

# Analysis of Support Schemes and the Possibilities of Settlement of the Balance of Electricity Generated from Renewable Energy Sources

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**Abstract** — Support for electricity produced from renewable energy sources is a key priority for the European Union due to reasons of security and diversification of the energy supply, environmental protection, sustainable development, and because the use of electricity from renewable sources is an important part of the measures necessary to comply with the Kyoto Protocol. The article is also focused on several options of the settlement balance between the producer and supplier of electricity produced from renewable energy sources.

**Keywords** — renewable energy sources, support, price of electricity, the settlement balance

## I. INTRODUCTION

The European Union (EU) committed to reduce greenhouse gases emission by 2020 by at least 20 % compared to the level in 1990. In order to achieve this objective, the EU is working on developing measures of efficient and energy saving technologies following the European Parliament and Council Directive 2009/28/EC of April 23, 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC (Directive 2009/28/EC) [1] which established European targets for 2020: achieve a 20 % share of the renewable energy sources (RES) in the Community gross final consumption of energy and 10 % share of energy from the renewable sources in the transport energy consumption in each Member State. According to the Directive 2009/28/EC the Member States are required to set their targets for the share of energy from RES in 2020 in the sectors of heating and cooling, electricity, and transport. In order to achieve this targets in 2020 the EU Member States established national action plans for renewable energy, which provide a detailed analysis of goals for each year. In the Slovak Republic the basic document in relation to the objective to reach 14 % increase in 2020 is the National Action Plan for renewable energy, approved by the Government on 6 October 2010 by the Government Resolution no. 677/2010. This document assumes to reach 15.3 % use of renewable energy in proportion to the gross final energy consumption in 2020 [2]. In 2013 the European Commission released Green Paper “A 2030

framework for climate and energy policies”. Based on the comments of stakeholders, the third sector and attitude of the Member States in January 2014, the Commission prepared a new EU framework for climate and energy in 2030. One of the objectives will be to increase the share of RES in gross energy consumption to 27 % by 2030 [3].

Currently a considerable dependence on the production of energy from fossil fuels is obvious, which is trying to suppress the production from alternative energy, especially from RES [4], [5], [6]. Multiple barriers are necessitating the support of RES in order to compete with conventional energy sources. These interventions cause an increase of costs that are being reflected in the regulated components of the electricity price. On one hand the development of RES and energetically efficient technologies provide an increased energy self-sufficiency, employment, investment and production. On the other hand most RES technologies increase the costs of electricity production compared to electricity production from fossil fuels; those costs increase the electricity price, which is ultimately paid by consumers. These are the costs of production, transmission and distribution, and balance. The majority of RES technologies are not profitable in the current market of the energy prices so their implementation is needed to be supported; i.e. guaranteed feed-in-tariffs, mandatory quotas, green certificates, fiscal measures such as tax benefits, investment, subsidies, grants, etc. [7].

The role of the EU Member States is to create a support system to enable achieving the targets set in the Directive 2009/28/EC in terms of lowest costs possible. The method of support mechanisms may vary as well as their effect on the final electricity price for consumers.

The purchase price (feed-in-tariff) is a fixed price for the amount of electricity produced from RES. It is set on a certain fixed period of time during which a producer of energy from RES has the purchase price guaranteed. The Member States have different ways of determining the level of the purchase price as well as the identification of various categories of producers who are eligible for the support. The purchase prices are the most used system of the RES support in the EU; i.e. in Austria, the Czech Republic, Denmark, France, Germany, Hungary, Lithuania, Slovakia and Spain.

Premium tariff is a method of the RES support which is a form of a fixed or variable bonus to the market price of electricity for a fixed number of years. It is provided for the electricity supplied to the network and the electricity that is consumed directly. An example would be green bonus in the Czech Republic or premium tariffs in Germany.

The quota system (tradable green certificates) represents a support system which obliges various electricity suppliers to buy a certain amount of electricity from producers of electricity from RES. The regulator in the Member States defines a minimum number of green certificates to be obtained over time by the electricity suppliers. Subsequently the suppliers are required to demonstrate their achievement to the regulator. In the event that the electricity supplier has failed to fulfil its quota of green certificates, he is required to pay to the regulator an aliquot amount. The greatest representative of this support system is the United Kingdom; also Belgium, Netherlands, Poland and Sweden use this system.

There are many other ways to support RES: fiscal measures such as tax benefits (recognition of a lower tax rate or total relief from taxes), loans (in the form of a loan with benefits such as lower interest rates for a certain period, which is used to finance the construction of RES technologies) or subsidies (provision of funds for RES technologies construction).

## II. SUPPORT OF ELECTRICITY FROM RES

The RES support system is a set of policies and measures to support the development of the electricity production from RES. The support of energy from RES and construction of facilities and technologies are used in various forms. Some examples are given further.

### A. Slovak Republic

According to Directive 2009/28/EC, the Slovak Republic, as the member state of the European Union [1], has a duty to increase the use of RES in proportion to the gross final energy consumption from 6.7 % in 2005 to 14 % in 2020.

The support for RES in Slovakia [8] is provided through the feed-in-tariffs, subsidies and remission of excise tax on electricity for producers that use electricity generated for self-consumption. The purchase prices are provided for all types of RES (excluding hydro power) and are guaranteed for 15 years, but limited by the installed capacity. The facility of electricity producer may not exceed 5 MW and in the case of wind power 15 MW. For facilities that exceed that limit, the purchase price is offered as ratio of the power production amount 5 MW, respectively 15 MW. To support the electricity production from RES, the National Council of the Slovak Republic in 2009 approved Act No. 309/2009 Coll. the promotion of the renewable energy sources and high efficiency cogeneration and on amendments to certain laws, as amended (Act No. 309/2009 Coll.), which creates a legal framework for the electricity support from the renewable sources.

### B. Czech Republic

According to Directive 2009/28/EC, the Czech Republic as the member state of the European Union [1] has a duty to increase the use of RES in proportion to the

gross final energy consumption from 6.1 % in 2005 to 13 % in 2020.

The Czech Republic [8] provides feed-in-tariffs, the amount of which is determined to provide a return of investment in 15 years. Currently, the purchase price can be selected only by the electricity producer from hydropower plant with the installed capacity of 10 MW and biomass, wind and geothermal power up to 100 kW. Another way of support is the green bonus, which acts as a supplement to the market price at which the producer sells electricity and applies to its own consumption of electricity and to the supplied power to the network and sale. The purchase prices and green bonuses cannot be combined and can always change on 1st January of the following year. Since 2014 the green bonuses are provided only to small hydropower plants with an installed capacity up to 10 MW and biomass, geothermal and wind power plants with an installed capacity up to 100 kW.

In the Czech Republic, the state support of the production of the renewable energy sources is regulated by the Act no. 180/2005 Coll., on the promotion of renewable energy, which was from 01/01/2013 replaced by Act no. 165/2012 Coll., on the supported energy sources.

### C. Austria

According to the Directive 2009/28/EC, Austria as the member state of the European Union [1] has a duty to increase the use of RES in proportion to the gross final energy consumption from 23.3 % in 2005 to 34 % in 2020.

In Austria [8] the purchase prices are to be provided with certain exceptions for all types of RES; the amount varies on base of the technology type and use. The amount of the purchase price is set by the government. As well as in Slovakia, the Czech Republic or Germany, RES is supported through subsidies based on individual challenges. The main types of subsidies in Austria are the investment subsidy for hydropower plants (intended for the construction or revitalization of small and medium-sized hydropower plants), investment subsidy for photovoltaics (for the construction and installation photovoltaics on buildings) and investment subsidy for power plants not connected to the network (for the construction of small hydropower, wind, solar and biogas power plants for own consumption).

### D. Germany

According to the Directive 2009/28/EC, Germany as the member state of the European Union [1] has a duty to increase the use of RES in proportion to the gross final energy consumption from 5.8 % in 2005 to 18 % in 2020.

In Germany [8] the purchase prices are provided to all kinds of RES at certain conditions, such as category of the installed capacity. For facilities put into operation after 1/1/2016, the purchase price is granted under condition that the installed capacity does not exceed 100 kW. The purchase prices are adjusted each year, subjected to decrease and guaranteed for 20 years (for hydro power for 15 years) plus the year in which the facility was put into operation. Instead of the purchase price, the producers may choose the premium tariffs which are paid for the electricity supplied to the network and purchased by a third party, they are calculated each month and consist of

two components. The first one is the difference between the purchase price and the monthly average market price of electricity, depending on the specific technology and type of RES. The second component is the bonus which covers the costs caused by the difference between the current supply of the network and forecast deliveries. The support for RES in Germany is provided through a loan, the current programme provides a long-term loan with low interest to finance projects with the possibility of covering 100 % of the investment costs.

#### E. Poland

According to the Directive 2009/28/EC, Poland as the member state of the European Union [1] has a duty to increase the use of RES in proportion to the gross final energy consumption from 7.2 % in 2005 to 15 % in 2020.

In Poland [8], electricity from the renewable energy sources is supported by a system of quotas and tax concessions. Feeding the electricity from the renewable energy sources to the grid system must be prior ensured by operators. Any producer of electricity from the renewable energy sources will receive one Green certificate for each 1 MW of the produced electricity. The law requires producers of electricity, electricity suppliers, dealers and end users who are members of the commodity exchange to buy a certain amount of Green certificates. This number (quota) is most often determined by the government. The case of non-quota is usually penalized. The electricity producers can sell electricity to the market or to the electricity supplier at the last year market price. Operators of micro assemblies (installations using renewable energy with a capacity up to 40 kW), who decided to sell the generated electricity, will receive only 80 % of the last year market price by the electricity supplier. The quota is a proportion of the total annual electricity sold quantity. The quota was set till 2021.

A change was from 01/01/2016 and it is the start of the auction system. It works so that the government decides how much electricity needs from the renewable sources. In accordance with the set criteria, the step is the announcement of the auction on production capacity and type of resources. That participant of the auction wins who proposes the lowest price.

#### F. Hungary

According to the Directive 2009/28/EC, Hungary as the member state of the European Union has a duty to increase the use of RES in proportion to the gross final energy consumption from 4.3 % in 2005 to 13 % in 2020.

The support in Hungary [8] is mainly based on a system of feed-in tariffs. The renewable energy facilities have priority when connected to the distribution system and access to the distribution network. The costs of connecting the renewable energy installations and network expansions are paid either by the operator or distribution system operators, depending on certain criteria. Three different tariff zones are defined, depending on the time of day, the fact whether it is a weekday or weekend, or whether it is winter or summer. The tariff level also depends on the installed capacity of the production equipment and production technology. The basic tariffs are set by law. At the end of each year, the energy authority sets tariffs for different technologies for the next year based on the method of calculation based on the basic fare.

### III. COMPARISON OF PURCHASE PRICES IN SELECTED COUNTRIES – SOLAR POWER, HYDROPOWER, BIOGAS

The regulatory Office for Network Industries (RONI) in Slovakia compared the RES support and purchase prices of electricity from RES in the selected EU countries in 2014 [9].

#### A. Solar Power

In regards to solar photovoltaic power plants with a total installed capacity of 29.99 kW were compared. In Slovakia, the price of electricity produced from RES by facilities put into operation after 1/1/2014 is determined directly with the fixed price and the value is 0.09894 €/kWh. In the Czech Republic the support for new photovoltaic power plants was not provided in 2014. In Hungary, there are several specifications under which differentiate the individual purchase prices. For comparison we used the value 0.095 €/kWh in the peak time. In Poland there are no system purchase prices, electricity from the renewable sources is promoted through the quota system and tax credits and the overall comparison is therefore not included. In addition to the purchase prices, the construction of the photovoltaic power plant on buildings and small and medium-sized hydro power plants are supported by subsidies in Austria. The purchase prices for the building integrated solar power plants were reduced by 28 % in January 2014 and the purchase price was 0.125 €/kWh. The purchase prices for a ground mount solar park is reduced to 0.10 €/kWh from 0.17 €/kWh. Additionally, the solar energy systems will be eligible for the purchase prices with an installed capacity of 350 kW instead of 500 kW. The overall value for the comparison is the purchase price of 0.125 €/kWh (installation of photovoltaics on buildings or noise barriers in power from 5 kW up to 350 kW) for applications submitted and contracts concluded in 2014. In Germany the purchase prices is determined by a fixed monthly decreasing rate of 1 % and flexible decreasing rate that is depending on the newly installed capacity. In the overall comparison the purchase price for the solar systems in the category with a total installed capacity up to 40 kW was set to 0.1298 €/kWh. Within the overall comparison of the mentioned countries the lowest value of the purchase price is in Hungary. In Slovakia, the value of the purchase price is higher of about 0.004 €/kWh. In Austria, the value of the purchase price is higher by 0.026 €/kWh than in Slovakia and the highest value in the compared countries is in Germany; about 0.03 €/kWh higher than in Slovakia.

TABLE I.  
SOLAR POWER PURCHASE PRICES, CAPACITY UP TO 30 kW, AFTER 1/1/2014 (€)

HU	SR	AT	DE
0,095	0,098	0,125	0,129

Source of data: RONI [9]

#### B. Hydropower

The purchase prices and support of hydropower, hydropower plants with a total installed capacity of 5 MW were compared. In Slovakia, the price of electricity produced from RES in the facility put into operation after 01/01/2014 is determined directly by specifying a fixed price in 5 categories of the purchase prices divided by the

installed capacity. The overall value for the comparison is the purchase price of 0.09798 €/kWh for hydro power plants with a capacity up to 5 MW. In the Czech Republic the choice of the double-tariff zone of operation for small hydropower plants has been restricted. It has been precisely defined which conditions must be met in order to be eligible for support in the double-tariff zone of operation. The support is provided for facilities with a total installed capacity up to 10 MW and is differentiated in 3 categories. The overall value for the comparison is the purchase price of 0.11757 €/kWh (category of small hydropower plant in new locations put into operation from 01/01/2014 to 31/12/2014 within single-tariff zone). In Hungary, there are several specifications under which the individual purchase prices are differentiated. The overall value for the comparison is the purchase price of 0.118 €/kWh in peak times within one of two categories with a total installed capacity up to 5 MW. In Poland there is no system purchase prices, electricity from the renewable sources is promoted through the quota system and tax credits and the overall comparison is therefore not included. In January 2014 in Austria the purchase prices for hydropower plants were reduced by 1 % of the 2014 budget to support for RES. Compared to the values of the two categories of the purchase prices - category (A): new or revitalized hydropower plants that increased their efficiency by at least 50 %, category (B): revitalized hydropower plants that increased their efficiency by at least 15 %. Since 2013 in Germany the degressive rate to support this type of energy is determined by 1 %. In comparison the average value of ranges of the purchase price is 0.0805 €/kWh and depends on the size of the facilities and the date of commissioning. The lowest value of the purchase price is in Austria – by 0.0219 €/kWh lower than in Slovakia. A lower value of the purchase price than in Slovakia has also Germany – by 0.0174 €/kWh. The Czech Republic has a higher value of the purchase price by 0.0196 €/kWh than Slovakia. The highest value of the purchase price is in Hungary – by 0.0201 €/kWh higher than in Slovakia.

TABLE II.  
HYDRO POWER PURCHASE PRICES, CAPACITY UP TO 5 MW, AFTER  
1/1/2014 (€)

AT	DE	SR	CZ	HU
0.048-0.104 (A) 0.031-0.081 (B)	0.033-0.125	0.0979	0.1175	0.118

Source of data: RONI [9]

### C. Biogas

Two categories were chosen in the comparison for biogas in Slovakia: (A) 0.0734 €/kWh burning landfill gas or gas sewage treatment plant, (B) 0.1072 €/kWh burning biogas produced by the anaerobic fermentation technology with a total capacity of 750 kW facilities. In the Czech Republic support for new production plants using biogas was not provided in 2014. In Hungary, there are several specifications according to which differentiate the purchase prices. For comparison, the value of 0.118 €/kWh in the peak times was used within one of three categories with a total installed capacity up to 20 MW. In Poland there is no system of the purchase prices, electricity from the renewable sources is promoted

through the quota system and tax credits and the overall comparison is therefore not included. For Austria two categories were compared: (A) 0.0496 €/kWh devices using landfill gas, sewage gas-using equipment, (B) 0.1292 – 0.194 €/kWh biogas plants. For Germany three categories were compared: (A) 0.0571 – 0.0834 €/kWh landfill gas, (B) 0.0571 – 0.0659 €/kWh sewage gas, (C) 0.0588 – 0.245 €/kWh biogas biomass. The average value of the range category (A) has been chosen to compare the purchase price for facilities using biogas. The result shows that the lowest value has Austria; Slovakia and Germany are at comparable levels. The highest value of the purpose price has Hungary.

TABLE III.  
BIOGAS PURCHASE PRICES, AFTER 1/1/2014 (€)

AT	SR	DE	HU
0.0496 (A)	0.0734 (A)	0.0571 - 0.0834 (A)	0.118
0.1292 - 0.194 (B)	0.1072 (B)	0.0571 - 0.0659 (B)	
		0.0588 - 0.245 (C)	

Source of data: RONI [9]

### IV. SETTLEMENT OF BALANCES BETWEEN PRODUCERS AND SUPPLIERS

One way how to increase the share of RES in the EU is a state grant for building small power plants using RES for electricity generation.

For example, in Slovakia, the Slovak Innovation and Energy Agency [10] launched 01/12/2015 national programme for “Green households”, which will be funded from the Operational Programme Environment Quality regulated by the Ministry of Environment. Within this programme a small power generation equipment with capacity up to 10 kW will be funded – photovoltaic panels and wind turbines or heat generator – solar collector, heat pump, biomass boiler. In application of the subsidy, households that produce higher energy than they consume supply excess energy to the distribution system free of charge. The effort, however, is that most of the electricity produced is also consumed by themselves and therefore also application to batteries will be granted.

Government policy on development of production of electricity from small renewable energy sources for household in the following 5 years could reach about 100 million EUR for the installation of photovoltaic panels, solar collectors, heat pumps, biomass boilers and wind turbines.

In the Czech Republic, the Ministry of Environment and State Environmental Fund published on 21/10/2015 another challenge in the “New Green Savings Program” designed for houses. In the call, it is possible to apply for subsidies by 2021, where it will be possible to draw up to 27 billion Czech Crowns. The challenge is for family houses for a total renovation. The households can also apply for subsidies for the installation of photovoltaic panels to produce electricity for own consumption.

Installation of small power plants using RES for the needs of the producers brings the issue what to do with

electricity what is not used in real time. Currently, this process is not covered in Slovakia by any legislation. In the world, there are several ways:

#### A. Netmetering

The netmetering [11] is a support system of RES for consumers, who are also producers of electricity from RES that is supplied to the network, but in periods of insufficient production they utilize the electricity from the network. The most frequent case of insufficient production is the production of electricity from photovoltaic power plants at night.

The netmetering is designed for the producers of electricity from RES which continuously fail to cover their own use and works by monitoring the difference between the amount of electricity produced and supplied to the network and the amount of electricity that was consumed and delivered from the network.

Producers are using the distribution network as “energy store” – how much it is stored, so much it is consumed from the grid. If they produce less energy than consume, they buy electricity as an ordinary purchaser at the market prices.

This support model is used, for example in Denmark, Italy, Spain, and France. Producers respectively consumers, opting for netmetering would not be dependent on the purchase prices laid down by the State, in Slovakia the Regulatory Office for Network Industries, and the administrative burden in the construction and operation of small power plants, e. c. photovoltaic roof installations is simplified.

The netmetering is more preferably for producers because they do not need to invest more money into energy batteries and also can use all the electricity generated at the time when they need it. On the other hand, the distributors of electrical energy take it at the time when producers do not need it and feed it back in time, when producers need it. Electricity, however, especially during the day flows regardless of its current needs and can cause network overloading, in extreme cases also failures.

#### B. Island Operation

Excluding the supply of unused electricity to the distribution system is a system of island operation. This method of settlement balance is economically challenging. Producers must invest funds into an accumulator battery, which is storing produced and not consumed electricity during the day and which is then used at the time when producers need the electricity, for example in the evening, night and early morning.

The island operation is preferable for distribution systems, which are not obliged to take any unused electricity and thus no possible overloading of the distribution system appears. The island operation involves higher initial purchase cost of accumulating batteries, but in this way all the electricity generated during the day can be consumed.

#### C. Form EPC (Energy Performance Contracting)

The Energy Performance Contracting (EPC) [12] is a form of creative financing for capital improvement which allows funding energy upgrades from cost reductions. Under an EPC arrangement an external organisation

implements a project to deliver energy efficiently, or a renewable energy project, and uses the stream of income from the cost savings or renewable energy produced to repay the costs of the project (including the investment costs). Essentially, the external organisation will not receive its payment unless the project delivers energy savings as expected.

The EPC form can be used for building small power plants. The external organisation prepared the project, it installed a small power plant – for example photovoltaic panels to the customer roof and the whole project would be financed. Electricity that would not be consumed by a customer would be supplied to the distribution system. Profit would then be paid to the external organisation that carried out the project.

But it is again duty to feed unused electricity to the distribution system, regardless of its actual use. This may cause a network overload or failures. For the efficiency of the method for companies, it is necessary to impose an obligation to the electricity distribution system.

#### D. Heating Water Using Solar PV Modules

Heating water using solar panels [13] is new technological solution of heating water by environmental-friendly energy sources. The photovoltaic panels collect solar energy from the sun and transform it into direct electric current to heat water in boiler. The brand new solution is an installation of the heating spiral and photovoltaic panels which do not generate any power losses. This solution is very effective and secures thermal protection and safety control of the entire system.

Installation of photovoltaic panels is simple and variable, requires maintenance-free operation, and offers unlimited opportunities of the system utilization in households, apartment units, industrial and commercial buildings thanks to simple connection with water boiler. It represents production of electricity by using renewable sources.

Heating water by using photovoltaic panels is an ecological and cost-effective way to produce hot water. Such energy is fully consumed by the system owner in the household or commercial building. It does not require any official permissions or purchase of additional devices. It is currently the most effective utilization of ecological electric energy without generating any power losses.

The patented direct current (DC) control that is used for water heating can be also used for the heating system that is connected to the source from the photovoltaic panels. When the water in the reservoir is heated to the pre-set temperature, the electricity (DC) is switched to the other water reservoir or from the heating system to the reservoir. Photovoltaic heating systems should always take precedence for water heaters. The systems of heating and water heating communicate between themselves automatically without the need for an additional electronic control. The photovoltaic heating can be also used for the electrical heating systems, or for the liquid heating systems.

The advantage of this system is use 99 % of the electricity generated from the photovoltaic panels and no problems with the excess energy from the sun. It is possible to place the panels more than 100 m from the water tank and connection is by cables only.

## V. CONCLUSION

There are many ways to support RES. The main assumption is conviction of their environmental benefit to sustainable development and the willingness of national governments to support the production of electricity from RES. Another assumption is the ecological awareness of the population, which is reflected in the willingness to pay more for environmentally clean electricity.

Support of RES through the purchase price is the most widespread support within the EU, but support for RES has an impact on the electricity price, which not only impacts the economy of households, but mainly penalizes industries against competition from the non-EU countries. The reason for the growth in the electricity prices is costly support for RES as well as increasing costs associated with the safe operation of the system which is setting even higher demands as the share of electricity from RES in the system increases.

A method of settlement balances between the producer and electricity supply is not legislative stated in Slovakia. In creation of legislation it is needed a broad discussion of the electricity suppliers, as well as the wider professional community. It will be necessary to take into account the requirements of the distribution companies that are required to ensure the continuity and security of supply as well as the requirements of producers.

Creating effective conditions for introduction of the renewable energy facilities – small power plants is a good alternative to the ever-increasing energy consumption. A suitable legislative amendment would have to electricity producers in small power plants be an incentive to invest in renewable energy, but it is necessary to set conditions so that the system has the least possible abuse.

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