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Potential use of photovoltaic panels in Moldova

Bachelor thesis

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I hereby declare that this thesis entitled „*Potential use of photovoltaic panels in Moldova*“ is my own work and all the sources have been quoted and acknowledged by means of complete references.

In Prague

Signature

Acknowledgment

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Abstract

The present thesis concerns to the area of renewable energy sources development, particularly of solar energy potential in Republic of Moldova. In the context of growing demand of alternative energy, as the global fossil fuel supply is not infinite, the objective of this thesis was to analyze the available methods and modern technologies used to convert solar energy into electric energy, in order to understand the potential power of solar energy, and to calculate the amount of produced energy by use of modern solar installations. Elaboration of these methods gives the chance to determine the possibility to implement innovative type of energy technologies such as solar photovoltaic installations in conditions of Republic of Moldova.

The bachelor thesis “Potential use of photovoltaic panels in Moldova” is divided in two parts, first is the literature review part, which was made up by the aid of latest information found in scientific publications, and the case study part where was analyzed the production of energy, and calculated the total amount of electricity that can be produced in a region of Moldova. The methodology of case study was based on analyzing the location, required steps and necessary costs for implementing a photovoltaic power plant project, and also calculation of the total amount of energy production by use of latest scientific calculators for solar energy in a certain region (selected village). As Moldova is highly dependent on energy import, implementing and investing in such innovative projects for the poorest country in Europe may be crucial challenge for making it more self-independent on energy supply. As the results showed, only a small installation of 0.33 ha of solar panels, could supply almost 1/5 of energy demand of a village with 2,500 inhabitants. The shareholders in the process of starting such new innovative projects need to understand that without any assistance and support from the government and professional know-how for implementing such projects and technologies, utilization of solar energy in Republic of Moldova is not perspective.

Key words: electricity, solar radiation, solar panels, renewable energy, orientation angle, Republic of Moldova

Abstrakt

Předkládaná práce se týká oblasti rozvoje obnovitelných zdrojů energií, zejména potenciálu solární energie v Moldavské republice. V souvislosti s rostoucí poptávkou po alternativních zdrojích energie a tenčícími zásobami fosilních paliv, cílem práce bylo identifikovat potenciál sluneční energie pomocí analýzy metod a technologií používaných pro přeměnu solární energie na elektrickou energii a pomocí výpočtu množství vyrobené energie prostřednictvím moderních solárních instalacích. Zpracování těchto metod přispěje k určení možných realizací inovativních energetických technologií, jako jsou solární fotovoltaické elektrárny, v podmínkách Moldavské republiky.

Bakalářská práce „Potenciální využití fotovoltaických panelů v Moldavsku“ je rozdělena na dvě části, první představuje literární rešerši, která byla sepsána pomocí nejnovějších poznatků nalezených ve vědeckých publikacích, druhá část představuje případovou studii, která se zabývala analýzou energetické produkce a vypočítáním celkového množství elektřiny vyprodukovaného z photovoltaických panelů v dané oblasti Moldavska. Metodika případové studie byla založena na analýze dané lokality, dále na rozboru potřebných kroků a nezbytných nákladů pro implementaci projektu fotovoltaické elektrárny a rovněž na výpočtu celkového množství vyrobené energie s použitím nejnovějších vědeckých kalkulátorů solární energie pro určitý region. Vzhledem k tomu, že Moldavsko je vysoce závislé na importované energii ze zahraničí, zavadění a investování do takovýchto inovativních projektů může být pro tuto nejchudší zemi Evropy zásadní výzvou pro to, aby se Moldavská republika stala méně závislou na zásobování energií. Jak ukázaly výsledky studie, malá instalace solárních panelů o rozloze 0,33 ha, může pokrýt téměř 1/5 energetické poptávky jedné vesnice s 2500 obyvateli. Všechny zainteresované subjekty, které jsou v procesu zahájení těchto projektů, si musí uvědomit, že bez jakékoliv pomoci a podpory ze strany vlády a bez odborné znalosti pro realizace takovýchto projektů a technologií, využití solární energie v Moldavské republice nemá perspektivu.

Klíčová slova: elektřina, solární záření, solární panely, obnovitelné zdroje energie, orientační úhel, Moldavska republika.

Content

1. Introduction

Technical and technological progress of the XX century, changed today's world economy and social life on the new level. Modern transportation, radio, television, computers smart phones, all of them changed our day to day lifestyle, and entirely transformed small boring villages in big highly active cities. All of these changes are based on the energy sector, which from the beginning of the last century till today, is using more than 90% as primary energy - the fossil fuels: petrol, gas, coal. Of course, this was a big path for the humanity, and even now the technological progress is continuing growing, but we need to think about the future and to understand that these types of fuels are not infinite. With today's proven reserves, we will run out of fossil fuels by 2112, where the coal will be the only remaining fossil fuel after 2042 *"fossil fuel reserve depletion times for oil, coal and gas is approximately 35, 107 and 37 years, respectively"* (Khan, 2013).

We all know that the climate change is unavoidable without a huge reduction of greenhouse gases from burning of fossil fuels, like is written in the book *"Ending the fossil fuel era*": fossil fuels – "*we can't live without them, the lifeblood of modern industrial civilization"*, and fossil fuels – *"we can't live with them, the fire in the oven destined to bake civilization beyond recognition"*(Princen, 2015). The rise of economic development has been influenced largely by expansion of using fossil fuels (oil, gas, coal). Today, we find that this fantastic progress is the same as the generated problems that occurred, never known before that in whole history. Civilization came into direct conflict with the environment, with the natural support of their existence and life on earth, not only by exhaustion of natural energy resources, but mainly by deteriorating the quality of our environment- water, soil, air. Accelerating the development of modern society amplified the pressure on nature to which we remain dependent. New forms of environmental imbalances such as ozone depletion in stratosphere, or the atmospheric warming which causes global warming- began to noticeably alert our ecosystems, our health, and our population. In such hard situations we need to undertake urgent and radical actions to avoid possible environmental crisis and to ensure future generations a healthy and sustainable development of our environment. In the process of solving these problems all countries need to be involved regardless their territorial dimensions or their economic potential. Being a house for all our nations, our Earth need to be protected with common efforts. That's why today several developed countries implemented comprehensive policies for developing low-carbon energy sources. One of them is solar energy.

Solar energy is the most inexhaustible and cleanest of all renewable sources of energy that we have today. The power from the sun that is coming to Earth is many times larger than the present rate of all energy consumption in the world. Modern technology, can transform solar rays into electricity, provide light, or heat the water for domestic, commercial or industrial use. This means that for the future, the transition from fossil fuels to renewable, mainly to solar energy will be the most crucial and monumental challenge for our society. Energy security rose to a new level in last decades, because today, the development of a country is highly based on the natural resources that it has, which begins to be as a strategic field for every single country, and for Republic of Moldova inclusively.

Because I am writing this bachelor thesis about the potential use of photovoltaic panels in the Republic of Moldova, in the next chapters I will describe the economical and energetic situation of this country, also by comparing with European Union, from which I will deduce mainly the need of this type of energy, and the amount of it or more precisely energy gap, so it will be clear the reasons of implementing and developing a new clean, renewable and sustainable type of energy in Republic of Moldova.

2. Literature review

2.1 European Union- new energy objectives

Republic of Moldova is a small landlocked country in Eastern Europe, bordered with Romania to the west and Ukraine to the north, east and south. This territory is also known as Bessarabia, which was annexed by the USSR in 1940 following the dividing of Romania in the Ribbentrop-Molotov pact between two dictators regimes. Once it obtained the independence in 1991, all energy industry that was constructed during the Soviet Union passed to the new formed constitutional government (World Bank, 2015). If talking about natural gas, according to scientific article Power Resources: The political agenda in Russo-Moldovan gas relations, in Moldova are constructed approximately 21, 000 km of gas pipelines, through by, Russian Federation is transiting annually 20 billion cubic meters, which is 10 time more than actually is consuming (Baltag, 2014). Generally, Republic of Moldova is wholly dependent on Russian gas, that's why is very important for the country to be more energy independent and to develop new sources of energy. Currently, rural and urban communities in Moldova are between tradition and modernity, with a small balance inclined to modernity. When it's called "tradition", it means that the infrastructure, buildings, roads or mentality didn't changed since last 2 decades, but it is important to notice that in many cities and villages we can find successful cases of implementing modern projects related to the use of renewable energy. In that context with an approaching of Republic of Moldova to European Union (EU) by signing in 2014 the Association Agreement with EU (European Council, 2014) are relevant the words of European Energy Commissioner Gunther Oettinger (2014) "*European renewable policy is now more important than ever*". Renewable energy has a crucial role in reducing greenhouse gas emissions and other forms of pollution, and increase the energy supply and safety which support the European energy industry that leads the world. For this reason EU leaders decided to adopt targets to increase the minimum use of 20% of renewable energy across the European Union by 2020. This is one of the goals that is set in Renewable Energy Directive, and represents the „headline" of the whole European framework. This is directive no. 13 (from 23-th of April, 2009) where is written that "*In the light of the positions taken by European Parliament, the council and the commission, it is appropriate to establish mandatory national targets consistent with a 20% share of energy* *from renewable sources and a 10% share of energy from renewable sources in transport in Community energy consumption by 2020*". This also means that EU needs to encourage and to provide a lot of possibilities for continuous development and growing of technologies which generate energy from all types of renewable energy.

In a globalized economy, energy strategy of a country is highly dependent on changes that are made worldwide. Developing countries, mainly China and India, but also those countries with economies in transition, exert great pressure on global energy demand due to economic growth and structural changes in economy. Basically between 1994-2004 these countries doubled their oil demand, and in 2006 exceeded 20 mln. barrels per day, which represents approximately 40% of global oil demand (BP, 2015). Primary energy demand changed in developing countries from 22% in 1970 to 39% in 2003, which indicates that total energy demand in 2030 will be about 50% higher than in 2003, and for oil about 46% higher (World Energy Council, 2016). That means that economic growth through a lot of countries are passing, indicates to a raising demand of natural resources. In March 2006, the European Commission has analyzed the EU's energy and possible developments in the field, publishing their conclusion in a document titled „Green paper- a European strategy for sustainable, competitive and secure energy". The title already reflects the objectives that European Union has set for its energy policy: a sustainable development of the field in good relation with the environment, as well as the transformation of energy sector in a factor of competitiveness and stability, both in terms of meeting EU energy requirements. Strategy develops six priority areas (European Council, 2015):

1 The development of competitive markets for electricity and natural gas.

2 An internal energy market that guarantees security of supply: solidarity between member states.

3 The community needs a real Community-wide debate on different energy sources.

4 Europe needs to deal with the challenges of climate change in a manner compatible with its Lisbon objectives.

5 A strategic energy technology plan.

6 A common external energy policy.

So the Green Paper sets out a number of areas where member states should cooperate most in: energy savings, promote renewable energy, investing in new energy technologies and use a single voice in international discussions and negotiations in energy problems.

2.2 Energy sector in Republic of Moldova

Moldova is dependent on energy imports by approximately 95% (UNDP, 2013). This dependence has demonstrated over recent decades a vulnerability of national economy and population, because of rising prices for energy purchase. At the moment, the development of energy sector in Moldova is controlled by Moldova's energy strategy until 2020 (approved by Government Decision no. 958 of 21.08.2007), the main purpose of which is to create an energy efficient structure, which will ensure the country's energy security, modernization of energy infrastructure and integration in the European energy market. As with today's approaching tendency of Republic of Moldova to the European family, this country need to make some reforms with its energy market and structure, to have a better efficiency policy, a modern energy industry, and a good understanding of working with the European countries.

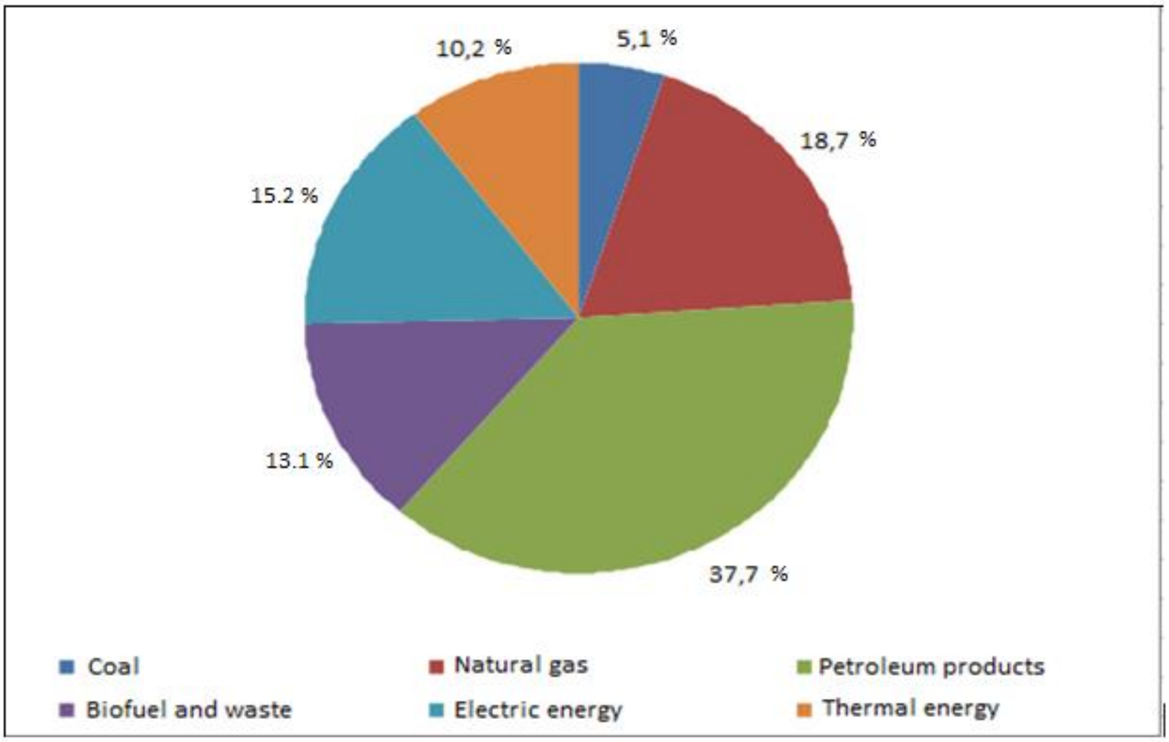


Figure 1. Forming of energy and fuel resources in Moldova, %

Source: National bureau of statistics, 2014

Moldova's energy stocks consist of electricity sector, thermal power, natural gas and petroleum products. National electricity sectors have a generating capacity of approximately 500 MW. It consists of heating power plant's (HPP) of 24 MW, 66 MW, 240 MW, also Costesti hydropower plants 16 MW and Dubasari 48 MW (Sula, 2014).

The electricity consumption of Moldova is presented in the Figure 2 below.

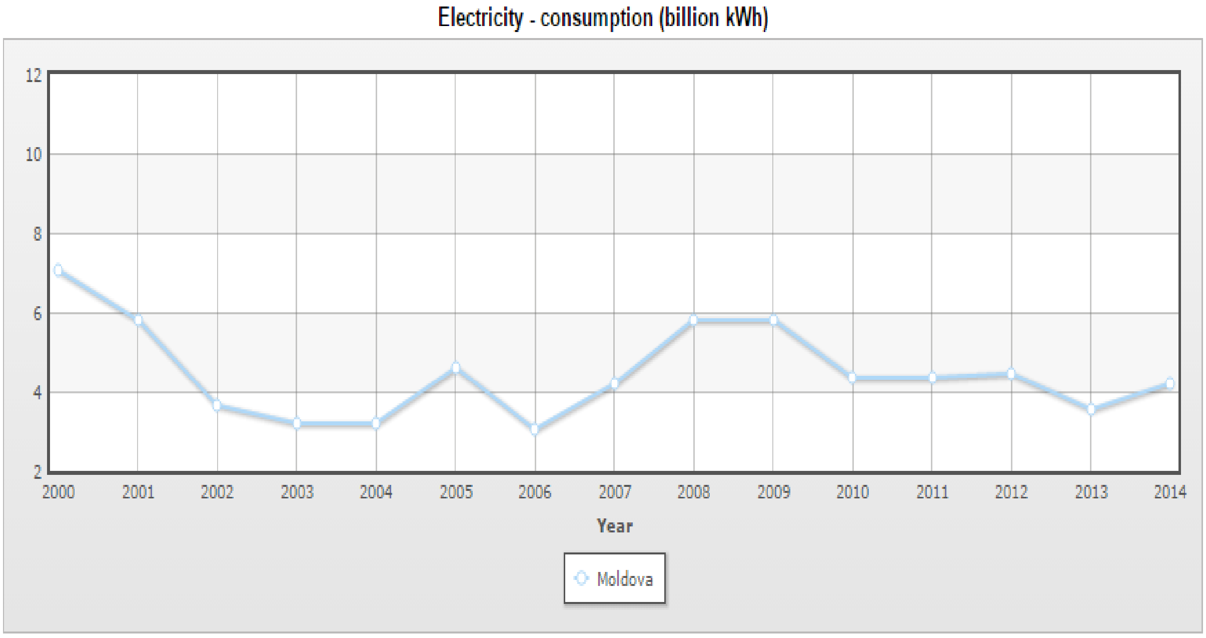


Figure 2. Electricity consumption in the Republic of Moldova

Source: CIA World Factbook, 2015

For distributing of electricity are responsible following companies: „Moldelectrical" for transmission and dispatching, RED Union Fenosa (private company) for distributing 72.6% of electricity for 65.13% consumers, RED NORD (state company) for the supply of electricity by 16.61% for 21.6% of total consumers, and RED NORD-VEST (state company) covers 8.74% of electricity market to 13.28% of consumers (Ministry of Economy of Moldova, 2013).

The natural gas sector is monopolized of gas imports from a single source. Moldovagaz is the main responsible for delivery of natural gas in Republic of Moldova. This company is managed by Russian Gazprom which is in possession of 50%, 35% are in possession of government of Moldova and 14% being held by Tiraspoltransgaz (Ministry of Economy of Moldova, 2013). According to International Energy Agency statistics (2006) Republic of Moldova is the leader among the countries that do not have his own energy resources, and the energy balance is monopolized by natural gas. These facts convince us that more than half of domestic gas industry is controlled by the Russian Federation, which causes the Moldavian government to have a very limited space for negotiations on natural gas import price (International Monetary Fund, 2013).

It is very important to note that the natural gas price development is very closely related to the electricity price (including the purchase from domestic power plants), heat and other industrial products whose production is based on natural gas. In the Figure 3, we can see how since 2005 costs for natural gas raised from 80 USD/1000m^3 till 374 USD/1000m^3 in 2014.

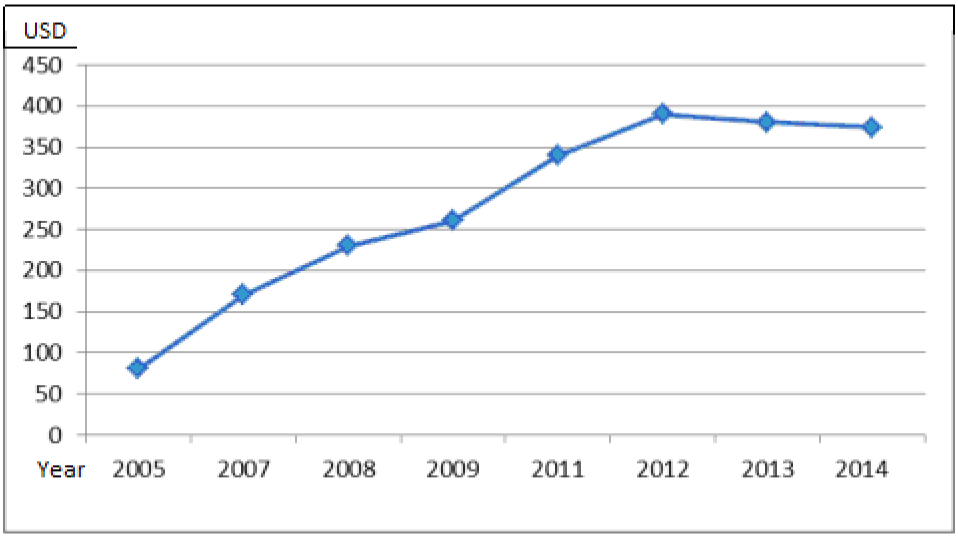


Figure.3 Natural gas import price in Republic of Moldova, USD for 1000 cubic meters
Source: National bureau of statistics, 2015

On imported electricity, I will mention that in 2002-2006 Republic of Moldova, imported this type of energy from Russia through Ukraine, under a trilateral agreement between Moldova-Russia-Ukraine (Oxford institute, 2016). But since 2006 electricity supplies were monopolized by Ukraine as imports from Russia has been stopped because of increasing transportations tariffs and transit via Ukrainian territory. At the same time, since 2008 appeared the Transnistrian alternative, which made possible in recent years to import electricity from both Ukraine and from Russia (through Transnistria which is under control of Russian Federation). The share of electricity in the structure of imports of energy resources had a small improvement, so in 1999 it constituted about 19% of the total volume of energy imports, in 2006 – approximately 12%, and in 2013 - 11% (National bureau of statistics of

Moldova, 2014). On import prices, the situation is as follows: 5.5 cents/kWh in 2008, 5.8 cents/kWh in 2009, 6.9 cents/kWh in 2012/2013 and 6.8 cents/kWh in 2014. Increased energy prices it is explained by the increasing price of natural gas, as in Ukraine, and in the Transnistrian region of Moldova, electricity production is based on natural gas, and it is purchased from a single source. As I said before, this is very important to understand, as the price of gas and electricity is influencing directly the need of using alternative sources of energy, otherwise renewable sources of energy which are very important in situation when the prices on gas and electricity are increasing each year. In Figure 4, we can see how price on electricity increased in last decade.

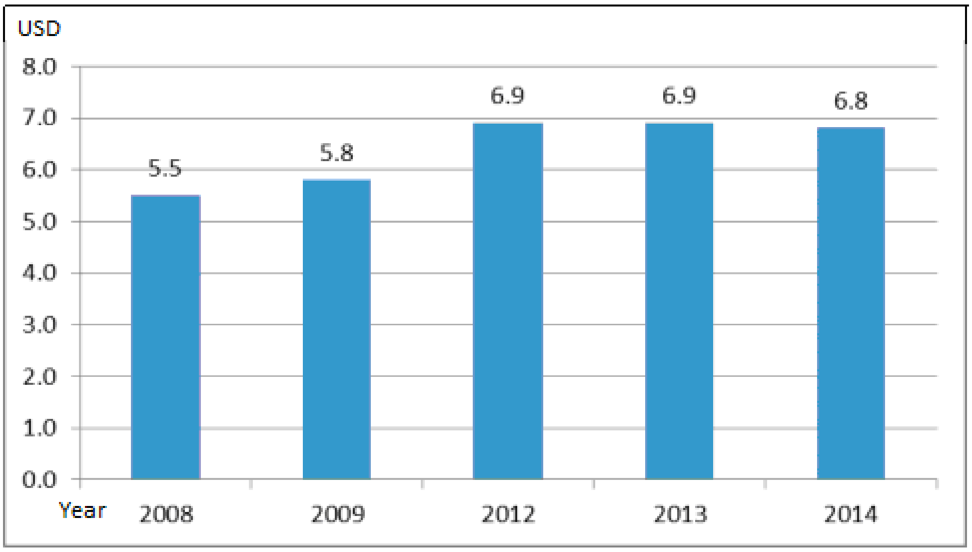


Figure 4. The price for electricity in Republic of Moldova, cents per 1 kWh

Source: National bureau of statistics, 2015

Referring to the domestic power system interconnection with neighboring states we can mention that with Romania Moldova have an airline of 400 kV, and three lines Vulcanesti-Isaccea of 110 kV (World Bank, 2015). Also, we need to know that there is a need for additional high voltage line to meet safety criteria and increase the capacity of the interface. By 2020, it is expected that interconnection with Romanian power system should be supplemented by high voltage line: Suceava-Balti, Straseni-Ungheni-Iasi. Also, it is appropriate to notice that at 18 February 2011 was signed an agreement between “Moldelectrica“ from Moldavian part and “Transelectrica“ from Romanian part on construction of 400 kV Balti (Moldova) - Suceava (Romania), for which a feasibility study was financed by EBRD (European Bank for Reconstruction and Development) showing a total cost of 66.5 million euro, of which about 37 million euro are for the Moldavian part. Project financing was expected from the EBRD and EIB (European Investment Bank) financial resources (Moldelectrica enterprise, 2013),

From the over side, on interconnection with Ukraine, there is a need of a increasing capacity by the construction of two overhead lines of 330 kV „Balti-Dniester“ with the length of 123 km (86 km in Moldova). The feasibility study on the Moldovan side has been completed, and the estimated cost of the project is about 15 million euro (6 million euro for the Ukrainian part and 9 million euro for the Moldavian part) (Ministry of Economy of Moldova, 2015).

2.3 Renewable energy sector in Republic of Moldova

Renewable energy and the topic of energy efficiency in Moldova is relatively new, which determined that this segment is one underdeveloped. Currently in Moldova still we can identify some infrastructure to generate energy from renewable energy sources (RES). Thus, one of the largest projects in this field is the project „Energy and biomass“, that was implemented between 2011-2014 and aimed to contribute a secure, competitive and sustainable energy production from renewable sources, especially biomass and agricultural waste. The project was working on increasing the use of renewable energy sources, especially for heating public buildings and households in rural areas. The project was based on the creation of many functional biomass technologies markets that should ensure sustainability of project effects even after it’s finishing. By replacing the traditional sources of energy with easily accessible biomass, the project focus was also to contribute to significant reduce of greenhouse emissions and environmental pollution. Training programs and specific national campaigns combined with a school education program supposed to change in substantial way the knowledge and the attitude of the population towards RES, laying the basis of increasing use of sustainable energy technologies in the future. The total budget of the project was 14.56 million euro allocated by European Commission (14 mln. euro) and UNDP (United Nations Development Programme, 560,000 euro). It should be noted that through the project „Energy and Biomass“ were installed modern installation based on biomass heating in 123 public institutions (schools, kindergartens, community centers and municipalities) in rural areas of Republic of Moldova, with energy and thermal comfort with costs less up to at least 30% for more than 37,000 people. The new biomass boiler led to the creations of 283 new jobs and to launch dozens of new societies and companies that are producing biomass fuel.

Regarding the wind power in the country, were installed about 25 stations producing this type of energy, of which 20 was with a small installed power, that operates at small agricultural enterprises (farms, agricultural plantations). Only in 2013 were launched four investment projects in wind energy.

In 2013, the total amount of produced energy from renewable sources in Republic of Moldova was 826,843 kWh (Energy efficiency agency, 2015). This energy was mainly produced from biomass, wind power and solar power. In Figure 5 is shown the total potential of these 3 types of renewable energy:

Solar	50.4 PJ
Wind	29.4 PJ
Biomass	21.5 PJ

Figure 5. Technical potential of the main renewable sources of energy in Moldova.
Source: Ministry of Economy of Moldova, 2015

As we can see from Figure 5, solar energy has the biggest potential in Moldova, but unfortunately this country doesn't have enough money and the know-how to implement this new type of energy on the market (EBRD, 2015).

Using RES presents a complex problem with many contradictory aspects. Back in the beginning of 20th century, Moldova was an entirely agrarian country, and its energy consumption was based only on renewable energy sources. With industrialization of the country, fossil fuels removed RES, and towards the middle of the last century, for instance disappeared one after another over 6,200 windmills, and hundreds of watermills also were destroyed. Some were replaced in the 50s with small hydropower plants, which by 80s were also closed. Thus, in the late 80s, the fossil fuels occupied the energy balance of Moldova by 98%, which was entirely imported from abroad (MoSEFF, 2015) So today's economic and ecological situation requires a returning, to the using of energy as it was 100 years ago, but in a modern way. But this is not so easy as it might seem at first glance. First, the use of renewable energy sources must be made at another technological level and of course economically justified. Beside this, RES utilization and implementation are retained by a number of barriers and impediments. The main barrier for most of cases is the investment costs of technologies that are need for using RES, which increases considerably the payback time. To this we can add also the fact that taking a loan from the bank is also unattractive because of high interest rate. This field is also unattractive to local business because of complete lack of financial mechanisms in budget policy of the country, including the VAT (value added tax) on the import of machines and components for using RES. Also there is no support for local producers of such products (Energy Efficiency Fund, 2015)

Another objective, that temporarily causes current retention of RES exploitation in Moldova, is access to cheap Russian energy market. I am saying cheap because comparing to the costs of RES technologies the price is comfortable, but this fact is only for short term, because by time, with raising prices of fossil fuels, the transition to alternative energy will be crucial, so purchasing new renewable energy technologies are worth it for long term period, which is important for a country that cannot influence the global prices of natural gas or oil, as it has no natural resources. Raising prices of fuel on the Russian domestic market and the need to renovate the capacity of energy generators in this country over net 5-10 years will bring prices to a new high level on a global scale (Henderson, 2011). A separate issue from this point of view is the natural gas. Natural gas is a very convenient fuel. The maintenance and burning of gas is very simple, and requires less operating costs than other liquid or solid fuels. But natural gas has a number of disadvantages associated with transportation through pipelines and with holding reserves near local business for example. These disadvantages reduces the energy security supply of consumers and of the country entirely, both of them are dependent on technological facts and on two or more interdependent monopolists that controls the gas supply, gas transportation or distribution. Monopolist character that is present in Europe, makes the gas price most expensive type of energy in Central and Western Europe (Drebentsov, 2015). In the energy balance of Republic of Moldova natural gas share is over 50%, so in the next 10 years this exaggeration of using natural gas so much, can cause to very unpleasant consequences and therefore the Moldavian government should take some action to reduce the negative impact on national economy of the republic (Luchian et al, 2014)

Although investments in RES are big and the prices of energy from fossil fuels are relatively small, there are several uses of RES where they are competitive with conventional energy sources. The use of this type of energy is complicated by the need to create industries and infrastructure, which would ensure technological chain: design - production equipment - installation - energy production- energy distributing. Also there is a barrier such as unfair competition from societies and companies that are trading and selling fossil fuels (Junginger et al, 2010). Through state structures or local government, which can influence, they block the creation and development of infrastructure to future rise of RES market. The lack of comprehensive database about potential use of renewable sources also slows down the development of this energy type. Although some data are available, they are scattered in various state institutions and not always accessible for everyone. Potential investors should have access to information freely and without additional payments (as it can happen usually in Moldova, many times even through corruption) to know the overall situation about distribution of this energy in different regions.

To all mentioned above I need to add also impediments as was published by Chetrusca, (2009) like:

1) Consumer habit with using large centralized systems of power supply of electricity, and renewable energy systems usually are based on low productivity and are autonomous.
2) Specialists got used to high concentrated centralized power plants, so they are not used to work with the smaller one.
3) Insufficient knowledge of new technologies and modern installation in this field.

2.4 Solar energy – basic principles

Solar energy is created by light and heat which is emitted by the sun, in the form of electromagnetic radiation. With today's new technologies, our generation is able to capture this radiation and turn it into usable forms of solar energy - such as heating (thermal) or electricity (photovoltaic) (National Renewable Energy Laboratory, 2013). Solar energy is the sun's nuclear fusion reactions within the continuous energy generated. Earth's orbit, the average solar radiation intensity is 1367 kw/m² (Stickler, 2013). Circumference of the Earth's equator is 40,000 km, thus we can calculate the energy the earth gets is up to 173,000 TW (NASA, 2014). Basically thinking, humans rely on solar energy to survive, including all other forms of renewable energy. Although the total amount of solar energy resources is ten thousand times of the energy used by humans, but the solar energy density is low, and it is influenced by location, season, which is a major problem of development and utilization of solar energy (Banu, 2015). The technical feasibility and economic viability of using solar energy depends on the amount of available sunlight (solar radiation) in the area where you intend to place solar heaters or solar panels (photovoltaic panels). This is sometimes referred to an available solar resource on that field, or the potential solar resources in that region. The amount of sunlight available is one of the most important factor to take into account when considering using solar energy. There are a few other factors, however, which need to be looked at when determining the viability of solar energy in any given location that also highly influence the decision to put solar panels (Li, 2010). These are as follows:

- Geographic location
- Time of day
- Season
- Local landscape
- Local weather

2.5 Photovoltaic Systems

The term "Photovoltaic" is derived from the combination of Greek word "*photos*" which means "light", and the unit name for electromotive force- volt. Thus the technology photovoltaic (PV) describe the generation of electricity using the sunlight (Bansal, 2015).

Already in ancient Greece it was known that light energy can be used, for example in battles where they focused the sunlight with mirrors and refer it to the fleet of Romans, and burning it in this way. Also they used light energy for burning the Olympic Flame. Alexander Edmond Becquerel in 1839 discovered that a battery exposed to the sun produces more electricity than one unexposed (Mondal, 2015). For this experiment he measured the potential difference between two platinum electrodes situated on one faced to the sun, and another faced to the shadow, and immersed in a acid chemical solution. When he exposed this to the sun, he noticed a passing current through the electrodes. So Becquerel discovered the photoelectric or photovoltaic effect (David et al. 2015)

Photovoltaic technology generates electricity measured in watts (W) or kilowatts (kW) of semiconductor when they are illuminated by photons (Hegedus, 2003). The main components of the solar panel are photovoltaic solar cells. PV modules from silicon (Si) crystalline (c-Si) are divided according to the type of the crystalline structure of the silicon used: multicrystalline (multi-Si), also called polycrystalline, monocrystalline (mono-Si), and hydrogenated amorphous (a-Si) (Hegedus, 2003). PV modules with thin layers are now in minority in the world, but with big market expansion in the world which are divided into a a-Si, CdTe (based tellurium cadmium, CdTe, or base material cadmium sulphide, CdS), and CIS (cooper, indium and selenium, CuInSe2) (Gușă, 2013). The remaining types of PV modules (eg. organic stacked) are still too immature developed to appear into the market (NREL, 2015). In the Figure 6, we can notice the evolution of photovoltaic cells and their efficiency.

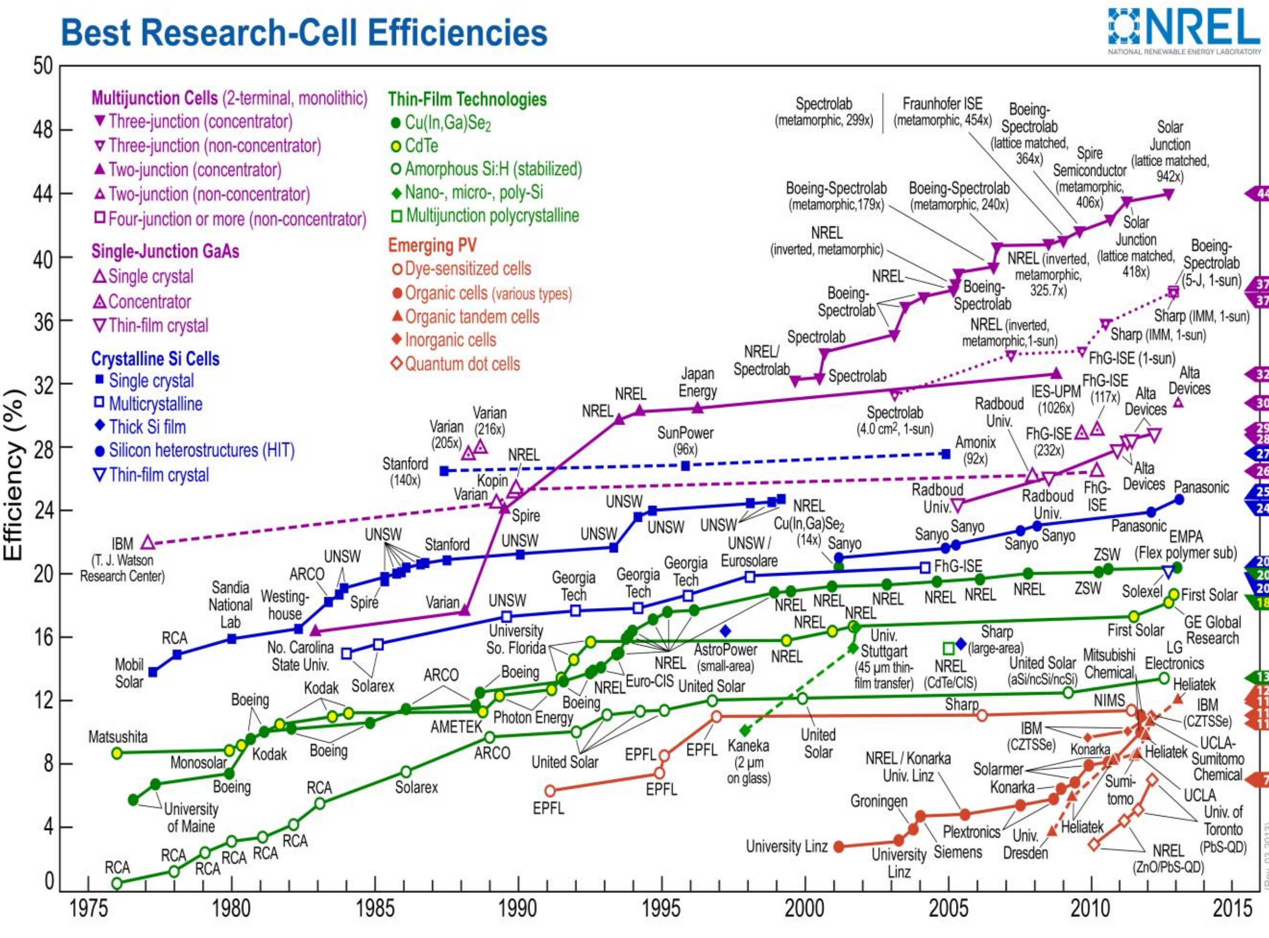


Figure 6. Evolution of cell efficiency

Source: National Renewable Energy Laboratory (NREL), 2015

PV systems are generally divided into two main big categories (Markvart, 2003):

1) System connected to the network
2) Autonomous systems

PV systems networked works in parallel with existing power networks, allowing electrical energy exchange with the grid.

In the following figures (Figure 7 - 9) of photovoltaic systems are presented some production systems of direct and alternative current (DC and AC) power, using photovoltaic panels. This type of application could allow for example providing with light the DC electric bulb, in properties located in ignored areas and without electricity. We can notice that the photovoltaic panels are not the only component of the entire system. Because the electricity is needed, not at the moment when the sunlight is present, electricity supplied to the panel is accumulated in one or more batteries to be used by the owners need. Between the photovoltaic panel and battery is sandwiched a regulator because the properties of electrical current at the exit of the panels are variable according to the intensity of solar radiation, and the parameters of electricity used to charge must be constant (Chen, 2007). Here are presented multiple technical systems incorporating photovoltaic panels.

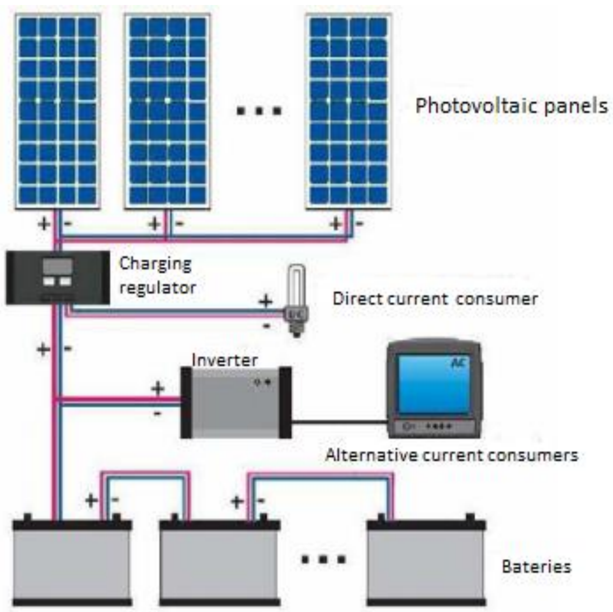


Figure 7. Photovoltaic system for production of direct and alternative current

Source: Edited according to Gusa, 2013

Such a system needs more electric power, and usually typical for DC consumers, that's why there is a need for a greater number of photovoltaic panels and the number of batteries is also higher, so that the system can provide a maximum electric power for a long time, before the battery is discharged. Also it's very important to mention that in such a system there is mandatory to have a inverter, which converts the direct current into AC (Gușă. 2013).

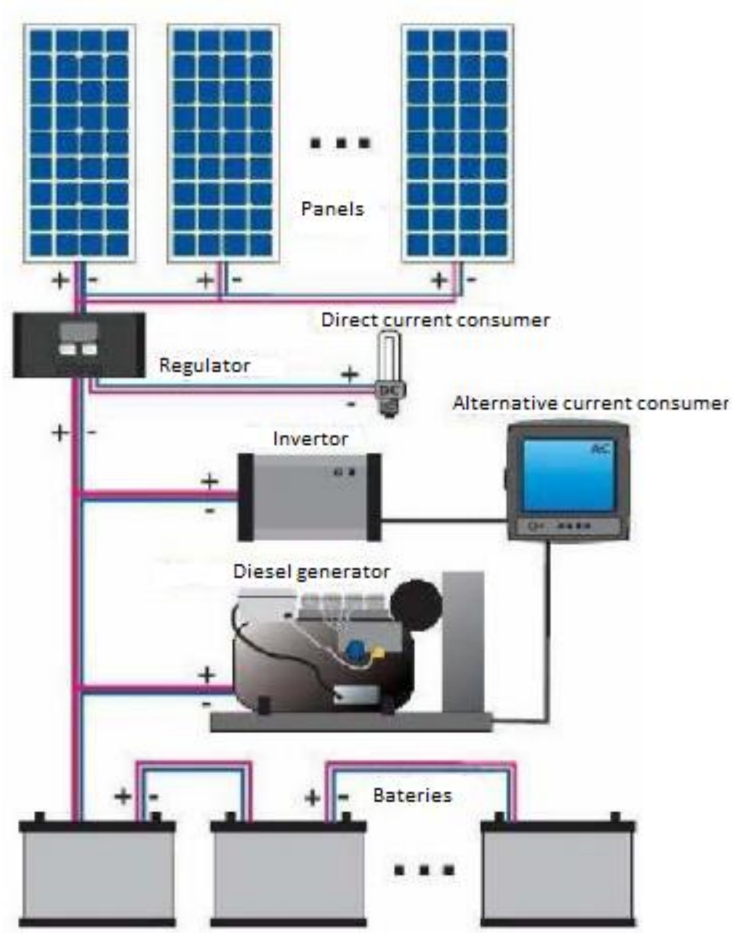


Figure 8. Hybrid photovoltaic system

Source: Edited according to Gusa, 2013

Comparing with the system that I described before, this hybrid system also comprises an electric generator driven by an internal combustion engine - Diesel type. This generator, which can produce both DC and AC, and has been designed to provide electrical power needed during peak periods of high intensity of solar rays, or during periods when sunlight is not intense enough (Agency for innovations and transfer technologies, 2011).

It is important to understand the fact that the energy can be manipulated, and maintained on a strict level of using or supplying is a big plus for stability in energy using, although there is a need of a diesel generator that is using fossil fuel (Diesel fuel), so in fact, this technology has no bright future, because of using non-renewable sources of energy.

In Figure 9 is represented a system for producing and using of alternative current by the aid of photovoltaic panels, connected to the local network power supply (this type of photovoltaic connection will be applied for the case study of the present thesis).

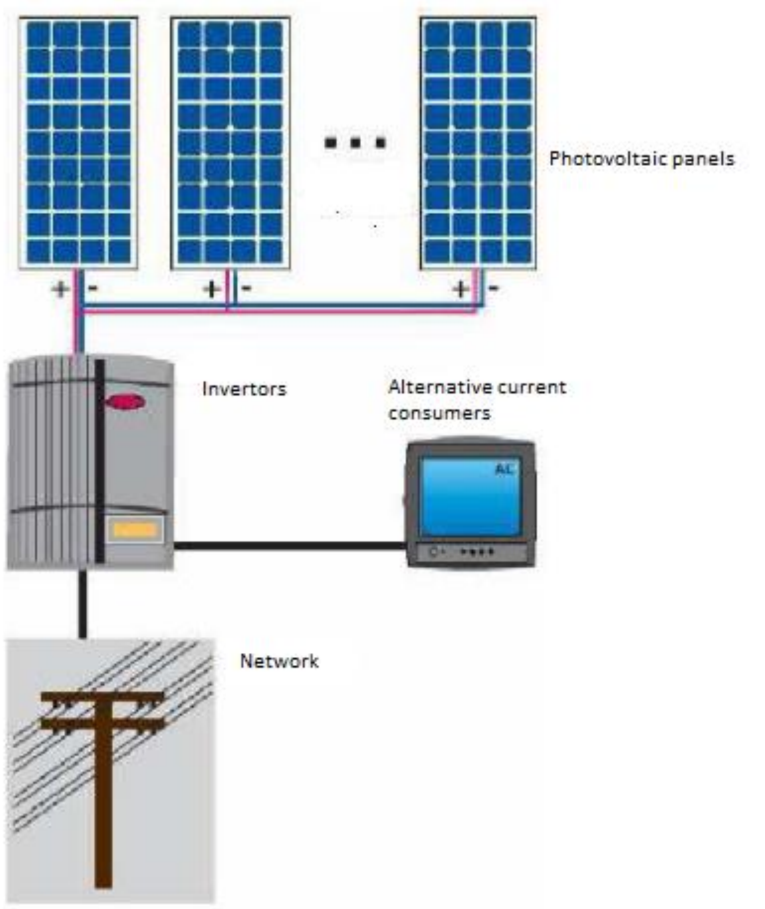


Figure 9. PV system connected to the network

Source: Edited according to Gusa, 2013

Such a system for producing alternating electric current, with using photovoltaic panels, allows the direct use of electricity produced by the photovoltaic system, and provides also a connection to the network with power supply, from which, this system is the electricity supplier. It is obvious that the buildings equipped with such a delivery system of electricity must be provided with one measuring device that will count the electricity supply to the network, and also that measures the electricity that is coming from the network (Schneider electric, 2012)

In Table 1 are shown the main advantages and disadvantages of using photovoltaic panels, where we can see that positive effects are much more than negative ones.

Table 1 Advantages and disadvantages of photovoltaics

Advantages of photovoltaics	Disadvantages of photovoltaics
Fuel source is vast and essentially infinite	Fuel source is diffuse (sunlight is a relatively low-density energy)
No emissions, no combustion or radioactive fuel for disposal (does not contribute perceptibly to global climate change or pollution)	
Low operating costs (no fuel)	High installation costs
No moving parts (no wear)	
Ambient temperature operation (no high temperature corrosion or safety issues)	
High reliability in modules (>20 years)	Poorer reliability of auxiliary (balance of system) elements including storage
Modular (small or large increments)	
Quick installation	
Can be integrated into new or existing building structures	
Can be installed at nearly any point-of-use	Lack of widespread commercially available system integration and installation so far
Daily output peak may match local demand	Lack of economical efficient energy storage
High public acceptance	
Excellent safety record	

Source: SMS Institute of Technology, 2009

2.6 Classification of solar cells

The solar cells can be classified according to several criteria (Lausch, 2013):

- Thickness of the material:
  1) Thick layer
  2) Thin layer

- Type of material used as semiconductor:
  1) CdTe
  2) GaAs
  3) CuInS
  4) Silicon

- Basic structure of materials:
  1) Crystalline (mono/polycrystalline)
  2) Amorphous

In producing photovoltaic cells in addition to semiconductor materials, there is a possibility of using organic materials or organic pigments.

From all this types of solar cells, I will describe only the most performant and efficient ones, that are most used today for producing electric energy such as the following:

- **Silicon cells:**

  Silicon cells are affected by module temperature. As the electricity produced and the outside temperature is high, the efficiency drop down 0.45 % per °C As module operating temperature increases, module voltage drops while current essentially holds steady (IPPC, 2012). These cells are divided also in:

1) Monocrystalline cells:

Invented in 1955, monocrystalline entered the market in 1981. It is similar in performance and reliability with poly crystalline cells but the difference is that the single crystal modules are composed of cells cut from a piece of continuous crystal. The material forms a cylinder which is sliced into thin circular wafers. To minimize waste, the cells may be fully round or they may be trimmed into other shapes, retaining more or less of the original circle. Because each cell is cut from a single crystal, it has a uniform color which is dark blue. With a thick layer, monocrystalline cells, in serial production can reach over 20 % of energy efficiency. Monocrystals are obtained under the form of wands, by pouring pure silicon. These wands are easily cut into very thin plates that are used for manufacturing photovoltaic cells. This technological process ensures the highest level of photoelectric efficiency but is also the most expensive (Henke, 2013).

2) Polycrystalline cells:

Polycristalline silicon cells have been widely used for photovoltaic solar cells. Because of the enormous demand for renewable solar power, a lot of efforts have been made to reduce the cost and improve the energy efficiency of polycrystalline Si photovoltaic cells (Rohrer, 2014). In serial production, these cells can reach an energy efficiency of 16 %, and have relatively low energy consumption in the manufacturing process, so today it has the best proportion price/performance. Polycrystals are obtained by a process less expensive, consisting of casting the silicon liquid into blocks, which subsequently are cut in thin plates. In the solidification process, crystals are made of different form size and shapes, and on the edge of these crystals are occurred some structural defects. Following these defects, photovoltaic cells manufactured by this method is less effective (Schweizer, 2013). From the other side, silicon as a substrate or an active working layer in electronic devices is due to its unique properties, compatibility with other semiconductors, and very low production costs. Also the optical and photoelectric properties of this silicon depend in its crystal structure, which can influence entirely the function of the solar cell, and also their efficiency power (Kabyshev, 2013).

3) Amorphous silicon cells

These cells have the largest share on market, with thin cells, where the energy efficiency of the modules is from 5 to 7%. Crystalline silicon cells, e.g. micro crystals in combination with amorphous silicon have big efficiency. Amorphous structure is obtained by depositing a extremely thin silicon layer on a glass surface, or on a substrate made of a different material. In this case, solidification is not performed in a crystalline structure, but into a irregular atomic arrangement called amorphous structure (Schweizer, 2013).

2.7 Performance and efficiency of solar cells

The efficiency of solar panels is highly dependent on many facts (Czech photovoltaic industry association, 2014) such as:

- Angles,
- Positioning
- Panel maximum performance
- Life expectancy of solar panels (which is roundly 30 years, where every year is decreasing efficiency by 1 %)
- Possible solar irradiance (sunny days)

In Table 2 are presented performances of the main three types of cells in terms of photovoltaic energy conversion of solar radiation into energy power.

Table 2 Performance of different types of solar cells

Material	Efficiency in laboratory conditions	Efficiency in serial production
Monocrystalline cell	~20 %	14 - 17 %
Polycrystalline cell	~18 %	13 - 15 %
Amorphous cell	~13 %	5 - 7%

Source: Edited according to Guta, 2013

As solar energy industry has largely improved in the last decades, it is really important to notice that the installed angle of panels influence a lot their efficiency. That's why, those panels must be installed incline at optimum angle to maximize the receiving energy. Moreover, determination of the optimum tilt angle of solar collectors is the subject of many investigations. Beside the fact that panels should be installed away from shade effects or industrial smoke, also there should not be any other barrier between the sun and collectors from sunrise till sunset; otherwise the installed angle will not have a big importance (Deymeh, 2014).

As I make my thesis based on a case study in Republic in Moldova with geographical coordinates between 45°25 and 48° 30' north latitude, 26°48' and 30°07' east longitude (World Bank, 2015), below is presented graph (Figure 10) that shows what are the best installation angles. As it is visible from Figure 10, the most optimum angle depending on positioning towards the sun and geographical positioning, in a region located in Eastern Europe. An annual production for an installed capacity of 1 kWp, has an average of electricity production between 1,200-1,500 kWh (Mandragon, 2015).

From Figure 10, we can see that the most optimum tilt angle between the ground and panel is from 20° to 30°, and orientation angle is towards south with a deviation not more than 10°.

ORIENTATION	WEST						SOUTH		EAST						
Tilt	90°	70°	50°	40°	30°	20°	10°	0°	-10°	-20°	-30°	-40°	-50°	-70°	-90°
0°	87%	90%	92%	92%	93%	93%	93%	93%	93%	93%	92%	92%	91%	89%	86%
10°	84%	90%	94%	95%	95%	96%	96%	97%	97%	96%	95%	94%	93%	89%	84%
20°	82%	90%	94%	96%	97%	98%	99%	99%	98%	97%	96%	95%	93%	88%	81%
30°	78%	87%	93%	96%	97%	98%	99%	100%	98%	97%	96%	95%	93%	85%	78%
40°	75%	84%	92%	94%	95%	96%	96%	96%	96%	95%	94%	92%	90%	82%	72%
50°	70%	79%	87%	90%	91%	93%	94%	94%	94%	93%	91%	88%	83%	76%	70%
60°	65%	73%	80%	83%	86%	87%	87%	87%	88%	87%	85%	82%	78%	71%	63%
80°	50%	60%	66%	68%	69%	70%	71%	72%	72%	71%	70%	67%	66%	57%	50%

Figure 10: Orientation towards geographical location

Source: the Energy Saving Trust, 2015

Also another important fact is the solar irradiation that is present in the region where should be installed solar panels. The overall intensity of the radiation in a specific area is influenced by the following four categories of factors (Oniga, 2014):

1) Geophysical – latitude and altitude of the settlement date
2) Astronomical – height angle of the sun towards horizontal field and declination angle depending on season
3) Constructional – tilt angle from the ground and inclination angle towards south
4) Meteorological – transparency of the atmosphere, cloud cover, temperature and air humidity.

Geographical factors for a certain location are usually constant and well known. Astronomical factors are also known but, with time varying values, requires serious analyze to determine and optimize the constructive factors of the photovoltaic panels. The influence of weather can be assessed only by the results that are observed and made by meteorological stations every year (Oniga, 2014)

3. Aim

The aims of my bachelor thesis was to analyze how solar energy could contribute to a more sustainable energy supplier in Republic of Moldova, and to analyze the opportunity to build a photovoltaic park/power plant, specifically in a small village called Boscana, near capital city Chisinau, that will partially supply the village with electricity.

The specific objective of the present thesis was a proposal of photovoltaic power plant for the selected location based on analysis of available technologies, solar potential in the region and evaluation of the most suitable installation angle. The other goal was to summarize and define the requirements for construction of photovoltaic power plant, including official steps and list of costs.

4. Methodology

4.1. Methodology of literature review

My bachelor thesis is divided in literature review part, and case study. First of all literature review was based on searching information through state institutions of Republic of Moldova such as:

- National Bureau of statistics
- Ministry of Economy
- Renewable energy agency of Moldova

As well, using key words such as: photovoltaic panels, solar energy, renewable energy, electricity, orientation angle, Republic of Moldova - searching through scientific databases such as: Web of Science and EBSCO Information Service, Scopus, Science Direct.

4.2. Methodology of case study

The case study part was based on analyzing the territory (Boscana), where theoretically can be build a photovoltaic installation and calculation of electricity amount that can be produce in this area. Evaluation of official steps and costs required for the construction of photovoltaic power plant was done as well.

4.2.1 Description of location

Characteristics of solar radiation for Chisinau, and regions that are nearby were used for the calculation of solar energy production characteristics in region near Chisinau. Of course they can be applied and in the other parts of the country, but as I am focusing on a region that is 20 km far from the capital city (I will describe it in the case study chapter). Moldova can be divided in three major climate zones (World Bank, 2015)

- Northern zone centered by Briceni
- Central zone centered by Chisinau
- Southern zone centered by Cahul

Possible insolation duration for these areas, are given in Table 3. The actual real duration is 50 - 55 % of the possible hours of solar days, and the number is between 2,066 hours on the north and 2,330 hours on center and south (Meteorological Institute of Moldova, 2015).

Table 3 Possible solar hours in 3 regions of Republic of Moldova

Month	1	2	3	4	5	6	7	8	9	10	11	12	Annual
Briceni	8.77	10.10	11.8	13.60	15.17	16	15.67	14.40	12.6	10.9	9.3	8.40	4470.8
Chisinau	**8.9**	**10.25**	**11.8**	**13.53**	**15.03**	**15.87**	**15.53**	**14.3**	**12.63**	**10.9**	**9.3**	**8.5**	**4467.1**
Cahul	9.0	10.33	11.8	13.5	15	15.7	15.4	14.23	12.63	11	9.4	8.67	4466.3
Average	8.89	10.21	11.8	13.54	15.06	15.86	15.53	14.31	12.62	10.9	9.3	8.5	4468.06

Source: (Meteorological institute of Moldova, 2015)

As I make my thesis based on a case study in Republic in Moldova with geographical coordinates between 45°25 and 48° 30’ north latitude, 26°48’ and 30°07’ east longitude (World Bank, 2015), we can deduct from the Figure 10 what are the best installation angles according to geographical positioning, in a region located in Eastern Europe. An annual production for an installed capacity of 1 kWp, has an average of electricity production between 1,200-1,500 kWh (Mandragon, 2015).

The territory is located near the capital city Chisinau, 20 km to north-east. The field is near a small village called Boscana with a population of 2500 inhabitants, and monthly electricity consumption approximately 80,000 kWh (Local public authority, 2015).

This territory was chosen for constructing the power plant due to the fact that in this region is a high % of non arable soil, with a hard composition of stones and sand, which means that it is not usable for agrarian activities.

The location of Boscana village on the map of Moldova is presented in the Figure 11.

Figure 11. Map of Republic of Moldova with the place of the village (red dot)

From this plan of the territory (Figure 12), we can deduce that the in total, the field have 0.33 ha (0.182 ha from first photo + 0.148 ha from second photo), or converting to meters, 3300 m^2.

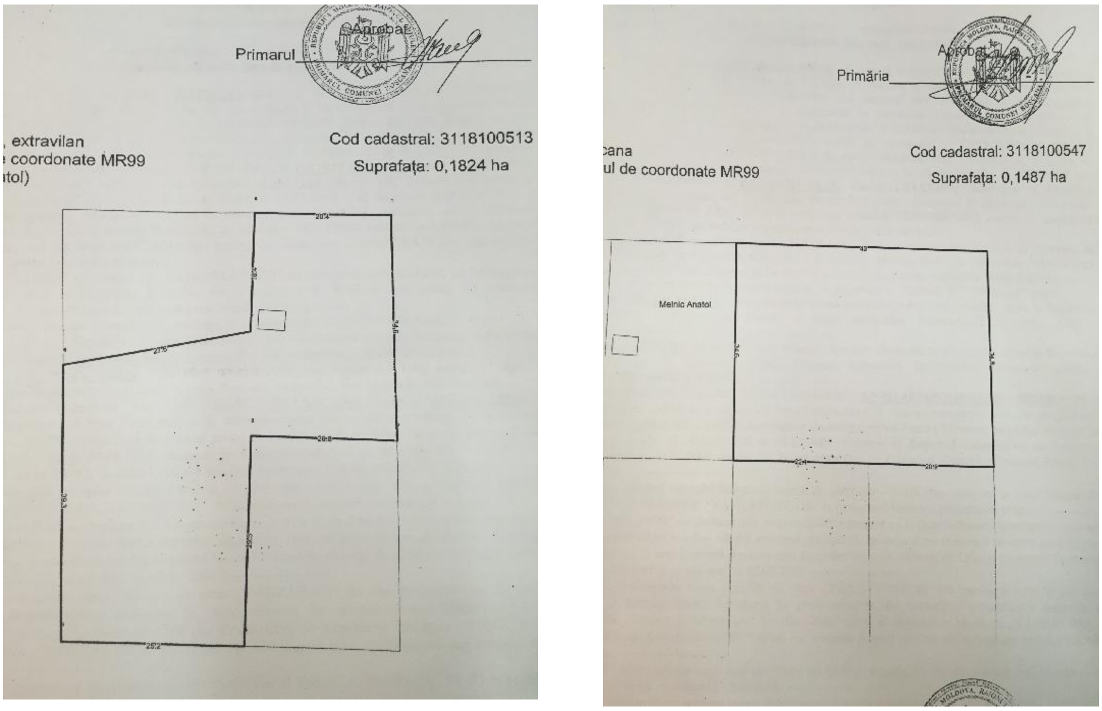


Figure 12. Target territory plan

Source: Local public authority, 2015

As it was written in the literature review, the panels on the field should be build orientated to the south, in this case as the territory is on a hill, the construction principles are the same as vineyards. But also there are more crucial characteristics for constructing a photovoltaic power plant, some of them are (International Renewable Energy Agency, 2015):

- Very big plus is also if nearby a connection to the grid is, where potentially will be possible to transfer produced electricity, or to sell it to national system operator.
- No shadows or industrial smoke in the area, that possibly can occur smaller efficiency to panels, as there are obstacles between solar rays and panels.
- Ownership of the territory form minimum 20 years, as the panels life expectancy is 30 years, so there should be insurance that the panels can work efficiently on the same field without stopping.

In Figure 13, it is shown where theoretically can be constructed the photovoltaic power plant, and at the same time, it is visible that there are no shadows because of high buildings or industrial smoke, and as well, there is a good connection to the grid, near the village Boscana.

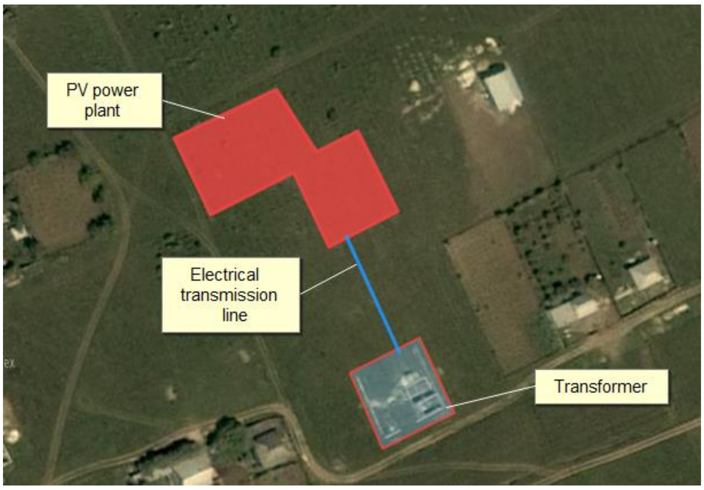


Figure 13. Theoretical placing of the photovoltaic power plant

4.2.2 Calculations

Calculations made for the total amount of energy produced by the solar panels was possible due to the scientific calculator that is a part of Photovoltaic Geographical Information System (PVGIS), which can be accessed at the web page bellow http://re.jrc.ec.europa.eu/pvgis/apps4/pvest.php. This is an online solar panel calculator funded by the European Commission and developed by the Joint Research centre in Italy (Ozgur, 2013). This is a very useful thing if you understand the basics of solar energy, and the main characteristics to calculate. The level of technical detail and enormous options can render it a powerful tool in the hands of a solar industry company, or for a planned project of installing a photovoltaic power plant. The detailed calculations of solar radiation, the ability to analyze both grid-connected and off-grid PV systems and various analysis output options are all making this calculator the latest innovative and interesting invention. To make the calculations of production for panels, on the web site, there is a need to take into account several factors, where we need to put the following characteristics such as:

- Photovoltaic technology - Monocrystalline sillicon cells
- Installed peak PV power – 132 kWp

The installed peak PV power was calculated based on a photovoltaic business plan model, which has shown the recommended amount of maximum solar power performance for the installed photovoltaic panels on such a territory. (Frantzis et al, 2008)

- Mounting position: Free standing
- Angles – Tilt angle: angle of 30° was selected, as it is recommended for this region
  Orientation towards south, which means an angle of 0°
- Geographical location of the installed photovoltaic power plant, where you can found an click on the map where the installation will be.

4.2.3 Analysis of steps and costs for implementing a photovoltaic power plant

Information found on sites from state institutions from Republic of Moldova, such as Regulations on Energy Efficiency Agency, Renewable Energy Agency, or National Energy Efficiency Program till 2020, that was adopted by law as a strategic national aim for developing renewable sources of energy (Directive on energy strategy, 2009), helped to find and summarize the paths for implementing such project for installing photovoltaic panels. Also based on information from several successful business plans, that helped also to estimate what kind of costs we should to consider when starting of such innovative project.

5. Results and discussion

5.1. Results on calculations

By calculating regarding an average production for one peak kW which is between 1200-1500 kWh of electricity (Mandragon, 2015), by the aid of scientific calculator which I mentioned in the methodology, I made some calculations for an annual production of installed photovoltaic panels on a territory of 0.33 ha where can be installed a maximum performance of 132 kWp on minimum and maximum performance.

From these calculations I have got the following results: for 132 kWp installed on 0.33 ha:

1200 kWh*132 kWp = 158,400 kWh

1500 kWh*132 kWp = 198,000 kWh

Approximately average production of electricity: 178,200 kWh per year (as is shown in the Figure 14 and 15).

Fixed system: inclination=30°, orientation=0°				
Month	E_d	E_m	H_d	H_m
Jan	180.00	5570	1.40	43.4
Feb	303.00	8490	2.37	66.4
Mar	525.00	16300	4.29	133
Apr	622.00	18700	5.31	159
May	711.00	22100	6.30	195
Jun	713.00	21400	6.38	191
Jul	723.00	22400	6.55	203
Aug	691.00	21400	6.24	193
Sep	552.00	16600	4.81	144
Oct	430.00	13300	3.58	111
Nov	237.00	7110	1.91	57.2
Dec	156.00	4850	1.21	37.6
Yearly average	**488**	**14800**	**4.21**	**128**
Total for year		**178000**		**1540**

E_d: Average daily electricity production from the given system (kWh)
E_m: Average monthly electricity production from the given system (kWh)
H_d: Average daily sum of global irradiation per square meter received by the modules of the given system (kWh/m^2)
H_m: Average sum of global irradiation per square meter received by the modules of the given system (kWh/m^2)

Figure 14. Approximately average calculated production of electricity

Source: Photovoltaic Geographical Information System, 2016

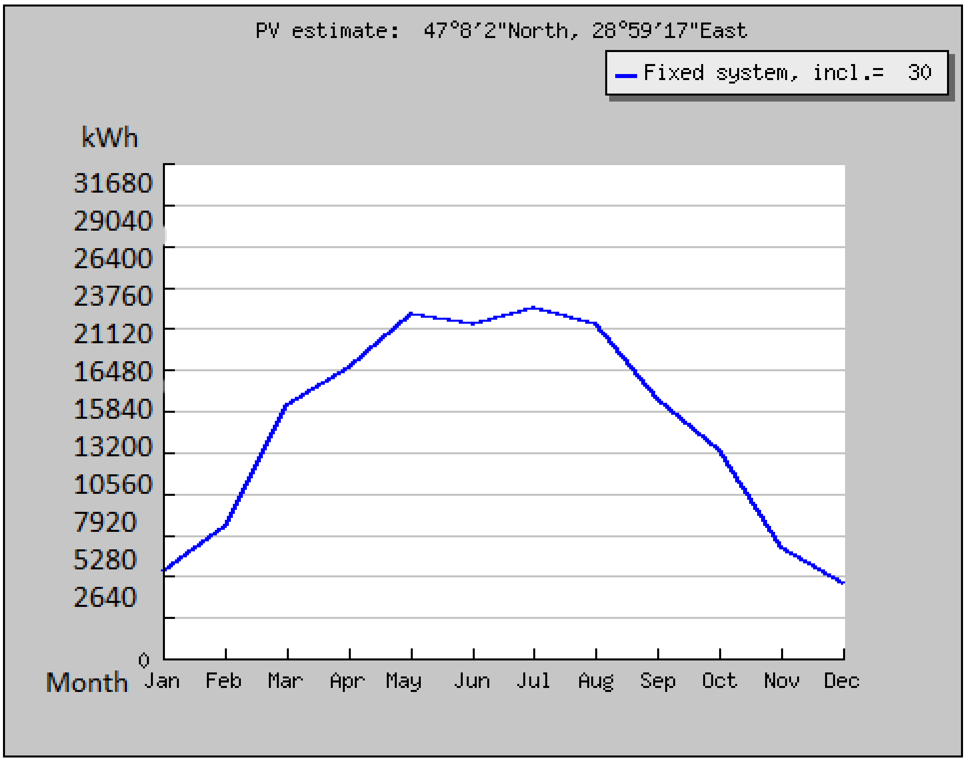


Figure 15. Average monthly production of electricity based on geographical coordinates with tilt and azimuth angles

Source: Photovoltaic Geographical Information System, 2016

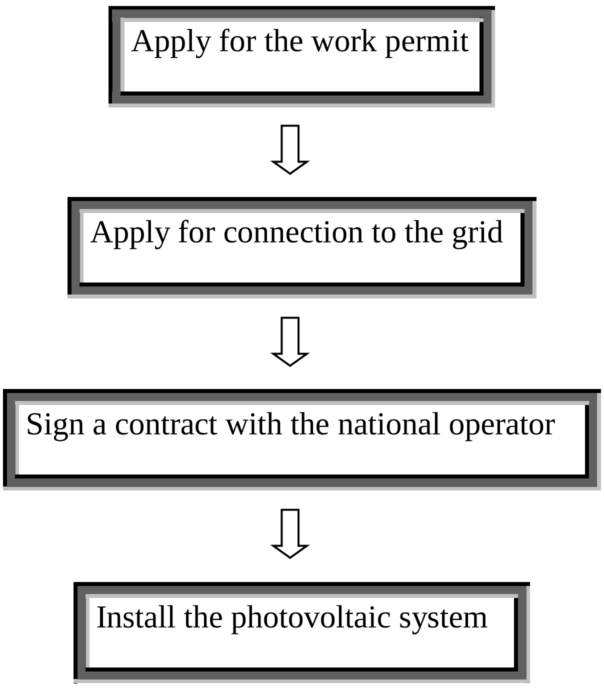
From Table 3, we can see that the settings of photovoltaic panels are fixed on tilt angle of 30° with an orientation towards south (0-5° maximum deviation from standard angle) (Energy saving trust, 2015) and also by putting geographical coordinates of Moldova which are between 45°25 and 48° 30' north latitude, 26°48' and 30°07' east longitude (World Bank, 2015) the scientific page made approximate calculation on how much can be produced in different times of the year, and also is showing the amount of energy produced each month . As it is shown, we can see that summer months are the most efficient and the panels in these days are producing the highest amount of electricity.

From the other side winter months are less efficient and panels are producing less energy, but anyway they are able to produce a good amount of energy for improving the average annual production of electricity.

In Boscana, monthly consumption of electricity is 80,000 kWh, which means that the annual will be 960,000 kW. The annual production of electricity thanks to photovoltaic panels will be approximately 180,000 kWh, which is 19 % of total consumption of this village.

5.2. Results on steps and costs.

Beside the fact that is a need to calculate approximate amount of energy produced, we need to understand that after having financial resources and a territory for constructing the photovoltaic power plant, there is a need for some administration work to do, and this means that there are 4 basic paths such as:



Applying for a work permit usually is not complicated in Moldova, especially if you want to build something that doesn't compete with someone. Then applying for a grid connection also shouldn't create problems, due to a simple procedure of applying to a permit that allows you to connect your photovoltaic system to the grid connection in that region.

Signing a contract with the national system operator means also that you need to have a license or a permit for selling electricity into the grid, that the national operator will buy it from you. There is a fixed price in Moldova for selling electricity produced from renewable sources of energy, and in this case from photovoltaic panels, which means a fixed price, or with other words feed-in-tariff, which means 1.92 lei/kW or converting to euro 0.08 euro/kW. (ANRE, 2016)

For implementing such a new project like installing a photovoltaic power plant, it is imported to understand that there is a need to accurately calculate all the costs that you will have during maintaining and construction process. So we distinguish first of all costs into four main categories:

- Construction costs to be incurred only at the time of implementing the project

It includes: PV panels, combiner, DC and AC breaking panels, inverter, cables and accessories, material for construction, logistics (transportation)

- License for selling electricity- is given for 25 years, and the fee is about 3,250 lei) (ANRE, 2015)
- Authorization costs, which you can have from local public authorities.
- Operating costs to be incurred with constant frequency during the operating life of the project. Among the previous things described, the operating costs also include:

1) Insurances against damage or theft
2) Routine maintenance and repairs
3) Consulting and administrative management
4) Periodic cleaning of the solar modules or photovoltaic cells (from snow, dust)

In 2011, was implemented with success a project for construction of photovoltaic panels in Chisinau, at an oncologic hospital, that after installation is generating electricity that permit to make economies in proportion of 20 % from total consumption of electricity. The project was realized due to investments from Japanese Agency on International Cooperation (Catlabuga, 2013), which invested almost 22 million lei in installing a photovoltaic panel system that will produce electricity for the next 30 years that could save a lot of money for reducing the electricity consumption from traditional supply of energy. If comparing with the case study from this bachelor thesis, I should notice that the project was very similar and a construction of such a project on a small field near the village could make happen for inhabitants of the village Boscana, to make some money-saves on produced electricity and to begin to be more energy independent.

6. Conclusion

Due to the fact that the ending of fossil fuel era is coming, and proven coal and oil resources are diminishing with each year, it is not wonder that the most developed countries in the world are aiming to develop alternative sources of energy. European Union each year is actualizing the energy policy that supports the development of renewable sources of energy, and at the same time tries to avoid by that the pollution and dangerous gas emissions. “EU 2020 Energy Strategy” is the example of improving and helping the energy field for a sustainable and clean future that had as aim until 2020 to establish mandatory national targets consistent with a 20% share of energy from renewable sources and a 10% share of energy from renewable sources in transport in Community energy consumption. This was a good example for the country situated at the border with EU, Republic of Moldova that is very dependent on import of fossil fuels, and has no energy independence. By this it is appropriate to notice that, in such a situation, the country needs an alternative supply of energy, one of them is solar energy that was demonstrated that have the biggest potential in this country with more than 2,300 solar days annually. So for a sustainable supply of energy, Republic of Moldova needs to focus on developing and implementing a new type of energy source. That’s why, in this bachelor thesis was analyzed a territory in the center of the country, that could supply a nearby village with electricity.

The implementation of such a new type of energy in a poor country, is a really innovating thing, this project could be risky from a lot of points of view. First, there should be more government support in this field like subsidies, grants or banks offering loans for good conditions, or reducing the VAT also could highly motivate to begin a project of this type. These characteristics at the same time should highly attract investors from abroad to invest in new type of energy in a country with big dollar potential, and due to the fact that Moldova is highly dependent on energy import, it is very actual to look at the opportunity to make the country more independent, and at the same time to earn some money from selling electricity into the grid. Without that aid, it is very difficult to implement such a big project, and in the next years without any help from the government, solar energy has no future. Implementing such big innovative projects could make more work places, to motivate people to change the traditional fuels to a new highly reliable and clean type of energy, and by this to ensure the next generations that will come with a good supply of energy. A country that is almost entirely dependent on energy imports, should think about diversifying its energy supply in all the fields, maybe even more than the richest countries with natural resources. As Moldova is highly dependent on energy import, implementing new technologies and investing in such innovative projects for the poorest country in Europe may be crucial challenge for making it more self-independent on energy supply. Based on the results from case study, we can deduce clearly that only a small installation of photovoltaic panels could make money saves up to 20% from total energy consumption of a village in center of Moldova.

Moldova need better energy supply, with an alternative choice of energy, so it can ensure a safe independent future for the next generations.

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