of 1.2 MW) suggests that there is no feasible potential for an increase of the current target. In the context of the current study, the total capacity of new biomass plants is therefore considered to be already defined and equal to 20 MW.
- In the context of the current study, all new RES stations considered are pure generation facilities (producers), rather than combined with consumption facilities within self-producer (prosumer) entities. However, it should be noted that the differentiation between producers and prosumers is a regulatory rather than a technical issue affecting the analysis conducted. Hence, although energy tariffs and regulated charges may be differentiated between producers and prosumers, the calculated hosting capacity of the network will not change when the addition of a certain RES capacity is considered at a certain location of the network.
  It is therefore clear that there is no reason whatsoever, related to the findings of this investigation, to exclude LV and MV prosumers from the development of distributed generation in the country. From a hosting capacity perspective, prosumers are technically equivalent to producers and any differentiation would have no impact on the results of the network investment planning analysis, with the possible exception of the direct connection cost at MV level (MV network service), if interfacing of embedded generation takes place within the private customer facilities.
- The current applications for new RES[3] indicate a rather limited interest for residential PV so far (< 1% of the total PV capacity). Larger PV plants connected directly to the MV network will represent the bulk of the new capacity required to reach the ambitious targets of the Energy Strategy. In the context of this study, it will be assumed that small scale (mostly residential & rooftop) PV, connected to the LV network, will constitute up to 10% of the total PV capacity. However, the exact

[3] Register of Applications for construction of new generating capacities and Admission to Support Scheme from RES, Energy Regulatory Office, 2020

location of small scale PV stations and their allocation to specific MV/LV substations cannot be defined in a planning study. Furthermore, the analysis conducted in subtask 2.3 (see Grid Analysis Report) has shown that the hosting capacity at LV level is ample to accommodate the anticipated PV capacities with negligible additional investment costs. Thus, LV PV stations are not explicitly considered in the distribution grid investment planning, but their impact on MV network operation will be considered through an appropriate selection of Generation/Load scenarios to be simulated (see section 2.2).

2.2 Criteria for the Connection of RES to the Distribution Network

There are several technical and operational limitations, restricting the integration of DG in distribution networks[4]. Based on all relevant literature and on the experience of the project team in planning and operation of distribution networks with high penetration of Distributed Generation (DG), the following are identified as most significant:

- **Capacity limits:** Each element of the distribution network (lines, transformers etc.) is characterized by its rated current-carrying capacity. Connection of DG has the effect of changing current flows in the network. Depending on size and connection scheme, the integration of DG will impact network loading, which needs to remain within the acceptable range of each element, especially under maximum generation and minimum load conditions.
- **Voltage regulation:** Voltage regulation is primarily achieved through on-load tap changers (OLTC), controlled by automatic voltage control (AVC) schemes at the MV busbars of HV/MV substations. These AVC schemes will typically maintain the busbar voltage at slightly higher than nominal voltage to allow for voltage drop along the outgoing feeders. Although DG may have a positive effect, compensating voltage drops, high DG penetrations complicate voltage control and may lead to overvoltage situations, necessitating more sophisticated regulation practices, exploiting active elements of the network, including DG itself, the installation of step voltage regulators along feeders, management of capacitor banks etc.
- **Fault level:** Distribution networks are characterized by a design short circuit capacity, which corresponds to the maximum fault current that can be interrupted by the switchgear used and the thermal and mechanical withstand capability of equipment and standardized network constructions. Since DG contribute to the fault current, their interconnection may lead to a short circuit capacity exceeding the design fault level of the network. The DG fault contribution is determined by a

[4] Capacity of Distribution Feeders for Hosting DER, CIGRES WG C6.24, June 2014

number of factors, including the type, distance, configuration of the network and the method of coupling to the network.

- **Reverse power flows:** Increasing levels of DG can lead to the export of power from distribution towards the upstream transmission system, when DG output exceeds local demand. In such cases, the local transformers will experience reverse power flows, which in principle may not constitute an issue by themselves[5], however they signify operating conditions, which are untypical compared to the standard mode of network operation, upsetting voltage regulation, power factor management and other operating practices for both transmission and distribution.

Additional technical factors related to network reliability, power quality, protection, operation of ripple control systems etc. do exist, however their application becomes too case specific to constitute criteria suitable for application in a generic grid integration study, intended to support high level policy decisions, rather than to establish technical practices and embark on detailed technical analysis. With regard to network reliability, it should be noted that the upgrade of reliability levels is a task and statutory obligation of a DSO that should take place regardless of anticipated connection of distributed generation, as it affects the service level offered to all network users. Hence, it cannot constitute a legitimate impediment to interfacing DG capacity to the network. On the other hand, in order to provide indemnity to the DSO against a reasonably anticipated level of continuity of service disturbance, the prevailing reliability levels of the distribution network should be reflected in the connection agreements of DG stations, as long as they remain within the statutory obligations of the DSO.

A brief generic discussion on protection and islanding issues, relevant for distribution networks with high DG penetration, was included in the Grid Analysis Report (Subtask 2.3).

Taking into consideration the status of the distribution network in Kosovo now and in the near- and mid-term[6], as well as the nature and primary focus of this study, the project team has adopted the following list of concrete technical criteria for the connection of RES to the distribution system, already discussed and confirmed by the Beneficiaries. These will serve as the basis for determining hosting capacities and network upgrades in Task 2.

[5] The possibility of reverse power flows in transformers has been reported to conflict with old OLTCs with single resistor bridging. In such cases, the regulator's ability to carry reversed power flows may be reduced to anywhere between 30% and 70% of the transformer rating. However, these are rather uncommon constraints.

[6] Development Plan of Distribution System Operator 2019 – 2028 (KEDS, 2019, Draft)

- **Generation/Load:** Technical evaluation of network constraints regarding the integration of RES is based on standard practice of using maximum generation/minimum load scenarios. More specifically:
  - **Maximum generation** is always considered equal to the RES capacity installed in the respective network segment (HV/MV substation, MV feeder, LV network)
  - **Minimum load** is estimated separately for the different network segments, based on the following methodology:
    - **For HV/MV substations**, the minimum load of each specific substation is considered, according to the data provided by KOSTT.
    - **For MV feeders**, the minimum load is calculated according to its maximum load and an estimated proportion of "minimum load / maximum load". At a HV/MV substation level, this proportion is equal to 47.6% on average, according to the data provided by KOSTT. At MV feeder level, taking into account the coincidence of the load among the feeders as well as the operation of RES stations at LV (see section 2.1), typical values will be much lower. Thus, a proportion of 25% is used in the context of this study as the ratio of minimum to maximum load of each MV feeder.
- **Network lines:** The capacity limit of network lines shall not be exceeded (100% rated current)[7].
- **HV/MV substations:** The maximum RES power minus minimum load per HV/MV-substation shall not exceed the installed transformer capacity at N-1 conditions.
- **HV/MV transformers:** According to the Draft Connection Charging Methodology[8], one of the criteria suggested for the examination of DG connection is the "Transformer Occupancy Rate", limiting the connected DG per HV/MV substation to 25% of the installed transformer capacity. As limits of this nature are commonly applied by DSOs all over the world[9], it makes sense to maintain such a screening criterion, which rationalizes the integration of RES, guiding new capacity towards

[7] In reality, the actual capacity of specific network sections and elements may be reduced, due to age and condition considerations. This study could not have addressed such a level of real world detail, unless incorporated in the models provided. Nevertheless, this does not affect the validity of the results: as the hosting capacity of the network is determined for maximum generation/minimum load conditions, the combined probability of simultaneous occurrence of these largely independent events is very low and the respective time duration of such extreme conditions would have been very short whenever they would occur. Furthermore, the hosting capacity limit of the great majority of examined MV network feeders is determined by voltage regulation constraints, well before reaching the thermal capacity limits of the feeders. As a result, considering 100% of the rated feeder capacity limit for the analysis of hosting capacity is considered appropriate.

[8] Distribution Network Operator Draft Connection Charging Methodology, KEDS, 2017

[9] Capacity of Distribution Feeders for Hosting DER, CIGRES WG C6.24, June 2014

more developed sections of the network. In the context of the current study, the 25% limit is applied as a guiding limitation, i.e. not as a strict technical constraint, but in a more flexible interpretation, allowing a transgression of that limit where major network investment can be avoided by doing so.

- **Voltage regulation:** The aggregate voltage rise due to all RES connected to a MV feeder shall not exceed 3%. The same limit applies to the aggregate voltage rise due to all RES connected to the LV network of a MV/LV substation. Assuming a typical OLTC voltage regulation of 104% at the MV busbars of the HV/MV substations, this leads to a maximum acceptable voltage of 107% in the MV network and 110% in the LV network, marginally within the voltage limits of EN50160[10]. For dedicated MV feeders, used exclusively for the connection of RES, a limit of 6 % for the aggregate voltage rise is adopted.
- **Fault level:** The short circuit capacity at the MV busbars of the HV/MV substations must remain below the design fault level, considering the contribution of the upstream network and the DG hosted downstream.

[10] EN50160, "50160: Voltage characteristics of electricity supplied by public distribution systems", CENELEC

3 OVERVIEW OF THE APPLIED METHODOLOGY

The main objective of Subtask 2.4 is to determine the optimal investment needs, necessary to host a target RES capacity, adopting least cost principles. The methodology applied to achieve this objective includes the following two main steps:

- **Spatial Distribution of RES:** The analysis conducted in Subtask 2.3 has shown that the hosting capacity of a given network and subsequently the needed network investments to host a target RES capacity, strongly depend on the spatial distribution and size of the RES stations considered. However, for a given target RES capacity there are infinite combinations of RES stations locations and sizes that could be considered. To address this issue, the project team has employed a methodology to develop a random but realistic spatial distribution of RES stations, described in more detail in **section 3.1** .
- **Investment Planning**: Having determined the spatial distribution of RES stations, the analysis then proceeds to distribution network planning, adopting a least cost perspective. This is based on the maximum exploitation of the available hosting capacity of existing feeders, aiming to accommodate as much RES capacity as possible in the existing network, then planning extensions as needed to host additional RES capacity. The result of the analysis gives an estimation of the needed distribution network investment per distribution area, to accommodate targeted RES capacity up to year 2030. A more detailed description of this part of the analysis is given in **section 3.2** .

With regard to the considered target RES capacity, the main analysis is conducted for a reference penetration target, defined and agreed between the project team and the Beneficiaries. A detailed description of the reference study as well as the respective results are given in **sections 4.1 and 4.2** .

To determine the effect that RES capacity variations will have on the investment plan, a sensitivity analysis is also conducted in the context of Subtask 2.4, using a representative distribution area as a study case. Results are presented in **section 4.3** . This will allow extrapolating the outcome of the reference study to other RES capacities, without repeating the entire network planning exercise.

Finally, two potential planning alternatives to the least cost planning approach are assessed in **chapter 5** , in order to further investigate their impact. The first of these variations (see section 5.1) examines an approach similar to the practice currently adopted in Kosovo, considering the integration of RES in the distribution network mainly through dedicated feeders. The second (see section 5.2) examines alternatives to integrate high RES capacities, exceeding the hosting capacity of the existing network, necessitating thus the construction of new HV substations.

3.1 RES spatial distribution

The applied methodology focuses on the spatial distribution of the target PV capacity, as the location of all new sHPP is already fully defined (see section 2.1), while the anticipated biomass potential is too low to warrant any particular consideration in terms of spatial distribution (see section 2.1). Biomass projects are therefore assumed to be distributed uniformly in the various distribution areas.

Regarding PVs, maximum exploitation of available hosting capacity of existing feeders could lead to unreasonable concentrations of installed PVs in specific distribution areas/substations/locations (e.g. near existing substations). A geographical distribution of PVs based solely on network costs could lead to unacceptable concentrations of capacity, if the spatial distribution does not take into account additional, non-technical factors (e.g. land availability, permitting constraints etc.). The latter are difficult to quantify, particularly in the context and timeframe of this study; nevertheless the project team has employed a methodology to provide an educated guess through the determination of specific allocation factors for the spatial distribution of PV amongst the different distribution areas and substations, as well as within the service area of each substation.

As illustrated in Figure 1 and described in detail in the following sections, the applied methodology, already discussed and confirmed by the Beneficiaries, defines such allocation factors at three different levels:

- **PV allocation per distribution area:** To avoid unreasonable PV concentrations in specific distribution areas, allocation factors at distribution area level were determined, reflecting geographical particularities and characteristics that are expected to guide and limit the development of PVs.
- **PV allocation per HV/MV substation:** At a second level, allocation factors at HV/MV substation level are determined, in order to guide the spatial distribution of PVs within the boundaries of each distribution area, determining how the entire area capacity is apportioned to each HV/MV substation within the area.
- **PV allocation within the service area of each substation:** Lastly, to ensure a plausible spatial distribution of PVs within the service area of each HV/MV substation, a third set of allocation factors is determined at this level too.

It needs to be noted, that the defined allocation factors do not represent technical potential estimations or absolute hosting capacity limits but rather serve as **indicators of the relative capability of each specific area to host PVs, ensuring a reasonable spatial distribution**. In this sense, all allocation factors are used as **guiding figures, rather than strict technical constraints**, permitting deviations to occur where major network investment can be avoided by doing so.

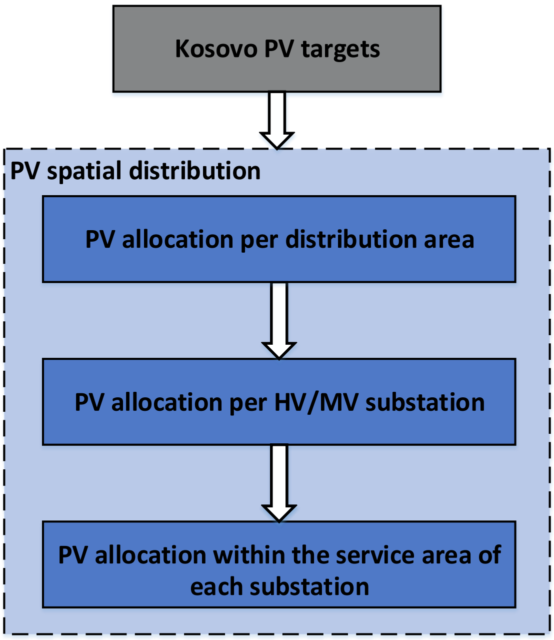

Figure 1 Applied methodology for PV allocation in Kosovo network.

3.1.1 PV Allocation per distribution area

To avoid unreasonable PV concentrations in specific distribution areas, allocation factors were determined, serving as indicators of the relative capability of distribution areas to host PV. This part of the analysis considers various factors, including land availability/suitability (excluding urban areas, forests, national parks etc. through Google Earth analysis), expressed investor interest (according to existing applications) and interdependencies between the different RES technologies (hydro or PV prioritization as explained in section 2.1). The results of Google Earth screening to determine land availability/suitability for all distribution areas are given in. Figure 2 illustrates the results in the distribution area of Peja, as an example of the methodology application in all distribution areas.

Through this analysis, PV allocation factors per distribution area were determined, as presented in

Table 3-1. In this manner, PV capacity is directed primarily towards locations with ample available/suitable land for PV deployment, mainly in non-urban environments and areas with expressed investor interest. Furthermore, in distribution areas where sHPP is the dominant RES technology (based on operational/licensed plants and known applications), PV development is not prioritized.

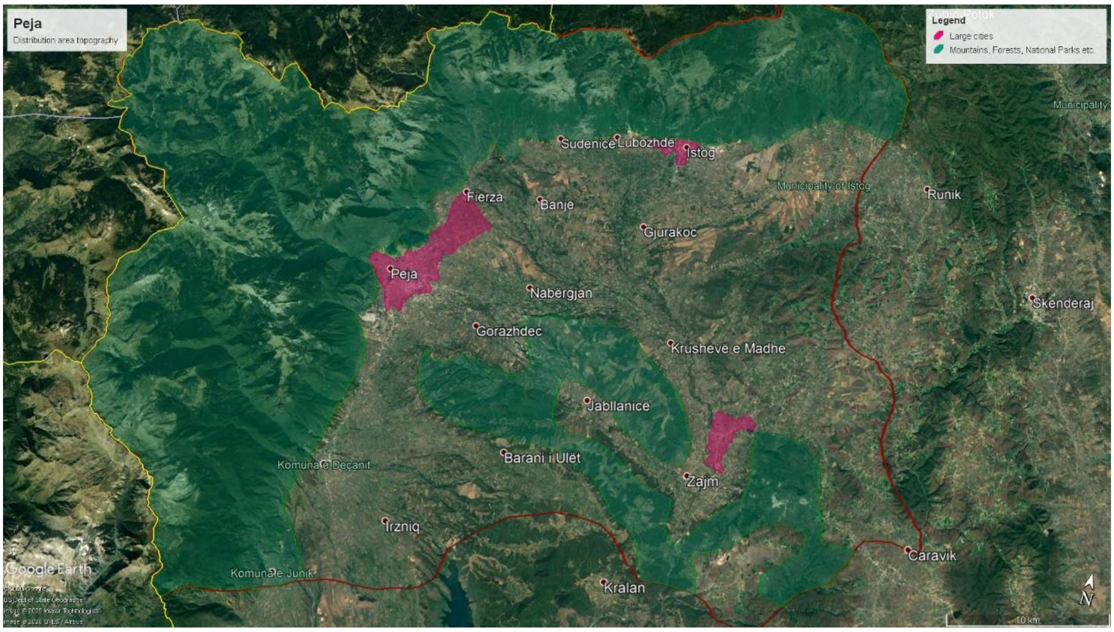

Figure 2 Land screening in the Peja distribution area for PV deployment purposes.

Table 3-1 PV Distribution Area Allocation Factors

Area	PV Distribution Area Allocation Factors
Prishtina	19.2%
Ferizaj	7.3%
Mitrovica	11.3%
Peja	20.9%
Gjakova	28.8%
Prizreni	5.2%
Gjilan	7.3%
Total	**100%**

3.1.2 PV Allocation per HV/MV substation

Having determined PV allocation per distribution area, the analysis advances to distribute area level PV capacity to the individual HV/MV substations located in each area, as the next step towards defining the distribution network requirements to host the targeted capacity. This part of the analysis is based on the same factors described in section 3.1.1 (land availability/suitability, expressed investor interest and interdependencies between different RES technologies), in order to quantify the suitability of each substation service area to host PVs. As an example, the service area of Klina HV/MV substation is presented in Figure 3, with areas identified as unavailable/unsuitable for PV deployment (mountains, forests, national parks, large cities, etc.) marked on the map. The same methodology was applied to all HV/MV substations.

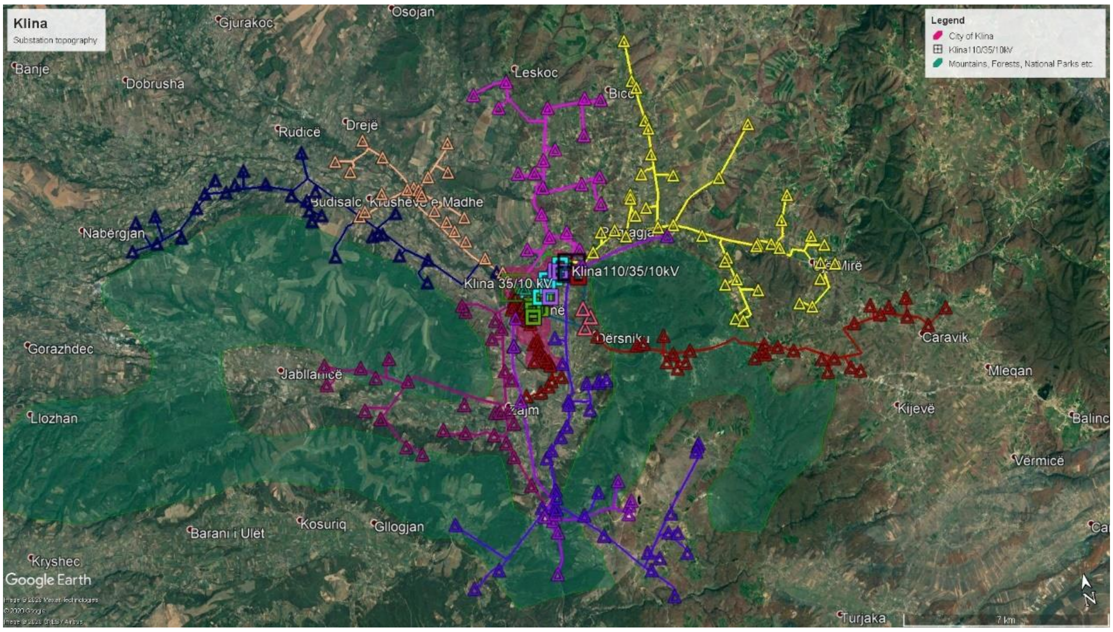

Figure 3 Areas identified as unsuitable for PV deployment in the service area of Klina HV/MV substation.

Main outcome of this analysis is the definition of "PV allocation factors per substation", as presented in Table 3-2, helping to direct PV capacity to specific HV substation service areas in a rationalized manner. Substations in areas with ample suitable land and demonstrated investor interest, which are not located in sHPP preferential development regions, are more probable to host new PV capacity. Following this approach, and taking into consideration already operating, authorized or in application stage sHPP, certain HV/MV substations in Table 3-2 were earmarked for sHPP development, being excluded from new PV generation development.

Table 3-2 PV Substation Allocation Factors

Distribution Area	HV/MV substation	PV Substation Allocation Factors
Prishtina	Prishtina 1	14.07%
	Prishtina 2	5.81%
	Prishtina 3	5.51%
	Prishtina 5	8.26%
	Prishtina 7	5.71%
	Bardhi (Palaj)	7.83%
	Drenasi	15.64%
	Podujeva	23.14%
	Fushë Kosova	14.03%
Peja	Peja 1	18.81%
	Peja 2	11.18%
	Decani	0.00%

	Burimi	29.20%
	Klina	40.81%
Gjilan	Gjilan 1	20.38%
	Gjilan 5	17.68%
	Vitia	34.92%
	Berivojca	27.02%
Prizreni	Prizreni 1	0,00%
	Prizreni 3	23,50%
	Dragashi	0,00%
	Theranda	76,50%
Ferizaj	Ferizaj (Bibaj)	0.00%
	Ferizaj 3 (Kastrioiti)	0.00%
	Sharr	0.00%
	Lipjani	100.00%
Gjakova	Gjakova 1	44.81%
	Malisheva	17.37%
	Rahoveci	17.37%
	Gjakova 2	20.45%
Mitrovica	Ilirida	19.10%
	Vushtrri 2	27.50%
	Skenderaj	53.40%

3.1.3 PV distribution in the service area of each HV/MV substation

The last step of the spatial allocation analysis is the creation of a realistic scatter of PV capacity allocated to each HV substation within this substation's service area. This is essential in order to avoid high PV concentrations in the direct vicinity of the substations, i.e. in a very small radius where the hosting capacity of the network is highest due to the small electrical distances involved. For this purpose, the service area of each HV/MV substation was divided in four geographical zones defined by three circles with their center at the HV/MV substation.

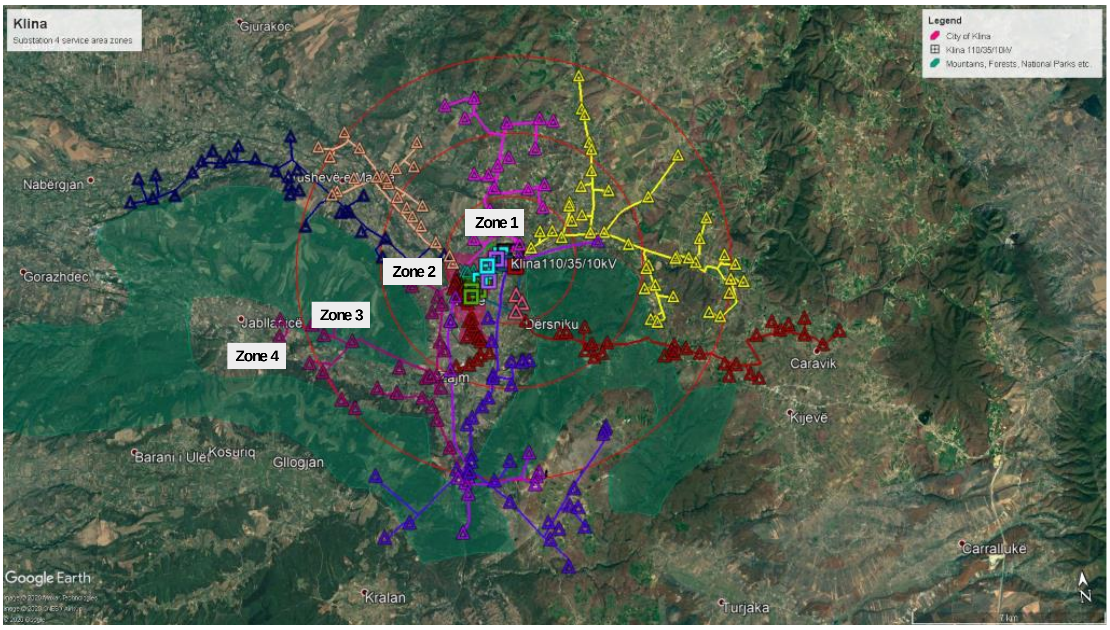

Figure 4 Illustration of the 4 service area zones of Klina HV/MV Substation.

This is illustrated in Figure 4 for Klina substation, where the routing of the existing MV network is also indicated; zones 1-3 include the greatest part of the substation's service area and network, while the 4th zone encompasses more distant locations. Under rational development conditions, even though electrical distance is not the only (arguably, not even the most significant) factor, the majority of PV stations is nevertheless expected to be deployed in zones 1-2, where hosting capacity is higher and connection cost lower. PV density is zones 3-4 will be lower for the same reasons. This qualitative reasoning is reflected in the allocation factors presented in Table 3-3, which quantify how the PV capacity of a particular HV substation will be spread over its geographical area.

Table 3-3 Accepted ranges of PV allocation per substation geographical zone

Zone	PV Zone Allocation Factor (%)
1	30-45%
2	30-45%
3	10-25%
4	0-10%

Figure 5 shows the results of this methodology for substation Klina and a target PV capacity of 16.7 MW, corresponding to the baseline analysis scenario (see section 4.1). The figure confirms that the proposed approach leads to a rational and potentially realistic spatial distribution of PV stations in the area surrounding the substation, excluding unreasonable concentrations in specific geographical areas.

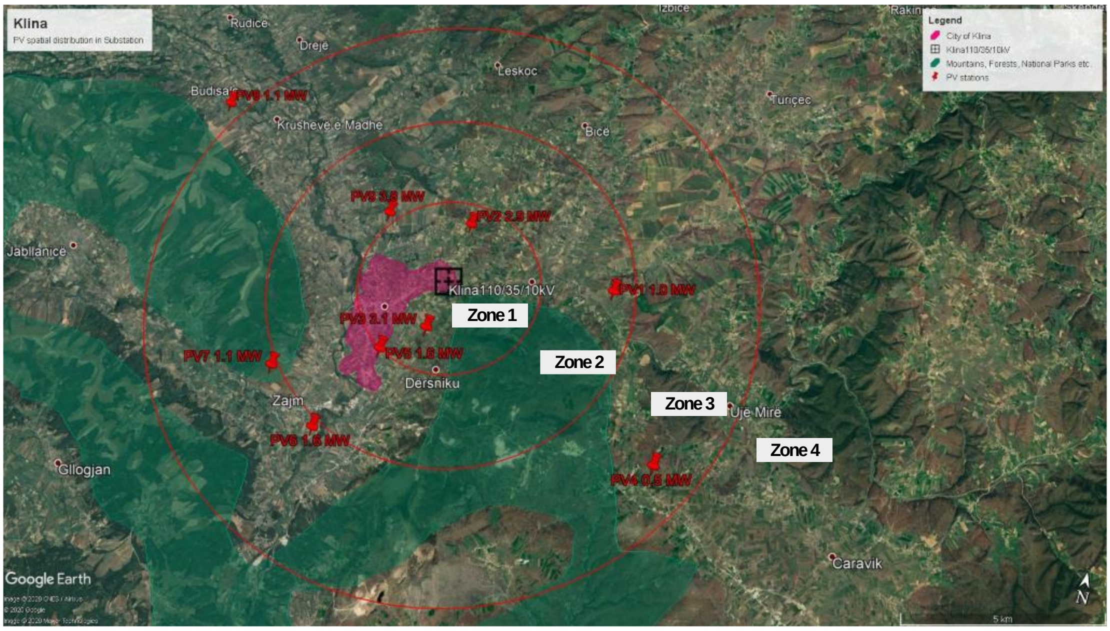

Figure 5 Illustration of indicative PV station spatial distribution in the geographical area of a single HV/MV substation (Klina substation).

3.2 Investment planning

Having determined a plausible spatial distribution of RES stations in each distribution area and substation service area, the analysis then proceeds to accommodate the target PV capacity in the existing distribution network and plan necessary upgrades and extensions. This is approached, adopting a least cost planning perspective, summarized in the following main principles:

- RES capacity is sought to be accommodated in the existing network, to the extent possible, applying necessary reinforcements when hosting capability is insufficient and can be remedied by simple upgrades to existing feeders. Thus, the connection potential to existing feeders is maximized, subject to the fundamental technical constraints defined in section 2.2 .
- Any additional capacity, that cannot be interfaced to the existing network, is connected through new dedicated MV feeders, developed specifically for the integration of RES generation. Deployment of new feeders is subject to planning restrictions at the MV side of HV/MV substations (max. number of MV departures per transformer vs. current occupation level) and the technical constraints defined in section 2.2 .

Based on these principles, the capacity and location of new RES stations is determined as follows:

- Existing and authorized RES stations are part of the target capacity, based on the following assumptions, discussed and agreed with the Beneficiaries in the inception phase:

  - Existing RES stations already in operation and connected at MV level are fully considered.
  - sHPP already authorized or in application stage, which are planned to be connected at MV level[11], are duly considered (see section 2.1).
  - Already authorized PV and Biomass stations are considered up to the limit of the current support scheme (30 MW for PV and 20 MW for Biomass).

  A detailed list of all existing and authorized RES stations, which were considered in the context of this study, according to the data provided by the Beneficiaries, is given in ANNEX 2.

- Beyond specific applications, the capacity and location of new PV and Biomass stations is determined through an exhaustive feeder-by-feeder analysis, aiming to identify suitable RES station locations and sizes to reach the defined target capacity with a least cost planning perspective. To this end, each substation's feeders were examined, based on the available GIS data and PowerFactory models and RES allocation was determined, taking into consideration the predefined geographical restrictions (see section 3.1.3).

Having specified the allocation of target distribution PV capacity, to a PV station level granularity, with specific locations and sizes of the facilities to be integrated to the network, the necessary distribution networks are then assessed through PowerFactory simulations, to ensure connection criteria specified in section 2.2 are met. Associated investment costs are then determined using the unit cost information presented in ANNEX 6.

Known **RES stations with preliminary or final authorization**, which are planned to be connected to the MV network (see ANNEX 2), are also included in this analysis. Their grid integration costs are estimated separately from the costs for new RES stations, as the location and size of authorized stations is not determined by the project team under a least cost planning perspective, but has already been defined (see section 2.1). Authorized RES stations have already received a connection offer from KEDS and the respective network planning and costs should already be known, but such data are not available to the project team, therefore respective connection costs are estimated in a generalized manner, based on reasonable assumptions.

[11] According to the data provided by the Beneficiaries, HPP Lepenci 1 (9.98 MW) is going to be connected to the 110kV network and is therefore not considered in the context of this study. Furthermore, the connection point of HPP Ecodri is not yet defined but due to the high capacity of the station (9.56 MW) it is assumed that it will also be connected to the 110kV network. Lastly, HPP Albaniku 1 and HPP Albaniku 4 are also not considered, as they will be connected to private, industrial substations (area Industria), which are not examined in the context of this study.

Based on this methodology, total grid integration costs are calculated per each distribution area, providing an estimate of the necessary distribution network investments to host the targeted distribution-level RES capacity up to year 2030.

The calculated grid costs are grouped into four main categories:

- **Direct connection cost**: Minimum cost for direct connection to the MV network, including equipment and labor costs for a standard metal-enclosed switchgear service solution as implemented in Kosovo . Such a cost excludes any upstream network extension and reinforcement and will be born in all connection cases.
- **Cost for upgrade and expansion of existing network:** Cost for network projects, such as reinforcements and short laterals required to connect RES stations to existing MV feeders.
- **Cost for new feeders:** Cost for new dedicated feeders, including feeder and MV departure switchgear in HV/MV substation. Relevant for those cases where the capacity of the existing network is fully utilized and additional RES is accommodated via new MV feeders.
- **Total connection cost**: Aggregation of the previous three cost categories.

4 REFERENCE STUDY CASE

During the main analysis phase, a reference distribution-level RES scenario was defined and agreed between the project team and the Beneficiaries, as the baseline scenario to use for conducting the network investment planning analysis, which will then be extrapolated to other potential distribution RES target capacities. The reference distribution RES capacity consists of 200 MW PV and 20 MW Biomass to be accommodated in the MV network, up until 2030. Furthermore, as clarified in section 2.1 , all sHPP already authorized or in application stage, which are planned to be connected to the MV network (see ANNEX 2), are also considered. The total target RES capacity to be accommodated in the MV network, for each distribution-level RES technology, is presented in Table 4-1.

Table 4-1 Target Capacity in the MV network per RES technology

RES Technology	Operating	Authorized	New	Total
PV	10 MW	20 MW	170 MW	**200 MW**
Biomass	0 MW	1.2 MW	18.8 MW	**20 MW**
sHPP	34.3 MW	40.7 MW	0 MW	**75 MW**
Total	**44.3 MW**	**41.9 MW**	**188.8 MW**	**295 MW**

This distribution-level RES capacity considered, provides the reference point for the entire network planning analysis. To allow extrapolation to other RES capacities, instead of adopting a direct proportionality coefficient between RES capacity and grid costs, a sensitivity analysis was conducted in the context of Subtask 2.4, to determine the effect that RES capacity variations will have on the investment plan, using a representative distribution area as a study case (see section 4.3). This provides a more valid basis to assess the level of network investment required for other target RES capacities at country level, as long as the total capacity remains at a level that does not warrant major HV projects to accommodate.

4.1 RES spatial distribution

The location of all new sHPP is already defined (see section 2.1), while Biomass projects are distributed equally in the different distribution areas (see section 3.1), leading to a Biomass capacity of 2.857 MW per distribution area. The spatial distribution of PVs, on the other hand, was determined using the methodology presented in section 3.1 leading to the distribution area and HV substation level allocation presented in Table 4-2.

Table 4-2 Target PV capacity per distribution area and HV/MV substation (all figures in MW)

Distribution Area	HV/MV Substation	Operating	Authorized	New	Total
Prishtina	Prishtina 1	0	0	5.4	**5.4**
	Prishtina 2	0	0	2.2	**2.2**
	Prishtina 3	0	0	2.1	**2.1**
	Prishtina 5	0	0	3.2	**3.2**
	Prishtina 7	0	0	2.2	**2.2**
	Bardhi (Palaj)	0	0	3.0	**3.0**
	Drenasi	0	0	6.0	**6.0**
	Podujeva	0	3.0	5.9	**8.9**
	Fushë Kosova	0	0	5.4	**5.4**
Total Prishtina		**0**	**3.0**	**35.3**	**38.4**
Peja	Peja 1	0	0	7.9	**7.9**
	Peja 2	0.4	0	4.3	**4.7**
	Decani	0	0	0	**0**
	Burimi	0.5	0	11.7	**12.2**
	Klina	0.1	0.3	16.7	**17.1**
Total Peja		**1.0**	**0.3**	**40.6**	**41. 9**
Gjilan	Gjilan 1	0	0	3.0	**3.0**
	Gjilan 5	0	0	2.6	**2.6**
	Vitia	0	0	5.1	**5.1**
	Berivojca	3.0	0	1.0	**4.0**
Total Gjilan		**3.0**	**0**	**11.7**	**14.7**
Prizreni	Prizreni 1	0	0	0	**0**
	Prizreni 3	0	0	2.4	**2.4**
	Dragashi	0	0	0	**0**
	Theranda	0	0	7.9	**7.9**
Total Prizreni		**0**	**0**	**10.3**	**10.3**
Ferizaj	Ferizaj (Bibaj)	0	0	0	**0**
	Ferizaj 3 (Kastrioiti)	0	0	0	**0**
	Sharr	0	0	0	**0**
	Lipjani	0	0	14.6	**14.6**
Total Ferizaj		**0**	**0**	**14.8**	**14.8**
Gjakova	Gjakova 1	3.0	12.0	10.8	**25.8**
	Malisheva	0	0	10.0	**10.0**

	Rahoveci	0	0	10.0	**10.0**
	Gjakova 2	3.0	4.7	4.1	**11.8**
Total Gjakova		**6.0**	**16.7**	**34.9**	**57.6**
Mitrovica	Ilirida	0	0	4.3	**4.3**
	Vushtrri 2	0	0	6.2	**6.2**
	Skenderaj	0	0	12.0	**12.0**
Total Mitrovica		0	0	22.5	**22.5**
Total Kosovo		**10.0**	**20.0**	**170**	**200**

4.2 Investment planning

Applying the methodology described in section 3.2 , specific locations and sizes for a total of **134 new PV and Biomass stations** are determined to reach the defined target capacity. A detailed list of all new stations is given in ANNEX 3, while the spatial distribution of all new stations per distribution area is illustrated in ANNEX 4. Figure 6 gives an overview of the spatial distribution in the entire country, confirming that the applied methodology leads to a plausible spatial distribution, avoiding unrealistic concentrations in areas with a marginal advantage in terms of insolation and network access. An overview of the total RES capacity per substation (including existing and authorized sHPP, PV and Biomass stations) is presented in Table 4-3.

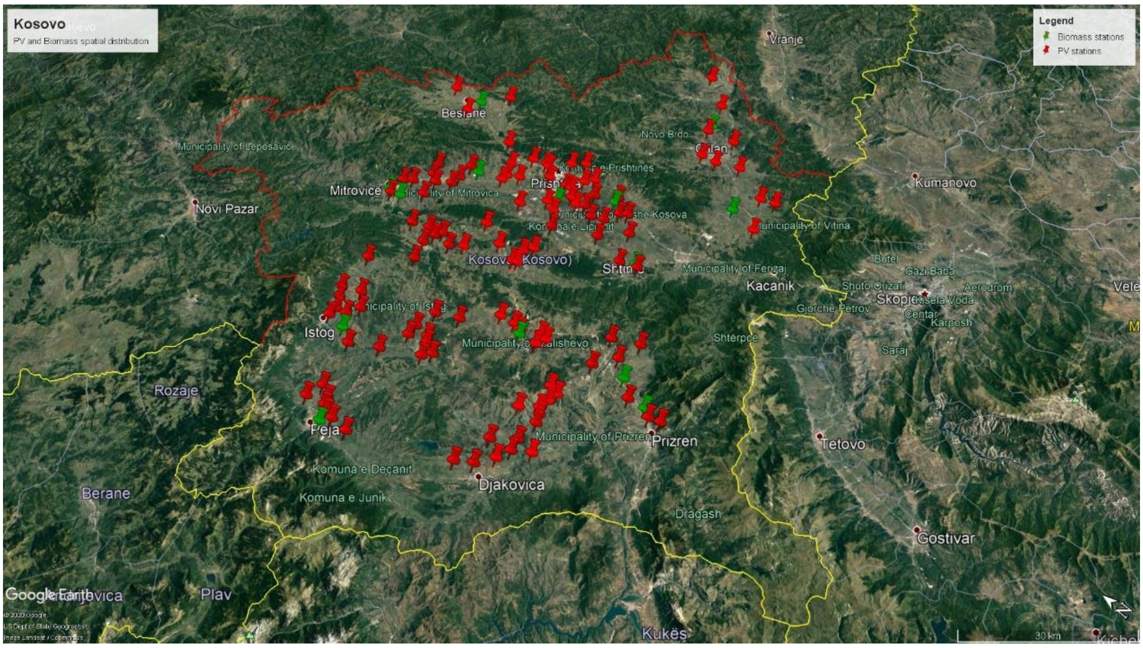

Figure 6 Spatial distribution of all new PV and Biomass stations in Kosovo.

Table 4-3 RES capacity allocation per distribution area and HV/MV substation (all figures in MW)

Distribution Area	HV/MV Substation	Hosting Capacity[12]	RES capacity			
			sHPP	Biomass	PV	Total
Prishtina	Prishtina 1	15.75	0	0	5.4	**5.4**
	Prishtina 2	17.875	0	0	2.2	**2.2**
	Prishtina 3	17.875	0	0	2.1	**2.2**
	Prishtina 5	20	0	0	3.2	**3.2**
	Prishtina 7	20	0	0	2.2	**2.2**
	Bardhi (Palaj)	20	0	0	2.8	**2.8**
	Drenasi	20	0	0	6.0	**6.0**
	Podujeva	20	0	1.6	8.9	**10.5**
	Fushë Kosova	20	0	1.2	5.4	**6.6**
Total Prishtina			0	2.8	38.3	**41.1**
Peja	Peja 1	20	0.9	1.9	7.9	**10.7**
	Peja 2	15.75	0	1.0	4.7	**5.7**
	Decani	17.875	0	0	0	**0**
	Burimi	17.875	0.9	0	12.2	**13.1**
	Klina	17.875	0	0	17.1	**17.1**
Total Peja			1.8	2.9	41.9	**46.6**
Gjilan	Gjilan 1	15	0	1.9	3.0	**4.9**
	Gjilan 5	17.875	0	0	2.6	**2.6**
	Vitia	17.875	4.0	1.0	5.2	**10.2**
	Berivojca	15.75	0	0	4.0	**4.0**
Total Gjilan			4.0	2.9	14.8	**21.7**
Prizreni	Prizreni 1	27.875	3.3	0	0	**3.3**
	Prizreni3	15.75	0	1.8	2.5	**4.3**
	Dragashi	20	28.2	0	0	**28.2**
	Theranda	17.875	0	1.1	8.0	**9.1**
Total			31.5	2.9	10.5	**44.9**

[12] According to the analysis conducted in Subtask 2.3 and presented in the Grid Analysis Report.

Prizreni						
Ferizaj	Ferizaj (Bibaj)	27.875	28.2	0	0	**28.2**
	Ferizaji 3 (Kastrioiti)	10	9.5	0	0	**9.5**
	Sharr	0	0	0	0	**0**
	Lipjani	25.75	0	2.9	14.8	**17.6**
Total Ferizaj			37.7	2.9	14.8	**55.3**
Gjakova	Gjakova 1	20	0	0	20.0	**20.0**
	Malisheva	20	0	1.7	12.0	**13.7**
	Rahoveci	15.75	0	0	12.2	**12.2**
	Gjakova 2	15.75	0	1.2	13.4	**14.6**
Total Gjakova			0	2.9	57.6	**60.5**
	Ilirida	20	0	2. 5	4.3	**6.8**
	Vushtrri 2	15.75	0	0.4	6.3	**6.7**
	Skenderaj	17.875	0	0	12.1	**12.1**
Total Mitrovica			0	2.9	22.6	**25.5**
Total Kosovo		-	75.0	20.0	200.5	**295.4**

For substations in Gjakova, the PV capacity in Table 4-3 slightly deviates from the initial capacity allocation in Table 4-2. This deviation is an example of the flexible treatment afforded to allocation factors and occupancy rate limits of substations (see sections 2.2 and 3.1). Specifically, the target PV capacity of 25.8 MW defined for substation Gjakova 1 (see Table 4-2) slightly exceeds the hosting capacity of the substation (20 MW in Table 4-3, due to the 25% occupancy rate limit). This excess PV capacity is diverted to adjacent substations in the same area, which have available spare margin, thus avoiding unreasonable major investments (e.g. in new HV substation capacity) for the sake of such a moderate transgression of the limit. Alternative approaches to address more substantial violations of the adopted limits are presented in section 5.2 .

An overview of the distribution of new PV stations in the four zones defined within the service area of each substation (see section 3.1.3) is presented in Table 4-4. Based on the aggregate results, it appears that the exploitation of the existing network, as dictated by the adopted least cost planning perspective, leads to an average PV station capacity of ca. 1.4 MW, while even in the vicinity of the substations (zones 1 and 2) only a limited number of PV stations with a capacity higher than 3 MW is selected. Hence, the analysis confirms the results of the Grid Analysis Report, indicating that the 3 MW typical PV station size, arising from the current FiT support scheme, is suboptimal from a hosting capacity perspective of the Kosovo distribution network, imposing the need for dedicated feeders to connect to the network.

Table 4-4 Distribution of new PV stations in the defined zones around each HV/MV substation.

Zone	% of Total Capacity	Range of Capacity per PV station (MW)	Average Capacity per PV station (MW)
1	33.6%	0.7 – 4.0	1.9
2	37.3%	0.5 – 3.8	1.4
3	23.1%	0.5 – 2.9	1.2
4	6.0%	0.5 – 1.8	0.8
Total	**100 %**	**0.5 – 4.0**	**1.4**

Grid integration cost for new distribution level RES stations

Having defined specific locations and sizes for all RES stations, the required distribution network investments are then assessed, according to the methodology described in section 3.2 . A detailed list of all network projects required for the integration of each RES station in the distribution network, along with the respective costs is given in ANNEX 5.

Figure 7 illustrates how the new PV and Biomass capacity is connected to the network, while Table 4-5 gives an overview of the required network projects. New capacity (83%) is predominantly connected to the existing MV network without the need for upgrades or new infrastructure, except for short laterals to connect RES stations to existing MV feeders and MV service facilities. For a small percentage (10%), limited network reinforcements/upgrades are deemed necessary (32.2 km of network lines need to be reinforced), while a small fraction (7%) of new stations will be connected via new dedicated MV feeders (a total of 5 new feeders with an overall length of 31.1 km).

Table 4-5 MV network projects required to enable the integration of all new PV and Biomass stations to the MV grid of Kosovo

No. of individual MV connections (no. of new PV and Biomass stations)	134
Average length of laterals required to connect RES stations to existing MV feeders	1.2 km
No. of individual MV network reinforcement projects	11
Total length of MV network to be reinforced	32.2 km
No. of new dedicated MV feeders	5
Total length of new dedicated MV feeders	31.1 km

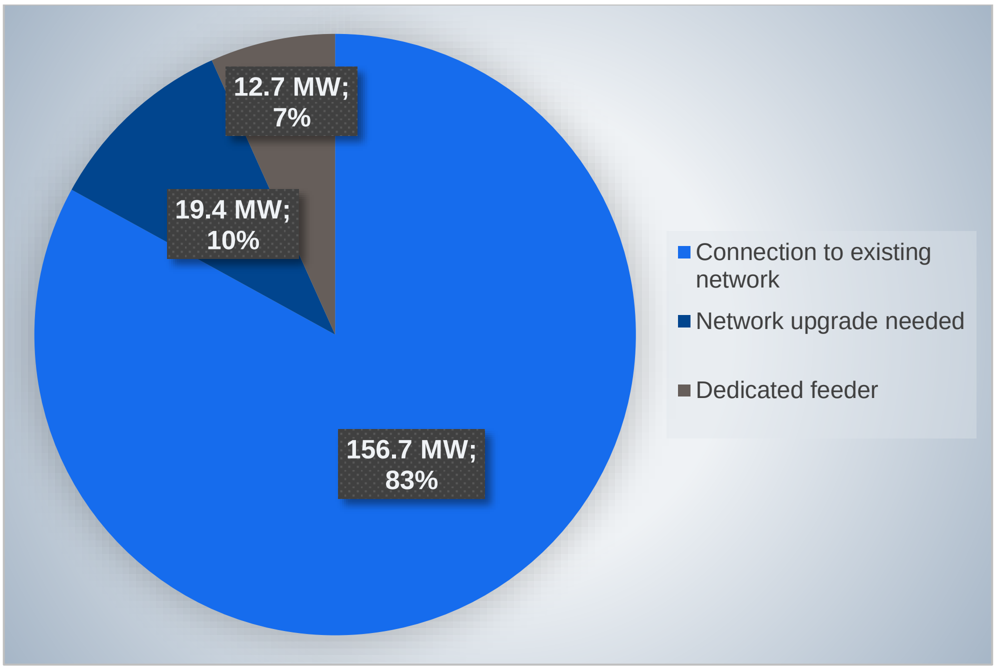

Figure 7 Connection to the grid for new PV and Biomass stations.

Table 4-6 presents the estimated average connection cost per MW in the four different geographical zones around each HV/MV substation. The results clearly show that the average cost strongly depends on the distance of the PV station from the HV/MV substation. PV stations in zone 4 (farthest from the substation) can be integrated at a cost almost three times higher compared to PV stations in zone 1 (closest to the substation). In this sense, the results confirm the rationality of the allocation factors defined in section 3.1.3, which were based on the assumption that the majority of PV stations will be deployed in zones closer to the substation, where hosting capacity is higher and connection cost lower.

Table 4-6 Average connection cost of new PV stations in the defined zones around each HV/MV substation.

Zone	Average Connection Cost (€/MW)
1	26,585
2	40,775
3	55,494
4	69,260
Total	**39,810**

In Figure 8, the evaluated costs per distribution area are presented in total values (€), while in Figure 9 the average costs in € per MW of installed RES capacity are displayed. The total connection costs vary strongly between the different distribution areas, subject to the different target PV capacities (see Table 4-2) and each area's topology and hosting capacity. The distribution areas of Gjakova, Peja and Prishtina host an overproportional part of the total new RES capacity (62%), which apparently also leads to the need for higher grid investments. Furthermore, in the distribution areas Gjakova and Peja the hosting capacity of the existing network is not sufficient to host the total target capacity, leading to the need for new dedicated feeders and thus to higher costs. The distribution area of Prishtina, on the other hand, has a much higher number of available substations and MV feeders suitable to host RES stations. As a result, the high target capacity can be reached in this case, without the use of dedicated feeders, but rather through the distribution of the total capacity to a larger number of RES stations. The slightly elevated costs in Pristhina are therefore mainly caused by the larger number of PV stations considered, leading to increased direct connection costs and increased costs for new laterals (included in the costs for upgrade and expansion of the existing network). For the same reasons, the average connection cost per MW of installed capacity is also higher in the aforementioned areas but generally shows smaller variations (30,190 – 45,832 €/MW) between the different areas.

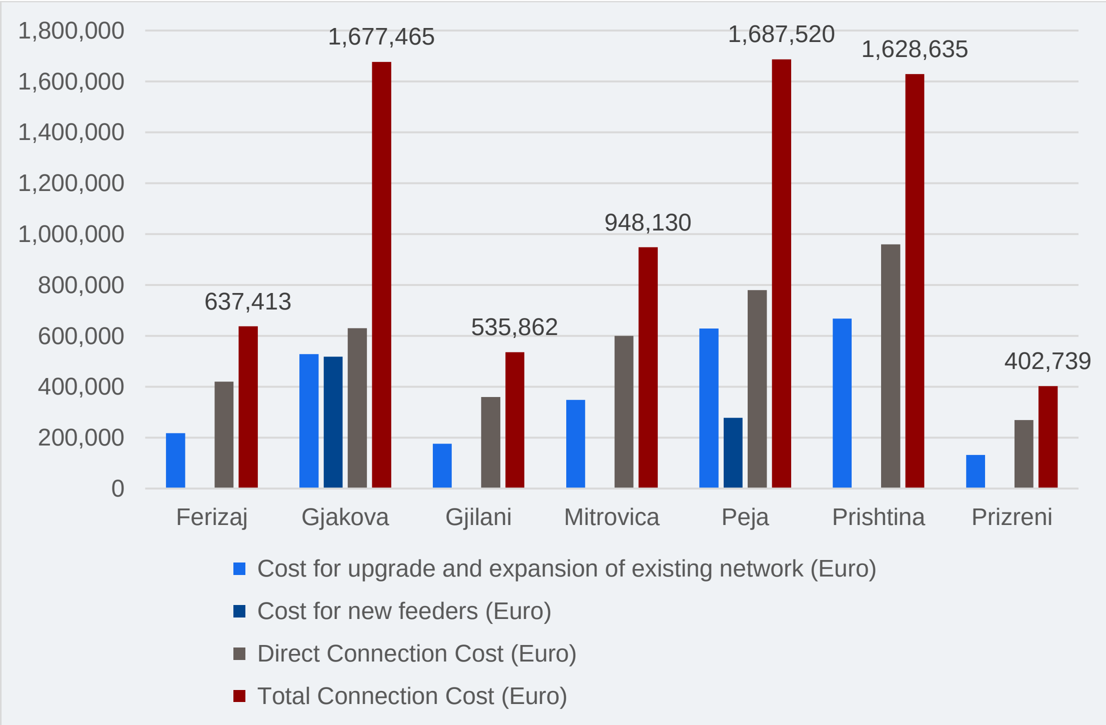

Figure 8 Grid connection cost per distribution area, in absolute numbers (€).

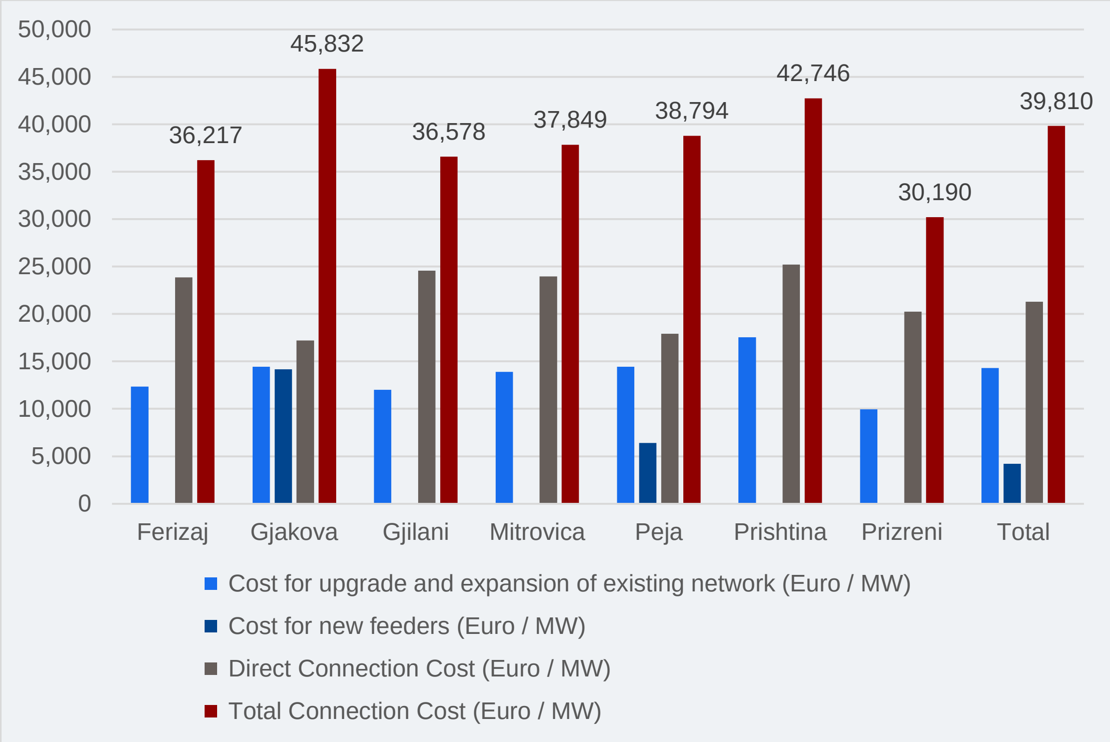

Figure 9 Average grid connection cost per distribution area, in €/MW of installed RES capacity.

For the entire country, the total connection cost for the defined target capacity until 2030 is estimated at ca. 7.5 million €, with an average cost of 39,810 €/MW. With regard to the different cost categories, it needs to be noted that the direct connection cost appears to be relatively high compared to the other cost categories, accounting for more than 50% of the total cost in most distribution areas. The high direct connection cost is attributed to the technical standardization of MV service equipment adopted by KEDS, whereby all RES stations are connected to the distribution network through a metal enclosed switchgear solution, while simple overhead network connection solutions are generally not used. This practice is optimal from a technical point of view, still it constitutes a relatively costly solution for small capacity stations, at 30000 €/connection, increasing their network integration costs.

For the sake of example, the results of the performed study, assuming an overhead MV network service solution at a cost of 15,000 €/connection in all cases, are given in ANNEX 7. In that case, the grid integration cost of the defined target RES capacity would have been ca. 5.5 million € (i.e. 25% lower), with an average connection cost of 29,166 €/MW.

On the other hand, it has to be emphasized that the direct connection costs are typically borne by the investors and do not constitute an additional investment for the DSO, that is socialized via network charges. Considered under this perspective, for low capacity RES stations, e.g. below 1 MW, a difference of 15000 € in its connection cost may represent a considerable fraction of the total investment cost (~4% for a 500kW PV-station, assuming a total investment cost of 800 €/kW), eventually impacting the levelized cost of energy

(LCOE) of such projects. If larger stations were considered, the impact would have been minimal (e.g. only 0.4% for a 5 MW PV station).

Taking into consideration the target PV capacity of 200 MW adopted in this reference study case, **it can be concluded that the integration of any reasonably anticipated new RES capacity in the distribution network of Kosovo can be achieved at an entirely rational cost, as long as least cost planning principles can be applied, promoting moderate RES station capacities (on average up to ca. 1.5 MW) and an optimized dispersion of new RES stations.**

Network investments to host such a level of distribution RES capacity are directly correlated to the development of RES facilities and therefore the timeline for investments will be dictated by the anticipated uptake of RES in Kosovo, rather than by a predefined schedule. In fact, as most investments concern minor routine projects, it is not advisable to establish a predefined implementation schedule, ignoring the actual needs for RES station interconnection.

Grid integration of already authorized RES stations

The grid connection costs for the integration of already authorized RES stations are estimated using the generic approach described in section 3.2 , as illustrated in Figure 10 and Figure 11. The results clearly show that the average cost for the authorized RES stations is significantly higher (+33%), than the respective cost for new RES stations under a least cost planning perspective. This is justified by the fact that the vast majority of authorized RES stations is planned to be connected through dedicated feeders (see ANNEX 2), leading to higher costs for new network infrastructure.

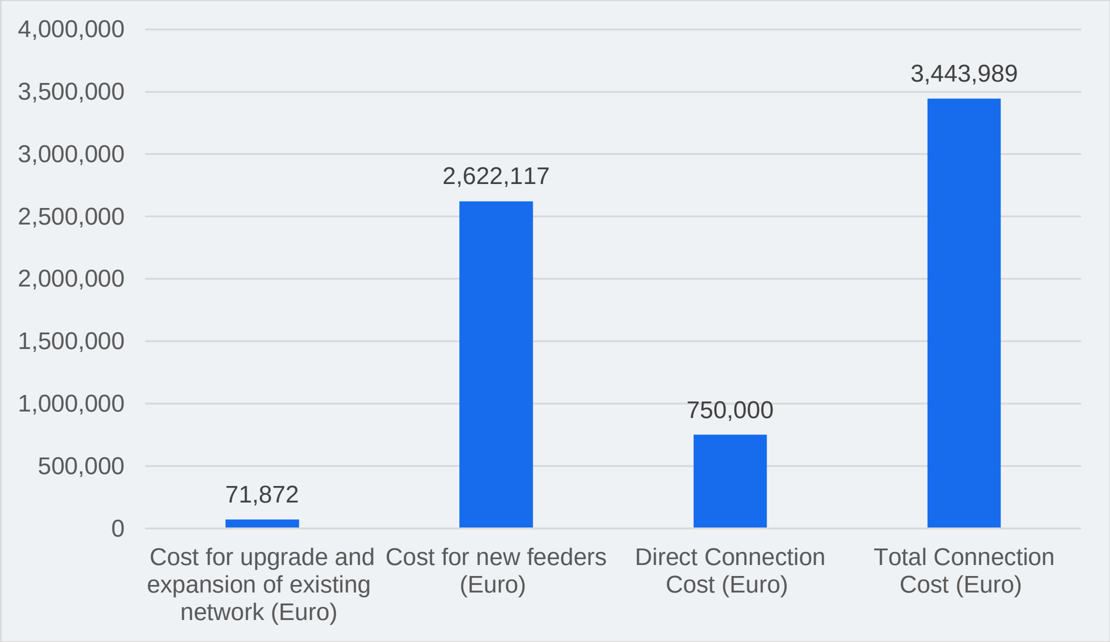

Figure 10 Grid connection cost for authorized RES stations, in absolute values (€)

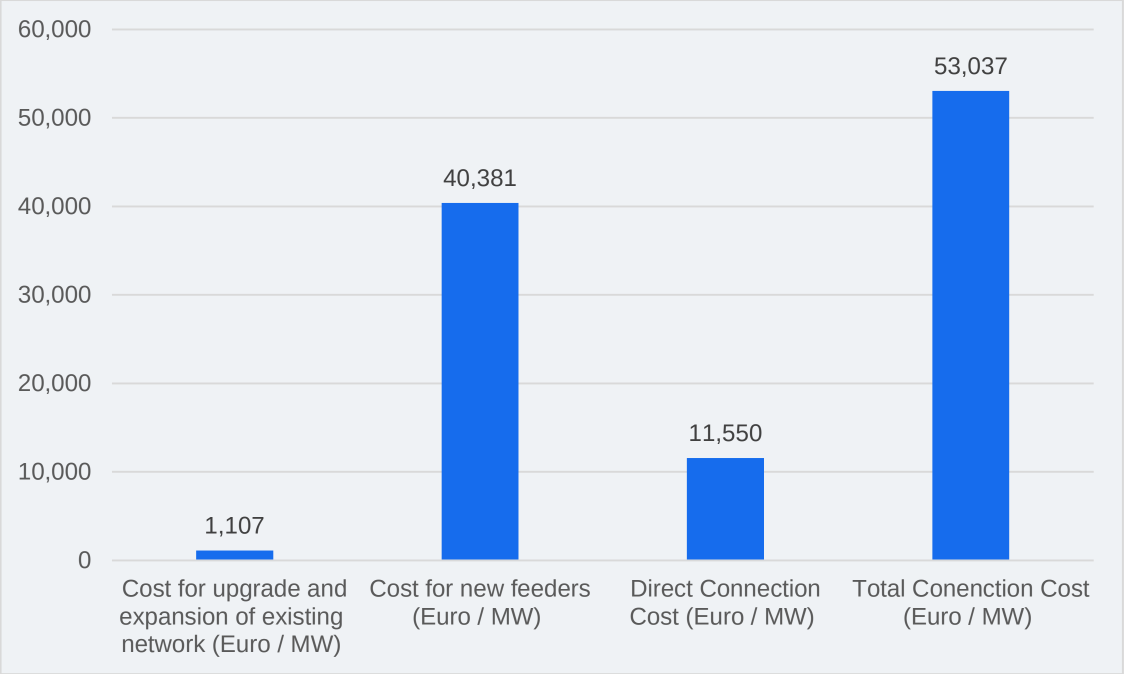

Figure 11 Average grid connection cost for authorized RES stations, in €/MW of installed RES capacity.

4.3 Sensitivity analysis

The sensitivity analysis conducted in the context of Subtask 2.4, aims to quantify the correlation between targeted RES capacity and investment plan fundamental indices, allowing thus to extrapolate to other RES capacities without conducting anew the entire detailed analysis. To perform this sensitivity analysis, two alternative RES penetration scenarios are adopted, while the distribution area of Mitrovica is selected as a representative study case:

- Reference study case – SCref (see section 4.2)
- Low RES capacity scenario – SClow
- High RES capacity scenario – SChigh

Since sHPP and Biomass capacities are already fully defined (see section 2.1), the different RES capacity scenarios are determined by varying the target capacity for new PV stations, as shown in Table 4-7. In SChigh, an elevated PV capacity was chosen (+ 50% compared to the reference study case), representing relatively ambitious RES targets, approaching the hosting capacity limits of the existing distribution network. In SClow, on the other hand, a relatively low target PV capacity is considered (- 50% compared to the reference study case), providing an alternative where PV capacity will be easily accommodated in the distribution network of the selected area. The target PV capacity is distributed among the respective HV/MV substations as presented in Table 4-8, according to already defined PV allocations factors (see section 3.1.2).

Table 4-7 Alternative PV capacity scenarios considered in the context of the sensitivity analysis

Scenario	Target PV capacity (MW)	Difference from Reference Study Case
SCref	22.5	-
SClow	11.3	- 50%
SChigh	33.8	+ 50 %

Table 4-8 PV capacity allocation per HV/MV substation in Mitrovica in all three scenarios

110/10 kV Substation	PV factor	Target PV Capacity (MW)		
		SCref	**SClow**	**SChigh**
Ilirida	19.10%	4.3	2.2	6.5
Skenderaj	53.40%	12.0	6.0	18.0
Vushtrri 2	27.50%	6.2	3.1	9.3
Total	**100%**	**22.5**	**11.3**	**33.8**

Applying the same methodology, used for the reference study case (see section 4.2), specific locations and sizes for all new PV stations are determined for each scenario. A detailed list of all new stations is given in ANNEX 3, while their spatial distribution is illustrated in ANNEX 4. The geographical constraints, regarding the PV allocation in the defined zones around each substation (see section 3.1.3) were also applied in the alternative scenarios, leading to the spatial distribution presented in Table 4-9.

Table 4-9 Distribution of new PV stations in the four defined geographical zones

Zone	No. of PV stations			PV capacity (MW)			% of Total Capacity		
	SCref	SClow	SChigh	SCref	SClow	SChigh	SCref	SClow	SChigh
1	5	2	7	7.40	4.00	12.95	32.7%	35.4%	38.3%
2	7	4	10	8.50	4.70	12.30	37.6%	41.6%	36.4%
3	3	2	3	4.70	2.00	4.90	20.8%	17.7%	14.5%
4	3	1	4	2.00	0.60	3.65	8.8%	5.3%	10.8%
Total	**18**	**9**	**24**	**22.60**	**11.30**	**33.8**	**100%**	**100%**	**100%**

Having defined specific locations and sizes for all PV stations, the required distribution network investments are then assessed for each scenario, according to the methodology described in section 3.2 . In the SClow scenario, as well as in the reference SCref case, all new PV stations can be integrated in the existing MV network. In the SChigh scenario, the hosting capacity of the existing network is fully utilized, while additional upgrades and dedicated feeders are necessary to accommodate a fair part (21%) of the target capacity (see Figure 12). The required network projects are presented in Table 4-10, while the total and the average grid integration costs of all three scenarios are illustrated in Figure 13 and Figure 14. A detailed list of all network projects required in each scenario, along with the respective costs is given in ANNEX 5.

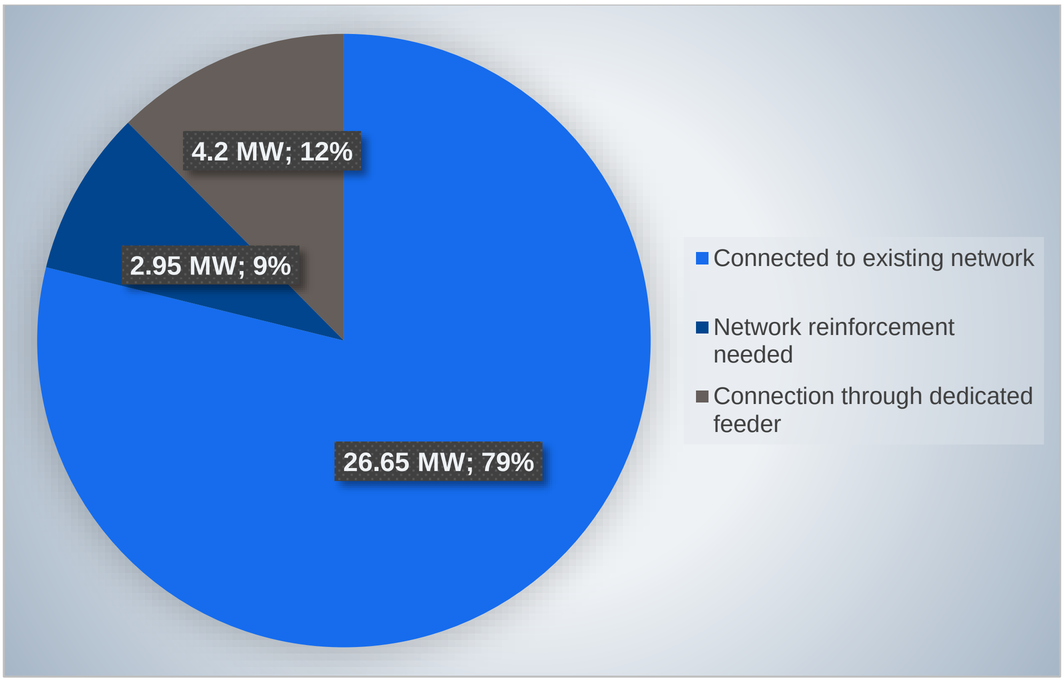

Figure 12 Connection to the grid for elevated new PV capacity, in SChigh scenario.

Table 4-10 Required network investments for the connection of all new PV and Biomass stations to the grid in all three scenarios

	SClow	SCref	SChigh
No. of individual MV connections (no. of new PV and Biomass stations)	9	18	24
Average length of laterals required to connect RES stations to existing MV feeders	1.1	1.2	1.1
No. of individual MV network reinforcement projects	0	0	3
Total length of MV network to be reinforced	0	0	14.5
No. of new dedicated MV feeders	0	0	1
Total length of new dedicated MV feeders	0	0	4.4

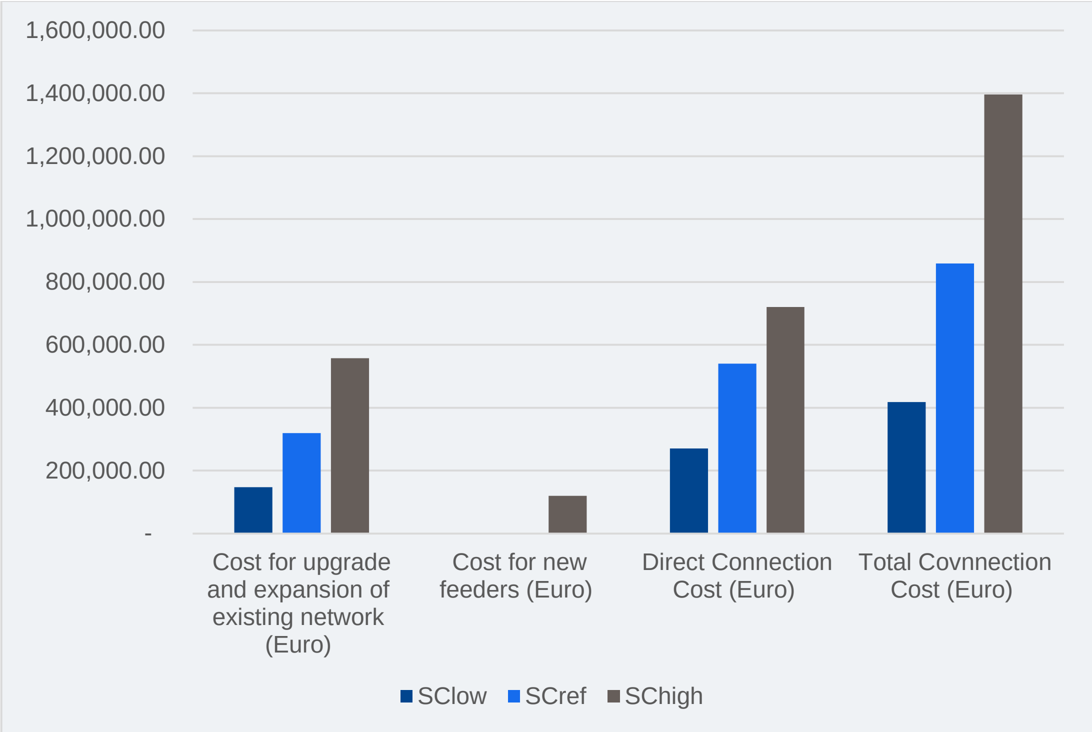

Figure 13 Grid connection cost (in absolute values, €) for all three scenarios.

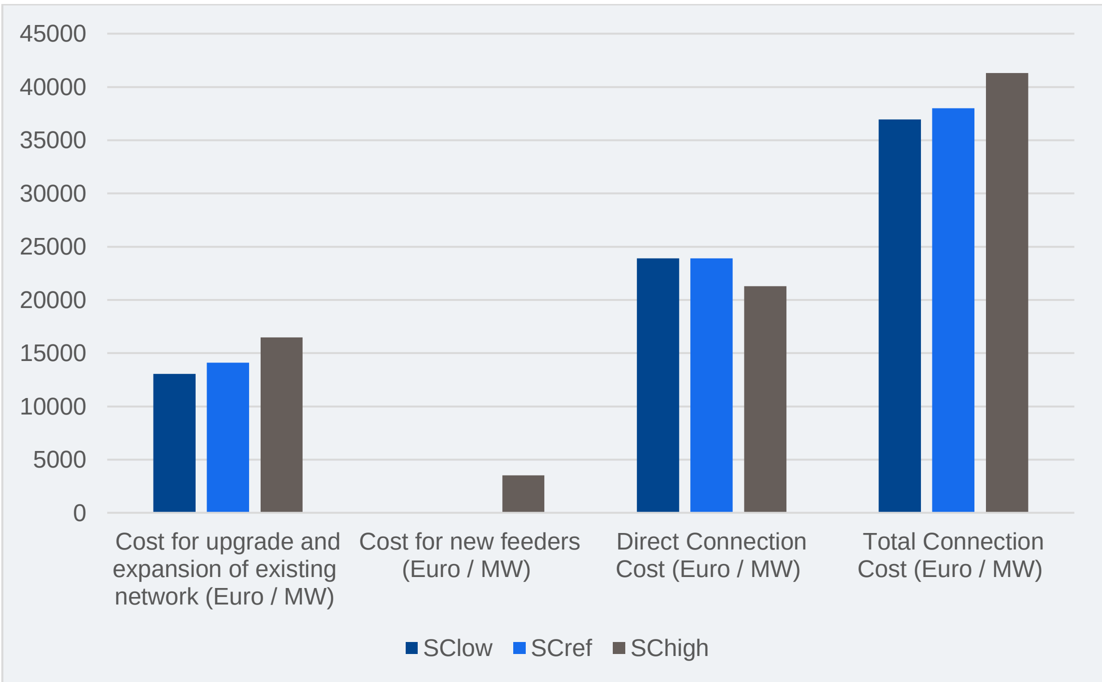

Figure 14 Average grid connection cost, in €/MW of installed PV capacity, for all three scenarios.

A more detailed comparison of the results for all three scenarios is given in Table 4-11, highlighting the effect of exceeding the hosting capacity of the existing network on the connection costs. SClow and SCref present similar connection costs per MW of installed PV capacity, as only minor works are needed to connect new stations, making the investment effectively proportional to the installed PV capacity. In SChigh, on the other hand, the required network upgrades and dedicated feeders lead to normalized connection costs increased by 9%, indicating a gradualloss of proportionality as soon as the hosting capacity of the network is exceeded; hence, an increase of the PV capacity by 50% leads to a cost increase by 63%.

Table 4-11 Comparison of the results for all three scenarios

Scenario	PV capacity		Total Grid Cost		Average Grid Cost	
	MW	+/- from SCref	€	+/- from SCref	€/MW	+/- from SCref
SCref	22.6		858,932		38,006	
SClow	11.3	- 50%	417,562	-51%	36,952	-3%
SChigh	33.8	+ 50 %	1,396,474	+63%	41,316	+9%

5 NETWORK PLANNING ALTERNATIVES

Besides the least cost approach adopted in chapter 4 potential planning alternatives are evaluated in this chapter at a high level, to further investigate their impact. This concerns first the integration of DG through dedicated MV feeders, as to a certain extent happens today in Kosovo. The second part of the analysis presents alternatives to integrate high RES capacities, exceeding the hosting capacity of the existing network, necessitating the construction of new HV substations.

5.1 Dedicated feeders

In this concept, all new PV and Biomass stations are directly connected to HV/MV substations via dedicated feeders. This planning alternative was applied to distribution area Gjakova for the target capacity of the reference study case, in order to determine its cost implications via application to the actual network of an example distribution area. The spatial distribution of all new PV and Biomass stations adopted in this planning variation is given in Figure 15 - Figure 18. A detailed list of all new stations is given in ANNEX 3. It is noted that fewer stations of increased unit capacity are assumed, as it is appropriate for this planning paradigm.

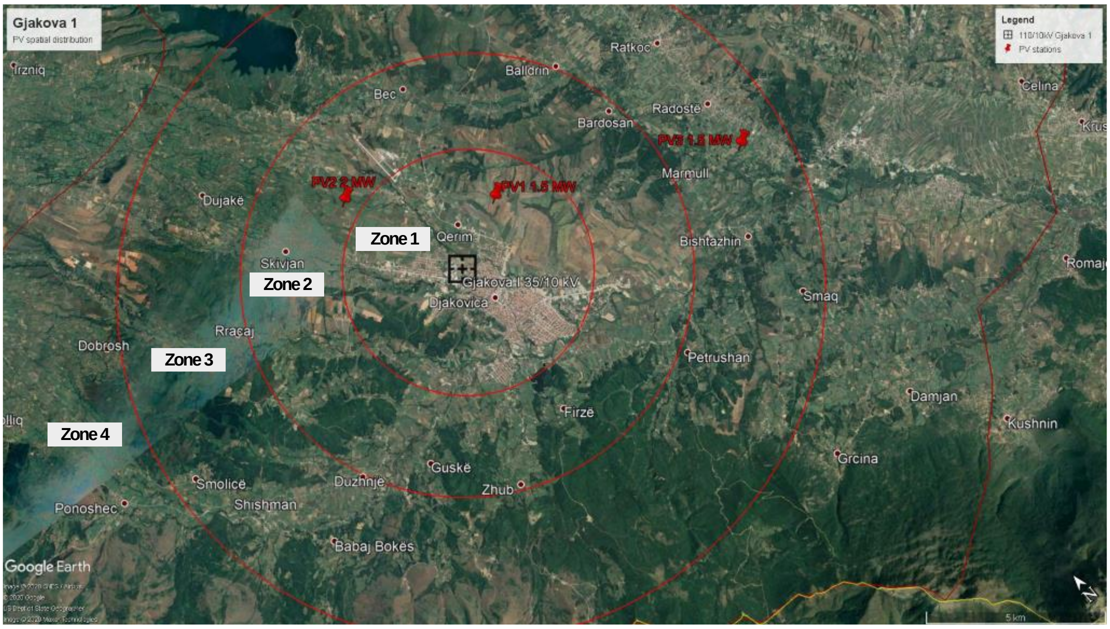

Figure 15 Spatial Distribution of PV stations for the substation Gjakova 1 in the "dedicated feeder" planning paradigm.

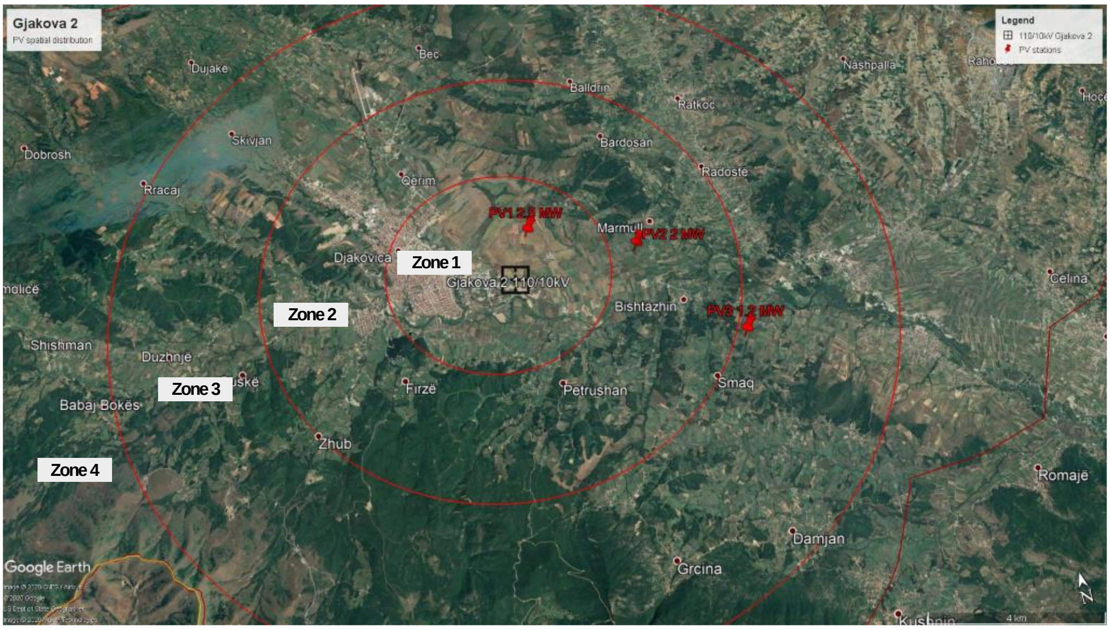

Figure 16 Spatial Distribution of PV stations for the substation Gjakova 2 in the "dedicated feeder" planning paradigm.

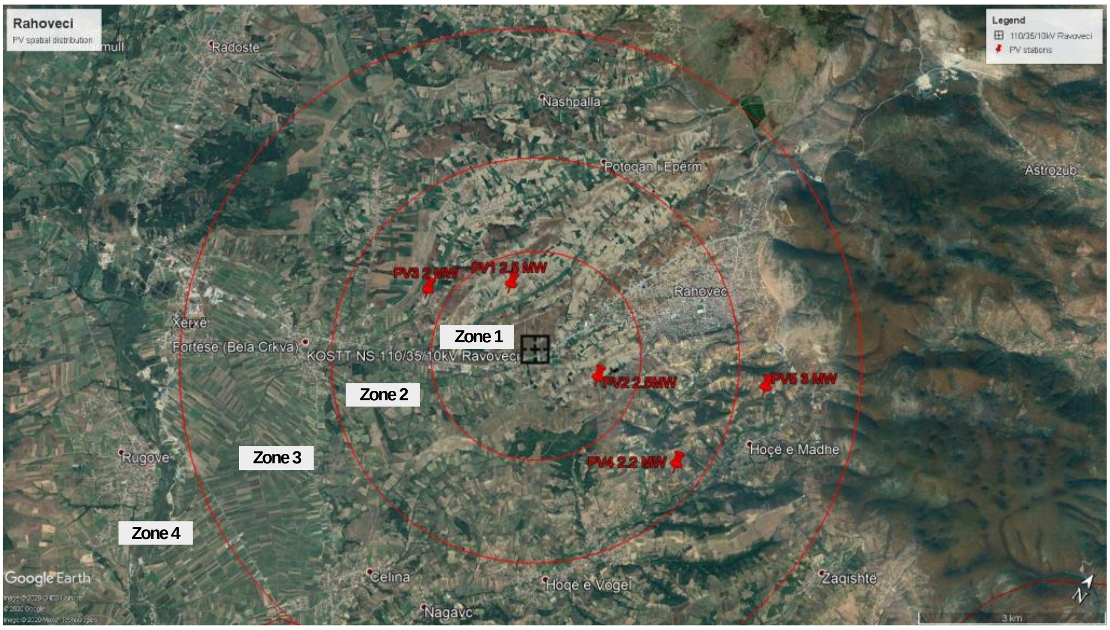

Figure 17 Spatial Distribution of PV stations for the substation Rahoveci in the "dedicated feeder" planning paradigm.

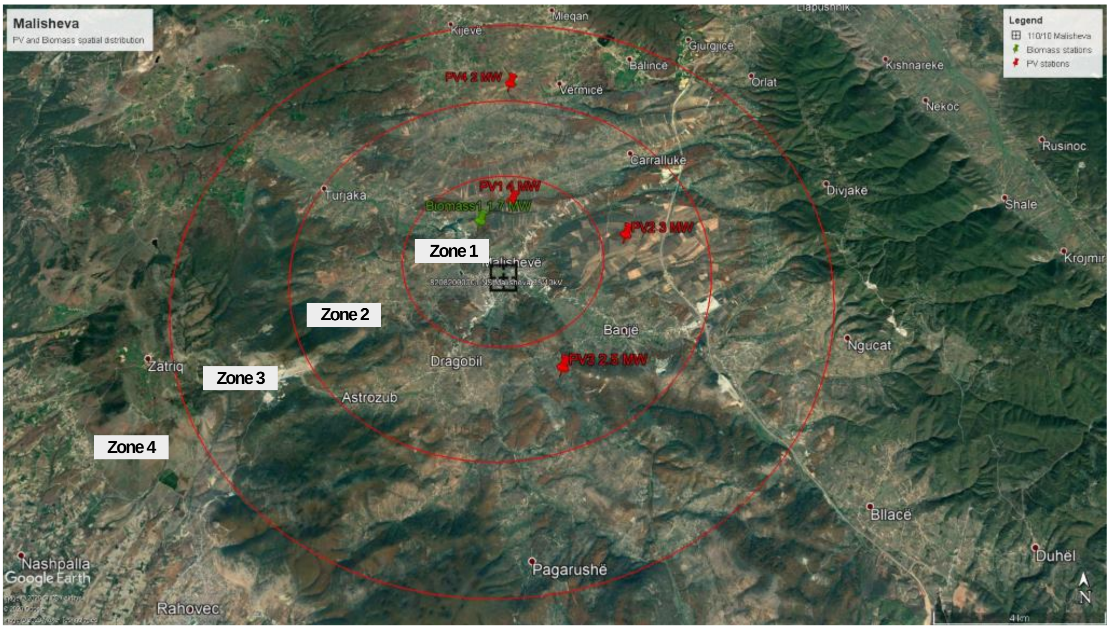

Figure 18 Spatial Distribution of PV and Biomass stations for the substation Malisheva in the "dedicated feeder" planning paradigm.

To assess the impact of exclusive use of dedicated feeders for new RES accommodation, a new series of simulations were conducted in PowerFactory. All technical criteria mentioned in section 2.2 were taken into account, along with the constraints set for PV spatial distribution in section 3.1 . A detailed list of all network projects required for the integration of each RES station in the distribution network, along with the respective costs is given in ANNEX 5. An overview of the results obtained, in comparison to the results for the reference study case, are presented in Figure 19.

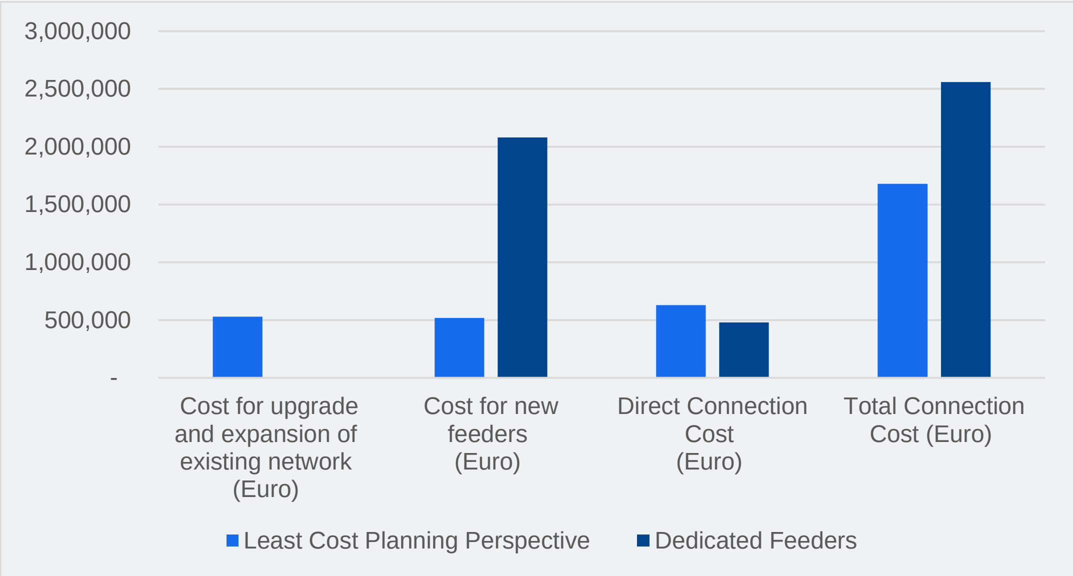

Figure 19 Grid integration cost for the reference study case, adopting the "dedicated feeder" planning alternative, in absolute values (€).

As already expected from the analysis conducted in subtask 2.3 and noted above, this approach allows increased average RES station capacities, as DG are not connected to mixed feeders suppling both loads and generation. Costs in order to host the same target RES capacity are now notably higher (+53%), reflecting the need for new network, while existing assets are not exploited to their full potential. In this sense, the results confirm once again that the 3 MW typical PV station size, arising from the current FiT support scheme and requiring mostly dedicated feeders, is not cost-optimal from a network planning perspective, and will lead to elevated investment costs if it remains the main planning approach.

5.2 New HV/MV substations

In this analysis variant, a deliberately high PV capacity is selected, exceeding the hosting capacity of the network, in order to explore options when very ambitious RES targets are adopted, testing the distribution network's limits. Gjakova is used again as a representative distribution area, assuming a target PV capacity of 86.6 MW. This PV capacity is distributed among the respective HV/MV substations as presented in Table 5-1, according to the defined PV allocation factors (see section 3.1.2).

Table 5-1 Target PV capacity allocation per substation in Gjakova, in the "new HV/MV substation" planning exercise

110/10 kV Substation	Existing substation[13]	PV Participation Factor (%)	Target capacity (MW)	Hosting capacity (MW)
Gjakova 1	Yes	44.8	38.9	20
Gjakova 2	Yes	20.4	17.7	15.75
Rahoveci	Yes	17.4	15.0	15.75
Malisheva	New	17.4	15.0	20
Total		**100**	**86.6**	**71.5**

The high target capacity leads to a violation of the hosting capacity limit of substation Gjakova 1 by 18.9 MW. To host this additional capacity, a new HV/MV substation is required. Two possible approaches were considered:

- SC1: A new HV/MV substation is developed, belonging to the public distribution network.
- SC2: A dedicated HV/MV substation is built to connect new RES capacity directly to the HV transmission system.

In SC1, the new substation comes through the upgrade of an existing 35/10 KV substation to 110/35/10 kV, with two new transformers, utilizing already existing MV networks, as this represents a least-cost solution. For SC2, on the other hand, an entirely new 110/10 kV substation is developed exclusively to host all excess RES capacity. Here one transformer is considered to be installed, as is typically the case in transmission substations optimized for RES. Pros and cons of each solution are summarized in Table 5-2.

Table 5-2 Alternatives for new HV/MV substation infrastructure

	New distribution network HV/MV substation (SC1)	New RES-only substation (SC2)
Substation cost	Higher (2 transformers needed to ensure continuity of supply in (N-1) conditions for consumers)	Lower (1 transformer is sufficient for a dedicated RES substation)

[13] Transmission Development Plan 2020-2029 (KOSTT, 2019)

Suitable for large RES capacities	Low potential	High potential
Utilization of existing network	Higher	Lower (new MV dedicated feeders needed)
Example for Gjakova	Upgrade of 35/10 kV substation Xerxa to 110/35/10 kV	New RES substation near Gjakova 1 (connection of 4x5 MW PV stations)

Taking into consideration the 8 operating and authorized PV stations with a total capacity of 22.7 MW (see ANNEX 2), new PV stations with an aggregate capacity of 63.9 MW are needed to reach the target capacity. Applying again the methodology described in chapter 3 , the total connection costs for the integration of all new PV stations in the network are determined for each scenario:

- First, specific locations and sizes for all new PV stations are determined for each scenario, adopting a least cost planning perspective. A detailed list of all new stations is given in ANNEX 3, while their spatial distribution is illustrated in ANNEX 4.
- Having defined specific locations and sizes for all PV and Biomass stations, the required distribution network investments are then assessed for each scenario. In this case, the cost for the construction of the required new HV/MV substations, even though they may not be formally a part of the distribution network asset base, are also included in the analysis, in order to have a more accurate cost comparison basis between solutions with and without HV/MV substation. Further investments in the transmission network may indeed be a significant part of the total investment but are too case specific to consider in a generic analysis intended to provide generalizable results and in any case do not constitute part of the distribution network investments addressed in this study. A detailed list of all network projects required for the integration of each station in the distribution network, along with the respective costs is given in ANNEX 5.

Resulting connection costs are presented in Figure 20 and Figure 21. It appears that both approaches (SC1 and SC2) are almost equally expensive, with a slight advantage for the new RES substation case (SC2). In both cases, the calculated average grid connection cost per MW of new PV is almost twice as high as the respective cost calculated for the reference study case (44,829 €/MW vs 76,000-83,000 €/MW), reflecting the high cost for the construction of new HV/MV substations, especially when built to accommodate moderate RES capacities.

Overall, the deployment of public distribution network major infrastructure, such as new HV/MV substations, should be best driven by network development needs, including the supply of the evolving consumer demand, rather than purely to accommodate new RES capacity.

New HV/MV substations dedicated to RES connection, on the other hand, do make sense as an option to host larger projects, whereby their full hosting capacity is exploited and thus the investment is apportioned to an appropriately larger connected MW base, leading to reasonable integration costs.

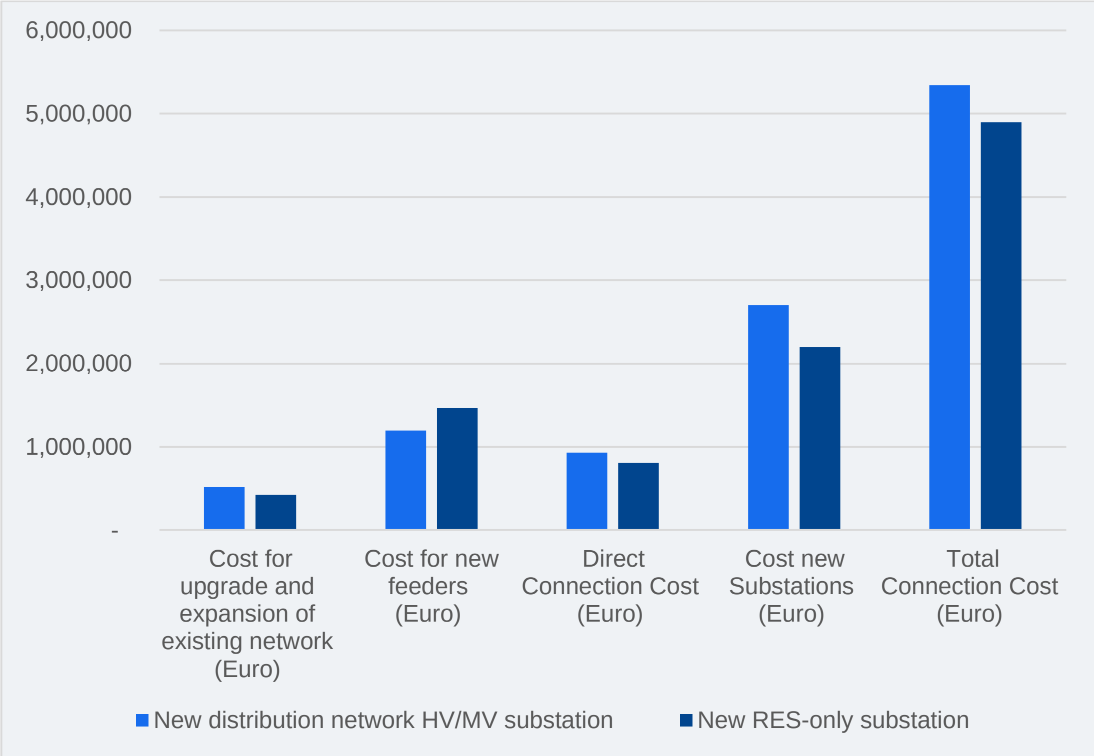

Figure 20 Total connection cost for each new HV/MV substation scenario, in absolute values (€).

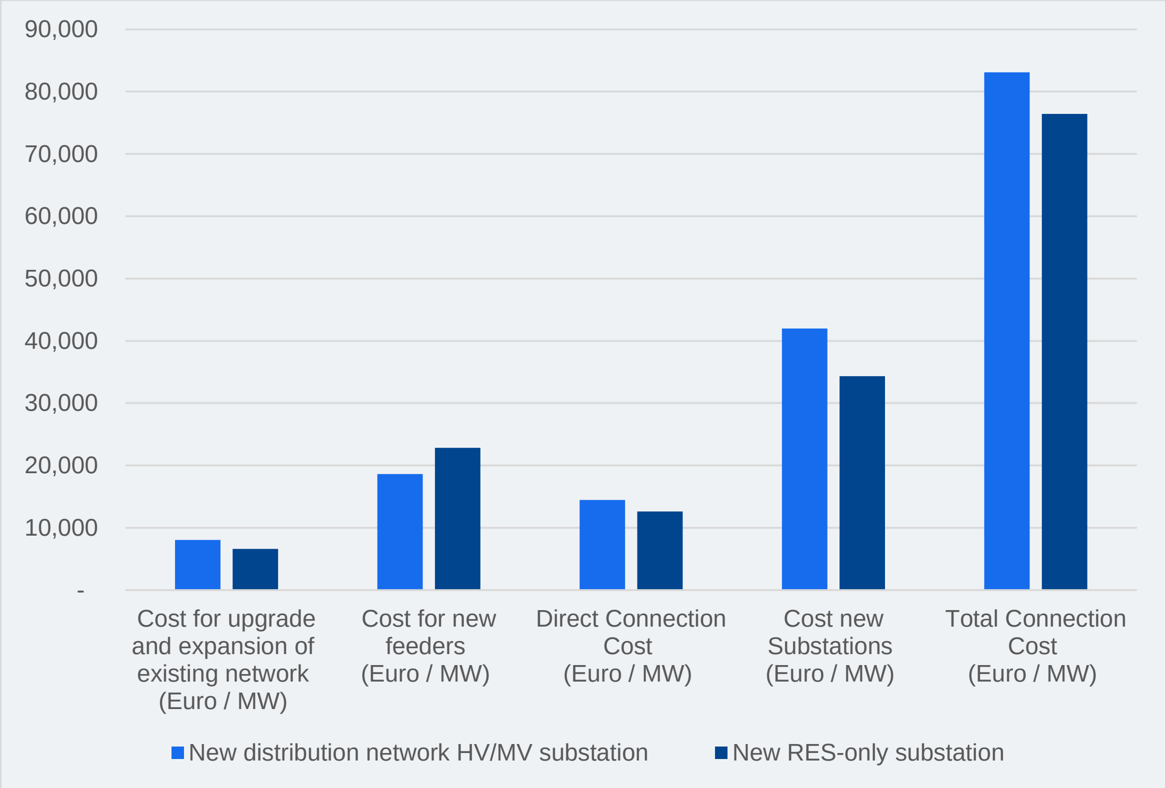

Figure 21 Average connection cost for new HV/MV substation scenario, in €/MW of installed RES capacity.

6 CONCLUSIONS AND RECOMMENDATIONS

Taking into consideration the results of the analysis for the reference study case as well as the sensitivity analysis, the following salient observations can be made, regarding the integration of RES in the distribution network of Kosovo:

- A total new RES capacity of ca. 100-150 MW (ca. 10-20 MW per distribution area) can be integrated in the distribution network of Kosovo at a minimum connection cost of ca. 35,000 €/MW, exploiting only the available hosting capacity.
- Higher RES capacities close to the level considered in the reference study case (ca. 200-250 MW) can be accommodated in the distribution network with limited reinforcements and new infrastructure, leading to a still entirely reasonable average cost of ca. 40,000-45,000 €/MW.
- RES capacities above this level tend to exhaust the hosting capacity of the existing distribution network, imposing the need for the development of new facilities, therefore leading to an increase of the average connection cost (see section 5.2) although their integration still remains technically possible.
- It appears that target capacities around 300 MW represent a borderline for the capacity that can easily and at minimum cost be integrated in the existing network. Beyond that level, additional MV and gradually HV facilities will be required, which will lead to a further escalation of the network integration cost. Therefore, at that point it would make sense to consider large-scale RES projects that will be connected directly to the transmission system, rather than initiate an expansion policy of the public distribution network driven solely by the integration of distributed generation.

Nevertheless, it should be noted that all previous estimates are based on the applied least cost planning perspective, assuming an optimized (but still realistic) RES spatial distribution, as well as RES station capacities optimized to exploit available hosting margins of the existing network. It is worth point out that the consideration of an even lower unit station capacity would have led to a higher number of individual stations to reach the same RES target capacity. This, is turn, would have inflated network connection costs, as each new station would require its individual connection arrangements, i.e. a short lateral for interfacing to an existing network feeder and MV service equipment. In this context, it should also be noted that the current technical standardization of MV service equipment adopted by KEDS (metal-enclosed MV service solution) is optimal from a technical point of view; still it constitutes a relatively costly solution for small capacity stations, increasing their network integration costs. A more case-specific practice, diversifying in certain occasions from the standard solution and allowing the connection of new RES srtations to the network via an overhead MV network solution, is adopted in various countries and is totally rational in terms of cost minimization, especially regarding small size RES stations with lower initial investment costs.

In reality, optimal least cost planning conditions will never be fully achieved, but they can be used as a target to be eventually approached through the adoption of suitable regulatory policies and incentives. According to the results of the current study, such policies for Kosovo may include the following:

- **Incentivization of moderate RES station capacities.**
  The 3 MW typical PV station size, arising from the current FiT support scheme, is not cost-optimal from a hosting capacity perspective for the Kosovo distribution network, imposing the need for dedicated feeders and therefore leading to elevated investment costs (see section 5.1 According to the results of this study and taking also into consideration the current practice and experience of KEDS with regards to the integration of RES stations in their network, the project team proposes an incentivitization of capacities around 1 MW (e.g. between 0.8 MW and 1.2 MW), representing a reasonable compromise between small size to exploit the hosting margin of existing feeders and large capacity to avoid overburdening the per MW (and eventually per MWh) connection cost. RES station capacities up to around 2.0 MW would still be reasonable, but station sizes beyond that point should not be incentivized in terms of network connectivity.
- **Restrictions to exclude unreasonable concentrations of RES capacity in specific geographical areas.**
  An example of such restrictions is the occupancy rate limit (25%-limit), proposed in the current Draft Connection Charging Methodology of KEDS[14]. Although lacking a solid technical basis, this limit may indeed serve as a reasonable first-level allocation driver, to rationalize RES spatial distribution.
- **Cost-reflective network connection charges and proper dissemination of information by ERO/KEDS that will provide the required signal to investors at an early stage of project development, in order to seek sites unconstrained by network connectivity issues.**
  To this end, the public availability of fundamental guiding figures regarding hosting capacity of the MV distribution network by KEDS would facilitate and direct investor interest towards areas with unimpeded network access. To this end, ERO could for example establish a requirement for KEDS to develop a web application providing information on RES hosting capacity per HV/MV substation or even at a higher granularity within the supply area of each HV/MV substation. Such information would never constitute a binding substitute to a proper connection terms offer; it

[14] Distribution Network Operator Draft Connection Charging Methodology, KEDS, 2017

would only provide an indication of congested areas that should best be avoided by investors, else increased connection costs may be faced.

ANNEX 1 Results of land screening for PV deployment purposes

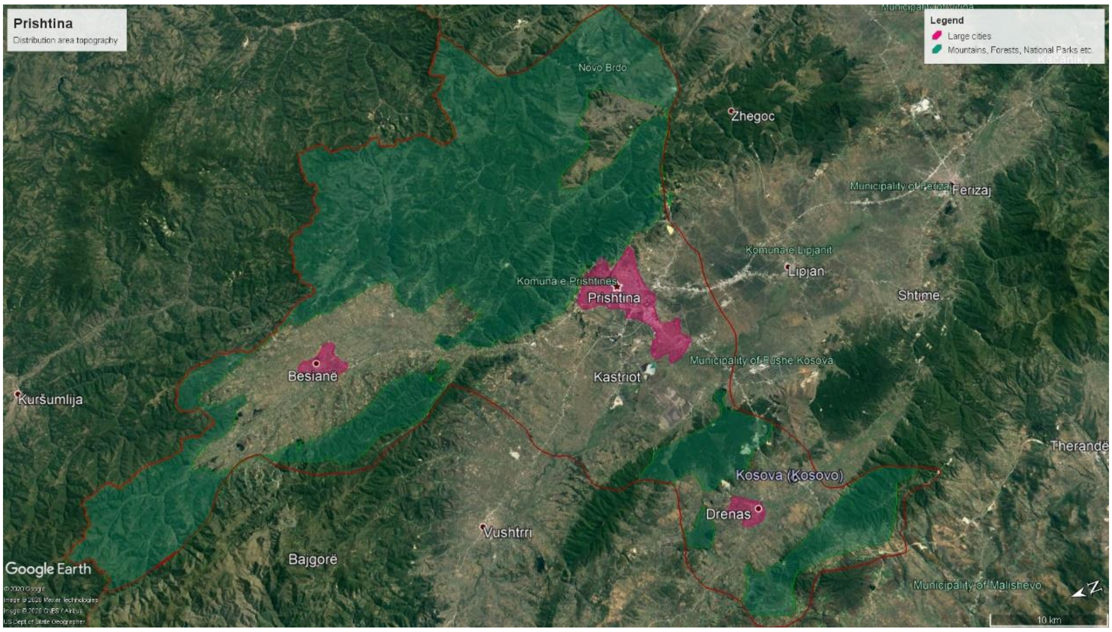

Figure 22 Land screening in the Prishtina distribution area for PV deployment purposes.

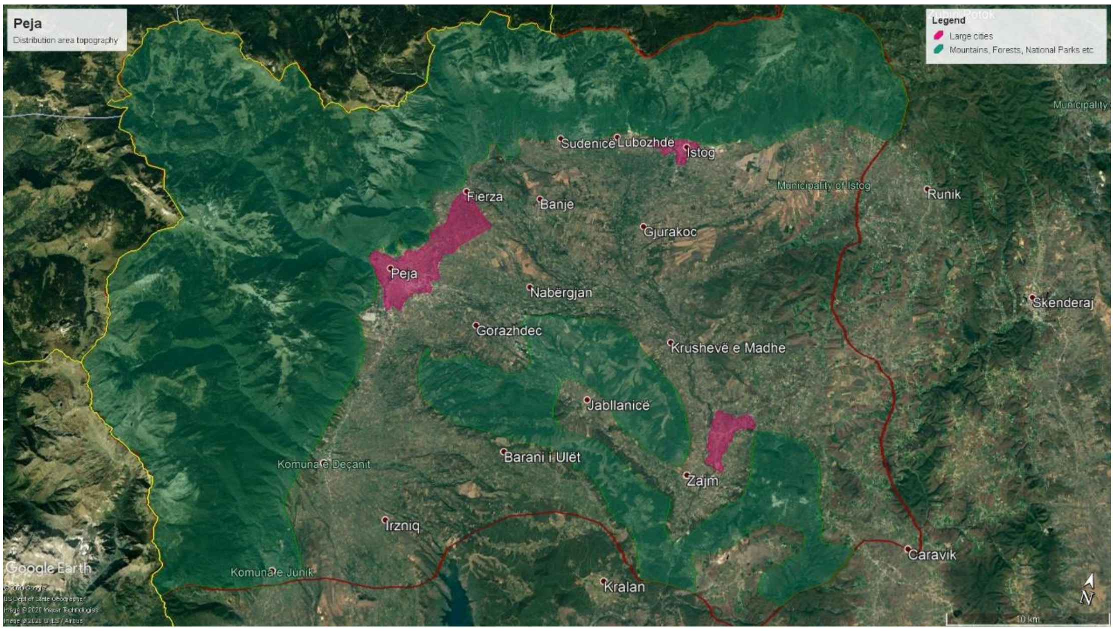

Figure 23 Land screening in the Peja distribution area for PV deployment purposes.

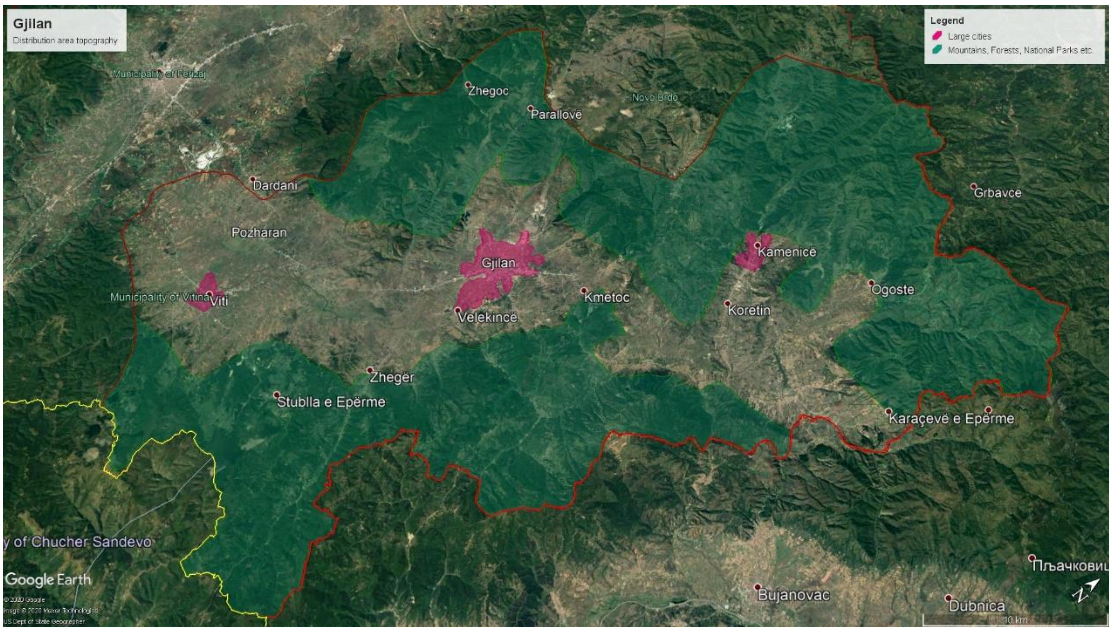

Figure 24 Land screening in the Gjilan distribution area for PV deployment purposes.

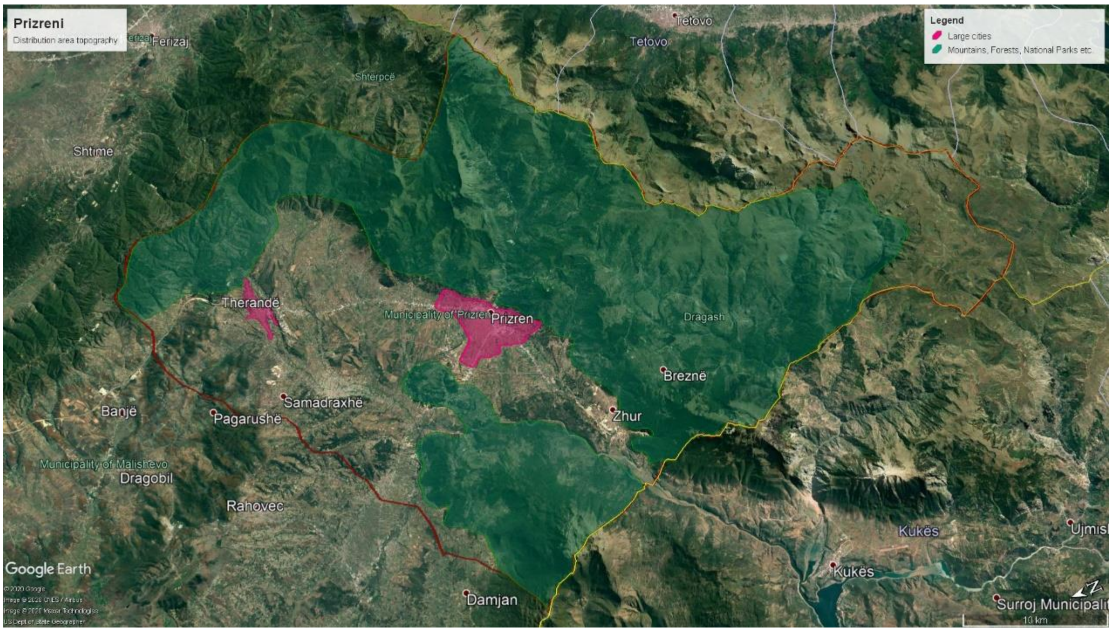

Figure 25 Land screening in the Prizreni distribution area for PV deployment purposes.

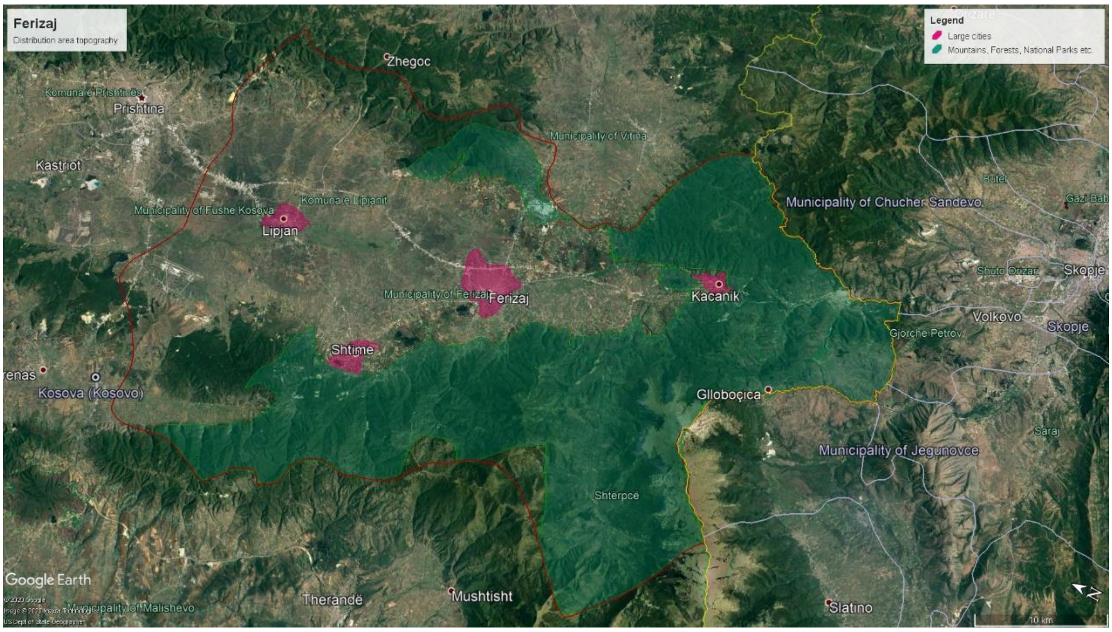

Figure 26 Land screening in the Ferizaj distribution area for PV deployment purposes.

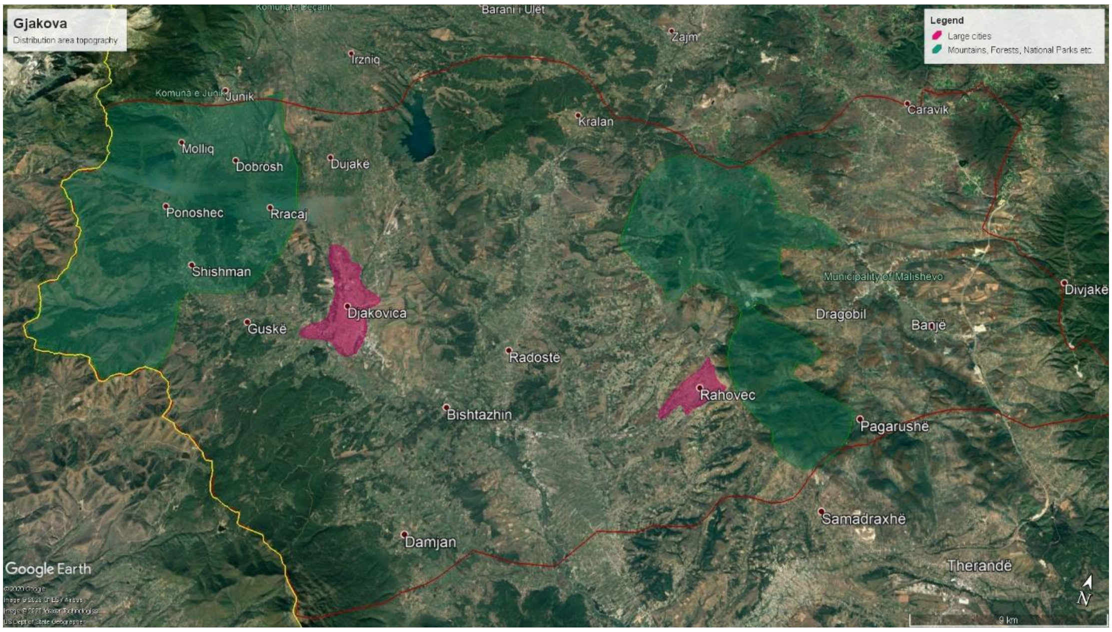

Figure 27 Land screening in the Gjakova distribution area for PV deployment purposes.

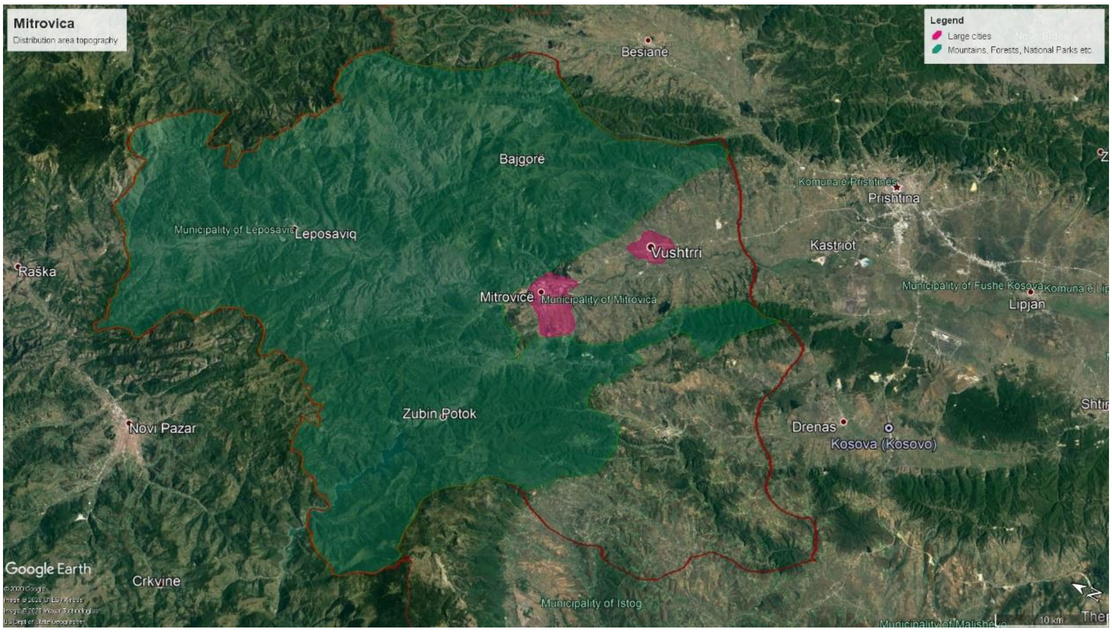

Figure 28 Land screening in the Mitrovica distribution area for PV deployment purposes.

ANNEX 2 Operating and authorized RES stations

Table A- 1 Operating and authorized RES stations, connected to MV network

RES Station	RES Technology	Distribution Area	Substation	Capacity (MW)	Connected via dedicated feeder	Status
HPP Brodi 2	HPP	Prizreni	Dragashi	4.8	yes	Operating
HPP Restelica 1&2	HPP	Prizreni	Dragashi	2.28	yes	Operating
HPP Brodi 3	HPP	Prizreni	Dragashi	4.7	yes	Operating
HPP Brezovica	HPP	Ferizaj	Ferizaj (Bibaj)	2.1	yes	Operating
HPP Orqusha	HPP	Prizreni	Dragash	4	yes	Operating
HPP Binqa	HPP	Gjilan	Vitia	1	yes	Operating
HPP Bresana	HPP	Prizreni	Dragash	0.31	no	Operating
HPP Lepenci 3	HPP	Ferizaj	Ferizaj (Bibaj)	9.98	yes	Operating
HPP Radavci	HPP	Peja	Peja 1	0.9	yes	Operating
HPP Burimi	HPP	Peja	Burimi	0.854	yes	Operating
HPP Dikanci	HPP	Prizreni	Prizreni 1	3.34	yes	Operating
PV LLT	PV	Peja	Klina	0.102	no	Operating
PV Onix	PV	Peja	Burimi	0.5	no	Operating
PV Birra Peja	PV	Gjakova	Gjakova 1	3	yes	Operating
PV FFK	PV	Gjakova	Gjakova 2	3	yes	Operating

PV Eling	PV	Peja	Peja 2	0.4	no	Operating
PV SGE	PV	Gjilan	Berivojca	3	no	Operating
HPP Shtrpce	HPP	Ferizaj	Ferizaj (Bibaj)	6.45	yes	Authorized
HPP Vica	HPP	Ferizaj	Ferizaj 3 (Kastrioiti)	4.6	no	Authorized
HPP Sharri	HPP	Ferizaj	Ferizaj (Bibaj)	5.032	yes	Authorized
HPP Soponica	HPP	Ferizaj	Ferizaj (Bibaj)	1.3	yes	Authorized
HPP Brodi 1	HPP	Prizreni	Dragashi	2.48	yes	Authorized
HPP Restelica 3	HPP	Prizreni	Dragashi	2.35	yes	Authorized
HPP Dragash	HPP	Prizreni	Dragashi	3.4	yes	Authorized
HPP Kotlina	HPP	Ferizaj	Ferizaji 3 (Kastrioiti)	4.9	yes	Authorized
HPP Soponica 2	HPP	Gjilan	Vitia	3	yes	Authorized
HPP Lepenci 2	HPP	Ferizaj	Ferizaj (Bibaj)	3.3	yes	Authorized
HPP Sharr Planina 1	HPP	Prizreni	Dragashi	1.65	no	Authorized
HPP Sharr Planina 2	HPP	Prizreni	Dragashi	2.2	no	Authorized
PV LLT	PV	Peja	Klina	0.267	no	Authorized
PV VBS	PV	Gjakova	Gjakova 1	3	yes	Authorized
PV Vita Energy	PV	Gjakova	Gjakova 1	3	yes	Authorized
PV Abrazen	PV	Gjakova	Gjakova 1	3	yes	Authorized
Energy Development group	PV	Gjakova	Gjakova 1	3	yes	Authorized

PV Solar Gate	PV	Prishtina	Podujeva	3	yes	Authorized
PV Alsi&Co Kosove	PV	Gjakova	Gjakova 2	3	yes	Authorized
PV Building Construction	PV	Gjakova	Gjakova 2	1.73	yes	Authorized
Biomass	Biomass	Gjakova	Gjakova 2	1.2	yes	Authorized

ANNEX 3 Size and location of all new PV and Biomass stations

› **Reference study case (see sections 4.1 and 4.2)**

Table A- 2 Size and location of all new PV and Biomass stations in the reference study case

RES Technology	Area	110/10 kV Substation	35/10 kV Substation	Feeder	MV node (connection point)	Installed Capacity (MW)
PV	Prishtina	Podujeva		14000003 Podujeva 3 J09	14000003268	1.50
PV	Prishtina	Podujeva		14000009 Fshatrat 1 J20	14000009065	1.00
PV	Prishtina	Podujeva	Besi	10013011 Lluzhan	10013011144	1.40
PV	Prishtina	Podujeva	Batllava	14015001 LP Batllava	14015001003	2.00
PV	Prishtina	Fushe Kosova	Fushe	15018007 Vragolia J10	15018007159	0.90
PV	Prishtina	Fushe Kosova	Fushe	15018018 Bardh I Madh	15018018062	1.20
PV	Prishtina	Fushe Kosova	Fushe	15018019 J14-Miradi e Eperme	15018019035	0.80
PV	Prishtina	Fushe Kosova	Mazgiti	15019002 Shkabaj	15019002223	0.70
PV	Prishtina	Fushe Kosova	Mazgiti	15019005 Millosheve	15019005164	0.90
PV	Prishtina	Fushe Kosova	Mazgiti	15019006 Lumi i Madh(Bizniset)	15019008230	0.90
PV	Prishtina	Drenasi		16021002 Drenasi 2	16021002228	1.70
PV	Prishtina	Drenasi		16021004 Shtrubullova	1602100322	0.50
PV	Prishtina	Drenasi		16021006 Orllat	16021006040	1.00
PV	Prishtina	Drenasi		16021007 Poklek i Ri	16021007231	0.70
PV	Prishtina	Drenasi		16021008 Baice-Cikatove	16021008137	0.50
PV	Prishtina	Drenasi		16021009 Iber Lepenci-Q.SH.	16021009088	1.10
PV	Prishtina	Drenasi		16021028 Gllobari2	16021028130	0.50
PV	Prishtina	Palaj		18024001 Palaj J03	18024001042	0.50

PV	Prishtina	Palaj		18024002 Obiliqi(Qyteti dhe Hashaent)	18024002107	1.50
PV	Prishtina	Palaj		18024003 Prelluzha	18024003091	0.80
PV	Prishtina	Prishtina 7		19000034 J34 Cagllavica-	19000034251	1.20
PV	Prishtina	Prishtina 7		19000041 J11 Matiqani	19000041238	1.00
PV	Prishtina	Prishtina 5		13000001 j5Bardhosh	13000001088	1.00
PV	Prishtina	Prishtina 5		13000018 J14Qendra e panaireve-	13000018116	2.20
PV	Prishtina	Prishtina 3		12000014 Arberia 5 J21	12000014060	2.20
PV	Prishtina	Prishtina 2		11000023 Nr. 30 Tregtia	11000023213	2.20
PV	Prishtina	Prishtina 1		10000001 Preoci J22	10000001001	1.00
PV	Prishtina	Prishtina 1		10000007 Kalabria 2 J16	10000007160	2.00
PV	Prishtina	Prishtina 1	Badovci	10014002 Hajvalia	10014004054	0.60
PV	Prishtina	Prishtina 1	Badovci	10014004 Graqanica 1 J02	10014004042	1.80
PV	Ferizaj	Lipjani		41000001 Bablaku(3)	41000001318	1.00
PV	Ferizaj	Lipjani		41000002 Kraishta(2)	41000002047	1.00
PV	Ferizaj	Lipjani		41000003 Sllovia(2)	41000003078	0.85
PV	Ferizaj	Lipjani		41000008 Shtëpia Korrektuese	middle of the line	2.50
PV	Ferizaj	Lipjani		41000009 Zona industriale(1)	41000009224	1.00
PV	Ferizaj	Lipjani		41000011 QMI(2)	41000011373	1.25
PV	Ferizaj	Lipjani		41000012 Banulla	41000012106	0.90
PV	Ferizaj	Lipjani		41000013 Gadime	middle of the line	1.00
PV	Ferizaj	Lipjani		41000020 Suhadolli(2)	41000020009	1.90
PV	Ferizaj	Lipjani	Shtime	41046002 Petrova	41046002027	1.00
PV	Ferizaj	Lipjani	Shtime	41046003 Shtimes	41046003043	1.00
PV	Ferizaj	Lipjani	Magure	41048003 Halilaqi(2)	41048003142	1.35
PV	Gjakova	Gjakova 1	Gjakova I	80080009 Skivjani	80080009044	1.20

PV	Gjakova	Gjakova 1	Gjakova I	80080011 Ereniku(1)	80080011333	1.50
PV	Gjakova	Gjakova 1	Gjakova I	80080012 Cermjani	80080012301	0.80
PV	Gjakova	Gjakova 1	Xerxa	82081008 Podrumi-	82081008001	0.50
PV	Gjakova	Gjakova 1	Xerxa	82081006 Ratkoci-	82081006010	1.00
PV	Gjakova	Gjakova 2		Qendra	81000002035	2.50
PV	Gjakova	Gjakova 2		Ura Terezive	81000004070	1.20
PV	Gjakova	Gjakova 2		Dedicated Feeder 1		2.00
PV	Gjakova	Rahoveci		Pataqani	82000001010	1.10
PV	Gjakova	Rahoveci		Shkoza	82000009002	1.50
PV	Gjakova	Rahoveci		Opterusha	82000010014	1.40
PV	Gjakova	Rahoveci		Stone Castle	82000018005	3.00
PV	Gjakova	Rahoveci		Canziba	82000019001	4.00
PV	Gjakova	Rahoveci		Qyetti 1	8200003005	1.20
PV	Gjakova	Malisheva new		Caralluca	82082001025	1.00
PV	Gjakova	Malisheva new		Banje	82082004005	2.10
PV	Gjakova	Malisheva new		Dragoboli	82082006007	2.50
PV	Gjakova	Malisheva new		Kijeva	82082007063	1.40
PV	Gjakova	Malisheva new		Dedicated Feeder 1		2.50
PV	Gjakova	Malisheva new		Dedicated Feeder 2		2.50
PV	Gjilan	Gjilan 1	Gjilan 1	60060016 - J16 - Uglari	60060016166	1.50
PV	Gjilan	Gjilan 1	Gjilan 2	60061006 - J06 - Kufca	60061006242	1.50
PV	Gjilan	Gjilan 5		63000008 - J08 - Pasjaku	63000008281	1.60
PV	Gjilan	Gjilan 5		63000011 - J11 - Ferma	63000011441	1.00
PV	Gjilan	Vitia	Lladova	61066004 - J04 - Parteshi-Budrika	61066004320	0.50
PV	Gjilan	Vitia	Vitia	61067001 - J01 - Stublla	61067001111	2.00
PV	Gjilan	Vitia	Vitia	61067006 - J06 - Smira	61067006048	0.90

PV	Gjilan	Vitia	Vitia	61067010 - J10 - Begunca	61067010069	1.80
PV	Gjilan	Berivojca		62000011 - J11 - Muqiverci	62000011070	0.50
PV	Gjilan	Berivojca		62000014 - J14 - Ropotova(1)	62000014223	0.50
PV	Mitrovica	Skenderaj		74000001 Likovci J19	74000001001	0.70
PV	Mitrovica	Skenderaj		74000002 Fab.e Municionit dhe Lodrave	74000002005	2.60
PV	Mitrovica	Skenderaj		74000003 Prekazi J17	74000003007	1.40
PV	Mitrovica	Skenderaj		74000004 Qirezi J16	74000004005	0.50
PV	Mitrovica	Skenderaj		74000005 Runiku 20kV	74000005039	1.00
PV	Mitrovica	Skenderaj		74000006 Turiqevci J03	74000006001	1.00
PV	Mitrovica	Skenderaj		74000006 Turiqevci J03	74000006012	0.65
PV	Mitrovica	Skenderaj		74000012 Ternavc J02	74000012011	1.30
PV	Mitrovica	Vushtrri 2		73000012 Iber Lepenci J02	73000012005	2.90
PV	Mitrovica	Vushtrri 2		73000003 Qytet e Fshatra J08	73000003029	1.20
PV	Mitrovica	Vushtrri 2		73000004 St.Hekurudhor J07	73000004005	1.20
PV	Mitrovica	Vushtrri 2		73000005 Novolani J06	73000005003	0.95
PV	Mitrovica	Vushtrri 2		73000009 Martiraj	73000009031	1.40
PV	Mitrovica	Vushtrri 2		73000011 Maxhunaj J18	73000011017	0.50
PV	Mitrovica	Vushtrri 2		73000015 KFORI J01	start line	1.00
PV	Mitrovica	Ilirida		71074002 Kqiqi J07	71074002020	3.00
PV	Mitrovica	Ilirida		71075004 Shupkovci (Bajri)	71075004011	0.50
PV	Mitrovica	Ilirida		71075012 Iber Lepenci(1)	71075012003	0.80
PV	Peja	Klina		52000001 Ujmiri	52000001024	1.00
PV	Peja	Klina		52000002 Klinavci	52000002005	2.90
PV	Peja	Klina		52000007 Dresniku	52000007001	3.10
PV	Peja	Klina		52000009 Gllareva	52000009004	0.50

PV	Peja	Klina		52000011 Gremniku	52000011035	1.60
PV	Peja	Klina	Klina	52056001 Voljaku	52056002008	1.60
PV	Peja	Klina	Klina	52056004 Zajmi	52056004005	1.10
PV	Peja	Klina	Klina	52056005 Jagoda	52056005008	1.10
PV	Peja	Klina		Dedicated Feeder 1		3.80
PV	Peja	Burimi		54000001 Mojstiri	54000001003	1.00
PV	Peja	Burimi		54000006 Dubrava- Rakoshi	54000006004	1.10
PV	Peja	Burimi		54000006 Dubrava- Rakoshi	54000006006	1.70
PV	Peja	Burimi		54000007 Istogu 2	54000007003	1.80
PV	Peja	Burimi		54000008 Istogi 1	54000008028	1.60
PV	Peja	Burimi		54000009 Burgu	54000009002	2.60
PV	Peja	Burimi		Dedicated Feeder 1		1.90
PV	Peja	Peja 1		50000004 Radavci	50000004005	2.80
PV	Peja	Peja 1		50000009 Fusha e Pejes(1)	50000009001	3.20
PV	Peja	Peja 1		50000010 Vitomirica	50000010027	1.10
PV	Peja	Peja 1	Gurrakoci	50052003 Zallqi	50052003001	0.80
PV	Peja	Peja 2		51000004 Dardania 2	51000004010	1.30
PV	Peja	Peja 2		51000007 Kastrati	51000007047	1.40
PV	Peja	Peja 2		51000008 Loxha	51000008017	0.50
PV	Peja	Peja 2		51000010 Zahaqi	51000010016	1.10
PV	Prizreni	Prizreni 3		31000009 Grnqari	31000009008	1.00
PV	Prizreni	Prizreni 3		31000010 Korisha	31000010065	1.50
PV	Prizreni	Theranda		32000002 Mushtishti	32000002001	1.20
PV	Prizreni	Theranda		32000008 Budakova J16	32000008023	1.40
PV	Prizreni	Theranda		32000018 Studenqani J19	32000018006	1.90
PV	Prizreni	Theranda		32000019 Shiroke e Re J10	32000019006	2.80

PV	Prizreni	Theranda		32000023 Shpenadia J13	32000023002	0.69
Biomass	Prizreni	Theranda		32000003 Gjinovci	32000003056	1.10
Biomass	Prizreni	Prizreni 3		31000030 Velezha J30	31000030039	1.75
Biomass	Peja	Peja 2		51000005 Lumi i Bardhe	51000012003	1.00
Biomass	Peja	Peja 1	Gurrakoci	50052001 Dobrusha	50052004001	1.90
Biomass	Mitrovica	Ilirida		71075005 Koshtova	71075005027	0.90
Biomass	Mitrovica	Ilirida		71075006 Ujsjellesi i ri	71075006001	1.55
Biomass	Gjilan	Vitia	Kllokoti	61065002 - J02 - Sllatina	61065002131	1.00
Biomass	Gjilan	Gjilan 1	Gjilan 3	60062002 - J02 - Perlepnica	600620	1.85
Biomass	Gjakova	Malisheva new		Mirusha	82082002008	1.70
Biomass	Ferizaj	Lipjani		41000004 Konjuhi(1)	41000004074	0.90
Biomass	Ferizaj	Lipjani	Shtime	41046006 Maxiti Putz(2)	41046006100	1.95
Biomass	Prishtina	Fushe Kosova	Fushe	15018008 Albana	15018008246	1.20
Biomass	Prishtina	Podujeva		14000016 Eurobllok	14000016075	1.60
					Total	**188.84**

- **Sensitivity Analysis (see section 4.3)**

Table A- 3 Size and location of all new PV stations in scenario SClow of the sensitivity analysis

RES Technology	Area	110/10 kV Substation	35/10 kV Substation	Feeder	MV node (connection point)	Installed Capacity (MW)
PV	Mitrovica	Ilirida		71074002 Kqiqi J07	71074002020	1.20
PV	Mitrovica	Ilirida		71075012 Iber Lepenci(1)	71075012003	1.00
PV	Mitrovica	Vushtrri 2		73000003 Qytet e Fshatra J08	73000003029	1.30
PV	Mitrovica	Vushtrri 2		73000009 Martiraj	73000009031	1.80
PV	Mitrovica	Skenderaj		74000001 Likovci J19	74000001001	0.70
PV	Mitrovica	Skenderaj		74000005 Runiku 20kV	74000005039	0.60
PV	Mitrovica	Skenderaj		74000006 Turiqevci J03	74000006001	2.70
PV	Mitrovica	Skenderaj		74000012 Ternavc J02	74000012011	1.00
PV	Mitrovica	Vushtrri 2		73000012 Iber Lepenci J02	73000012005	1.00
					Total	**11.30**

Table A- 4 Size and location of all new PV and Biomass stations in scenario SChigh of the sensitivity analysis

RES Technology	Area	110/10 kV Substation	35/10 kV Substation	Feeder	MV node (connection point)	Installed Capacity (MW)
PV	Mitrovica	Ilirida		71074002 Kqiqi J07	71074002020	1.80
PV	Mitrovica	Ilirida		71075004 Shupkovci (Bajri)	71075004011	0.60
PV	Mitrovica	Ilirida		71075005 Koshtova	71075005027	0.90
PV	Mitrovica	Ilirida		71075008 Sollana	71075008004	1.75

PV	Mitrovica	Ilirida		71075012 Iber Lepenci(1)	71075012003	1.40
PV	Mitrovica	Vushtrri 2		73000003 Qytet e Fshatra J08	73000003029	1.30
PV	Mitrovica	Vushtrri 2		73000004 St.Hekurudhor J07	73000004005	1.25
PV	Mitrovica	Vushtrri 2		73000005 Novolani J06	73000005003	1.00
PV	Mitrovica	Vushtrri 2		73000009 Martiraj	73000009031	1.75
PV	Mitrovica	Vushtrri 2		73000010 Mulliri Pestova J05	73000010003	0.40
PV	Mitrovica	Vushtrri 2		73000011 Maxhunaj J18	73000011017	0.75
PV	Mitrovica	Vushtrri 2		73000012 Iber Lepenci J02	73000012004	1.00
PV	Mitrovica	Vushtrri 2		73000014 Nedakovci J17	73000014001	0.85
PV	Mitrovica	Vushtrri 2		73000015 KFORI J01	start line	1.00
PV	Mitrovica	Skenderaj		74000001 Likovci J19	74000001001	1.10
PV	Mitrovica	Skenderaj		74000002 Fab.e Municionit dhe Lodrave	74000002005	2.80
PV	Mitrovica	Skenderaj		74000003 Prekazi J17	74000003007	1.40
PV	Mitrovica	Skenderaj		74000004 Qirezi J16	74000004005	0.85
PV	Mitrovica	Skenderaj		74000005 Runiku 20kV	74000005039	1.90
PV	Mitrovica	Skenderaj		74000006 Turiqevci J03	74000006001	1.00
PV	Mitrovica	Skenderaj		74000006 Turiqevci J03	74000006012	1.00
PV	Mitrovica	Skenderaj		74000012 Ternavc J02	74000012011	1.30
PV	Mitrovica	Vushtrri 2		73000012 Iber Lepenci J02	73000012005	2.50
PV	Mitrovica	Skenderaj		Dedicated 1		4.20
					Total	**33.80**

Network Planning Alternatives: Dedicated Feeders (see section 5.1)

Table A- 5 Size and location of all new PV and Biomass stations in the "dedicated feeder" planning paradigm

RES Technology	Area	110/10 kV Substation	35/10 kV Substation	Feeder	MV node (connection point)	Installed Capacity (MW)
PV	Gjakova	Gjakova 1	Gjakova I	Dedicated Feeder 1		2.00
PV	Gjakova	Gjakova 1	Gjakova I	Dedicated Feeder 2		1.50
PV	Gjakova	Gjakova 1	Xerxa	Dedicated Feeder 3		1.50
PV	Gjakova	Gjakova 2		Dedicated Feeder 4		2.50
PV	Gjakova	Gjakova 2		Dedicated Feeder 5		1.20
PV	Gjakova	Gjakova 2		Dedicated Feeder 6		2.00
PV	Gjakova	Rahoveci		Dedicated Feeder 7		3.00
PV	Gjakova	Rahoveci		Dedicated Feeder 8		2.20
PV	Gjakova	Rahoveci		Dedicated Feeder 9		2.00
PV	Gjakova	Rahoveci		Dedicated Feeder 10		2.50
PV	Gjakova	Rahoveci		Dedicated Feeder 11		2.50
PV	Gjakova	Malisheva new		Dedicated Feeder 12		4.00
PV	Gjakova	Malisheva new		Dedicated Feeder 13		2.00
PV	Gjakova	Malisheva new		Dedicated Feeder 14		3.00
PV	Gjakova	Malisheva new		Dedicated Feeder 15		2.50
Biomass	Gjakova	Malisheva new		Dedicated Feeder 16		1.70
					Total	**36.10**

Table A- 6 Size and location of all new PV stations in scenario SC1 of the "new HV/MV substation" planning exercise

RES Technology	Area	110/10 kV Substation	35/10 kV Substation	Feeder	MV node (connection point)	Installed Capacity (MW)
PV	Gjakova	Gjakova 1	Gjakova I	80080007 Dobroshi	80080007213	0.60
PV	Gjakova	Gjakova 1	Gjakova I	80080010 Beci(1)	8080010272	2.10
PV	Gjakova	Gjakova 1	Gjakova I	80080011 Ereniku(1)	80080011333	1.70
PV	Gjakova	Gjakova 1	Gjakova I	80080012 Cermjani	80080012301	0.80
PV	Gjakova	Gjakova 2		Intermedi	81000032016	2.80
PV	Gjakova	Gjakova 2		Ura Terezive	81000004070	1.20
PV	Gjakova	Gjakova 2		Bistrazhini	81000005122	0.50
PV	Gjakova	Gjakova 2		Dedicated Feeder 1		5.00
PV	Gjakova	Rahoveci		Pataqani	82000001010	1.10
PV	Gjakova	Rahoveci		Shkoza	82000009002	1.50
PV	Gjakova	Rahoveci		Opterusha	82000010014	1.40
PV	Gjakova	Rahoveci		Stone Castle	82000018005	2.00
PV	Gjakova	Rahoveci		Canziba	82000019001	4.70
PV	Gjakova	Rahoveci		Qyetti 1	8200003005	1.20
PV	Gjakova	Rahoveci		Dedicated Feeder 1		3.00
PV	Gjakova	Malisheva new		Caralluca	82082001025	1.00
PV	Gjakova	Malisheva new		Mirusha	82082002009	0.80
PV	Gjakova	Malisheva new		Banje	82082004005	2.10
PV	Gjakova	Malisheva new		Dalia	82082005004	1.00
PV	Gjakova	Malisheva new		Dragoboli	82082006007	3.10
PV	Gjakova	Malisheva new		Kijeva	82082007063	1.40
PV	Gjakova	Malisheva new		Dedicated Feeder 1		2.50

PV	Gjakova	Malisheva new		Dedicated Feeder 2		2.80
PV	Gjakova	Xerxa new	Xerxa	82081003 Xerxa	82081003005	3.00
PV	Gjakova	Xerxa new	Xerxa	82081009 Fortesa-	82081009001	3.00
PV	Gjakova	Xerxa new	Xerxa	82081008 Podrumi-	82081008001	1.90
PV	Gjakova	Xerxa new	Xerxa	82081006 Ratkoci-	82081006010	1.50
PV	Gjakova	Xerxa new	Xerxa	Dedicated Feeder 1		4.50
PV	Gjakova	Xerxa new	Xerxa	82081007 Denji-	82081007033	0.60
PV	Gjakova	Xerxa new	Xerxa	Dedicated Feeder 2		2.50
PV	Gjakova	Xerxa new	Xerxa	Dedicated Feeder 3	80080007213	3.00
					Total	**64.30**

› **Network Planning Alternatives: New HV/MV substations (see section 5.2)**

Table A- 7 Size and location of all new PV stations in scenario SC2 of the "new HV/MV substation" planning exercise

RES Technology	Area	110/10 kV Substation	35/10 kV Substation	Feeder	MV node (connection point)	Installed Capacity (MW)
PV	Gjakova	Gjakova 1	Gjakova I	80080009 Skivjani	80080009044	1.20
PV	Gjakova	Gjakova 1	Gjakova I	80080010 Beci(1)	8080010272	2.10
PV	Gjakova	Gjakova 1	Xerxa	82081008 Podrumi-	82081008001	1.90
PV	Gjakova	Gjakova 2		Intermedi	81000032016	2.80
PV	Gjakova	Gjakova 2		Ura Terezive	81000004070	1.20
PV	Gjakova	Gjakova 2		Bistrazhini	81000005122	0.50
PV	Gjakova	Gjakova 2		Dedicated Feeder 1		5.00
PV	Gjakova	Rahoveci		Pataqani	82000001010	1.10
PV	Gjakova	Rahoveci		Shkoza	82000009002	1.50
PV	Gjakova	Rahoveci		Opterusha	82000010014	1.40
PV	Gjakova	Rahoveci		Stone Castle	82000018005	3.00
PV	Gjakova	Rahoveci		Canziba	82000019001	3.50
PV	Gjakova	Rahoveci		Qyetti 1	8200003005	1.20
PV	Gjakova	Rahoveci		Dedicated Feeder 1		3.00
PV	Gjakova	Malisheva new		Caralluca	82082001025	1.00
PV	Gjakova	Malisheva new		Mirusha	82082002009	0.80
PV	Gjakova	Malisheva new		Banje	82082004005	2.10
PV	Gjakova	Malisheva new		Dalia	82082005004	1.00
PV	Gjakova	Malisheva new		Dragoboli	82082006007	3.10
PV	Gjakova	Malisheva new		Kijeva	82082007063	1.40

PV	Gjakova	Malisheva new		Dedicated Feeder 1		2.50
PV	Gjakova	Malisheva new		Dedicated Feeder 2		2.80
PV	Gjakova	RES		Dedicated Feeder 1		5.00
PV	Gjakova	RES		Dedicated Feeder 2		5.00
PV	Gjakova	RES		Dedicated Feeder 3		2.50
PV	Gjakova	RES		Dedicated Feeder 4		4.00
PV	Gjakova	RES		Dedicated Feeder 5		3.50
					Total	**64.10**

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ANNEX 4 Spatial distribution all new PV and Biomass stations per distribution area

- **<u>Reference study case (see sections 4.1 and 4.2)</u>**

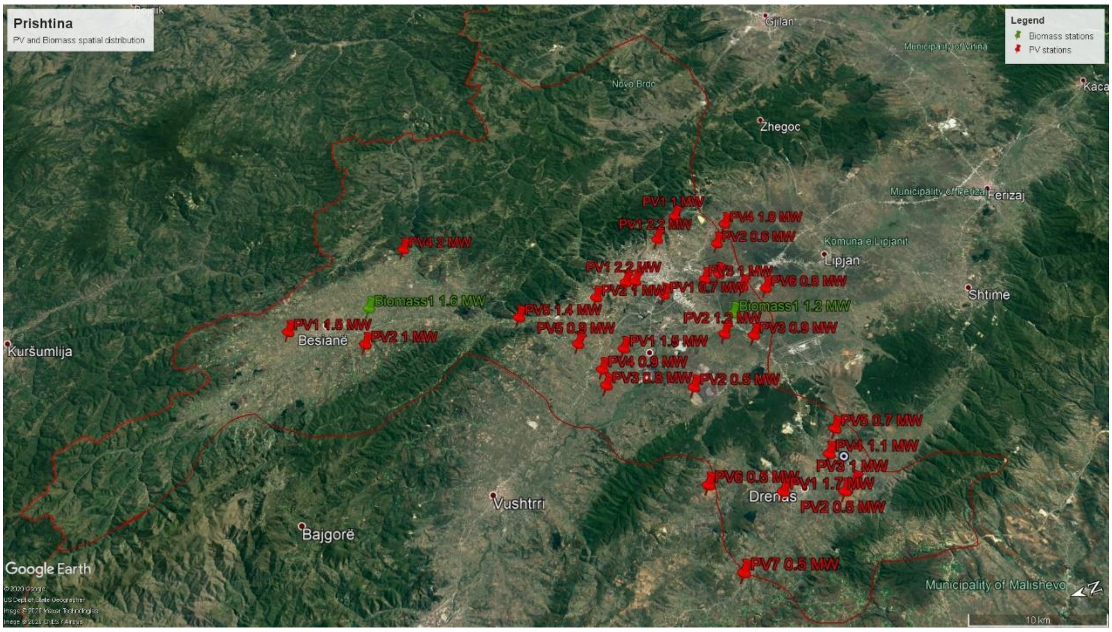

Figure 29 Spatial distribution of all new PV and Biomass stations in Prishtina, in the reference study case.

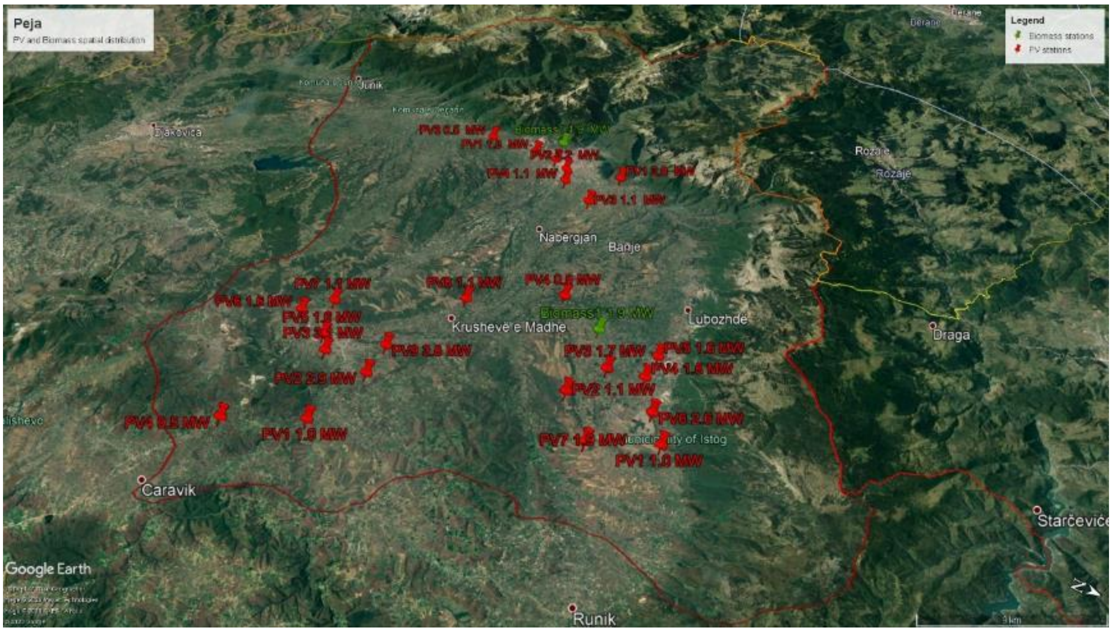

Figure 30 Spatial distribution of all new PV and Biomass stations in Peja, in the reference study case.

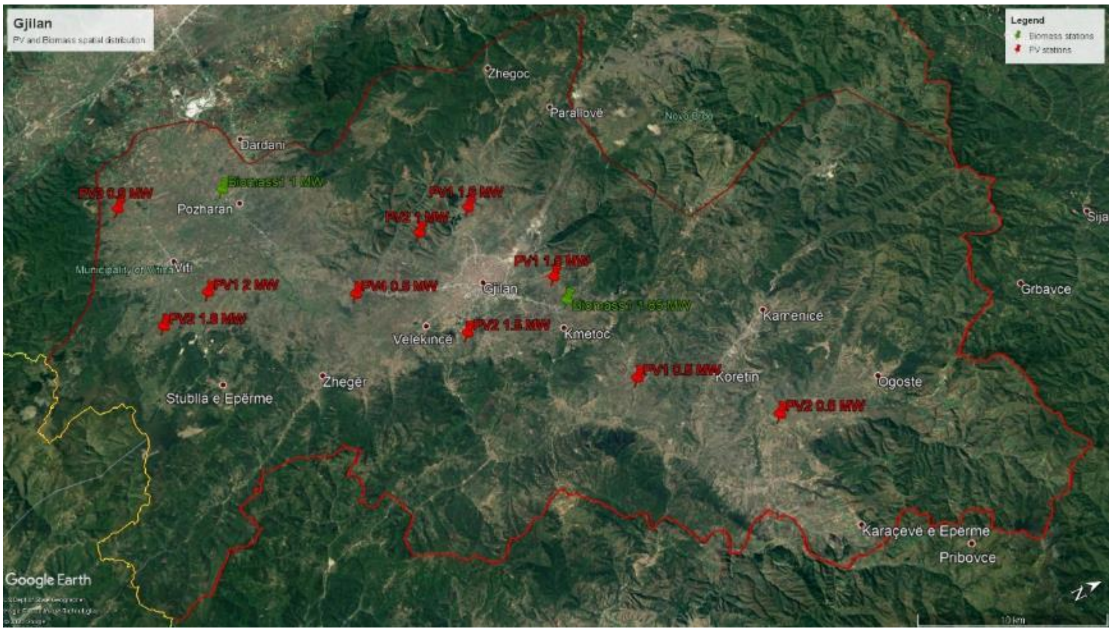

Figure 31 Spatial distribution of all new PV and Biomass stations in Gjilan, in the reference study case.

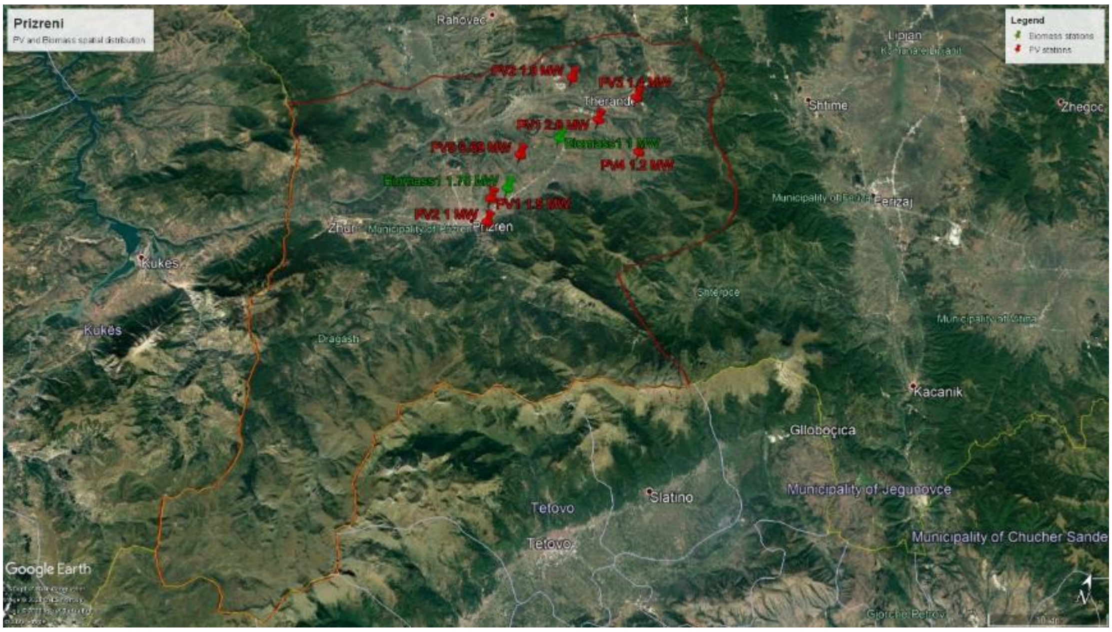

Figure 32 Spatial distribution of all new PV and Biomass stations in Prizreni, in the reference study case.

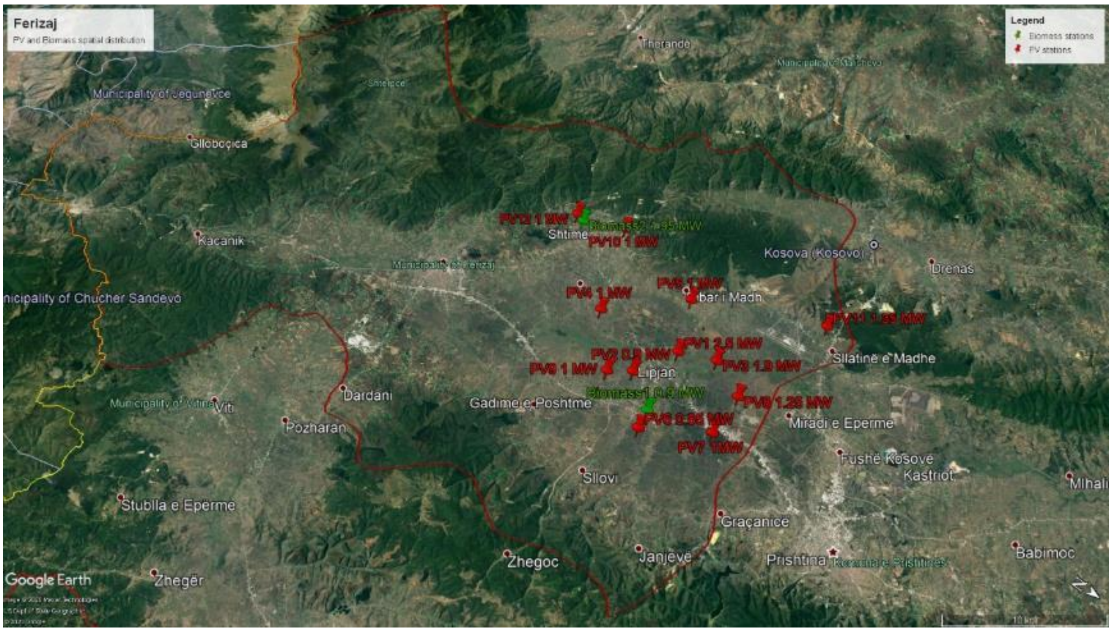

Figure 33 Spatial distribution of all new PV and Biomass stations in Ferizaj, in the reference study case.

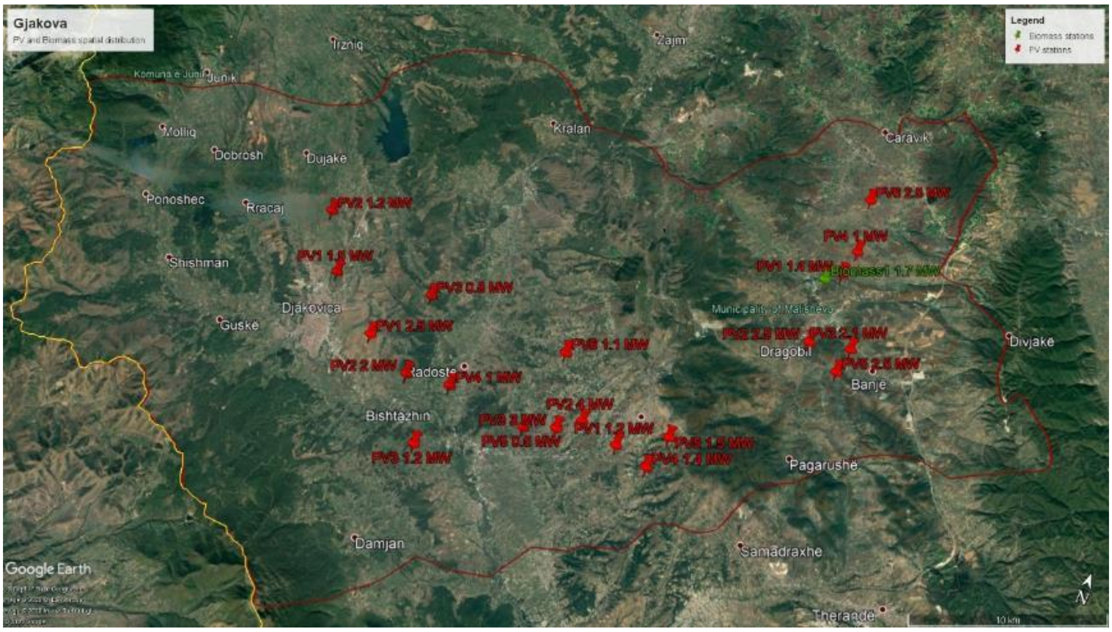

Figure 34 Spatial distribution of all new PV and Biomass stations in Gjakova, in the reference study case.

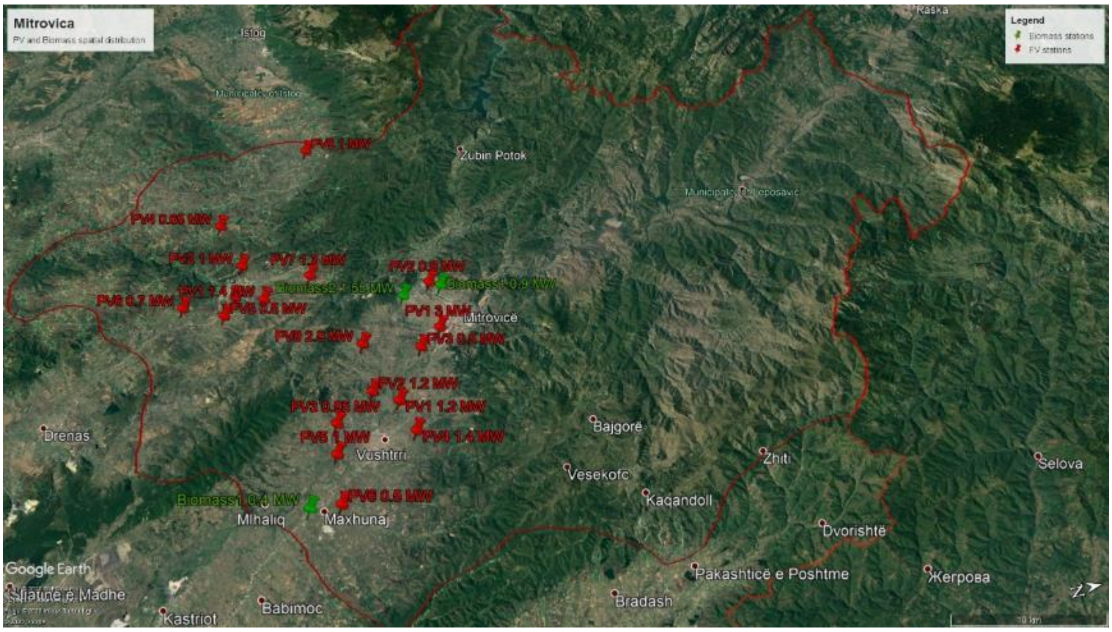

Figure 35 Spatial distribution of all new PV and Biomass stations in Mitrovica, in the reference study case.

Sensitivity Analysis (see section 4.3)

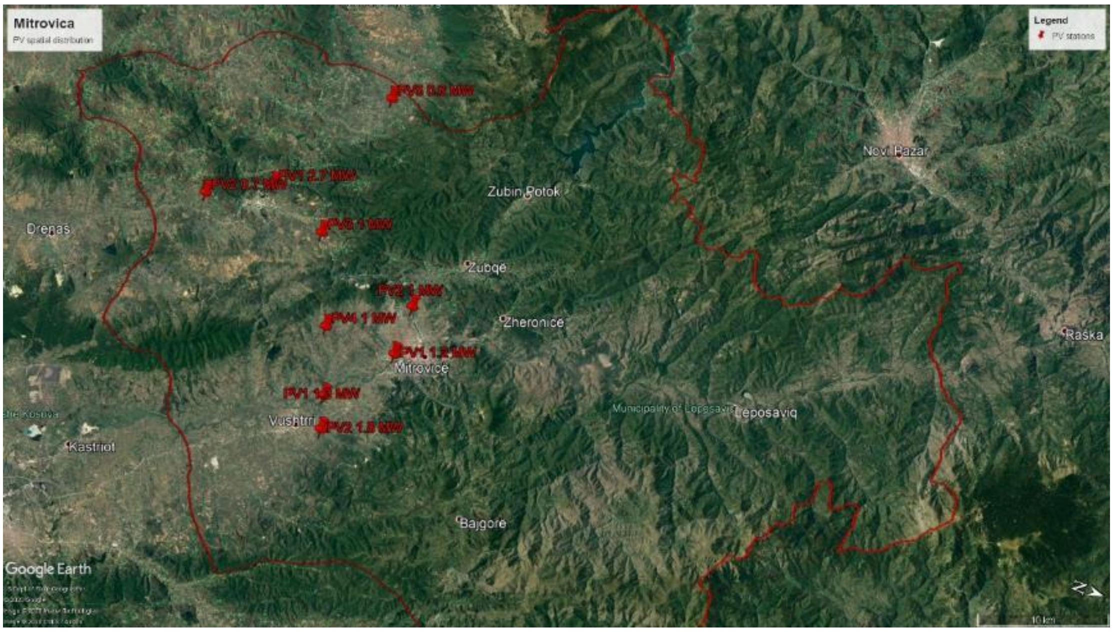

Figure 36 Spatial distribution of all new PV stations in Mitrovica, in scenario SClow of the sensitivity analysis.

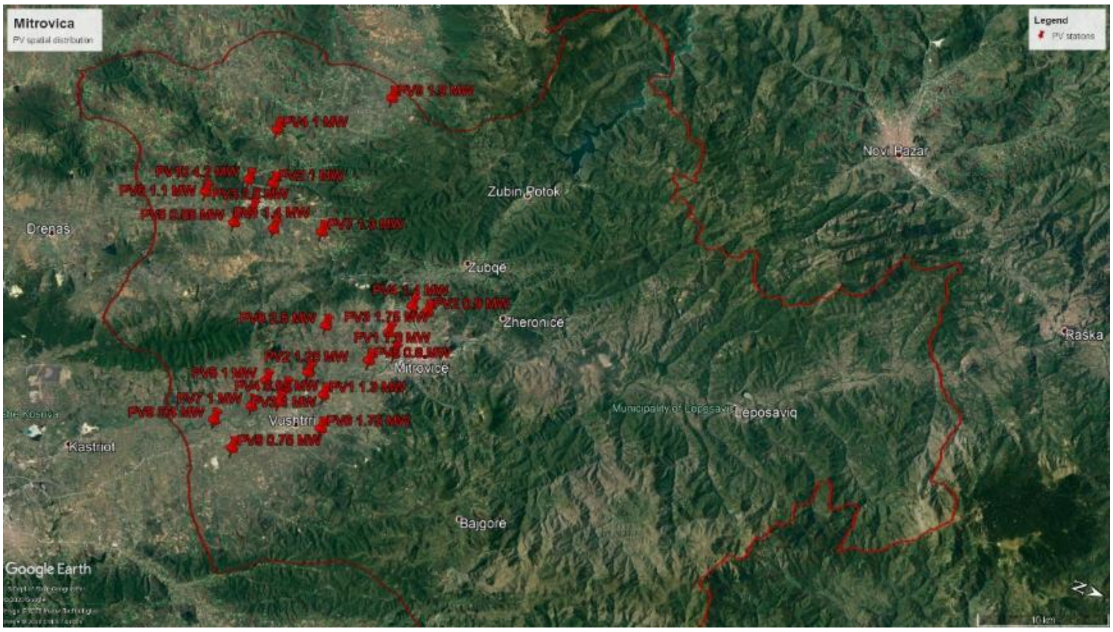

Figure 37 Spatial distribution of all new PV stations in Mitrovica, in scenario SChigh of the sensitivity analysis.

- **<u>Network Planning Alternatives: Dedicated Feeders (see section 5.1)</u>**

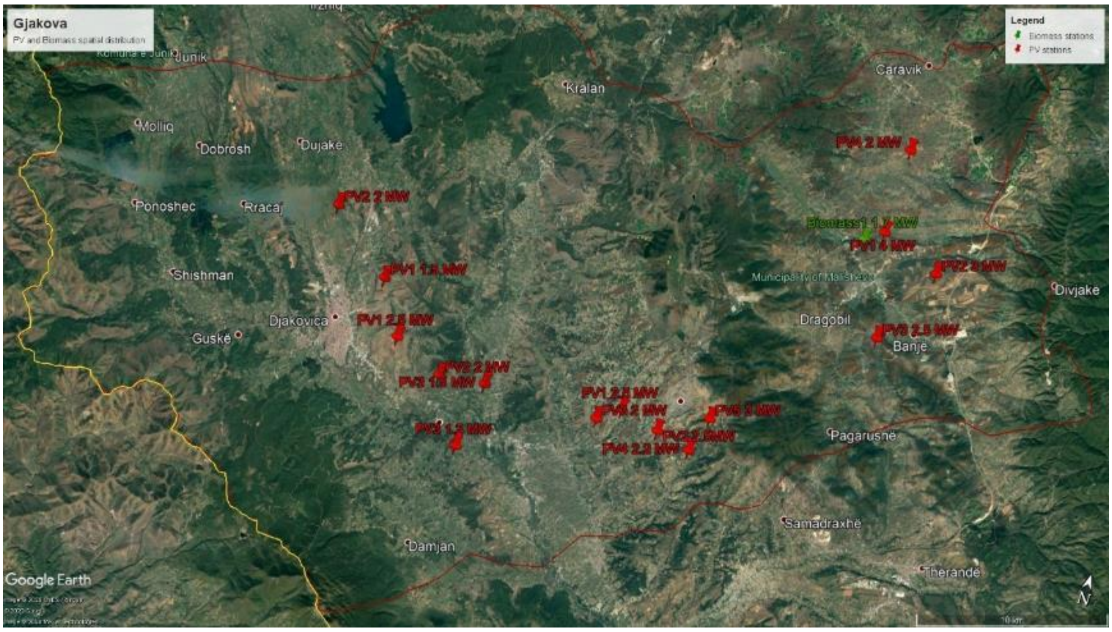

Figure 38 Spatial distribution of all new PV and biomass stations in Gjakova, in the "dedicated feeder" planning paradigm.

- **<u>Network Planning Alternatives: New HV/MV substations (see section 5.2)</u>**

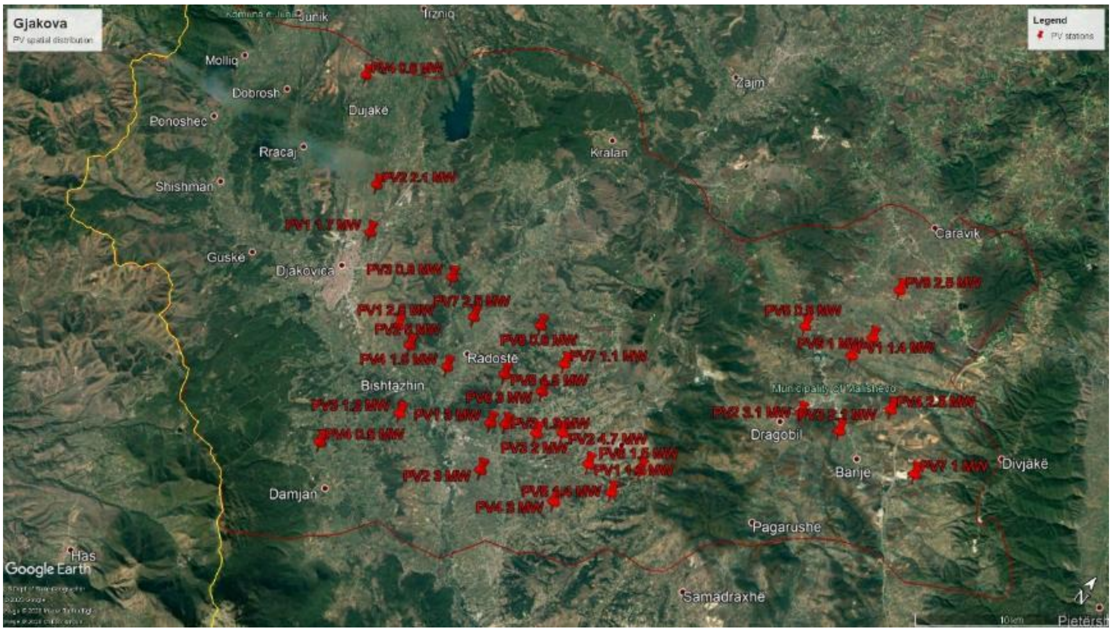

Figure 39 Spatial distribution of all new PV stations in Gjakova, in scenario SC1 of the "new HV/MV substation" planning exercise.

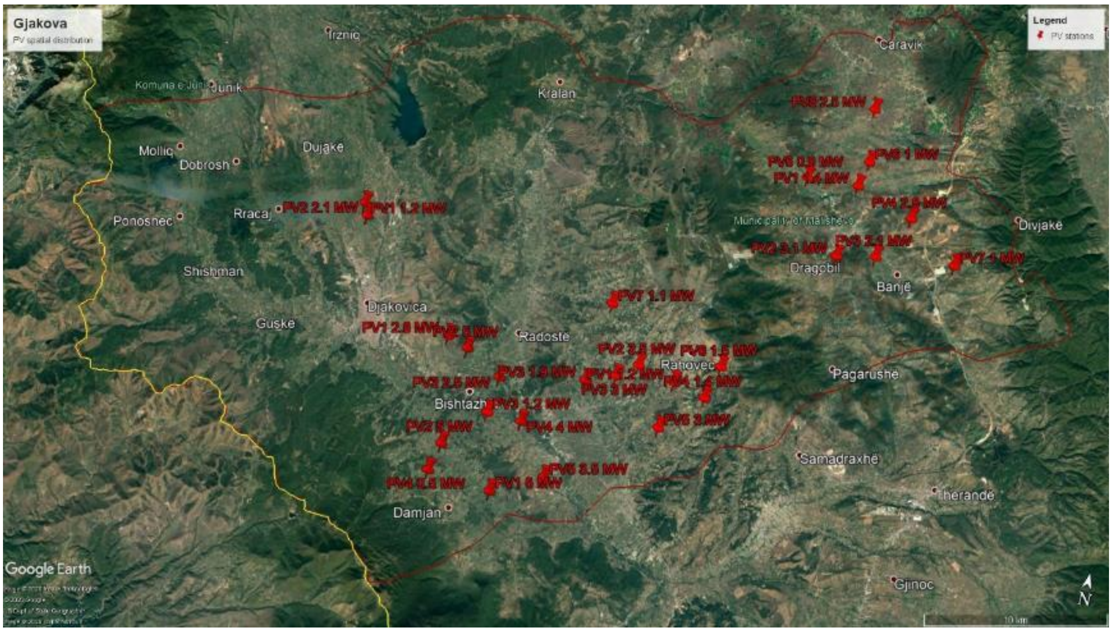

Figure 40 Spatial distribution of all new PV stations in Gjakova, in scenario SC2 of the "new HV/MV substation" planning exercise.

ANNEX 5 Network investments required for the integration of all new PV and Biomass stations in the distribution network

- **Reference study case (see sections 4.1 and 4.2)**

Table A- 8 Required network projects for the integration of all new PV and Biomass stations in the reference study case

Feeder	Installed Capacity (MW)	Connection Lateral (km)	Line reinforcement (Type)	Line reinforcement (km)	Dedicated Feeder (Type)	Dedicated Feeder (km)
14000003 Podujeva 3 J09	1.5	1.05				
14000009 Fshatrat 1 J20	1.0	1.65				
10013011 Lluzhan	1.4	1.20				
14015001 LP Batllava	2.0	1.20				
15018007 Vragolia J10	0.9	0.60				
15018018 Bardh I Madh	1.2	0.60				
15018019 J14-Miradi e Eperme	0.8	1.65				
15019002 Shkabaj	0.7	1.05				
15019005 Millosheve	0.9	1.05				
15019006 Lumi i Madh(Bizniset)	0.9	1.50				
16021002 Drenasi 2	1.7	1.05				
16021004 Shtrubullova	0.5	1.20				
16021006 Orllat	1.0	0.75	OHL 70/12	0.80		
16021007 Poklek i Ri	0.7	1.50				
16021008 Baice-Cikatove	0.5	1.65				

16021009 Iber Lepenci-Q.SH.	1.1	2.40				
16021028 Gllobari2	0.5	1.95				
18024001 Palaj J03	0.5	1.05				
18024002 Obiliqi(Qyteti dhe Hashaent)	1.5	1.13	OHL 95/15	4.50		
18024003 Prelluzha	0.8	1.50				
19000034 J34 Cagllavica-	1.2	1.88				
19000041 J11 Matiqani	1.0	1.65				
13000001 j5Bardhosh	1.0	1.05				
13000018 J14Qendra e panaireve-	2.2	0.60				
12000014 Arberia 5 J21	2.2	1.20				
11000023 Nr. 30 Tregtia	2.2	0.53				
10000001 Preoci J22	1.0	1.20				
10000007 Kalabria 2 J16	2.0	1.35				
10014002 Hajvalia	0.6	1.35				
10014004 Graqanica 1 J02	1.8	1.35				
41000001 Bablaku(3)	1.0	1.50				
41000002 Kraishta(2)	1.0	1.91				
41000003 Sllovia(2)	0.9	0.93				
41000008 Shtëpia Korrektuese	2.5	1.05				
41000009 Zona industriale(1)	1.0	1.22				
41000011 QMI(2)	1.3	1.13				
41000012 Banulla	0.9	1.07				
41000013 Gadime	1.0	0.86				
41000020 Suhadolli(2)	1.9	0.98				
41046002 Petrova	1.0	0.98				
41046003 Shtimes	1.0	1.07				

41048003 Halilaqi(2)	1.4	1.08				
80080009 Skivjani	1.2	2.06				
80080011 Ereniku(1)	1.5	0.96				
80080012 Cermjani	0.8	2.04				
82081008 Podrumi-	0.5	1.05				
82081006 Ratkoci-	1.0	1.80				
Qendra	2.5	2.10				
Ura Terezive	1.2	1.10				
Dedicated Feeder 1	2.0				OHL 50/8	4.85
Pataqani	1.1	2.10	OHL 95/15	5.00		
Shkoza	1.5	1.20				
Opterusha	1.4	1.25	OHL 95/15	2.80		
Stone Castle	3.0	1.35				
Canziba	4.0	1.80				
Qyetti 1	1.2	1.35				
Caralluca	1.0	1.13				
Banje	2.1	0.98				
Dragoboli	2.5	2.25				
Kijeva	1.4	2.25				
Dedicated Feeder 1	2.5	0.00			OHL 95/15	9.86
Dedicated Feeder 2	2.5	0.00			OHL 70/12	5.09
60060016 - J16 - Uglari	1.5	1.14				
60061006 - J06 - Kufca	1.5	1.20				
63000008 - J08 - Pasjaku	1.6	1.04				
63000011 - J11 - Ferma	1.0	1.50				
61066004 - J04 - Parteshi-Budrika	0.5	0.84				

61067001 - J01 - Stublla	2.0	1.65				
61067006 - J06 - Smira	0.9	0.99				
61067010 - J10 - Begunca	1.8	1.22				
62000011 - J11 - Muqiverci	0.5	0.80				
62000014 - J14 - Ropotova(1)	0.5	0.75				
74000001 Likovci J19	0.7	1.11				
74000002 Fab.e Municionit dhe Lodrave	2.6	1.50				
74000003 Prekazi J17	1.4	1.19				
74000004 Qirezi J16	0.5	0.98				
74000005 Runiku 20kV	1.0	1.49				
74000006 Turiqevci J03	1.0	0.99				
74000006 Turiqevci J03	0.7	0.96				
74000012 Ternavc J02	1.3	1.37				
73000012 Iber Lepenci J02	2.9	1.05				
73000003 Qytet e Fshatra J08	1.2	1.14				
73000004 St.Hekurudhor J07	1.2	1.16				
73000005 Novolani J06	1.0	1.40				
73000009 Martiraj	1.4	1.26				
73000011 Maxhunaj J18	0.5	1.31				
73000015 KFORI J01	1.0	1.32				
71074002 Kqiqi J07	3.0	1.17				
71075004 Shupkovci (Bajri)	0.5	1.05				
71075012 Iber Lepenci(1)	0.8	0.89				
52000001 Ujmiri	1.0	1.50				
52000002 Klinavci	2.9	1.17	OHL 70/12	2.33		
52000007 Dresniku	3.1	0.68	OHL 50/8	1.53		

52000009 Gllareva	0.5	0.59				
52000011 Gremniku	1.6	0.87				
52056001 Voljaku	1.6	1.14	OHL 95/15	3.10		
52056004 Zajmi	1.1	1.43				
52056005 Jagoda	1.1	1.70	OHL 70/12	5.89		
Dedicated Feeder 1	3.8	0.00			OHL 70/12	3.98
54000001 Mojstiri	1.0	0.90				
54000006 Dubrava- Rakoshi	1.1	1.92	OHL 95/15	1.09		
54000006 Dubrava- Rakoshi	1.7	0.87				
54000007 Istogu 2	1.8	0.21	OHL 70/12	4.01		
54000008 Istogi 1	1.6	1.79				
54000009 Burgu	2.6	1.04				
Dedicated Feeder 1	1.9				OHL 70/12	7.35
50000004 Radavci	2.8	1.02	OHL 95/15	1.16		
50000009 Fusha e Pejes(1)	3.2	0.71				
50000010 Vitomirica	1.1	1.65				
50052003 Zallqi	0.8	1.35				
51000004 Dardania 2	1.3	0.98				
51000007 Kastrati	1.4	0.78				
51000008 Loxha	0.5	1.35				
51000010 Zahaqi	1.1	1.20				
31000009 Grnqari	1.0	1.49				
31000010 Korisha	1.5	0.66				
32000002 Mushtishti	1.2	1.34				
32000008 Budakova J16	1.4	1.20				
32000018 Studenqani J19	1.9	1.20				

32000019 Shiroke e Re J10	2.8	1.23				
32000023 Shpenadia J13	0.7	0.69				
32000003 Gjinovci	1.1	0.62				
31000030 Velezha J30	1.8	0.45				
51000005 Lumi i Bardhe	1.0	0.86				
50052001 Dobrusha	1.9	0.71				
71075005 Koshtova	0.9	0.68				
71075006 Ujsjellesi i ri	1.6	1.28				
61065002 - J02 - Sllatina	1.0	0.30				
60062002 - J02 - Perlepnica	1.9	0.33				
Mirusha	1.7	0.45				
41000004 Konjuhi(1)	0.9	0.24				
41046006 Maxiti Putz(2)	2.0	0.54				
15018008 Albana	1.2	0.30				
14000016 Eurobllok	1.6	1.20				

Table A- 9 Grid integration costs for all new PV and Biomass stations in the reference study case

Feeder	Installed Capacity (MW)	Cost for upgrade and expansion of existing network (€)	Cost for new feeders (€)	Direct connection cost (€)	Total connection cost (€)
14000003 Podujeva 3 J09	1.5	15,722	0	30,000	45,722
14000009 Fshatrat 1 J20	1.0	24,706	0	30,000	54,706
10013011 Lluzhan	1.4	17,968	0	30,000	47,968
14015001 LP Batllava	2.0	17,968	0	30,000	47,968
15018007 Vragolia J10	0.9	8,984	0	30,000	38,984
15018018 Bardh I Madh	1.2	8,984	0	30,000	38,984
15018019 J14-Miradi e Eperme	0.8	24,706	0	30,000	54,706
15019002 Shkabaj	0.7	15,722	0	30,000	45,722
15019005 Millosheve	0.9	15,722	0	30,000	45,722
15019006 Lumi i Madh(Bizniset)	0.9	22,460	0	30,000	52,460
16021002 Drenasi 2	1.7	15,722	0	30,000	45,722
16021004 Shtrubullova	0.5	17,968	0	30,000	47,968
16021006 Orllat	1.0	20,074	0	30,000	50,074
16021007 Poklek i Ri	0.7	22,460	0	30,000	52,460
16021008 Baice-Cikatove	0.5	24,706	0	30,000	54,706
16021009 Iber Lepenci-Q.SH.	1.1	35,936	0	30,000	65,936
16021028 Gllobari2	0.5	29,198	0	30,000	59,198
18024001 Palaj J03	0.5	15,722	0	30,000	45,722
18024002 Obiliqi(Qyteti dhe Hashaent)	1.5	87,061	0	30,000	117,061
18024003 Prelluzha	0.8	22,460	0	30,000	52,460
19000034 J34 Cagllavica-	1.2	28,075	0	30,000	58,075

19000041 J11 Matiqani	1.0	24,706	0	30,000	54,706
13000001 j5Bardhosh	1.0	15,722	0	30,000	45,722
13000018 J14Qendra e panaireve-	2.2	8,984	0	30,000	38,984
12000014 Arberia 5 J21	2.2	17,968	0	30,000	47,968
11000023 Nr. 30 Tregtia	2.2	7,861	0	30,000	37,861
10000001 Preoci J22	1.0	17,968	0	30,000	47,968
10000007 Kalabria 2 J16	2.0	20,214	0	30,000	50,214
10014002 Hajvalia	0.6	20,214	0	30,000	50,214
10014004 Graqanica 1 J02	1.8	20,214	0	30,000	50,214
41000001 Bablaku(3)	1.0	22,460	0	30,000	52,460
41000002 Kraishta(2)	1.0	28,524	0	30,000	58,524
41000003 Sllovia(2)	0.9	13,925	0	30,000	43,925
41000008 Shtëpia Korrektuese	2.5	15,722	0	30,000	45,722
41000009 Zona industriale(1)	1.0	18,193	0	30,000	48,193
41000011 QMI(2)	1.3	16,845	0	30,000	46,845
41000012 Banulla	0.9	15,947	0	30,000	45,947
41000013 Gadime	1.0	12,802	0	30,000	42,802
41000020 Suhadolli(2)	1.9	14,599	0	30,000	44,599
41046002 Petrova	1.0	14,599	0	30,000	44,599
41046003 Shtimes	1.0	15,947	0	30,000	45,947
41048003 Halilaqi(2)	1.4	16,171	0	30,000	46,171
80080009 Skivjani	1.2	30,770	0	30,000	60,770
80080011 Ereniku(1)	1.5	14,374	0	30,000	44,374
80080012 Cermjani	0.8	30,546	0	30,000	60,546
82081008 Podrumi-	0.5	15,722	0	30,000	45,722
82081006 Ratkoci-	1.0	26,952	0	30,000	56,952

Qendra	2.5	31,444	0	30,000	61,444
Ura Terezive	1.2	16,396	0	30,000	46,396
Dedicated Feeder 1	2.0	0	118,576	30,000	148,576
Pataqani	1.1	109,462	0	30,000	139,462
Shkoza	1.5	17,968	0	30,000	47,968
Opterusha	1.4	62,332	0	30,000	92,332
Stone Castle	3.0	20,214	0	30,000	50,214
Canziba	4.0	26,952	0	30,000	56,952
Qyetti 1	1.2	20,214	0	30,000	50,214
Caralluca	1.0	16,845	0	30,000	46,845
Banje	2.1	14,599	0	30,000	44,599
Dragoboli	2.5	33,690	0	30,000	63,690
Kijeva	1.4	33,690	0	30,000	63,690
Dedicated Feeder 1	2.5	0	269,676	30,000	299,676
Dedicated Feeder 2	2.5	0	130,306	30,000	160,306
60060016 - J16 - Uglari	1.5	17,070	0	30,000	47,070
60061006 - J06 - Kufca	1.5	17,968	0	30,000	47,968
63000008 - J08 - Pasjaku	1.6	15,497	0	30,000	45,497
63000011 - J11 - Ferma	1.0	22,460	0	30,000	52,460
61066004 - J04 - Parteshi-Budrika	0.5	12,578	0	30,000	42,578
61067001 - J01 - Stublla	2.0	24,706	0	30,000	54,706
61067006 - J06 - Smira	0.9	14,824	0	30,000	44,824
61067010 - J10 - Begunca	1.8	18,193	0	30,000	48,193
62000011 - J11 - Muqiverci	0.5	11,904	0	30,000	41,904
62000014 - J14 - Ropotova(1)	0.5	11,230	0	30,000	41,230
74000001 Likovci J19	0.7	16,620	0	30,000	46,620

74000002 Fab.e Municionit dhe Lodrave	2.6	22,460	0	30,000	52,460
74000003 Prekazi J17	1.4	17,743	0	30,000	47,743
74000004 Qirezi J16	0.5	14,599	0	30,000	44,599
74000005 Runiku 20kV	1.0	22,235	0	30,000	52,235
74000006 Turiqevci J03	1.0	14,824	0	30,000	44,824
74000006 Turiqevci J03	0.7	14,374	0	30,000	44,374
74000012 Ternavc J02	1.3	20,439	0	30,000	50,439
73000012 Iber Lepenci J02	2.9	15,722	0	30,000	45,722
73000003 Qytet e Fshatra J08	1.2	17,070	0	30,000	47,070
73000004 St.Hekurudhor J07	1.2	17,294	0	30,000	47,294
73000005 Novolani J06	1.0	20,888	0	30,000	50,888
73000009 Martiraj	1.4	18,866	0	30,000	48,866
73000011 Maxhunaj J18	0.5	19,540	0	30,000	49,540
73000015 KFORI J01	1.0	19,765	0	30,000	49,765
71074002 Kqiqi J07	3.0	17,519	0	30,000	47,519
71075004 Shupkovci (Bajri)	0.5	15,722	0	30,000	45,722
71075012 Iber Lepenci(1)	0.8	13,251	0	30,000	43,251
52000001 Ujmiri	1.0	22,460	0	30,000	52,460
52000002 Klinavci	2.9	43,222	0	30,000	73,222
52000007 Dresniku	3.1	25,266	0	30,000	55,266
52000009 Gllareva	0.5	8,759	0	30,000	38,759
52000011 Gremniku	1.6	13,027	0	30,000	43,027
52056001 Voljaku	1.6	65,487	0	30,000	95,487
52056004 Zajmi	1.1	21,337	0	30,000	51,337
52056005 Jagoda	1.1	90,482	0	30,000	120,482
Dedicated Feeder 1	3.8	0	112,776	30,000	142,776

54000001 Mojstiri	1.0	13,476	0	30,000	43,476
54000006 Dubrava- Rakoshi	1.1	37,253	0	30,000	67,253
54000006 Dubrava- Rakoshi	1.7	21,531	0	30,000	51,531
54000007 Istogu 2	1.8	47,475	0	30,000	77,475
54000008 Istogi 1	1.6	26,727	0	30,000	56,727
54000009 Burgu	2.6	15,497	0	30,000	45,497
Dedicated Feeder 1	1.9	0	166,077	30,000	196,077
50000004 Radavci	2.8	33,373	0	30,000	63,373
50000009 Fusha e Pejes(1)	3.2	10,556	0	30,000	40,556
50000010 Vitomirica	1.1	24,706	0	30,000	54,706
50052003 Zallqi	0.8	20,214	0	30,000	50,214
51000004 Dardania 2	1.3	14,599	0	30,000	44,599
51000007 Kastrati	1.4	11,679	0	30,000	41,679
51000008 Loxha	0.5	20,214	0	30,000	50,214
51000010 Zahaqi	1.1	17,968	0	30,000	47,968
31000009 Grnqari	1.0	22,235	0	30,000	52,235
31000010 Korisha	1.5	9,882	0	30,000	39,882
32000002 Mushtishti	1.2	19,989	0	30,000	49,989
32000008 Budakova J16	1.4	17,968	0	30,000	47,968
32000018 Studenqani J19	1.9	17,968	0	30,000	47,968
32000019 Shiroke e Re J10	2.8	18,417	0	30,000	48,417
32000023 Shpenadia J13	0.7	10,332	0	30,000	40,332
32000003 Gjinovci	1.1	9,209	0	30,000	39,209
31000030 Velezha J30	1.8	6,738	0	30,000	36,738
51000005 Lumi i Bardhe	1.0	12,802	0	30,000	42,802
50052001 Dobrusha	1.9	10,556	0	30,000	40,556

71075005 Koshtova	0.9	10,107	0	30,000	40,107
71075006 Ujsjellesi i ri	1.6	19,091	0	30,000	49,091
61065002 - J02 - Sllatina	1.0	4,492	0	30,000	34,492
60062002 - J02 - Perlepnica	1.9	4,941	0	30,000	34,941
Mirusha	1.7	6,738	0	30,000	36,738
41000004 Konjuhi(1)	0.9	3,594	0	30,000	33,594
41046006 Maxiti Putz(2)	2.0	8,086	0	30,000	38,086
15018008 Albana	1.2	4,492	0	30,000	34,492
14000016 Eurobllok	1.6	17,968	0	30,000	47,968
Total	**188.8**	**2,700,352**	**797,411**	**4,020,000**	**7,517,763**

Sensitivity Analysis (see section 4.3)

Table A- 10 Required network projects for the integration of all new PV stations in scenario SClow of the sensitivity analysis

Feeder	Installed Capacity (MW)	Connection Lateral (km)	Line reinforcement (Type)	Line reinforcement (km)	Dedicated Feeder (Type)	Dedicated Feeder (km)
71074002 Kqiqi J07	1.2	1.17				
71075012 Iber Lepenci(1)	1.0	0.89				
73000003 Qytet e Fshatra J08	1.3	1.14				
73000009 Martiraj	1.8	1.26				
74000001 Likovci J19	0.7	1.11				
74000005 Runiku 20kV	0.6	0.89				
74000006 Turiqevci J03	2.7	0.99				
74000012 Ternavc J02	1.0	1.37				
73000012 Iber Lepenci J02	1.0	1.05				

Table A- 11 Grid integration costs for all new PV stations in scenario SClow of the sensitivity analysis

Feeder	Installed Capacity (MW)	Cost for upgrade and expansion of existing network (€)	Cost for new feeders (€)	Direct connection cost (€)	Total connection cost (€)
71074002 Kqiqi J07	1.2	17,519	0	30,000	47,519
71075012 Iber Lepenci(1)	1.0	13,251	0	30,000	43,251
73000003 Qytet e Fshatra J08	1.3	17,070	0	30,000	47,070

73000009 Martiraj	1.8	18,866	0	30,000	48,866
74000001 Likovci J19	0.7	16,620	0	30,000	46,620
74000005 Runiku 20kV	0.6	13,251	0	30,000	43,251
74000006 Turiqevci J03	2.7	14,824	0	30,000	44,824
74000012 Ternavc J02	1.0	20,439	0	30,000	50,439
73000012 Iber Lepenci J02	1.0	15,722	0	30,000	45,722
Total	**11.3**	**147,562**	**0.0**	**270,000**	**417,562**

Table A- 12 Required network projects for the integration of all new PV stations in scenario SChigh of the sensitivity analysis

Feeder	Installed Capacity (MW)	Connection Lateral (km)	Line reinforcement (Type)	Line reinforcement (km)	Dedicated Feeder (Type)	Dedicated Feeder (km)
71074002 Kqiqi J07	1.8	1.17				
71075004 Shupkovci (Bajri)	0.6	1.05				
71075005 Koshtova	0.9	1.05				
71075008 Sollana	1.8	1.16				
71075012 Iber Lepenci(1)	1.4	0.89				
73000003 Qytet e Fshatra J08	1.3	1.14				
73000004 St.Hekurudhor J07	1.3	1.16				
73000005 Novolani J06	1.0	1.40				
73000009 Martiraj	1.8	1.26				
73000010 Mulliri Pestova J05	0.4	1.32				
73000011 Maxhunaj J18	0.8	1.31				
73000012 Iber Lepenci J02	1.0	0.75				

73000014 Nedakovci J17	0.9	0.93				
73000015 KFORI J01	1.0	1.32				
74000001 Likovci J19	1.1	1.11	OHL 70/12	4.10		
74000002 Fab.e Municionit dhe Lodrave	2.8	1.50				
74000003 Prekazi J17	1.4	1.19				
74000004 Qirezi J16	0.9	0.98	OHL 70/12	4.76		
74000005 Runiku 20kV	1.9	1.49				
74000006 Turiqevci J03	1.0	0.99				
74000006 Turiqevci J03	1.0	0.96	OHL 70/12	5.63		
74000012 Ternavc J02	1.3	1.37				
73000012 Iber Lepenci J02	2.5	1.05				
Dedicated 1	4.2				OHL 70/12	4.40

Table A- 13 Grid integration costs for all new PV stations in scenario SChigh of the sensitivity analysis

Feeder	Installed Capacity (MW)	Cost for upgrade and expansion of existing network (€)	Cost for new feeders (€)	Direct connection cost (€)	Total connection cost (€)
71074002 Kqiqi J07	1.8	17,519	0	30,000	47,519
71075004 Shupkovci (Bajri)	0.6	15,722	0	30,000	45,722
71075005 Koshtova	0.9	15,722	0	30,000	45,722
71075008 Sollana	1.8	17,294	0	30,000	47,294
71075012 Iber Lepenci(1)	1.4	13,251	0	30,000	43,251
73000003 Qytet e Fshatra J08	1.3	17,070	0	30,000	47,070
73000004 St.Hekurudhor J07	1.3	17,294	0	30,000	47,294

73000005 Novolani J06	1.0	20,888	0	30,000	50,888
73000009 Martiraj	1.8	18,866	0	30,000	48,866
73000010 Mulliri Pestova J05	0.4	19,765	0	30,000	49,765
73000011 Maxhunaj J18	0.8	19,540	0	30,000	49,540
73000012 Iber Lepenci J02	1.0	11,230	0	30,000	41,230
73000014 Nedakovci J17	0.9	13,925	0	30,000	43,925
73000015 KFORI J01	1.0	19,765	0	30,000	49,765
74000001 Likovci J19	1.1	61,946	0	30,000	91,946
74000002 Fab.e Municionit dhe Lodrave	2.8	22,460	0	30,000	52,460
74000003 Prekazi J17	1.4	17,743	0	30,000	47,743
74000004 Qirezi J16	0.9	67,220	0	30,000	97,220
74000005 Runiku 20kV	1.9	22,235	0	30,000	52,235
74000006 Turiqevci J03	1.0	14,824	0	30,000	44,824
74000006 Turiqevci J03	1.0	76,625	0	30,000	106,625
74000012 Ternavc J02	1.3	20,439	0	30,000	50,439
73000012 Iber Lepenci J02	2.5	15,722	0	30,000	45,722
Dedicated 1	4.2	0	119,409	30,000	149,409
Total	**33.8**	**557,065**	**119,409**	**720,000**	**1,396,474**

› **Network Planning Alternatives: Dedicated Feeders (see section 5.1)**

Table A- 14 Required network projects for the integration of all new PV and Biomass stations in the "dedicated feeder" planning paradigm

Feeder	Installed Capacity (MW)	Connection Lateral (km)	Line reinforcement (Type)	Line reinforcement (km)	Dedicated Feeder (Type)	Dedicated Feeder (km)
Dedicated Feeder 1	2.0				OHL 70/12	5.40
Dedicated Feeder 2	1.5				OHL 70/12	3.00
Dedicated Feeder 3	1.5				OHL 70/12	5.55
Dedicated Feeder 4	2.5				OHL 50/8	2.10
Dedicated Feeder 5	1.2				OHL 95/15	9.39
Dedicated Feeder 6	2.0				OHL 50/8	4.85
Dedicated Feeder 7	3.0				OHL 95/15	5.85
Dedicated Feeder 8	2.2				OHL 50/8	4.50
Dedicated Feeder 9	2.0				OHL 50/8	3.00
Dedicated Feeder 10	2.5				OHL 50/8	1.65
Dedicated Feeder 11	2.5				OHL 50/8	1.65
Dedicated Feeder 12	4.0				OHL 70/12	3.50
Dedicated Feeder 13	2.0				OHL 95/15	9.86
Dedicated Feeder 14	3.0				OHL 70/12	4.50
Dedicated Feeder 15	2.5				OHL 70/12	5.09
Dedicated Feeder 16	1.7				OHL 50/8	3.00

Table A- 15 Grid integration costs for all new PV and Biomass stations in the "dedicated feeder" planning paradigm

Feeder	Installed Capacity (MW)	Cost for upgrade and expansion of existing network (€)	Cost for new feeders (€)	Direct connection cost (€)	Total connection cost (€)
Dedicated Feeder 1	2.0	0	135,281	30,000	165,281
Dedicated Feeder 2	1.5	0	97,378	30,000	127,378
Dedicated Feeder 3	1.5	0	137,650	30,000	167,650
Dedicated Feeder 4	2.5	0	79,723	30,000	109,723
Dedicated Feeder 5	1.2	0	259,311	30,000	289,311
Dedicated Feeder 6	2.0	0	118,576	30,000	148,576
Dedicated Feeder 7	3.0	0	180,401	30,000	210,401
Dedicated Feeder 8	2.2	0	113,693	30,000	143,693
Dedicated Feeder 9	2.0	0	92,462	30,000	122,462
Dedicated Feeder 10	2.5	0	73,354	30,000	103,354
Dedicated Feeder 11	2.5	0	73,354	30,000	103,354
Dedicated Feeder 12	4.0	0	105,196	30,000	135,196
Dedicated Feeder 13	2.0	0	269,676	30,000	299,676
Dedicated Feeder 14	3.0	0	121,067	30,000	151,067
Dedicated Feeder 15	2.5	0	130,306	30,000	160,306
Dedicated Feeder 16	1.7	0	92,462	30,000	122,462
Total	**36.1**	**0.0**	**2,079,889**	**480,000**	**2,559,889**

Network Planning Alternatives: New HV/MV substations (see section 5.2)

Table A- 16 Required network projects for the integration of all new PV stations in scenario SC1 of the "new HV/MV substation" planning exercise

Feeder	Installed Capacity (MW)	Connection Lateral (km)	Line reinforcement (Type)	Line reinforcement (km)	Dedicated Feeder (Type)	Dedicated Feeder (km)
80080007 Dobroshi	0.6	1.3				
80080010 Beci(1)	2.1	1.2				
80080011 Ereniku(1)	1.7	0.6				
80080012 Cermjani	0.8	1.4				
Intermedi	2.8	0.9				
Ura Terezive	1.2	0.7				
Bistrazhini	0.5	1.1				
Dedicated Feeder 1	5.0				OHL 95/15	4.85
Pataqani	1.1	1.4	OHL 95/15	5.00		
Shkoza	1.5	0.8				
Opterusha	1.4	0.8	OHL 95/15	2.80		
Stone Castle	2.0	0.9				
Canziba	4.7	1.2				
Qyetti 1	1.2	0.9				
Dedicated Feeder 1	3.0				OHL 95/15	4.00
Caralluca	1.0	0.8				
Mirusha	0.8	0.4				
Banje	2.1	0.7				
Dalia	1.0	1.4	OHL 95/15	2.00		

Dragoboli	3.1	1.5				
Kijeva	1.4	1.5				
Dedicated Feeder 1	2.5	0.0			OHL 95/15	8.50
Dedicated Feeder 2	2.8				OHL 95/15	4.75
82081003 Xerxa	3.0	1.4				
82081009 Fortesa-	3.0	0.7				
82081008 Podrumi-	1.9	0.7				
82081006 Ratkoci-	1.5	1.2				
Dedicated Feeder 1	4.5				OHL 95/15	4.83
82081007 Denji-	0.6	1.0				
Dedicated Feeder 2	2.5				OHL 95/15	7.81
Dedicated Feeder 3	3.0				OHL 95/15	4.14

Table A- 17 Grid integration costs for all new PV stations in scenario SC1 of the "new HV/MV substation" planning exercise

Feeder	Installed Capacity (MW)	Cost for upgrade and expansion of existing network (€)	Cost for new feeders (€)	Direct connection cost (€)	Total connection cost (€)
80080007 Dobroshi	0.6	18,717	0	30,000	48,717
80080010 Beci(1)	2.1	17,219	0	30,000	47,219
80080011 Ereniku(1)	1.7	9,583	0	30,000	39,583
80080012 Cermjani	0.8	20,364	0	30,000	50,364
Intermedi	2.8	13,177	0	30,000	43,177
Ura Terezive	1.2	10,931	0	30,000	40,931
Bistrazhini	0.5	16,471	0	30,000	46,471
Dedicated Feeder 1	5.0	0	137,999	30,000	167,999
Pataqani	1.1	98,981	0	30,000	128,981
Shkoza	1.5	11,979	0	30,000	41,979
Opterusha	1.4	56,118	0	30,000	86,118
Stone Castle	2.0	13,476	0	30,000	43,476
Canziba	4.7	17,968	0	30,000	47,968
Qyetti 1	1.2	13,476	0	30,000	43,476
Dedicated Feeder 1	3.0	0	139,163	30,000	169,163
Caralluca	1.0	11,230	0	30,000	41,230
Mirusha	0.8	6,289	0	30,000	36,289
Banje	2.1	9,733	0	30,000	39,733
Dalia	1.0	51,421	0	30,000	81,421
Dragoboli	3.1	22,460	0	30,000	52,460

Kijeva	1.4	22,460	0	30,000	52,460
Dedicated Feeder 1	2.5	0	239,472	30,000	269,472
Dedicated Feeder 2	2.8	0	155,881	30,000	185,881
82081003 Xerxa	3.0	20,513	0	30,000	50,513
82081009 Fortesa-	3.0	10,781	0	30,000	40,781
82081008 Podrumi-	1.9	10,481	0	30,000	40,481
82081006 Ratkoci-	1.5	17,968	0	30,000	47,968
Dedicated Feeder 1	4.5	0	157,665	30,000	187,665
82081007 Denji-	0.6	14,973	0	30,000	44,973
Dedicated Feeder 2	2.5	0	224,147	30,000	254,147
Dedicated Feeder 3	3.0	0	142,228	30,000	172,228
Total	**64.3**	**516,767**	**1,196,556**	**930,000**	**2,643,322**
Cost new distribution network HV/MV substation					**2,700,000**

Table A- 18 Required network projects for the integration of all new PV stations in scenario SC2 of the "new HV/MV substation" planning exercise

Feeder	Installed Capacity (MW)	Connection Lateral (km)	Line reinforcement (Type)	Line reinforcement (km)	Dedicated Feeder (Type)	Dedicated Feeder (km)
80080009 Skivjani	1.2	1.4				
80080010 Beci(1)	2.1	1.2				
82081008 Podrumi-	1.9	0.7				
Intermedi	2.8	0.9				
Ura Terezive	1.2	0.7				

Bistrazhini	0.5	1.1				
Dedicated Feeder 1	5.0				OHL 95/15	4.85
Pataqani	1.1	1.4	OHL 95/15	5.00		
Shkoza	1.5	0.8				
Opterusha	1.4	0.8	OHL 95/15	2.80		
Stone Castle	3.0	0.9				
Canziba	3.5	1.2				
Qyetti 1	1.2	0.9				
Dedicated Feeder 1	3.0				OHL 95/15	4.00
Caralluca	1.0	0.8				
Mirusha	0.8	0.4				
Banje	2.1	0.7				
Dalia	1.0	1.4	OHL 95/15	2.00		
Dragoboli	3.1	1.5				
Kijeva	1.4	1.5				
Dedicated Feeder 1	2.5				OHL 95/15	8.50
Dedicated Feeder 2	2.8				OHL 95/15	4.75
Dedicated Feeder 1	5.0				OHL 95/15	2.45
Dedicated Feeder 2	5.0				OHL 95/15	3.45
Dedicated Feeder 3	2.5				OHL 95/15	7.32
Dedicated Feeder 4	4.0				OHL 95/15	4.68
Dedicated Feeder 5	3.5				OHL 95/15	5.51

Table A- 19 Grid integration costs for all new PV stations in scenario SC2 of the "new HV/MV substation" planning exercise

Feeder	Installed Capacity (MW)	Cost for upgrade and expansion of existing network (€)	Cost for new feeders (€)	Direct connection cost (€)	Total connection cost (€)
80080009 Skivjani	1.2	20,513	0	30,000	50,513
80080010 Beci(1)	2.1	17,219	0	30,000	47,219
82081008 Podrumi-	1.9	10,481	0	30,000	40,481
Intermedi	2.8	13,177	0	30,000	43,177
Ura Terezive	1.2	10,931	0	30,000	40,931
Bistrazhini	0.5	16,471	0	30,000	46,471
Dedicated Feeder 1	5.0	0	157,999	30,000	187,999
Pataqani	1.1	98,981	0	30,000	128,981
Shkoza	1.5	11,979	0	30,000	41,979
Opterusha	1.4	56,118	0	30,000	86,118
Stone Castle	3.0	13,476	0	30,000	43,476
Canziba	3.5	17,968	0	30,000	47,968
Qyetti 1	1.2	13,476	0	30,000	43,476
Dedicated Feeder 1	3.0	0	139,163	30,000	169,163
Caralluca	1.0	11,230	0	30,000	41,230
Mirusha	0.8	6,289	0	30,000	36,289
Banje	2.1	9,733	0	30,000	39,733
Dalia	1.0	51,421	0	30,000	81,421
Dragoboli	3.1	22,460	0	30,000	52,460
Kijeva	1.4	22,460	0	30,000	52,460

Dedicated Feeder 1	2.5	0	239,472	30,000	269,472
Dedicated Feeder 2	2.8	0	155,881	30,000	185,881
Dedicated Feeder 1	5.0	0	104,501	30,000	134,501
Dedicated Feeder 2	5.0	0	126,903	30,000	156,903
Dedicated Feeder 3	2.5	0	213,169	30,000	243,169
Dedicated Feeder 4	4.0	0	154,321	30,000	184,321
Dedicated Feeder 5	3.5	0	172,711	30,000	202,711
Total	**64.1**	**424,381**	**1,464,121**	**810,000**	**2,698,502**
Cost new RES-only substation					**2,200,000**

ANNEX 6 Investment Planning Costs

The quantification of investments was based on typical cost data provided by the Beneficiaries, as well as on standard international pricing methods. According to the data provided by KOSTT, the costs for the development of a new HV/MV substation in order to accommodate RES generation are estimated at 2.200.000€ with one transformer and 2.700.000€ with two transformers.

Moreover, the total costs for the construction of new overhead MV lines were provided by the Beneficiaries for every standardized line type, as summarized in Table A- 20 . The costs for line upgrades are estimated at 70% of the costs for the construction of a new line of the same type.

Furthermore, the cost for the direct connection of a new RES station to the MV network, including equipment and labor costs for a standard metal-enclosed MV service solution as implemented in Kosovo (metal kiosk with basement, switchgear (Incoming/Measurement/Outgoing), MV cables, MV cable splices, cable channels, manholes and pipes) metering outfit and load switch for overhead network service is estimated at 30,000 €/RES station.

The cost of a HV/MV substation equipment for a new MV departure is estimated at 50.000 €.

Table A- 20 Cost for standardized types of overhead lines

Line type	Cost for new line (€)
OHL 50/8 mm²	14.153,89
OHL 70/12 mm²	15.792,76
OHL 95/15 mm²	22.290,82

ANNEX 7 Grid integration cost in the Reference study case considering alternative direct connection costs

The following Figures repsesent the outcomes of the performed analysis, considering an alternavite approach to the one currently adopted in Kosovo for the direct connection of distributed RES to the MV network. In this case, instead of a metal enclosed switchgear solution, a simple overhead network connection solution is considered and the service cost is estimated at 15,000 €/connection for alle new RES stations.

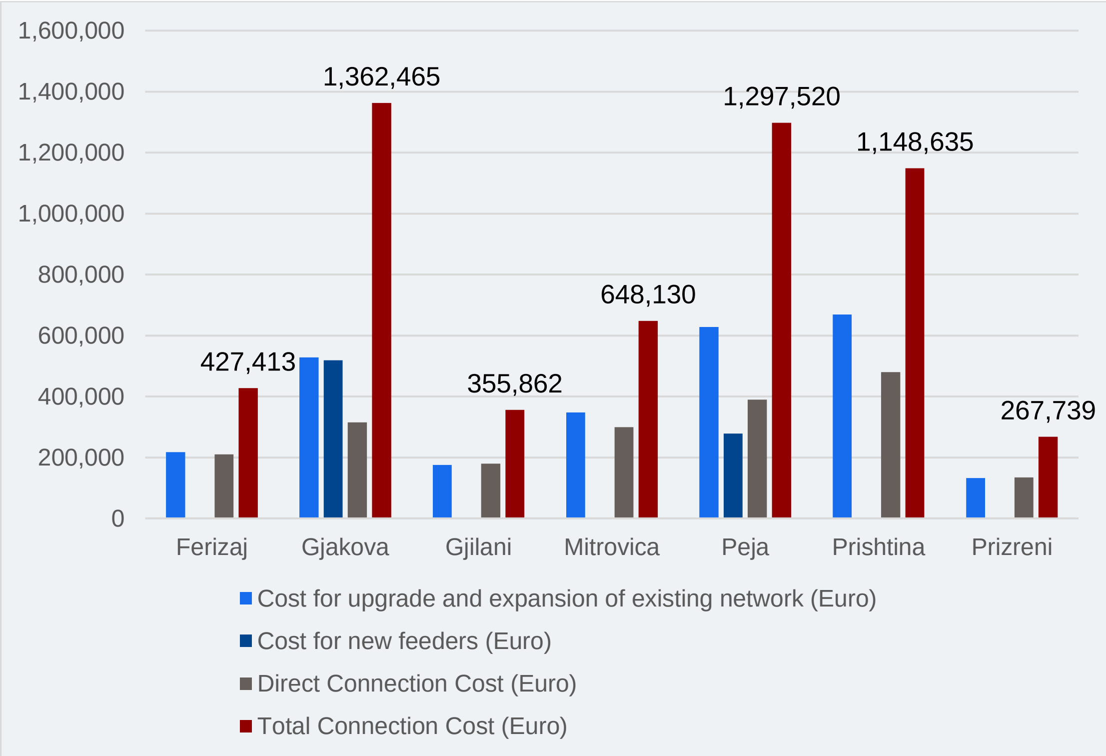

Figure 41 Grid connection cost per distribution area in absolute numbers (€) for the RES stations of the Reference study case, considering an overhead network connection solution.

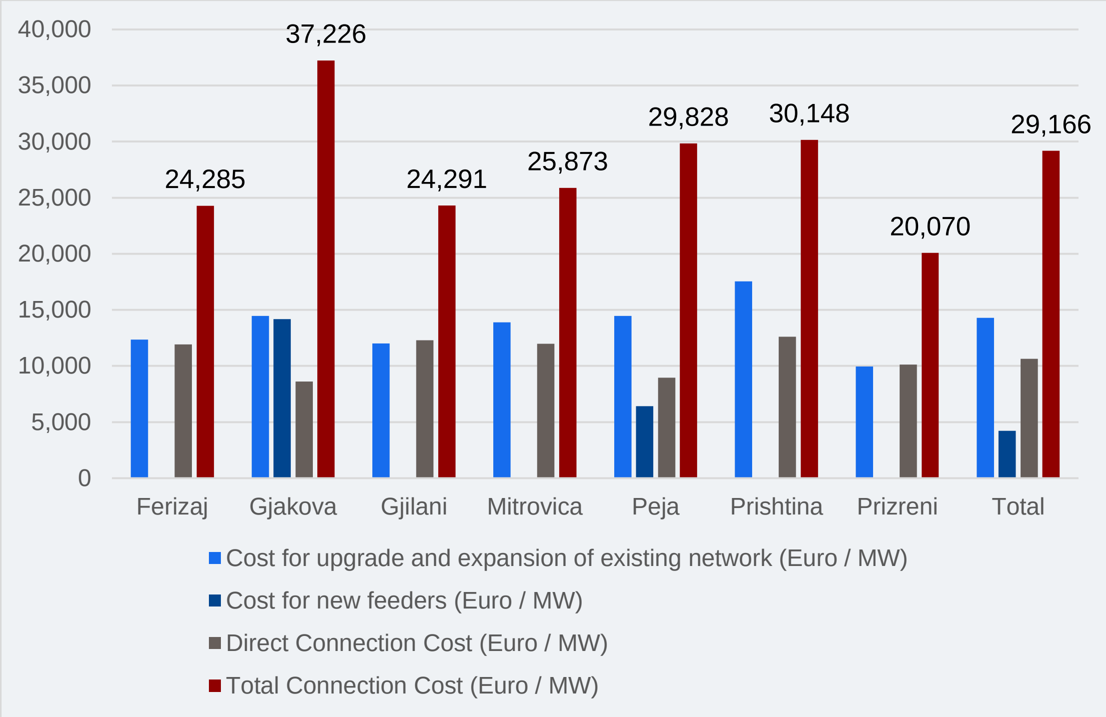

Figure 42 Average grid connection cost per distribution area in €/MW, for the RES stations of the Reference study case, considering an overhead network connection solution.