The Impact of Renewable Energy on the Price of Energy in Romania

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Abstract- In order to meet the targets of the Europe 2020 strategy in the environment sector, the Romanian government has set up several support schemes. The objective of the paper is to analyse how the introduction of Renewable Energy Sources – Windfarms has affected the price of energy and the sustainability of the measures for the Romanian Economy. For assessing the impact of the RES we have used monthly data from 2008 to 2014 for the wholesale price of energy and the percentage of each energy type that was introduced into the energy grid. In the article we have used the Least Squares methodology and multiple regression analysis to see the impact of each source (coal, nuclear, gas, hydro etc.). The results provide a very positive approach and could lead to major policy changes and to long-term sustainability of energy production in Romania.

Keywords renewable energy, wind farms, solar energy, price.

1. Introduction

The social-economic impact of the introduction of renewable energy has not been a topic for the Romanian research community. In fact, with the exception of some reports published by corporations and the European Union, there are only a handful of researchers that have studied this issue: Grecu [1], Ionescu [2], Plumb and Zamfir [3], Alexandru *et al.* [4], Stefan *et al* .[5], Țăpurică and Tache [6], Bendek *et al.* [7]and Câmpeanu and Pencea [8].

Plumb and Zamfir [3] present the way in which Romania has implemented the support scheme for this priority. While their analysis is correct, they published the study in 2009, i.e. prior to the start of the energy investment boom in Romania. Câmpeanu and Pencea [8] in their article make an overview of the RES, presenting the opportunities that were created through the establishment of the support scheme by the Romanian government. Romania, at the time of the implementation of the support scheme, was among the most attractive countries, being ranked between 10th and 24th place. The authors show that in the first stages of the implementation of the RES the consumer price increased in Europe, but after the cut in the support scheme prices returned to comparable values.

In their work, Ruiz *et al.* [9]present the Spanish experience related to the switch to renewable energy. In Spain, the socio-economic impact of the renewable energy sector promised to be high, with over half a million jobs created and a reduction in energy prices. Empirical evidence from the Spanish case shows that energy companies invest six times more money in research and development than in other sectors of energy, with the goal of the country becoming Europe's leader in renewable energy. Kaldellis *et al.* [10] have studied the introduction of renewable energy sources in Greece and the public's attitude towards them and concluded in their paper that the public is supporting the switch, but they have not analysed the changes in the prices of energy production and consumption. Timilsina *et al.* [11] present in their paper an economic analysis of the introduction of renewable energy and take into account the cost for the construction of renewable energy sources (RES). From their data it becomes clear that RES are not among the cheapest and have one of the shortest durations. Lang *et al.* [12] have analysed property values in the vicinity of wind

farms in the United States and concluded that there is a negative effect on the value of the houses and property in urban areas. A study by Hirth *et al.* [13] focuses on the integration cost of RES into the energy grid. One of their first conclusions is that wind and solar integration costs are high if these technologies are deployed at a large scale.

There are also studies that focus on the impact of renewable energy sources on price in certain countries. While in Germany the switch from nuclear to clean energy, "Energiewende", is highly debated, Dillig *et al.* [14] show in their article, based on Spot Price and data from 2011-2013, that in fact the price dropped after the introduction of renewable energy. The main reason for the abovementioned conclusion is "a deficit in the installed capacities from non-renewable power sources". A different conclusion was reached in a study conducted on the Swiss Market [15]. In this analysis, which focuses on the change from nuclear energy to renewable energies, prices would increase in the long term if the energy grid consisted more of variable energy sources. Studies focusing on the impact of renewable energy sources on the markets and on the price of electricity have also been conducted in Italy [16], Portugal [17] and China [18], while some authors have focused broadly on the relationship between renewable energy and price [19]. While our paper will focus on the effect of renewable energy sources on the price of electricity, we do not include in the analysis the impact of the support scheme that encourages investors. We have opted to focus in this study on the impact of the RES on the price of electricity because of the effect it has on households' budgets. When introducing a new source of energy there will always be a discussion related to costs. There are several models of the implementation of new strategies. The first one is based on a social model, where the state would finance the changes in the policy. This social model in the end also relies on the budget of households because the state budget is supported by taxes collected. The second option is based on the liberal model, where the risk of the introduction of new strategies is passed on to the market – the provider covers the entire risk and the success of the strategy relies on market forces. Given that in Romania public authorities have opted for a third way, a mix between open market price and subsidies (the issuing of Green Certificates), we have chosen to analyse how the price of RES would impact the price of energy. In other words, we have aimed to test whether the introduction of RES would increase the price of electricity and thus lead to an impact on households. A study by Winkler [20] shows that introducing the support schemes reduces the impact of renewables on electricity prices and maximizes their market values.

2. The Romanian Energy Sector

After the economic downturn of 2007-2008, a lot of countries have suffered from a lack of investments due to investors' mistrust and lack of financing. The Romanian economy has gone through the same pattern, a fact that is noticeable from statistics.

While exports suffered from the economic situation of partner countries, the Romanian economy was in need of a new driver to start the economy. The Europe 2020 Agenda set in 2010 is a 10-year growth and job strategy that was created not only to help economies overcome the shortcomings of the crisis, but also to address the issues of the current growth model and create the conditions for smart, sustainable and inclusive growth. Albeit the Europe 2020 Agenda sets five targets for the EU to achieve by the end of 2020 (covering employment; research and development; climate/energy; education; social inclusion and poverty reduction), this article mainly focuses on climate and energy [21].

In the Romanian legislation, the first decisions to promote sustainability in the energy sector, with the help of a support scheme, were the Electric Energy Law [22], changed by [23] and [24]. The documents introduced the notion of Green Certificates and also created the mechanisms for a green energy market. The support scheme was renewed through [25], which also imposed thresholds on the amount of energy produced with the help of the support scheme and delivered into the grid. The most important targets are 10% for 2014 and 16.8% in 2020 of the energy to be produced through the help of the support scheme, whereas 38% of the total energy should be green energy. A very important point is that Romania has an important advantage in the well-developed hydropower energy sector, which produces around 28% of its energy annually. The most important issue is how to manage the 16.8% of the power produced through the support scheme. As the paper will show, the impact on the price of electricity is very high and with Romania having one of the lowest GDPs/capita and average incomes, it is very difficult to see the price of electricity comparable to the ones on the international market. The discussion concerning the energy market has to be split into two parts: on the one hand we have the issue of the energy produced which goes into the grid and where we will see whether there is an impact on the change of energy produced, and on the other hand we have the market for green certificates that has to be treated separately.

The support scheme has introduced a system of quotas for each energy supplier which requires them to purchase a specific amount of green energy and sell it further on to the consumer. A supplier can only prove the acquisition and the distribution of green energy by showing the purchase of green certificates. The specific quotas are set by the regulatory agency, which also registers producers of green energy that are eligible for green certificates. Thus, the producer of green energy has two ways of generating revenue: through the sale of energy and the sale of green certificates. The respective markets set the price of each MWh and green certificates, and transactions can be conducted either bilaterally or through the general market. For the time frame 2008-2014, the price of one green certificate was set between 27 and 55 euro. Given the support scheme, investments have focused on establishing new capacities for renewable energy sources. The issue of Green Certificates is important for our study because the decision of financing an investment in RES in Romania will be based, as

we have explained, on the sale of these Green Certificates and the sale of energy.

Table 1. Net investments in the Romanian economy between 2008 and 2014

Branch of the economy	**2008**	**2009**	**2010**	**2011**	**2012**
	Million lei	Million lei	Million lei	Million lei	Million lei
Agriculture, forestry and fishing	3.393,3	2.919,5	2.659,8	3.285,1	3.371,7
Mining	4.477,2	3.639,4	2.797,2	4.581,7	4.747,0
Manufacturing	21.113,9	15.492,9	12.753,2	17.497,2	17.371,2
Energy	5.103,3	5.039,2	9.895,4	9.326,2	11.497,1
Water distribution, waste and waste management	1.377,1	1.508,4	1.741,9	1.703,6	1.904,4
Construction	13.538,0	9.175,5	9.228,3	12.649,1	13.049,6
Trade	14.403,6	8.974,7	6.840,9	8.389,3	8.632,3
Transport and storage	8.656,9	5.959,7	4.381,6	6.775,5	5.564,4
Hotel and restaurant	1.993,4	1.353,3	1.528,2	1.134,2	1.223,3
Information Technology and Communication	4.824,7	3.395,3	2.438,7	2.844,2	2.729,5
Financial intermediation and insurance	1.382,3	879,4	829,1	600,4	588,3
Real estate	3.388,0	3.650,0	3.795,0	3.159,2	3.666,4
Professional and technical services	3.262,8	1.909,4	1.273,3	2.285,0	2.359,0
Administrative and support services	2.053,2	1.194,1	1.347,3	2.257,8	1.664,7
Public administration, defence and public social securities	6.180,3	6.551,3	8.064,9	8.199,1	7.901,4
Education	2.087,8	1.064,0	919,3	1.005,1	570,8
Healthcare and social services	1.223,5	1.275,6	980,5	943,9	1.283,5
Showbiz, entertainment and recreation	430,9	381,5	359,0	273,5	210,2
Other Services	635,4	576,1	461,1	905,7	757,5

Source: National Institute of Statistics

3. Methodology and Data

The hypothesis of our paper is that introducing renewable energy sources into the grid will lead to an increase in the cost for the final consumers. We base our hypothesis on the fact that the infrastructure for windfarms has to be built from zero and this would mean higher costs. Increasing the price of electricity would in the end lead to an increase in the costs for households, reducing the budget for other expenses or for investments. At the same time an increase in the price of electricity due to the introduction of RES would have a high impact on the costs for business. This increase in cost would normally lead to lower margins or to higher selling costs for products and services sold. Furthermore, if the introduction of RES led to a reduction of the price of energy for households and businesses, then these would have lower costs and higher financial resources available – at this time our initial assumption is to exclude this possibility given the expenses for the construction of infrastructure. In order to test this, we have used statistical data from the Romanian National Institute of Statistics, the European Statistics Agency Eurostat, the Romanian National

Regulatory Authority for Energy and the Ministry of Public Finance. We have extracted data that refers to the percentage of each type of energy source that is available in the grid. Knowing the exact amount of energy in the grid and the percentage of each source (Solid, Liquid, Hydro, Gas, Wind, Solar, Nuclear), we could also estimate the amount of energy that is produced through each source, but that is irrelevant to this study. Using the multiple regression analysis, we have aimed to see whether there is a link between the source of energy and the price for consumers. The theory of regression analysis has been used in several articles and theorized by authors over the years - see [26] [27] [28] or more recently [29]. In the paper we have tested several assumptions related to the impact of renewable energy on the economy. The first assumption is that net investments in the energy sector were a driver for the recovery of the national economy. The most important issue to be discussed is the influence of the quantity of energy produced on the medium prices of power in Romania. In order to check our assumption we have created a multiple logarithmic model where we have introduced monthly data consisting of the percentage of energy inflow into the grid, from the National Regulatory Authority for Energy [30] and the Romanian gas and electricity market operator [31].

In the discussions concerning the fulfilment of the targets of the Europe 2020 Agenda, Romania has set a 38% threshold of green energy that has to be delivered to the energy basket. Even though Romania has a developed hydro energy network, statistics show that during the years 2007-2014 the maximum monthly production of the hydro energy sector was 35%, whereas the average rate was around 28% [30]. In the light of these results, the Romanian government established a support scheme for producers of renewable energy.

The support scheme that was set in place generated wide interest among investors and thus, net investments in the energy sector in Romania doubled between 2008 and 2014. Most of these investments were supported by foreign capital. As we have mentioned before, the goal of the investments was not only to produce energy but also to have the production sold in the Energy Grid. Only a handful of renewable energy producers have this opportunity, while others struggle to sell energy on the free market and have to compensate through the sale of Green Certificates. In 2014, out of more than 500 renewable energy producers, only 73 were major players on the market and could deliver a substantial amount of energy into the Grid [30].

If we were to look at the effects of green certificates on companies, we would realize that the introduction of the support scheme has generated revenues amounting to 1.276.862.394,1 lei from the 7.051.648,00 Green Certificates issued between March 2013 and November 2013. The Romanian consumer supported the entire amount, as all the energy suppliers are obliged to purchase 0,26 green certificates for every 1 MWh delivered.

In our analysis we have used a multiple logarithmic function to analyse the impact of each type of energy source on the average price. For this, we have collected monthly data from January 2008 to January 2014 from the National Regulatory Agency for Energy, indicating the percentage of each type of energy source. The data that we have collected was available in the online published Monitoring Reports of the Energy Market and presents the following categories of energy sources: Nuclear, Solid, Liquid, Gas, Hydro and Wind. Starting with January 2014 we also see that there is energy from Solar Energy Producers but given that there are limited observations we have not taken that into account. The monthly average price of the energy that we have used in the model is also given by the National Regulatory Authority for Energy and appears in the same Reports.

4. Discussion of Results

We have taken the data obtained and used a multiple regression analysis to see whether renewable energy sources have had an impact on price. First of all, we have taken the price of energy as a dependent variable. We have tested whether the source of the energy (Nuclear, Solid, Liquid, Gas or Hydro) has an effect on the end price, given that the production price of energy is highly regulated. For the analysis to be accurate we have the logarithmic numbers of the abovementioned variables.

As a dependent variable we have used the wholesale price of energy as published by the market authorities Price. The other variables are the sources of energy that are put into the energy grid. Nuclear% represents the percentage of Nuclear energy that was produced in Romania and stems from a state-owned company "Nuclear Electrica". Solid% represents the percentage of energy that is delivered into the grid from coal. This represents one of the most important sources if we look at the number of employees, and it has created the most social problems in the last years because of inefficient production and restructuring of the companies. Hydro% represents the percentage that is produced by hydropower plants and represents on average ¼ of the total energy from the grid. The energy is produced by "Hidroelectrica", a state-owned company which is also experiencing financial difficulties. Liquid% represents energy that is produced as a secondary source when refining petrol and Gas% represent the energy that is produced from Gas sources. The new renewable energy sources are represented by Wind%, which is the percentage of energy that is produced from wind farms.

Multiple Logarithmic

The Dependent Variable is lnDprice

Table 2. Results from STATGRAPHICS Software based on authors' own calculations

	Standard T			
Parameter	Estimate	Error	Statistic	P-Value
Constant	0.255379	0.223643	1.14191	0.2577
lnDnuc	-0.00261909	0.102545	4.05546	0.0001

lear%				
lnDsolid%	-0.00261909	0.0535848	0.0488775	0.9612
lnDliquid%	0.0451065	0.034739	1.29844	0.1988
lnDgas%	0.443265	0.0814839	5.43991	0.0000
lnDhydro%	0.314061	0.0800285	3.92437	0.0002

Analysis of Variance

Source	Sum of Squares	DF	Mean Square	F-Ratio	P-Value
Model	2.34509	5	0.469017	14.47	0.0000
Residual	2.075	64	0.0324219		
Total (Corr.)	4.42009	69			

R-squared = 53.0552 %

R-squared (adjusted for d.f.) = 49.3876 %

Standard Error of Est. = 0.180061

Mean absolute error = 0.113883

Durbin-Watson statistic = 1.61336

Source: authors' own calculations

The output shows the results of fitting a multiple linear regression model to describe the relationship between lnDprice and 5 independent variables. The equation of the fitted model is

lnDprice = 0.255379 + 0.415867*lnDnuclear% - 0.00261909*lnDsolid% + 0.0451065*lnDliquid% + 0.443265*lnDgas% + 0.314061*lnDhydro%

As we can observe the P-Value for the selected model is less than 0.01, which indicates that there is a clear relationship between the price of electricity and the sources that energy comes from, at 99% confidence level. More so, the T-Squared statistic indicates that this relationship (the model that we have estimated) explains 53.0552% of the changes in the lnDprice and the adjusted R-squared statistic is 49.3876%. Both figures prove that around half of the change in the price of electricity is linked to the type of production. The rest of the percentage is explained through other variables that set the price of energy – level of taxation, income margin and other variables. We have aimed to see whether there still is a serial correlation in the model, but the DW value was greater than 1.4, so there is probably no serious autocorrelation in the residuals. As we see from the model, the highest P-value belongs to the lnDsolid (0.9612) and because it is close to 0.10 it indicates that this variable is not statistically significant at 90% or higher confidence level. This is economically proven because when it comes to the production of energy from solid materials, there is a very important subsidy that is given by the state due to the importance of this sector from the perspective of employment.

The first test was conducted in an energy basket that contained only conventional energy sources. We can see that the whole model is significant and tests our assumptions that the type of energy source used influences the price. We can see that gas, nuclear and hydro have the highest impact, whereas energy from liquid source and solid have no impact on price change.

Change in price after the introduction of Wind farms

As seen from table 1, starting with 2008 there have been a lot of investments in the energy sector. Most of these are linked to the construction of wind farms. In our analysis we have also entered the variable lnDwind, which represents the percentage of energy that was produced with the help of Renewable Energy Sources. We have aimed to test whether by introducing this new variable we would see a change in the pattern of the energy price, whether the price increases or decreases.

Dependent variable: lnDprice

Table 3. Results from STATGRAPHICS Software based on authors' own calculations

Standard T

Parameter	Estimate	Error	Statistic	P-Value
Constant	0.0518113	0.259022	0.200026	0.8421
lnDnuclear%	0.424177	0.101672	4.17201	0.0001
lnDsolid%	0.00756049	0.0534754	0.141383	0.8880
lnDliquid%	0.0623728	0.0362335	1.72141	0.0901
lnDgas%	0.464345	0.0818646	5.6721	0.0000
lnDhydro%	0.37365	0.0884635	4.22378	0.0001
lnDwind	0.075403	0.0497884	1.51447	0.1349

Analysis of Variance

Source	Sum of Squares	DF	Mean Square	F-Ratio	P-Value
Model	2.41798	6	0.402996	12.68	0.0000
Residual	2.00211	63	0.0317796		
Total	4.42009	69			

(Corr.)					
R-squared = 54.7043 %					
R-squared (adjusted for d.f.) = 50.3904% Standard Error of Est. = 0.178268					
Mean absolute error = 0.109796					
Durbin-Watson statistic = 1.68344					

Source: authors' own calculations

Using the same multiple linear regression model the following relationship between the price and the 6 independent variables resulted:

lnDprice = 0.0518113 + 0.424177*lnDnuclear% + 0.00756049*lnDsolid% + 0.0623728*lnDliquid% + 0.464345*lnDgas% + 0.37365*lnDhydro% + 0.075403***lnDwind**

The model is statistically significant at a confidence level of 99% as the P-vale is less than 0.01. Similar to the model that did not include the **lnDwind,** this model explains more than 50.39% of the changes in the price according to the adjusted R-squared statistic. Also, we notice that the Durbin-Watson value is greater than 1.4, so again we do not have any serial correlation in the residuals. The highest P-value are lnDwind and lnDsolid – neither is statistically significant at a 90% or higher confidence level. Again, this is explained through the fact that the two sectors are favoured by the state and strongly subsidized. We see that in our model the price of energy from Renewable Energy Sources (RES) had little impact on the end price, but reduced the impact of the energy produced from gas and the residual amount.

Following the model that we have used we notice that our hypothesis has not been confirmed. The introduction of renewable energy sources, wind farms, has not led to an increase in the price of energy. The effect has only been on the producers of classic energy, which have produced less than before, and it has led to social problems because the companies involved in that type of activities had a lot of employees, while RES do not require manpower. The introduction of wind energy does not change the results of the model. The model is still 99% verified and a change in the percentage of the type of energy source produces a change in the average sale price of energy to the consumer.

5. Conclusions and Policy Implications

In the last years the energy sector has been among the driving forces in the recovery of the Romanian economy. Due to large recent investments, the Romanian economy has benefited from job creation and capital inflows, and all of these have helped it recover, but despite the massive investments in the energy sector in the last years this branch of the economy has continuously decreased the amount of people employed. Besides the greenfield investments which have mostly occurred in renewable energy, the Romanian state has also privatized two of the biggest players in the energy industry, S.C. Romgaz S.A. and S.C. Electrica S.A., through a public initial offering. Private investors currently own more than 70% of the companies dealing with energy. The high percentage can be dangerous when talking about energy security, but in the long run we see that private capital is the only one that can lead to healthy investments and effective management. While companies that are under the control of the state struggle to keep the margins (see the cases of Hydroelectrica and Complexul Energetic Oltenia), others like S.C. Petrom S.A. have reported record incomes. One of the drivers of investments in the energy sector has probably been the support scheme for creating renewable energy sources. As we have demonstrated, the introduction of RES has not created an imbalance in the economy, due to the fact that the impact of these has been split between the consumers and the state, through the subsidy scheme – Green Certificates. In our analysis we have created a model so as to see whether there has been an impact of wind energy on price. We have seen that the impact is limited and there has been no major increase in price due to the introduction of the RES.

As we have shown in the article, Romania has been a net receiver of investments in the energy industry, due to its potential, but also to the support scheme set in place. The investments in RES were made by private investors and this would not have been possible if the state had not helped the companies by issuing Green Certificates (valued in 2013 at 1.276.862.394,1 lei, equivalent to 290.323.203 euro), allowing them to rely on a second type of revenue stream besides the sale of energy. If this support scheme had not been set in place, we are sure that the investors would have avoided investing in the energy sector in Romania. Overall, investments in Romania have questionable success, as in the Romanian economy the revenue of companies is 230 billion euro, but the income is only 1,2 billion, creating a 0,5% net margin.

The idea that investments in renewable energy sources have been a safe bet is proven by the constant investments (as seen in Table 1), but the recent changes in Romanian legislation have created a feeling of mistrust among investors. As long as the income and margins of companies are still higher than in other regions, this feeling will fade away. One barrier that we foresee is the fact that the market will reach saturation and the increase in production of energy will only be possible if Romania, through its state-owned companies, which have the monopoly over the transport of energy, creates an interconnected network that will allow the country to be a major player in the region and export the supplementary amount.

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