Abstract: The primary objective of this research was to determine the impact of renewable energy, alternative and nuclear energy, urbanization, energy use, and fossil fuel energy consumption on Romanian economic development. To investigate the relation between variables, we employed the Autoregressive Distributed Lag (ARDL) technique in conjunction with FMOLS (Fully Modified Least Squares) and CCR (Canonical Cointegrating Regression). Long-run and short-run findings suggest that alternative and nuclear energy, as well as fossil fuel consumption, has a positive association with economic growth, but renewable energy, urbanization, and energy usage have an adversative relationship with economic growth. Similarly, FMOLS and CCR statistics indicate that alternative and nuclear energy and fossil fuel consumption have a favorable impact on economic development. Renewable energy consumption, urbanization, and energy use, on the other hand, revealed a negative connection with economic progress. Conservative solutions are necessary to implement appropriate policies to address energy consumption concerns in Romania in order to improve economic development.

Keywords: renewable energy; urbanization; environmental sustainability; energy consumption; economic development

1. Introduction

The farming, energy, and other commodities sectors in Romania are among the most extensive in the country, relying mainly on exports to drive their development. This growth may continue eternally if natural resources are paired with value-added industries. As a consequence, enhanced transportation and trade routes linking the region’s landlocked economy would benefit the world’s economic and energy markets. Despite the abundance of these natural resources, concerns have been raised about the economy’s dependence on oil and gas. Oil and natural gas are generated and used more quickly than coal when it comes to fossil fuels. The quantity of energy used in net generation varies greatly from region to country [1,2]. The economic growth relies heavily on the use of renewable energy. It has become more necessary to create energy from depleting conventional resources as the world’s population has grown rapidly in recent decades. Because of environmental concerns and soaring energy costs, a booming economy is under jeopardy. After replenishing natural resources and addressing climate change and global warming, renewable power
is needed. To achieve long-term prosperity, countries must turn to sources of renewable energy [3,4]. In light of the world’s reliance on nonrenewable energy sources, there are a number of problems and difficulties that arise. As a result of these major challenges and concerns in recent decades, renewable energy and investments in renewable energy technologies have been prioritized by governments. This has led to rapid development and reductions in the cost of renewable energy technologies. Planning for energy resources is a crucial component of economic growth and sustainable development [5]. Sustainable development is strongly reliant on an appropriate energy supply. Expanding access to power and increasing the country’s export potential are just two examples of how the growth of the energy sector may help with both of these goals. The energy industry is crucial for producing employment, reducing poverty, and promoting community well-being [6–8].

Global warming and greenhouse gas emissions have made renewable energy an increasingly important part of the world’s energy usage. Reduced carbon dioxide emissions and environmental protection are the primary benefits of renewable energy. Although fossil fuels may theoretically be able to regenerate themselves over vast periods of time, they are under risk of extinction in the near future [9]. Many worldwide issues arise from relying on conventional energy sources. The most basic global challenges are the insecurity of the energy supply, the volatility of energy prices, the nonrenewal ability of fossil fuels such as coal, gas, and oil, and the rise of global temperatures. Countries and cultures are now forced to explore alternatives to conventional energy sources because of this. The key solution tool is the replacement of conventional energy with renewable energy, which is focusing on renewable energy as a substantial alternative energy source [10–12]. Traditional energy sources have gradually been replaced by nontraditional ones during the last several decades. Conventional energy production and usage have noteworthy negative environmental implications, and the finite returns of traditional energy sources mean that the usage of renewable energy sources is becoming more important. The consumption of renewable energy sources is critical to promoting economic development in most economies due to the low environmental effect of these sources, while, as a consequence, renewable energy is critical because it contributes to energy security, as many countries have lenient restrictions on the importation of fossil fuels [13,14]. As energy is the backbone of the global economy, it is critical to its success. Trade, industry, and our contemporary way of life would be impossible without it. Demand for energy is expected to expand dramatically as the global economy improves and new opportunities emerge. Various industrial sectors and researchers have methodically investigated the relationship between energy use and economic growth over the past few decades. The present study contributes to the previous literature by investigating the influence of renewable energy, urbanization, and nuclear energy on economic development in Romania. Time sequence annual data were utilized in this study and the stationarity of these data was verified by utilizing unit root testing. The ARDL approach with FMOLS and CCR techniques was employed to uncover the impact of renewable energy consumption, urbanization, alternative and nuclear energy, and energy use on economic growth.

Following the introduction part, the remainder of the paper is laid out as follows: Section 2 begins with a literature evaluation that focuses on past investigations on the area. Section 3 demonstrates the methodology, model, and data, and the empirical results are presented in Section 4. Section 5 shows the discussion, while Section 6 contains the concluding thoughts and policy recommendations.

2. Literature Review
2.1. Fossil Fuel Consumption, Renewable Energy, and Economic Development

The efficient use of energy is a contentious issue in the energy economics literature in the industrialized as well as developing worlds. Understanding the connection among energy use, carbon dioxide emissions, and economic development is, thus, crucial for policymakers and decision-makers who are tasked with enacting sound policies related to both the environment and the economy. It is unclear which factors cause the other,
but it is possible that economic success and energy intensity are linked [15]. Economic production and the capacity to maintain an appropriate quality of life for the population, which is heavily reliant on energy usage, may be adversely affected by an unstable supply of energy. When fossil fuels are burnt, they emit greenhouse gases such as carbon dioxide into the atmosphere. Sustainable growth and development in the global economy pose a major issue due to the growing energy consumption. It carries with it the dismal premise that conventional energy supplies based on fossil fuels are running short. Conventional energy’s influence on the environment, on the other hand, is startling. Importing fossil fuels is becoming more expensive, and the resulting air pollution makes it imperative that new sources of energy be found that are affordable, efficient, and ecologically beneficial. As a result, the rest of the globe has become increasingly interested in renewable energy. It is critical that we employ renewable energy to avoid the dire implications of climate change. Energy availability is connected to economic progress and social well-being. The conventional output factor is always present in the location of energy. Oil is critical for both development and economic advancement, which can only occur if an adequate and sustainable supply of energy is available [16–18].

The assumption in environmental policy and analysis is that the development of renewable energy will help separate economic expansion from carbon dioxide emissions. Even while economic productivity rises, renewable energy generation seems to be reducing carbon dioxide emissions by substituting fossil fuels. As one of the most important sociological findings demonstrates, technological innovation and social behavior may have a variety of unanticipated consequences. When it comes to the development of clean solutions such as renewable energy generation, empirical evidence shows that the interdependence of political and economic systems usually prevents these technologies from providing the expected environmental benefits [19,20]. As a consequence, the geopolitical discussion has shifted to a green economy built on renewable energy. It is critical to understand that renewable energy is generated from renewable energy sources that are constantly replenished yet flow in a limited quantity. As a consequence, geothermal heat, wind, solar radiation, liquid biomass, tides, and ocean currents are all renewable energy sources. Renewable energy has the potential to replace traditional fossil fuels, reduce carbon dependency, and offer up new industrial development prospects, in addition to lowering CO$_2$ emissions. Environmental challenges and sustainable development solutions must be addressed as part of the sixth technology revolution. Green transition may increase living conditions while minimizing environmental stress by updating and modernizing the energy sector’s present technological capability [21–23].

Renewable energy sources have become more widely available owing to a number of key events and technological advances throughout the world. Global warming, oil price volatility, political and societal pressure to reduce emissions, and a heavy dependence on foreign energy supplies are just a few of the factors driving the current energy security and climate change debates. The worries about global warming and climate change have put renewable energy sources such as wind, solar, and geothermal power in the forefront. In recent years, many countries have been increasing their investments in the clean energy sector and supporting them through various national policies, such as tax credits for renewable energy supplies, discounts for the installation of renewable energy mechanisms, and renewable energy portfolio measures [24–26]. There has been a growing focus on the link among renewable energy utilization and economic growth because of attempts to minimize air pollution and cut energy prices throughout the world. In many European economies that depend on energy usage to generate economic activity, trade-offs may exist between attempts to reduce air pollution and improve energy efficiency. Reforms aimed at structural changes in energy consumption have a lower cost for the economy in countries where growth is decoupled from energy consumption [27,28]. The large rise in energy consumption that comes along with economic expansion has prompted researchers to investigate whether or not consumption and growth are linked in any way. If there is a causal connection between them, the direction of the relationship is important, because
it will provide policymakers with crucial information on how programs are planned and implemented. Energy-saving methods, for example, will have no effect on economic growth if GDP (Gross Domestic Product) and energy usage are unrelated. Although limiting energy use may have a negative impact on economic growth, the connection is from energy consumption to GDP [29].

Concerns regarding price volatility, energy supply security, and environmental impact afflict the world’s energy supply system. Humanity will soon have to cope with two major concerns. The usage of fossil fuels pollutes the environment, and their depletion is accelerating. Fossil fuels represent a significant component of the energy mix, which is substantially to blame for these problems. Oil companies are becoming more active in the power and renewable energy sectors as a strategic response to the growing potential of the renewable energy industry and rising hydrocarbon extraction costs. Despite the fact that they are still dealing with the value of renewables, major oil companies are devising new strategies to capture a piece of the fast-increasing renewable energy business, determining the accurate quantity of gas as well as the length of time. As a consequence of the transfer of this money, capital allocation choices have been made for them. As a response to global warming and climate change, there is a compelling argument to be made for the development of renewable energy and the prudent use of fossil fuels. The capacity of renewable energy to compete with conventional energy sources in terms of price and cost is the most revealing indicator of their future development and utilization [30–32].

2.2. Urbanization, Energy Use, and Economic Development

Urbanization, human migration, and economic advancements in both developed and developing economies have had significant impacts on development, energy consumption, human life, and the environment [33]. Converting from fossil fuels to renewable energy is critical for mitigating the negative environmental consequences of urbanization [34]. Urbanization and population growth are expanding the need for energy, and this trend will only increase. Despite the fact that energy is critical to human existence and economic prosperity, it has been connected to a number of major environmental challenges. Uncontrollable greenhouse gas (GHG) emissions are acknowledged as a key cause to global warming and other environmental issues. For millennia, human-caused greenhouse gases such as carbon dioxide, nitrous oxide, and methane have been slowly growing in the atmosphere, contributing considerably to global climatic change. It is widely acknowledged that the increasing reliance on renewable energy sources can significantly reduce greenhouse gas emissions, and because these environmental issues are linked to widespread fossil fuel consumption, increasing the reliance on renewable energy sources is the most advanced way to address them [35–37].

Economic development relies heavily on the availability of energy. Energy is the primary input for producers. The cost of the item goes up because of a rise in this input’s price. A household’s energy use is a major factor in the overall cost of living. Energy demand has decreased while nonrenewable energy supplies have been disrupted, putting energy prices at considerable danger. This is because irregular work and homes utilize nonrenewable energy sources. Global warming, greenhouse gas emissions, CO₂ and methane emissions, and the fast increase in global warming are all linked to the simultaneous use of nonrenewable energy sources. Solar, wind, tidal, wave, and waste are a few examples of renewable energy sources. Renewable energy has a number of benefits, including being clean, safe, and unlimited. Because of the increasing demand and the finite supply of renewable energy sources, it is unavoidable that the output will climb constantly [38–40]. Table 1 shows the time series analysis by making use of a variety of econometric approaches, while many studies have been carried out to illustrate the link among various variables.
Table 1. Previous studies demonstrating the linkages among various variables.

| Author’s Names                  | Data Ranges | Methods (Econometric Techniques)                                                                 | Variables                                                                 |
|--------------------------------|-------------|-----------------------------------------------------------------------------------------------|--------------------------------------------------------------------------|
| Vo et al. (2019) [41]           | 1971–2014   | (Time-series econometrics approaches)                                                          | (CO₂ emissions, Energy consumption, Renewable Energy Consumption)        |
| He et al. (2022) [42]           | 1971–2018   | (Auto-regressive distributed lag bounds approach)                                              | (Renewable energy consumption, Economic growth, Oil rent, Natural resources, Greenhouse gas emissions) |
| Kahia et al. (2020) [43]        | 1990–2016   | (Fully Modified Ordinary Least-Squares and Dynamic Ordinary Least-Squares)                    | (Economic growth, renewable energy, CO₂ emissions)                       |
| Destek and Sinha (2020) [44]    | 1980–2014   | (Second-generation panel data methodologies)                                                   | (Renewable energy use, Nonrenewable energy use, Trade openness)          |
| Eren et al. (2019) [45]         | 1971–2015   | (Dynamic ordinary least squares (DOLS), Granger causality test)                               | (Financial development, Economic growth, Renewable energy)               |
| Rahman and Velayutham (2020) [46]| 1990–2014   | (Fully modified ordinary least squares, Panel dynamic ordinary least squares)                 | (Renewable and Nonrenewable Energy Consumption, Economic Growth)         |
| Al-Mulali et al. (2015) [47]    | 1990–2013   | (Pedroni cointegration test, Fully Modified Ordinary Least-Squares, VECM Granger causality)   | (CO₂ emission, GDP growth, Urbanization, Financial Development, Renewable Electricity Production) |
| Rehman et al. (2021) [48]       | 1975–2017   | (Nonlinear Autoregressive distributed lag (NARDL) bounds testing model)                       | (Urbanization, energy utilization, fossil fuel energy, CO₂ emission, economic progress) |
| Ali et al. (2016) [49]          | 1971–2011   | (Autoregressive distributed lag (ARDL) approach)                                               | (Urbanization, Economic Growth, Energy Consumption, Trade Openness, CO₂ emissions) |
| Koengkan et al. (2020) [50]     | 1980–2014   | (Panel vector autoregression)                                                                  | (Carbon Dioxide emissions, Renewable and Nonrenewable energy consumption, Economic Growth, Urbanization) |
| Khoshnevis Yazdi and Shakouri (2017) [51]| 1992–2014 | (Autoregressive distributed Lag (ARDL) model)                                                  | (Economic Growth, Renewable energy, energy consumption, capital fixed formation, globalization, trade openness, urbanization) |
| Rehman et al. (2022) [52]       | 1982–2020   | (Symmetric (ARDL) technique, FMOLS and DOLS)                                                   | (Renewable energy usage, Economic progress, urbanization, trade, Carbon emissions) |

The literature from multiple techniques, summarized in the table above, illustrates the interaction between the several aspects under investigation. The sources we discovered during our literature review prompted the formulation of a specific study topic aimed at elucidating the link between alternative and nuclear energy, fossil fuel consumption, renewable energy consumption, urbanization, and economic growth. Many empirical studies have been conducted using various methodologies to study how economic expansion influences the energy use. A recent study has revealed that the significant roles of renewable energy, urbanization, and fossil fuel energy consumption all contribute considerably to economic growth. As a consequence, we use the ARDL technique in conjunction with the FMOLS and CCR methods to explore the linkages between alternative and nuclear energy, fossil fuel consumption, renewable energy consumption, urbanization, and energy usage to economic growth in Romania. Table 2 reveals the study’s hypotheses.
Table 2. Hypotheses of the Study.

| Study Hypotheses (H1-H2-H3-H4-H5) |
|-----------------------------------|
| ➢ H1 Alternative and nuclear energy significantly impacts economic growth. |
| ➢ H2 Fossil fuel consumption has a constructive linkage with economic growth. |
| ➢ H3 Renewable energy positively improves economic growth. |
| ➢ H4 Urbanization negatively associated with economic progress. |
| ➢ H5 Energy usage negatively impacts economic growth. |

3. Data and Methodology

The influence of renewable energy consumption, urbanization, energy usage, and fossil fuel energy consumption on economic development was uncovered in this investigation by utilizing annual data series varying from 1990 to 2020, which was collected from the World Bank website. Table 3 shows the details of the variables with their units of measurement.

Table 3. Description of the study variables.

| Variables                      | Units                                      | Short-Form | Sources of Data | Online Data Links                      |
|--------------------------------|--------------------------------------------|------------|----------------|----------------------------------------|
| Economic Growth                | (annual %)                                 | ECG        | WDI            | https://data.worldbank.org/            |
| Renewable Energy Consumption   | (% of total final energy consumption)      | REC        | WDI            | country/RO (accessed on 25 July 2022)  |
| Alternate and Nuclear Energy   | (% of total energy use)                    | ANE        | WDI            |                                        |
| Urbanization                   | (annual %)                                 | URB        | WDI            |                                        |
| Energy Use                     | (kg of oil equivalent per capita)          | EUS        | WDI            |                                        |
| Fossil Fuel Energy Consumption | (% of total)                               | FFE        | WDI            |                                        |

Furthermore, in the econometric analysis, we first employed the basic statistical tests including descriptive analysis and correlation among the variables, and then stationarity was tested by using the ADF and P–P unit root testing. After this, the study utilized the bounds tests for the approval of cointegration with the J-Cointegration test for further robustness. At the end, short-run and long-run estimations were carried out via the ARDL technique with the conjunction of FMOLS and CCR techniques. Figure 1 illustrates the map of the study variables to the economic development, while Figure 2 shows the variables trend based on annual data ranges from 1990 to 2020.

Figure 1. Variables nexus for the study (author’s own illustration).
Study Model

Several studies have been conducted to determine the influence of energy use on economic development. Tang et al. (2016) [53] examined energy consumption, FDI, capital stock, and economic growth in Vietnam and found that energy consumption, foreign investment, and capital stock all had a favorable influence on economic development. Using a fixed-effect model and a nonlinear threshold model, Wang and Wang’s (2020) [54] study on renewable energy consumption and economic development demonstrated that renewable energy had a threshold influence on economic growth in OECD economies. Furthermore, Khan et al. (2019) [55] investigated the effects of coal consumption, oil consumption, natural gas consumption, and economic growth on environmental degradation in Pakistan, and the findings showed that economic growth, coal consumption, oil consumption, and natural gas consumption all had a positive impact on environmental degradation. Similarly, in a study on foreign direct investment, economic development, and renewable energy, Wei et al. (2022) [56] discovered that renewable energy was substantial and negative in terms of greenhouse gas emissions, but foreign direct investment was significant and beneficial. The primary goal of this study was to analyze the influence of renewable energy consumption, alternative and nuclear energy, urbanization, energy usage, and fossil fuel energy consumption on Romanian economic growth. In order to discover the relationship between variables, we developed the following model:

\[
\text{Economic Growth} = f (\text{Renewable Energy Consumption}, \\
\text{Alternate and Nuclear Energy}, \text{Urbanization}, \text{Energy Use}, \\
\text{Fossil Fuel Energy Consumption})
\]

(1)

Equation (1) can be extended further as:

\[
\text{Economic Growth}_t = \xi_0 + \xi_1 \text{Renewable Energy Consumption}_t \\
+ \xi_2 \text{Alternate and Nuclear Energy}_t + \xi_3 \text{Urbanization}_t \\
+ \xi_4 \text{Energy Use}_t + \xi_5 \text{Fossil Fuel Energy Consumption}_t + \epsilon_t
\]

(2)
We can write Equation (2) as:

$$E_{\text{CG}} = \xi_0 + \xi_1 \text{REC}_t + \xi_2 \text{ANE}_t + \xi_3 \text{URB}_t + \xi_4 \text{EUS}_t + \xi_5 \text{FFE}_t + \varepsilon_t$$  \hspace{1cm} (3)

where ECG represents economic growth, REC represents renewable energy consumption, ANE represents alternative and nuclear energy, URB indicates urbanization, EUS represents energy use, and FFE represents fossil fuel consumption. In addition, $\varepsilon_t$ indicates the error term and time is measured through $t$. The coefficients of the model are uncovered through $\xi_1$-$\xi_4$. Additionally, an ARDL technique was utilized in this investigation, which was first established by the famous economist Pesaran et al. (2001) [57], in the directive to demonstrate the linkages among the various variables. The ARDL technique is used when there is a long-term association among the variables. In consequence, when the variable is considered stationary at $I(0)$ and $I(1)$, the constraint is no longer relevant, because it no longer happens. In a manner comparable to this, it has been found that the technique of ARDL offers an efficient explanation to the problem of incorrect regressions brought on by variables that have been omitted or left out. The main motive of this investigation was to examine both the long-term and short-term connection that exists between economic growth and the other variables under analysis. If we want to find cointegration in a model, we may use an ARDL model with an error correction term. The ARDL model is specified in the following way:

$$\Delta E_{\text{CG}}_t = \eta_0 + \sum_{k=1}^{k} \omega_k \Delta E_{\text{CG}}_{t-k} + \sum_{k=0}^{k} \omega_k \Delta \text{REC}_{t-k} + \sum_{k=0}^{k} \omega_k \Delta \text{ANE}_{t-k} + \sum_{k=0}^{k} \omega_k \Delta \text{URB}_{t-k} + \sum_{k=0}^{k} \omega_k \Delta \text{EUS}_{t-k}$$

$$+ \sum_{k=0}^{k} \omega_k \Delta \text{FFE}_{t-k} + \pi_1 \text{ECG}_{t-1} + \pi_2 \text{REC}_{t-1} + \pi_3 \text{ANE}_{t-1} + \pi_4 \text{URB}_{t-1} + \pi_5 \text{EUS}_{t-1}$$

$$+ \pi_6 \text{FFE}_{t-1} + \varepsilon_t$$  \hspace{1cm} (4)

The long-term dynamics of the variables are shown in Equation (4). Furthermore, the demonstration of the short-run error correction is shown in the equation below:

$$\Delta E_{\text{CG}}_t = \eta_0 + \sum_{k=1}^{k} \omega_k \Delta E_{\text{CG}}_{t-k} + \sum_{k=0}^{k} \omega_k \Delta \text{REC}_{t-k} + \sum_{k=0}^{k} \omega_k \Delta \text{ANE}_{t-k} + \sum_{k=0}^{k} \omega_k \Delta \text{URB}_{t-k} + \sum_{k=0}^{k} \omega_k \Delta \text{EUS}_{t-k}$$

$$+ \sum_{k=0}^{k} \omega_k \Delta \text{FFE}_{t-k} + \pi_1 \text{ECG}_{t-1} + \pi_2 \text{REC}_{t-1} + \pi_3 \text{ANE}_{t-1} + \pi_4 \text{URB}_{t-1} + \pi_5 \text{EUS}_{t-1}$$

$$+ \pi_6 \text{FFE}_{t-1} + \text{ECM}_{t-1} + \varepsilon_t$$  \hspace{1cm} (5)

Equation (5) explores the presentation of the short-run dynamics among economic growth, renewable energy use, urbanization, energy usage, and fossil fuel energy consumption.

4. **Empirical Results**

The descriptive analysis for the study variables is shown in Table 3. Energy use has the highest maximum and minimum values, while the standard deviation and J-Bera statistics are positive for all the variables. Correlation analysis, on the other hand, is also examined in Table 4, which demonstrates that all variables such as the ECG, REC, ANE, URB, EUS, and FFE are correlated.

**Table 4.** Descriptive analysis and correlation among the variables.

|        | ECG   | REC    | ANE    | URB    | EUS    | FFE    |
|--------|-------|--------|--------|--------|--------|--------|
| Mean   | 1.637062 | 17.31766 | 8.155621 | -0.493249 | 1804.966 | 82.32016 |
| Median | 3.608724 | 17.73397 | 6.658021 | -0.443190 | 1777.106 | 84.32978 |
| Maximum| 10.42811 | 27.98152 | 15.90728 | 1.523033 | 2683.179 | 96.14829 |
Table 4. Cont.

| ECG       | REC       | ANE       | URB       | EUS       | FFE       |
|-----------|-----------|-----------|-----------|-----------|-----------|
| Minimum   | -12.91821 | 3.355766  | 1.329432  | -1.966977 | 1469.566  | 68.34356  |
| Std. Dev. | 5.917834  | 6.800425  | 4.824673  | 0.583638  | 255.9210  | 8.673756  |
| Skewness  | -1.018764 | -0.508765 | 0.108300  | 0.514130  | 1.327832  | 0.005027  |
| Kurtosis  | 3.436363  | 2.296867  | 1.679013  | 7.458607  | 5.583453  | 1.804875  |
| Jarque-Bera| 5.608335 | 1.975947  | 2.314567  | 27.04297  | 17.73042  | 1.845048  |
| Probability| 0.060557 | 0.372330  | 0.314339  | 0.000001  | 0.000141  | 0.397514  |

4.1. Stationarity Analysis among the Variables

If the time series variable has a unit root, the unit root test will reveal whether the series is stationary or not. The null hypothesis is often defined by the existence of a unit root. The alternative hypothesis, on the other hand, might be stationarity, trend stationarity, or explosive root, depending on the particular test that is being used. Furthermore, ADF and P–P unit root tests are utilized in this analysis [58,59]. ADF and Phillips–Perron unit root tests are used to assess whether any of the analyzed variables has an order I(2). The stationarity of variables in ARDL models is not checked in advance using unit root tests. In the I(2) for example, the ARDL bounds test function fails with a null outcome. The consequences of the ADF and the Phillips–Perron unit root test demonstrate that none of the variables have integrals in the order of I(2), as shown in Table 5. Because of this, the ARDL bounds test model is chosen for use.

Table 5. Unit root testing for the variables.

|                    | ECG       | REC       | ANE       | URB       | EUS       | FFE       |
|--------------------|-----------|-----------|-----------|-----------|-----------|-----------|
| ADF test at I(0)   |           |           |           |           |           |           |
| (T-statistics)     | -3.283981 | -1.408322 | -0.218422 | -4.549702 | -1.670838 | -0.457882 |
| (p-values)         | (0.0248)  | (0.5649)  | (0.9256)  | (0.0011)  | (0.4551)  | (0.8861)  |
| ADF test at I(1)   |           |           |           |           |           |           |
| (T-statistics)     | -5.473489 | -4.623524 | -4.567374 | -5.239736 | -5.322321 | -4.461187 |
| (p-values)         | (0.0001)  | (0.0009)  | (0.0011)  | (0.0002)  | (0.0002)  | (0.0015)  |
| PP test at I(0)    |           |           |           |           |           |           |
| (T-statistics)     | -3.635023 | -1.745039 | 0.165341  | -6.004159 | -4.241733 | -0.173545 |
| (p-values)         | (0.0109)  | (0.3993)  | (0.9655)  | (0.0000)  | (0.0024)  | (0.9316)  |
| PP test at I(1)    |           |           |           |           |           |           |
| (T-statistics)     | -5.580434 | -4.996493 | -4.969451 | -7.380901 | -12.23111 | -5.405479 |
| (p-values)         | (0.0001)  | (0.0004)  | (0.0004)  | (0.0000)  | (0.0000)  | (0.0001)  |

4.2. Bounds Testing for the Validation of Cointegration

Table 6 shows the results of the bounds test to assess whether or not cointegration occurs, which demonstrates that F Statistics exists (4.525976). The results of the cointegration show the association among economic growth, renewable energy consumption, urbanization, energy utilization, and fossil fuel energy.
Table 6. Bounds tests to cointegration.

|                | (F-Bounds Test) | (N-Hypothesis: Establishes No Levels Relationship) |
|----------------|-----------------|--------------------------------------------------|
|                | F-statistic     | Critical Values | Lower Level I(0) | Upper Level I(1) |
|                | (4.529976)      | 10%             | 2.08             | 3                |
| K              | 5               | 5%              | 2.39             | 3.38             |
|                |                 | 2.5%            | 2.7              | 3.73             |
|                |                 | 1%              | 3.06             | 4.15             |

It is shown in Table 7 that the long-term relationship is strong enough to utilize the J-cointegration test [60]. Cointegration is not found by trace test statistic results, which demonstrates that the null hypothesis is rejected. Neither the trace statistic nor the largest eigenvalue exceeds the critical value.

Table 7. Johansen cointegration test.

| Hypoth.-No. of CE(s) | E-Value | T-Statistic | C-Value | p-Values ** |
|----------------------|---------|-------------|---------|-------------|
| (None *)            | 0.827039 | 136.3359    | 95.75366 | 0.0000      |
| (At most 1 *)       | 0.659831 | 85.44993    | 69.81889 | 0.0017      |
| (At most 2 *)       | 0.538574 | 54.17884    | 47.85613 | 0.0113      |
| (At most 3 *)       | 0.482482 | 31.74925    | 29.79707 | 0.0294      |
| (At most 4)         | 0.300166 | 12.64660    | 15.49471 | 0.1284      |
| (At most 5)         | 0.076124 | 2.296153    | 3.841466 | 0.1297      |

(M-Eigenvalue Statistics)

| Hypoth.-No. of CE(s) | E-Value | Max-Eigen Stat. | C-Value | p-Values ** |
|----------------------|---------|-----------------|---------|-------------|
| (None *)            | 0.827039 | 50.88595        | 40.07757 | 0.0021      |
| (At most 1)         | 0.659831 | 31.27108        | 33.87687 | 0.0992      |
| (At most 2)         | 0.538574 | 22.42960        | 27.58434 | 0.1992      |
| (At most 3)         | 0.482482 | 19.10265        | 21.13612 | 0.0939      |
| (At most 4)         | 0.300166 | 10.35045        | 14.26460 | 0.1899      |
| (At most 5)         | 0.076124 | 2.296153        | 3.841466 | 0.1297      |

Note: * signifies 0.05 denial, and ** signifies probability values of (MacKinnon-Haug-Michelis, 1999).

4.3. Results of the Short- and Long-Run Estimations through ARDL

Table 8 shows the results of the ARDL technique. The results in Panel A show that the variables alternative and nuclear energy and fossil fuel energy consumption have positive coefficients, demonstrating the constructive impact on economic growth, while the variables renewable energy consumption, urbanization, and energy usage have negative coefficients, showing the negative impact on economic progress in Romania.
Moving to the results of Panel B, the long-run estimation shows that the variables alternative and nuclear energy and fossil fuel energy have positive coefficients of (0.902461) and (0.656882), respectively, demonstrating the constructive impact on the economic development. Further, renewable energy consumption, urbanization, and energy usage have negative coefficients, uncovering the adverse influence on economic development. It is difficult for most economies to implement sustainable energy systems, despite the efforts of governments, international organizations, and other stakeholders. New guidelines and incentives for renewable energy have been established during the last several decades, including support mechanisms such as feed-in tariffs. To solve the obstacles faced by the transition to low-carbon-energy schemes, several alternative techniques, such as demand-side management and smart grids, have been implemented. Energy systems and energy policies must be evaluated in order to ensure that the selected strategy is working. A collection of indicators is typically defined by the technique, and the results of each region may then be analyzed and compared. To measure the sustainability of the energy system, this collection of data might include information on energy efficiency, availability, and the use of renewable resources. Some of these are applicable worldwide, while others are exclusive to a certain country, such as a city. Indicators of progress toward a more sustainable energy system may be directly influenced by economic factors, such as subsidies [61–63].

| Variables | Coefficients | S-Error | t-Stat. | Prob. |
|-----------|--------------|---------|---------|-------|
| REC       | −0.151453    | 0.94285 | −0.16063 | 0.8738 |
| ANE       | 0.902461     | 3.51949 | 0.25641 | 0.0800 |
| URB       | −0.247195    | 3.15451 | −0.07836 | 0.9382 |
| EUS       | −0.010301    | 0.01118 | −0.92120 | 0.3669 |
| FFE       | 0.656882     | 2.48650 | 0.26417 | 0.0794 |
| C         | −36.73000    | 236.809 | −0.15510 | 0.8782 |

Moving to the results of Panel A, the short-run estimation shows that the variables alternative and nuclear energy and fossil fuel energy have positive coefficients of (−24.04690) and (−0.590836), respectively, demonstrating the constructive impact on the economic development. Further, renewable energy consumption, urbanization, and energy usage have negative coefficients, uncovering the adverse influence on economic development. It is difficult for most economies to implement sustainable energy systems, despite the efforts of governments, international organizations, and other stakeholders. New guidelines and incentives for renewable energy have been established during the last several decades, including support mechanisms such as feed-in tariffs. To solve the obstacles faced by the transition to low-carbon-energy schemes, several alternative techniques, such as demand-side management and smart grids, have been implemented. Energy systems and energy policies must be evaluated in order to ensure that the selected strategy is working. A collection of indicators is typically defined by the technique, and the results of each region may then be analyzed and compared. To measure the sustainability of the energy system, this collection of data might include information on energy efficiency, availability, and the use of renewable resources. Some of these are applicable worldwide, while others are exclusive to a certain country, such as a city. Indicators of progress toward a more sustainable energy system may be directly influenced by economic factors, such as subsidies [61–63].

| Variables | Coefficients | S-Error | t-Stat. | Prob. |
|-----------|--------------|---------|---------|-------|
| C         | −24.04690    | 152.685 | −0.15749 | 0.8763 |
| ECG(-1)   | −0.654694    | 0.18213 | −3.59473 | 0.0016 |
| REC       | −0.099155    | 0.61566 | −0.16105 | 0.8735 |
| ANE       | 0.590836     | 2.23309 | 0.26458 | 0.0038 |
| URB       | −0.161837    | 2.08497 | −0.07763 | 0.9388 |
| EUS(-1)   | −0.006744    | 0.00679 | −0.99191 | 0.3320 |
| FFE       | 0.430056     | 1.58195 | 0.27185 | 0.0883 |
| D(EUS)    | 0.017231     | 0.01014 | 1.69936 | 0.1033 |
| CointEq(-1)| −0.654694   | 0.10932 | −5.98897 | 0.0000 |

**Table 8. Findings of short- and long-run.**

**Panel A: Short-Run Outcomes**

| Variables | Coefficients | S-Error | t-Stat. | Prob. |
|-----------|--------------|---------|---------|-------|
| REC       | −0.151453    | 0.94285 | −0.16063 | 0.8738 |
| ANE       | 0.902461     | 3.51949 | 0.25641 | 0.0800 |
| URB       | −0.247195    | 3.15451 | −0.07836 | 0.9382 |
| EUS       | −0.010301    | 0.01118 | −0.92120 | 0.3669 |
| FFE       | 0.656882     | 2.48650 | 0.26417 | 0.0794 |
| C         | −36.73000    | 236.809 | −0.15510 | 0.8782 |

R-squared (0.630397)
Log likelihood (−77.47249)
Prob(F-statistic) (0.001092)
Schwarz criterion (6.071819)
D-Watson stat (2.009536)

Adjusted R² (0.512796)
F-stat. (5.360467)
Akaike info criterion (5.698166)
Hannan-Quinn criter. (5.817701)
The statistical values of $R^2$, Adjusted $R^2$, F-statistic, and Durbin–Watson are (0.630397), (0.512796), (5.360467), and (2.009536), respectively. Figure 3 shows the long-term connection of renewable energy use, alternative and nuclear energy, urbanization, and energy use with economic growth.

![Figure 3](image-url)

**Figure 3.** Long-term association of the study variables.

Furthermore, the results of the diagnostic and stability tests are shown in Table 9, which includes F-statistic values of (0.324981) and (0.487143), and probability values of (0.7263) and (0.8336), respectively.

| (Tests)                                 | (F-Statistics) | (Prob.-Values) |
|-----------------------------------------|----------------|----------------|
| Breusch–Godfrey serial correlation LM test | 0.324981       | 0.7263         |
| Heteroskedasticity test (Breusch–Pagan–Godfrey) | 0.487143       | 0.8336         |
| CUSUM test                              | Stable         |                |
| CUSUM of squares test                   | Stable         |                |

Similarly, Figure 4 shows the plot of CUSUM and its square at the level of 5 percent, and the trends of the plots show the stability in the study model.

![Figure 4](image-url)

**Figure 4.** Plot of the CUSUM and its squares.
4.4. FMOLS and CCR Outcomes

The FMOLS and CCR approaches are also used to examine the long-term connection between the variables. The results of Panel C (FMOLS) presented in Table 10 show that the variables alternative and nuclear energy and fossil fuel energy use have positive coefficients of (1.583260) and (1.583260) with p-values of (0.0064) and (0.0813), respectively, uncovering the positive connection with economic growth, while the variables renewable energy usage, urbanization, and energy consumption have negative coefficients of (−0.212036), (−5.046183), and (−0.001122), respectively, showing the adversative linkage to economic growth.

Table 10. FMOLS and CCR.

Panel C: FMOLS (Fully Modified Least Squares)

| Variables | Coefficients | S-Error  | t-Stat.  | Prob.   |
|-----------|--------------|----------|----------|---------|
| REC       | −0.212036    | 0.666249 | 0.318253 | 0.7530  |
| ANE       | 1.583260     | 2.188517 | −0.723440| 0.0064  |
| URB       | −5.046183    | 1.799578 | −2.804093| 0.0098  |
| EUS       | −0.001122    | 0.007333 | 0.152946 | 0.8797  |
| FFE       | 0.896445     | 1.603440 | −0.559076| 0.0813  |
| C         | 80.53286     | 156.1517 | 0.515735 | 0.6108  |

(R^2) 0.298975  (Mean dependent var) 2.122238
(Adjusted R^2) 0.152928  (SDD var) 5.355323
(S-E. of regression) 4.928853  (Sum-squared resid) 583.0462
(Long-run variance) 16.63541

Panel D: CCR (Canonical Cointegrating Regression)

| Variables | Coefficients | S-error  | t-stat.  | Prob.   |
|-----------|--------------|----------|----------|---------|
| REC       | −0.209424    | 0.791360 | 0.264638 | 0.7935  |
| ANE       | 1.908298     | 2.79969 | −0.68306 | 0.0011  |
| URB       | −5.829786    | 2.399555 | −2.429123| 0.0230  |
| EUS       | −0.001415    | 0.008139 | 0.173884 | 0.8634  |
| FFE       | 1.102651     | 2.100179 | −0.525027| 0.0044  |
| C         | 99.26495     | 200.2502 | 0.495705 | 0.6246  |

(R^2) 0.299003  (Mean dependent var) 2.122238
(Adjusted R^2) 0.152962  (SDD var) 5.355323
(S-E. of regression) 4.928753  (Sum-squared resid) 583.0226
(Long-run variance) 16.63541

On the other hand, the results of Panel D (CCR) show that alternative and nuclear energy, renewable energy consumption, fossil fuel consumption, urbanization, energy use, and economic growth were explored in this investigation using the ARDL approach in conjunction with FMOLS and CCR methodology.

5. Discussion

The impact of alternative and nuclear energy, renewable energy consumption, fossil fuel consumption, urbanization, energy use, and economic growth was explored in this investigation using the ARDL approach in conjunction with FMOLS and CCR methodology.
gies to identify the relationships between the variables. The results showed that alternative and nuclear energy, as well as fossil fuel energy consumption, had a favorable impact on economic development, but the variables renewable energy consumption, urbanization, and energy usage had a negative effect on economic advancement in Romania. A long-term energy plan is required to ensure that the energy supply keeps track of economic development and progress. To be economically viable in the short term, there must be a continuous supply of energy and a stable cost. The instability of the fossil fuel sector, on the other hand, puts importing economies at risk. Energy supply and demand mismatches are expected to have serious economic consequences. As a consequence, countries that depend significantly on energy face limitations aimed at limiting usage. The use of renewable energy as a source of energy variety has the potential to be advantageous. We will be more robust to energy market disruptions if we reduce our reliance on fossil fuels. Using renewable energy sources may help to alleviate further environmental problems. While it is feasible to switch from fossil fuels to renewable energy sources, the transition may be difficult. While it is possible to change from fossil fuels to renewable sources of energy, the transition might be challenging. The high implementation costs of renewable energy are a serious problem [64–66].

The world’s population and economic activities are increasingly concentrated in cities as a result of urbanization. Migration from rural to urban areas has resulted in a change in labor force composition from agriculture to industry and services. This economic structural revolution has significantly transformed natural resources and energy usage. Despite the fact that production has shifted from a low-energy agricultural sector to a high-energy industrial sector, new technologies and industrialization have had an influence on this industry. Over the previous few decades, urbanization has resulted in an increase in manufacturing output and market reach. The usage of fuel-powered vehicles to get to and from work, as well as to create, operate, and maintain urban substructures and facilities such as housing, water supply, roads, and bridges, is predicted to use more energy in cities than in rural regions [67–69]. A significant element of urbanization is the rapid migration of people from rural to urban areas. Urbanization has made a significant contribution to economic development, household income, and living standards. On the other hand, urbanization has considerably increased total energy use. Urbanization, on the other hand, helps to improve industries, technology, and goods, and thus improves energy efficiency in buildings and other structures. As a result, it is critical to monitor the impact of new urbanization on energy consumption and find ways to encourage urbanization and construction while minimizing environmental harm [70]. Urbanization and industry have become essential indicators of economic growth and modernization. As the economy shifts from a rural to a manufactured one, the amount of industrial value contributing to GDP rises alongside the increase in urban population. Although increased wages and living standards are associated with this modernization process, it also has significant implications for energy consumption. One of the primary causes of urbanization is increased densification caused by people migrating from rural to urban areas [71].

We presently obtain the majority of our energy from fossil fuels. Without a doubt, their usage has negative implications such as global warming, environmental degradation, and sea level rise. Renewable energy and other ecologically acceptable kinds of energy are becoming more popular as energy and environmental issues gain prominence [72]. Given the critical role that fossil fuels play in today’s energy production systems, the uneven distribution of fossil fuels raises concerns about energy security as well as environmental and health problems [73]. When development initiatives are focused toward economic growth, regional incomes and growth are enhanced. Because of the global economy’s and society’s reliance on natural resources, there is an opportunity to forge a global agreement for fair and equitable regional economic development. Economic growth has supported success in the region, but this development has been accompanied by growing inequities, environmental degradation, and overdependence on fossil fuels. Global warming, fueled by increased pollution from fossil fuels, has emerged as one of our century’s most pressing
concerns. Energy security is dependent on the stability, affordability, and long-term sustainability of the energy supply. Energy security is inextricably tied to service distribution and the segments served [74,75]. Renewable energy, with its decentralized structure, helps to mitigate the impact of potential technological failures or extremist attacks on national networks, diverting oil income that would otherwise go to governments in risky countries. In terms of rural labor markets, the operation of bioenergy plants may have a positive impact in terms of out-migration [76].

6. Conclusions and Policy Directions

We determined the impact of renewable energy consumption, alternative and nuclear energy, urbanization, energy use, and fossil energy consumption on Romanian economic development by utilizing the annual data series. The stationarity among variables was rectified through unit root testing. The connection among variables was uncovered by using the ARDL approach in conjunction with FMOLS (Fully Modified Least Squares) and CCR (Canonical Cointegrating Regression) techniques. Evidence of the long-run and short-run suggests that alternative and nuclear energy, as well as fossil fuel consumption, has a positive association with economic growth, but renewable energy consumption, urbanization, and energy usage have an adverse linkage to economic progress. Similarly, FMOLS and CCR statistics indicate that alternative and nuclear energy, as well as fossil fuel usage, has a positive impact on economic growth. Further, renewable energy consumption, urbanization, and energy use, on the other hand, revealed an adverse connection with economic progress. In order to handle Romania’s energy consumption issues and boost the country’s economic growth, conservative measures are required.

Because of globalization, increasing disparities between economies and socioeconomic groups, and the importance of environmental issues, sustainable development is now a must for all economies worldwide. Although energy consumption varies by sector and there is debate regarding its influence on economic development, it is plausible to assert that energy has a considerable impact on economic output and growth. Human civilization needs sustainable energy sources to exist and grow. The development of big and contemporary energy sources impedes the economic prosperity of a region. It is critical for long-term global development to reduce the intensity of energy use in both developed and emerging nations. Many present challenges, such as global energy scarcity, climate change mitigation, and the health consequences of regional air and water pollution, might be alleviated by lowering the energy intensity. Energy resources in Romania vary from hydropower and geothermal potential to wind and concentrated solar. They are spread all around the country, and as technology progresses and becomes more widely available, they will be able to use it more extensively. This level can only be reached via the development of new technologies and infrastructure. A significant portion of Romania’s wind and solar energy potential has already been exploited. Wind power is the least harmful to the environment when compared to other renewable energy sources. Long-term consumer expectations will be met if Romania’s energy business becomes more economically strong, technologically advanced, and environmentally friendly than it is currently. Hydropower is an efficient, clean, renewable, and long-term energy source in Romania, and can harness such kinds of energy due to its geographical position. In accordance with this consequence, the Romanian government must prioritize energy by defining goals and focusing on hydropower to lessen the dependency on fossil fuels. As this study looks at the link between renewable energy and the environmental effect of urbanization, alternative and nuclear energy, and economic growth, it does have certain limitations. Moreover, it paves the way for further study to combat environmental deterioration and global warming, including examining the connection between (1) financial development, institutional quality, trade openness, green energy, and environmental pollution; (2) using other econometric techniques to encounter the nexus among the variables by taking the larger samples of data; (3) introducing new strategies and policy recommendations to create a direction in
order to develop the energy consumption strategies to foster the economic potential of developing countries.

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