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International Conference on Energy Efficiency Engineering

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30-31 OCTOBER

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INTERNATIONAL CONFERENCE ON ENERGY EFFICIENCY ENGINEERING

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International Conference is the 10th international interdisciplinary peer reviewed conference which publishes works of the scientists as well as practitioners in the area where UBT is active in Education, Research and Development. The UBT aims to implement an integrated strategy to establish itself as an internationally competitive, research-intensive institution, committed to the transfer of knowledge and the provision of a world-class education to the most talented students from all backgrounds. It is delivering different courses in science, management and technology. This year we celebrate the 20th Years Anniversary. The main perspective of the conference is to connect scientists and practitioners from different disciplines in the same place and make them be aware of the recent advancements in different research fields, and provide them with a unique forum to share their experiences. It is also the place to support the new academic staff for doing research and publish their work in international standard level. This conference consists of sub conferences in different fields: - Management, Business and Economics - Humanities and Social Sciences (Law, Political Sciences, Media and Communications) - Computer Science and Information Systems - Mechatronics, Robotics, Energy and Systems Engineering - Architecture, Integrated Design, Spatial Planning, Civil Engineering and Infrastructure - Life Sciences and Technologies (Medicine, Nursing, Pharmaceutical Sciences, Phycology, Dentistry, and Food Science),- Art Disciplines (Integrated Design, Music, Fashion, and Art). This conference is the major scientific event of the UBT. It is organizing annually and always in cooperation with the partner universities from the region and Europe. In this case as partner universities are: University of Tirana – Faculty of Economics, University of Korca. As professional partners in this conference are: Kosova Association for Control, Automation and Systems Engineering (KA – CASE), Kosova Association for Modeling and Simulation (KA – SIM), Quality Kosova, Kosova Association for Management. This conference is sponsored by EUROSIM - The European Association of Simulation. We have to thank all Authors, partners, sponsors and also the conference organizing team making this event a real international scientific event. This year we have more application, participants and publication than last year.

Congratulation!

Edmond

Hajrizi, Rector of UBT and Chair of IC - BTI 2021

Energy Efficiency:

Case of Study for an Italian Railway Station

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Abstract. The study will analyze the thermal and electrical energy consumption of the largest Italian railway stations, comparing the clustered data from yr.2014 to yr. 2018, to evaluate the energy consumption trend in TOE, Tonnes of Oil Equivalent.

The aim will be the electrical and thermal consumption reduction, thanks to the use of the photovoltaic technology, integrated with batteries and BACS (building automation and control system).

A specific software (Termolog Design Photovoltaic and Acca Solarius PV) has been used to carry out the results; to identify improvement solutions, an algorithm made it possible to identify the best set point of integration between energy supply and production.

Keywords: Energy Efficiency, CO2 Reduction, Renewable Energy, Photovoltaic System, Eco-Sustainable Development, Green Energy, Circular Economy, Smart Mobility.

1 Introduction

According to the law 115/2008, the Energy Audit (EA), is defined as "a systematic procedure aimed at obtaining adequate knowledge of the energy consumption profile of a building or group of buildings, of an industrial activity, plant, commercial, public or private services, to identify and quantify energy saving opportunities".
More, the Law nb. 102/2014, which transposes in Italy the Directive 2012/27 / EU, indicates the energy audit as one of the fundamental tools to start a sustainable path that can lead to a reduction of energy consumption and emissions. At the same time, it underlines the obligation, for particular subjects, to perform an energy diagnosisperiodically (every four years).

In this study the energy consumption of the nb. 14 most important Italian railway stations are reported, indicating that in recent years there has been not a reduction in energy consumption, but an increase. This is due to the growth of the offered services of these large stations and the increasing use of electricity.
The study analyzes a station in particular (the one of Palermo, in Sicily, an Italian Island) and suggests to install a PV system connected to the network and equipped with storage batteries, in order to reduce the energy consumption.

2 Energy consumption of large railway stations

The energy consumption of the main analyzed Italian stations in recent years is shown in Table 1 and Table 2.
The clustered results are carried out from long studies over many years. The reported consumptions are in Tons of Oil Equivalent (TOE). In the case of analysis, the

conversions will be shown in more detail.

Table 1. Energy consumption of the railway station for the year 2014.

#	SITE	Consumption 2014 [TOE]	%
1	Milan CENTRAL	4.626	24,80%
2	Rome TERMINI	3.601	19,30%
3	Turin PORTA NUOVA	2.833	15,20%
4	Naples CENTRAL	2.245	12,00%
5	Rome TIBURTINA	1.441	7,70%
6	Florence SANTA MARIA NOVELLA	1.331	7,10%
7	Verona PORTA NUOVA	685	3,70%
8	Venice SANTA LUCIA	603	3,20%
9	Genoa PIAZZA PRINCIPE	545	2,90%
10	Bologna CENTRALE	356	1,90%
11	Genoa BRIGNOLE	220	1,20%
12	Bari CENTRAL	93	0,50%
13	Venice MESTRE	52	0,30%
14	Palermo CENTRAL	34	0,20%
SUM		**18.655**	

Table 2. Energy consumption of the railway station for the year 2018.

#	SITE	Consumption 2018 (TOE)	%
1	Milan CENTRAL	4.415	20,74%
2	Rome TERMINI	4.271	20,07%
3	Turin PORTA NUOVA	2.905	13,65%
4	Rome TIBURTINA	1.899	8,92%
5	Florence SANTA MARIA NOVELLA	1.709	8,03%
6	Naples CENTRAL	1.654	7,77%
7	Bologna CENTRAL	912	4,28%
8	Genoa PIAZZA PRINCIPE	763	3,58%
9	Verona PORTA NUOVA	731	3,43%
10	Venice SANTA LUCIA	711	3,34%
11	Genoa BRIGNOLE	379	1,78%
12	Venice MESTRE	358	1,68%
13	Palermo CENTRAL	245	1,15%
14	Bari CENTRAL	239	1,12%
SUM		**21.285**	

Figure 1 shows the variations in terms of consumption from 2018 to 2014, considering thatmost of the stations had an incremental trend in consumption, except for Milan Central and Naples Central.

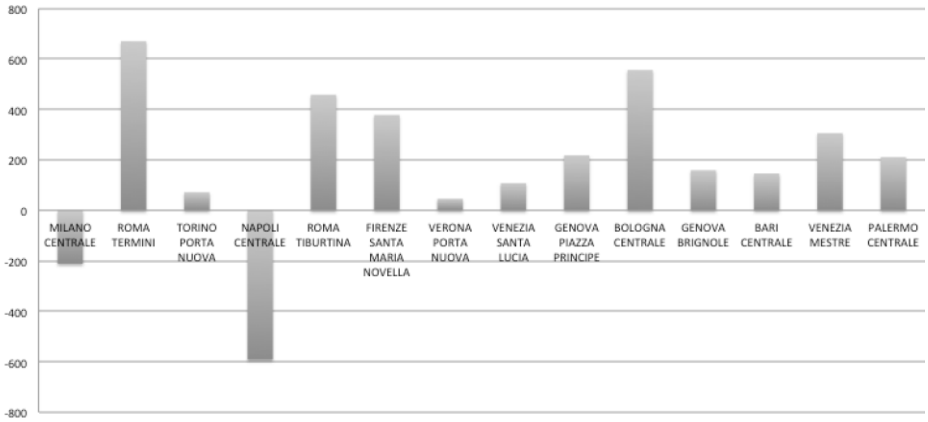

Fig. 1. Change in consumption between 2018 and 2014 in terms of TOE

3 Palermo Central: historical - architectural analysis and energy consumption

3.1 General information about the station

The focus of this work is the Palermo Central Railway Station (Figure 2) , that can benefit from favorable solar conditions and, at the same time, needs to strongly improve the technical conditions.
Built in 1885 and inaugurated on 7 June 1886, it is one of the oldest Italian stations. Its monumental front is testimony to the eclectic architectural style typical of Palermo at the end of the XX century.

Fig.2. Today's photo of Palermo Centrale.

3.2 Energy consumption of the station

The Energetic diagnosis was performed in accordance with Italian Law nb. 102/2014, the further modifications of the Italian Ministry of the Economic Development of May 2015 and the UNI CEI EN 16274 (module 3), based on the documentation provided during the work.
The thermal power plants present in the station are currently not in use. The heating and DHW services in use in 2019 were provided by systems powered by electricity; therefore, the consumption of the railway station was totally electric and no diesel consumption was recorded for 2019.
The distribution of the energy needs was carried out by main activities always linked to the auxiliary systems, but in terms of process services, i.e. those that determine the correct thermo-

hygrometric conditions of the station, auxiliary services and general services.
In this document, all the energy carriers considered are reported following the units of measurement shown in table 4. Each carrier is also correlated with the conversion factor in tonnes of oil equivalent (in accordance with the MISE circular of 18 December 2014).

1. Electricity kWhe 0,187 x 10-3 TOE;
2. Natural gas Sm^3 0.82 x 10-3 TOE

Adjustment factors are variables capable of influencing the energy consumption of a system, such as environmental conditions for buildings and production volumes for industrial sites. Their knowledge is necessary and useful, for example, to translate current consumption data intoenergy performance and to reliably estimate future ones.
The energy performance indices depend, in fact, on user efficiency as well as on the "surrounding conditions": to consider and analyze only the first aspect, it is important to outsource the latter by normalizing their consumption. The distribution of the energy needs was carried out by main activities always linked to the auxiliary systems, but in terms of process services, i.e. those that determine the correct thermo-hygrometric conditions of the station, auxiliary services and general services. Finally, the synthesis of the electrical and thermal model is reported (see following figures).
Attached to the diagnosis report, the models in detail:

- Average energy consumption of the station for the year 2019 (2018):
  - Electricity Requirement: 253.87 TOE;
  - Thermal Requirement (Diesel): 0.0 TOE.

The almost total consumption, attributable to the Station and is divided between:
- Lighting;
- Electric heating;
- Lifts;
- Air handling unit and refrigeration unit.

Table 3. Subdivision of station consumptions detected by the energy audit.

	kWh	**%**
Lighting	943.388,82	70,24%
Electric heating	358.809,60	26,72%
Lifts	17.797,40	0,25%
AHU and refrigeration unit	37.449,00	2,79%

4 Energy improvement intervention with a photovoltaic system equipped with storagebatteries

The space available for a photovoltaic system (Figure 3) is considerable along the buildings of the station, so it is desired to create a series of dislocated systems, so as to reduce the distance between use and production of electricity.
It was suggested to insert on each building photovoltaic systems from 3 to 8.5 kWp, connectedto storage batteries, in order to make these systems autonomous and, theoretically, disconnectable from the grid.
The photovoltaic plants are 15 in total. The total installed power is approximately 118.5 kW (peak).

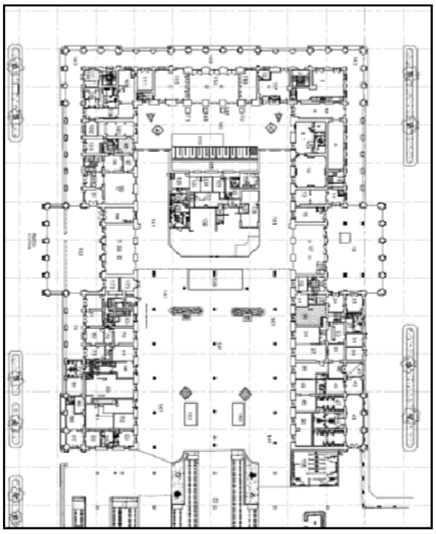

Fig. 3. Available areas for the PV systems.

A software from Acca Solarius PV and SolarGis was used for the simulation and design of the PV system.

Table 3. Productivity of all plants.

Period	Productivity (kWh)
January	7.151,63
February	9.394,94
March	14.581,90
April	18.695,51
May	23.405,34
June	25.077,15
July	25.913,05
August	23.405,34
September	17.616,92
October	12.538,57
November	8.359,05
December	6.408,60
Total Year	**192.548,00**

Evaluating the CO^2 emissions saved by the Italian electricity mix, the saving value is 102.05tons of carbon dioxide per year.
The annual energy saving of this intervention on the total consumption amounts to 14%, and against an investment of about 212,000 euros (including the batteries and the photovoltaic system); so, the investment presents a short payback period.

Conclusions

In this work has been evaluated the importance of photovoltaic systems, integrated in structures where the electrical demand is in line with the electricity produced by the generation system.The Italian territory is favorable to the electric microgeneration from solar systems thanks to the strong presence of the sun throughout all the territory during the calendar year.

If it is expected to reduce by 15%, the energy consumption of the 14 major stations, thanks to photovoltaic technology, it would have a saving of about 3,000 TOE per year and approximatelya reduction of 9,396.00 tons of carbon dioxide per year (data ENEA). It should be remembered that 1 million invested in renewable energy sources, creates 7.5 jobs (data lifegate.it) and the expected value is about 6,300,000.00 €, with over 48 new jobs created for the 14 railroad locations.

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The calculation of appropriate surfaces for installation of solar thermal collectors and solar panels, case study city of Pristine

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Abstract. In Kosovo participation of renewable resources is very symbolic, most of the generated electricity produced from fossil fuel, a part of the energy comes from the import. Pristina is ranked among the most polluted sites and this is mainly: by transport, old power plants, and fossil fuel use as a heating fuel for winter seasons.

Therefore, the aim of this paper is the use of solar energy knowing that the average sun duration for the city of Pristine is 5.44[h], while the average horizontal irradiation is 3.79[kWh/m²] per day. In this paper, the first step is analyzing and mapping of appropriate surfaces for installation of solar thermal collectors and solar panels.

To realize the demand for sanitary hot water for the city of Pristine, need total gross surface area: **186,084.5** [m^2], for the number of inhabitants 210,282, was taken the total of residential household in Pristine with around 38,289 units, and the average number of people per house 5 occupants.

While to realize the demand for electricity for 38,289 residential household with 5 members, a minimum of 199.1028 [MWp] is required, if we take the panel monocrystalline with 400[Wp], we need a total of 497,757 panels with an area of **981,120.9** [m^2].

It means that to realize the demand: for electricity and sanitary hot water, from solar energy, for the city of Pristina requires total gross surface area **1,167,205.4** [m^2].

Keywords: Renewable Energy, PV, Solar Thermal Energy, Domestic Hot Water, Saving Electricity, CO_2 Reduction.

1 Introduction

Kosovo is landlocked in the central Balkan Peninsula. With its strategic position in the Balkans, it serves as an important link in the connection between central and south Europe, the Adriatic Sea, and Black Sea. With an area of 10,908 [km^2]. it is one of the smallest countries in Europe.

Kosovo lies between latitudes 41°50’58’’and 43°51’42’’N, and longitudes 20°01’30 and 21°48’02 E [9].

Pristine is the capital city, and the biggest city in Kosovo. Located at coordinates 42°40'0" North and 21°10'0"East. The surface of the Municipality of Pristine is about 523 [km^2]. The climate is continental, with cold winters and hot summers, the precipitation average of about 600 mm per year. The average sun duration for the city of Pristine is 5.44[h], while the average horizontal irradiation is 3.79 [kWh/m^2] per day.

The electricity generation capacities in Kosovo are mainly from power plants which account for 90.02% of the installation capacity or 87.36% of the operating capacity, and the rest are hydropower plants and renewable energy sources (hydropower plants, wind farms and photovoltaic panels).

The participation of household customers in the total billed consumption still remains dominant with about 57.06%, in the district of Prishtina the realized consumption is 32% or 1,688,271MWh of the total consumption.

Therefore, the purpose of this paper is to calculate for the city of Prishtina the appropriate surfaces for installation of solar thermal collectors and solar panels, in order to reduce energy demand. It is imperative to try and globalize the use of renewable energy to the maximum we can, the use of solar energy for sanitary heating of water and energy is certainly extremely beneficial to our environment.

2 Mapping of Appropriate Surfaces for Installation of Solar

To estimate how much energy could be generated from the sun on a surface, we first calculate the area to see how many solar panels could be placed on it. There are various rooftop measuring tools online or software which we can use to calculate appropriate surface. In this work we have use AutoCad software which is so accurate to done the measuring, while the recordings were taken from the Geodesy Sector in Pristina.

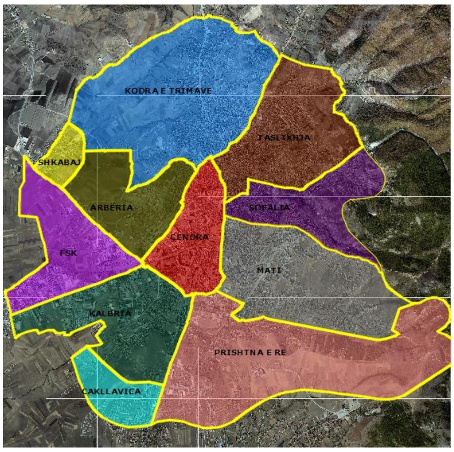

Fig.1. Map of Pristine dived in some area [1].

To analyze the appropriate roof space for solar collector installation, the division of the city into some areas is made, after that we have use AutoCAD software to done the measuring the roof space. The suitable surface is taken the part turned from the south by removing all the part that have possible obstacles on the roof.

In the figure below is presented the city center - dominate the high buildings, multiple residential building, this area includes: the Cathedral, National Library, a part of the University Campus, market, where in these areas is not recommended the application of solar collectors. The appropriate surface for installation of solar collectors is 297403.46m^2, Fig.2.

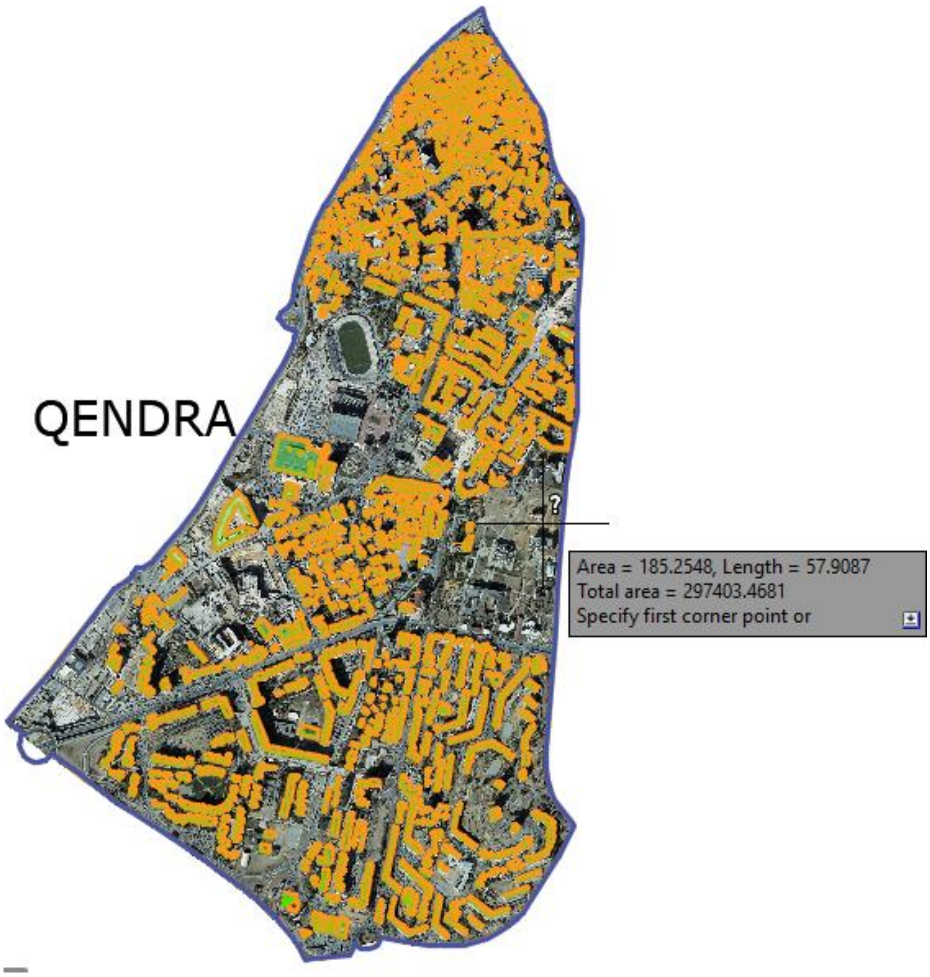

Fig. 2. The Mapping roof surfaces in city center of Pristine

In the same way is calculated the appropriate area for all parts of city, the results are presented in the table below.

Table 1. Appropriate surface

Locaion	$[m^2]$
New Pristine	86957.54
Taskixhe	340393.562
Shkabaj	17041.61
Mati	295747.7
Arbëria	126272.42
Sofali	129128.352
KSF Zonë	32249.95
Çagllavica	47511.0034
Kalabria	103484.204
Kodra e trimava	305276.95
The city center	297403.46
Total	**1781467**

From the table, we can be seen that the appropriate surface of calculated is 1,781,467 $[m^2]$. For additional accuracy when calculating your usable roof area with software the object should be looked at closely to analyze obstacles if they can be eliminated.

3 Annual Solar Thermal Heat Production and Value

To provide a more complete support for all those who want to design, finance, install and utilize solar energy for sanitary hot water or to produce electricity from solar energy, besides other things, are required to possess data with the following information:

- Solar radiation on the optimum horizontal and sloping (tilt) plains for the specific area / location where solar panels will be installed;
- Other climate conditions of the region / location, including average temperatures of air, water, etc.,

Table 1.1 shows values for **latitude**, **longitude**, average monthly and annual temperatures, Insolation, Horizontal Irradiation, and average total radiation on a tilted surface according to estimates by the European Commission, and Hydrometeorological Institute of Kosovo.

Table 2. Calculation for location of Pristina: Latitude - N 42 °39'46, Longitude - E 21°9' 55"

Monthly and yearly average total radiation on a tilted surface $\overline{H}_T$ [kWh/m²]													
Pristine	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
Daily	3.031	3.857	4.187	4.299	4.646	5.178	5.518	5.467	4.697	3.972	2.937	2.585	4.198
Monthly	93.96	107.99	129.80	128.97	144.01	155.34	171.06	169.48	140.92	123.13	88.12	80.14	1532.93
Horizontal Irradiation [kW·h/m²]													
Daily	1.64	2.44	3.41	4.31	5.24	6.18	6.44	5.70	4.15	2.80	1.75	1.38	3.79
Monthly	50.90	68.44	105.68	129.37	162.60	185.65	199.69	176.83	124.51	87.03	52.68	42.90	1386.32
Insolation [h]													
Daily	2.39	3.41	4.71	5.72	7.12	7.60	9.26	8.71	6.25	4.60	3.37	2.15	5.44

Monthly	74.10	95.70	146.14	171.76	220.3	228.05	287.03	269.95	187.6	142.48	100.89	66.62	165.48
Average 24-hours daily temperatures for every month [$^0 C$]													
Average	*-0.3*	*0.6*	*5.4*	*10.3*	*15.3*	*19.1*	*22.0*	*22.3*	*16.9*	*11.6*	*6.1*	*0.8*	*10.9*

The demand for domestic hot water is calculated for a family with five people. The average of sanitary hot water per person ranges from 30 to 50 liters, in the calculations 40 liters per person is taken, so the number of persons (5) should be multiplied with 40 liters.

$$G = 5 \cdot 40 = 200[l/day] \qquad (1)$$

Where:[3]

G=200*[l]* - the volume of the boiler,
T_{min}=12°C - the temperature in the boiler entry (of water supply),
T_{max}=60°C - the temperature at the exit of the boiler,
C_p=1.16[Wh/kgK] - specific capacity of water,
h=0.81 - utilization coefficient [8],
p=2.23[m²] - effective area of the collector [8],
q=4.1[kWh/m²day] - the capacity of sunlight.

$$Q = \frac{G \cdot C_p (T_{max} - T_{min})}{1000} = \frac{200 \cdot 1.16 \cdot (60 - 12)}{1000} = 11.14[kWh/day] \qquad (2)$$

Collector area:

$$S = \frac{Q}{q \cdot \eta} = 3.35[m^2] \qquad (3)$$

The number of collectors:

$$n = \frac{S}{p} = 2 \text{ collectors.} \qquad (4)$$

For this case, we have used TSOL 2018 software, to gained data for: solar fraction, solar contribution, CO2 avoided, collector temperature, financial analysis etc. For simulation the desired DHW temperature is taken 45°C. The schematic of the simulated system is shown in Fig. 3.1.

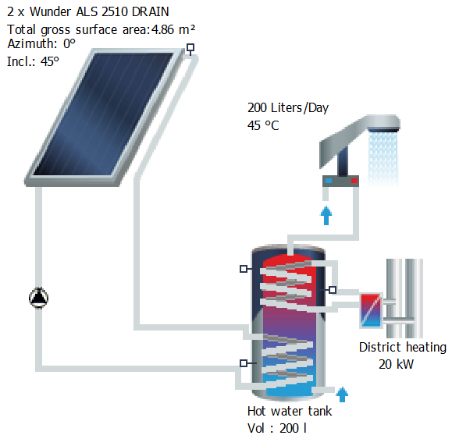

Fig. 3. Schematic of solar system for DHW

It should be noted that the solar panels tilt angle was 45º, the type of collector in our case we have taken **So-limpks Solar Energy Crop [7],** Type **Wunder ALS**

2510 DRAIN, azimuth angle 0 °. The result we can see in Figure below. The results are presented in Figure below.

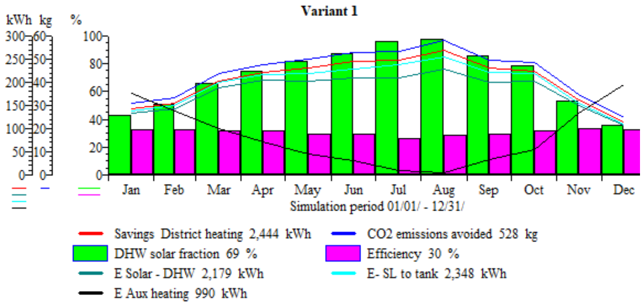

Fig. 4. Annual simulations

Based in this calculation we can conclude that: to realize the demand for sanitary hot water for a residential house with 5 persons need 2 collectors with total active solar surface area 4.86[m²]. The data from the Kosovo Agency of Statistics the number of residential households in Pristine is 38,289[5].

Then, the total suitable surface, to realize the demand with sanitary hot water for Pristina city, is 186,084.5 [m²] with 76,578 collectors.

4 Annual Solar PV Electricity, Production and Value

To estimate how much energy your solar PV project could generate, simply find its location on the map below. In this paper is calculated for house in city of Pristina with Location: Aktash 42°39'26.06''N, 21° 9'57.03''E the street "Behije Dashi" that presented in the figure below.

Fig. 5. a) Photovoltaic Power potential,
b) The roof surface which is appropriate for installing solar panels

Relying on the "Net metering" support scheme, this house at the moment that produces more energy than it consumes then injects the surplus into the electricity grid, and when there is cloudy weather or at night this injected energy is compensated.

Based on our data, for an average family with 5 persons, require minimum 5.2kWp, with number of PV Modules 13 and PV Generator surface 25.6 m^2 and one Inverter.

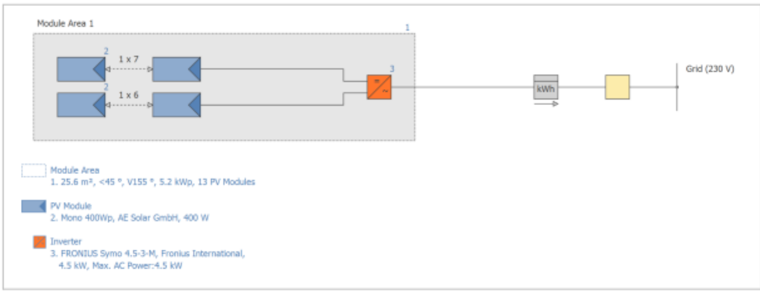

Fig 6. Schematic of PV solar system[10]

To supply with electricity all of residential households in Pristine, the number for residential house is 38, 289.

Table 3.

Parameters	A house	All of residential house
PV Generator Power AC grid [kWh]	5253	201 132 117
Annual Yield [kWh/kWp]	1010.12	38 676 484 .68
CO_2 Emissions avoided[kg/year]	3145	120 418 905
Number of PV Modules	13	497 757
PV Generator Surface [m^2]	25.6	981 120.9

The house presented above is connected to the 0.4kV line. In the tariff group 4/02.
In this tariff group we have, high tariff in which the price per kWh is 0.0675 €, while the low tariff per kWh is 0.0289 €. By multiplying the electricity that could be generated annually (5253 kWh) by the value of that electricity (0.0675 € per kWh), we estimate that we could reduce the electricity bill by roughly € 354.5775 per year.

5 Conclusion

The goal of the paper is to enable to provide information regarding the application of solar energy, case study for the city of Prishtina.

To locate suitable locations for the installation of solar collectors serving sanitary hot water, and PV panels for electricity, for 38289 residential house the first step is to divide the city in some areas, and after that, to calculate appropriate roof space the software AutoCAD is used.

- Appropriate surface for the city is 1781467 m^2.
  - The total suitable surface, to realize the demand with sanitary hot water for Pristina city, is 186084.5 [m²] with 76578 collectors.
  - The total suitable surface, to realize the demand electricity for Pristina city, is 981120.9[m²] with 497 757 panels.

As a general conclusion it can be suggested that: to provide sanitary hot water and electricity from solar energy for 38289 households in the city of Prishtina requires, space area of 1166282.9 [m2], based on our measurements Pristine have enough roof space for the installation solar systems.

CO_2 Emissions avoided is (69127.5 +120 418 905) [kg/year], that is another very important factor, when it is known that the city of Prishtina has high pollution.

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Technical Impacts of Distributed Generation in Distribution Network, Voltage Drops

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Abstract. This paper presents the technical impacts of distributed generation in the distribution network in order to reduce the voltage drops. Input data, including the lengths, power factory, active and reactive load in each busbar of 10 kV distribution line is used to create the network model using a digital simulation and electrical network calculation. With the connection of distributed generators in the network, the need for investments in the distribution network infrastructure is reduced. When they are optimally located, the power losses and voltage drops within the distribution network are reduced and the reliability of the power supply stability is achieved. The model is used to analyze voltage drops in the last busbar of 10 kV line in the distribution network. The results show that, with the sufficient capacity of the installed distributed generator, the voltage drops in the last point of 10 kV line are reduced. It is seen that the distributed generation has a significant impact on reducing the voltage drops and are also successful in eliminating the bottlenecks, specifically to reduce the power losses and stabilize the electricity supply.

Keywords: Distributed generation, Distribution network, Power losses, Voltage drops.

1. Introduction

Numerous studies related to distributed generators (DG) can be found in the literature, as well as numerous definitions describing this type of production. Thus, DGs can be defined as electricity production in power plants of small dimensions and power, which are usually connected to the distribution network and not connected to the transmission network, and whose production is not coordinated with other conventional power plants [1].

DG are small electricity producers located near the consumption and load [1]. Their production capacities can range from several kW to several MW and are directly connected to the distribution radial network. The presence of the DG changes the power flow and load characteristics of the distribution network. It gradually becomes an active load network and it implies changes in the power flow [2].

To synchronize DG and distribution network voltages, the three main parameters are:

- Voltage magnitude - voltage values can vary up to 0.5 % from the nominal voltage.
- Voltage frequency - frequency values can vary up to 0.1 [Hz].
- Phase angle between voltages - can be up to 10^0.

The connection of the DG has affected in the voltage profile, power flow, losses, stability, short circuit currents and radial distribution network. The influence will depend on the number, type, location, and size of generators.

DG is supposed to support and improve the voltage of the distribution system, but the question that arises is to what extent this statement is correct, as it has been demonstrated that the penetration of DGs into the distribution system can cause voltage fluctuations. Moreover, specific DG technologies change their output power with time, as in the case of photovoltaics and wind generators. As a result, voltage fluctuations occur that worsen the quality of energy delivered to consumers [3].

DG helps to deliver backup power during the times of increased electricity demand, having also as a result the reduction of the distribution power losses [3].

On the other hand, the implementation of DG has had positive impact on the distribution network because they contribute to the compensation of reactive power for voltage control, frequency regulation and can act as backup resources, in the event of system failure, and primary resources.

DG is one of the possible options for mitigating the problems of load increase, line overload, quality of supplied electricity, system reliability and reduction of line losses [4]. DG generates power at the local level to meet the requirements of local consumption.

DG can provide benefits for both the consumer and the distribution system, especially in locations where conventional generation is not feasible or where there is no adequate infrastructure [5].

The anaother positive impacts of DG on the distribution network are: Free produced energy, environmental friendliness avoiding emissions, the possibility to supply places where power systems have not been built, easiness in use and low operating costs [6].

In addition to the advantages, the integration of DG into the power system has certain disadvantages, and the basic one is to increase the voltage at the connection point. Also have other negative impacts, such as the unexpected power flows, which are reflected in the quality of the voltage and system parameters respectively and the frequency of the system [7].

Negative tchnical impacts of DG connection to the distribution network can be sublimated through the following aspects [8]:

- High specific investment costs;
- Voltage profile instability due to bidirectional power flow;
- System frequency deviations;
- Higher harmonics; some DGs must be connected to the network via a DC/AC interface, which can contribute to the appearance of higher harmonics;

It has been proven that DG can minimize energy losses (active and reactive) of distribution networks due to their installation near load centers. Consequently, the specific location of a DG in a distribution network and the specific capacity of the DG resulting in minimal energy loss are generally identified as the optimal location.

This paper treats the technical impact of DG after its installation in the observed part of the distribution system. It has been analyzed what are the impacts of the installed DG on voltage drops and energy losses in 10 kV lines, based on Exact loss formula, according to Olle Ingemar Elgard.

The paper is structured as follows: Technical Impacts of Distributed Generators presented in section 2, Impact of DG in voltage drop presented in section 3 and Conclusions of this paper are summarized in section 5.

2. Technical impacts of DG in distribution network

The technical impact of DG connection on the distribution network is reflected through [9-11]:

- Improving of voltage stability;
- Improving the quality of energy;
- Increase the reliability and security of the system;
- Impact on protection coordination;
- Reduction of power losses.
- Reduction of voltage drops.

2.1 Voltage deviations and influence on voltage regulation

The effect of voltage increase is a key factor limiting the number of added DGs in the distribution network. If the capacity of DG units increases, then voltage regulation analysis is required [12].

DG integration does not have to be a problem when the DG is connected to a system that has low voltage problems.

3.2 Improving the quality of energy

The integration of DG can contribute to improving the quality of energy, through raising the voltage value and correcting the power factor. Conversely, the integration of DG, ie the occurrence of two-way power flows and complex control of reactive power can be problematic and lead to voltage fluctuations, ie. degradation of energy quality.

Different DGs have different characteristics, and therefore different levels of impact on energy quality. Thus e.g. a large wind generator connected to an insufficiently strong electricity grid can lead to significant problems in terms of energy quality [13]. Also, the power electronics that monitor the connection of DG to the network tends to generate higher harmonics, which again makes it a problem for the quality of energy.

In general, from the aspect of energy quality, DGs affect the occurrence of:

- voltage oscillations (fluctuations);
- voltage flicker (flicker);
- harmonic voltage distortions.

3.3 Reliaiblity and possible security of the system

Reliability issues relate to permanent interruptions in electricity supply.

DG systems can potentially provide the following options to increase the reliability of the power system:

- Increasing the total production capacity of the system;
- Increasing system reserves and
- Reducing the load on distribution network.

The higher the available reserve, the higher the reliability of the system. In this regard, DGs can be used as backup generators, which can be put into operation in the event of a system failure.

3.4 Coordination of protection

DG integration requires protection coordination that can sustain two-way power flows. The contribution of the DG strongly depends on the type of DG and the way the DG unit is connected to the distribution network [13].

During the operation of the DG parallel to the distribution network, it is necessary to install its protection, to protect it from daily events that occur in the distribution network such as: Power outage in the distribution network, short circuit currents and protection from voltage changes as well as frequency changes.

3.5 Reduction of power losses

One of the main impacts of DG is the impact on power losses in distribution lines and therefore it should be positioned so as to contribute to the reduction of power losses.

The goal of DGs is to decentralize and partially abandon the construction of large power plants where energy is transmitted over long distances, which leads to losses in the system. Since these are small production units that are connected to a medium voltage network or a low voltage network, during planning it should be ensured that the produced energy is used at the same or lower voltage levels. Otherwise, there would be an increase in network losses.

Calculations, analyzes, estimates and measures to reduce power losses represent a significant technical and economic task [4].

The exact loss formula is a nonlinear load-based equation to determine the optimal location and size of the DG unit in a radial network to improve the voltage profile and reduce power losses.

Losses in a network are dependent on the operating conditions of the system and are given by the formula known as the exact loss formula.

$$P_L = \sum_{i=1}^{n}\sum_{j=1}^{n} a_{ij}\left(P_iP_j + Q_iQ_j\right) + b_{ij}(Q_iP_j - P_iQ_j) \qquad (1)$$

$$a_{ij} = \frac{r_{ij}}{V_iV_j}\cos(\delta_i - \delta_j) \qquad (2)$$

$$b_{ij} = \frac{r_{ij}}{V_iV_j}\sin(\delta_i - \delta_j) \qquad (3)$$

Where:
P - active power;
Q - reactive power,
V – voltage, and
r_{ij} - resistance between busbars i and j.

It has been proven that in the case of networks with increasing power losses, the installation of a DG unit will significantly affect the reduction of technical losses in the network.

3. Impact of DG in voltage drop

During the calculation of voltage drops in the distribution nework, it must be taken into account the ratio X/R, because in the distribution grid cannot be ignored the active resistance.

This way, we can model the distribution lines with the impedance $Z = R + jX$ and voltage drops are as in (4).

$$\Delta V = (R + jX)I = \frac{P_L R + Q_L X}{V_L} \tag{4}$$

Where:

$$I = \frac{P_L - jQ_L}{V_L} \tag{5}$$

Where:
ΔV - voltage drop;
$R + jX$ - line impedance;
P_L - active power;
Q_L - reactive power;
V_L– voltage amplitude, and
I - the rms value of the current flowing through the line.

Due to the small X/R ratios in the distribution networks and the radial structures of these networks, the influence of DG on the distribution network voltage is significant [14]. The above equations should be considered as one of the constraints of the optimization problem [15].

4. Simulation results

For the analysis is taken in consideration to work in parallel with network DG with S_{inst}= 918.95 kVA. It will be connected to the 10 kV line "Llukari" located in the Pristina distribution network. This10 kV line is supplied from Substation 110/10(20) kV, "Pristina 5" whose length is L=15.57 km. From this 10 kV line, 15 SS 10/0.4 kV are supplied with an installed capacity S_{inst}=5.14 MVA.

Load distribution diagram in case of DG connection in 10 kV line is presented in Fig.1.

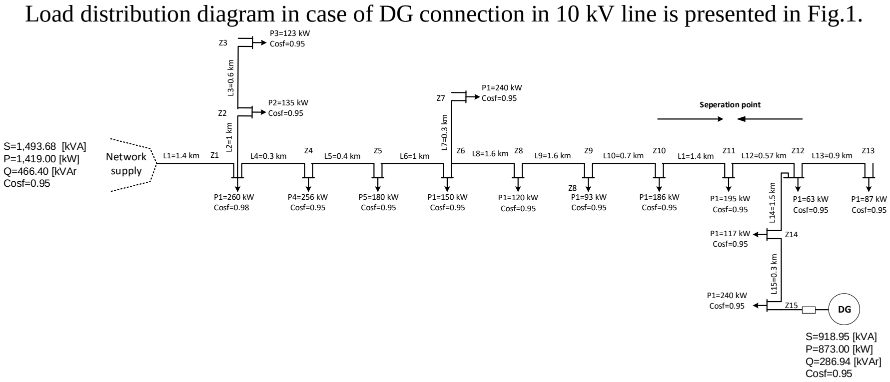

Fig.1 Single line diagram of line "Lukari", supplying from two sources (system and DG)

In the Table 1 presented calculation of voltage drops in 10 kV line without DG.

Table 1. Calculation of voltage drops in 10 kV line in case without DG

Busbar nr.	P [kW]	Q [kVAr]	ΔU%=100/Un²*{ri*Pi*li+xi*Qi*li) [V]	ΔU%=100/Un²*(ri*Pi*li+xi*Qi*li) [%]	U_2 [V]	U_{2f} [V]
SS					10.50	6.06
Z1	513.00	168.61	262.62	2.50%	10.24	5.91
Z4	108.00	35.50	42.51	2.91%	10.19	5.89
Z5	180.00	59.16	53.24	3.41%	10.14	5.86
Z6	390.00	128.19	118.77	4.54%	10.02	5.79
Z8	120.00	39.44	140.32	5.88%	9.88	5.71
Z9	93.00	30.57	125.03	7.07%	9.76	5.63
Z10	186.00	61.14	49.51	7.54%	9.71	5.60

Z11	195.00	64.09	78.29	8.29%	9.63	5.56
Z12	150.00	49.30	23.02	8.51%	9.61	5.55
Z14	117.00	38.46	42.66	8.91%	9.56	5.52
Z15	240.00	78.88	5.74	8.97%	9.56	5.52
Total	**2,292**	**753.34**	**941.70**	**8.97%**	**9.56**	**5.52**

Voltage drop at the end of the 10 kV line, are presented in Fig.2.

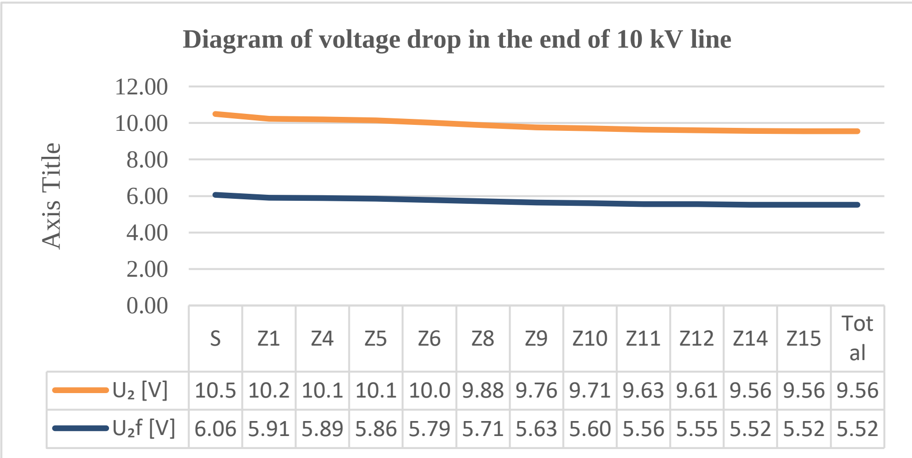

Fig.2 Voltage drops diagram at the end of the 10 kV line.

In the Table 2 presented calculation of voltage drops in 10 kV line with DG.

Bus-bar nr.	P [kW]	Q [kVAr]	ΔU%=100/Un^2*{ri*Pi*li+xi*Qi*li) [V]	ΔU%=100/Un^2*{ri*Pi*li+xi*Qi*li) [%]	U_2 [V]	U_{2f} [V]
S					10.50	6.06
Z1	513.00	168.61	123.67	1.18%	10.38	5.99
Z4	108.00	35.50	16.54	1.34%	10.36	5.98
Z5	180.00	59.16	19.45	1.52%	10.34	5.97
Z6	390.00	128.19	37.73	1.88%	10.30	5.95
Z8	120.00	39.44	22.64	2.10%	10.28	5.94
Z9	93.00	30.57	11.03	2.20%	10.27	5.93
Z10	21.00	6.90	0.89	1.03%	10.39	6.00
Z10	165.00	54.23	10.56	0.63%	10.43	6.02
Z11	195.00	64.09	7.99	0.53%	10.44	6.03

Z12	150.00	49.30	27.01	0.46%	10.45	6.03
Z14	117.00	38.46	6.92	0.20%	10.48	6.05
Z15	240.00	78.88	14.04	0.13%	10.49	6.05
Total	**2,292**	**753.35**	**174.80**	**0.13%**	**10.49**	**6.05**

Table 2. Calculation of voltage drops in 10 kV line, suplied from substation and DG.

Voltage drop at the end of the 10 kV line, supplied from substation and DG, are presented in Fig.2.

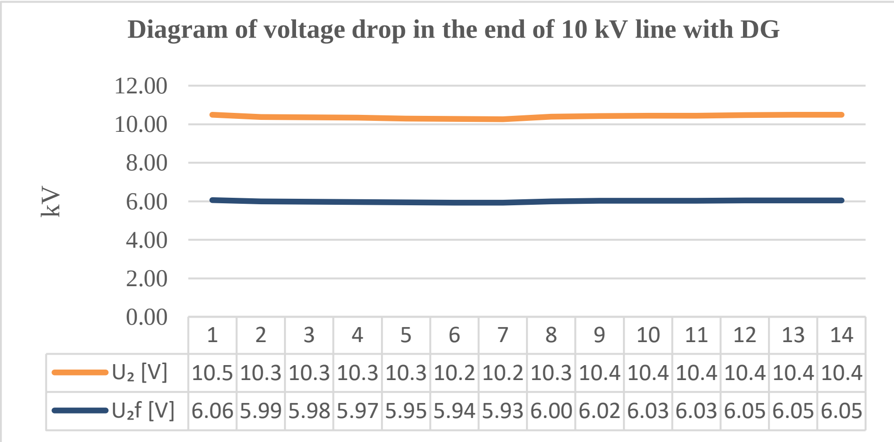

Fig.3 Voltage drops diagram at the end of the 10 kV line, suplied from two sources, system and DG.

The results for voltage drop in the end of 10 kV line “Llukari” for both cases can be shown at the Fig.2 and Fig.3, respectively. The voltage drop in the case without DG in the end of the 10 kV line “Llukari”is: ΔU=8.97%. Voltage drop in the case with DG in the end of this 10 kV line is: ΔU=0.13 %.

5. Conclusions

From the simulated results obtained, some conclusions can be drawn in terms of operation and integration of DG and their impact in the distribution system. From this, it can be concluded that DG also have their role in improving the performance of the parameters of the integrated power system or even of isolated substations. Thus, they affect the security of supply of consumers as well as the quality of tensions and reduction of losses. From this paper, it is also possible to conclude that voltage drops are under the allowed maximum voltage drop range as is the IEC 61000 standard applied for distribution networks which is ±10% to ±15%. This is also shown in the results obtained, that the capacity of DG, its location and size of load play an important role for voltage drop as it is shown at Fig.3.

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Testing of the Oil Type Distribution Transformers

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Abstract. This paper proposes to present the testing of oil type distribution transformers in order to supply with adequate voltage for all consumers, regardless of the voltage level where they are connected. One of the main challenges of the distribution system operator remains the proper selection of the transformer, application of the modern methods of commissioning and testing them, as a necessity to provide a reliable electrical supply. With the technological advancement, has been achieved to proportionally increase the quality of transformers, contributing to the increase of the efficiency of the power system as a whole. Input data, including construction and operation principles of the transformers are used to create the testing model by discussing and analyzing the cause and consequences of the failures. Finally, based of these findings, the types of testing of transformers and their elements, create a realistic reflection of what needs to be considered when it comes to the testing of these devices. This paper will discuss the techniques and types of testing applied around the world, with special emphasis in Kosovo on testing of oil type transformers. The working methodology for the preparation of this paper is based on the practical knowledge and scientific research about worldwide experiences for the testing of oil power transformers.

Keywords: Oil type transformers, Testing of transformers, Commissioning of transformers, Type of testing.

1 Introduction

Operation tests are intended to check the design features of the equipment against the specified standards. This may include failure tests to assess the extreme capabilities of the equipment.

Commissioning is the last phase of the final project cycle, in which the objective is to verify the performance of the new equipment/systems/processes according to the purpose of the design and demand as well as the level of service of those equipment [1].

The aim of the preventive maintenance is to keep the components from aging and wearing out, or to restore and replace aged or worn components before they fail. Preventive maintenance is scheduled periodically or is performed on some other time table based on the past experience of the component failure modes [2].

The aim of the predictive maintenance, on the other hand, is to detect the aging or wear out in the components so that the preventative maintenance can be performed before the ultimate failure occurs. Predictive maintenance is commonly referred to as testing [2].

These same criteria apply to the testing. There are a number of site tests that are considered as good predictive maintenance practices and which are also useful for diagnosing the transformers' trouble, which should be performed periodically [2].

Transformers are exclusively used in the power systems to transfer the power by electromagnetic induction between the circuits at the same frequency, usually with changed values of the voltage and current [3, 4].

Transformers increase the voltage starting from 110 kV to approximately 1000 kV for long transmission lines with very small losses. Then, they reduce the voltage in the range of 0.4 kV to 34.5 kV for the distribution, and finally electricity can be safely used by the consumers.

If we know the fundamentals of the transformer's theory, design and operation, these principles can be applied for the maintenance, testing and troubleshooting.

A transformer may have a very long life or it may go out of function after its first energizing. The average longevity of a transformer usually depends to some extent on how well it is maintained [3].

Every transformer that is manufactured undergoes some form of factory testing. For power transformers, these tests are quite extensive and 5% of the test failures do occur. Test requirements are spelled out in a number of industry standards and specifications [5, 6].

This paper treats the techniques and types of testing applied around the world, with special emphasis in Kosovo on testing oil type transformers. It has been analyzed classification of faults in the transformers and the testing of oil type distribution transformers.

The paper is structured as follows: Construction and principle of transformers presented in section 2; Classification of faults in the transformers presented in section 3; Testing of oil type transformers presented in section 4 and Conclusions of this paper are summarized in section 5.

2 Construction and operation principles of the transformer

Power transformers are available as single-phase or three-phases [7].

According to the external form of transformers, they are distinguished as:

- Dry transformers, in which the windings are insulated with solid and gaseous materials. Dielectric gas also serves as a coolant, and
- Oil transformers, in which the windings between themselves and other conductive parts are insulated with solid and oily materials. The oil simultaneously serves as a coolant for the coils and for the magnetic circuit.

Like any other device, the transformer consists of its internal and external parts. The main internal parts of the transformer are the windings and the magnetic core. The internal composition of the transformer can also be considered as oil, if the transformer is of oil type.

2.1 Transformer windings

Windings are the most important and at the same time the most delicate parts of the transformer. The winding connected to the power grid is called primary, while the winding connected to the load is called secondary winding. The windings are electrically insulated from each other. The transformer has two or more windings that are electromagnetically connected to each other by means of a common magnetic flux. Transformer windings are usually made with copper conductors and less often with aluminum conductors.

If the number of windings in the secondary N_2 is greater than the number of windings in the primary N_1, $N_2>N_1$ then $u_2>u_1$, $i_2<i_1$ and the transformers are called step-up transformers. If the number of windings in the secondary N_2 is less than the number of windings in the primary N_1, $N_2<N_1$ then $u_2<u_1$, $i_2>i_1$ and the transformers are called step-down transformers (Fig.1).

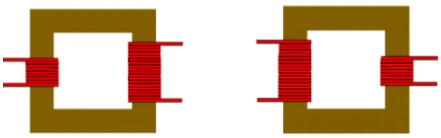

Fig. 1. Winding of step-up and step-down transformers

2.2 Transformer’s core

To strengthen the magnetic connection between the windings in most transformers, the windings are placed in the steel core, which represent a closed magnetic circuit.

2.3 Transformer’s oil

In oil type transformers, the magnetic cores together with the windings are inserted into the oil-filled boiler. The primary functions of transformer oil are its insulation and cooling. In order for these functions to be properly performed, the oil must have high dielectric strength, thermal conductivity and chemical stability.

2.4 Operation principle of the transformer

The function of the transformer is based on the principle that electricity is efficiently transferred through electromagnetic induction from one circuit to another. From fig. 2, we show that by connecting the primary winding at the voltage u_1 flows the current i_1. As a result of this current, the magnetic flux ϕ_1 is created which due to the very small value of magnetic resistence of the cores is closed mainly inside it. This flow represents the main flow ϕ and the rest of the flow closes through the airspace and is called leakage flow ϕ_{11}. Therefore we have: $\phi_1 = \phi + \phi_{11}$, the same analogy applies to the secondary winding.

This flux as well as the current that creates it, being alternative, induces in the primary and in the secondary winding the corresponding f.e.m:

$$e_1 = -N_1 \frac{d\phi_1}{dt} \quad (1)$$

$$e_2 = -N_2 \frac{d\phi_2}{dt} \quad (2)$$

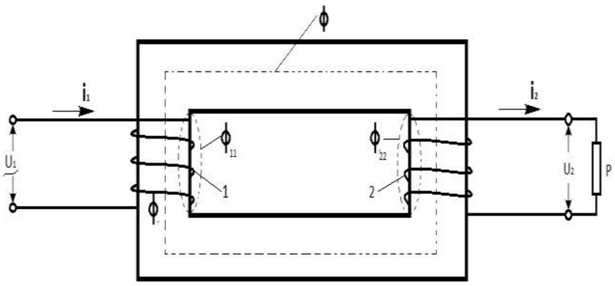

Fig. 2. The principle of operation the transformer

By closing the secondary circuit under the action of e.m.f e_2 in the secondary circuit will flow the current i_2, which shows that the electricity $(e_2 i_2 dt)$ is transmitted through the magnetic field from the primary to the secondary winding. The equations of e.f.m. for primary and secondary confusion are marked:

$$u_1 + e_1 = i_1 r_1 \quad (3)$$

$$e_2 = i_2 R_{load} + i_2 r_2 = u_2 + i_2 r_2 \quad (4)$$

Since the active winding resistances are very small, the above equations will be:

$$u_1 = -e_1 \quad (5)$$

$$u_2 = e_2 \quad (6)$$

$$\frac{u_1}{u_2} = \frac{|e_1|}{|e_2|} = \frac{N_1}{N_2} \quad (7)$$

Since in the power transformers, the current values of voltage and corresponding e.m.f for each current time are practically the same, then the ratio of current values is equal to the ratio of effective values:

$$\frac{U_1}{U_2} = \frac{E_1}{E_2} = \frac{N_1}{N_2} = k \quad (8)$$

$$\frac{i_1}{i_2} = \frac{I_1}{I_2} = \frac{N_2}{N_1} = \frac{1}{k} \quad (9)$$

Where k represents the ratio between the number of N_1 and N_2.

3 Classification of faults in the power transformers

Faults in the dsitribution transformers can occur:

- Due to the user: Overloaded transformer, one-phase overloaded, unbalanced loads, faults ocured by short circuits in the network, non-periodic maintenance and wrong transformer installation.
- Due to the manufacturer: Wrong design, poor quality of the material used, work performed not according to the technical specifications, improper transport, improper conductor insulation;

Belove are the most common faults during the operation mode.

3.1 Oil leakages

The oil, in addition to serving as an insulating tool, it serves also to transfer the heat generated in the windings and core towards the tank walls and radiators. For this reason it has:

- High dielectric strength
- Low viscosity

If the oil leaks from the transformer tank for any reason, the oil level in the tank will drop. In the worst case, the insulator connections and winding parts will be exposed to the air. This will increase the temperature of the windings. This, in turn, would damage the insulation of the windings. In addition, moisture can penetrate through the leak, and degrade the transformer oil leading to the transformer's overheating.

Oil leakages can occur from many parts of the transformer's tank: radiator arms (Fig.3.a), gaskets (Fig.3.b), bad welds, valves that control the oil flow between the radiator and the main oil tank.

3.2 Improperly fixed bolt connections

In the Fig.3 (c) , there is an example where the maintenance workers made improper connections to the terminals in the distribution transformer. This resulted into overheating of the transformer near the bolts (connections), causing failure.

3.3 Damage of the insulating oil

Insulating oil is gradually damaged by its use. The main cause is the absorption of the moisture inside the oil type transformer. Whenever the humidity doubles in a transformer, the life span of the insulation is halved. Faults due to moisture absorption are the most common causes of the transformer failures. The moisture content in the oil increases, and when the transformer is activated, water begins to migrate to the colder part of the transformer. There is almost twice as much moisture at the bottom than at the top (Fig.3 (d)).

3.4 Failures due to the winding strain and shrinkage of the windings

Transformer failure can occur due to the strain of the several windings of the same phase, which

occurs due to the overheating (Fig.3.e).
Shrinkage can cause looseness in the coil mounting, which can result into failure due to the short-circuit forces (Fig.3.f). To overcome such failures, it is recommended to be used good quality insulating bolts.

3.5 Failures from the magnetic circuit damage

When the insulation between the iron rods is damaged, it results into local overheating. Thus, the temperature of the coil rises and its insulation may fail (Fig.3.g).

Fig. 3. Failures in the power transformer: (a) Oil leak from the radiator and (b) gaskets; (c) Released connections; (d) Moisture damage to transformer oil; (e) Strengthening the coils; (f) failure due to shrinkage and (g) Failures from magnetic circuit insulation

4 Testing of oil power transformers

To carry out a successful operation of the electrical equipment and apparatus, it is essential to set up an effective maintenance and testing program [8].

The schedule for all required tests and inspections is listed on the Power Transformer Acceptance and Maintenance Checklist.

According to [9] the transformer, tests are divided into: type, routine and special tests.

- Type test includes: Dielectric measurement, temperature rise test, noise level measurement and tap changer tests.
- Routine test includes: Winding resistance measurement, voltage ratio check, phase relationship check, impedance voltage, load loses, no-load loses, high voltage test and on-load tap changer functional test.
- Special test are made at the request of the client or the engineer. It should be appreciated that such test may put a considerable strain on the transformer. The special test actually simulate the conditions that could really occur in the practice.

The requirements for a good test are as follows:

a) The test should have a sensitivity; in other words, it should give an early warning of the impending trouble.

b) The test should have selectivity; in other words, it should not give off false positive indications of the trouble and should give a clear indication of what is wrong.

c) The test should be practical; in other words, it should not require an unusually high skill level to perform the test or interpret the results.

d) The test should be nondestructive.

Below we will address some types of testing.

4.1 Inspection

A transformer maintenance program should be based on the detailed routine inspections. Determining the existing condition of the distribution transformers is an essential step in analyzing the risk of the failure. New transformers should be inspected for the damage during the transport when accepted. All connections that may have been dismantled during transport must be strengthened before being activated.

4.2 Insulation resistance test - *IR*

Insulation resistance tests are performed to determine the insulation resistance from the individual windings with earthing or between individual windings. Insulation resistance tests are usually measured directly with mega Ohm (Fig.4.a) or can be calculated from the measurements of applied voltage and leakage current.

4.3 Winding resistance test

Winding resistance measurements are an important diagnostic tool for assessing the potential transformer damage resulting from the poor design, mounting, handling, adverse environments, overloading, or poor maintenance.

The main reason of this test is to check for the large differences between the windings and open points which may be in the windings. Measuring the resistance of the transformer windings ensures that each circuit is properly connected and tightly tightened.

The winding resistance in the transformers will change due to the loose connections or deteriorated contacts in the tap changer. Regardless of the configuration, resistance measurements are normally done step-by-step and readings are compared with each other to determine if they are acceptable.

Transformer winding resistance measurements are taken by passing a known DC current, through the winding in which the tests are being carried out and by measuring the voltage drop across each terminal.

4.4 Polarization index test - *PI*

Insulation of the system prevents winding defects. The excessive temperature rise dehydrates the air and oxidizes and makes the insulation brittle.

Insulation Resistance (*IR*) and Polarization Index (*PI*) are two universally accepted diagnostic tests for the insulation tests.

PI is a variation of the *IR* test and it is the ratio of *IR* measured after voltage has been applied for 10 minutes (R_{10}) to *IR* measured after one minute (R_1).

$$PI = \frac{R_{10}}{R_1} \qquad (10)$$

A low *PI* value indicates that the windings may have been contaminated with dirt or have absorbed moisture.

$$R_1 = \frac{V}{I_t} \quad (11)$$

Where: V is the DC voltage applied and I_t is the current flowing in the circuit.

4.5 Power factor test

Power factor tests are used to measure dielectric losses, which are related to the moisture, dryness or deterioration of the transformer insulation. The power factor testing of a two-winding transformer is performed by activating a nominal voltage (usually 10 kV for winding) in the short connected windings.

The general results of the power factor test on the power transformers reflect the state of the insulation of the winding, tap changer, bushings and oil. Modern oil type power transformers must have $cos\varphi$ of 0.5% or less, at a temperature of 20^0 C.

4.6 Dielectric test

The dielectric strength of the transformer oil is also known as the breakdown voltage (BDV) of the transformer oil. The permability voltage is measured by observing the voltage, between the two electrodes immersed in the oil, separated by a specific gap. A low value of BDV indicates the presence of the moisture content and accompanying substances in the oil. This measurement is taken 3 to 6 times in the same oil sample, and we obtain the average value. BDV is an important transformer oil test, as it is the main indicator of oil health and can be easily performed on site (Fig.4.b).

Dry and pure oil gives BDV results, better than the oil with moisture content and other accompanying impurities. The minimum breakdown voltage of the transformer oil or dielectric resistance of the transformer oil in which this oil can be safely used in the transformer, is considered as 30 kV. Water content in the oil is allowed up to 50 ppm as recommended by IS - 335 (1993).

4.7 PCB Test

Polychlorinated biphenyls (PCBs) were widely produced worldwide between the 1930s and 1980s wich were widely used in many appliances such as at the transformers, capacitors and other electrical appliances because of their useful quality as resistant to fire, where they were used as lubricants and as coolants. Polychlorinated biphenyls (PCBs) were recognized as an environmental pollutant, when they were classified as hazardous waste. Although prohibited by law and severely punished, a large number of transformers contaminated with PCBs are still in service. Unfortunately, still a large number of transformers with PCBs remain which can be a source of pollution in the environment, and it can contain a worth of 500ppm or less.

4.8 Transformation ratio test

Transformation Ratio Tester (TTR) is a device used to measure the transformation ratio between windings (Fig.4.c). Ratio measurements are performed at all tap changer positions and are calculated by dividing the reading induced voltage by the value of the applied voltage.

When transformation of ratio test is performed on the three-phase transformer, the ratio is taken in one phase at the same time as a three-phase TTR until the three-phase ratio measurements are completed. The measured ratio changes must be within 0.5%.

4.9 Testing of the transformer protection components

Transformer components that are routinely tested are:

- Buchholz relay (Fg.4.d);
- Thermometer (Fig.4.e);

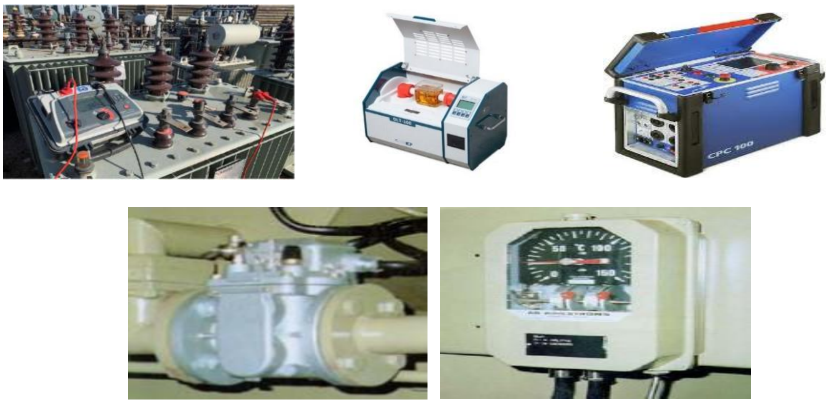

Fig. 4. (a) Insulation resistance test of 10/0.4 [kV] transformer; (b) Equipment for testing the dielectric strength of oil; (c) OMICRON CPC 100; (d) Buchholz relay and (e) Thermometer

Below are some types of the tests performed on a 35/10 kV oil power transformer and the results obtained from these tests are presented in Fig.5.

The tests performed are:

- Insulation resistance test *IR*, performed with the Megger instrument;
- Winding resistance test, measured with Omicron CPC 100 (mΩ);
- Transformation ratio test, performed with Omicron CPC 100 (%)
- Dielectric test - strength of oil (kV/cm) and
- Earthing resistance (Ω).

5 Conclusions

The importance of studying the transformers during their work in the power system is quite great. As key components in the overall operation of the system, early detection of failures would reflect on ensuring the continuity of the power supply.

Based on the chronology of developing testing oil type transformers, it was concluded that commissioning and testing are crucial phases, which provide a guarantee of proper operation and justify the intended service life of this device.

Testing of transformers as preventive measure for possible failures that may occur, guarantee their functionality and ensure that the devices serve the purpose within the foreseen period. Except the type tests performed after the manufaturing of transformers, it can also be realized the site test as a measuremet unit included in the maintenance phase. Inspection is also equally important which contributes greatly to obtaining the records, routine tests and create a safe database.

All type tests treated in this paper, executed into oil power transformers on a periodic basis, are a necessary processes that contribute greatly to the achievement of the goals set by

35/10 [kV] Transformer Test

Substation - Place	Fushe Kosova Warehouse	Serial Number	XXXX	
Power	8 [MVA]	Connection Group	Dy 5	
Type	VT 8000/35-10.5	Production Year	1981	
Producer	Energoinvest	Position of TR	Reserve	
Uk %	6.95 [%]	Oil / Total Weight	3.3 [t]	15.3 [t]

Insulation Resistance Test (Test with Megger)

		HV -with ground - R' (GΩ)			LV - with ground - R" (GΩ)		
Measurement Time		1U-m	1V-m	1W-m	1u-m	1v-m	1w-m
1	15 sec	1.350	1.600	1.812	1.295	1.548	1.722
2	60 sec	2.300	2.600	2.820	2.850	3.470	3.820
3	R (GΩ) HV-LV (U-u)	0.909			2.340		
Factor		High Voltage			Low Voltage		
4	Rad=R (60 s)/R (15 s)	1.703	1.625	1.556	2.200	2.241	2.218
5	Insulation quality	Rad.>1.25	Rad.>1.25	Rad.>1.25	Rad.>1.30	Rad.>1.30	Rad.>1.30

Winding Resistance - Omicron CPC 100 or Multimeter (mΩ)

1U-1V	1U-1W	1V-W	2u-2v	2u-2w	2v-2w	2u-2n	2v-2n	2w-2n
1.5	1.5	1.5	0.1	0.1	0.1	0.1	0.1	0.1

Ratio Test - Omicron CPC 100 (%)

1U-1V/2u2n	1U-1W/2v2n	1V-W/2w2n
0.04%	0.02%	0.02%

Oil Dielectric Strength (kV/ cm)

	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Average (1+2+3+4+5+6)/6
kV	53.30	59.90	75.00	95.40	54.20	59.10	66.15

Ground Resistance (Ω)

Point 1	Point 2
0.1 Ω	0.3 Ω

Date: 06.01.2021

Tested by: Team

professionals in this field.

Fig.5. Tests performed in 35/10 kV oil transformer

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Analysis of Wind Data and Calculation of Energy Yield Potential

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Abstract. Wind energy has a relatively strong potential for electricity generation in various parts of Europe and it has increasingly taken its place in the energy mix in recent years. Kosovo has limited sources of renewable energy and its energy production sector is based on fossil fuels. This may come from the policies used so far in subsidizing such resources. Such a situation emphasizes the importance of active research and efficient use of renewable energy potential. According to the analysis of meteorological data for Kosovo, it can be concluded that the place with high potential is Kaçandoll. Due to the shared terrain and the allowed capacity, it can be considered as Kaçandolli 1 and 2. The measurements provided are measurements from the virtual meter. In both terrains we have measurements at the same height therefore the comparison and calculation of performance will be easier. Information on wind speed interpolation at central altitude and power turns at each wind farm location are also presented. Since the difference in wind speed is quite large versus a change in altitude that is not very large, then analyzes are made regarding terrain characteristics including terrain relief features.

Keywords: wind turbines, wind energy, Kaçandoll, wind speed, energy efficiency

Introduction

Because of the harmful consequences of pollution from the emissions of various gases, renewable energy sources increasingly gain in importance. The wind is a natural phenomenon related to the movement of air passes caused primarily by differential solar heating of the earth's surface [1,11]. The European Union (EU) has agreed to supply 20 percent of its total energy demand from renewable sources by 2020. In two years (2008 and 2009), more than 24,000 MW of new power capacity based on wind energy was installed in the EU countries [1]. Nowadays, wind energy, as an alternative clean sustainable energy source, has been recognized as one of the fastest developing renewable energy source technologies. Wind power generation has made a remarkable contribution to daily life across the globe and has grown rapidly over the past 20 years [6]. As a renewable energy source with the highest growth rate in the last two decades, wind energy is considered a very important resource of electricity production in the future. The forecasts for the development of wind energy are highly optimistic and state that this type of energy will be important in the future [2]. It is also important that the small wind systems also have potential as distributed energy resources. Distributed energy resources refer to a variety of small, modular power-generating technologies that can be combined to improve the operation of the electricity delivery system [3]. Air density, and hence power in the wind, depends on atmospheric pressure as well as temperature. Since air pressure is a function of altitude, it is useful to have a correction factor to help estimate wind power at sites above sea level [4]. The primary meteorological factor in evaluating a prospective wind turbine site is the mean wind speed. Another important parameter is the anticipated extreme wind speed [5]. Wind power plants generate electricity when the wind is blowing, and the plant output depends on the wind speed. Wind speeds cannot be predicted with high accuracy over daily periods, and the wind often fluctuates from minute to minute and hour to an hour [7]. In fact, the wind also varies every second due to turbulence caused by land features, thermal sources, and specific weather conditions. It also blows more strongly higher above the ground than closer to it, due to surface friction [12]. Total energy production and capacity factor are fundamental aspects of a wind power project. To determine the optimum energy output, it is essential to select the right turbine design for a location [8]. Wind turbine operation is dependent on wind speeds to generate power [9]. Sustainability evaluation of wind resources can be performed using different approaches that are complementary between each other: thermo-economic analysis (energy and/or exergy calculations), life cycle assessment (which is a multicriteria product-oriented analysis), emerge approach (a holistic approach donor side oriented). These different assessment approaches were compared one by one by Kharrazi et al. (2014) and/or combined (Duan et al. (2011)) [10]. Annual energy produced is typically calculated referring to the annual mean wind speed of the site. Unfortunately, the annual average wind speed varies significantly [13]. Operation of the individual wind turbines may be adversely impacted by the turbulent wakes from other upwind turbines, with the magnitude of the impact depending largely on the turbines' respective rotor sizes and distance between one another, as well as on the overall shape of the wind farm and turbine spacing therein [14]. Wind shear is the variation of wind speed with elevation. It is important to understand because it directly impacts the power available at different wind turbine hub heights and strongly influences the cyclic loading on the turbine blades [18]. Based on the analysis done, we can assess precisely whether these two countries have the potential to contribute to the local energy production.

2. Site description and data for Kaçandoll

Kaçandoll mountain site is in a complex mountainous region, shown in figure below. Although the slopes of the terrain were high, no cliffs were observed. Turbines are planned on the plateau of mountain ridge running northwest-southeast direction. Site elevations range from 960 m to 1090 m from sea level. The site consists of agricultural land, short shrubs, and forest areas. Most of the wooded areas are on the northern hillside of the site. Forest areas are showing similar characteristics of about 10 m height and closed formation. Windrose also is presented in figure 1.

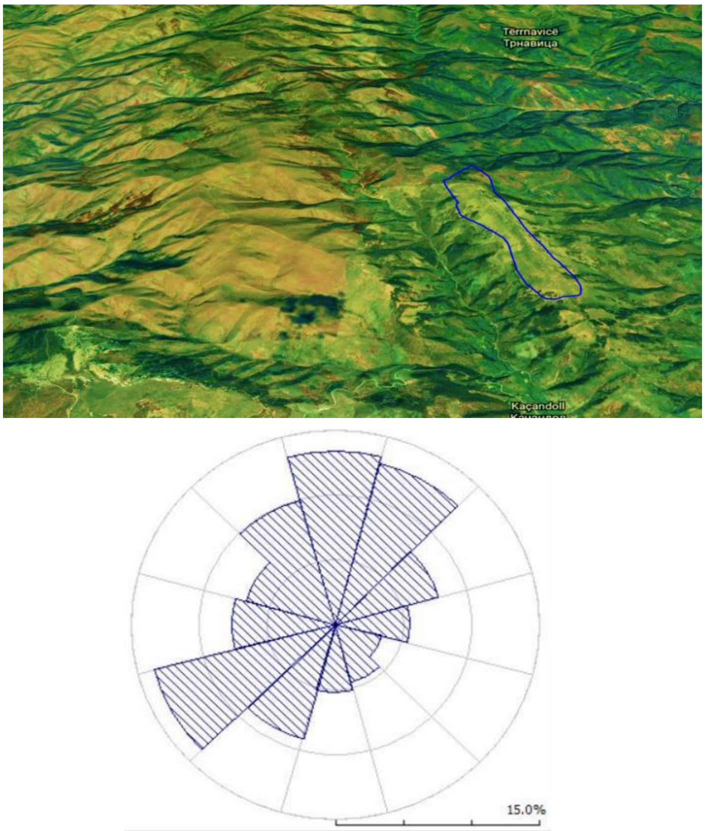

Fig. 1. Kaçandoll mountain and its wind rose

Main characteristics of the manufacturer, the capacity and the surface of the turbine are used to perform the calculations of the produced energy and the cut-in and cut-off speeds.

Tab. 1. Technical details for wind turbines in Kaçandoll

Location	**Wind turbines used in Kaçandoll**
Nominal power, MW	P_{nom}=3.4 MW
Swept area, m^2	13273 m^2

The way of their organization of the farm with 10 same wind turbines is further given by the figure 2.

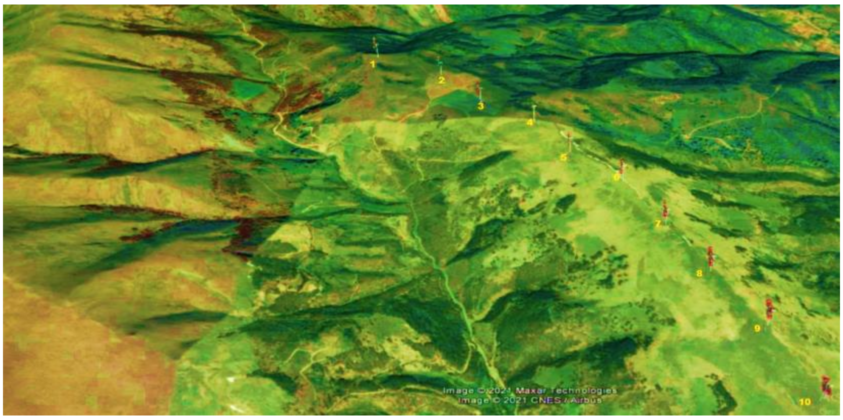

Fig. 2. Kaçandoll layout

Another important parameter is efficiency of energy converting or given from wind turbines. First, we start with Kaçandoll, where the average wind speed per year is 7.1 m/s, and capacity factor generated by WAsP is 47.145%.

Based on the installed capacity the efficiency is calculated as below [19]:

$$\eta = \frac{P_{real}}{P_{theoritically}} \tag{1}$$

The theoretical power of a wind turbine is calculated according to the following formula:

$$P = \frac{1}{2} \cdot \rho \cdot A \cdot w^3 \tag{2}$$

Then, the real power is described by:

$$P_{real} = C_P \cdot \frac{1}{2} \cdot \rho \cdot A \cdot w^3 \tag{3}$$

The probability of occurrence of speeds less than 3 m / s and more than 25 m / s is described by the following formulas [20]:

$$F(w_{\min}) = prob(w < w_{\min}) = 1 - \exp\left[-\frac{\pi}{4} \cdot \left(\frac{w_{\min}}{w_{average}}\right)^2\right]$$
$$\tau_{w>25m/s} = 8760 \frac{h}{vit} \cdot \exp\left[-\frac{\pi}{4} \cdot \left(\frac{w_{\max}}{w_{average}}\right)^2\right] \tag{4}$$

The annual energy is further calculated should also consider the efficiency of the turbines in the wind park:

$$Energy\ yield = Capacity\ factor \cdot P_w \cdot number\ of\ turbines \cdot number\ of\ hours\ during\ year \tag{5}$$

C_P- capacity factor in the targeted region, %

ρ – air density, kg/m^3

A – turbine area, m^2

w – wind speed, m/s

Measurements made for those different terrains, which are shown above, can be recalculated using probabilistic methods, so we can calculate how many hours during the year the wind speed will be below 3m/s, the speed which is considered as the average at which the wind turbines start moving, we will have:

This is described also by figure below:

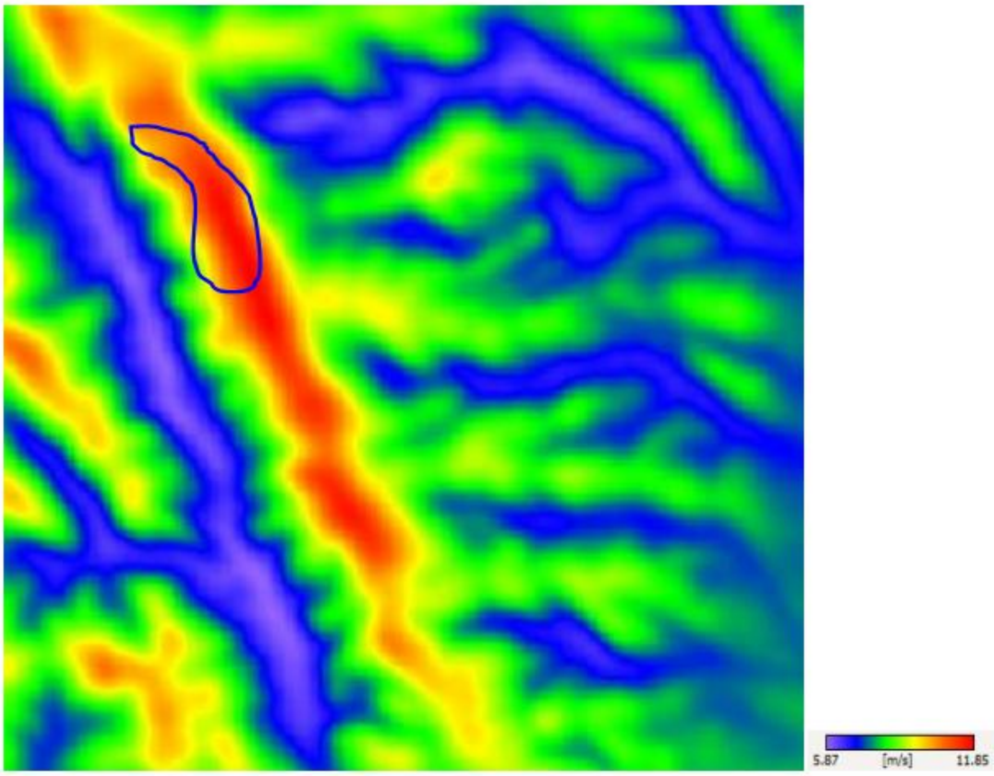

Fig. 3. Mean wind speed in Kaçandoll

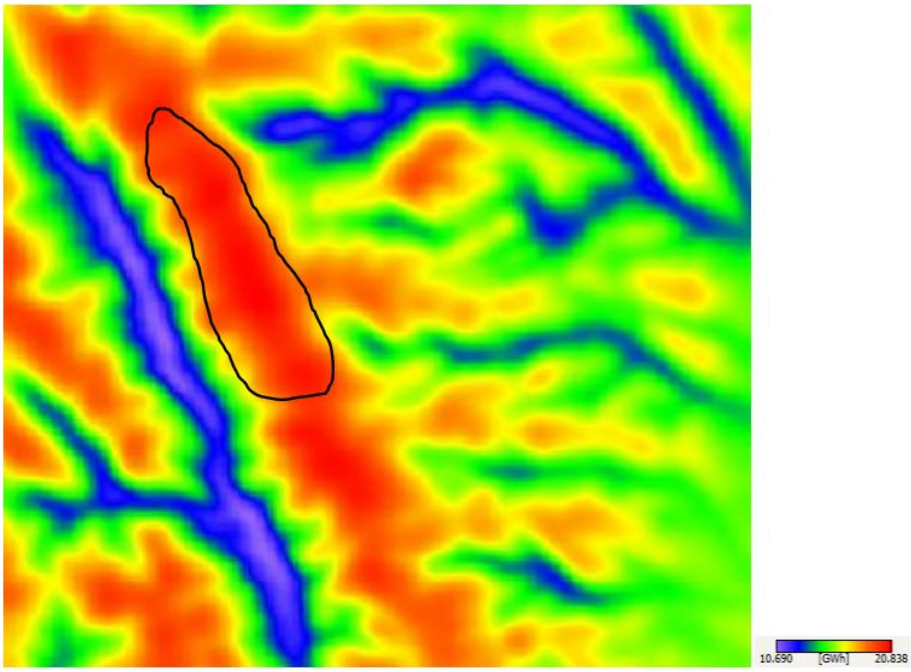

Fig. 4. Energy yield for Kaçandoll mountain, in GWh

From the presented figure we have a high potential of wind energy and this potential in terms of energy generated minimum capacity is 10.690 GWh at a maximum capacity of 20.838 GWh. The fact that we have some hours with speeds less than 3m/s shows that this country has a potential for development. Also, that we do not have many hours of extreme speeds, over 25 m/s shows that we have a stability in terms of speeds.

Conclusions

From the performed and presented analyzes we have a considerable energy potential. The measurements were taken by Vortex for which we thank them for the opportunity given to use this analysis in the framework of doctoral studies. From our analysis we have the results as follows, the potential power to be achieved is 1208.398kW. The efficiency achieved is 35.5%. The probability of hours of occurrence of cut-in speed, <3m/s is 1136.802 h/yr. On the other hand, the cut-off stop speed of 25m/s, has the probability of occurrence at 0.51975 h/yr. In these operating conditions, we will have a minimum annual production of 49932.117MWh during the year. It can be concluded that there is a significant capacity of wind energy in this country and that we have a significant probability of utilizing wind energy in this country. This will of course play a role in the CO_2 considered.

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ENERGY ANALYSIS OF THERMAL COLLECTORS WITH WORKING MEDIUM WATER AND AIR FOR KOSOVO CLIMATE CONDITIONS

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Abstract

To overcome the impact on the environment and the declining source of fossil fuels, renewable energy sources must meet the growing demand for both electricity and heat. Solar energy is clean and endless, suitable for being a good substitute for fossil fuels and meeting energy demands. Solar collectors are a major part of solar thermal systems, there are a variety of types of solar collectors which we can use depending on the conditions in which they will operate. In this study, the energy performance of the flat plate solar collector with working medium water and air for climatic conditions of Kosovo was analytically analysed. This paper will provide a clearer picture of these two analyzes for both types of solar collectors for a given location. As it is known, the main purpose of using one type of solar collector is to maximize its use and achieve the highest parameters of the energy used. At the end of this paper it will be clear which type of collectors with a certain working medium produce more energy and have greater efficiency given the importance of better use of solar energy and achieving maximum benefits of the collector used.

1. Introduction

Energy is the most valuable resource and foundation of civilization. It is also our heritage for future generations. Preserving this resource for future requires a thorough understanding of energy resources, optimal operation and sustainable usage. Solar energy is one of the most important sources of energy as it is free and other country can't charge for the use of the sun. Solar energy, on the other hand can be important because this energy is infinite [1].

The sun, as main source of light and heat for the earth, is considered an inexhaustible resource of energy, of easy access, free, clean, and renewable; from which it is possible to obtain direct benefits through systems capable of transforming the direct solar radiation into other types of useful energy to then be used in industrial processes or in small applications for the home [2].

Solar energy collectors are special kind of heat exchangers that transform solar radiation energy to internal energy of the transport medium. The major component of any solar system is the solar collector. This is a device which absorbs the incoming solar radiation, converts it into heat, and transfers this heat to a fluid (usually air, water, or oil) flowing through the collector. The solar energy thus collected is carried from the circulating fluid either directly to the hot water or space conditioning equipment, or to a thermal energy storage tank from which can be drawn for use at night and/or cloudy days [3].

1.1. Water solar Collectors

Flat-plate collectors are the most common solar collector for solar water-heating systems in homes and solar space heating. A typical flat-plate collector is an insulated metal box with a glass or plastic cover (called the glazing) and a dark-colored absorber plate. These collectors heat liquid or air at temperatures less than 80°C [4].

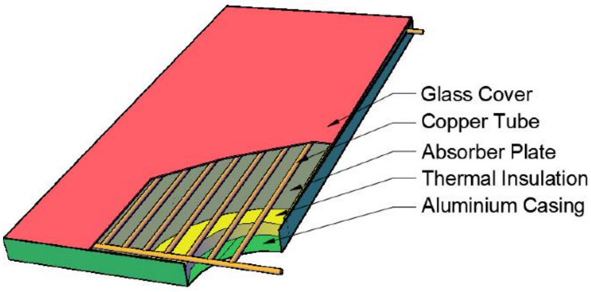

Fig. 1. The structure of a flat plate collecto

[5].

Sunlight passes through the glazing and strikes the absorber plate, which heats up, changing solar energy into heat energy. The heat is transferred to liquid passing through pipes attached to the absorber plate. Absorber plates are commonly painted with "selective coatings," which absorb and retain heat better than ordinary black paint. Absorber plates are usually made of metal typically copper or aluminum because the metal is a good heat conductor. Copper is more expensive, but is a better conductor and less prone to corrosion than aluminum. In locations with average available solar energy, flat plate collectors are sized approximately one-half- to one-square foot per gallon of one-day's hot water use [6].

1.2. Air solar collectors

An air-based collector is a type of solar collector in which air is is used as the medium for heat transfer instead of a liquid. The heat thus obtained from the incident solar energy is stored in holders, which may be filled with gravel, for example. The energy collected from air-based solar collectors can be used for ventilation air heating, space heating, or crop drying [7].

Fig 2. The structure of air solar collector [8].

Solar hot air collectors are mounted on south-facing vertical walls or roofs. Solar radiation reaching the collector heats the absorber plate, and the air passing through the collector picks up heat from the absorber plate [9].

1.3. Literature survey

Flate-plate collectors are widely used in various engineering applications. Despite this type of collectors have been well analyzed for a long time, there is still much interest in the different aspects of efficiency analysis. As solar collectors are an important technical component when energy sustainability is considered, a substantial performance evaluation becomes inevitable to evaluate possible configurations improvements of these systems. Exergy analysis has proved to be one of the useful tools when considering either the solar collectors alone or the complete system to identify sources of irreversibility [10].

An optimisation analysis of the solar collectors by the use of the exergy method leads to a conclusion that the energy efficiency increases without extremum points with the change of operating parameters. The absence of such maximum points has created difficulties in the design of flat plate solar collectors. However, the exergy efficiency analysis demonstrates the existence of local maxima points and a point of overall maximum [11].

A way to present the thermal performances of a flat plate solar collector, including the collector efficiency has been shown in [4]. A more precise and detailed analysis should include the complex interaction among the overall heat loss coefficient (U_L) and other factors as the heat removal factor (F_R).

By increasing total solar radiation, the energy and exergy efficiencies increase. But when the ambient temperature rises, the exergy efficiency decreases [12]. In general, although the performance of solar collectors can be examined from the exergy standpoint, that is a useful method to complement, not to replace the substantial energy analysis [13]. Another method to describe the thermal performance of a flat plate solar collector in specific conditions has been presented in [14].

In this paper will be presented the energy analysis of two different types of solar collectors for a given location. Their energy performance depends on different climatic conditions.

2. Analysed solar collectors

Location analysed is the roof of laboratory buildings at the Faculty of Mechanical Engineering in Prishtina (latitude 42.6667◦N, longitude 21.1667◦E) Kosovo. The region is characterized by a mild continental climate accompanied by warm summers and cold winters. The modules are fixed, inclined at an angle of 45◦, facing south and with no buildings or other structures around, which would possibly shade them and cause lower power output to be generated [15]. Energy analysis will be done for the same location but for solar thermal collectors with working medium water and air. Energy analysis will be done for climate change in the location where solar thermal collectors can be located.

Table 1. Specification of water solar collector and air solar collector [16] [17].

Parameters	**Air solar sollector**
Max air volum, m^3/h	98
Appro temperature rise, ℃	11
Max performance, W/h	550
Product size, cm	$101 \times 72 \times 6$
Gros weight, kg	19

Parameters	**Water solar collector**
Zero heat loss efficiency η_0, %	78.1
Heat loss coefficient a_1, $W/m^2/k$	3.83
Absorption, %	95
Emission, %	5
Max operating pressure, bar	10
Nominal flow rate, l/min	2
Thickness, mm	3.2
Collector length (mm)	1870
Collector width (mm)	1150
Wight (kg)	34

3. Performance of the solar collectors

The useful heat gain (Qu) by the working fluid is:

$$Q_u = \dot{m} C_p (T_{out} - T_{in}), \quad (1)$$

where T_{in}, T_{out}, C_p and $\dot{m}$ are the working fluid inlet and outlet temperature, its specific heat capacity and mass flow rate, respectively. The Hottel–Whillier equation for the useful heat gain (Q_u) of a flat plate solar collector system, considering the heat losses from the collector to the surroundings, is:

$$Q_u = A_p F_R [S - U_I (T_{in} - T_a)], \quad (2)$$

where T_a is the ambient temperature and the heat removal factor (F_R) is defined as:

$$F_R = \frac{\dot{m} C_p}{U_I A_P} \left[1 - exp\left\{-\frac{F'' U_I A_p}{\dot{m} C_p}\right\}\right], \quad (3)$$

where F" and ϕ are the collector efficiency factor and plate effectiveness. An energy balance on the absorber plate yields the following equation for a steady state operating conditions:

$$Q_u = A_p S - U_I A_p (T_p - T_a), \quad (4)$$

In Eqs. (2) to (4) Tp, S and Ap are the average temperature of the absorber plate, absorbed radiation flux by unit area of the absorber plate and the area of the absorber plate, respectively. For simplification, the overall loss coefficient U_I, is often assumed as a constant. However, a serious study on collector efficiency must take into account its variability. The calculation of U_I is based on simulation of convection and radiation losses from the absorber plate to the surrounding ambient, taking into consideration the real ambient conditions.

Thermal efficiency of the collector is given by

$$\eta_{en} = \frac{Q_u}{I_T A_p}, \quad (5)$$

where I_T is the incident solar energy per unit area of the absorber plate.

4. Results and discussion

As it is known, the purpose of using a solar panel is to achieve the best parameters from it and to have more energy generated. Solar collectors have the sun as a source of energy and depending on solar radiation we also have the change of energy gained by the collector.

Knowing that solar collectors for water heating are used to meet thermal needs, and inside the collector there is a change in temperatures that is achieved. The following is a diagram of how much thermal energy is gained depending on the change in temperatures expected to be reached by the collector.

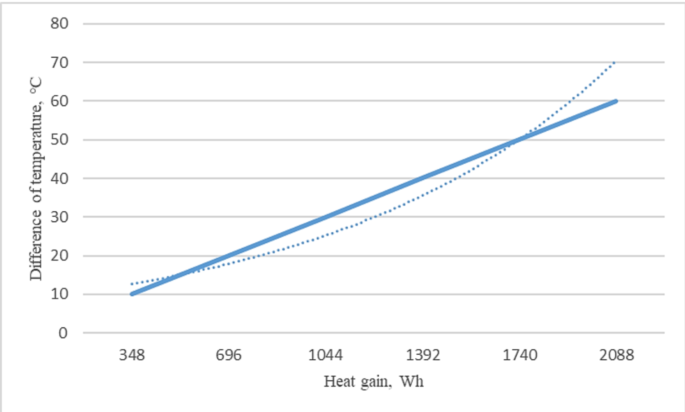

Fig 3. Thermal energy gained from changing temperatures.

The working medium in most cases in this type of collectors is the water which comes to the collector with a certain flow, in the following is presented the change of thermal energy depending on the change of water purification in the collector for a certain temperature change.

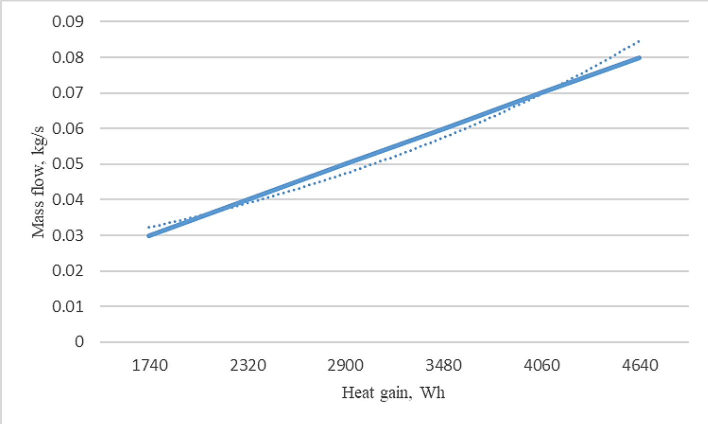

Fig 4. The change of thermal energy depending on the change of the mass flow of water.

The main indicator of the solar collector is the efficiency of the collector which indicates the degree of adequate utilization of solar energy. Here we present the diagram of efficiency for the main types of solar collectors.

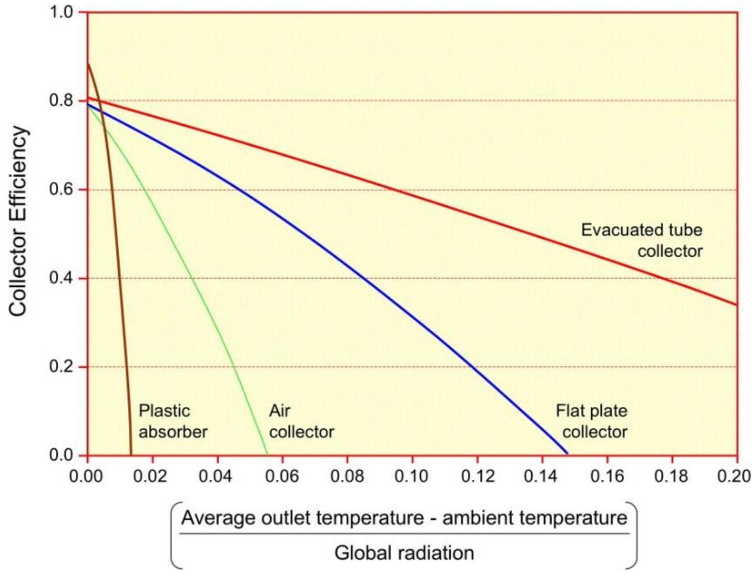

Fig 5. Efficiency diagram of solar thermal collectors [18].

Air collectors which are used for heating air for heating systems as working medium use air which transfers heat. The following is a diagram of the change of thermal heat depending on the change of temperatures reached in the collector.

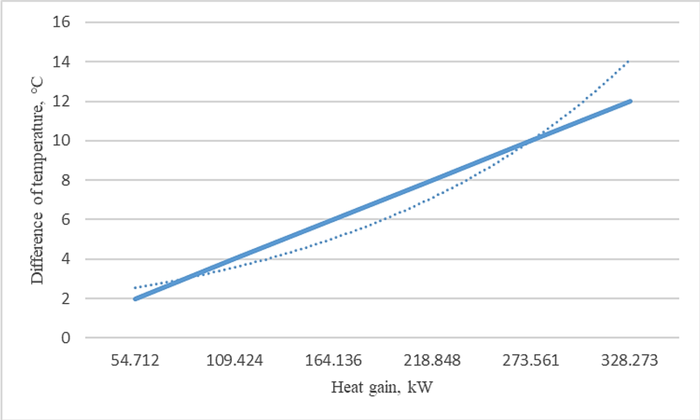

Fig 6. Heat change depending on the change of air temperatures.

The change in thermal heat depending on the change in air volume is shown in the following figure.

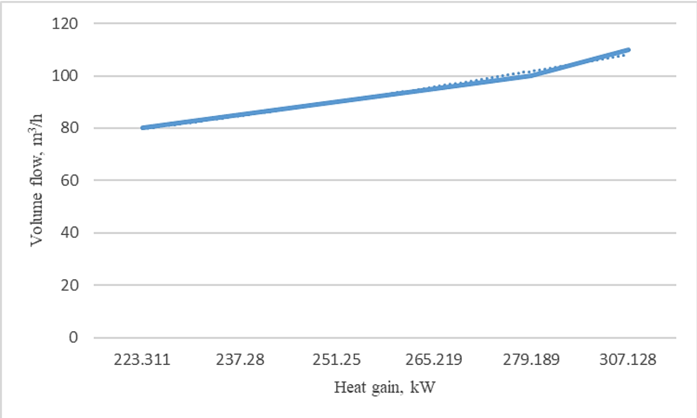

Fig 7. The change in thermal energy gained depending on the change in air volume.

5. Conclusions

Renewable energy sources are an inexhaustible source of energy, the use of which is growing more and more every day. Global warming and environmental pollution from the use of fossil energy sources has shifted the focus from the greatest use of renewable energy sources, primarily solar energy as a vital energy source. Solar energy is an inexhaustible source of energy which can be used for the production of electricity and thermal energy.

Kosovo has a high potential for the use of solar energy depending on its geographical position in which it is located. Considering the large number of sunny days during the year, it makes it a place that has the potential to use solar systems for thermal energy generation. Its small area can be seen as an obstacle to enable the greatest use of its potential in relation to this energy source.

From the energy analysis made for solar collectors with working medium water and air it is seen that there is a high potential which can be obtained from the use of these two types of collectors. Flat collectors for water heating can be used to meet the requirements for sanitary water with a good performance and high potential that can be exploited by the use of this type of collectors. Solar air heating collectors have a great potential which can be used to heat spaces to meet the needs for thermal energy. Based on the analysis made for the climatic conditions of Kosovo, the efficiency of flat plate collector with working medium water is about 50 % while the efficiency for air collectors is about 60 %.

The production of electricity for the most part from fossil fuels has affected the pollution of the environment and the increase of the air quality index in the country by aggravating the air in the country. A large part of the electricity which is used for water heating for sanitary needs and for heating in winter time can be saved by using solar collectors to cover these energy needs. Their use would have a positive impact both in terms of energy and the environment.

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Analysis and performance of hydro generation of electricity from small hydropower plants

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Abstract: The application of the latest technology in HPPs of the Dragash region and the generation benefits with multifunctional approach enable sustainable operation of generators with full efficiency in the environment where it is part of this research. Exploitation of energy resources from renewables, particularly the utilization of hydro resources through engineering works called hydropower plants today is of particular importance not only nationwide but also wider. Electricity represents one of the most eminent and underlying sources of human activities. Energy sources are different, as are the modes, equipment and plants for its generation. Indeed the geographical position and the influence of climate conditions influence the potential of the exploitation of the generating energy in the minimal flow of water flow in the turbines by the decanters. The paper highlights the use of advanced SMART technology, the form of communication between plants installed in hydropower plants and the generating performance with some characteristics of turbines used in hydropower plants, as well as the results of efficiency analysis for small hydropower plants. Nowadays various types of turbines are used in the power system of the hydroelectric power generation type. Whereas the efficiency analysis of small and large hydropower plants depends on the design, size, and amount of water flowing into the profile in which a small power hydropower plant are generated electricity in the region of Dragash.

Keywords: energy efficiency, HPP machinery, turbine automation, regulation voltage.

1 Introduction

Most of the hydropower plants planned to be built in Kosovo fall mainly in special natural and protected areas where the hydropower potential is smaller. Problematic remains the fact that 62% of existing and planned small hydropower plants are located within areas of special natural importance, such as national parks, strict nature reserves, special protected areas, and areas with numerous features of natural, plant habitats and animal. Based on the strategic plan for alternative energy sources and prefeasibility studies for the identification of water resources for small hydropower plants in Kosovo, 77 sites for small hydropower plants, with a capacity of about 128 MW, with a production of 621 GWh have been identified per year under average hydrological climatic conditions. The underlying objective is to stimulate the use of renewable energy sources, a 'feed-in' tariff scheme has been set up in Kosovo [1]. Above all, this incentive measure for RES aims to meet the energy targets of RES planned for 2020, as required by Directive 2009/28 / EC, transposed and implemented under the auspices of the Energy Community Secretariat.

Energy sector laws, in particular the Energy Law, have consistently dealt with resources renewable energy in terms of inducing the optimization regarding their utilization. This includes the establishing of annual and long-term targets of energy production from these sources. The main criterion for the mechanical study and selection of machinery is the full utilization of the aquatic energy of the selected hydro technical axis, to gain maximum power in the hydro turbines, which will be transmitted to the generator on the shaft to produce electricity [2].

In the respective case, relying on the turbine type diagram, the most appropriate choice for the water regime given by the hydrological study and the working height is for the Frencis type figure 1. After then the parameters in the diagram, it has been drawn the conclusion that turbines subjected to performance work are of the type Frencis. For minimal feeds that the Frencis aggregate does not reach, we propose to build an efficient turbine prototype that can generate electricity from water flows with a minimum amount of up to 20% that fits our project, or by dividing it into two aggregates [3].

- Shaft Francis turbine – H = (2 ÷ 20) [m]
- Kaplan turbine - H = (3 ÷ 40) [m]
- Mitchell-Banks turbine – H = (10 ÷ 100) [m]
- horizontal axis of Francis turbine – H = (25 ÷ 100) [m]
- Pelton turbine – > 100 [m].

2 Energy produced in power plants

Based on the size of the hydroelectric power plant, the energy produced ie. river volume flow, hydropower power is estimated using the following equation:

$$P = q\,\rho\,g\,h\,k \qquad (1)$$

Where in;
P - gained power and electricity (electricity), W;
q - volume of available water volume, m3 / s;
ρ - water density (approximate value is 1000 kg / m3);
g - acceleration of gravity (gravitational forces), 9.81 m / s2;
h - height of the water column, ie the available water drop (m);
k - operation coefficient of a hydropower plant receiving values between 0 and 1;
The coefficient k depends only on the type of turbines built in hydropower plants.
As the turbines are larger and more modern, k is approaching the value of 1 [5].

2.1 Equipment for building HPP

Devices which bear SMART technology for small hydropower automation have the option of a synchronous or asynchronous generator solution as a unit of hydraulic power and all the metering elements it possesses, such as procedures, protection and control regulations for the equipment required for automatic starting, the generator (stimulant), and obligatory network synchronization and secure normal and emergency aggregate network. The most important benefits are the automation of SMART modules for small hydro: power installation (MWh) turbine generator, stimulation regulator, temperature control module, synchronizer to start and stop the protection system for all types of Francis, Bankijevu, Pelton, Kaplan turbines ect. [4].

2.2 Generators synchronous and asynchronous

Synchronous and asynchronous type generators, three phase transformers and distribution system lines comprise the key link of the power system. The synchronous generator converts the mechanical power of the pT turbine into electric power and as matter of fact it is a tie between the generating unit and the electricity transmission network. Hydro generators, owing to their low rotational speed, are prepared with visible poles [7].

In the stator they contain three vented windings of current and voltage in the space of 120 °, while in the rotor usually in addition to the excitement winding fed with continuous current they also contain the winding of the horizontal and vertical relaxation system.

During the analysis of the synchronous generator, in order to make it solvable, a series of analyzes are performed with the measuring instrument system including the SMART operating meter of the following:

• The magnetic circuit of the synchronous generator is accepted as voracious; that the dependence of the magnetic fluxes on the electric current is linear and so the principle of superposition can be applied

• The stator and rotor coils that are actually scattered in the space are replaced by concentrated coils.

• Losses of active power in the magnetic circuit are inconsiderable.

• Magnetic induction in the air space of the synchronous generator, as well as voltage or current modes is expected to vary compliant to sinusoidal law.

• Active and reactive machine winding resistances are accepted independent of temperature and frequency, particularly the phenomenon of surface effect is ignored.

- Practice shows that the errors that cause the above releases are usually admissible [4-5].

2.3 Voltage regulation in synchronous generators

In the power system one of the main factors of electricity transmission is also the maintenance of a certain level of voltage at its various points (in cases where there are variations of voltages and frequencies), for the following reasons:

Various appliances that consume electricity are designed to operate at a certain voltage level, otherwise called nominal voltage. In the case of a voltage deviation from this value, the quality of the work of the equipment will be impaired. Nevertheless, the flow of lamp lighting relies a lot on voltage etc.

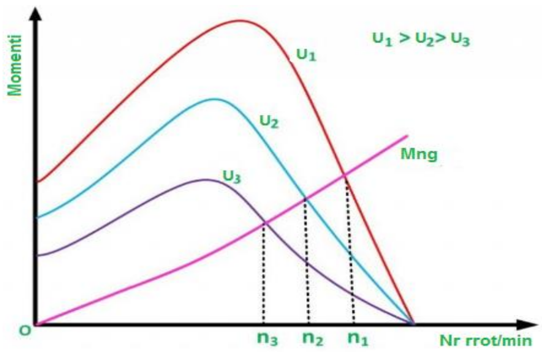

Figure 1 Asynchronous motor with different voltage

• Maintaining certain levels of voltage in the system is also related to the impact on the transmission capability of transmission lines. The voltage U1 (figure 1) at the initial phase of the transmission line is distinguished by the voltage of the system U and with ΔU, which is determined by the active P and reactive power Q passing through the line:

$$\dot{U}_1 = \dot{U} + \Delta\dot{U} \qquad (2)$$

From (2) and the vector diagram of Fig. 6 shows the phase difference between U1 and ΔU1.

$$P = \frac{|U_1|\cdot|U|}{x_l} \cdot \sin\delta_l = \frac{U_1 \cdot U}{x_l} \qquad (3)$$

During instantaneous voltage reductions as well as short circuits in the system, maintaining synchronous operation of the plant generators, relies on the speed of resetting the voltage both during and after the short circuit disconnection. In the case of asynchronous modes, the success of resetting synchronous plant operation in the system depends on the speed of resetting voltage levels [5].

2.4 Performance of small HPP-s

The maximum flow water is 10m3 / s per second.
The technology exploited in Dikance HPP is 2 Francis Horizontal turbines.
One turbine has a generation capacity of 2700kV and the other has a generation capacity of 1300kV.

Table 1. Climatic conditions and efficiency of utilized energy in HPP Dragash

Time of the year as %	Natural water inflow	Ecological flow	Water flow available to be used	Water flow passing the turbines	Total efficiency (turbines, generators and transformers)	Net Head	Installed capacity	Electricity generation
%	m³/s	m³/s	m³/s	³/s	%	m	kW	kWh
8.30 %	13.023	0.249	12.774	10.5	84.82%	45.5	3,975.51	2,890,512.68
16.70 %	8.271	0.249	8.022	8.022	85.72%	45.5	3,069.50	2,258,664.29
25.00 %	6.76	0.249	6.511	6.511	84.87%	45.6	2,472.00	1,797,340.20
33.30 %	6.102	0.249	5.853	5.853	85.94%	45.6	2,250.23	1,636,093.81
41.70 %	5.248	0.249	4.999	4.999	85.51%	45.7	1,916.47	1,411,894.13
50.00 %	4.989	0.249	4.74	4.74	83.60%	45.7	1,776.44	1,290,057.52
58.30 %	4.161	0.249	3.912	3.912	80.40%	45.7	1,410.14	1,025,286.47
66.70 %	3.589	0.249	3.34	3.34	84.73%	45.8	1,271.50	935,620.61
75.00 %	3.042	0.249	2.793	2.793	85.29%	45.8	1,070.25	778,157.55
83.30 %	2.381	0.249	2.132	2.132	79.92%	45.9	767.21	557,825.08
91.70 %	1.611	0.249	1.362	1.362	67.35%	45.9	413.06	303,943.02
100.00%	1.026	0.249	0.777	0.777	0.00%	46		
							Total kWh/year	**14,885,395.36**

The results measured in compliance with the feasibility plan and the measurements of energy produced by water turbines at HPP Dikance 2 in the two types of Frenzies and Piston turbines [6]. Francis type generator with 4 MW installed power, the characteristics of which are presented in the table, show some operating factors of operation (generation) of electricity dependent on flow of water with capacities of 5.3 m3 / s, amount of water used during generation of 5.5 m3/s. According to statistical analysis the efficiency of electricity generation on average is over 80%, which means that the efficiency of generation relies on the amount of water flows [7]. The generator and the turbine are connected to each other on a vertical axis. Pouring of water through the pipes (installed ducts) produces rapid water flow through the turbine - generator, and the generator provides electricity [8]. The energy acquired by the power plant is equal to the production of height (H) and amount of water (Q) according to the expression:

$$P = 9.81 * Q * H * ŋ \quad (kW) \quad (4)$$

Where are:

Q-quantity of electricity (m3/s),

H-height (fall) of water (m)

ŋ- coefficient of exploitation of generator and turbine.

The water deposed from the turbine continues further into the tailgate which is closed to the dam, as it is often the continuation of the river. The control gate enable the continuity of the turbine activity. In case of closure, dispose of drainage channels and excess water will either surround the riverbed itself, or open the gates to remove it.

Generating a Dependent Service on Factories and Installations on the premises, does not allow you to be efficient in generating citizen turbines when it is reduced at a large extent reduced the amount of road possible [9-10].

Table 2 Generating power of generators in Dragash

Per-centag e	Large turbine	Gener-ator 3200kVA	Small turbine	Gener-ator 1600 kVA	Trans-former
	%	%	%	%	%
100	92.70%	97.40%	92.83%	97.10%	94.00%
90	93.87%	97.40%	93.44%	97.10%	94.00%
80	93.40%	97.40%	92.72%	97.10%	94.00%
70	91.40%	97.30%	90.60%	97.10%	94.00%
60	87.91%	97.30%	87.03%	97.69%	94.00%
50	82.86%	97.00%	81.83%	96.60%	94.00%
40	75.94%	96.65%	74.52%	96.15%	94.00%
30	66.18%	96.30%	64.12%	95.85%	94.00%
20	52.42%	95.60%	53.23%	94.80%	94.00%
10	0.00%	0.00%	0.00%	0.00%	0.00%

The efficiency of the generating power shown in Table 3 presents the comparative data divided by the generating potentials for the 3200KVA and 1600 KVA turbines while maintaining the same voltage transformation of 94%. Generator with higher generating power of 3.6-4 MW, for full water potential up to 50% has better performance, while generator with lower performance has less than 50% of generating potential. Consequently, if the amount of water reaches 20% the generation ratio is 52% and 53%.

Table 1 Comparison of data between planning and setting up HEC

Production of electric energy in turbines of water generator in Dikance HEC, Francis turbine

Month	Planning (MWh)	Realiza-tion (MWh)	% Effi-ciency Ppr/Pinst
Janu-ary	2,187,516	738	34
Febru-ary	2,186,500	1850	85
March	2,189,153	1011	46
April	2,190,757	1326	60
May	2,192,567	1234	56
June	2,193,377	2047	93
July	2,199,127	1431	65
August	2,184,676	1123	51
Sep-tember	2,182,445	954	43
Octo-ber	2,185,895	1456	66
No-vember	2,196,546	1259	57
De-cember	2,194,765	1458	66
Janu-ary	2,184,556	1345	61
Febru-ary	2,185,925	1250	57

The SMART Monitoring Center of the entire production process is monitored by the PC system for electricity generation, the generation information system, and the protection of power plants and a complete set of other HEC operational information [11].

2.5 Analysis of efficacity of turbines in small HPPs

The process concerned with carrying out the estimated flow, is primarily based on known recommendations in the field of design of small HPPs with derivation where it is expected to guarantee it for 25% of the year. According to the above, based on the stability curve of daily flows in the Dragashi 1 HPP intake axis, this flow is

Q_{ll} = 0.42 m^3 / s. the resulting HPP uptake results Q_o = 0.31 m^3/s. Indeed, the feed coefficient turns out to be K_q = Q_{ll} / Q_0 = 0.42/0.31 = 1.35 and with the following data:

Q_{log} = 0.42 = m^3/s and H = 169m, based on materials recommended in the field of hydropower machinery, two Pelton turbines [12-13] will be selected.

2.6 Performance of turbines in large hydro power plants

In this perspective, it is worth emphasizing that large hydropower plants do not differ from the principle of operation with small hydropower plants but it is normal that there are differences in terms of turbine size and installation power. Generally speaking these plants are accumulative and their management is easier and can be used in a more rational way. Francis and Pelton turbine types also apply to large HPPs. Another type of Kaplan type turbine which is used in some cases in high-capacity hydropower plants and also in large flows should be mentioned. [14]. Technical Indicators Fierza Hydropower Plant is of dam type and reservoir type. The dam is filled with stones and clay cores. The dam is 161.5m high and 380m long, the width of the dam ranges from 576 m at its base to 13m at the dam ridge. The Fierza Dam, when it was built, was the second of its kind in Europe to its height. The dam has a total volume of 8 million m^3. The dam has created a reservoir with a volume of 2.7 billion m^3 of water and an area of 72 km^2, Fierza Lake, which is the largest artificial lake in the country. The useful volume of the reservoir is 2.3 billion m^3 [15]. The HPP Fierza is foreseen as a first class offense in terms of risk. Likewise to any hydropower turbine whether small or large, the flow of water and altitude are considered as determinant factors to indicate the class or type of river or lake. The type of turbine designed for these types of hydropower plants is the vertical Francis type which are installed with a power of 125 MW and there are four turbines of this type [15].

CONCLUSION

Small hydropower plants help the sustainable development of RES in Kosovo. The type of technologies used to generate energy in terms of efficiency have differences in generation between turbines in the same river flow for the same installed power. The Dikanca 2 hydropower plant that is supplied through the Brod River according to the production plan in relation to the generation realization is at 62.5%. The methodology used in the generation analysis of water turbines ensures that the new technology used is efficient and effective in generating electricity. Internal areas of environmental sustainability are considered important therefore caution is required in the various discriminations that may occur with the environment. The use and implementation of technology in small HPPs enables functional operation at nominal generating stability. The analysis and generation performance is also influenced by the slope angle factor in the water supply pipe to the turbine blades. The inter-technological communication approach is multidisciplinary that enables stable and functional operation in monitoring and generation of electricity up to the distribution system at the level of 35 kV. The integration of the generating network and the distribution network provides the benefits of the subsidized price for several years and the longevity of the operating technology in the system.

The efficiency of the technology exploited in the parameters between large and small turbines, the ratio is 89% to 87%. Generating power efficiency between 3600KVA and 1600kVA ratio varies from 97% to 96%. The voltage transformation for all types of generation is 94%. Electricity generation from water generator turbines at HPP Dikance 2 for Francis type turbines% efficiency Ppr / Pinst 64.6%. The Dragashi HEC stimulation system is ES202 type with a radiator bridge. The main functions of this system are feeding the rotor with continuous current and regulating the voltage. For the no-load regime, a simulation was conducted to test the regulator for a degree of excitation at the reference voltage. For the + 5% excitation at the reference voltage the override is 0, and the stabilization time is 0.597 sec. While for -5% excitation at the reference voltage the override is 0 and the stabilization time is 0.485 sec. The kinds of turbines which are installed in these hydropower plants are mainly of the Francis and Pelton type. Based on the analyzes carried out in this case, has been drawn the conclusion that small hydropower plants are prioritized for construction in the conditions offered by the territory of the Republic of Kosovo.

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