Solar Energy an Instrument for Reducing High Electricity Prices in Industry Sector in Albania

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Abstract: *The research focus addresses to installation of PV modules in industry sector in Albania. Due to energy crises, the prices are going higher and with the new regulations that are defined by Albanian government, businesses that are connected to 20kV, 10kV, 6kV transmission lines must secure the energy supply by their selves in open market, since a part of price was covered by government, now companies are facing higher prices. The new price is expected to increase more than 70%, up to 0.16 €/kWh from 0.092 €/kWh. Also, companies that will be in the open market will face price volatilities, hence with the installation of PV modules, reduction of electricity price is possible, since the LCOE (levelized cost of electricity) for the PV in Albania, including 20% VAT tax, is calculated around 0.035 €/kWh. To calculate the effect in electricity price a simulation using RETScreen Expert is performed. The simulations are made for a company connected to a 20kV electricity transmission line where an on-grid PV system 217.28 kW power installed is integrated on the roof. The PV modules covers 52.4% of the company electricity demand, by generating 286055 kWh electricity yearly from which 68% of electricity generated from PV is consumed by the company and 32% is exported to grid because company works 8 h/day and there is not an electricity storage system installed. With the price increment from 0.092 €/kWh to 0.16 €/kWh, the total earnings from PV installed system will be increased by an average 65.3% and if the electricity price in the open market is doubled the total earnings will be increased by an average 85.3%.*

Keywords*: SOLAR ENERGY, ENERGY SECURITY, ELECTRICITY PRICE, INDUSTRY SECTOR, RETSCREEN EXPERT, ALBANIA.*

1. Introduction

The war in Ukraine has increased more the world's attention among others and for energy security and sustainable energy system. In his book "The Routledge Handbook of Energy Security", Professor Benjamin K. Sovacool, has illustrated a series of energy security challenges at three different scales including things like geopolitical struggles over resources, transboundary environmental pollution, and climate change. He has found 45 different definitions of energy security [1].

According to European Commission, energy security means: "Uninterrupted physical availability of energy products on the market at an affordable price for all consumers". Energy is the life blood of the society. The well-being of the people, industry and economy depends on safe, secure, sustainable and affordable energy [2]. EU energy security challenges have changed dramatically in the past 15 years. Ongoing crises through Russia and Ukraine, which culminated in February 2014 with the annexation of Crimea and currently with the new invading military aggression against Ukraine, have undermined historical partnership on energy between Russia and EU [3, 4]. Also, deep transformations in the structure of global energy supply and demand, triggered by technological advances and geopolitical and economic dynamics influence European countries in their energy security strategy [3]. But historically, conflicts and crises have been accompanied by higher energy prices, which result in an increase in the cost of living.

Under these conditions, energy security is back on the policy agenda of most countries, especially those with high energy import dependence. One of the main policies that improves a state's security in electricity supply is the diversification of energy sources using renewable energies. As this diversification increases, energy security improves [5, 6].

Reforms of the energy sector have advanced and in Albania the first steps towards diversification of the energy mix are taken. Since 2018, Albania has successfully promoted investments into solar power to begin diversifying its energy mix, so far dominated by hydropower, which is dependent on rainfall. So, Albania could significally improve its energy security and reduce energy system vulnerability to climate impacts by developing its vast solar and wind resources [7]. Generally, Albania is a net importer of electricity. The Figure 1 illustrates that the annually imports varies up to 30% [7, 8].

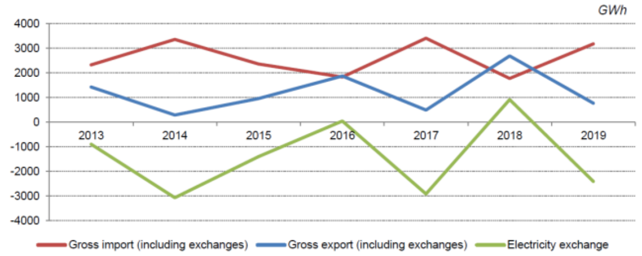

Fig.1 *Electricity exchange dynamics of Albania 2013-2019 [8].*

Electricity exchange refers to the difference between imported and exported electricity, also including transits and necessary exchanges of electricity with other countries in the region.

So, for establishing energy security, energy sector sustainability and an ensured energy supply at cost-competitive prices, increasing the share of renewable energy in the Albanian national energy mix and diversifying the country's electricity sector is wanted [9]. Albania has a considerable potential of Renewable Energy Sources (RES). Albanian government has considered the promotion of renewable energy use as an important tool of energy policies for the increase of the security for energy supply, economic development, energy sector sustainability and environment protection [10].

Albania, with a favorable geographical position in the Mediterranean Sea basin, has very favorable climate conditions for the exploitation of solar energy. High intensity of solar radiation, duration of this radiation, temperature and air humidity, Mediterranean climate, with a mild winter and wet and hot and dry summers, determine greater energy potential than the average energy potential for solar energy use.

In Albania, average solar radiation reaches from 1185 kWh/m^2 per year up to 1700 kWh/m^2 per year. On clear weather, every square meter of the horizontal surface may absorb around 2200 kWh per year (see in Figure 2). The estimates made by the Hydrometeorological Institute show that the most favored regions for natural energy potential are the western regions. The number of sunny hours throughout the territory is about 2400 hours, while in the western part it is over 2500 hours and in the Myzeqea Field reaches over 2700 hours a year [11]. So, Albania has some of Europe's highest number of sunshine hours per year, presenting significant potential for development of solar PV for power generatin [9].

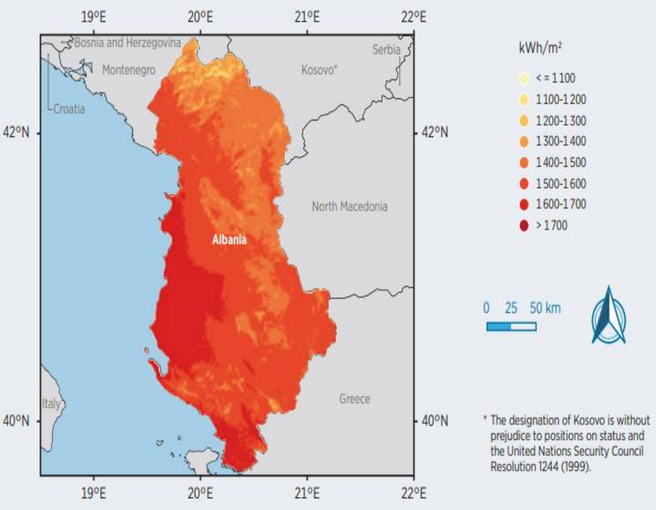

Fig.2 *Albania's annual average Global Horizontal Irradiance [kWh/m^2]. (Source: Global Solar Atlas [9])*

With the implementation of law Nr. 7/2017 "On promoting usage of energy from renewable sources", promoting schemes were immediately applied for photovoltaic (PV) plants (up to 2MW installed power) and wind farms (up to 3MW installed power). In July 27th 2017 Energy Regulatory Authority (ERE) approved Feed-in-Premium tariffs of 100€/MWh for PV plants (up to 2MW installed power) and 76€/MWh for wind farms (up to 3MW installed power). On June 12th 2018, the Council of Ministers of Albania passed a decision for PV projects over 2MW. The law introduces the granting of support to renewable energy producers through an open, non-discriminatory, transparent and competitive process for the projects that offer optimal conditions in terms of energy cost, level of technology and building plan. It also incorporates a net metering scheme for photovoltaic (PV) panels on rooftops with a capacity of up to 500 kW [12]. According to the law, the self-producer status predicts the exchange of electricity with the distribution network and the balance of annual energy production by the PV plant, less than the annual needs of a SME or a family consumer.

This legal support has influenced the progress Albania has made in recent last year's towards the diversification of electricity production by PV power plants. According to the energy balance of 2020, from 21MW of installed PV power plants (Table 1) was produced 32,265MWh electricity which constituted only 0.61% of the net energy produced in Albania or 0.43% of the total electricity consumption for this year.

Table 1: *Grid connected large-scale PV plants. Source: NANR*

PV power plant	MW	Connection	Annual Production in 2020 in MWh
UKKO	1		
Seman-2	2	35kV	4,119
Topojë	2	35kV	4,095
Topojë 2	2	35kV	4,088
Topojë (Sheq Marinas)	2	35kV	4,100
Topojë (Sheq Marinas)2	2	35kV	4,124
Seman1solar	2	35kV	4,079
ES 2019	2	36kV	244
Smart Watt	2	37kV	243
Tren Bilisht	2	35kV	3,228
Plug Lushnje	2	10kV	3,946
Total	21		32,265

According to National Agency of Natural Resources of Albania, following the auctions, large-scale PV projects with 50MW, 100MW and 140MW installed power are still in planning or construction phase.

The research focus in this study addresses to installation of PV modules in industry sector in Albania. Interest in PV module installations for self-consumption, especially in the industry sector but not only, is growing. In a previews study [13], it is shown that the use of PVWP technology for irrigation in Albanian agriculture sector, is considered an innovative and sustainable solution with the aim to provide a lot of economic benefits to the farmers including the reduction of specific energy use and also help to mitigation of GHG emissions.

Under the current conditions of the energy crisis that the world is going through, electricity prices are going higher both for family consumers and businesses. With the new regulations that are defined by Albanian government, businesses that are connected to 20kV, 10kV, 6kV transmissions lines must secure the energy supply by their selves in open market. Since a part of price was covered by government in the past, now companies are facing higher prices. The new price is expected to increase more than 70%, up to 0.16 €/kWh from 0.092 €/kWh but the expectation for the future is that they can grow up to 3 times in open market conditions.

The opening of the electricity market offers promising opportunities on the increase of the use of alternative technologies, especially for solar power, not only for businesses but also each family in Albania. The distributed photovoltaic energy resources have the advantage of avoiding network problems as they are produced directly in the place where their consumption is needed. Another advantage in Albanian conditions is the fact that out of the total number of consumers one third is located in the capital and the rest in the largest urban and rural areas of the western lowland or in other areas with high solar radiation [14]. But besides this, the dramatic decline in solar photovoltaic (PV) costs in the last decade, driven significantly by technological innovations, has also helped to enhance product's performance by making LCOE's values for electricity produced by rooftop photovoltaic investments, as well as other economic benifits such as the payback time, to satisfy customer needs. So, companies that will be in the open market will face price volatilities, hence with the installation of PV modules, reduction of electricity price is possible.

Between 2010 and 2020, total installed system costs in the commercial rooftop markets decreased between 69% and 88% and the solar modul prices fell by up to 93%, as the cumulative installed capacity of solar PV grew from 40GW to 750GW. Whereas, the LCOE for commercial PV up to 500 kW declined between 50% and 79%. In 2020, the lowest average LCOEs for commercial PV up to 500 kW were in India and China, at USD 0.055/kWh and USD 0.060/kWh, respectively (see in Figure 3) [15].

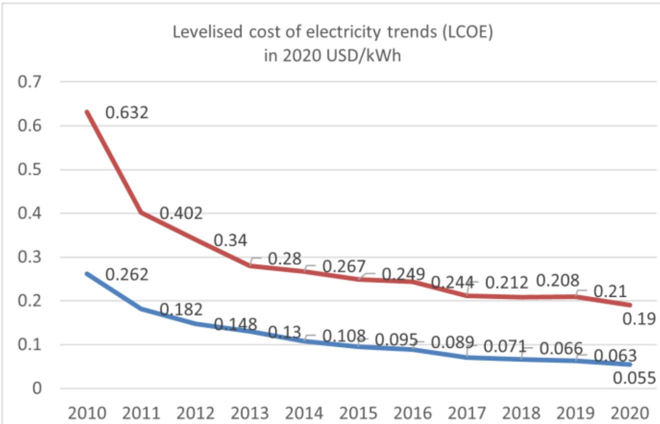

Fig.3 *The levelized cost of electricity (LCOE) trends for commercial rooftop photovoltaic PV up to 500kW between 2010 and 2020. Source: IRENA [15].*

By all expectations, the current crisis will not be transient, with estimates predicting high prices for at least two years. This situation has especially encouraged businesses in the free market to find alternative forms, to reduce the burden of high energy bills.

Until now, there are about 7 businesses in Albania, mainly in Tirana, Durrës and Korça that have installed PV modules for self-consumption.

2. Materials

The case study we have considered is that of a rooftop photovoltaic investment of 217.18 kWp installed power, at a packaging factory in Durrës ($41^0$19’38.4’’N, $19^0$28’26.0’’E) as it shown in Figure 3.

Fig.4 *The location of the proposed rooftop photovoltaic plant.*

The roof surface of the object covered by photovoltaic (PV) plant is 1520.96 m^2.

The data provided both from Albanian Meteorogical Institute and Nasa [16] show that Durrës region where is the PV plant, has a high solar potential (see Figure 5).

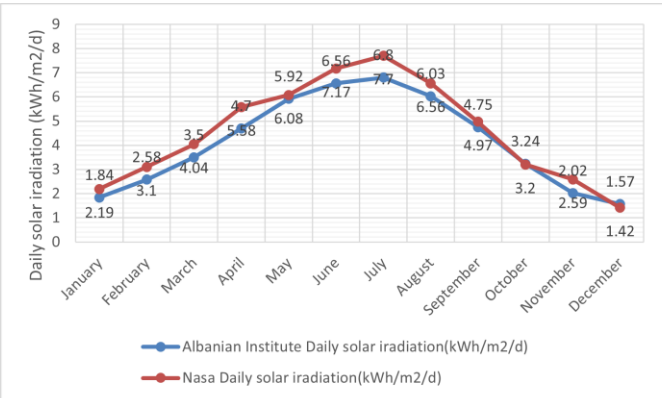

Fig.5 *Daily solar radiation (kWh/m^2/d) at the location of photovoltaic plant.*

As it shown the highest values are observed during the summer season of the year, while the lowest values are observed in the winter months. The highest solar radiation value 7.7 kWh/m^2/d is reached in July, while the lowest value 1.42 kWh/m^2/d hits in December. In Table 2 are shown the site-specific solar energy data for the site of proposed PV plant in Durrës region.

Table2: *The specific solar energy data for Durrës region.*

Specific photovoltaic power output	PVOUT specific	1554.9	kWh/kWp
Direct normal irradiation	DNI	1708.3	kWh/m^2
Global horizontal irradiation	GHI	1630.6	kWh/m^2
Diffuse horizontal irradiation	DIF	614.9	kWh/m^2
Global tilted irradiation at optimum angle	GTI opta	1901.4	kWh/m^2
Optimum tilt of PV modules	OPTA	34/180	^{0}
Air temperature	TEMP	17.6	^{0}C
Terrain elevation	ELE	-5	m

Through this case study we seek to support the idea that the use of rooftop photovoltaic PV plants for self-consumption is one of the ways that businesses in the free market in Albania, can reduce their high energy bills. The main incentive mechanism is economic benefit (net benefits). Solar photovoltaics (PV) is already the cheapest form of electricity generation in many countries and market segments [17]. The cost of the electricity generated by a PV system is determined by the capital cost (CAPEX), the discount rate, the variable costs (OPEX), the level of solar irradiation and the efficiency of the solar cells. Of these parameters, the capital cost, the cost of finance and the efficiency are the most critical and improvements in these parameters provide the largest opportunity for cost reductions [18]. The capital expenditure of a PV system consists of PV modules, inverters, controls and other components of BOS (Balance of System) including mounting structures, cabling, transformers, infrastructure, planning, documentation and everything else except for the PV modules. Each time the global cumulatively produced volume of modules has doubled, the average price of PV module has been reduced by 23 to 24%. During the past decade, when more than 95% of all historic cumulative PV capacity has been installed, the price has decreased significantly faster, due to a combination of accelerated economies of scale, massive industrialization, and most probably a change in the equipment cost due to new equipment manufactures from Asia, using highly automated production lines [17, 18].

IRENA has projected a 59% cost reduction for electricity generated by solar PV by 2025.

Monocrystalline (Mono c-Si) PV modules were used for this project. Typical conversion (solar energy to electrical energy) efficiencies for common crystalline silicon modules are in the 11 to 15% range. Commercial production of c-Si modules began in 1963 when Sharp Corporation of Japan started producing commercial PV modules and installed a 242 Watt PV module on a lighthouse, the world’s largest commercial PV installation at the time. Crystalline silicon technologies represent 84% of market in the United States. In 2020 the vast majority of global PV module shipments (96%) used crystalline silicon technology [19].

There are a number of closely related, commonly used methods for evaluating economic performance of an energy project. These include levelized cost of energy (LCOE) method, net present value (NPV) method, benefit/cost (or savings-to-investment) ratio (SIR) method, internal rate of return (IRR) method, and discounted payback (DPB) method.

The LCOE considers all the costs associated with an investment alternative and take into account the time value of money for the analysis period. It is generally used to compare two alternative energy supply technologies or systems. But in the case of application of rooftop photovoltaic PV plant for self-consumption, it is natural that investor who is both the sole consumer of the energy produced by the plant, to be interested in the part covered by the electricity produced by the plant which is closely related to the time of repayment of the investment (equity payback). For economic calculations for this case study the RETScreen program was used. The technical parameters and the specific consumptions are provided from the monthly bills of factory’s owner.

The RETScreen International Photovoltaic Project Model can be used world-wide to easily evaluate the energy production, life-cycle costs and greenhouse gas emissions reduction for three basic PV applications: on-grid; off-grid; and water pumping. For on-grid applications the model can be used to evaluate both central-grid and isolate-grid PV systems. The on-grid model is the simplest system model (see in Figure 6). In particular no load is specified and no array size is suggested. Instead, the latter is suggested by the user. The suggested inverter is simply equal to the nominal array power. The energy available to the grid is what is produced by the array (E_A), reduced by inverter losses (equation 1):

$$E_{grid} = E_A * h_{inv} \qquad (1)$$

where h_{inv} is the inverter efficiency. Depending on the grid configuration not all this energy may be absorbed by the grid. The energy actually delivered is given by equation 2:

$$E_{dlvd} = E_{grid} * h_{abs} \qquad (2)$$

where h_{abs} is the PV energy absorption rate [20].

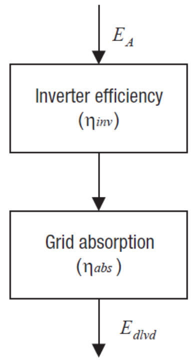

Fig.6 *Flowchart for PV On-Grid Model.*

3. Results

The designed photovoltaic plant is placed on the facility roof and the installed power is 217.28 kW. There are used 448 PV modules, manufactured by SUNPOWER, model SPR P3 480/485/480 UPP. The rate power of single model is 485W. It's a fixed solar tracking mode, with a sloped angel of 12.5 degrees, the same as the roof, and azimuth angel approximately 45 degrees, defined by facility orientation. The overall efficiency after 25 years of the PV models installed will be 85.5 % regarding the 1st year. With a capacity factor 15% calculated from RETScreen, the electricity exported to grid is calculated 286 MWh in a year. While, the electricity export revenue is calculated 28,600 €/year, with a specific price of 100 €/MWh. Furthermore, the O&M costs regarding practical projects and applications in Albania is calculated 8 €/kW-year, with a total cost of 1,738 €/year. The equity payback calculated in RETScreen results in 5.6 years, in the case where all the electricity is exported to grid as shown in Figure 7.

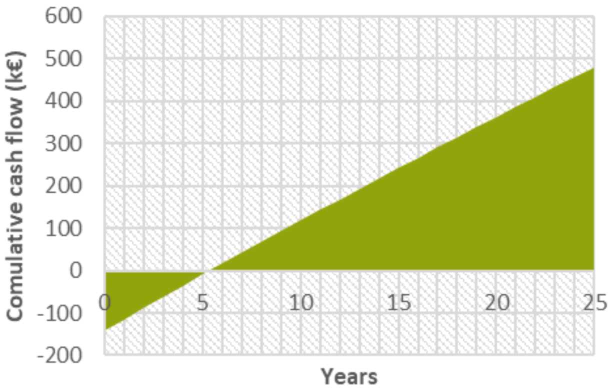

Fig.7 *The equity payback in the case where all the electricity is exported to grid.*

The PV plant generated electricity is equal to 52.4% of the company demand. But, only 68% or 194.5 MWh of the electricity generated from PV is consumed by the company, while 32% or 91.537 MWh is exported to grid because company works 8 h/day and there is not an electricity storage system installed. The calculated LCOE in Albanian referred to real projects is 0.035 €/kWh, including *20%* VAT tax. The total consumption of electricity in the company is 545.4 MWh a year, from which 35.7% or 194.5 MWh is generated from PV with cost 0.035 €/kWh and 64.3% or 350.9 MWh is supplied from the grid with cost 0.09 €/kWh.

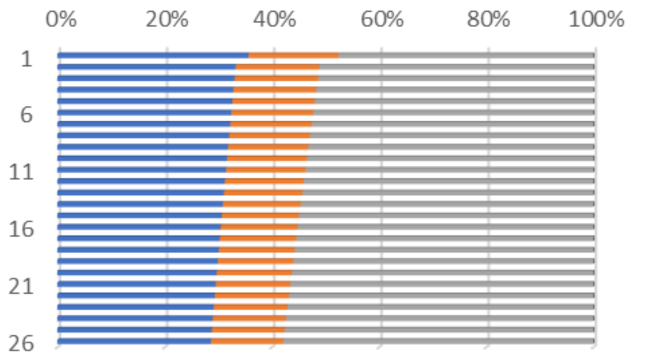

Fig.8 *Visualization of the electricity consumed by facility, exported to grid form the PV, and electricity generated from PV which is consumed by the company, respectively gray, red and blue colors in the chart.*

Which means in the first year the company will spend 32,286 € for the energy from the grid and 6,808 € for the energy supplied from the PV plant, with an overall cost of 39,094 €. While, if the energy supply will be only from grid, the company will pay 50,181€. So, the company will save 11,087 € in a year. Meantime revenues from electricity exported to grid generated by PV are 9,153€ (91.537 MWh x 100 €/MWh). In total company saves 20,240 € from electricity exported to the grid and to the company. That's only for the first year, while after 25 years, regarding efficiency 85.5% from the first year, the company will save 16,271€. In this case the equity payback calculated in RETScreen will be in 7.62 years (see in Figure 9).

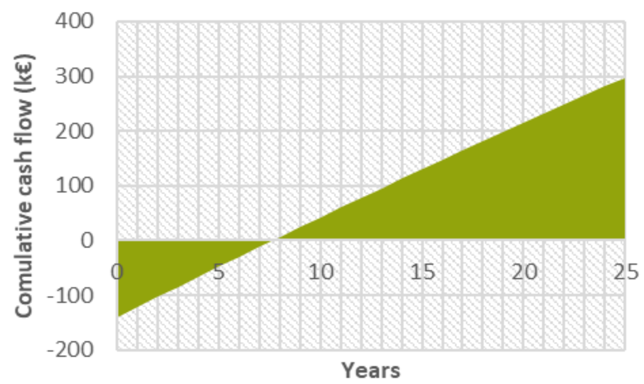

Fig.9 *The equity payback in the case where the electricity consumption is 35.7% from PV and 64.3% from the grid with electricity price 0.092€/kWh.*

In the other case where the price of electricity from the grid is 0.166 €/kWh, which is the price that companies connected to 20kV transmission line will face in the open market, for the same ratio of energy supply from the grid and PV, the company will save 33,468 € in total in first year, while after 25 years will save 26,905 € in a year. In this case the equity payback calculated in RETScreen will be in 4.56 years (see in Figure 10).

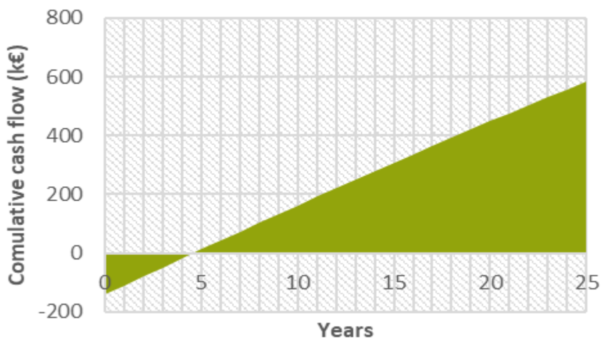

Fig.10 *The equity payback in the case where the electricity consumption is 35.7% from PV and 64.3% from the grid with electricity price 0.166€/kWh.*

There is taken also the scenario where the electricity price is doubled from 0.09 €/kWh to 0.18 €/kWh, for the same initial data as the other cases, in the 1st year will be saved 37,358 €, while after 25 years will be saved 30,032 €. Regarding RETScreen, the equity payback period will be in 4.1 years (see in Figure 11).

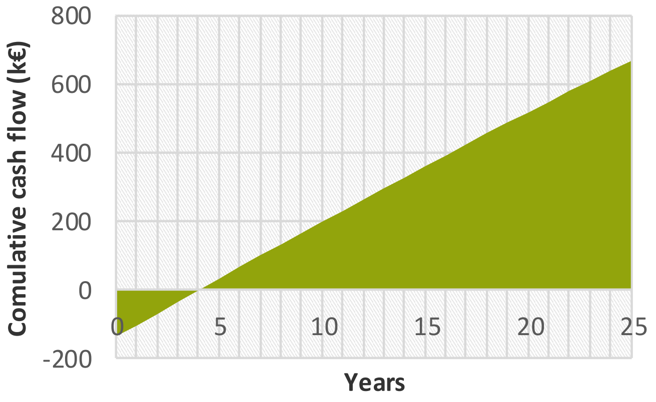

Fig.11 *The equity payback in the case where the electricity consumption is 35.7% from PV and 64.3% from the grid with electricity price 0.18€/kWh.*

4. Conclusions

The present study shows the financial effect of the integration of PV plant with electricity company grid in Albania. The PV installed power is 217.28 kW, which generates 286 MWh yearly, with an LCOE including 20% VAT tax in Albania equal to 0.035 €/kWh. While the electricity consumption of the company is 545.4 MWh yearly, from which 35.7% is generated from PV and 64.3% is supplied from the grid. The electricity grid price is 0.092 €/kWh. According to new decisions made by the Albanian government the price of electricity will increased to 0.166 €/kWh for businesses that are connected to 20kV, 10kV, 6kV transmission lines. In this study are taken four different cases. In the first case all the electricity generated from PV is exported to grid, with an electricity price of 0.1 €/kWh, payback period will be 5.6 years with cumulative cash flow (CCF) equal to 478,949€. In the second case electricity consumption is (35.7%) from PV and (64.3%) from grid with prices respectively 0.035 €/kWh and 0.092 €/kWh, the payback period is calculated 7.62 years with a CCF equal to 297,608€. The third case has the same ratio of electricity consumption from PV and grid, but changes the price of electricity supplied from the grid, which is 0.166 €/kWh and will be the new electricity price as mentioned above. In this case the payback period is calculated 4.56 years and CCF equal to 584,380 €. Also, in the fourth case the ratio of electricity supplied from the grid and PV is the same, but the price changes to 0.18 €/kWh, which is a supposed price in case the price of electricity doubles. In this case the payback period is calculated 4.1 years and CCF is 668,725€, (Table 3).

Table 3: *Electricity prices and payback year for all the cases*

Cases	Electricity price [€/kWh]	Payback year
Case 1: All electricity generated from PV is exported to grid	0.1	5.6
Case 2: Electricity consumption (35.7%) from PV and (64.3%) from grid	0.035 (35.7%) 0.092 (64.3%)	7.62
Case 3: Electricity consumption (37.5%) from PV and (64.3%) from grid	0.035 (35.7%) 0.166 (64.3%)	4.56
Case 4: Electricity consumption (37.5%) from PV and (64.3%) from grid	0.035 (35.7%) 0.18 (64.3%)	4.1

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