Environmental cost-benefit analysis on a wind farm

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ABSTRACT
Romania is one of the most attractive countries, in terms of investment in green energy, and this is due both to the green energy potential and to green energy system promotion based on green certificates. This study presents the results of an environmental cost-benefit analysis that was made on a wind farm example. Forecasting costs and revenues was performed for a period of 23 years and relied on the use of inflation rate for obtaining the discount rate. The need of using renewable energy sources requires cost-benefit analysis in this area, to show all the impacts and especially the profitability of a wind park in order to attract more investors in Romania.

Keywords: *environmental cost-benefit analysis, risk and sensitivity analysis, Romania, the profitability of green energy production, wind farm.*

INTRODUCTION
The monetary analysis of socio-environmental costs and benefits is still a challenge, even though, in the last century, studies have showed that this analysis can be feasible and that the intangible goods, such as air pollution, noise pollution, can be measured.(Johansson,1993; Hanley & Spash, 1993; Quah & Toh, 2012) Thus, the developed countries are debating the usefulness of this technique and more often are applying forms of the improved cost-benefit analysis, as a result of increased challenges appeared in the area of social economy, climate change, sustainable development and global environmental policies. The major challenge of applying this technique is precisely the difficulty of assigning a monetary value for the externalities (positive, if are assigned the benefits, or negative, that are costs in the moment of assessment).(Johansson,1993) When is not possible its achievement, are being used other additional methods, such as multicriteria analysis.
Impact assessment of an investment project or a policy presents five different ways of approach, namely: assessment to choose, assessment to manage, assessment to justify, assessment to learn and assessment to motivate.(Martini & Sisti,2007; Polin,2012) So, the cost-benefit analysis is a tool used for choosing.
According to experts in the field (Johansson,1993; Quah & Toh,2012; Momigliano & Nuti,2001), cost-benefit analysis (CBA) is a tool in studying the impact of an investment project or a policy by evaluating and comparing the economic, social and environmental costs and benefits under several design options, which contribute directly or indirectly to the growth of social welfare. In order to be accepted the investment projects, the cost-benefit analysis is defined by the existence of the following equation:
Net Benefit = Total benefits - Total costs > 0.

Cost-benefit analysis is increasingly used to evaluate projects and policies that affect natural capital and, as well as, to select those projects that maximizes the net benefit as a result of services brought to the society.(Carpenter, Mooney & et al,2009) It should be noted that the analysis requires the assumption of a number of hypotheses, of complicated calculations and, finally, careful and objective judgment of the analyst.(Cellini & Kee,2010)

The question that should be put before using an environmental cost-benefit analysis is whether this technique really is effective and applicable in today's reality. Some experts(Hahn & Sunstain,2002; Ackerman, Heinzerling, et al.,2005) believe that in fact this analysis is unreliable because is difficult to use it in a neutral manner, that involves an objective assessment of socio-environmental costs and benefits and a transparent evaluation, regardless of the result. If we think further, we agree with the fact that the cost-benefit analysis could not fully consider the multiple dimensions of human welfare, the complexity of ecosystems and the implications of space-time framing(Wegner & Pascual,2011), but also we think that the point of such an analysis is to find the best solution from the existing ones.

In Romania, the investment projects have to have, besides other studies, also a cost-benefit analysis in order to obtain European funding. An existing guide of such an analysis is presented by the European Commission (2008) and an actual exercise-template is presented by Ilie Florin (http://www.metodologie.ro/analizacostbeneficiu.htm). This template is very simplistic and must be completed a lot in the area of environment and social rate of discount.

We chose to do an environmental cost-benefit analysis in the field of wind energy because of Romanian's potential and because of the fast growth of wind energy market after 2011, when has been stabilized the Romanian legislation. According to the Energy Strategy of Romania for 2007-2020, updated for 2011-2020, Romania's wind potential is 23,000 GWh, which means an economic equivalent of 1.978 million toe, and the wind turbines have a capacity of up to 14,000 MW(Ministry of Economy, 2007). Until 2012, many wind farm investments were made in Dobrogea (TPA Horwath & Schoenherr,2011), but there is also potential in the regions of Moldova and Banat according to the Romanian wind map. In what concerns the promotion system of wind energy, according to the law 220/2008 (2010), the wind power producers were assigned two green certificates until 2017 and from 2018 one green certificate for each 1 MWh produced and delivered by the producers of electricity from wind energy, which are tradable on the green certificates market in the range of 27 - 55 euro/MW. Although the number of green certificates has declined since July 2013 by the enactment of the Emergency Ordinance no. 57/2013, the analysis was performed according to the 220/2008 law, republished in 2010.

The objectives of this study were: to determinate what are the economical, social and ecological impacts of a wind farm in Romania and to perform an environmental cost-benefit analysis, taking into consideration the green certificate promotion system.

We chose this topic due to the increasing need to attract investment in wind energy sector, for ensuring energy security and for achieving the objectives in the field, assumed at European and global level. We believe that the expected results will conclude that the net benefit of the project will be positive and so on we will encourage the investments in wind energy projects, although the initial investment costs are huge.

METHODOLOGY

This study is using the ex-ante cost-benefit analysis to assess the economic, social and environment impacts of a wind farm on the local and national community and biodiversity. First, we have identified these impacts, than we have made its monetary assessment and in the end we applied the steps of the cost-benefit analysis. According to the Guide for developing cost-benefit analysis of investment projects, for the achievement of a viable and effective cost-benefit analysis there are certain stages of organizing the evaluation (Comisia Europeană,2008), namely:

1. General presentation of the project, which involves: identifying and defining objectives, determining socio-economic and environmental benefits and costs of implementing the project and also presenting the ex-ante evaluation advantages of the investment's impact.
2. Options analysis, which involves establishing the alternatives that are intended to be analyzed and the feasibility analysis. Several alternatives can be considered, namely: the situation with the project, without the project and one that involves the completion of a part of the project. In this moment, economically, the optimum distribution of resources is very important. In the case study of this paper will make a comparison between the alternative with project and alternative without project. With regard to the feasibility analysis, this is complying with legal, economic, technological, environmental constraints.
3. Financial analysis, which aims to determine the economic outcome at market prices, ensuring financial balance between needs and funding, adequate financial coverage over the project life and even ensuring the achievement of the non-financial objectives. For projects with high environmental impact the choice of the discount rate and of the time horizon is particularly important because it can lead to very different assessments of profitability
4. The economic analysis, which aims to determine the project's contribution to social wellbeing. In the end, it analyzes the calculated economic performance indicators.
5. Other evaluation criteria, which complements cost-benefit analysis. Here should get carrying out an analysis or multi-criteria environmental impact study or an economic impact analysis.
6. Sensitivity analysis and risk analysis, which involves finding those critical variables that have the greatest impact on the financial and economic performance of the project and analyze all forms of risk and also describe how to prevent them. In order to determine the risk, may be used the Monte Carlo method which can be easily used due to the existence of a software.
7. Submission of the results, which implies the delivery of the conclusions and proposals. At this stage, is determined the best solution of the project. In addition, it will also present the analysis limits, ie environmental and social benefits and cost, which could not be monetized.

We consider that structuring as clear as possible the working methodology and establishing as clear as possible the assumptions will help the investor to reduce working hours and performing this analysis with an accuracy as high as possible.

The results were obtained by using computer programs as: Google Earth, WindPRO, Global Mapper, GIS. The gathered data came from the National Energy Regulatory Authority, the National Institute of Statistics of Romania, and from other national and international databases. Also, we applied a personnel interview of the SC EPC Consultanță de Mediu SRL 's employees about the renewable energy engineering field.

For a decision on the achievement or not of the project it had to be calculated a number of financial indicators (Cellini & Kee,2010; Pertile,2012):

a*) Financial internal rate of return (FRR) / Economical internal rate of return (ERR*):

$$FRR/ERR = \frac{B_0-C_0}{(1+r^*)^0} + \frac{B_1-C_1}{(1+r^*)^1} + \frac{B_2-C_2}{(1+r^*)^2} + \ldots + \frac{B_n-C_n}{(1+r^*)^n},$$

where *n* represents the number of years and *r** represents the discount rate.

FRR/ERR must be higher than the minimum 5% rate imposed by the European Commission, through the methodology established by 28/2008 Government Decision. In addition to this condition, in order to make a decision on the acceptance or not of the project they must be correlated with the net present value. The project is accepted when FRR / ERR> 5.5% if and only if NPV> 0. .

b) Financial net present value (FNPV) / Economical net present value (ENPV)

$$FNPV/ENPV = \frac{B_0-C_0}{(1+r)^0} + \frac{B_1-C_1}{(1+r)^1} + \frac{B_2-C_2}{(1+r)^2} + \ldots + \frac{B_n-C_n}{(1+r)^n},$$

where *n* represents the number of years and *r* represents the rate based on which is calculated the discount rate. The project will be accepted if NPV> 0. Note that this indicator is influenced by subjective estimate of the discount rate. This is calculated as follows:

$v_t = \frac{1}{(1+r)^t}$, where v_t is the discount rate.

RESULTS

The wind farm on which it was done the cost-benefit analysis consists of 10 Gamesa G90 turbine type of 2MW, with a height of 78m. Total energy production of the park will be 20 MW and the annual estimated production without its own consumption will be: 365,25 days/year * 24h/day * 30% * 20 MW * 90% = 47336 MWh/year.(Zaharia,2013)

Forecasting the costs and revenue of the park was made for a period of 23 years because the average lifespan of these types of projects is 20-25 years. The assumptions made to do this analysis were:

- The company that invests has its own capital of 10 million euro and contracts a loan from Unicredit Company to cover the rest of the amount needed for the project (ie 19.502 million euro), which will enter into the current account in 2015 (80% of total amount) and 2016 (20%).
- In the tenth year will be carried out a general planned maintenance facility, which has a cost of 1.2 million euro and in the fifteenth year will be done a major repair, which involves a cost of 2.1 million euro.
- Operating expenses are calculated to be higher costs in the early years and in the last years of operation of the wind farm;
- The received price for the distributed electricity in the grid is considered to be, in the first year, 52.13 euro/MWh (OPCOM, 2011)

The benefits of implementing the project that were taken into consideration when doing the analysis were: the distribution of green energy in the national grid, which contributes to the targets assumed by Romania at European level (Europe 2020, 2010); benefiting from green certificates; incomes granted for the locals; increasing the locals incomes by creating two permanent jobs for the security services of the park; reduction of CO_2 emissions. The costs of implementing the project that were taken into consideration when doing the analysis were: total cost of building the park; the loss of agricultural production by removing from use the agricultural land; air pollution through the CO2 emissions; the impact of noise pollution and shading effect. During these 23 years, we forecast the operational costs considering the fact that the prices will increase annually based on the annual change of the European inflation rate, that is considered to be of 2%, the unemployment rate over the last 10 years and the increase in labor cost index and consumer index. Thus, the inflation rate has a decreasing trend when the unemployment rate is rising and the cost of labor has an increasing trend. When estimating the operational incomes we consider that until 2017 will be granted 2 green certificates /MWh while from 2018 will only be granted 1 green certificate/MWh (Zaharia, 2013)

We took into consideration the appearance of a green certificate market balance in 2016, which will lead to a decrease in the value of their trading. (Badi & Popov, 2011)

Financial analysis

The difference between financial and economic analysis is that economic analysis takes into account all costs and benefits of the project (including internalized externalities are), while financial analysis focuses on cash-flow analysis.

Table 1.1: Financial analysis of the wind farm (I)

Thousand euro / Year	2013	2014	2015	2016	2017	2018	2019	2020
Total incomes	**0**	**0**	**0**	6594,91	5984,58	4428,58	4487,80	4552,85
Total operational costs	-1150,54	-1173,5508	-1197,02	-1220,96	-1245,38	-1270,29	-1295,69	-1321,61
Total investment costs	-10000	0	-15602	-7800	3900	0	0	0
Total costs	**-11150,54**	**-1173,551**	**-16799**	**-9020,96**	**2654,62**	**-1270,29**	**-1295,69**	**-1321,61**
Net financial flows	**-11150,54**	**-1173,551**	**-16799**	**-2426,05**	**8639,20**	**3158,29**	**3192,11**	**3231,24**

Source: Zaharia, 2013

Table 1.2: Financial analysis of the wind farm (II)

Thousand euro / Year	2021	2022	2023	2024	2025	2026	2027	2028
Total incomes	4619,01	4686,30	4754,75	4824,37	4895,21	4967,26	5040,57	5115,16
Total operational costs	-1348,04	-1375,00	-1402,50	-1430,55	-1459,16	-1488,35	-1518,11	-1548,48
Total investment costs	0	0	0	0	-1200	0	0	0
Total costs	**-1348,04**	**-1375,00**	**-1402,50**	**-1430,55**	**-2659,16**	**-1488,35**	**-1518,11**	**-1548,48**
Net financial flows	**3270,96**	**3311,30**	**3352,24**	**3393,82**	**2236,04**	**3478,92**	**3522,46**	**3566,69**

Source: Zaharia, 2013

Table 10.3: Financial analysis of the wind farm (III)

Thousand euro / Year	2029	2030	2031	2032	2033	2034	2035
Total incomes	5191,05	5268,27	5346,84	5426,80	5508,16	5590,97	5675,24
Total operational costs	-1579,44	-1611,03	-1643,25	-1676,12	-1709,64	-1743,83	-1778,71
Total investment costs	0	-2100	0	0	0	0	0
Total costs	**-1579,44**	**-3711,03**	**-1643,25**	**-1676,12**	**-1709,64**	**-1743,83**	**-1778,71**
Net financial flows	**3611,61**	**1557,24**	**3703,59**	**3750,68**	**3798,52**	**3847,13**	**3896,52**

Source: Zaharia, 2013

The financial indicators have the following results:

- Internal rate of financial return on investment: FRR = 8,14% > 5%
- Financial net present value of the park: FNPV = 8.701,41 € > 0.

Of these two financial indicators results that the project is financially viable because it will generate funds that ensures return on the loan made, meaning that the revenues cover the costs. The discount rate used is 5% because this value is set by the European Commission to be used by EU Member States as a reference parameter for the opportunity cost of capital on a long term. We took into account also the inflation because the analysis is done in current prices. Net present value is even bigger as the investment is higher. According to the ,,Guide for cost-benefit analysis of investment projects" made by the European Commission(2008), energy financial rate of return should be around 7%, but it must be pointed that this project is about the production of electricity obtained from renewable sources and thus can be explained the size of the financial rate.

Economic analysis

To conduct this analysis were internalized the positive and negative externalities and was used a conversion factor for taking into account the opportunity cost.

Table 2.1: Economic analysis of the wind farm (I)

ECONOMIC ANALYSIS (thousands euro)	Factor conversie	2013	2014	2015	2016	2017	2018	2019
Electricity sales	1,5	0	0	0	3928,03	4006,59	4086,72	4168,46
The sale of green certificates	1,1	0	0	0	4373,85	3644,87	1874,51	1879,71
Total incomes		**0**	**0**	**0**	**8301,88**	**7651,46**	**5961,23**	**6048,17**
Incomes granted for locals		0	0	0	18,1	18,1	18,1	18,1
Reducing unemployment by creating 2 permanent jobs		0	0	0	4,39	4,39	4,39	4,39
Emissions reduction of CO_2		-	-	-	504,92	504,92	504,92	504,92

External benefits		**0**	**0**	**0**	**527,41**	**527,41**	**527,41**	**527,41**
The labor force	0,8	-26,88	-27,42	-27,97	-28,53	-29,10	-29,68	-30,27
Other operational costs	1,1	-1228,63	-1253,21	-1278,27	-1303,84	-1329,91	-1356,51	-1383,64
Total operational costs		**-1255,51**	**-1280,62**	**-1306,24**	**-1332,36**	**-1359,01**	**-1386,19**	**-1413,91**
Total investment costs	0,9	**-10000**	**0**	**-15602**	**-7800**	**3900**	**0**	**0**
Total costs		**-11255,51**	**-1280,62**	**-16908,24**	**-9132,36**	**2540,99**	**-1386,19**	**-1413,91**
Loss of agricultural production	1	0	0	-101,98	-1,18	-1,18	-1,18	-1,18
Air pollution by CO_2 emissions		-	-	-	-5,41	-5,41	-5,41	-5,41
Shadow flicker effect		0	0	0,00	-0,98	-0,98	-0,98	-0,98
External costs		-	-	**-101,98**	**-7,57**	**-7,57**	**-7,57**	**-7,57**
Total Benefits - Costs		**-11255,51**	**-1280,6**	**-17010,2**	**-310,65**	**10712,3**	**5094,88**	**5154,1**

Source: Zaharia, 2013

Table 2.2: Economic analysis of the wind farm (II)

ECONOMIC ANALYSIS (thousands euro)	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**
Electricity sales	4251,83	4336,86	4423,60	4512,07	4602,31	4694,36	4788,25	4884,01
The sale of green certificates	1890,13	1900,54	1910,95	1921,37	1931,78	1942,20	1952,61	1963,02
Total incomes	**6141,95**	**6237,40**	**6334,55**	**6433,44**	**6534,09**	**6636,55**	**6740,86**	**6847,03**
Incomes granted for locals	18,1	18,1	18,1	18,1	18,1	18,1	18,1	18,1
Reducing unemployment by creating 2 permanent jobs	4,39	4,39	4,39	4,39	4,39	4,39	4,39	4,39
Emissions reduction of CO_2	652,49	652,49	652,49	652,49	652,49	652,49	652,49	652,49
External benefits	**674,98**	**674,98**	**674,98**	**674,98**	**674,98**	**674,98**	**674,98**	**674,98**
The labor force	-30,88	-31,49	-32,12	-32,77	-33,42	-34,09	-34,77	-35,47
Other operational costs	-1411,31	-1439,54	-1468,33	-1497,70	-1527,65	-1558,20	-1589,37	-1621,16
Total operational costs	**-1442,19**	**-1471,03**	**-1500,46**	**-1530,46**	**-1561,07**	**-1592,30**	**-1624,14**	**-1656,62**
Total investment costs	**0**	**0**	**0**	**0**	**0**	**-1200**	**0**	**0**
Total costs	**-1442,19**	**-1471,03**	**-1500,46**	**-1530,46**	**-1561,07**	**-2792,30**	**-1624,14**	**-1656,62**
Loss of agricultural production	-1,18	-1,18	-1,18	-1,18	-1,18	-1,18	-1,18	-1,18
Air pollution by CO_2 emissions	-7,04	-7,04	-7,04	-7,04	-7,04	-7,04	-7,04	-7,04
Shadow flicker effect	-0,98	-0,98	-0,98	-0,98	-0,98	-0,98	-0,98	-0,98
External costs	**-9,20**	**-9,20**	**-9,20**	**-9,20**	**-9,20**	**-9,20**	**-9,20**	**-9,20**
Total Benefits - Costs	**5365,54**	**5432,15**	**5499,88**	**5568,75**	**5638,8**	**4510,04**	**5782,49**	**5856,19**

Source: Zaharia, 2013

Table 2.1: Economic analysis of the wind farm (III)

ECONOMIC ANALYSIS (thousands euro)	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
Electricity sales	4981,69	5081,32	5182,95	5286,61	5392,34	5500,19	5610,19	5722,40
The sale of green certificates	1973,44	1983,85	1994,27	2004,68	2015,09	2025,51	2035,92	2046,34
Total incomes	**6955,13**	**7065,18**	**7177,22**	**7291,29**	**7407,44**	**7525,70**	**7646,11**	**7768,73**
Incomes granted for locals	18,1	18,1	18,1	18,1	18,1	18,1	18,1	18,1
Reducing unemployment by creating 2 permanent jobs	4,39	4,39	4,39	4,39	4,39	4,39	4,39	4,39
Emissions reduction of CO_2	652,49	652,49	726	726	726	726	726	726

External benefits	674,98	674,98	748,49	748,49	748,49	748,49	748,49	748,49
The labor force	-36,18	-36,90	-37,64	-38,39	-39,16	-39,94	-40,74	-41,56
Other operational costs	-1653,58	-1686,65	-1720,38	-1754,79	-1789,89	-1825,69	-1862,20	-1899,44
Total operational costs	**-1689,76**	**-1723,55**	**-1758,02**	**-1793,18**	**-1829,05**	**-1865,63**	**-1902,94**	**-1941,00**
Total investment costs	**0**	**0**	**-2100**	**0**	**0**	**0**	**0**	**0**
Total costs	**-1689,76**	**-1723,55**	**-3858,02**	**-1793,18**	**-1829,05**	**-1865,63**	**-1902,94**	**-1941,00**
Loss of agricultural production	-1,18	-1,18	-1,18	-1,18	-1,18	-1,18	-1,18	-1,18
Air pollution by CO_2 emissions	-7,04	-7,04	-7,83	-7,83	-7,83	-7,83	-7,83	-7,83
Shadow flicker effect	-0,98	-0,98	-0,98	-0,98	-0,98	-0,98	-0,98	-0,98
External costs	**-9,20**	**-9,20**	**-9,99**	**-9,99**	**-9,99**	**-9,99**	**-9,99**	**-9,99**
Total Benefits - Costs	**5931,15**	**6007,4**	**4057,69**	**6236,61**	**6316,89**	**6398,57**	**6481,67**	**6566,23**

Source: Zaharia, 2013

The financial indicators have the following results:

- Economical internal rate of return: ERR = 14,85% > 5,5%
- Economical net present value of the park: ENPV = 29504,5 € > 0

These two indicators argue that the project is socially beneficial and can be implemented.
For the economic analysis, the European Commission recommended the 5.5% rate of discount and that why in this analysis it was also used.

Risk and sensitivity analysis

Risk analysis is performed to allow decision makers and not only to understand what risks may arise on costs and how they would influence economic and financial indicators. The challenge of performing this analysis is that we need to identify those critical variables that affect the costs and benefits and cause major changes when they occur.(Lurie, Goldberg, & et al,1993) This analysis includes analysis a sensitivity, which is performed to select the critical variables and to determine what influence they have on the rate of return and net present value.

In this case, the following critical variables were analyzed: the inflation rate (Ri, which influences the forecasting of the costs and revenues during the 23 years), the discount rate (Ra, which influences the net present value), the conversion factor (FC) in the sale of electricity (because European Commission proposes a conversion factor of 2 for the energy sector, but must be taken into account that the renewable energy production is particular). These variables have been analyzed individually and the inflation has the biggest impact between those three and its influence is presented in Table 3.

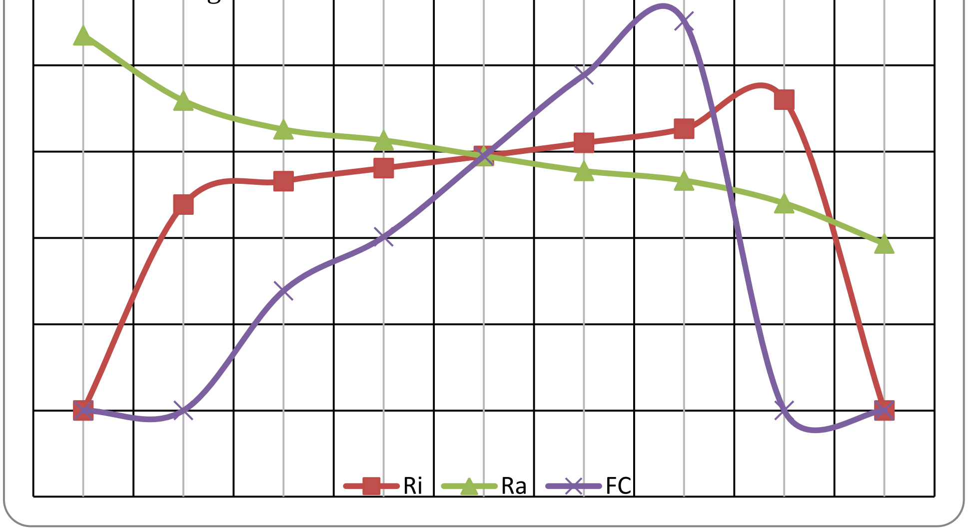
Tabel 3: The influence of inflation rate on the rate of return and on the net present value (financial)

Inflation modification	-1%	Modification	-0,50%	Modification	0%	0,50%	Modification	1%	Modification
FRR (%)	7,64	-0,50%	7,88	-0,26%	8,14	8,40	0,26%	8,67	0,53%
FNPV (€)	7.037,27	-19,12%	7.838,76	-9,91%	8.701,41	9.629,72	10,67%	10.628,52	22,15%
ENPV (€)	23.861,82	-19,12%	26.579,50	-9,91%	29.504,5	32.652,24	10,67%	36.038,95	22,15%

Source: Zaharia, 2013

Therefore, a lower inflation rate will lead to a decrease in the rate of return, because it contributes both to reduce costs and lower revenues due to lower prices. Inflation affects economic indicators in the same way as financial ones are influenced. Would be interesting to see how the exchange rate evolves in the future, to see how economic and financial indicators are influenced in this case. The critical variables influences on the ENPV are illustrated in the following chart:

Figure 1: The critical variables' influence on ENPV



Regarding the influence of the discount rate on net present value (financial and economic), it is observed that with increasing rate, the net present value decreases for both the financial and the economic one. Also, by increasing the conversion factor for electricity sale, the economic indicators of the park have a tendency to increase.

CONCLUSION

This paper shows that each green energy project must be analyzed separately according to its specific conditions, as well as we have done in this work. Considering the model presented in this study and all the assumptions made, we conclude that total benefits exceed the total costs, which means that the project can be implemented and will have a positive influence on the social welfare. Of course, this analysis has its limits because took into account only some externalities, such as: increasing the locals' incomes, reduction of CO_2 emissions, the loss of agricultural production by removing from use the agricultural land, air pollution through the CO2 emissions, the impact of noise pollution and shading effect. Also, there are other impacts that were not considered such as the impact on birds.

Therefore, no monetary assessment method of environmental and social costs and benefits is 100% safe and effective when speaking of social welfare and of environment assessment. But, with the use of several methods, increases the probability of achieving a more comprehensive and safer study. Usually, to minimize the effects of cost-benefit analysis' limits are used as additional methods: multi-criteria analysis, environmental impact assessment, taking into account those impacts that could not be monetized. In Romania, the cost-benefit analysis complements the feasibility study of an investment project. We believe that in fact the basis of this method should be the feasibility study, environmental impact, impact on the community, the analysis using some software (WindPRO, GIS) and other studies that would help to identify costs and benefits of the projects.

In the future, it would be interesting to conduct a cost-benefit analysis to make a comparison between a project that includes the incomes obtained from green certificates and another that do not include this incomes, in order to identify the impact of green certificates in the wind energy sector. Also, thorough in such analysis should be calculated other indicators such as internal financial rate of the national capital, that highlights the period of time in which would have to be paid the long term loan. At the same time, would be interesting to forecast the discount rate based on several variables (not only the inflation rate) so that the analysis to be clear and precise.

In conclusion, applying a cost-benefit analysis in environmental economics is a challenge and a necessity to achieve a landmark investment. So, investing in a wind farm it is profitable and at the same ensures both the protection of social and natural capital and the obtain of economic benefits.

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