Economic Assessment of the Ecological Benefits from Rooftop Photovoltaics in Bulgaria

Pavlin Pavlov*

Summary:

Alternative energy sources, due to their ecological orientation and benefits for society, have the potential possibility to lead to an environment friendly development of humankind. Most studies on the topic cover only the financial dimensions, whereas others focus mainly on the ecological benefits. This paper puts an emphasis on the inclusion of the ecological benefits in the economic evaluation. Thus, a realistic economic accounting is achieved of the impact on the environment. The first part of the article suggests a methodology carrying out a multi-criteria analysis of rooftop photovoltaic power systems. The second part addresses the monetisation of the amounts of CO2 emissions saved and their inclusion in the economic evaluation of the ecological benefits from the rooftop photovoltaics. In the third part, some possible perspectives for development of the rooftop photovoltaics in Bulgaria are presented. The end of the article outlines the expectations and effects of the future development of the rooftop photovoltaic power stations in Bulgaria.

Key words: economy, ecology, photovoltaics, energy, renewable energy sources

JEL Classification: Q4, Q5

1. Introduction

In Bulgaria the installed rooftop photovoltaic power stations are as few as 9 megawatts towards the end of 2013 based on data from the National Construction Control Directorate. Compared to the functioning 820 megawatts in the beginning of 2014, the rooftop photovoltaic power stations encompass a share of only 1,10% as opposed to 98,9% ground-mounted photovoltaic (PV) power stations. This ratio presents an exceptionally great potential for increase in the installed rooftop-mounted PV power stations. When comparing the ground-mounted and the rooftop-mounted PV power stations, the latter hold a significant advantage as they not only make use of rooftop spaces, but also do not take up fertile lands, thus saving money on their purchase and change of use. In the case of ground-mounted solar installations countrywide they are more often than not mounted on lands suitable for agriculture, which further increases the expenses that are not typical of rooftop-mounted solar power stations. All this, combined with the emissions of CO2 saved, shifts the focus onto the greater use of rooftop PV power stations, taking into account not only the economic demands but also the ecological aspect. So far the latter has been left in the background, giving way entirely to the financial interest. The need for change calls for the implementation of adequate tools for evaluating the effectiveness of the rooftop PV power systems. They should be flexible and affordable enough to be understood by potential investors.

* PhD, Department of Strategic Planning, D. A. Tsenov Academy of Economics; e-mail ppavlov@uni-svishtov.bg

1. Reconciling economic and environmental benefits of the rooftop photovoltaics

There are various approaches to making an economic evaluation, however, preference should not be given only to criteria connected with the return on a given investment without taking into account the environmental impact. Otherwise, the evaluation could not be entirely objective. Research in this respect has been carried out by different authors (Nikolova and Co., 2012), (Andonov, 2009) and others.

Thus, when assessing the ecological benefits of the rooftop PV power stations indicators combining all benefits have to be used.

The economic parameters for the rooftop PV power stations are undoubtedly important, however, in Bulgaria they take into consideration only the interests of one of the stakeholders – the investors. On the other hand, the ecological parameters are also significant but they take into account only the interests of the other stakeholder – the society. Reconciling the economic with the ecological indicators is a demanding task, since seemingly incommensurable things need to be compared. Currently, recording the economic and ecological parameters is generally presented as a recommendation for the investors in rooftop PV power stations. The reason for this is that the ecological benefits are rather seen as serving public interests rather than as a financial concept to be used in planning the solar photovoltaic power system. Therefore, this paper proposes a methodology for carrying out a multi-criteria analysis (MCA) of rooftop PV power systems. This type of analysis is effective in case it is hard or even impossible to monetize costs and benefits. Such an analysis allows for the overall planning of the project where the environmental impact is expressed in monetary terms in order to be included in the calculation of the aggregate indicators. The multi-criteria analysis allows for various approaches and methods to be applied in the research of a given object. It therefore avoids giving preference to purely economic or environmental criteria, which would be

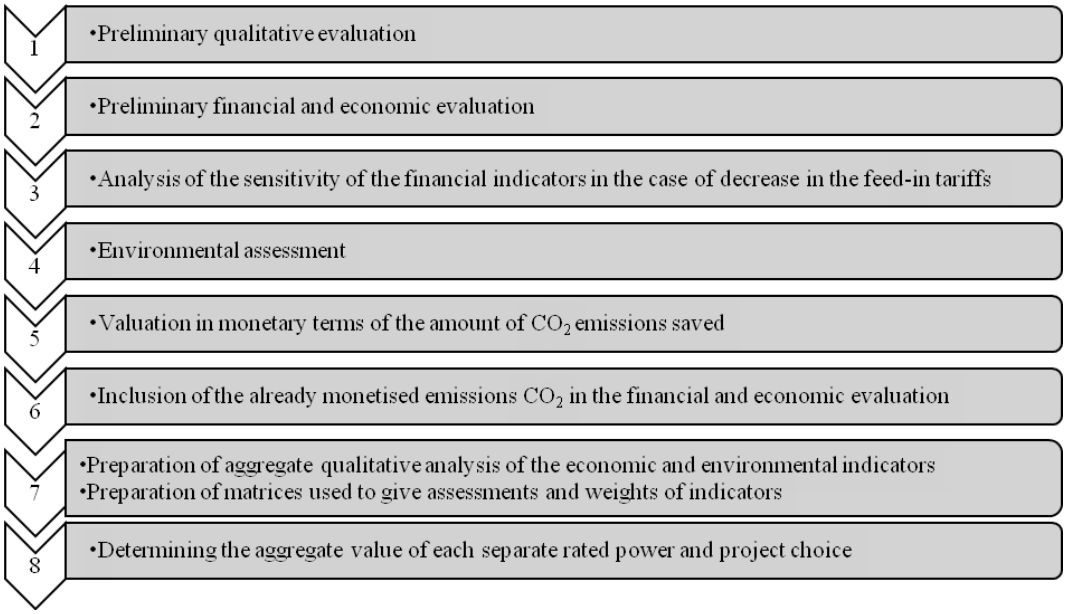

Fig. 1. Methodology for carrying out a multi-criteria analysis of rooftop-mounted PV power systems

the case if separate approaches were applied. In MCA it is essential to decide which criteria, methods and approaches should be combined and how to do so in order to arrive at the most comprehensive and accurate analysis.

The proposed methodology has been developed by the author on the basis of the approach to the assessment of the impact on people's health and the environment, suggested by the Department for evaluation with the Directorate-General (DG) for Regional Policy of the European Commission, in the Guide to cost-benefit analysis of investment projects (Assessment department, DG for Regional Policy, European Commission, 2008). The steps of the methodology for rooftop PV power stations are as follows:

The preliminary qualitative evaluation (step 1) includes a review of the economic, social and ecological criteria for evaluation and project selection for rooftop-mounted PV power station.

The preliminary financial and economic evaluation (step 2) reviews various indicators of a given investment in rooftop photovoltaics: return on investment in years; internal rate of return (IRR); net present value (NPV).

The analysis of the sensitivity of the financial indicators in the case of decrease in the feed-in tariffs (step 3), determines the effect of the implemented policy of State Energy and Water Regulatory Commission (SEWRC) on the profitability of investments in rooftop solar power stations.

The environmental assessment (step 4) includes the calculation of the contribution of a given power station to the reduction of greenhouse gas emissions in the atmosphere both globally and nationally.

The assessment in monetary terms of the amount of CO_2 saved (step 5) by applying given approaches in fact suggests that the amount of saved CO_2 emissions is monetized.

The inclusion of the already monetized CO_2 emissions in the financial and economic evaluation (step 6) requires the calculation of the economic regulators (IRR, payback period and NPV), thus reflecting the monetary value of the non-emitted amount of carbon dioxide. Incorporating them in the financial and economic evaluation requires that they be added to the net cash flow in the economic analysis. Thus not only are the ecological benefits included in the cash flow, but also higher positive values of the financial and economic criteria are achieved.

The preparation of aggregate qualitative analysis of the economic and environmental indicators (step 7 in the methodology) allows for refining the results after accurate estimates that incorporate the ecological benefit have been made. This step is not a mandatory element. However, it would more clearly identify investors' preferences with regard to return on investment, on the one hand, and to ecological benefits, on the other, which in 2013 were classified more as external benefits, i.e. relating only to society. Moreover, it would help determine the capacities that would be profitable to set up without the need to make a compromise with one or another indicator. Another thing that would be identified is the type of capacity of rooftop PV power stations that should be promoted.

In step seven in the methodology the following are prepared:

- A matrix that scores the economic and environmental indicators of the project. Since both the period of return and the internal rate of return depend on the net present value, when determining the scoring, the net present value and the emissions of CO_2 saved are calculated;
- A matrix that gives weights to the indicators that are taken into consideration. Thus the importance of each indicator of the project for rooftop PV power stations is determined. The weight could range within 0 and 1 (it is determined separately for each project), and the total sum of weights should equal 1.

In order to establish the project's aggregate value, the results from the matrices are calculated by applying the

following algorithm: 1. Multiplication of the scoring by the weight of each indicator which gives as a result the impact force; 2. Summation of the impact forces for each capacity which gives as a result the total impact for the given capacity; 3. Comparison of the total impact of the indicators for each capacity.

2. Monetizing the saved greenhouse gases

The following capacities are subject to economic evaluation – 29.97 kW; 179.82 kW; 989.01 kW. They are adopted as borderline and outline the extreme options in SEWRC's feed-in tariffs for the rooftop PV power stations[1]. The lowest capacity considered is almost 30 kW, since it has been identified as the lowest capacity of the power stations installed in companies by the Sustainable Energy Development Agency (SEDA). Capacity, lower than the given one, is more common for households than for companies.

The essence of the methodology is focused on monetizing the amount of saved CO_2 emissions and their inclusion in the economic evaluation of the ecological benefits of the rooftop-mounted PVs in Bulgaria.

Taking into account the direct link between the saved CO_2 emissions and the forest plantations that absorb the greenhouse gases, we will use sample expenses necessary for the planting and maintaining of one hectare of forest for monetizing the saved CO_2 emissions from the operation of rooftop PV power station (step 5 from the methodology). For this purpose we need information about the relation between the number of hectares of forest and the respective amount of CO_2 emissions saved from the operation of the given rooftop PV power station. The values of CO_2 calculated by the Retscreen 4 software package, related to hectares of forest, are as follows:

Table 1 establishes the monetary value of the saved emissions of CO_2 for different capacities of rooftop PV power stations. It is evident that the higher the installed capacity, the higher the monetary value of the avoided gas emissions.

Table 1. Annual monetized values of emissions of CO_2 saved

	Rooftop PV power station with capacity of 29,97 kW	Rooftop PV power station with capacity of 179,82 kW	Rooftop PV power station with capacity of 989,01 kW
Saved emissions per annum, tonnes of CO_2	23,4	140,5	772,8
Equivalent in hectares of forest, absorbing CO_2	2,2	13	71,1
Total expenses for planting and maintenance of the equivalent hectares (BGN)[1]	152 460	540 540	2 580 930
Annual expenses for planting and maintenance[2]	7 623	27 027	129 047
Monetary value of the saved emissions of CO_2 from the rooftop PV power station (BGN)	7 623	27 027	129 047

Source: Author's table

In the basic cases (with no change in the subsidies), when comparing the economic

[1] When determining the feed-in tariffs SEWRC divides PV power stations into two groups: first group – rooftop and façade up to 5 kW, over 5 to 30 kW, over 30 to 200 kW, over 200 to 1000 kW; second group – PV power stations (non-rooftop) up to 30 kW, over 30 to 200 kW, over 200 to 10000 kW, over 10000 kW.

Table 2. Comparison of the economic indicators including and excluding the monetary values of CO_2 emissions

	Values of the economic indicators including the monetary values of the saved emissions of CO_2			Values of the economic indicators excluding the monetary values of the saved emissions of CO_2		
Capacities (kW)	29,97	179,82	989,01	29,97	179,82	989,01
Net present value (BGN)	121 741,7	370 822,6	1 634 310,5	26 742,2	34 006,4	26 099,6
Internal rate of return (%)	19	12	11	8	6	5
Payback period (years)	5,3	7,4	8	9,8	11,9	12,5

Source: Author's table

indicators which do not include CO_2 and the ones that include the already monetized CO_2 amounts, the following results are observed:

The data from Table 2 show that the economic indicators of the given capacities improve when the monetary values of the saved emissions of CO_2 are included. Thus the efforts of the society to appreciate the level of saved CO_2 emissions are expressed. Adding the monetized amounts of carbon dioxide in the financial and economic calculations also increases the end revenues from a given capacity. The higher result values, however, are not real but hypothetic and reflect the potential benefits estimated in monetary terms from the saving of greenhouse gases. If at a given moment the monetary value of the ecological benefit from the rooftop PV power stations is estimated in real terms through suitable mechanisms, this would lead to a balance between the interests of the stakeholders in the long run.

If an aggregate qualitative analysis is made of the economic and ecological indicators, it is advisory to use the following matrix for scoring of the economic and ecological indicators of the project:

Internal rate of return is directly related to the net present value and payback period on an investment in rooftop PV power station. Therefore comes into consideration IRR, together with amounts of CO_2 saved. In this context the matrix above (Table 3) gives an opportunity to be applied for all kinds of capacities of rooftop PV power stations.

3. Prospects for development of the rooftop photovoltaics in Bulgaria

The implementation of state policy for promoting renewable energy sources in the country should not mean disregard for the final consumer. On the other hand, policies for the restriction of renewable energy sources disregarding the basic interest of the investor (such as payback period, NPV and others for the given project) are not preferable either. In the search for a balance between the interested parties, the methodology suggested by the author for carrying out of a multi-criteria analysis of rooftop photovoltaic power systems, allows for the preparation of scenarios for the prospects lying before the sector of renewable energy sources in Bulgaria by introducing

Table 3. Matrix of scoring of the economic and ecological indicators

	Range of scores					
Indicators	**1**	**2**	**3**	**4**	**5**	**6**
Internal rate of return (%)	0-10	over 10	0-10	over 10	0-10	over 10
Saved emissions of CO_2 (tonnes)	0-100	0-100	100-500	100-500	over 500	over 500

Source: Author's table

certain national measures and the appropriate adaptation of the methodology to the taken measures. Thus a number of advantages will be achieved, such as:

- A greater diversification of the energy sources;
- More saved emissions of CO_2;
- Higher investor interest in the rooftop-mounted PV power stations, respectively in the fully integrated installations in the buildings;
- Not increasing the prices for the final consumer.

The methodology for pricing of the electricity generated from the renewable energy sources that is applied in the country does not give a balanced report of the interest of the different stakeholders (producers, consumers, etc.), nor does it take into account the environmental protection due to the saved CO_2 emissions. Therefore the European Renewable Energy Council (EREC) gives a series of recommendations for a change in the now effective mechanisms for promoting (European Renewable Energy Council, 2013, pp. 12-13). They need to be considered carefully before being implemented in order to avoid populist decisions which could be to the detriment of investors and/or consumers. The measures include examining of:

- *Fixed and premium pricing* – the fixed price of electricity from renewable energy sources is not affected by the fluctuations in the price of energy generated from other sources. Renewable energy sources are subsidized and they do not take part in the free energy market. The relation to the final consumer's interest is expressed in the charging of considerably higher prices for green energy than the ones charged for the energy generated from conventional sources. The premium pricing incorporates a premium over the market price of the energy produced from conventional energy sources, whereby a more accurate interpretation of the ecological and social characteristics of green energy production is achieved. With this market-dependent model for preferential pricing, the level of purchase prices of alternative energy is directly linked to the electricity market. Accordingly, with the rise in electricity prices the owners of renewable energy systems earn a bigger profit, whereas the decline in electricity prices reduces the profits. The price for the final consumer is considerably lower. Yet, in order to achieve a return within the effective lifetime of a given alternative energy source, a lower limit of variation of the purchase price could be introduced with premium pricing;
- *The 'polluter pays' principle* – With the introduction of the 'polluter pays' principle, the companies that carry out activities with harmful effect on the environment are obliged by the effective legislation to buy a certain number of green certificates, and the collected revenues are paid into the fund, which is later granted as a subsidy to the power stations using renewable energy sources. The latter, combined with the premium pricing, leads to the effective promotion of the producers of 'green energy' and decreases the prices for consumers;
- *'Green fund'* – Since premium pricing can lead to both higher revenue for investors and revenue which only ensures the return on investment without any profit, a conclusion is reached that the focus is on the ecological benefits. This is directly contingent on the establishment of the so called 'green fund', and the money is to be raised by the sale of the certificates for origin of energy (green certificates);
- *Smart networks* – they could ensure easy connection and operation of the energy sources, respectively a sophisticated structure of the energy networks.
- Naturally, the measures offered by EREC have both advantages and disadvantages. However, the disadvantages could be well avoided provided that sufficient resources (both human and financial) are spent on the implementation of the necessary changes at the appropriate speed and adequacy of actions. What follow is three probable scenarios that can be realized by applying the methodology for multi-criteria analysis of the rooftop photovoltaics.

➢ Optimistic scenario

This scenario envisages that all European recommendations are covered in the national policies and strategies. It focuses on the establishment of a stable and long-term strategy, based on promotion of the rooftop PV power stations with premium prices and subsidies from the 'green fund'. This could lead to real account of the environmental contribution of the solar installations, as well as to finding a balance between the interests of both producers and consumers. The changes that are expected to occur are the following:

- Elimination of the fixed pricing and introduction of premium pricing;
- Putting into effect the 'polluter pays' principle in parallel to the establishment of a 'green fund'.

Through the methodology for carrying out a multi-criteria analysis of rooftop PV power systems, the difference in the values of the fixed and premium pricing is calculated.

The majority of subsidies for the rooftop PV power stations come from the 'green fund'. In this context calculations are made that include support for the green energy producers through premium pricing and subsidy from the fund, replenished on the 'polluter pays' principle. This on the one hand affects the cost of electricity of the final consumer and on the other, ensures a return for the investors. In view of possible reductions in the subsidy from the 'green fund', an analysis is prepared of the sensitivity of the economic indicators.

In case there is more money in the fund it is possible to make allocations for reducing other types of pollution (e.g. of the soil, water, etc.), and not only for reducing the CO_2 emissions. The benefits from the realisation of the optimistic scenario are:

- Focus on the ecological benefits of the rooftop PV power stations when taking into account the economic interest of the investors;
- Significant relief of the burden on the final consumer;
- Orientation towards green national economy;
- Full implementation of commitments in respect to 'Europe 2020';
- Achieving higher shares of renewable energy sources in the energy mix and greater reduction in CO_2 emissions compared to the stipulated amounts in 'Europe 2020'.

According to this scenario, the government could be in the position to possibly meet standards set out in Roadmap 2050 for the prosperity of low-carbon Europe (European Climate Foundation, 2010). This document presents an option for the reduction of CO_2 emissions of a far higher level than the one set out in Europe 2020. The option is 80% lower greenhouse gases by 2050, by first achieving a reduction of 20-30% by 2020, where the energy renewable technologies prevail (mostly the ones associated with the wind and sun).

➢ Pessimistic scenario

The scenario which excludes all European proposals, suggests, in view of economic interest, keeping the status quo of the conventional energy sources as main ones, restriction or termination of the introduction and use of the rooftop PV power systems and renewable energy sources as a whole.

The analysis of the sensitivity in regard to the reduction in the feed-in tariffs, set by SEWRC in amounts comparable to those of 2020, shows that the realisation of PV power stations becomes extremely unprofitable. Given these circumstances it would be highly improbable for any investor to direct their funds to PV power stations. With regard to the environmental contribution, we could conclude that it is not taken into particular account, since the withdrawal of entrepreneurs, respectively, the failure to build new PV power stations, also means a lack of environmental contribution from the projects for new power stations that have not been realised. A possible result from the scenario could be the failure to achieve a share of 16% of renewable energy sources in Bulgaria by 2020. On the other hand, in case the stipulated level is achieved, its sustainability is questionable both in the pessimistic, as well as in the realistic scenario.

➢ Realistic scenario

In the realisation of the scenario in question, only a part of the European proposals are included, namely putting into effect an energy strategy directed at achieving the national objectives, arising from 'Europe 2020'. This means that the current mechanism in force for fixed pricing and the establishment of a 'green fund' remains as a way of promoting rooftop PV power stations. The money from the 'green fund', however, will be allocated not to support the rooftop PV power stations, but to assist other sectors of Bulgarian economy. In fact the environmental contribution of the rooftop PV power stations is taken into account only to the extent necessary for achieving the state's commitments to 'Europe 2020' strategy. In fact it is not promoted financially.

The analysis of sensitivity defines the following limits of drop in the purchase prices (as compared to the ones in effect in 2013) within the range where a positive net present value of the rooftop PV power stations is to be ensured: for capacity up to 30 kW – drop to 241,55 lv./mW; for capacity from 30 to 200 kW – drop to 200,83 lv./mW; for capacity from 200 to 1000 kW – drop to 196,58 lv./mW. The most significant benefit in the realistic scenario would only be the possible accomplishment of our national goals under 'Europe 2020'. However, this could be the case without taking into account the investors' and the public interest together. Not enough attention is paid to the ecological benefits of the rooftop PV power stations. The considered scenario and the measures applied in it could lead to an imbalance in the future in the different spheres of economic and social life in our country.

4. Expectations and effects

The economic evaluation of the ecological benefits of the rooftop photovoltaics requires taking into account the interest of all stakeholders. In this context it is worth noting that the implementation of any of the three scenarios is directly linked with the national and sectoral policy regarding renewable energy sources. This suggests establishing a balance, as well as rearrangement of priorities. The sustainable condition must take into account the interest of both society in its role as a final customer, and the creation of viable conditions for the companies, directed at the implementation of a project for renewable energy sources (rooftop PV power stations).

As a pessimistic scenario in respect to the current situation in the sector of alternative energy sources in Bulgaria, we can outline the one excluding all European recommendations. Taking into consideration, however, the commitments Bulgaria has made to the European Union, the most realistic scenario would be the one including only part of the European recommendations. Provided the state proceeds with the exclusionary scenario with regard to renewable energy sources, it is natural that restrictions and fines will follow. The government is unlikely to risk losing a financial resource in the form of sanctions imposed by EU.

The optimistic scenario where all European recommendations are applied is also possible though hardly feasible. It would mean a lot of changes which require willpower and efforts on the part of those in power. This calls for a condition for a more active and balanced policy in support of the renewable energy sources in Bulgaria. Precisely this scenario, however, reduces the burden on the final consumers, stimulates investors and focuses on the environmental contribution of the renewable energy sources. It's a matter of choice how to use the funds from the 'green fund', namely, entirely for subsidising the renewable energy sources in view of reduction of the emissions of CO_2 in the atmosphere or for reduction of other types of pollution (for example soil pollution, water pollution, etc.). In this respect we can outline the following main recommendations in the economic evaluation of the rooftop-mounted PV power stations in Bulgaria in view of their future development:

- Development and implementation of clear and long-term national strategies in the sphere of renewable energy sources;
- Annulment of the preferential prices applied so far;
- Introduction of premium pricing, taking into account the type and capacities of the power stations, producing electricity from alternative energy sources;

- Establishment of a 'green fund' and introduction of the 'polluter pays' principle;
- Promotion of renewable energy sources both through the premium purchase prices and through a subsidy from the 'green fund'.

The effect of this policy would lead to sustainability and transparency in the national policies and strategies, and they are in fact the condition for preserving the current investors and attracting new ones, and respectively for preventing the increase in the final prices of electricity. At this stage of development and use of the renewable energy sources in Bulgaria we cannot claim that sufficient efforts have been put into establishing effective regulations. The application of all European regulations suggest a lot of work, but in view of ensuring the sustainable development of the sector of renewable energy sources in the country, and in particular of the rooftop solar installations, it would be best to focus namely on them.

Conclusion

The policies, implemented in the European Union and in particular in Bulgaria, connected with the energy supply, become increasingly important. On the one hand this is determined by the dependence on the import of energy carriers, and on the other, by the depletion of the traditional energy sources, such as oil, coal, among other sources. The issues connected with the depleted traditional energy sources and the need to use alternative energy sources, have acquired pronounced political nature. All this is necessitated by several reasons:

First – Sustainable development requires the implementation of policies and decision making that affects broad social groups;

Second – Postponing the solution of the problems involving the depleted conventional energy sources threatens the principles of sustainable development, as well as the energy security of the countries;

Third – The greater energy independence with regard to the exhaustible fossil fuels and the import of such would enable the countries to meet their energy needs without self-imposing restrictions.

All this comes to expose the great importance of the alternative energy sources for the protection of the environment and human health. This is where the methodology for carrying out of a multi-criteria analysis of the benefits from the PV power systems comes into place. It takes into account the interests of investors and final consumers alike. Meanwhile, the methodology can possibly be adapted and applied under the dynamically changing conditions in the sector of renewable energy sources.

All this gives us reason to conclude that the Bulgarian sector of renewable energy sources has a potential for growth. It is therefore necessary to seek ways not only to preserve the current state of affairs, but also to improve it by making the adequate evaluation of both economic and environmental benefits.

References

Andonov, K. i drugi, 2009. Model za otsenka efektivnostta na proektite za fotovotaichni energiini parkove, *Nauchni trudove na Rusenskia universitet*, 48(3.1), pp. 9-13.

Direkcia za natcionalen stroitelen kontrol http://www.dnsk.mrrb.government.bg [Accessed November,29th, 2013].

European Climate Foundation, "Roadmap 2050 a practical guide to a prosperous, low-carbon Europe" 2010.

European Renewable Energy Council, EU Policy Recommendations Report, 2013.

Nikolova, M., Simeonov, S., Linkova, M. and P. Pavlov. 2012. Opolzotvoriavane na rastitelna biomasa chrez proizvodstvo na toplo i elektroenergia (otsenka na potentsiala I efektivnostta). Biblioteka Obrazovanie i nauka. Al Tsenov.

Otdel za otsenka, GD Regionalna politika, Evropeiska komisia. Rakovodstvo za analiz razhodi-polzi na investitsionni proekti, 2008.

RetScreen 4 http://www.retscreen.net [Accessed November,10th, 2013].

State Energy and Water Regulatory Commission http://www.dker.bg [Accessed June, 28th, 2013].

Sustainable Energy Development Agency http://www.seea.government.bg [Accessed October, 28th, 2013].