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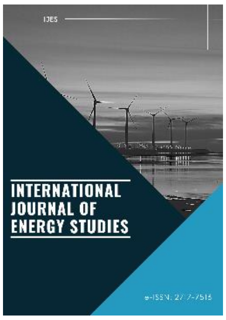

Research Article

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Should the European Union prioritize renewble energy or tackle energy poverty?

Yagmur Saglam[a*], Mehmet Samet Erdem[b]

[a]Sinop University,Boyabat Faculty of Economics and Administrative Sciences, Department of Real Estate Development and Management Sinop, Türkiye, ORCID: 0000-0001-6465-0297

[b]Sinop University, Boyabat Faculty of Economics and Administrative Sciences, Department of Healthcare Management,, Sinop, Türkiye, ORCID: 0000-0001-7344-2166

*(*Corresponding Author: yagmur.saglam@sinop.edu.tr)*

Highlights

- The impact of renewable energy consumption on energy poverty in the European Union from 1996 to 2020 was examined.
- A control variable has been created through the use of Principal Component Analysis (PCA) in order to adjust for variations in economic development.
- Second-generation panel data tests and the Common Correlated Effects Model were used both for the short and long-term effects.
- Renewable energy consumption had both positive effects in developed countries and negative effects in transition economies.
- Energy poverty is a key priority in Europe's energy policies, emphasizing the need to provide affordable and sustainable energy sources to underprivileged communities.

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ABSTRACT

Energy poverty is a type of poverty that is not solely based on monetary factors. It has recently been highlighted in the literature alongside the acknowledgment of energy as a key component of sustainable economic growth. Many studies focus on replacing fossil fuels with renewable energy sources to address this issue. This study aims to analyze the impact of renewable energy consumption on energy poverty in the European Union from 1996 to 2020. The study incorporates a control variable, developed using Principal Component Analysis (PCA), to account for economic development. Second-generation panel data tests and the Common Correlated Effects Model are utilized to assess the short and long-term effects. The findings indicate that the control variable had no significant impact on energy poverty during the relevant period. Still, renewable energy consumption had both positive effects in developed countries and negative effects in transition economies. According to the results, energy poverty measures remain a key priority in most of Europe's energy policies. This highlights the significance of ensuring that the underprivileged section of society has access to affordable and sustainable energy sources.

Keywords: Economic development, Panel data analysis, Renewable energy

1. INTRODUCTION

Sustainable development has become a crucial concept in energy studies in recent years. The accessibility and affordability of energy consumption, the efficiency of energy resources, and energy production are the key indicators used to test energy economics. Sustainability refers to the environmentally friendly way of utilizing energy resources, also known as renewable energy.

The majority of the world's demand for energy is fulfilled by fuels, such as oil and coal. However, these fuels significantly negatively impact the environment, with global warming being one of the major concerns. As a result, researchers have started exploring alternative sources of energy, such as wind, wave, biomass, geothermal, and hydroelectric power, to replace or supplement traditional fuels. Renewable energy sources have been found to promote economic growth, reduce environmental concerns, ensure energy security, provide foreign currency savings to countries, and improve socioeconomic factors, reduce current account deficits [19].

Renewable energy consumption and production play a vital role in supporting sustainable development and reducing the volatility in the economy. A stable economy is one with an acceptable level of change in economic indicators, free from uncertainties. Thus, any economic shock, such as an energy-induced shock, fluctuation, or crisis, can disrupt the balance in the economy, leading to instability. It is crucial to note that using clean and sustainable alternative energy resources can significantly contribute to reducing possible imbalances in economic indicators [18].

Economic development has been a research subject for many years, focusing on sustainability. This research dates back to Solow's study in 1956, which examined some determinants of micro and macroeconomics, such as inflation, income, labor, capital, and trade. Since then, other factors have been added to the discussion, including education, income, energy poverty, carbon emissions, taxes, foreign direct investment, industrialization, and urbanization. Researchers such as [1], [27] and [43] have expanded their research in this area.

Energy is the primary source of development for humanity, and poverty cannot be separated from it. The consequences of poverty are multidimensional, but in this paper, we focus on energy poverty and its macroeconomic effects. In 2010, the World Economic Forum defined energy poverty as ‘’the lack of access to sustainable modern energy products and services’’. In some cases, it is referred to as fuel poverty. The European Fuel Poverty and Energy Efficiency study defines it as ‘’the inability to keep the home adequately warm at an affordable cost’’.

Sometimes, the phrases ‘’energy poverty’’ and ‘’fuel poverty’’ are used interchangeably. However, Robic, Olshanskayab, Vrbenskyb and Morvajb [39], have defined basic energy services as household lighting, cooking, and heating. Affordability, in this context, refers to the share of utility payments in total household expenditure. In their study on Tajikistan, Robic and his colleagues they had to make certain statements because there is no universally accepted definition of energy poverty or methodology or techniques to provide certain answers. This is because some lifestyles, such as the Amish or the Masaii, refuse modern energy. Moreover, in some parts of the world, there are no cold periods, and it can also be challenging to calculate the affordability of energy when it comes from remittances or informal ways.

The focus of this study is to examine the relationship between energy poverty and the use of renewable energy, which has not been tested extensively in the literature. The model hypothesizes that "the decrease in the use of renewable energy sources is closely linked to energy poverty", as stated by Selçuk, Gölçek and Köktaş [45].

To test the hypothesis, we have selected Europe as the area of focus for the period between 1996 and 2020. This is because there are high levels of energy poverty in certain parts of Europe, such as East-Central Europe and Southern Europe, as noted by Rademaekers, Yearwood, Ferreira, Pye, Hamilton, Agnolucci and Anisimova [37]. This study aims to investigate whether renewable energy within domestic households can be used as a policy to combat energy poverty.

The study is divided into several sections. The introduction discusses the relationship between economic (sustainable) development and energy sources. In the following section, the importance of addressing energy poverty in Europe is explained. The section dedicated to current empirical literature examines previous studies on energy poverty and renewable energy, summarizing and grouping them. The methodology and empirical findings are presented in the panel data analysis section. Finally, the policy recommendations are evaluated based on empirical findings in the conclusion.

2. ENERGY POVERTY AND RENEWABLE ENERGY IN EUROPE

Most of the studies on developed nations in Europe have been conducted due to poor conditions for fossil fuel production, except for the United Kingdom and Norway. European countries, facing a high energy demand, are dependent on the import of natural gas and oil from countries with major reserves such as the United Arab Emirates, Qatar, Azerbaijan, and Kazakhstan. Russia was also a major supplier, but the imports stopped after the war. This is the reason why households in European countries either pay high fees for energy transportation or cannot meet their energy demands [25].

In light of recent events such as the COVID-19 pandemic and the Russian-Ukrainian war, it is important to consider increasing the use of renewable energy sources as a Following the Ukraine-Russia conflict, the cost of energy bills has significantly increased due to a limited supply of fossil fuels. This trend is expected to continue due to political uncertainty and the shift towards clean energy sources. According to Simionescu, Radulescu, Cifuentes-Faura and Balsalobre-Lorente [47], these factors have contributed to the rise in energy costs. Non-renewable resources like oil and gas are limited to a few nations, and political and economic crises in those regions can have a significant impact on the global energy supply. Therefore, countries should rely more on domestic renewable energy sources to reduce their dependence on imported energy. This will not only decrease energy poverty but also help to eliminate it as a global issue [25]. The government of the European Union has the necessary legislative solutions to address both the goals of carbon neutrality and sustainable development. One of the crucial issues that require attention is reducing energy poverty. This can be achieved through various measures such as energy price regulations, social tariffs, tax exemptions, social transfers to vulnerable communities, subsidies for renewable and affordable energy sources, and improving energy efficiency by renovating buildings. According to Heffron and McCauley [20], these measures can help alleviate the problem of energy poverty in the EU.

According to a report by the EPEE Consortium in 2023, indicators of fuel or energy poverty include poor living conditions, homes with low energy, disconnection from energy supply, inability to pay energy bills, and health impacts such as diseases. Energy poverty is a multiple form of poverty. Between 50 and 125 million people in Europe are estimated to be fuel-poor, leading to significant political and social consequences across Europe. The EU-SILC (European Union Statistics on Income and Living Conditions) data, coordinated by EUROSTAT, provides valuable comparative information on the prevalence of fuel poverty in Member States, both objective and subjective.

The EU Commission published a report in 2023, ‘’The Recommendation and Staff Working Document", which highlights that energy poverty has been a long-standing issue in the EU. The rising energy prices and cost of living have made millions of consumers vulnerable, making it essential to address the root causes of energy poverty. The EU must move beyond crisis response measures and adopt long-term, sustainable solutions. The recommendations focus on structural measures such as ensuring access to energy-efficient housing and appliances, as well as promoting the use of renewable energy sources. These measures will not only help tackle energy poverty but also drive Europe's clean energy transition.

In energy economics, it is accepted that renewable energy increases economic growth. Because it creates new employment areas and reduces environmental concerns, it has a more competitive structure than fossil fuels and has a crucial role in sustainable development. Renewable energy is more efficient and contributes current account deficit by providing foreign currencies. It has a positive impact on socio-economic and macroeconomic indicators.

However, in the world, clean, inexhaustible energy sources are only limited per unit of time called renewable energy by the International Energy Agency (IEA) in 2017 and so far meets the global demand for energy by only 20 % [22]. Renewable Energy Policy Network for the 21st Century (2018) is a promising interest and awareness raising among policymakers, and Europe has always been a pioneer in implementing clean energy policies [17].

3. LITERATURE REVIEW

As an extensive research subject, the relationship between renewable energy consumption and economic growth has been widely studied in the field. Table 1 briefly represents the studies about the EU in tackling energy or fuel poverty. The literature will hold studies all around the world not only about energy poverty but also renewable energy to be able to fully understand the link between and to make a decision for the EU.

Table 1. Empirical energy poverty studies in Europe

Countries	**Authors**	**Variables**	**Methodology**	**Results**
Spain	Scarpellini et al. (2019), [44]	Social and economic impacts of energy poverty on the population	Holistic analysis and surveys, mid-2012-mid 2017	Multiple factors play different roles in determining the levels of energy poverty
England (UK)	Burlinson et al. (2021), [8]	Energy poverty and financial distress of households	Panel data analysis (fixed effects) January 2018 - May 2020	They found positive results.
Italy	Delugas and Brau (2021), [12]	Well-being and energy poverty	Multidimensional energy poverty index (MEPI model)	The effect of subjective indicators is low and the impact of objective indicators is even lower.
France	Chaton and Gouraud (2020), [9]	Fuel poverty and household resources, energy prices, dwelling quality, energy expenditures, thermal renovations, disposable income.	%10 approach 2012-2014.	Fuel poverty of households in France is. %10.4.
Lithuania	Streimikiene (2022), [49]	Energy poverty and population, energy prices, Covid-19 (impacts of pandemics).	VAT analysis from 2017 to 2020.	Energy prices increased after Covid-19 so the negative impacts of the pandemic on energy

				poverty were seen.
Greece	Spiliotis (2020), [48]	Energy and income, their combination in the energy poverty index	A real-life case study, %10 and LICH approach 1981-2010.	energy poverty is a multi-dimensional problem that contains household income, dwelling particularities, and weather conditions.
Netherlands	Dalla Longa et al. (2021), [10]	Energy expenditure and population, average house value, average household size, the share of rented houses, and the share of houses built after 2000.	Machine Learning (ML model), 2013-2018.	ML is an effective tool to tackle energy poverty.

Source: Compiled by the authors.

Table 2 presents the results of causality tests conducted on various studies that focus on the importance of renewable energies to the economic conditions of European countries. Along with the literature summary table, this section also includes several studies conducted on this topic.

Table 2. Literature review on causality between economic growth and renewable energy consumption in Europe

Year	**Author(s)**	**Countries and Period**	**Methodology**	**Data**	**Results**	**Hypothesis**
2010	Tsani, [51]	Greece 1960-2006	Todo and Yamamoto	World Bank	EC → GDP	Growth Hypothesis

				WDI, IEA	RS and IS↔ GDP	Feedback Hypothesis
2016	Alper and Oguz, [4]	Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Poland, Romania, and Slovenia 1990-2009	Asymmetric Causality Test Approach of Hatemi-J	World Bank WDI	REC ≠ EG Cyprus, Estonia, Hungary, Poland and Slovenia EG → REC Czech Republic REC → EG Bulgaria	Neutrality Hypothesis Conservation Hypothesis Growth Hypothesis
2018	Saad and Taleb, [40]	12 European Countries 1990-2014	Granger Causality	World Bank, United Nations Division and Eurostat Database	EG→ REC (SR) EG↔ REC (LR)	Conservation Hypothesis Feedback Hypothesis
2019	Saint Akadiri et al. [42]	28 European Union Countries 1995-2015	Granger Causality	World Bank Database	REC↔EG	Feedback Hypothesis
2020	Piłatowska, Geise and Włodarczyk, [36]	Spain 1970–2018	Granger Causality	BP Energy Outlook 2019	NEC ↔ EG REC → EG	Feedback Hypothesis Growth Hypothesis

2021	Asiedu, Hassan and Bein, [7]	26 European Countries 1990-2018	Granger Causality	World Bank Database	EG↔REC REC→ NREC REC→ CO^2	Feedback Hypothesis
2021	Pehlivanoglu, Kocbulut, Akdag and Alola, [32]	21 European Union Countries 1995-2016	Panel Causality Test	Eurostat	EG ↔EE EG ↔EI EG ↔REC	Feedback Hypothesis

→: Unidirectional causality between variables, ↔: Bidirectional causality between variables, **≠:** No causality between variables, **GDP**: Gross Domestic Product **EG:** Economic Growth, **EC**: Energy Consumption, **REC**: Renewable Energy Consumption, **NREC**: Non-Renewable Energy Consumption **NEC**: Nuclear Energy Consumption, **SR**: Short Run, **LR:** Long Run, , **EE**: Energy Efficiency, **EI**: Energy Intensity, **IS**: Industrial Sector, **RS**: Residential Sector, **CO^2**: CO^2 Emission, **WDI**: World Development Indicators, **IEA**: International Energy Agency. Source: Compiled by the authors.

Sadorsky [41], examined the relationship between per capita renewable energy consumption and real per capita income for a panel of emerging economies using a panel cointegration test. The test showed a statistically significant positive relationship between the two variables.

In a study conducted by Apergis and Danuletiu [6], 80 countries were analyzed using the Canning and Pedroni (2008) long-run causality test for the period of 1990-2012. The results of the study showed that renewable energy plays a crucial role in promoting economic growth. Additionally, economic growth was found to encourage the utilization of more renewable energy sources.

Inglesi-Lotz [23], conducted a study on the impact of renewable energy consumption on economic welfare in 34 OECD countries from 1990 to 2010 using panel data. The study found that the consumption of renewable energy has a positive and statistically significant impact on economic growth. This result is consistent with Sadorsky [41].

Ahmed and Shimada [2], conducted a study on the relationship between renewable energy consumption and sustainable economic development in emerging and developing countries. They used panel data from the period of 1994-2014. The study found that there is a significant long-term correlation between renewable energy consumption and economic growth in selected South Asian, Asian, and most African countries. However, the economic growth of Latin American and Caribbean countries depends on non-renewable energy consumption.

In a study conducted by Sharma, Tiwari, Erkut and Mundi [46], the researchers investigated the relationship between economic growth and sustainability indicators in 27 European Union countries from 1990-2016. The indicators used were renewable energy consumption, non-renewable energy consumption, urban population, human development index, financial development index, ecological footprints, and carbon emissions. The researchers used three different models - Arellano-Bond dynamic panel data estimation, system dynamic panel data estimation, and Augmented Mean Group model - to analyze the data. The results showed a two-way negative relationship between economic growth and renewable energy consumption and a two-way positive relationship between economic growth and non-renewable energy consumption. This means that an increase in renewable energy consumption could negatively impact economic growth.

Wang, Dong, Li and Wang [54], conducted a study to explore the relationship between renewable energy consumption and economic growth in OECD countries from 1997 to 2015 using panel data. The results suggest that the positive impact of renewable energy consumption on economic growth is conditional. In general, renewable energy consumption has a positive impact on economic development.

4. METHODOLOGY AND DATA

Four related energy studies inspired both the written function and model [5], [11], [47], [18],

$$EP = f(REC, EDI) \quad (1)$$

$$EP_{it} = \alpha + \beta REC_{it} + \theta EDI_{it} + u_{it} \quad (2)$$

Energy poverty is a result of the interplay between renewable energy and economic development (1) – (2). The reduction in the usage of renewable energy sources is closely associated with energy poverty, which negatively impacts economic development. In this equation, "i" stands for the unit, and "t" represents the time dimension. The error term, denoted by "uit", is defined as individual country effects that only change across units. The constant coefficient is represented by "α", whereas "β" and "θ" indicate the slope coefficients.

Principal Component Analysis (PCA) was used by the authors to create the Economic Development Index (EDI) using four different macroeconomic indicators (GDP per capita %, FDI net inflows %, Unemployment ILO estimations %, and Inflation rate %). Principal Component Analysis (PCA) is a widely used multivariate analysis technique that was developed by Pearson in 1901, and later improved by Hotelling [21] and Jolliffe [26]. Its purpose is to reduce the number of dimensions in a multivariate dataset while preserving the relevant information structure. PCA is a linear function of the original variables, transforming independent and sequential variables into a new dataset. This transformation is linear, and since the basic components are independent of each other, there is no multicollinearity problem or inter-variable dependency issue. PCA is not only an analysis technique in itself, but also used as a method for eliminating the dependency structure between variables and for dimension reduction, which is a crucial step in data preparation.

The explanatory variable REC, with the control variable EDI, predicts Energy Poverty (EP). All data from 27 EU countries between 1996 and 2020 is collected from the World Bank Development Indicators Data Bank. Luxembourg is excluded due to data constraints and previous years are unavailable.

According to economic theory:

1. Foreign Direct Investment (FDI) is a type of investment where multinational companies invest in other countries. It is considered to be an important factor in the development of economies. FDI brings capital, technology, and knowledge to the host countries, which in turn promotes economic growth, creates wealth, and reduces energy poverty [52].
2. Energy poverty can be measured by a lack of access to electricity or an inability to pay energy bills.
3. Income (GDP per capita) plays a key role in fighting energy poverty and pollution. It is expected to reduce energy poverty [29].
4. Renewable energy (as a proxy for renewable energy consumption - REC) may reduce energy poverty but in some studies due to the lack of access, renewable energy consumption has no significant impact on energy poverty.

5. Unemployment leads to loss of income and difficulty meeting basic needs, resulting in lower living standards. possible to maintain energy needs [53].

In 2008, a test was conducted to check the homogeneity of series in the regions of Peseran and Yamagata. The null hypothesis of this test assumes that the series are homogeneous. If the null hypothesis is rejected, it means that the series are heterogeneous. Table 1 below (*) shows the significance of probability at a 5% level. The symbol △ represents small samples, while Δ_adj represents big samples. As per the results, the null hypothesis has been accepted, indicating that the variables are homogeneous.

Table 3. Slope homogeneity test

Delta Test	***Test Statistics***	***Probability***
$\hat{\Delta}$	-0.353	0.638
$\hat{\Delta}_{adj}$	-0.376	0.646

Cross-sectional dependence of the all units discussed with CDlm test. The null hypothesis assumes that no cross-section dependence exists, and significance levels are marked by (*) at the 5% level. However, according to Table 2, the null hypothesis has been rejected for all models, indicating that there is indeed a cross-section dependency present.

Table 4. Cross-section dependence test results for the model

CD Test	***Test Statistics***	***Probability***
LM (Breusch, Pagan 1980)	643.605	0.000*
CD LM 1 (Pesaran 2004)	11.044	0.000*
CD LM 2 (Pesaran2004)	5.770	0.000*
Bias-adjusted CD (Pesaran et all. 2008)	-1.597	0.945

A unit root test was developed by Enders and Lee in 2004 [14], to model for the panel, and it has been improved over time by others. The purpose of this test is to assume that structural breaks may occur with unpredictable frequency and structural form. They aim to change the a priori prediction that "series are subject to at most one or two structural breaks in level or trend," which is accepted in the existing unit root literature. The method they used is called the Fourier approximation or function, which transformed the process into selecting the appropriate frequency component to estimate the model rather than selecting specific fracture dates or fracture forms. Frequency values (single frequency) were chosen as k=1,2,3. In the application part, the Gauss code written by Karul [28], was adapted to this study by the writers to check the effect of unknown forms and nonlinear deterministic terms on the existence of the unit root.

Table 5. Co-integration Test Results

		t-statistics	Boostrap Prob.
g_τ	Group mean	-4.359	0.031*
g_α	Group mean	-4.754	0.015*
p_τ	Panel	-3.328	0.063*
p_α	Panel	-6.709	0.008*

The Error Correction Mechanism (ECM) co-integration test is a statistical method used to determine if there is a long-term relationship between variables. The test analyzes the relationship between time and cross-sectional units and is reliable in providing accurate results. Westerlund (2007), the null hypothesis states that there is no co-integration between the variables. Table 5, proves that there is a co-integrated relationship between cross-sectional units, the null hypothesis is rejected.

Table 6. Fourier KPSS unit root test results

Variables	***Panel FKPSS (k=1)***	***Probability (k =1)***	***Panel FKPSS (k= 2)***	***Probability (k= 2)***	***Panel FKPSS (k= 3)***	***Probability (k =3)***
EP	7.1359	0.0000*	3.3909	0.0003*	3.5102	0.0002*
REC	16.4487	0.000*	5.8972	0.0000*	4.6639	0.0000*
EDI	7.1057	0.0000*	5.9642	0.0000*	6.3204	0.0000*

The text describes the results of conducting Panel Fourier KPSS tests on both constant and trend values. The panel test statistics were obtained using the Bartlett Kernel rule as per Kurozumi [30]. The probability values (p) were calculated based on a normal distribution. As per Table 6, the null hypothesis that there is no unit root has been rejected. This indicates that for the EU-27 countries, there is a unit root even with gradual structural breaks, and the variables are I(1).

To draw an economic conclusion for both individual countries and the entire balanced panel in the short and long term, the preferred method was the Common Effects Model (CCE). The coefficient was estimated, and CCE pool group estimators were reported due to the homogeneity of the variables and cross-sectional dependence [35].

Table 7. Pool group estimations of CCE test

Dependent Variable: EP	Coefficients	SE (NP)	T(NP)	SE (NW)	T(NW)
REC	0.00000	0.00000	0.014909	0.00000	1.127669
EDI	-0.00000	0.00000	-0.01610	0.00000	-1.70201

Significance of Standard Error (SE) and Newey West (NW) type test statistics are based on (N x T= 27 x 25 for bias: 0.02, RMSE: 2.75, size: 5.25, power: 45.30) table 2A of Pesaran (2006) [35], at page 995, and for small samples. According to Table 4, short-term consumption of renewable energy does not impact energy poverty and negatively affects economic development. However, the coefficients are not comparable, as they are calculated as minus zero.

Table 8. Country specific long term coefficient estimations of CCE model

EU Countries	*REC*	*Se (NW)*	*EDI*	*Se (NW)*	*T (time)*	*N*
Deutschland	112.020	383.577	-0.000	0.000	1996-2020	25
Italy	1236.732	42754.02	-0.000	0.000	1996-2020	25
France	9.634	1.015	0.000	0.000	1996-2020	25
Spain	-1.240	0.781	0.000	0.000	1996-2020	25
Portugal	0.261	0.105	-0.000	0.000	1996-2020	25
Sweden	-0.963	0.200	0.000	0.000	1996-2020	25
Belgium	-54.185	2.282	-0.000	0.000	1996-2020	25
Austria	9.449	1.627	0.000	0.000	1996-2020	25
Denmark	373.010	2072.418	-0.000	0.000	1996-2020	25
Ireland	4.660	0.000	-0.000	0.000	1996-2020	25
United Kingdom	3.271	0.533	0.000	0.000	1996-2020	25
Netherlands	-2.508	0.176	0.000	0.000	1996-2020	25
Finland	76.034	447.082	-0.000	0.000	1996-2020	25
Estonia	-9.169	4.612	-0.000	0.000	1996-2020	25
Czech Republic	-11.467	3.585	0.000	0.000	1996-2020	25

Lithuania	-15.995	7.736	0.000	0.000	1996-2020	25
Slovak Republic	-7.211	0.000	0.000	0.000	1996-2020	25
Slovenia	32.744	83.863	0.000	0.000	1996-2020	25
Latvia	-0.049	0.012	-0.000	0.000	1996-2020	25
Malta	-11.198	4.804	0.000	0.000	1996-2020	25
Poland	-0.331	0.132	-0.000	0.000	1996-2020	25
Switzerland	1.135	0.139	0.000	0.000	1996-2020	25
Bulgaria	-30.046	3.821	-0.000	0.000	1996-2020	25
Hungary	-13.273	9.041	-0.000	0.000	1996-2020	25
Cyprus	1.657	0.000	-0.000	0.000	1996-2020	25
Romania	7.822	3.535	0.000	0.000	1996-2020	25
Croatia	3.527	2.110	-0.000	0.000	1996-2020	25

To analyze the relationship between variables for each country, the table includes coefficient estimates, standard errors (SE), and Newey West (NW) type test statistics. The interpretation of the findings in the table will be discussed in the conclusion section to ensure statistical and economic integrity.

5. RESULTS AND DISCUSSION

In the last few decades, issues related to energy poverty and the environment have become increasingly significant. This has prompted researchers to explore potential solutions, such as renewable energy sources and their potential impact on a country's economic stability and development. The European Union (EU) is a prime example of analyzing these dynamics, as it has been a leader in implementing various energy policies aimed at combating energy poverty. Over the years, the EU has made substantial investments in this area. The results of our study align with Wang et al.[56] and contradict with Aldieri, Gatto and Vinci [3].

According to our dynamic panel data analysis, there are several countries where the consumption of renewable energy has negative effects. These countries include Spain, Hungary, Bulgaria, Latvia, Poland, Malta, Estonia, the Czech Republic, Lithuania, the Slovak Republic, Sweden, Belgium, and the Netherlands. According to the literature and our expectations, post-socialist economies are particularly vulnerable to energy poverty, which makes it difficult for them to access renewable energy sources due to insufficient capacity and high energy bills. However, Spain, Sweden, Belgium, and especially the Netherlands were surprised by the negative impacts of energy poverty. Among these countries, Belgium (-54.185) was the biggest contributor to energy poverty during the relevant period.

The following countries; Deutschland, Italy, France, Portugal, Austria, Denmark, Ireland, the United Kingdom (which was a member of the EU until 2020), Finland, Slovenia, Switzerland, Cyprus, Romania, and Croatia, all have positive coefficients which indicate that they were able to access renewable energy resources and technology during a specific period. These are mostly developed economies within the EU. Access to renewable energy resources can help combat energy poverty in these countries. Italy, Denmark, Deutschland, Finland, and Slovenia have made the highest contributions towards this effort. Slovenia, being a post-socialist country, has successfully implemented energy policies to reach alternative energy sources.

6. CONCLUSION

It is important to note that the Economic Development Index (EDI) has both positive and negative effects on energy poverty. It cannot be assumed that economic development automatically reduces energy poverty because the coefficients of the EDI were obtained as zero. This means that it is not possible to draw any economic interpretations from the results. This finding is significant because it challenges previous claims that suggest a direct relationship between economic development and energy poverty. Renewable energy is not only an efficient policy tool from an environmental perspective but also a solution for energy poverty for policymakers.

Our research is in line with Selçuk, Gölkçek, and Göktaş (2019), who argue that renewable energy sources are linked to energy poverty. It also aligns with Alper and Oğuz (2016), who propose a neutrality hypothesis between renewable energy and economic growth. Our study's findings are consistent with those of Spiliotis (2020) and Streimikiene (2022). However, our empirical search has yielded contradictory results to those of Saad and Taleb (2018), Saint Akadiri et al. (2019), and Asiedu, Hassan, and Bein (2021), who support the feedback hypothesis in various European countries.

Our study revealed that most of the post-socialist and some developed EU economies may invest in renewable energy sources to tackle energy poverty but policymakers should prioritize reducing bill prices or enabling people to access any energy source. The EPEE (European Fuel Poverty and

Energy Efficiency) Consortium has published guidelines for policymakers to address fuel energy poverty in Europe. These guidelines are based on the "Intelligent Energy for Europe" project, which was the winner in five European countries including Spain, Belgium, Italy, Spain, and the United Kingdom in 2011. The guidelines should be used as a directive for addressing fuel energy poverty in Europe.

NOMENCLATURE

CCE: Common Effects Model

CO_2: CO_2 Emission

EC: Energy Consumption

EDI: Economic Development Index

EE: Energy Efficiency

EG: Economic Growth

EI: Energy Intensity

EPEE: The European Fuel Poverty and Energy Efficiency

EU: The European Union

EUROSTAT: The Statistical Office of The European Union

EU-SILC: European Union Statistics on Income and Living Conditions

FDI: Foreign Direct Investment

GDP: Gross Domestic Product

IEA: International Energy Agency.

IEA: International Energy Association

IS: Industrial Sector

LR: Long Run

NEC: Nuclear Energy Consumption

NREC: Non-Renewable Energy Consumption

NW: Newey West

PCA: Principal Component Analysis

REC: Renewable Energy Consumption

RS: Residential Sector

SE: Standard Error

SR: Short Run

WDI: World Development Indicators

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DECLARATION OF ETHICAL STANDARDS

The authors of the paper submitted declare that nothing which is necessary for achieving the paper requires ethical committee and/or legal-special permissions.

CONTRIBUTION OF THE AUTHORS

Yagmur Saglam: Design of the article, Hypothesize of the article, implementation of the analysis; and interpretation of the results.

Mehmet Samet Erdem: Writing the introduction, empirical literature part and the references of the article, following the spelling rules of the journal.

CONFLICT OF INTEREST

There is no conflict of interest in this study.

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