Generation of Electrical Energy from Solar Energy: Lessons of Experience from Slovenia Case

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Abstract: Due to the increasing environmental awareness, international agreements and legal regulations that require reducing of carbon emissions and improvement of energy efficiency, there is need to increase the share of renewable energy in the total energy balance of the community. Renewable energy sources such as water energy, solar energy, wind energy, biomass, continue to set record levels for investment. This paper gives an overview of legislation development and constructed solar power plants in Slovenia. Described situation, especially related to the implementation of the decree about tariff rates, has some defectiveness, while conclusions could be applied in some countries where an increased economy level is about to start. In that manner the current situation of Bosnia and Herzegovina about the area of solar power plants is presented in the paper as well.

Keywords: Renewable Energy, Solar Power Plants, Legislation, Slovenia, Bosnia and Herzegovina

1 Introduction

Environmental awareness and obligations arising from international agreements impose the need for increasing the share of renewable energy in the total energy mix of the community. Renewable energy sources have a large total energy potential, but much lower possibilities of their effective exploitation, low energy concentration. Their important disadvantage is also unsteadiness due to weather changes. Most of renewable energy sources, with the exception of hydropower, are currently not competitive with the conventional non-renewable sources due to their high investment costs, relatively low utilisation rates and low efficiencies. These shortages can be to some extent mitigated with tax reliefs or governmental incentives that stimulate development and use of renewable energy sources (RES) [1] - [3].

RES are often discussed in the context of the use of low-carbon energy sources, i.e. sources the conversion of which does not cause emissions of CO_2, which is the most important greenhouse gas (GHG) in terms of human impact to the global climate. In addition to the exploitation of RES, the low-carbon technologies include nuclear power plants and fossil fuel power plants equipped with carbon capture and storage facilities [1].

2 Development of legislation for RES support

In 1997 the European Union (EU) set in its White Paper for a Community Strategy and Action Plan (AP) titled “Energy for the Future: Renewable Sources of Energy” the goal of meeting 12 % of its overall energy consumption and 22.1 % of electricity consumption by RES till year 2010. In the Directive 2001/77/EC on Electricity Production from Renewable Energy Sources on the promotion of electricity produced from renewable energy sources in the internal electricity market it alas set indicative RES targets for all EU Member States [1], [2].

The EU expansion in 2004 brought setting of a new target for the EU-25, according to which 21 % of electricity should be produced from RES. Due to the insufficient progress in meeting the 2010 targets a more comprehensive legislative framework was adopted. The "Renewable Energy Road Map - Renewable energies in the 21st century: building a more sustainable future" set long-term strategy for renewable energy in the EU by 2020 and proposed mandatory targets, in accordance to which by the year 2020 20 % of the overall EU energy demand should be met by RES and 10 % of consumption of motor fuels by biofuels. The roadmap also anticipated the creation of a new legislative framework [2], [4].

3 Directive 2009/28/EC

The Directive 2009/28/EC [4] requires that each EU Member State adopts national renewable AP and establishes support schemes for RES. The AP also include the estimations of the current shares of RES in production and consumption of electricity, heat and energy for transport and projected trajectory of this shares until the year 2020. The commitments adopted from the national renewable AP are based on the existing RES shares in the overall energy production and consumption, as well as on the RES potential of each individual EU Member State.

For example, an Article 4 from Directive 2009/28/EC: "Each Member State shall adopt a national renewable energy action plan. The national renewable energy action plans shall set out Member States’ national targets for the share of energy from renewable sources consumed in transport, electricity and heating and cooling in 2020, taking into account the effects of other policy measures relating to energy efficiency on final consumption of energy, and adequate measures to be taken to achieve those national overall targets, including cooperation between local, regional and national authorities, planned statistical transfers or joint projects, national policies to develop existing biomass resources and mobilise new biomass resources for differentuses, and the measures to be taken to fulfil the requirements of Articles 13 to 19. " [4].

The most common support schemes for increasing the share of RES are various tariff systems that proved to be very effective not only in Europe but also in other parts of the world. Such tariff systems are in most cases either a feed-in tariff system with fixed purchasing price for electricity produced or a system that provides an additional premium to the market price that the producers achieve in the electricity market.

4 Slovenian case

In order to provide for better energy efficiency and environmental sustainability, the Government of RS (Republic of Slovenia) in 2004 adopted the Resolution on the National Energy Programme (ReNEP), which layed down the objectives of the energy policy: competitiveness of the energy companies, the economy and the Government, reliability in providing energy services and reduction of environmental impacts. The National Energy Programme 2004-2010 (NEP-I) sets up the long-term development targets and orientations of energy systems and energy supply in the Republic of Slovenia [2], [5].

The Renewable AP is an implementing act laying down the sectorial targets and measures to achieve the national target regarding the share of RES in the national gross final energy consumption in 2020. The Renewable AP comprises national policy for RES, expected gross final energy consumption in the period 2010-2020, targets and orientations regarding RES, measures for achieving the mandatory RES shares, as well as estimations of costs of foreseen measures, environmental impacts and creation of new jobs [2], [5], [6]. The mandatory targets of the Slovenian energy policy for RES are to ensure 25 % of RES in the national gross final energy consumption and 10 % of RES in transport by the year 2020 [4], [6].

The new Energy Act (EA-1) was adopted by the National Assembly of the Republic of Slovenia on 24 February 2014 and entered into force on 22 March 2014. It deals with RES and RES connected issues in several sections [7]. The Energy Concept of Slovenia (ECS) is the basic development document in the field of energy that on the basis of EA-1 [7], forecasts of economic, environmental and social development of the country and on the basis of international commitments sets up the goals of reliable, sustainable and competitive energy supply for the next 20 years and indicatively for the next 40 years. The principal goals of ECS are reduction of energy related GHG emissions for at least 40 % until 2035 with regard to the level of 1990 and their further reduction for at least 80 % until 2055 with regard to the level of 1990.

4.1 Renewable energy sources

The share of RES in the gross final energy consumption significantly increased in 2009 due to the economic crisis on one side and due to an increased use of RES on the other hand (Fig. 1). One of the factors that contributed to this was also the methodological improvement

of statistical monitoring of the use of RES in households and increase of installed capacities in hydro power plants. The use of RES has been increased every year since 2009 and in 2013 it was approximatelly 28 % higher than in 2005.

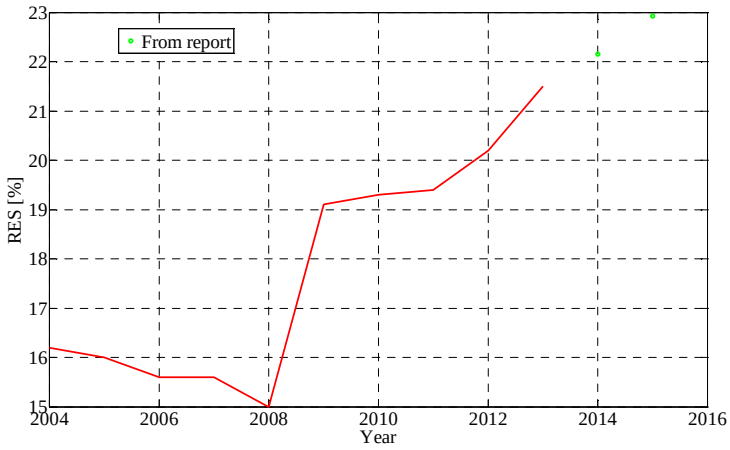

Fig. 1: The share of RES in the gross final energy consumption

4.2 Solar power plants

The energy of solar radiation is inexhaustible and can be exploited in all countries of the world. The global growing trends in energy policy are characterised by increased demand for energy, increased prices of conventional energy sources and by efforts for increasing the use of RES. One of the results of these initiatives is a fast growth of installed capacities in photovoltaic systems [5], [8]. The average annual solar irradiation in Slovenia amounts to more than 1000 kWh/m^2. Fig. 2 shows a cumulative power of photovoltaic (solar) power plants (SPP) in Slovenia from 2007 till 2014.

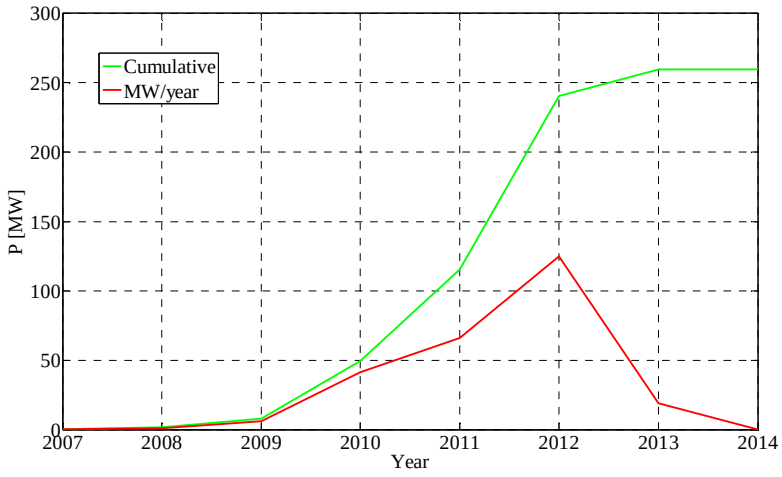

Fig. 2: Power of SPP in Slovenia

The purchase of electricity produced in SPP is governed by the Decree on support for electricity generated from renewable energy sources (2009). According to the provisions of this Decree, SPP are classified in several groups with regard to installed capacity and their location (on a building or stand-alone). In the first years of the implementation of the Decree the Tariff Rates (TR) were changed once a year, after that every half a year and from December 2012 on they are every month reduced by 2 % (Fig. 3).

The Fig. 3 also shows the electricity price including all associated duties for a typical household customer and EEX conditions.

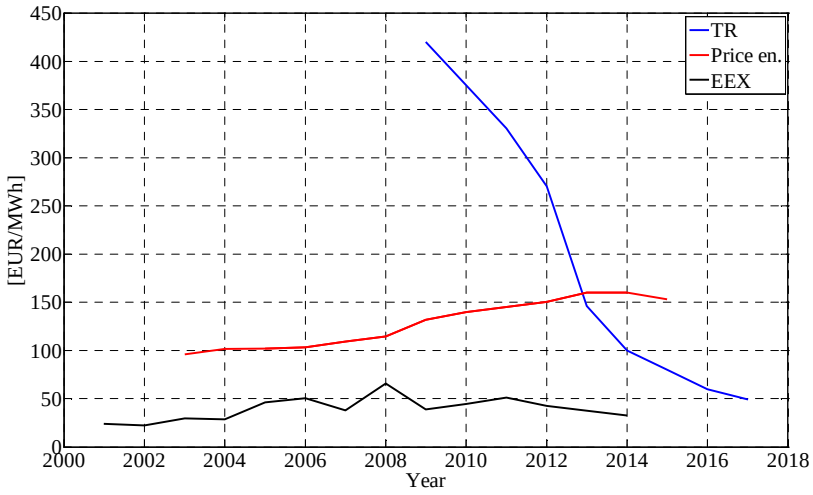

Fig. 3: Price of electricity including all associated duties for a typical household customer, EEX conditions and the TR

In the comparison of production costs of SPP and prices for guaranteed purchase (feed-in tariffs) it is necessary to take into consideration the investment costs of SPP that in the period between 2008 and today significantly decreased (Fig. 4). Apart from that the conditions in Slovenia's electricity feed-in support scheme related only to the SPP are presented in the Fig. 5.

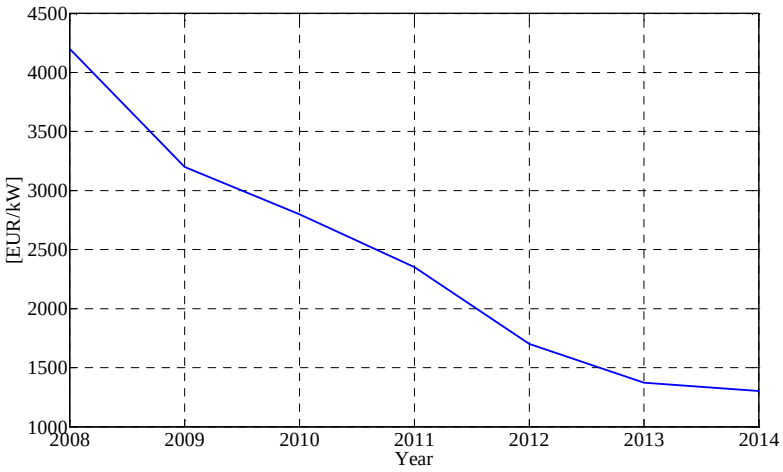

Fig. 4: Investment costs of SPP

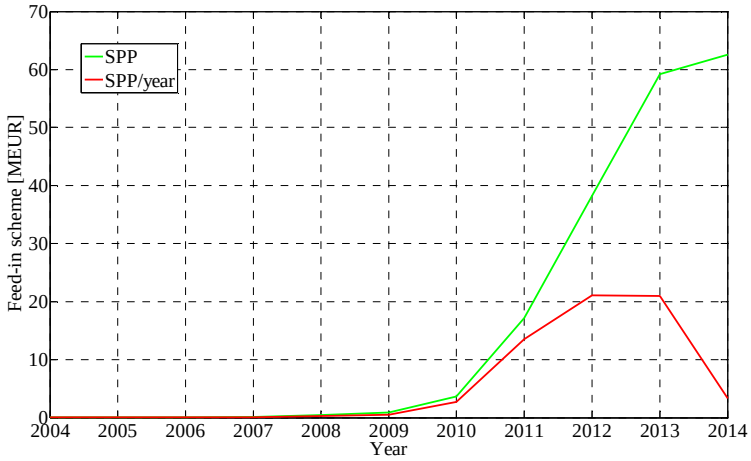

Fig. 5: Slovenia's electricity feed-in support scheme related to the SPP

Based on aforementioned data, related to the price of electricity, amount of MEUR in Slovenia's electricity feed-in support scheme related to the SPP and investment costs of SPP, the cash flow curve could be obtained by classical investment method application (Fig. 6) [9], [10]. Within presented curve all of the negative consequences basically related to the high TR, especially at the beginning stage, are considered. With elimination of aforementioned negative reasons the time of cash flow crossing the value 0 MEUR could be significantly reduced.

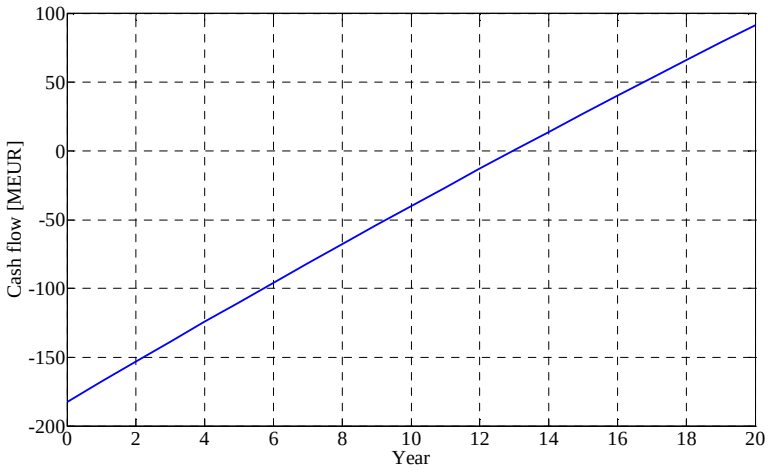

Fig. 6: The cash flow curve

5 Current situation in Bosnia and Herzegovina

Described Slovenian situation has some defectiveness, while conclusions could be applied in some countries where an increased economy level is about to start. In that manner the current situation of Bosnia and Herzegovina about the area of SPP is shortly presented [11] - [16]. Fig. 7 shows a cumulative power of SPP in Bosnia and Herzegovina from 2012 till 2015, where the power of additional SPP still under constructions is equal to 36.32 MW [12]. In additional subsections some informations about the investment costs of SPP, subsidies in recent years and electricity market in Bosnia and Herzegovina are provided.

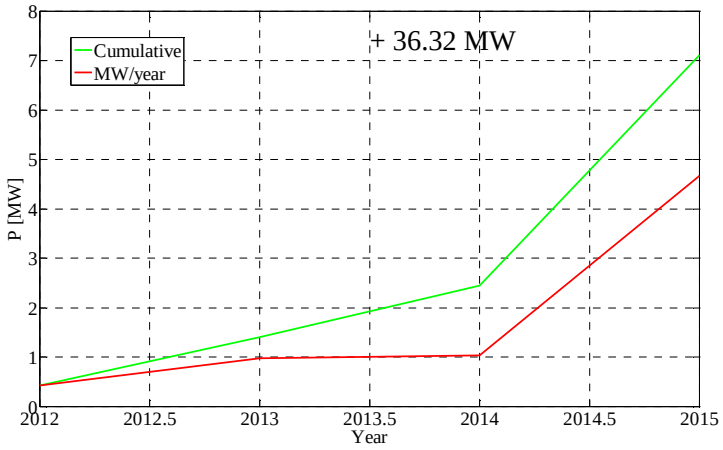

Fig. 7: Power of SPP in Bosnia and Herzegovina

5.1 The investment costs of SPP

The investment costs for 1 kW of SPP are influenced by several factors. With regard to installed capacity, method of construction, location, orientation, type of the power plant and

weather factors the investment costs of 1 kW in Bosnia and Herzegovina can vary from 1200 to 2300 EUR.

5.2 Subsidies in recent years

Basically, the guaranteed price is calculated using different coefficients and the defined reference price (R_c). The guaranteed price is determined for each kind of production devices [13] - [16].

In the years 2010 and 2011 the subsidised (purchasing) electricity price from RES was formed as a multiplication product of tariff rates for the 10 kV level in the period of high daily and high seasonal tariffs and the coefficient of 0.8. Each regional power company individually negotiated the purchase of total quantities of electricity from RES producers. In this period only small hydro power plants were built [16].

Due to different tariff rates for customers at the 10 kV voltage level the purchasing prices were different for Public Enterprise Electric Utility of Bosnia and Herzegovina (JP EP BiH). In 2012 and 2013 the Renewables Act entered into force, as well as the Decision on reference price issued by Regulatory Commission for Electricity in Federation of Bosnia and Herzegovina (FERK) - in force since 1 September 2014. The guaranteed purchasing price for electricity from RES is defined in the first paragraph of Article 14 of the Decree on the use of RES and Combined Heat and Power (CHP), where the reference price amounts to 62.7 EUR/MWh. The guaranteed price is obtained by multiplying of the reference price with the adequate tariff coefficient for a certain kind of RES production devices. According to the Decree on the use of RES and CHP, the guaranteed prices and tariff coefficients are determined individually for each energy source and capacity of the generator. The guaranteed prices in the period from 2014 to March 2016 are calculated on the basis of the reference price R_c = 54.0384 EUR/MWh and adequate tariff coefficient [13] - [15].

5.3 Electricity market

The electricity market legally exists. Unfortunately, at this moment, there are several barriers that completely prevent practical use of all permitted methods of trading. The necessary trading mechanisms have not yet been established at the territory of Bosnia and Herzegovina.

6 Conclusion

Solar energy is the main driving force of climate cycles and all life cycles on Earth. It is inexhaustible and it can be basically used in all countries of the world. As a result of the initiative to use renewable energy, solar systems have recently recorded a rapid increase in installed capacity. Currently, solar systems are the leading producers of electrical energy in relation to the number of installed capacity, and they have outscored wind energy and gas systems. This paper gives an overview of constructed photovoltaic (solar) power plants in

Slovenia. Fig. 2 shows a cumulative power of solar power plants from 2007 till 2014. The reason for increased situation is mainly in electricity feed-in support scheme for renewable energy source and high-efficiency cogeneration power plants. For example, the subventions provided by the Slovenian government to green power producers in 2014 were about 130 million euro, where the bulk of the subventions went to the solar power plants - 62.6 million euro. Described situation has some defectiveness, while conclusions could be applied in some countries where an increased economy level is about to start. In that manner the current situation of Bosnia and Herzegovina about the area of solar power plants is dealt, as well.

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