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Energy Poverty in European Union: Assessment Difficulties, Effects on the Quality of Life, Mitigation Measures. Some Evidences from Romania

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Abstract: The scope of this research is to explore the relations between energy poverty, quality of life and renewable energy. First, an analysis of concept evolution, economic and social implications and the difficulties in assessing energy poverty was conducted by analyzing the data from Eurostat regarding electricity prices for households and arrears on utility bills between 2009 and 2018 and the solutions for combating energy poverty from the EU. In the next part, a cross-country analysis regarding Granger causality between indicators representing all three dimensions was conducted. The period of the analysis was between 2010 and 2019 for the 28 EU member states. In the final part of the article, the situation of Romania was analyzed. The phenomenon of energy poverty is not marginal but is underestimated and superficially approached. Starting from the dominant discussions on the concepts and tools practiced at international level, this article makes a proposal for a working model for various regions in Romania, taking in consideration the financial potential of the geographic areas and the possibilities of accessing unconventional energies by local communities. Through a case study based on the analysis of relevant energy resource statistics, the article identifies main shortcomings and opportunities for Romania and proposes concrete recommendations of sustainable public policies on the elimination of energy poverty. In some geographic areas where this was not possible, we propose how to diminish the effects of this social phenomenon. Our proposals for the case study focus on supporting populations in areas where access to energy sources is difficult and there is a lack of energy infrastructure, the government programs being an alternative to access green (renewable) energies. Even if this may seem expensive to some specialists in the economy, access to energy sources of any kind brings social advantages by improving quality of life-in this case, a real victory in the fight against energy poverty.

Keywords: energy poverty; quality of life and renewable energy

1. Introduction

The launch of the Sustainable Development Goals (SDGs), by United Nations Organization, in 2015, demonstrated the importance of access to energy in order to ensure the quality of life for all the citizens. Compared to the Millennium Development Goals (MDGs) the new goals are more diversified, complex: through the links between them, sustainable development will be generated. Even the Millennium Development Goals advocated for reducing extreme poverty, improving living conditions and sustaining progress for sustainable development, no direct reference to access to energy was done [1,2]. This situation was remedied in 2015, the energy being the topic of a distinct goal, with many connections and with other objectives.

Goal 7-"Affordable and clean energy"-is one of the 17 objectives, but considering that energy accessibility has consequences on the quality of life and the environment, it may be said that energy is the core of SDGs. Access to energy ensures the guarantee of fundamental human rights, but also social-cultural rights such as the right to food, to a heated home, to education, to decent working conditions, to maintaining a healthy state consistent with age. Moreover, the idea of a fundamental right to energy, launched by the UN Secretary-General, Ban Ki-Moon, came up with the 2014 "Sustainable energy for All" Initiative. The energy problem has become more nuanced by launching the concept of clean energy or sustainable energy because the poor population is frequently in the situation of using polluting fuels, with negative effects on the health of the users and the environment [2–5]. The magnitude of this phenomenon worldwide and its consequences on the population are demonstrated by the statements of World Health Organization officials who have declared that energy poverty generates more deaths compared to malaria or tuberculosis [2]. In addition, indoor air pollution caused by the use of polluting fuels to heat the home and to prepare food favors the appearance of specific diseases, such as respiratory infections, which puts pressure on public health systems that are not very strong in developing countries anyway.

Therefore, energy has gained its proper place not only in scientific and political debates, but also in the concerns of researchers and public authorities. The energy-economic development relationship is analyzed bidirectionally. On one hand, economic development affects energy consumption. In the initial phases, energy consumption increases as production capacities develop. Later, growth of energy consumption is tempered as a result of more efficient use of the energy with the generation of technical progress. On the other hand, energy generates economic growth, being considered a factor of production [6–12]. Additionally, limited access to energy or reduced energy efficiency have negative effects on quality of life, environmental protection or economic growth. Energy dependence has economic, social and political consequences [13–15]. For this reason, renewable energy has gained importance, being seen as a tool for achieving the goals of sustainable development [16–18].

The scope of this research is to explore the relations between energy poverty, quality of life and renewable energy for EU countries and especially for Romania. The novelty of the scientific approach is given by the analysis of the statistical data for the period 2010–2019 and the measures proposed for the specific situation of Romania. The article is structured into several sections. In part one, we present the concept of energy poverty, and we pointed out that the evolution of the concept captured the specificities of developed countries, developing countries, warm areas and cold areas. Reducing and eliminating energy poverty is a goal of all public authorities, given the negative consequences that the phenomenon has on the welfare of the population. In the next section, an analysis of the difficulties in assessing energy poverty is conducted by analyzing data from Eurostat concerning electricity prices for households and arrears on utility bills between 2009 and 2018-and the solutions for combating energy poverty from the EU countries. After this, a cross-country analysis concerning Granger causality between indicators representing all three dimensions is conducted. In the final part of article, the situation of Romania is analyzed in order to propose concrete measures for mitigation of this phenomenon.

2. Energy Poverty and Quality of Life

The reduced accessibility to energy for certain categories of the population has generated international debates in various forums, but also the emergence of numerous concepts such as energy poverty, fuel poverty, vulnerable consumer/energy vulnerability, energy efficiency, energy richness (which involves not only meeting needs through proper access to energy, but energy efficiency) or establishing connections with other concepts such as social exclusion, energy culture [4,19], energy security, decarburization of the economy, energy transition, energy union [20]. The tools for ensuring the access to energy are multiple and the stakeholders involved have specific responsibilities. If the public authorities have the mission to create the specific legal and institutional framework, companies must develop technologies and products that ensure energy efficiency, adopt green and lean management strategies, the employees must acquire the specific competences to use the equipment, and the consumers must have responsibilities regarding the consumption of energy, home improvement conditions [21–25].

Energy poverty is defined as the inability of a person or household to meet the minimum energy needs [4] or the specific situation of a household that faces inadequate access to essential energy services [19], the situation being specify not only

- for the cold season, but also in the hot season, when energy is needed to operate the air conditioning equipment in order to reduce the temperature in the living spaces [26]; the problem became more stringent with the climate changes and the temperatures increase;
- countries in temperate and cold areas and also in hot areas, where the population needs energy for cooling purposes [27].

As expected, as in other fields of activity, there is no unanimity regarding the definition of the concept, indicators of measurement or political approach, not even within the European Union, which is why, at European level, the principle of subsidiarity is applied and the European Commission plays an important role in the coagulation process of European initiatives [5,26,28].

This situation is characterized by other specialists as the need for a household to spend disproportionately much of the income obtained on energy services [29]. The causes of this socio-economic complex phenomenon are numerous and are multiple interdependencies between them. The low level of income, rising energy prices as a result of reforms (privatization of companies with majority state owned capital) and liberalization of the energy sector, volatility of the international oil price, reduced efficiency of buildings and electrical appliances that are used in a household, a system of property ownership that does not encourage energy efficiency, specific to Central and Eastern European countries, energy needs also consumer behavior, age and consumer health [4,5,19,20].

Although the concepts of energy poverty and fuel poverty are sometimes considered synonymous, the idea that energy poverty is a broader concept has been prevailed in scientific literature [30]. This concept is used at EU level, in official documents like the Third Energy Package. The United Kingdom and Ireland have been among the first countries to have concerns regarding cold and inefficient homes, but later also the countries of Central and Eastern Europe, but also of Western Europe it was concerned about the problem of access to energy of the population, of the determined factors, of the economic and social consequences. The involvement of the EU in creating a transnational framework to address and solve this problem, the activity of international development organizations and researchers who have expanded their concerns and studies on countries in Africa, Asia and Latin America have generated a geographic diversity of specific aspects of energy access and consecration of energy poverty concept.

Researchers such as Bouzarovski & Herrero [31] even draw attention to the situation in Central and Eastern Europe, which it is considered one of the 'hotspots' of energy poverty in the EU, with Bulgaria, Romania, Poland and Lithuania leading. The international financial crisis and the austerity measures adopted by all states have deepened the vulnerabilities of the population regarding access to energy [32]. In the countries of Africa, paradoxes are the order of the day. Countries, such as Nigeria, characterized by massive economic dependence on the oil and gas sector, are characterized by high demand for energy, acute energy poverty, inefficient energy use and inadequate supply.

Therefore, the ratio of the population to the energy poverty is different depending on the level of development of the country: in developing countries, a reduced access on a large scale to energy services is observed, while, in developed countries, difficulties in ensuring energy consumption according to needs could be identified.

The problem could be approached in a multidimensional way, considering the numerous consequences of energy poverty (or the inverse phenomenon, of energy wealth) on the quality of life or on the pollution of the environment. Studies from international literature [27,33,34] have drawn attention to the negative consequences of energy poverty on the health status of the population, the researchers observing an indirect relation between access to energy and winter mortality, heart and respiratory diseases. In addition, the consequences extend to the quality of life. Moreover, the predominant use of certain fuels, in developing countries, in households-wood, coal or material waste generates negative effects on the health status as a result of poor combustion, the non-ventilation of houses generating indoor air pollution characterized by the existence of high levels of carbon dioxide and suspended particles [2] in some cases, even larger than those specific to large cities for outdoor pollution.

Indoor pollution is a very serious phenomenon affecting mainly children and women. Statistical data from World Health Organization demonstrated that, indoor pollution doubles the risk of pneumonia and other acute infections for children under five years. The indoor pollution has long-term negative repercussions on health of adolescents and adults; This situation generates not only direct (medical), but also indirect (social) costs. At the EU level, treating asthma and other lung diseases involves costs of EUR 82 million. Raising the price of energy bills can generate a restructuring of family budgets, meaning that for the coverage of specific expenses, citizens can reduce their income for food to cover these expenses, which can have adverse effects on the health status.

Energy poverty mainly affects people in rural areas who, in order to meet the heating needs of homes and food, use different fuels or biofuels; in households, as a rule, women are responsible for providing these fuels. The lack of energy services offered on a commercial basis (absence of commercially supplied energy) generates, in these communities, an accentuation of the gender asymmetry of living conditions [35] limits the access to education, information and participation in political life [20]. Moreover, there are researchers who draw attention to fires generated by inadequate use of cooking or heating equipment [36]. Children are the most vulnerable segment of the population, given their low risk assessment capacity. Unfortunately, their involvement in fires has immediate repercussions on the state of health, but also long-term effects in the form of educational, psychological and social deficiencies.

The issue of energy poverty was initially addressed in the UK, which, together with Ireland, were the only countries in the EU that recognized and tried to solve this problem [37,38]. Subsequently, several countries became aware of this problem, and the fight against energy poverty has become an economic policy objective at national and European level, entering the concerns of many EU institutions. The EU Directives 2018/2002 and 2012/27 regarding energy efficiency consider the modeling of the energy demand and the improvement of the energy efficiency, one of the objectives being to reduce the energy poverty [39,40].

3. Assessment Difficulties

Within the EU borders, it is recommended that every member state suggests countermeasures to combat energy poverty. Obviously, these countermeasures have to be tailored in order to suit the national reality. Currently, Romania has gaps in correctly assessing the level of energy poverty. On the other hand, combating this phenomenon has proved being inefficient. The issue resides in the fact that both measuring the phenomenon and combating are limited to aspects regarding the level of household income, social tariffs implemented by providers and granting State supported benefit schemes to cover heating costs for a certain category of vulnerable consumers.

In Romania, there are 8.92 mil. homes and 7.494 mil. households [41] (In Romanian Census practices there is a difference between home and household. A home is an apartment or a house and a household consists of the individuals (persons) who live in that house or apartment (they may form a family or not). Hence, there can be more households in the same home, but also a household can own more homes). According to data from the [42–45], considering the European context and the specifics of Romanian economy and society, the issue of energy poverty can be summarized as follows:

- Approximately 3.75 million households in Romania use biomass, usually firewood, as the main heating source (about 90% in rural areas and 15% in urban areas), spending 10.50 EUR/month on average for this type of fuel.
- Less than half of Romania's households are connected to the natural gas network (44.2%) and around 2.97 million homes (i.e., a third of the total homes in the country) use natural gas directly as their source of heating.
- Although the end-price of natural gas and electric power is considerably lower in Romania than the European average, Romania has the lowest consumption level of electric energy per capita in the entire European Union-37.5% of the EU average (approximately 0.6 MW h/person/year than the EU28's average of 1.6 MW h/person/year). And this is although there are approximately 287,000 homes in Romania not yet connected to the grid.

In the past 10 years, electricity prices for households in Europe have been constantly on the rise. In EU28, the average price per kilowatt hour has risen from 0.24 EUR in the first half of 2009 to 0.39 EUR in the first half of 2019 (Eurostat), with obvious differences between states (Table 1). The highest prices are in Spain (0.65 EUR), Germany (0.49 EUR) and Belgium (0.47 EUR); the lowest prices in the EC are registered in Hungary (0.11 EUR), Lithuania (0.13 EUR) and Romania (0.13 EUR).

Table 1. Electricity prices for households.

	S1-2009	S1-2010	S1-2011	S1-2012	S1-2013	S1-2014	S1-2015	S1-2016	S1-2017	S1-2018	S1-2019
EU28	0.2487	0.2644	0.2725	0.2769	0.3011	0.3145	0.3252	0.3290	0.3398	0.3487	0.3948
BE	0.2628	0.2930	0.3034	0.2921	0.2907	0.2661	0.2641	0.4088	0.4988	0.4300	0.4742
BG	0.0844	0.0823	0.0840	0.0857	0.0957	0.0851	0.0969	0.0978	0.0977	0.1000	0.1014
CZ	0.2517	0.2612	0.2883	0.2915	0.2922	0.2587	0.2578	0.2670	0.2693	0.2878	0.3204
DK	0.2991	0.2973	0.3215	0.3308	0.3304	0.3325	0.3865	0.3843	0.3767	0.3838	0.3662
DE	0.3599	0.3664	0.3835	0.3917	0.4257	0.4329	0.4366	0.4555	0.4742	0.4731	0.4985
EE	0.0945	0.0995	0.1008	0.1143	0.1424	0.1347	0.1347	0.1247	0.1237	0.1537	0.1644
IE	0.4330	0.4034	0.4262	0.5466	0.6076	0.6475	0.6970	0.4091	0.4151	0.3842	0.3633
EL	0.1049	0.1175	0.1580	0.1818	0.2071	0.2302	0.2629	0.2642	0.2300	0.2303	0.2276
ES	0.3097	0.3870	0.3584	0.3418	0.3714	0.4760	0.5072	0.5215	0.5735	0.5952	0.6570
FR	0.2169	0.2276	0.2422	0.2411	0.2828	0.2678	0.2870	0.2821	0.3203	0.3468	0.3817
HR	0.2059	0.1896	0.1822	0.2229	0.2386	0.2286	0.2156	0.2266	0.2035	0.2176	0.2182
IT	0.2935	0.2833	0.2654	0.2571	0.2789	0.2935	0.2957	0.3135	0.3496	0.3063	0.5561
CY	0.1393	0.2120	0.2353	0.3180	0.3073	0.2638	0.2274	0.1860	0.2262	0.2976	0.3333
LV	0.1053	0.1050	0.1168	0.1171	0.1168	0.1164	0.1501	0.1614	0.1900	0.2270	0.2055
LT	0.1011	0.1212	0.1278	0.1315	0.1421	0.1367	0.1287	0.1261	0.1137	0.1121	0.1303
LU	0.2684	0.2454	0.2492	0.2492	0.2390	0.2357	0.2397	0.2328	0.2681	0.2913	0.3456
HU	0.1411	0.1973	0.1887	0.1693	0.1572	0.1369	0.1280	0.1262	0.1274	0.1182	0.1162
MT	0.2483	0.4235	0.4278	0.4385	0.4265	0.3882	0.3738	0.3522	0.4047	0.3677	0.3573
NL	-	-	-	-	-	-	-	-	−0.1168	−0.0260	0.0792
AT	0.2727	0.2538	0.2946	0.2978	0.3181	0.3175	0.3550	0.3695	0.3699	0.3652	0.3796
PL	0.1447	0.1729	0.1889	0.1797	0.1879	0.1845	0.1836	0.1602	0.1881	0.1724	0.1780
PT	0.3309	0.3379	0.3330	0.3914	0.3251	0.3989	0.3874	0.3819	0.3883	0.4077	0.3759
RO	0.0982	0.1039	0.1084	0.1085	0.1357	0.1334	0.1366	0.1302	0.1213	0.1332	0.1340
SI	0.2656	0.2610	0.2300	0.2212	0.2394	0.2527	0.2192	0.1865	0.2638	0.3395	0.3358
SK	0.2349	0.2246	0.2320	0.2563	0.2734	0.2389	0.2447	0.2154	0.2400	0.2460	0.2556
FI	0.2429	0.2505	0.2790	0.2851	0.2949	0.2967	0.3039	0.3091	0.3352	0.3446	0.3712
SE	0.2550	0.3443	0.3635	0.3524	0.3728	0.3554	0.3408	0.3642	0.3745	0.4057	0.4121
UK	0.1578	0.1470	0.1523	0.1821	0.2031	0.2404	0.2566	0.2480	0.2581	0.2720	0.3042
IS	-	-	-	0.2015	0.3111	0.3242	0.3302	0.3495	0.4048	0.3791	0.3409
LI	-	-	-	-	-	0.1541	0.1852	0.1729	0.1800	-	-
NO	0.3705	0.4573	0.4738	0.4567	0.4636	0.4124	0.4041	0.3729	0.3965	0.4144	0.4328
ME	-	-	0.1044	0.1247	0.2129	0.2260	0.2229	0.2065	0.1781	0.1819	0.1817
MK	-	-	-	-	0.0836	0.0812	0.0840	0.0829	0.0829	0.0802	0.0800
AL	-	-	0.1152	0.1163	0.1156	0.1156	0.0812	0.0824	0.0844	-	-
RS	-	-	-	-	0.2081	0.1646	0.1460	0.2420	0.2439	0.2568	0.2586
TR	0.1144	0.1341	0.1217	0.1329	0.1500	0.1194	0.1361	0.1266	0.1047	0.0916	0.0847
BA	-	-	-	0.2164	0.2270	0.2269	0.2447	0.2130	0.2224	0.2206	0.2090
XK	-	-	-	-	0.0804	0.0803	0.0914	0.0872	0.0941	0.0927	0.0789
MD	-	-	-	-	-	-	0.0794	0.0940	0.0942	0.0993	0.0912
UA	-	-	-	-	-	-	-	0.0249(p)	0.0393	0.0308	0.0339

Source of data: [42].

- Approximately 422,000 homes (i.e., 4.73% of total homes) have informal access to electrical power, which means these houses are built without building permits;
- On average, Romanian households spend around 20 EUR/month on power, and around 12 EUR/month on natural gas.
- Around 14% of Romania's population is unable to adequately heat their homes (UE average is 8.7%), and around 15% of households have difficulties paying electricity bills;
- Around one million households in Romania benefit from some form of social assistance: heating benefits (emergency ordinance 70/2011), respectively social tariffs for electricity (Order no. 176/20,154 of NAER);
- Heating benefits (covering only approximately 5% of the population) are the only social benefits not included in the national information system. Over 50% of the amount of heating benefits cover heating with firewood; support for heating with electricity has a weight of only 2% of the total (i.e., approximately 8000 households). In addition, 56% of the granted benefit goes towards the poorest 20% of the households. Although almost a quarter of the benefits is directed towards the poorest households, with an income of up to 155 RON (approximately 32 EUR) per family member, data reveals that approximately 70% of the households with this income do not receive any benefit;
- Twelve percent of Romania's population benefits from social tariffs, but 42% of the households applying for this tariff do not correctly dimension their consumption and exceed the minimum consumption threshold provided by law; consequently, the tariffs in their case are above the social level
- According to the EU's Observer of Energy Poverty, the main indicators for identifying energy poverty are low absolute energy expenditure, arrears on utility bills, high share of energy expenditure in income and the inability to keep the home adequately warm. A series of secondary indicators can be added, the European Commission recommend list with 180 indicators which are adapted to specific regional/local coordinates.

A relevant indicator of energy poverty (regardless of whether) reflecting poor access to energy or fuel poverty) in low-income countries with high poverty rates is 'arrears on utility bills', which can reveal the rate of households inability to pay utility bills (heating, electricity, natural gas, water, etc.) on time, due to low purchasing power and/or high prices. In EU-28, the average for these types of situations decreased from 9.1% to 6.6% between 2010 and 2018, with major differences between countries (Table 2). In 2018, 36.9% of the inhabitants of North Macedonia, 35.6% of Greeks, 30.1% of Bulgarians and 17.5% of Croatians registered delays in the payment of energy bills. Above the Eurozone average of 6%, there are countries like Romania (14.4%), Slovenia (12.5%), Hungary (11.1%), Cyprus (12.2%), as well as Spain (7.2%) and France (6.4%).

- There is a 'hidden' energy poverty represented by households with very low energy bills expenditures because they limit their consumption partially, or almost totally. M/2 is used to estimate this type of energy poverty. The M/2 indicator indicates the share of households whose absolute energy expenditure is below half of the national median (the median of absolute energy expenses of households).

Table 2. Arrears on utility bills (%)-EU-SILC survey.

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
European Union-27 countries (from 2020)	-	9.6	9.6	10.1	10.4	10.3	9.4	8.4	7.3	6.8
European Union-28 countries (2013–2020)	-	9.1	9.0	9.9	10.2	9.9	9.1	8.1	7.0	6.6
European Union-27 countries (2007–2013)	8.9	9.0	8.9	9.8	10.0	9.8	8.9	7.9	6.9	6.5
Euro area (EA11-1999, EA12-2001, EA13-2007, EA15-2008, EA16-2009, EA17-2011, EA18-2014, EA19-2015)	-	-	7.4	7.7	8.0	8.5	8.4	7.3	6.1	6.0
Euro area-19 countries (from 2015)	7.3	7.4	7.5	7.9	8.1	8.6	8.4	7.3	6.1	6.0
Euro area-18 countries (2014)	7.2	7.4	7.5	7.8	8.1	8.5	8.4	7.2	6.1	5.9
Belgium	5.9	5.8	6.0	6.1	5.0	5.8	5.1	5.0	4.0	4.5
Bulgaria	32.1	31.6	28.6	28.4	34.0	32.9	31.4	31.7	31.1	30.1
Czech Republic	4.0	4.2	4.3	4.1	4.0	4.7	3.0	3.0	2.1	2.1
Denmark	2.6	3.2	3.4	3.5	3.6	4.6	3.4	2.5	3.5	5.1
Germany (until 1990 former territory of the FRG)	3.6	3.5	3.9	3.4	3.6	4.2	4.0	3.0	2.8	3.0
Estonia	10.0	11.0	11.8	10.9	10.4	10.0	7.9	7.9	6.3	6.5
Ireland	11.2	12.6	14.8	17.4	17.9	18.2	15.2	11.9	9.9	8.6
Greece	18.9	18.8	23.3	31.8	35.2	37.3	42.0	42.2	38.5	35.6
Spain	6.3	7.5	5.7	7.5	8.3	9.2	8.8	7.8	7.4	7.2
France	7.5	7.1	7.1	6.7	6.2	6.3	5.9	6.1	6.1	6.4
Croatia	-	28.0	27.5	28.9	30.4	29.1	28.7	25.3	21.0	17.5
Italy	11.3	11.2	12.0	11.7	11.9	12.2	12.6	8.9	4.8	4.5
Cyprus	13.3	16.3	16.9	18.4	21.9	20.5	20.1	15.4	13.7	12.2
Latvia	17.8	22.5	23.4	22.4	20.7	19.6	16.7	13.2	11.9	11.6
Lithuania	8.4	10.9	11.8	12.6	13.2	10.4	8.4	9.7	7.9	9.2
Luxembourg	2.3	2.1	2.2	2.2	3.1	3.2	2.4	4.0	1.7	3.6
Hungary	20.7	22.1	22.7	24.4	25.0	22.3	19.4	16.2	13.9	11.1
Malta	7.9	6.8	8.6	10.1	11.6	14.6	10.2	9.5	5.6	6.9
The Netherlands	2.1	2.1	2.4	2.3	2.4	3.0	2.7	2.0	2.1	1.5
Austria	4.0	4.4	4.0	3.8	4.6	3.5	3.5	4.2	3.6	2.4
Poland	12.5	13.9	12.9	14.1	14.0	14.4	9.2	9.5	8.5	6.3
Portugal	6.1	6.4	6.7	6.3	8.2	8.5	7.8	7.3	5.6	4.5
Romania	25.1	26.5	27.3	29.7	29.7	21.5	17.4	18.0	15.9	14.4
Slovenia	16.9	18.0	17.3	19.3	19.7	20.3	17.5	15.9	14.3	12.5
Slovakia	11.3	9.6	6.4	5.8	5.9	6.1	5.7	5.7	5.5	7.9
Finland	7.5	6.9	7.8	7.9	8.4	7.9	7.5	7.7	7.8	7.7
Sweden	5.4	5.2	4.6	4.3	4.7	3.6	3.2	2.6	2.2	2.2
United Kingdom	-	5.6	5.0	8.9	8.7	7.2	7.0	5.7	5.0	5.4
Iceland	3.9	7.0	7.5	7.0	7.5	7.5	6.6	6.0	-	-
Norway	6.5	6.3	6.9	4.6	4.5	3.1	3.2	2.4	3.0	2.7
Switzerland	5.6	4.8	3.5	3.6	3.0	4.2	3.6	4.5	3.6	4.1
Montenegro	-	-	-	-	37.3	52.3	38.4	34.8	31.6	-
North Macedonia	-	39.3	36.2	38.9	39.6	38.8	40.1	41.0	38.6	36.9
Serbia	-	-	-	-	36.7	41.4	34.8	34.8	18.1	28.4
Turkey	39.7	-	44.0	41.8	39.8	35.8	33.2	29.0	26.3	-

Source of data: [42].

4. Micro-Solutions for Combating Energy Poverty. Examples of Good Practices in Europe

In countries such as Spain, Germany, Belgium and the UK, there is a successful practice of countering energy poverty by counseling vulnerable families who encounter difficulties in paying their utility bills [46–52]. These solutions are less costly (falling into the category of non-financial measures), partly rely on volunteers and are applicable at the local community level in any European country. Some different projects-with various stakeholders, different financial implications and structures of implementation-aimed at reducing energy poverty and improving household resilience to energy needs, are presented below.

4.1. Spain-The Ni un Hogar Sin Energia (No Home without Energy) Project

In Spain, about seven million people are affected by arrears on utility bills and/or experience abnormal temperatures in their homes [46]. Such a situation affects quality of life by detrimental effects on health, children's education and personal savings. In this context, a non-governmental organization has initiated a project to assist the people who do not understand the content of the bills and do not know how to act in order to reduce costs while also ensuring a comfortable temperate inside the house. The program's objectives are to make recommendations to people about adjusting the electricity supply contracts, to propose measures in order to increase the energy efficiency by thermal rehabilitation works on residential buildings or changing the consumption habits [47]. From 2013 to date, the foundation's assistants (social workers) have visited over 2000 households in over 30 Spanish cities and drew up a personalized energy diagnosis for each of them. Additionally, the foundation used the gathered data in order to build an on line platform, so that advice and knowledge were made available for over 4400 Spanish households to date, resulting in savings of about 125 EUR/household/year on average, hence a total of about 550,000 EUR/year [48].

4.2. UK-The Plymouth Energy Community Initiative

In Plymouth, over 1500 natural persons, economic operators and non-profits teamed up to establish a social enterprise with the purpose of rendering the energy production, purchase and use more efficient. The Plymouth Energy Community Initiative addresses both natural person's residents and local authorities, public institutions and economic organizations. The project is not limited to offer only advice in view of increasing energy efficiency and decreasing costs, but also to elaborate an investment scheme in which every participant (above the age of 16) can buy social shares with values between 50 and 100,000 pounds, under the motto: ˝People care more about things that they own˝. The shareholders become members of the Plymouth Energy Community, they can be a part of the organization's board and will collect an interest of 6% of the invested capital. The organization invests the amounts collected from selling social shares into the installation of solar panels on schools, public buildings or brownfield sites and for building community-led housing. These installations help the host building to reduce its energy consumption and the extra revenue is transferred to Plymouth Energy Community. Thus, a business model was created that helps citizens benefit from energy from renewable sources at reduced costs, the investors collect interest (usually above market level), and, additionally, more financial resources are created to generate new projects for reducing carbon emissions and energy poverty [49].

4.3. Belgium-The Papillon Project

The project implemented in the Flemish region of Westhoek in Belgium is a partnership between a company producing electric appliances and the local authorities. The project started from the following premises: one in three consumers affected by energy poverty owns energy inefficient household appliances that consume three to five times more than new ones; most consumers stricken by energy poverty cannot afford purchasing new appliances [50]. The project focuses on 100 households and offers them the possibility to rent new appliances for a fee of seven EUR/month. It includes ten types of household appliances; the rental fee covers installation, maintenance and warranty for a period of 10 years. The leasing fee is paid once per year by the social enterprise (Samenlevingsopbouw West-Vlaanderen, which is owned by the local authority) to the supplier of electric appliances, who remains the legal owner. After the contract expires, the appliances are returned to the supplier for reuse or recycling. The project is part of a broader implementation strategy of a circular economy, and is based on the following cost/benefit synthesis (Table 3)

Table 3. The Papillon Project, cost/benefit synthesis.

	The Classic Model	The Papillon Model
Energy consumption	591 kWh	204 kWh
Energy cost 10 years (0,36 €/kWh)	2128 €	735 €
Repair	300 €	included
Provision new appliance	500 €	-
Rental fee	-	694 €
Total cost	2928 €	1429 €

Source: [51].

4.4. Germany-The Program for the Reduction of Interruptions in Electricity Supply

Even in Europe's most powerful economy, Germany, there were 370,000 cases of disconnection from gas and power networks in 2017 alone. Implemented in the German state of North Rhine-Westfalia (in the fief of the Rhenish model of social market economy), the program includes energy suppliers, local authorities, institutions of social protection, but also non-governmental organizations. The program carries various activities such as offering advice to vulnerable consumers as well as providing legal representation in their relationship with energy suppliers and associated services, organizing debates, lobbying for domestic consumers, but also a series of other public relations activities. To date, the program was successful in offering legal and technical advice to a number of over 15,000 consumers, in preventing disconnection from the network for 80% of the households that benefited from advice and representation, in obtaining the revocation of over 60% of the already operated disconnections, and, ultimately, in raising public awareness about the fuel poverty issue [52].

5. Cross-Country Analysis

In this part, a cross-country analysis regarding Granger causality between indicators representing all three dimensions was conducted. This is needed to see if there is a connection between indicators of the three dimensions, quality of life, energy poverty and renewables. The study starts from the hypothesis that there is a Granger causality between all selected variables. If one or more relations are found the number of indicators will be expanded in a future research in order to create a better connection chart between the three dimensions indicators. The selected indicators are the main used in each of the three dimensions. The period of the analysis is between 2010–2019 for the 28 EU member states. The indicators included in the analysis are:

- ➢ electricity prices for households, medium size, EUR/Kwh, (PR);
- ➢ inability to keep the home adequately warm,%, (WARM);
- ➢ arrears on utility bills between,%, (ARR);
- ➢ gross domestic product, million EUR, (GDP);
- ➢ share of renewable energy in gross final energy consumption,%, (RENEW).

In order to avoid autocorrelation, the data series were investigated for unit root using Levin, Lin & Chu t*, Im, Pesaran and Shin W-stat, ADF-Fisher chi-squared, PP-Fisher chi-squared tests. For unit root tests, we used Schwarz info criterion, Newey-West automatic band width selection and Bartlett kernel.

To test causality relations between the variables, we started from the Granger (1969) hypothesis [53] that tested how much of the variable y may be deduced from the past values of x, and then asked if that, by adding the past values of x, we can obtain a better approximation of y. A variable y is Granger-caused by x when x improves the predictive capacity of y or when the past coefficients of variable x are statistically significant. It must be acknowledged that a two-way causality is a frequent case when x Granger causes y, and y Granger causes x.

In order to apply a Granger causality test, a Lag length 1 must be specified. Usually it is better to use more lags in order to get relevant information from the past. In our study, we tested the Granger causality relation between the variables for 1, 2 and 4.

After establishing the lag length, we estimated a bivariate regression of the form:

$$y_t = \alpha_0 + \alpha_1 y_{t+1} + \ldots + \alpha_l y_{t-l} + \beta_1 x_{t+1} + \ldots + \beta_l x_{t-l} + \varepsilon_t \quad (1)$$

$$x_t = \alpha_0 + \alpha_1 x_{t+1} + \ldots + \alpha_l x_{t-l} + \beta_1 y_{t+1} + \ldots + \beta_l y_{t-l} + \mu_t \quad (2)$$

for each possible pair of (x,y) series of the group. F-statistic reported values were the Wald statistics for the consolidated hypotheses:

$$\beta_1 = \beta_2 = \ldots = \beta_1 = 0 \quad (3)$$

For each equation, the null hypothesis was that x did not Granger-cause y in the first regression and y does not Granger-cause x in the second regression.

In order to estimate the regression equation, it was started from the linear regression using the OLS method with panel data of the form:

$$Y_{it} = f(X_{it}, \beta) + \delta_i + \gamma_t + \epsilon_{it} \quad (4)$$

This specific case implies a conditional mean linear specification so that we achieve:

$$Y_{it} = \alpha + X'_{it}\beta + \delta_i + \gamma_t + \epsilon_{it} \quad (5)$$

where Y_{it} is the dependent variable, X_{it} is a regression vector k and ϵ_{it} error terms for i = 1, 2, . . . , M transversal units, observed for the dated periods t = 1, 2, . . . , T. α is the general constant of the model while δ_i and γ_t represents the effects specific to transversal section or time period.

As Engle and Granger [54] pointed out that a linear combination of two or more non-stationary series may be stationary. If this happens the non-stationary series are said to be co-integrated. The test for co-integration Kao test [55] it was used because it is suited for panel data. In Table 4 results of the testing for unit root are presented for all variable included in the analysis.

Table 4. Unit root tests.

Variable	Method	Level			1st Difference		
		Statistic	Prob	Obs	Statistic	Prob	Obs
ARR	Levin, Lin & Chu	−1.13972	0.1272	199	−6.23052	0.0000	171
	Im, Pesaran and Shin W-stat	0.85448	0.8036	199	−1.52648	0.0634	171
	ADF-Fisher chi-squared	50.7773	0.6723	199	77.4935	0.0302	171
	PP-Fisher chi-squared	51.2924	0.6534	227	140.190	0.0000	199
GDP	Levin, Lin & Chu	10.3967	1.0000	222	−10.1537	0.0000	194
	Im, Pesaran and Shin W-stat	9.54792	1.0000	222	−1.33694	0.0906	194
	ADF-Fisher chi-squared	12.8363	1.0000	222	74.6374	0.0487	194
	PP-Fisher chi-squared	20.7650	1.0000	250	69.7879	0.1019	222
PR	Levin, Lin & Chu	−9.87802	0.0000	224	-	-	-
	Im, Pesaran and Shin W-stat	−3.51807	0.0002	224	-	-	-
	ADF-Fisher chi-squared	111.535	0.0000	224	-	-	-
	PP-Fisher chi-squared	110.542	0.0000	252	-	-	-
RENEW	Levin, Lin & Chu	−8.19314	0.0000	196	−6.47698	0.0000	168
	Im, Pesaran and Shin W-stat	−0.70777	0.2395	196	−2.08310	0.0186	168
	ADF-Fisher chi-squared	82.1251	0.0130	196	85.0848	0.0073	168
	PP-Fisher chi-squared	74.6963	0.0482	224	130.768	0.0000	196
WARM	Levin, Lin & Chu	−0.79261	0.2140	202	−83.8692	0.0000	174
	Im, Pesaran and Shin W-stat	1.58888	0.9440	202	−8.78641	0.0000	174
	ADF-Fisher chi-squared	42.0318	0.9169	202	87.8995	0.0041	174
	PP-Fisher chi-squared	50.3423	0.6880	230	187.726	0.0000	202

Source: authors calculation based on data from Eurostat.

After testing for the unit root, it can be observed that electricity prices for households (PR) was the only variable that did not have a unit root at level, while the inability to keep the home adequately warm (WARM), arrears on utility bills between (ARR), gross domestic product (GDP) and share of renewable energy in gross final energy consumption (RENEW) had a unit root at level, but they became stationary at the first difference. In this case the decision was to take all variables at the first difference.

Before analyzing the Granger pairwise causality tests results, the correlation matrix should be inspected for the analyzed variables. In Table 5, the correlation matrix is presented.

Table 5. Correlation matrix.

	ARR	GDP	PR	RENEW	WARM
ARR	-	−0.756816	0.026646	−0.542304	0.958573
GDP		-	0.597827	0.954403	−0.882561
PR			-	0.776807	−0.174426
RENEW				-	−0.727907
WARM					-

Source: authors calculation based on data from Eurostat.

As can be seen from the correlation matrix, there was a very strong positive correlation between gross domestic product (GDP) and share of renewable energy in gross final energy consumption (RENEW), and a strong negative correlation with the inability to keep the home adequately warm (WARM). This was expected as the renewable energy sources are most explored by high income countries and higher share of inability to keep warm can be observed in lower income countries. The level of arrears on utility bills between (ARR) has a very strong positive correlation with inability to keep the home adequately warm (WARM), a strong negative correlation with gross domestic product (GDP), a moderate negative correlation with share of renewable energy in gross final energy consumption (RENEW) and no correlation with electricity prices for households (PR). Electricity prices for households (PR) had a strong positive correlation with share of renewable energy in gross final energy consumption (RENEW) and very low negative correlation with the ability to keep the home adequately warm (WARM).

Although the correlation between variables can be observed, there is no way to know, at this stage, if there is a causality relation between the variables or if a different variable has a result-determining influence on both. To see if there is a causality link, the pairwise Granger causality test must be used.

Next, in Table 6, there are the results of the pairwise Granger causality test. To have a better understanding of the causality relation in time between variables, it was tested for Lag 1, 2 and 4.

After analyzing the results of the pairwise Granger causality tests, several causality links were found. Arrears on utility bills between (ARR) Granger-caused gross domestic product (GDP) with a significance of 10% at Lag 4, but not at Lag 1 and 2, and that electricity prices for households (PR) Granger-caused arrears on utility bills between (ARR), with a significance of 5% at Lag 1 and 4, but not 2, which means that there was a short-term shock of electricity price and a long-term influence. The inability to keep the home adequately warm (WARM) Granger-caused arrears on utility bills between (ARR) with a significance level of 1% for all three lag lengths examined. This result was expected as low-income households would accumulate arrears on utility for keeping warm, but not at a comfortable level.

Gross domestic product (GDP) Granger-caused electricity prices for households (PR) at a significance level of 5% for Lag4, but not for Lag 1 and 2. Hence, the level of GDP generated and influenced electricity prices after four periods. Electricity prices for households (PR) Granger-caused the inability to keep the home adequately warm (WARM) with a significance level of 5% for Lag 1, but not for 2 and 4, so the shock of price increase will be absorbed in first lag and will not create future influences as households adapt to it.

Table 6. Pairwise Granger causality test.

Null Hypothesis: X Does Not Granger Cause Y	Obs	Lag1 F-Statistic	Prob.	Obs	Lag2 F-Statistic	Prob.	Obs	Lag 4 F-Statistic	Prob.
GDP → ARR	199	0.65741	0.4185	171	0.12821	0.8798	115	0.63582	0.6381
ARR → GDP		0.70168	0.4032		0.81076	0.4463		2.05587	**0.0918**
PR → ARR	199	4.50500	**0.0351**	171	2.27040	0.1065	115	2.91410	**0.0248**
ARR → PR		0.00374	0.9513		0.26519	0.7674		0.50699	0.7307
RENEW → ARR	196	0.85506	0.3563	168	2.08921	0.1271	112	1.30609	0.2727
ARR → RENEW		1.88433	0.1714		0.10233	0.9028		0.32235	0.8624
WARM → ARR	199	10.7082	0.0013	171	14.4907	0.000002	115	3.54172	0.0094
ARR → WARM		2.07083	0.1517		0.01139	0.9887		0.92337	0.4533
PR → GDP	222	0.16866	0.6817	194	0.02139	0.9788	138	0.16035	0.9580
GDP → PR		0.04526	0.8317		0.06253	0.9394		2.50856	**0.0451**
RENEW → GDP	196	0.18214	0.6700	168	0.51432	0.5989	112	0.68400	0.6046
GDP → RENEW		0.00550	0.9409		0.06587	0.9363		0.60201	0.6620
WARM → GDP	202	0.08995	0.7645	174	0.52699	0.5913	118	0.59411	0.6676
GDP → WARM		0.03966	0.8423		0.03294	0.9676		0.15206	0.9617
RENEW → PR	196	0.09995	0.7522	168	2.44530	**0.0899**	112	0.31634	0.8665
PR → RENEW		6.85317	0.0096		2.07078	0.1294		0.74513	0.5634
WARM → PR	202	0.05949	0.8075	174	0.04344	0.9575	118	1.75279	0.1437
PR → WARM		4.07290	**0.0449**		0.88235	0.4157		1.69942	0.1553
WARM → RENEW	196	0.90347	0.3430	168	1.69796	0.1863	112	0.69011	0.6004
RENEW → WARM		0.97074	0.3257		0.39134	0.6768		1.17125	0.3279

1% significance level, **5% significance level**, **10% significance level**; source: authors calculation based on data from Eurostat.

All relations presented until now are unidirectional and the only bidirectional relation was found between electricity prices for households (PR) and share of renewable energy in gross final energy consumption (RENEW) as PR Granger-caused RENEW with a significance level of 1% at Lag 1, but not on leg 2 and 4. RENEW Granger-caused PR with a significance level of 10% at Lag 2, but not on leg 1 and 4. Even though the causality relation is bidirectional this manifested at different lag lengths, and at different levels of significance. An increase of electricity prices could spike new investments in renewables at first lag, but the influence of renewables on electricity prices takes 2 lags and has lower probability.

Next the cointegration test is realized using Kao residual cointegration test for the analyzed variables presented in Table 7. In the test there were included 280 observations with no deterministic trend, lag-length selection based on SIC, Newey-West fixed bandwidth and Bartlett kernel.

Table 7. Kao residual co-integration test.

Kao Residual Co-Integration Test				
			t-Statistic	**Prob.**
ADF			−4.820553	0.0000
Residual variance			4.219468	-
HAC variance			1.937356	-
Augmented Dickey-Fuller Test Equation				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
RESID(-1)	−0.950714	0.071779	−13.24495	0.0000
R-squared	0.473336	Mean dependent var		−0.045481
Adjusted R-squared	0.473336	S.D. dependent var		2.106597
S.E. of regression	1.528791	Akaike info criteria		3.691921
Sum squared resid.	455.7545	Schwarz criterion		3.708646
Log likelihood	−360.8082	Hannan-Quinn criteria		3.698692
Durbin-Watson stat	2.076981			

Source: authors calculation based on data from Eurostat.

In addition, there are presented the results for ADF test equation on residuals using least square method with 1986 observations after adjustment.

6. Subsidies-Sustainability's Motor in the Tackle Energy Poverty?

In the last part of the study, an analysis of Romania's renewable sources potential was conducted also a comparison with the income data for each county.

Many experts believe that renewable energy is a solution that could solve the problem of energy poverty despite the challenges and limitations of using this energy source. Even if the generation of such an energy involves in some cases, higher costs than the production of traditional one, specialists emphasize the short-term and long-term benefits that its use induces. The implementation of renewable energy projects does not generate only disputes related to costs and investment financing, but also to their acceptance by local communities (given the negative externalities generated-like aesthetics, noise, biodiversity degradation, etc.). However, the renewable energy production projects could be a solution for the development of rural communities, which, in this way, providing the necessary energy, attracting the local labor force, thus ensuring the increase of the incomes of the local population [56–64].

Taking into account the current context regarding the access, in general of the European Union's population and in particular of Romania's people, to the energy sources for the creation of the minimum comfort in the households, it will be tried to define a model, for the future period which starts from the idea that, by implementing it, it will be able to lead to an improvement in the standard of living of vulnerable consumers affected by energy poverty.

The hypotheses from which it will be started the study are the following:

➢ The proposed model is addressed to the governmental factors of analysis and decisions, at the level of the Ministry of Energy;
➢ It is desired that all citizens have access to at least one of the green energy sources;
➢ It is required, according to the provisions of the European norms, the reduction of the greenhouse gas emissions by 20% compared to the level of 1990;
➢ In addition, in accordance with the European provisions, it is desired to increase to 20% the share of renewable energy sources in the final energy consumption;
➢ In the same context it is desired to reduce by 20% the primary energy consumption by improving the energy efficiency.

The most widely accepted indicators in practice and literature with a view to sizing the energy poverty phenomenon and targeting measures in order to combat it, consider a ratio between population incomes and household energy expenditure. In Romania, the only criterion used is the income per household, which leads to an incomplete understanding of the phenomenon. In the next lines of the article it will be presented an analysis of the statistical data, regarding the income of the population, for all the counties of the country.

Botosani, Vaslui, Calarasi and Giurgiu counties represent the extreme poles, with the lowest purchasing power. It follows in the ranking Suceava, Neamt, Vrancea, Buzau, Ialomita, Teleorman, Olt and Mehedinti a short distance from the first. The group of counties with purchasing power below the national average is completed by Satu-Mare, Maramures, Bistrita-Nasaud, Harghita, Covasna, Bacau, Iasi, Braila, Tulcea, Valcea, Dolj, Caras-Severin, Gorj, Salaj, Mures.

The counties located near the average in the country from the point of view of purchasing power are those that include cities in the development competition: Prahova, Arges, Constanta, Alba and Arad. In these counties, significant economic growths are foreshadowed, they serve as satellites of the big economic centers and benefit from the investments of the players who relocate their activities in the proximity of the big economic centers that become inadequate (Cluj, Timisoara and Brasov). All these cities occupy top places in the absorption of European funds and in the development of infrastructure. Arad has provided a large number of transport connections with the European road network, while Alba Iulia is the absolute national leader among the smart cities in the country, with most of the smart city projects implemented. The group of counties with high purchasing power begins with Brasov and Sibiu, "stars" on the map of the economic development of the country and the engines of the central area of Romania. For several years here, a new industrial area of the country has been configured, attracting massive investments.

Brasov County has developed on several market segments, mainly on real estate and Business Service, due to the number of people with technical skills and language skills, the central geographic positioning, and the lower costs compared to other localities and the very good living conditions. At the same time, the county owns the most industrial parks in the country (10), after Prahova (15) and Cluj (11), and the development of the automotive and retail industry also generated an explosion of residential constructions. Thus, in 2017 was completed the largest number of homes in residential complexes in the post December '98 history of Brasov.

Sibiu County, in turn, has become a magnet for investors coming to Romania, being attractive to the auto and IT industry. The largest industrial employer in the county and the giant in the automotive industry-Continental-expanded its investment in 2018, followed by other big players (Kika Automation) who transfer their activities to this region.

Counties such as Cluj, Timis and Ilfov, in front of Bucharest are the traditional poles of development of the country (red areas) where the purchasing power is at least 20% above the country average. These areas keep their development rates stable and have the quality of "diffusers" of investments for the neighboring areas, making them positive corrections.

In general, the reasons for developing cities outside Bucharest are related to the cheap and educated workforce. The industries that have found the best opportunities in such cities are the automotive, IT and Business Service industries. Another important factor is the transport infrastructure.

According to GfK [65], it is estimated that Sibiu, Brasov, Arad, Constanta and Alba Iulia are the cities that will soon see a greater development than Bucharest, precisely because they have a good infrastructure, but also university centers that will form the workforce market (Figure 1). Last, but not least, another factor that changes the map of local development is the dynamics of costs-the classic development areas become expensive for new investors (the case of Cluj which has the most expensive industrial land in 2019 in the country), and this causes them to orient to less explored areas of the country.

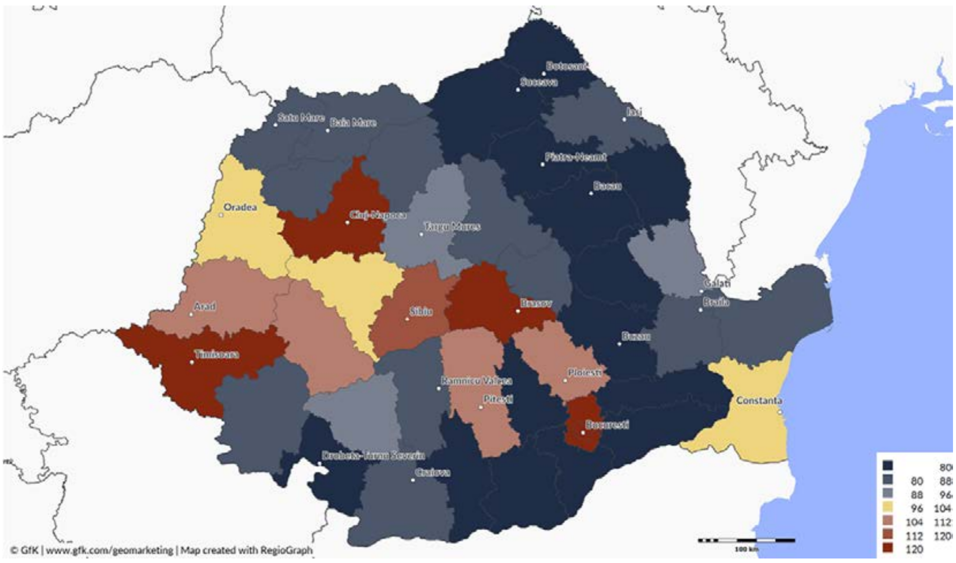

Figure 1. The purchasing power in Romania-2019; Source [66].

In addition, the regional competition intensifies with the availability of European funds. In this regard, some counties have adopted strategies and alliances to boost the attractiveness of these funds to develop their infrastructure-as is the case of the "Western Alliance", an alliance between four counties (Cluj, Timis, Arad and Oradea)-meant to boost the attractiveness of financing, for regional development.

Solar energy is considered as a renewable energy source, as it is energy emitted by the sun. Solar energy can be used for generating electricity through solar cells (photovoltaics) or through solar thermal power stations (heliocentric); heating buildings directly or through heat pumps; heating buildings and produce hot water for consumption through solar thermal panels [65].

In order to increase sustainability and viability of the model, the proposal for government's factors was subsidization purchasing of solar panel systems for households in counties that have-according to the map of the sun-the benefits of this type of energy. For example, the counties that can benefit from such subsidies for solar panels are Prahova, Buzau, Ialomita, Olt, Dolj, Constanta, Calarasi, Giurgiu and Arges.

Romania is in an area with a good solar potential of 210 sunny days per year and an annual solar energy flow between 1000 kWh/m^2/year and 1300 kWh/m^2/year. From this total amount it is possible about 600 to 800 kWh/m^2/year. The most important solar regions of Romania (Figure 2) are the Black Sea coast, Dobrogea de Nord and Oltenia, with an average of 1600 kWh/m^2/year.

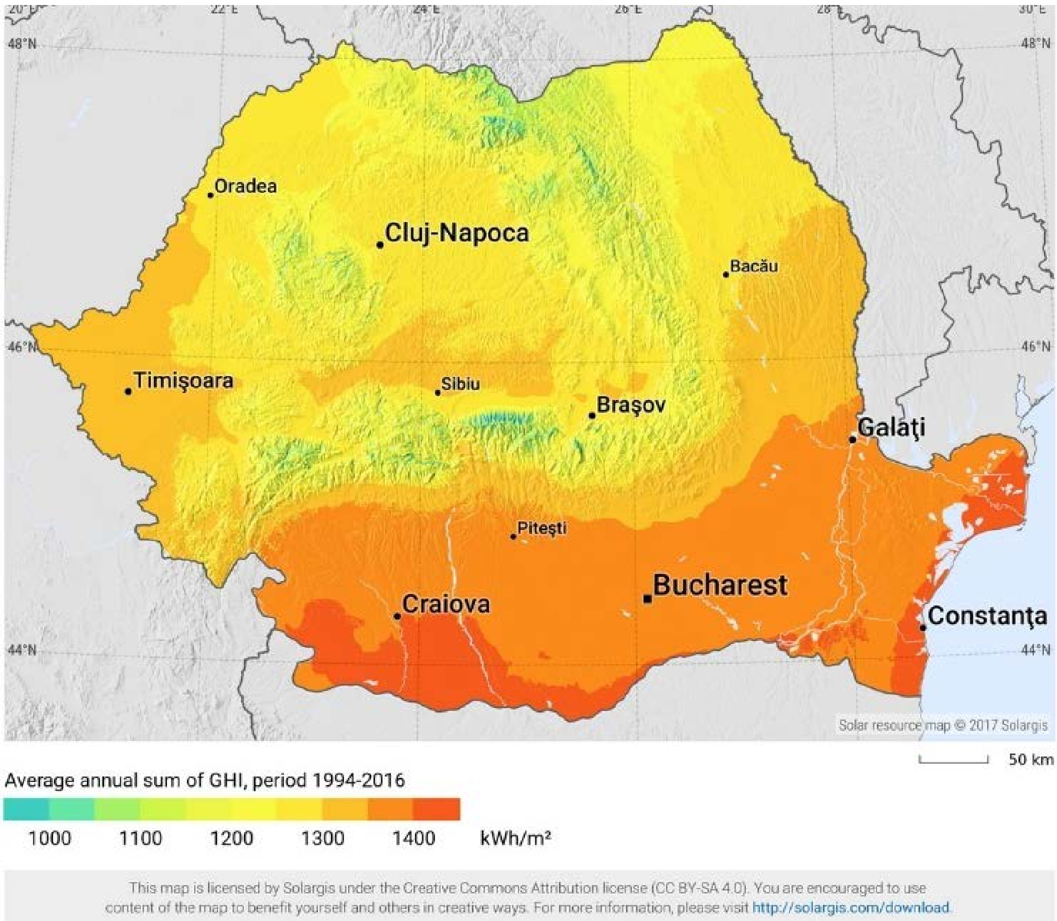

Figure 2. Map of sunshine in Romania (average between1994–2016). Source [67] https://www.fabricadecercetare.ro/regenerabil/.

Between the 1970s and 1980s, Romania was an important player in the solar energy industry, installing around 800,000 m^2 (8,600,000 ft^2) of low-quality solar panels, which placed the country in third place worldwide for total photovoltaic cell surface area. One of the most important solar projects was the installation of a 30 kW solar panel on the roof of the Polytechnic University of Bucharest, capable of producing 60 MWh of electricity per year.

Geothermal energy is energy stored in the form of heat beneath the solid layer of the earth's surface. The two fields of exploitation of geothermal energy are:

(i) Up to 500 m representing surface geothermal;
(ii) Over 500 m representing geothermal depth.

Referring to the map below, it has been found that the areas marked in gray shades have geothermal energy and are located in the west of the country (Bihor County, Arad, Timis and Satu Mare) and near Bucharest, more precisely in Ilfov County.

In order to increase the sustainability and viability of the model it was proposed to the governmental factors, the subsidization of the households in the counties that have, according to the map below, the benefits of this type of energy, for the purchase of some systems of valorization of this resource. For example, the counties that can benefit from such subsidies for green energy are: Bihor, Arad, Timis, Satu Mare and Ilfov. Geothermal energy can be used as a ventilation heating system with air conditioning systems to exploit geothermal energy on the surface.

In Romania, the Panonian Depression (Banat and western Apuseni mountains) is rich in geothermal deposits (Figure 3). In Timisoara there are geothermal resources with temperatures up to 80 °C.

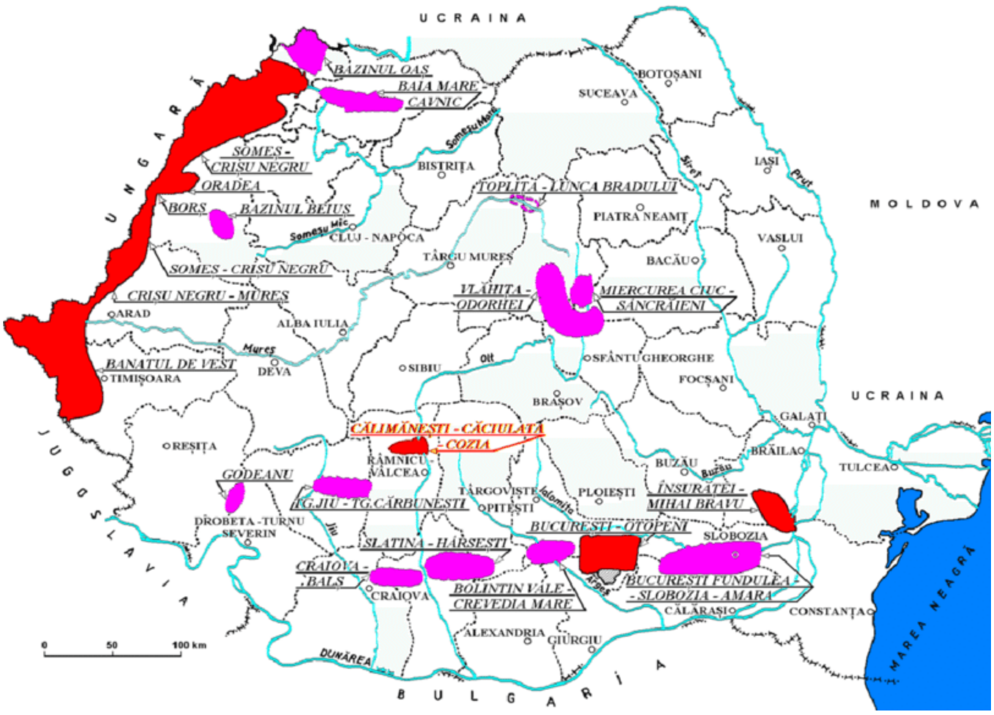

Figure 3. Map of geothermal potential in Romania. Source: [68] https://www.researchgate.net/figure/Repartition-of-geothermal-resources-in-Romania_fig1_312284159.

Wind power is a renewable energy source generated by wind power. The advantages of using wind energy are the following:

(i) The use of renewable resources is addressed not only to the production of energy, but through the particular way of generation it also reformulates the development model by decentralizing the sources;
(ii) Reduced costs per unit of energy produced;
(iii) Zero emission of polluting substances and greenhouse gases, due to the fact that they do not burn fuels;
(iv) Green energy source, no waste, is produced. To capture and harness this type of energy, wind turbines will be used to generate electricity.

Wind turbines-also known as windmills-transform the kinetic energy of the wind into mechanical energy, which is in turn, further transformed into electricity. Electricity is produced by a system using a charging regulator and it is stored in different ways. Thus, through this model we propose a solution for subsidizing households in counties that have this type of energy. In this sense, the inhabitants of these counties will be able to benefit from low rates for electricity. For example, the areas that could benefit from such subsidies for the implementation of wind systems for electricity production are Constanta, Bistrita-Nasaud, Braila, Tulcea, Vaslui, Ialomita and Galati (Figure 4).

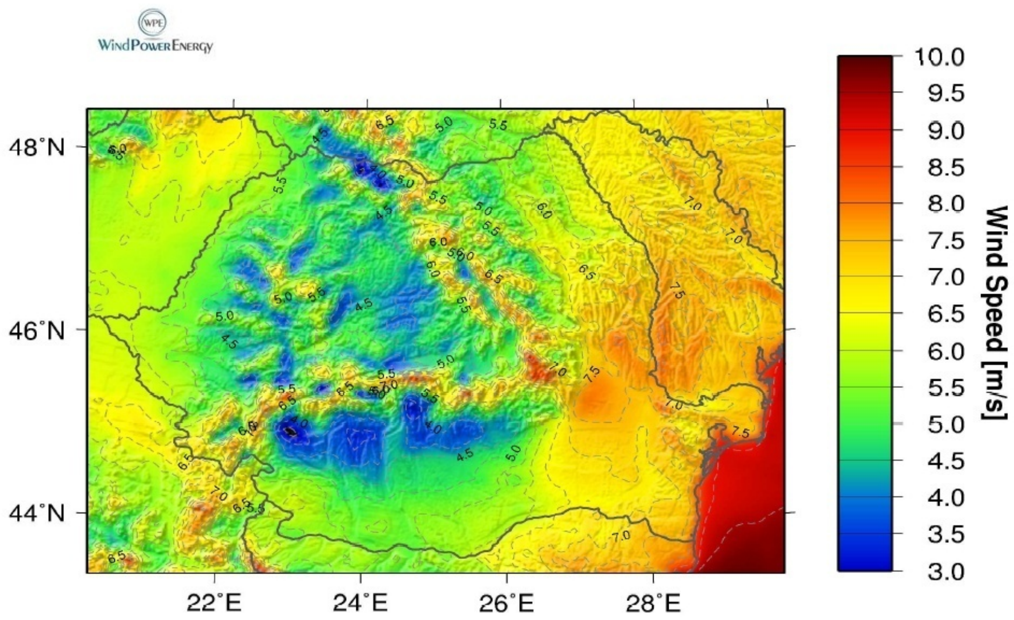

Figure 4. Map of the wind speed in Romania; Source [69] http://energielive.ro/energie-eoliana-harta-de-vant-a-romaniei-potential-de-14-000-mw/harta-vant-romania/.

The current structure of the natural gas market in Romania comprises (Figure 5):

- ➢ 1 operator of the National Transport System-SNTGN Transgaz SA Medias;
- ➢ 6 natural gas producers: OMV Petrom SA, SNGN Romgaz SA, SC Amromco SRL, SC Foraj Sonde SA, SC Raffles Energy SRL, Stratum Energy Romania LLC Wilmington Bucharest Branch;
- ➢ 2 operators for underground storage depots: SNGN Romgaz-Underground Storage Branch of Ploiesti Natural Gas, SC Depomures GDF Suez;
- ➢ 38 natural gas distribution and supply companies-the largest being SC Distrigaz Sud Retele SRL and SC Delgaz Grid SRL;
- ➢ 75 suppliers operating in the wholesale market.

The internal market for natural gas has two components:

- ➢ the competitive segment comprising:
- ➢ the wholesale market that operates on the basis of:
- ✓ bilateral contracts between economic operators in the field of natural gas;
- ✓ transactions on centralized markets, administered by the natural gas market operator or the equilibrium market operator as appropriate;
- ✓ other types of transactions or contracts.
- ➢ the retail market where suppliers sell natural gas to final customers through contracts at negotiated prices.
- ➢ the regulated segment that includes the activities of a natural monopoly, the activities related to them and the supply at regulated prices and based on the framework contracts approved by ANRE.

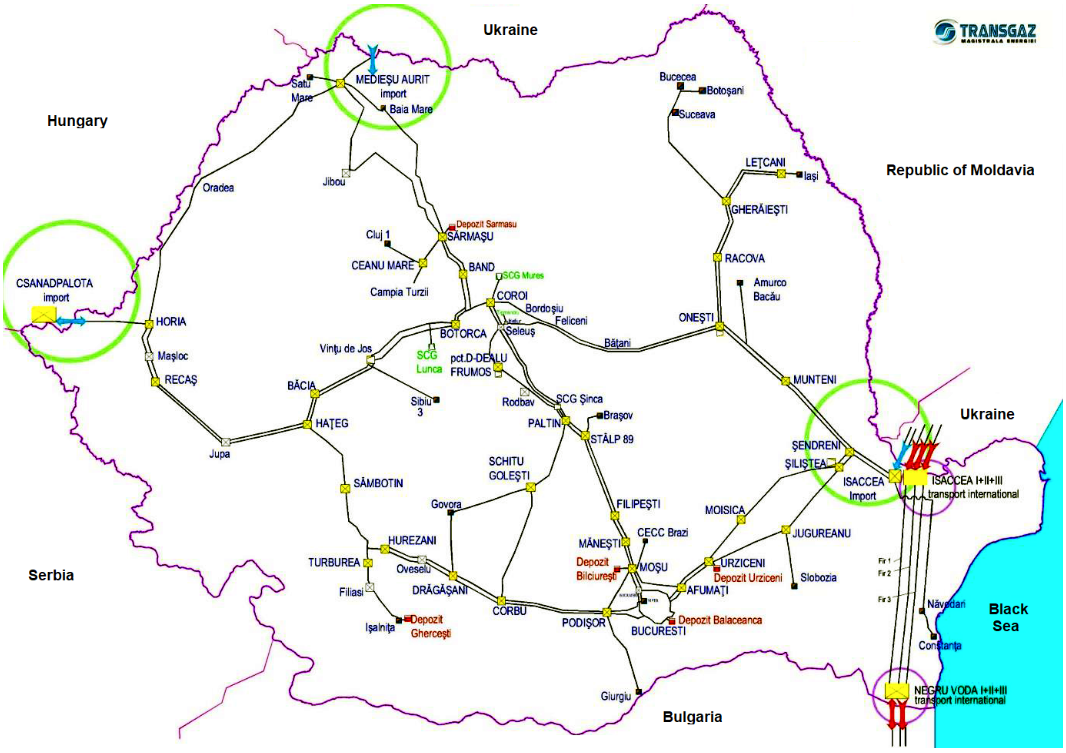

Figure 5. Map of the natural gas transmission network in Romania; Source [70] https://www.transgaz.ro/sites/default/files/uploads/users/admin/plan_de_dez_2017_-_2026.pdf.

Following the analysis of the data presented above, the transformation and synthesis of the values may be observed n showing Table 8.The analysis is necessary in order to come to the demographic areas of the country and the potential of accessing the different alternative sources of energy of the consumption of natural eyes, recommendations can be issued in order to be able to method us and the technologies, to take care to have the main objective population in ensuring comfort in households, implicitly the phenomenon of energy poverty.

Based on the synthesized information, correlated proposals can be made, depending on the values of population incomes from different areas of the country and the potential of energy sources (natural gas vs. alternative energy sources), regarding the opportunity to subsidize different technologies that allow access to the energy needed for the households comfort in different areas of Romania.

Considering the geographic profile of Romania, it can be observed, from the analysis of the previous data, that there are areas where access to transport and distribution networks, for natural gas to consumers is impossible or possible, but with very high costs.

By superimposing the map with the national network of natural gas transmission and distribution buses with the other maps with energy potential from other sources, largely renewable and environmentally friendly, policies can be issued correlated with the level of population incomes, at government level and ministerial, regarding the support of the population, in a sustainable way, by granting subsidies for the implementation of technologies, that allow the access to the sources of alternative energy, that fight the phenomenon of energy poverty.

In addition, where possible, it is preferable to replace the consumption of natural gas with green or renewable energy sources, which are more environmentally friendly, leading of course to reducing the greenhouse effect on the planet.

Table 8. Information on population incomes and energy potential in Romania.

Romanian's Counties	Net Income Lei* per Habitant	Sun Power kWh/m^2	Wind m/s	Geothermal T (°C)	Natural Gas
Alba	2023	1300	7		1131.06
Arad	2133	1370	5	80	137.06
Arges	2222	1320	5		265.89
Bacau	2047	1300	8		358.46
Bihor	1900	1290	7	85	220
Bistrita-Nasaud	1871	1250	9		501
Botosani	1921	1270	7		52.9
Braila	1840	1390	9		100.12
Brasov	2383	1300	8		912.22
Buzau	1890	1390	8		342.04
Calarasi	2013	1400	6		31.76
Caras-Severin	1912	1300	7		199.31
Cluj	2670	1290	3		533.83
Constanta	2126	1450	10		103.77
Covasna	1837	1290	5		159.76
Dambovita	1946	1370	4		1232.65
Dolj	2082	1400	5		171.9
Galati	2193	1410	8		137.51
Giurgiu	1895	1420	6		115.93
Gorj	2193	1300	3		891.04
Harghita	1791	1250	5		436.95
Hunedoara	1966	1220	5		555.65
Ialomita	1824	1390	8		106.52
Iasi	2278	1280	7		467.89
Ilfov	2913	1400	5	45	676.99
Maramures	1837	1190	4		692.66
Mehedinti	2161	1390	5		10.57
Mures	2128	1320	4		2733.31
Neamt	1883	1330	6		212.2
Olt	2148	1400	6		299.06
Prahova	2189	1370	4		1526.99
Salaj	1915	1300	5		252.44
Satu Mare	1936	1330	5	80	269.88
Sibiu	2468	1290	4		929.12
Suceava	1833	1240	6		183.89
Teleorman	1780	1400	4		21.28
Timis	2501	1340	5	75	234.37
Tulcea	1937	1400	9		33.74
Vaslui	1882	1380	8		91.52
Valcea	1870	1370	5		362.01
Vrancea	1890	1380	6		46

* 1 Euro = 4.85 Lei. Source [66] https://www.gfk.com/ro/noutati/comunicate-de-presa/puterea-de-cumparare-a-romanilor-a-crescut-in-2018-dar-odata-cu-ea-si-polarizarea-regionala.

For each county of the country, as shown in Table 9, alternative solutions for granting, subsidies are correlated with the incomes, in parallel and/or combined with the expansion of the natural gas transmission and distribution networks can be proposed to allow access easy for the population to source of energy.

Table 9. Proposals for subsidizing the technologies for obtaining the energy from various sources taking into account the area alternatives.

Romanian's Counties	Solutions for Improving Access to Energy/Combating Energy Poverty
Alba	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the force of the wind (wind energy) and sunshine (solar energy).
Arad	In addition to extend the natural gas distribution networks, subsidies may be granted for the installation of technologies that harness the force of the wind (wind energy), the heat of the ground water (geothermal energy), and the sun (solar energy).
Arges	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the sun (solar energy).
Bacau	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the force of the wind (wind energy).
Bihor	In addition to expand the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the heat of the water from the earth (geothermal energy).
Bistrita-Nasaud	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the force of the wind (wind energy).
Botosani	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the sun (solar energy).
Braila	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the force of the wind (wind energy).
Brasov	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the force of the wind (wind energy).
Buzău	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the sun (solar energy).
Calarasi	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the sun (solar energy).
Caras-Severin	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the force of the wind (wind energy).
Cluj	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the force of the wind (wind energy) and sunshine (solar energy).
Constanta	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the sun (solar energy) and wind power (wind energy).
Covasna	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the force of the wind (wind energy).
Dambovita	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the sun (solar energy).

Table 9. *Cont.*

Romanian's Counties	**Solutions for Improving Access to Energy/Combating Energy Poverty**
Dolj	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the sun (solar energy).
Galati	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the force of the wind (wind energy).
Giurgiu	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the sun (solar energy).
Gorj	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the force of the wind (wind energy).
Harghita	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the force of the wind (wind energy).
Hunedoara	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the force of the wind (wind energy).
Ialomita	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the sun (solar energy) and wind power (wind energy).
Iasi	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the sun (solar energy).
Ilfov	In addition to expand the natural gas distribution networks, subsidies can be awarded for the installation of technologies that harness the heat of the water from the earth (geothermal energy) and solar (solar energy).
Maramures	In addition to expand the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the heat of the water from the earth (geothermal energy).
Mehedinti	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the force of the wind (wind energy).
Mures	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the force of the wind (wind energy) and sunshine (solar energy).
Neamt	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the force of the wind (wind energy).
Olt	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the sun (solar energy).
Prahova	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the sun (solar energy).
Salaj	In addition to expand the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the heat of the water from the earth (geothermal energy).

Table 9. *Cont.*

Romanian's Counties	Solutions for Improving Access to Energy/Combating Energy Poverty
Satu mare	In addition to expand the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the heat of the water from the earth (geothermal energy).
Sibiu	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the sun (solar energy) and wind power (wind energy).
Suceava	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the sun (solar energy).
Teleorman	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the sun (solar energy).
Timis	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the heat of the water from the earth (geothermal energy), and sunshine (solar energy).
Tulcea	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the sun (solar energy) and wind power (wind energy).
Vaslui	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the force of the wind (wind energy).
Valcea	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the sun (solar energy).
Vrancea	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the force of the wind (wind energy).

Considering the above figure (Figure 6), it may be noticed that a very large number of wind projects-so the areas suitable for subsidizing this type of renewable energy-are found in Dobrogea, Moldova and Transylvania. In addition, photovoltaic projects are also a good alternative in areas where they can be installed, especially the southern areas of the country such as Danube Delta, Dobrogea and Romanian Plain. Renewable alternatives for geothermal projects can be found in Western Plain and Panonian Depression (Banat and Western Apuseni Mountains) and Romanian Plain, respectively Ilfov.

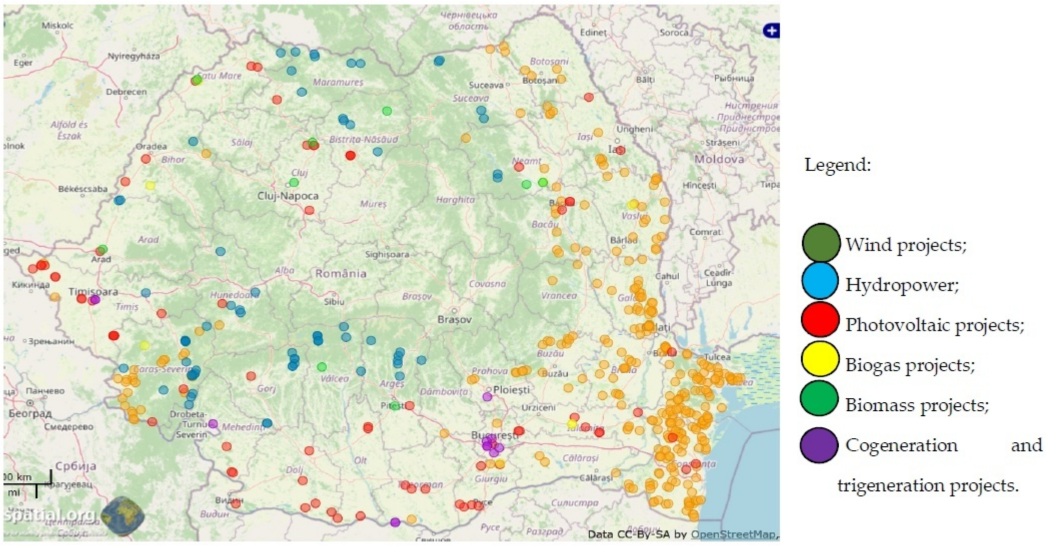

Figure 6. Interactive map of Romania's renewable energy projects; Source [67] https://www.fabricadecercetare.ro/regenerabil/.

The use of renewable energy sources-and the transition to the green economy-implies not only broad structural, institutional, technological, social, economic changes targeting the energy sector, transport, housing stock, equipment used by the population and companies in different fields, but also the behavior of consumers who must become more responsible in use of energy [68–77]. Modern societies must move towards an inclusive energy transition path that is achieved, on one hand, by reducing energy poverty, and on the other hand by controlling the impact of energy production and consumption on the environment through carbon emission [78–81].

7. Conclusions

Energy poverty is a dynamic and complex phenomenon with peculiarities depending on geographic location and level of development of each country. Energy poverty is generated by a combination of factors, namely low household incomes, high energy prices and poor access to the energy system for reasons other than lack of money and housing-specific energy shortages. Therefore, the financial situation of consumers, energy quality of the housing environment and the existence of a deficient energy system generate this phenomenon that occurs in both developed and developing countries, both in cold and warm areas.

Energy poverty is a multifaceted phenomenon because it affects different categories of people, involving numerous factors that generate consumer vulnerability. The heating and lighting needs of people-and the need for energy to power various appliances-are generated by the structure of households (the existence of several generations-the elderly and children with different needs), the state of health that could induce special requirements to ensure a certain temperature in the home or the professional status of household members (employees working from home, unemployed).

Solutions to solve this problem must be adapted to the specifics of each category of vulnerable consumers (urban or rural), and require the involvement of many categories of stakeholders such as local communities, NGOs, banks that must have adapted credit offers, public institutions which provides the legal framework, but also possible subsidies to encourage the production and use of renewable energy. As society develops, we will probably witness a paradigm shift in the sense of promoting and using the concept of well-being energy, so as to take into account not only the degree of satisfaction of needs, but also efficiency energy use.

Until such time as aggregate models or indicators will be able to sufficiently take all levels, dynamics and structure of energy poverty into account, we believe that an approach adapted to local specificities is necessary. For example, the same model of energy poverty and fuel poverty cannot be applied to a highly developed urban community in Europe, and at the same time, to a rural community in developing country, where households use woody biomass for heating and are often illegally connected to the electricity grid. Both in the effort to assess energy poverty and in trying to find solutions to these issues, a regional or local approach is needed that includes a series of indicators (in turn difficult to record and analyze) with reference to the cultural model, habits consumption, real incomes of households (not just declared or registered). Concerning the fight against energy poverty, on one hand, macro-solutions (i.e., the strategic approach, highlighted by the government policies to increase the level of energy independence by accessing and exploiting all available resources, obviously in environmentally friendly conditions) were highlighted. On the other hand, the micro-solutions (which focus on identifying vulnerable consumers and target their specific needs through joint efforts of local governments, civil society and economic agents) were also explored.

According to the results of the pairwise Ganger causality test, causality relations were found between pairs of variables. A causality circuit appeared: GDP Granger-caused electricity prices for households, electricity prices for households Granger-caused arrears on utility bills, arrears on utility bills Granger-caused GDP.

Taking into account the above, in the case study in Section 6-based on the synthesized information-proposals were made to access different sources of alternative energy. These were made in correlation with the population's income levels in the different areas of the country-and the potential of energy resources (natural gas vs. alternative energy sources), in terms of the opportunity to subsidize various technologies that allow access to the energy needed for the comfort of households in different areas of Romania. In these cases of accessing alternative energy sources (wind, sun, geothermal, etc.), even if the initial material efforts are high, the results are remarkable:

➢ Increasing the quality of life by reducing the effects of the energy poverty phenomenon;
➢ Protecting the environment by reducing the effects of the use of polluting resources.

In conclusion, this case study, through the proposed solutions, brings a plus for the social framework and also for the environment.

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