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Market Value of Electricity Generated Based on RES Utilization

M. Benes, J. Knápek

Czech Technical University in Prague, FEL
Technicka 2, 166 27 Praha 6, Czech Republic

Abstract

Proper calculation of required support for electricity generation from RES needs information about market value of the electricity with respect to the electricity market rules and unique features of electricity from individual RES. The production of typical independent power units (IPU) is valuated by prices of electricity from competitive power plants. The economy of transition network and other high voltage networks has been considered as well because the IPU is usually not connected to the transition network. The production diagram of IPU and the production diagrams of entire electricity system in general do not fit. The differences of the diagrams are valued by short term (spot) market prices. Other factors being taken into account are deviations of the actual electricity delivery from agreed diagrams due to heating regimes or we-ther conditions like wind speed variance. These deviations are appraised from data from electricity market operator. The article presents results of RES electricity market valuation for the Czech Republic. Those market prices of IP electricity can be used for economic evaluation of investment to IPU or for regulation body for setting of green certificates or for other applications.

Keywords *: electricity value, load diagram, electricity pricing, system services*

1. Introduction

The need for correct pricing of electricity from RES raised in the Czech Republic at 2005 in relation to the new Act 180/2005 Col. on support of RES for the electricity generation.

The Act on RES support introduces two options of the support for power generation from RES - support in the form of feed-in tariffs and in the form of green bonuses.

Green bonuses are a supplement to the (expected) market price so that the sum of the market price and bonus equals to the minimum price (feed-in tariff). The calculation of green bonuses needs the proper estimation of market price of the electricity from RES. The Czech electricity market is fully liberalised and the market generally creates the price of electricity. It means that the technical characteristics of sold electricity from RES like reliability, diagram of delivery, expected deviations from contracted diagram, etc. have to be respected in calculations. It results in different estimations of the market price of the electricity from RES for different types of RES or technologies. There is no average or uniform price of the electricity from RES that can be used for the calculation of green bonuses.

The operator of RES power station sells electricity for the price at maximum equal to competitive offers at the electricity market respecting technical characteristics. Supply of electricity at the market is based on electricity generated in classical power stations.

2. Marginal valuation of electric energy

The valuation of the electric energy can be made in two ways, either using the market price of the energy or using the marginal cost within the electricity system. The second approach is more appropriate from the theoretical point of view because the current state of the electricity system is respected without short term market biases of the electricity price. On the other hand the marginal cost valuation respects the planned cost of the new power stations but the situation concerning the actual power unit commissioning is slightly different. So the best solution should link together the short-term and long-term prices.

The best valuation of the long-term (one year) prices of the electric energy in the Czech Republic is use of the prices of standard CEZ business offer (SCO) supplied by CEZ, a. s. CEZ is the dominant electricity producer in the Czech Republic and operates the core power stations in the country (nuclear, coal fired, pump storage and the biggest water dam power stations). The standard business offer consists of several types of the diagram (each diagram having the individual price of electricity), from the totally flat diagram delivered through the whole year to the electricity supplied in working days from 8:00 to 20:00 specifiable for each month. SCO can be fairly used for medium and long-term pricing of electricity (up to one year) because it is generally available and the prices are known to all subjects in the electricity market.

The most appropriate prices of the short-term electricity including the valuation of the deviations could be made using the Electricity market operator statistics. It is evident that the situation in the market cannot be forecasted for the future exactly but the experience of the authors is that the overall valuation is relatively correct because the over-average prices during some time period are compensated by the under-average prices in the other time. Also the market with the ancillary services is relatively stable so the prices from one year can be used as the base for pricing in the coming year.

3. Valuation of renewable sources production

The above-described methodology was used to set the expected market prices and resulting sales value of the electricity generated from renewable sources. The characteristics of the sources are very different. The small hydro power stations have relatively easily predictable production varying only in the periods of months due to changes in overall precipitation conditions. The biomass stations are usually used as combined stations supplying both electricity and heat. In such case the generation of electric energy depends on the supply of heat that depends on the many factors from which the outside air temperature is the most important one. But the temperature could be predicted at least within the day-to-day period. On the other hand the wind power stations have the hardly predictable production that can vary in ten minutes significantly.

The valuation of the generated electricity is calculated in the following steps:

a) The expected "average" diagram of production is estimated.

b) The diagram is covered by the one or several components of standard CEZ offer that represents the best long-term electricity value.

c) The differences between the generated diagram and the SCO are calculated and traded in the short-term daily and spot market organized by OTE (Operator of electricity market). If the expected generation is greater than the SCO diagram value, the excess of the energy is sold in the spot market, in the opposite case the lack of electricity is bought from the spot market. The total sum of the trades represents the basic value of the generated diagram.

There are several possibilities how to cover the diagram using the SCO components and the short-term market. The volume and composition of SCO diagram can be various; usually it is important whether to use the high or low energy volumes of the SCO. If the valuator wants to minimize risk it is correct to set SCO volume in the way minimizing the trade on spot OTE market and therefore the market risk for the RES power stations. On the other hand the lower SCO volume can bring the higher sales to the sources despite of bringing the greater market risk to the source due to the changing prices on OTE market.

d) The next part of the calculations is the valuation of the electric energy deviations. It is possible to gather the data from the OTE market statistics called "Additional Expenditures, Deviations and Ancillary Service Prices". The price of electricity deviations is published for each hour of the year. The authors have decided to forecast the deviations as the percentage from the electricity volume generated during every hour. For example the biomass sources have the specific deviations of 10 % while the wind power stations have the deviations of 60 % from the electricity generated.

It is obvious that the actual deviations will be different. But we as the author have the experience that the real deviation payments are close to the expected values.

e) The total sum obtained from the points c) and d) represents the value of the power source annual diagram. After that it is possible to calculate the specific value often called "price" by dividing the total value by the volume of the electricity.

f) The value of the diagram from the point of view of the electricity system as the whole can be also influenced by other factors. One of the most important factors is the change of the electricity losses in the network imposed by the source (adjacent lines). If the losses are lower comparing with the situation without the given source operation the part of the benefit improves the value of the electricity generated. It takes place in the case when the source is located close to the points of electricity consumption. Similarly the distributed source can improve the stability and reliability of the electricity supply. These influences must be evaluated on the individual basis because each independent source has the completely different placement within the network.

4. Electricity market calculations

4.2 Biomass source

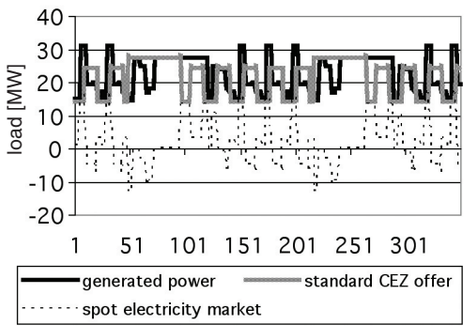

Figure 1. Load diagram of biomass combined station (sample for several days)

The thick line shows the generated electricity, the shadow one represents the relevant diagram of standard CEZ offer and the dotted line is the balancing trade at OTE market. The values below zero are bought (must be paid) in the spot market while the values above zero are sold (income). The total annual value of the diagram (see ***Figure 1***) is 3.76 million EUR. The volatility of diagram is predicted to be 10 %, the value of deviations is -0.24 million EUR. So the total value of the electricity generated is 3.52 million EUR, the specific value is 40.8 EUR/MWh.

4.2 Wind source

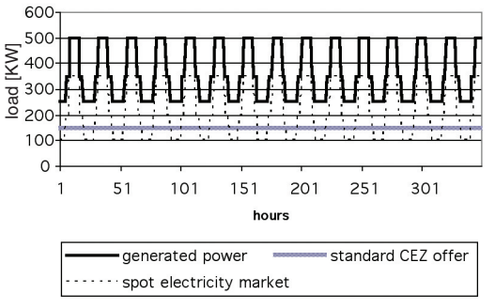

Figure 2. Load diagram of wind station

The deviations and the generated power were obtained from the planned power station located in the "above" average wind conditions. Standard CEZ business offer is the constant shadow line and therefore the excessive electricity is always sold on OTE spot market at average. The generation in wind power station is too risky to ensure the higher level for customers. The value of the diagram is 82.8 thousand EUR. The deviation coefficient is 60 % so the respective payments for the deviations is -41.2 thousand EUR. The total value of the diagram is 41.6 thousand EUR, the specific value is 18.1 EUR/MWh.

4.3 Estimations of market prices for the Czech Republic

For each type of RES sources several reference projects has been analysed. The valuation has been based on electricity market rules and prices valid for the year 2006. The results of calculations are summarised at the following table:

TABLE 1. Expected market prices of RES electricity, the Czech Republic, 2006

	Biomass	Biogas	S. hydro [EUR/MWh]	Wind	PV
A	39.3	39.7	39.8	12.6	**28.4**
B	**37.0**	**37.4**	**37.4**	**18.9**	19.6
C	25.8	28.0	28.1	12.6	10.8

The basic estimation of the price was modified by the different behaviour of the subjects in the spot OTE market:

A. The load diagram is primarily covered by SCO published for 2006. The positive and the negative differences are traded in the spot market so the active trading of the RES source operator is expected. The sum of positive and negative differences is close to zero.

B. SCO for 2006 is used for the minimum disposable production so the negative difference is zero. The positive differences are sold in the spot market.

C. All generated electricity is sold in the OTE spot market.

The most probable behaviour of the RES sources is close to B scenario because the active approach of the small sources cannot be expected. The active trading in the spot market for the large sources (bigger biomass or hydro) is more likely to occur.

5. Economic calculations

Investor is economically motivated to invest into RES project only when the rate of return of capital invested is favourable. It means that investor needs such price (or aggregate income) for the sold electricity assuring not only the cost but also the required rate of return. According to the Czech scheme he can choose either feed-in tariff or green bonus. Feed-in tariffs are derived from so called minimum price of electricity. Green bonuses are set up as the difference between feed-in tariff and the expected market price of electricity.

Calculation of green bonuses is thus divided into two steps:

- estimation of business risk of investor (differs for individual types of RES)
- calculation of minimum prices and definition of feed-in tariffs for individual types of RES
- calculation of expected market price for generated diagram (for given type of RES)

5.1 Minimum price of electricity

The minimum production price is the price, for which the net present value of project is zero:

$$NPV = \sum_{t=1}^{T_z} CF_t \cdot (1 + r_n)^{-t} = 0$$

where

CF_t difference between revenue collected and costs paid in the year t of the project realization

r_n nominal discount (with inflation respected)

T_z project lifetime

When NPV=0, the investor gets in the return from the capital invested in the project in the amount of the discount used to calculated the NPV. Energy Regulatory office uses for calculation of minimum price of electricity from different types of renewable energy sources (based on data of reference projects) nominal discount equal to 7 %. Discount has meaning of weighted average cost of capital (WACC).

5.2 Discount rate

The nominal discount rate should respect both the minimum risk-free return from the investor's assets and the risk premium. The risk premium is higher whenever the investor bears the higher risk (market risk, credit risk, technological risk, etc.). The formula for the calculation of WACC respecting the indebtedness is

$$WACC = r_{ed}\frac{E}{E+D} + i\cdot(1-d)\frac{D}{E+D}$$

where

i long-term interest rate

r_{ed} nominal discount after taxes

d income-tax rate

E firm's equity

D firm's long-term debt

The final risk premium for the RES consists of low risk component derived from guaranteed tariffs and risky component that includes the electricity market risk (changes of prices).

The range of typical discount rate used for green bonuses calculation range from 7.5 to 8.5%. This value is derived for the Czech Republic based on CAPM model and share of market price on total revenues (market price + green bonus) of power station. The discount rate is higher than discount rate used for feed-in tariffs calculation because of business risk connected with sell of electricity on (spot) market.

5.3 Green bonuses

The price decision of the Czech Energy Regulatory Office No. 10/2005 defines green bonuses for electricity from RES for the year 2006 - see table.

TABLE 2. Green bonuses for RES electricity, the Czech Republic 2006

Biomass	Biogas	S. hydro [EUR/MWh]	Wind	PV
68.8				
57.2	70.5	50.2	70.9	441.8
46.3				

These bonuses are valid for new power plants put into service in 2006. In case of biomass utilization bonuses are differentiated according to the type of biomass fired. The categories are: intentionally planted biomass (highest bonus), residuals from forestry and agriculture and wooden chips and wooden residuals (e.g. sawdust).

6. Conclusion

The estimates of market price of the electricity from RES should be based on competitive electricity offers in power market. The methodology of evaluation of any type of diagram of electricity supply has been developed and successfully applied by the Czech Energy Regulatory Office for setting green bonuses. The methodology is based on covering of the supply diagram by the standard medium and long term electricity offers. The differences and deviations are traded on spot market and valued by expected prices of spot market.

Green bonuses as the support tool has been introduced to give investors the incentive for optimization of their behaviour according to needs of electricity system. It is expected that smaller producers will choose feed-in tariff system and that bigger producers will choose green bonus scheme. Green bonuses reflect higher business risk compared to the feed-in tariff scheme.

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