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Energy of Rural Spaces – Technical, Economic and Social Analysis of Renewable Energy in Isolated Communities

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Abstract*— *With the arising necessity of new homes for the population also comes the necessity of energy for heating and electricity. In big cities the energy is easily attainable while the most remote areas have difficulties finding reliable sources of energy.

In Romania, home heating in remote villages is usually provided through wood burning, using a fireplace or a boiler. The access to the electricity is assured only to the villages in proximity of the cities, main reason being the enormous price for the connection of few households to the national power grid, which makes the electricity directly related to poverty. Access to electricity may improve economic and social status of isolated communities.

One of the main advantages of renewable energy, is its decentralized characteristic. This means that every household can produce its own energy without relying on the national power grid.

This paper aims to research, from a techno-economic point of view, the possibility of creating small power grids in remote villages from Dobrogea - Romania and its social benefits for the communities.

The first step is to identify how many villages in Dobrogea do not have access to electricity, to analyze from a technical, economic, social and environmental perspective the possibility of implementing project in rural areas by using mathematical models. Second step is to identify possibilities of private or governmental funding for implementing such projects.

Keywords*— *renewable energy, isolated communities, social impact, economic impact

I. INTRODUCTION

Compared to other countries from the European Union, Romania is still a developing country. As developing country, it is characterized by a slow-paced industrialization. The revenue is generated mostly by service sector such as tourism and trading. This leads to an economy based only on consumption with low to moderate per capita income and moderate standard of living of people. According to Romanian National Statistics Institute, circa 44.8% of the population lives in the countryside where the standard of living is even worse than in big cities. This results in non-effective use of resources, especially when it comes to electricity.

The recent conflict between Russia and Ukraine and sanctions applied to Russia because of its military action against Ukraine led to an energy crisis across Europe, with huge impact on energy price increase. This aspect highlights even more the necessity of having decentralized and reliable sources of energy that might guarantee an independence of each country from another one and may result in stable energy prices.

The national power grid is available in each village of Dobrogea, however there are some individual households for which electricity is not available due to poverty. [2,3,4]

II. ENVIRONMENTAL, ECONOMICAL AND SOCIAL ASPECTS

A. Area of the study

The area of this study is the village Vadu, located in the southern part of Dobrogea. Vadu is a touristic village as it is close to the only protected beaches of Romania due to its fauna and flora.

Fig. 1. Tailing dumps in Vadu – area of the study

Fig. 2. Abandoned rare metals processing plant

Although this is a delicate area, Vadu represented a focal point for industrial processes and is and has been home for industries of national interest. During communist times, Vadu hosted the largest plant for processing rare metals, such as titanium and zirconium, metals used in the aeronautical or nuclear industries. After the fall of communism, the plant has been abandoned.

Currently, Vadu hosts a Gas Treatment Plant which processes the methane extracted from the Black Sea. The Gas Treatment Plant belongs to the company Black Sea Oil and Gas and the production of methane has begun in July 2022 and it's planned to operate for circa 15 years. In the meantime, to align with European Union directive of reducing the carbon emissions by 2030, the company Black Sea Oil and Gas is also exploring switching to green energy. The abandoned rare metals processing plant is surrounded by tailing dumps which vegetation hasn't grown for years and this land can be used for a future wind farm, a photovoltaic plant or both.

B. Method and research

To determine the impact of a potential green energy farm in the area of the tailing dumps V.Rojanski method was used. Rojanschi method or creditworthiness method involves the estimation of environmental quality indicators according to their creditworthiness scale.

For each environmental factor, a credit rating obtained following environmental analyzes is assigned.

With the help of the obtained credit ratings, a diagram is drawn up, represented by a regular geometric figure whose radius is 10 credit units. Through this method, the global the global pollution index (GPI) can be calculated, which simulates the synergistic effect of pollutants on the environment. measures proportionately more than is customary.[1]

Creditworthiness indicators are assigned using the values below:

TABLE I. CREDITWORTHINESS SCORES ACCORDING TO V. ROJANSCHI METHOD

"Creditworthiness Score	**Environmental Impact**
10	The environment is not affected by human activity
9	The environment is affected within the allowed limits – high positive impact
8	The environment is affected within the allowed limits – medium positive impact
7	The environment is affected within the allowed limits – low positive impact
6	The environment is affected above the allowed limits – negative impact
5	The environment is affected above the allowed limits – medium negative impact
4	The environment is affected above the allowed limits – high negative impact
3	The environment is degraded – negative impact
	to long exposure
2	The environment is degraded – negative impact to medium exposure
1	The environment is degraded – negative impact to short exposure"

To determine the environmental impact, observations have been made on site and creditworthiness scores have been assigned to 5 indicators: soil, water, air, social and economic environment. The observations have been made on site between the months of January and February of 2023.

Creditworthiness scores for each indicator have been assigned from 1 to 10, where 10 represents the environmental condition unaffected by human activity and score 1 corresponds to a very serious situation.

The analyzed environmental factors were classified on 3 levels: what is the ideal situation, the current situation, and the potential situation (this being divided into optimistic scenario and pessimistic scenario), following which the credit ratings were established. Thus, the data obtained has been entered in the following table II, where *Si* indicates the ideal status while *Sr* represents the real status.

TABLE II. CREDITWORTHINESS SCORES ASSIGNED TO THE WORKS IN VILLAGE OF VADU DURING IN SITU OBSERVATIONS

Indicator	**Aspect**	**Creditworthiness Scale of Environmental Aspects**				**Average**
		Si	***Sr***	***Scenarios***		
				Optimistic	***Pessimistic***	
Soil	Non-compliant storage of materials during construction works	10	6	6	1	5
	Rehabilitation of the road DC83 between Vadu and Corbu	10	1	4	3	
	Using heavy vehicles for the construction works	10	1	5	4	
Water	Accidental pollution of groundwater with petroleum products from the OMV company	10	1	5	3	7
	Exceeding the level of ammonia (NH_3) in the groundwater	10	8	9	8	

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	because of animal droppings from the grazing area					
Air	Exceeding the level of nitric oxides (NOx) because of technical processes of Rompetrol Navodari Refinery	10	4	6	5	6
	Exceeding the level of persistent organic compounds because of technical processes of Rompetrol Navodari Refinery	10	4	6	5	
Social quality	Creating new job opportunities for people living in the village of Vadu	10	10	9	9	10
	Improving life quality by offering cheaper electricity to people living in the village of Vadu and surroundings	10	10	9	9	
Economic environment	Economic growth because of employment of people living in the village and surroundings	10	10	10	10	10

C. Geometric Representation

Data obtained in table II is used to draw the Rojanschi diagram which consists of a pentagon with its radius of 10 units (representing the ideal status of the environment). The geometric figure was drawn using SketchUp software.

Inside of the geometric figure, it was drawn another geometric figure by connecting the points marked on the radius corresponding to the value of the creditworthiness of each environmental component. In diagram below (fig. 3), the geometric shape colored in pink represents the real status of the environment at the moment of the evaluation, while the grey (the entire pentagon, represents the ideal status).

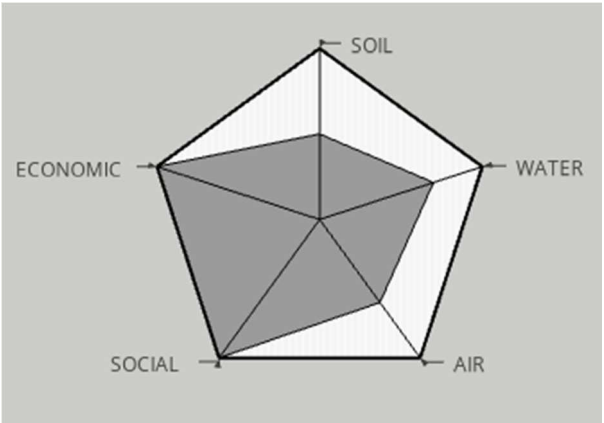

Fig. 3. Geometric representation of environmental impact according to five environmental aspects

D. Calculation of Global Pollution Index (GPI)

For easier calculation of the Global Pollution Index, the pentagon representing the ideal status has been divided in 5 isosceles triangles with the 2 equal sides of 10 units. From each triangle, we will calculate then the area of the smaller triangles representing the real status of the environment.

The triangles were named as per below figure (Figure 4).

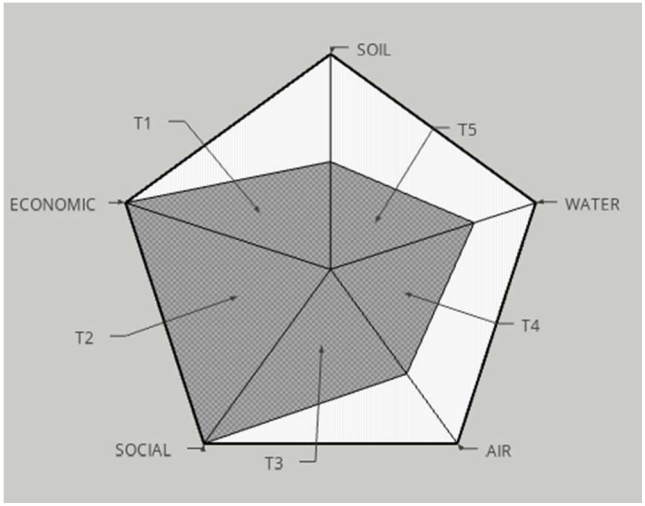

Fig. 4. Geometric representation of triangles representing real status of the environment

Date obtained is written in the chart below (Table III).

TABLE III. CALCULATION OF INDIVIDUAL AREAS OF EACH TRIANGLE REPRESENTING THE REAL STATUS OF THE ENVIRONMENT

Triangle number	**Calculation**	**Area**
T1	$\frac{10 \times 5 \times \sin 72°}{2}$	23,8
T2	$\frac{10 \times 10 \times \sin 72°}{2}$	47,6
T3	$\frac{10 \times 6 \times \sin 72°}{2}$	28,5
T4	$\frac{6 \times 7 \times \sin 72°}{2}$	20,0
T5	$\frac{7 \times 5 \times \sin 72°}{2}$	16,6

The area of the pentagon representing the real status is therefore calculate by summing the 5 areas obtained above.

$$Sr = 23{,}8 + 47{,}6 + 28{,}5 + 20{,}0 + 16{,}6$$

$$Sr = 136{,}5$$

$$Si = \frac{10 \times 10 \times sin72°}{2} \times 5$$

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$$Si = 238$$

Global Pollution Index (GPI) is calculated with the equation (1), where *Sr* represent real status of the environment and *Si* represents the ideal status of the environment.

$$GPI = \frac{Si}{Sr} \quad (1)$$

$$\text{GPI} = \frac{238}{136,4} = 1,74$$

E. Interpretation of the results

For easier interpretation of the GPI, Rojanschi methodology offer a scale from 1 to 6, 1 representing the ideal status, the entire geometric figure, in this case the entire pentagon.

- GPI = 1 means the environment is not affected in any way by human activity;
- 1 < GPI < 2 means the environment is affected within acceptable limits or lightly affected;
- 2 < GPI < 3 means the environment undergoes discomfort caused by human activities;
- 3 < GPI < 4 means the environment is affected by human activities creating harm to life forms;
- 4 < GPI < 5 means the environment is seriously affected by human activity, life forms being endangered;
- GPI over 6 means the environment is permanently degraded and not suitable for life forms. [14]

Using the scale above we can appreciate that a GPI of 1,74 indicates that the environment is lightly affected by human activities, not creating any harm on long, medium, or short term.

III. TECHNICAL CONSIDERATIONS AND POSSIBILITIES OF FUNDING

From a technical perspective, Dobrogea has a convenient position as it is the only region which has access to Black Sea and Danube River which brings more opportunities in terms of jobs and development.

In terms of renewable energy, its position close to the sea makes Dobrogea an exceptional location for the exploitation of wind and solar energy.

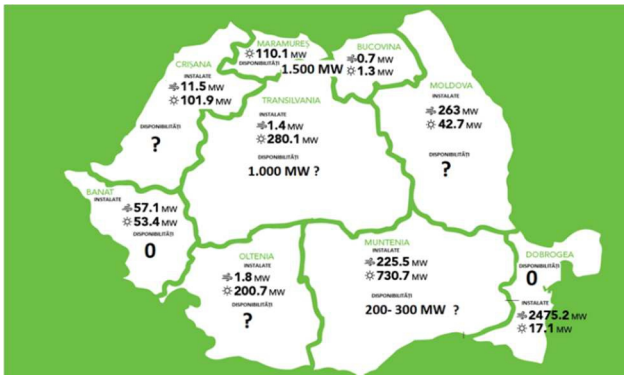

Fig. 4. The map of Romania's national power grid capacity of storing/distributing green energy [12]

The average wind speed in Dobrogea is 6m/s while solar radiation is the highest in this region compared to other parts of the country. Regardless its huge potential of green energy, the national power grid doesn't have the capacity of processing more energy coming from renewable sources. The map (fig. 4) illustrates the amount of green energy that the national power grid can store or distribute.

In terms of possibilities of funding, Romania does not offer any governmental funds for projects on a larger scale involving green energy in Vadu (not for Dobrogea) due to national power grid's limitations. However, it offers the *Green House Project* (Proiectul Casa Verde) where people/small companies can apply for funding for solar panels for individual use [7, 8, 9, 10].

Private investments come from the company Black Sea Oil and Gas, which is exploring the possibility of green park close to the Gas Treatment Plan and in accordance to European objective to reduce carbon emissions by 2030. The project is called Midia Green Energy and it is presented on their website [11, 12].

IV. CONCLUSIONS

The result obtained with Rojanschi's method shows that anthropogenic activities that might take place to create a green energy installation in Vadu would not create any harm on the environment. As presented in the first chapter, the area where the plant might be constructed is already lightly affected by the other activities that were performed in the past.

To reduce further the anthropogenic impact, it should be taken into consideration to change or improve the technological processes that are already happening in the area.

The advantages of using Rojanschi methodology is that it allows the user to identify if there are technical processes that might need improvement or change. Additionally, it illustrates the affected environment.

The disadvantages of the method are represented by the subjectivity with which credit ratings are awarded, which is due to the experience of the team assigned to assess the risk.

Implementing a green energy project in the area of Vadu would bring an enormous advantage to the development of the community. Vadu beach is already known as a protected area by Natura2000 and every year it attracts a large number of tourists. By this means, it is crucial to have a sustainable development to protect the endangered species and to preserve the natural habitat.

On an economic level, it may bring job opportunities which transforms into growth on every level – from education, to infrastructure and population well-being.

Thus the climate is optimum, a project on a larger scale cannot be implemented as for now due to infrastructure limitations.

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