energies

Article

Not Fit for 55: Prioritizing Human Well-Being in Residential Energy Consumption in the European Union

Michael Carnegie LaBelle [1], Géza Tóth [2] and Tekla Szép [2,*]

[1] Department of Environmental Sciences and Policy, Central European University, Quellenstraße 51, 1100 Vienna, Austria
[2] Institute of World and Regional Economics, Faculty of Economics, University of Miskolc, Miskolc-Egyetemváros, 3515 Miskolc, Hungary
* Correspondence: regtekla@uni-miskolc.hu; Tel.: +36-204403531

Abstract: An analysis of the 27 European Union (EU) member states over the years 2000–2018 examines the relationship between residential energy use per capita and human well-being, measured by the Human Development Index (HDI). The EU's 'Fit for 55' policy package to reduce greenhouse gas emissions may derail post-communist member states' convergence (PCMS) to the same level of well-being of households in old member states (OMS). The aim of this article is to assess both the direct and indirect relationship between residential energy use per capita and human well-being. The findings indicate a direct connection in addition to the indirect effect between them. Therefore, reducing or leveling off residential energy consumption in PCMS will prevent human development convergence within the EU. The findings indicate the lack of convergence, because of the 'Fit for 55' policy package assumption of a decline of residential energy consumption in all member states could stagnate or lower HDI in PCMS and prevent policy implementation.

Keywords: residential energy use; path analysis; human well-being; Fit for 55; HDI

Citation: LaBelle, M.C.; Tóth, G.; Szép, T. Not Fit for 55: Prioritizing Human Well-Being in Residential Energy Consumption in the European Union. *Energies* **2022**, *15*, 6687. https://doi.org/10.3390/en15186687

Academic Editors: Krystian Heffner and Brygida Klemens

Received: 27 July 2022
Accepted: 9 September 2022
Published: 13 September 2022

1. Introduction

The European Union launched the 'Fit for 55' package of policies seeking to reduce greenhouse gas emissions (GHGs) by a net 55% by 2030. This is a mid-term goal toward implementing the EU's Green Deal to make Europe "the first climate neutral continent by 2050" [1]. Across all countries, the policy packages envision residential energy consumption to drop, facilitated by energy efficiency improvements and higher energy costs. Social welfare, in the form of the 'Social Climate Fund', may be given to those households living in energy and mobility poverty [1]. The EU recently responded to the energy crisis brought about by Russia's war in Ukraine with the REPowerEU, which accelerates the ambition of Fit for 55. Nonetheless, the underlining dynamics do not change; as this article articulates, the Fit for 55 proposal runs counter to the EU's goal of economic and social convergence between the member states.

This article questions the policy assumption of 'Fit for 55' that decreasing household energy consumption can be neutral or even beneficial for households in most post-communist member states (PCMS) in the short timeframe up to 2030. This article aims to demonstrate that higher energy use in the residential sector is correlated with a higher Human Development Index (HDI). Therefore, based on historical trends, PCMS households will need to increase energy consumption for human development convergence with households in old member states (OMS), which have higher energy consumption. Convergence towards an EU equilibrium in human well-being is an embedded policy objective of the European project that can be quantitatively assessed.

The quantitative analysis assesses both the direct and indirect relationship between residential energy consumption per capita and HDI up to 2018. There is an immediacy to this analysis, the rapid rise in energy prices and inflation in 2022, due to shifts in the global economy and Russia's war in Ukraine, only adds to the difficulty around convergence. As household consumers are now experiencing, higher energy prices and reducing energy consumption is changing how they live, making the findings of this article even more salient for policy debates.

The connection of human development and residential energy consumption is important to consider as PCMS attempt to converge their economies with OMS. The division within the EU of OMS and PCMS refers to the wave of expansion after 2004 with the addition of 22 member states. All but two in these waves comprise countries with previous communist governments, while OMS refers to democratic member states joining by 1995. With the fall of the Berlin Wall in 1989, a massive integration of Europe has been occurring, with the ultimate objective of economic convergence between these two halves. The EU agency, Eurofound, tasked with improving living and working conditions, identifies social and economic convergence as a common expectation as EU integration unfolds. However, the lack of convergence "may spread the feeling of social injustice and unfairness among citizens, fueling anti-European sentiment and undermining the European project" [2]. From the perception of PCMS, who joined after 2004, convergence with the Western living standard fueled structural adjustments in all areas of economic, political, and social life. Now more than 30 years after the fall of communism, there is still momentum and a desire for convergence.

As the World Bank points out, the "convergence machine" is picking up in the post-communist region after the impact of the 2008 financial crisis [3]. If a key benefit of EU membership is convergence to a higher living standard, with higher GDP and social rights (education, income, housing), then it can be expected that household energy consumption will also reach a levelized amount equal with OMS. Despite the historical push for equality across Europe, the convergence of residential energy consumption and HDI is not factored into the projections for 'Fit for 55' or for the 2050 carbon-neutral goals of the EU and member states. If anything, EU membership has increased energy poverty due to neoliberal reforms and increased energy costs in terms of household purchasing power [4].

On the cusp of another economic (and energy) crisis, it is even more imperative social rights and economic convergence are not given up. Energy convergence in the European Union, to achieve human development convergence, is an unresolved policy challenge. As one of the authors of this paper wrote in 2016, "the results should be taken into account when the European Union countries set up the new climate and energy objectives to 2030" [5]. Our argument in this paper is human development and energy convergence still needs to be considered when setting 2030 and 2050 goals for PCMS.

Two research questions are developed to examine the direct and indirect relationships between residential energy use per capita and human well-being. The first research question seeks to identify a relationship between them (RQ1). The second asks whether increasing residential energy use benefits consumers (RQ2). As the research on 'energy quality' highlights, the relationship needs to be contextualized in residential well-being [6,7]. Jointly, these questions and their answers provide a basis to begin discussing energy convergence and the equitable distribution of energy consumption in the EU, along with the direct connection to well-being to those who have not decoupled their economic growth from energy consumption. The following research questions are answered in this article:

RQ1: Can a significant relationship be identified between residential energy use and HDI in the European Union?

If so, what are the most significant indicator(s) of this direct and indirect relationship?

RQ2: Does the increasing residential energy use have a positive (push) effect on HDI?

This paper examines the causal relations of residential energy use and the connection to the HDI. The purpose of this paper is to highlight HDI and energy convergence as an essential social and economic justice theme. The limitations of the article mean that issues of degrowth are not addressed, because the historical and policy trajectory is towards human development convergence tied to increasing energy production to 2030. In addition, the paper does not delve deeply into the spatial injustices around convergence; that is, either PCMS fail to catch up to OMS energy consumption and HDI levels or that OMS should converge down to PCMS levels. Further research and exposition of the spatial HDI differences within the EU should be done in relation to the 2030 and 2050 climate change goals. Overall, the article highlights the spatial impact energy consumption could have on the well-being of EU households as measured by HDI due to 'Fit for 55' policies.

The relationship between energy consumption and HDI is discussed in the rest of this section, along with the spatial differences between PCMS and OMS. Furthermore, it provides an overview of the literature on energy consumption and HDI. Section 2 explains the methodology and the applied datasets used for investigating residential energy consumption and HDI. Section 3 presents the results and the main findings to the research questions. The real threat to convergence emerges around higher household energy prices preventing the growth of HDI and stagnation in PCMS. Section 4 reviews and answers the research questions and results while outlining potential scenarios as Fit for 55 policies progress. Section 5 concludes and proposes 'Fit for 55' policies be adjusted to address spatial inequality of HDI in the EU. Drawing on the findings, a research agenda is proposed to address HDI withing the present energy crisis of the EU. Collectively, the paper provides a novel contribution to examine human well-being in the EU.

Background and Literature Review: Energy Consumption and Well-Being

The authors assume the EU did not abandon the idea of economic and social convergence. Convergence and decoupling of economic activity from energy consumption in PCMS is important to understand if 'Fit for 55' projections will be met. In the past, due to the high energy intensity of the centrally planned economies of communist countries, the collapse of heavy industry resulted in a dramatic drop in energy consumption. This gave them generous room to meet Kyoto and the EU's Europe 2020 Strategy (20-20-20) goals with minimal effort [8]. However, it is important to note, as households' incomes rise and their energy consumption increases, so does the HDI. There is a direct correlation between increased energy consumption and HDI. Therefore, what was once a high energy intensity by industry in OMS is now a higher energy use by households due to higher income [9].

As our previous analysis show (e.g., [10,11]), in OMS, there is a decoupling between HDI and residential energy consumption. This is not the case in PCMS. While some countries show a positive trend towards (relative) decoupling, energy consumption in the household sector continues upward as the economy grows. Even with energy efficiency improvements accounted for—in PCMS, convergence towards higher energy consumption indicates, "those countries that have a weak initial level of energy efficiency and emissions (the new members) tend to grow comparatively faster than those with high initial levels", which are the OMS [5]. As Semieniuk et al. [12] indicate in this push–pull dichotomy of energy reduction vs. economic growth (or HDI growth), "large efficiency improvements are thermodynamically possible, achieving the projected absolute decoupling alongside successful industrialization presents an unresolved policy challenge". For Csereklyei and Stern [13], increased energy consumption is coupled to economic growth, being strongest in low and middle-income countries, with weaker decoupling in high-income countries.

The EU is confronted with a policy dilemma for reducing household energy consumption. Figure 1 demonstrates the historical trends of residential energy consumption with the EU goals of 2020 and 2030. Energy consumption by PCMS remains below OMS. The 2030 target indicates three general scenarios balancing energy reduction efforts with HDI convergence. Each scenario reflects the energy use-HDI coupling and decoupling conditions of each region. These scenarios are:

1. Energy equilibrium: OMS households reduce energy consumption to the PCMS level and PCMS consumption remains constant but with no energy–HDI uncoupling and no HDI convergence;
2. HDI-Energy disequilibrium: Energy consumption of both OMS and PCMS is jointly reduced, with a HDI decline in PCMS;

3. HDI equilibrium: PCMS energy consumption is allowed to increase so HDI converges on a reducing OMS energy path, thereby achieving an EU equilibrium for households.

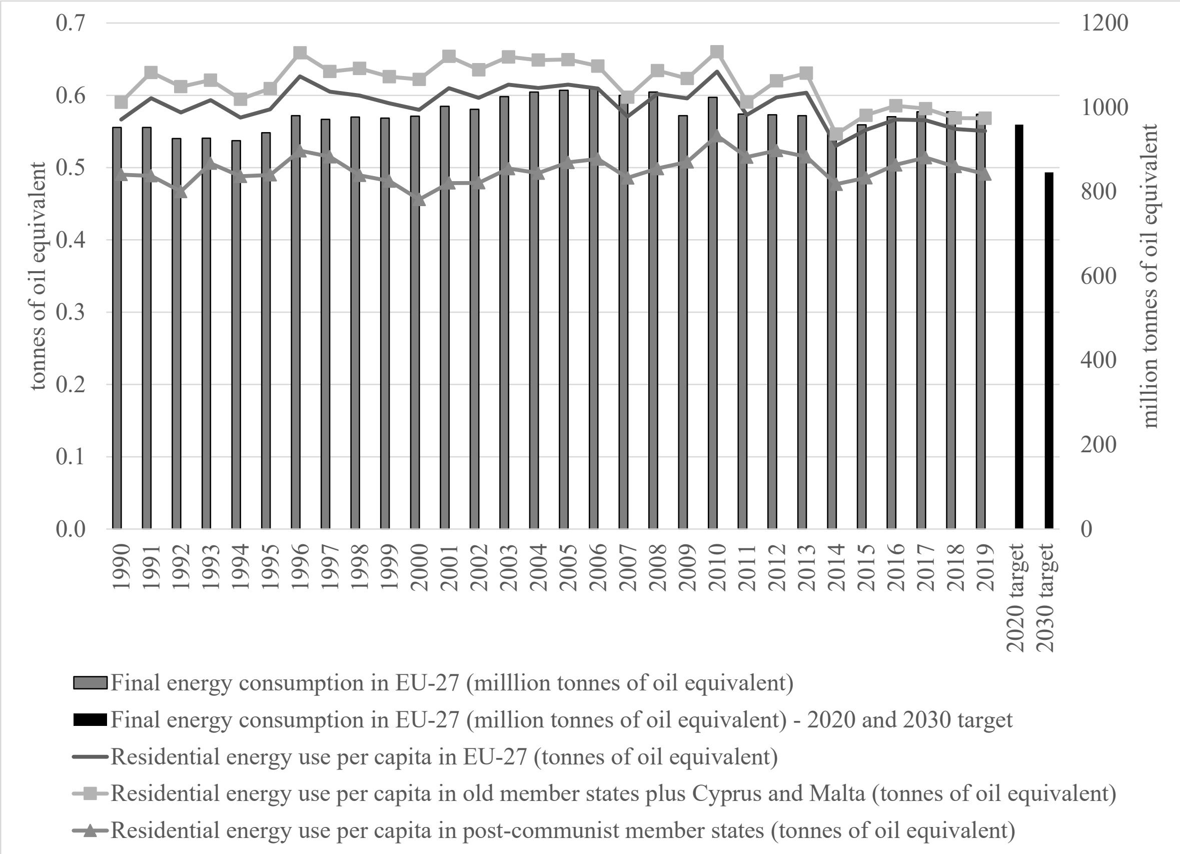

Figure 1. Residential energy use per capita (toe), final energy consumption (Mtoe), and energy efficiency targets (2020 and 2030, Mtoe) in the European Union (1990–2019).

Human development convergence, based on the goals of EU enlargement needs to occur in some form. Households across the EU will bear the cost of human development convergence and 2030 energy consumption goals in some form. In PCMS, this burden is proportionally higher due to lower incomes; therefore, in the energy equilibrium scenario, it is unlikely households and firms could afford to uncouple energy use at a lower level when OMS cannot afford to achieve this (the current energy crisis demonstrates the actions and efforts OMS need to take to reduce consumption levels and the economic and social impact).

The European Union is comprised of 27 member states. Europe was divided by the Iron Curtain and different political–economic systems for more than fifty years. The history and the Eastern enlargement of the European Union beginning in 2004 has sought both economic and political means to raise the living standards of those in the former communist countries in Eastern Europe. Due to the Cold War divisions in political–economic development, these two distinct groups are perceptible in data analysis. In short, because of geographic and historical influences, including the legacy of communism, there are different energy cultures [14] present in post-communist member states in the East, which are still attempting to catch up to the living standards of OMS.

As this section outlines, in recent years, a number of studies have focused on the relationship between energy consumption and human well-being [7,15–21]. Empirical evidence shows that higher residential energy use is associated with higher HDI. However, as countries develop, the strength of the relationship weakens [13], the importance for energy use declines, and its push effect on human well-being diminishes [21]. Households play a significant role in the environmental, energy, and climate goals of the European Union (regarding both 2030 and 2050 targets). In 2018, the household sector (as the second-largest end-use sector after transport) was responsible for 26.09% of final energy consumption in the European Union [9]. Nevertheless, the relationship between residential energy use and human well-being, including the differences between countries, is an underrepresented research area of energy economics, and it has received limited attention [21]. Both a direct and indirect relationship between energy consumption and HDI are important to assess. This section provides a review of the literature about the role of energy consumption in human development and the decoupling of energy use and economic growth (and HDI), along with outlining the policy implications of the EU's 'Fit for 55' when assessed through HDI indicators.

The spatial impact of the 'Fit for 55' package, with an expanded Emissions Trading Scheme (ETS), could increase household energy costs. As the ETS is expanded to include the building and transport sectors, energy costs are projected to increase [22]. Based on these projects, higher household energy costs place PCMS households in a precarious position. Under the present linking of HDI to residential energy consumption, as PCMS income and consumption (attempts to) grow to converge at an EU average, they will be constrained by higher energy costs (connected to ETS) and therefore forced into a cycle of lower consumption and mobility levels in comparison to OMS. Preventing human development convergence will maintain the current spatial inequality of HDI in the EU.

The consideration to expand ETS to road transport and the building sector would impact all EU households, such as doubling the cost of gas heating in France or an increase of 70% in Poland by 2030 (with 17% currently living in energy poverty); choosing a non-ETS heat source, household expenditure to heat could still increase 25%, thereby reducing the disposable income [22]. The deprivation of other energy services, such as cooling [23,24] and transport [25,26], also needs to be considered in terms of energy poverty, not only heat. The link between energy poverty and physical and mental health is established [27] and, in light of the COVID-19 pandemic, requires even more effort to ensure human development convergence within the EU.

The growth of HDI relies on a range of actions, but the correlation with energy consumption is well-established. Energy consumption and human well-being provide a corollary relationship whereby increasing energy production and consumption improves people's lives [7,15–21]. This correlation sustains itself up to a certain level; however, when energy consumption reaches a comparatively advanced stage, the relationship to well-being weakens. It is a turning point or called a saturation point (e.g., [28,29]) or a plateau (e.g., [19,30,31]). Increasing energy use past this 'plateau' does not necessarily contribute to a higher development stage. Here, we note that PCMS have not reached this point yet.

Decoupling occurs when the rates of economic growth (or HDI) is higher than rates of growth in energy consumption (relative decoupling) or the economic growth (or HDI) can be sustained with declining energy consumption (absolute decoupling) [11]. At this tipping point, the correlation between improving energy consumption and economic growth (or HDI) weakens (referring to the neutrality hypothesis, see more details in [32]). For countries reaching this decoupling stage, this means their economies can continue to grow without the expenses associated with increasing energy production. Human development convergence and decoupling become self-sustaining and can buffer societies from upheavals in the energy system.

The literature on the relationship between energy consumption and human development is extensive and several approaches can be found. Identifying the saturation point or threshold, is vital to understand when the correlation begin to weaken (e.g., [16,19,20,28,29,32–36]). Causal relations are also identified (e.g., [7,30,31,37–43]). The lack of convergence indicates spatial inequalities (e.g., [17,18,21,44,45]). Overall, the saturation level, once reached, buffers the well-being and economic growth from energy shocks that may hit those groups with a direct relationship between energy consumption and well-being. One group of studies focuses on determining the minimum quantity of energy (thresholds or minimum levels) needed to achieve a certain level of human development [16,19,20,29,34,36,46,47]. In [34], this certain level coincides with the 'high human development' category defined by the UNDP (it means exactly a life expectancy of 70 years at birth, a GDP of 10,000 USD, a literacy rate of 80%, and an HDI of 0.8). According to their results, the energy threshold is 60 GJ per capita in 2005 (and is predicted to decline to 45 GJ per capita in 2030). Mazur [30] points out a significantly higher level of energy use: in 2006, all nations consuming above 40 MWh (144 GJ) per capita have life expectancies near 80 years. Dias et al. [35] also set a higher level of HDI (0.85) and found that, for achieving this development stage, approximately 2.9 tep (121.42 GJ) per capita is needed.

In a case study focused on India [46], the threshold value is ca. 2400 kgoe per capita (100.48 GJ)—beyond which, this country would be able to reach the highest quality of life. Brecha [16] concluded that, in 2014, there was no country with an HDI score of 0.8 or above that had less than 40 GJ final energy consumption per capita. This practically means achieving this high HDI level needs at least this amount of energy use. Based on these studies, we conclude that the dispersion of thresholds is quite high. Furthermore, most researchers agree that these minimum levels are constantly declining as a function of technological development and time.

Not all energy is equal. There needs to be caution over the analysis of the well-being/economic buffer because of the type of energy or the energy quality a decoupled economy may hold. A new strand of empirical work highlights the importance of the energy quality and concludes different strengths of association. Ouedraogo [7] analyzed fifteen developing countries for the period of 1988–2008 and pointed out that a 1% increase in per capita electricity consumption still results in an HDI growth (by 0.22%). Still, a 1% increase in per capita energy consumption reduces the HDI by 0.8%. The results were also confirmed in another analysis [32], which went beyond the previous research. In this analysis, Tran et al. [32] could not even confirm the existence of a nonlinear relationship between the growth of HDI and energy consumption (neither in a global sample or in different development groups). This literature indicates there is more to the topic of energy and well-being than a corollary relationship of consumption and production. This article sets out to examine this relationship and uncover any direct and indirect relations between household energy consumption and human well-being.

2. Materials and Methods

This paper combines cross-sectional analysis with qualitative analytical methods, and this combination allows for a wider economic analysis. The three years chosen highlights the pathway analysis: 2000, 2008, and 2018. The availability and adequacy of the data justifies the selection of the starting year (2000) and the ending year (2018). The year 2008 is chosen as the intermediate year, because: (a) the peak of European energy consumption before the 2008–2009 financial crisis and (b) the time interval of 2009–2013 (as a result of the 2008–2009 global crisis) can be interpreted as a structural break (see more details in [11]). The 27 European Union member states are clustered into two main groups:

- Fourteen old member states plus Cyprus and Malta (OMS): Austria, Belgium, Cyprus, Denmark, Finland, France, Germany Greece, Ireland, Italy, Luxembourg, Malta, the Netherlands, Portugal, Spain, and Sweden;
- Eleven post-communist member states (PCMS): Bulgaria, Croatia, Czechia, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, and Slovenia.

The classification system in this paper allows a deeper comparison of country groups (highlighting the differences between OMS and PCMS). After the collapse of the communist regime in the USSR and in Eastern Europe in 1989–1992, there was a transition from a centrally planned economy to a market economy. Due to deindustrialization and technological advancement, the economic structure dramatically changed, and the energy intensity improved. However, compared to OMS, a lower energy efficiency in the end-use sectors is observed in PCMS. Structural problems in the residential sector still exist. Energy poverty is observed in the poor (technically obsolete and deteriorating) buildings, relatively higher energy prices, and low levels of disposable income [48,49].

The data analysis draws on the annual data, as listed in Table 1. Here, we note that the energy data are in tons of oil equivalent (toe) following the internationally accepted rules and conventions. Such energy use measures (but not SI metric units) is commonly used in energy, environmental, and sustainability studies [40]. The World Bank, International Energy Agency, and Eurostat provide this data also in this unit of measure.

Energy consumption is assessed in several types of indicators: (1) electricity consumption [16,19,37,38,47], (2) energy footprint (per capita) [28], (3) total primary energy footprint [33], (4) total primary energy consumption [34], or (5) quality energy usage [39]. As described in the next section, in this paper, we take a different approach, using residential energy use per capita as an independent variable; this addresses the motivation of this paper, which is to examine how the energy use of the household sector affects human development.

By focusing on human development, through the 'capabilities approach' developed by Sen and Nussbaum [50,51], well-being can be measured and considered in a broader social and economic system. This approach, described by Steinberger and Roberts [34], provides a definition and uniform measurement for human well-being. As a consequence, in this paper, human well-being is measured with the human development indicator (HDI) developed by the UNDP. The methodology of HDI is presented in detail [52]. The HDI is a widely used composite indicator, used in a range of studies [16,20,21,28,30,35,38]. The aim of HDI is to measure three key dimensions of human development, i.e., long and healthy life, knowledge, and a decent standard of living [52]. The data set for HDI is collected by the EU and available for a consistent comparison over a period of time in the member states, thereby lending itself to measuring spatial convergence.

Table 1. Applied data and their abbreviations.

Abbreviation	Indicator	Source
HDI	Human development index	[52]
POP	Population on 1 January—total (persons)	[9]
RES	Final energy consumption in households per capita (Final consumption—other sectors—households—energy use/Population on 1 January—total) (toe)	own calculation based on [9]
SHE	Share of households in final energy consumption (Final energy consumption in households/Final consumption for energy use) (%)	own calculation based on [9]
DIST	Inequality of income distribution [The ratio of total income received by the 20% of the population with the highest income (top quintile) to that received by the 20% of the population with the lowest income (lowest quintile); income must be understood as equivalised disposable income] (%)	[9]
URB	Urbanization (urban population, % of total population)	[53]
MAN	Manufacturing, value added (% of GDP)	[53]
GDP	GDP growth (Gross domestic product at market prices, 2010 = 100%)	[9]
FDI	Foreign direct investment, net inflows (% of GDP)	[53]
CO2	Carbon dioxide emission per capita (ton)	[9]
MET	Methane emission per capita (ton)	[9]
NIT	Nitrous oxide emission per capita (ton)	[9]
REN	Share of renewable energy in gross final energy consumption (%)	[9]
HDD	Heating degree days (number)	[9]
CDD	Cooling degree days (number)	[9]

The main methodological steps primarily assume a significant linear relationship between residential energy use per capita and HDI. The 'classical' pathway analysis is applied for different country groups (OMS and PCMS) to determine whether the residential energy use directly or, through other variables, indirectly affects the HDI.

Beyond the 'classical' pathway analysis, to test and evaluate the multivariate causal relationships, several methods are available, such as the Vector Autoregressive Model (VAR) or Structural Equation Modeling (SEM). This latter is often called a path analysis, referring to its origin [54]. However, the SEM uses factors for which the weight matrices of the input vectors are nonstationary and the clustering of the initial state vectors constituting the factors may also be a function of the year of observation. Due to that, the predetermination of clusters and weights for a selected year may bias the results for other years. To avoid this, the 'classical' pathway analysis is used. Furthermore, our primary goal is to reveal the magnitude and the proportion of the direct and indirect effects and testing them on pre-assumed causal relationships. Supporting this decision, Tarka [55] provided a detailed review of SEM highlighting its advantages and controversies.

In the path models, the zero-order linear correlation between the independent variables and the dependent variable is divided into two parts. One part is the effect that our independent variables have directly on the dependent variable, and the other part is the effect that the independent variables exert through other intermediate variables.

Wolfle [56] described the method in detail, and the main steps are presented below. The path analysis is a series of simple linear regressions and linear multiple regression. The method is clearly described by Alwin and Hauser [57] and Duncan [58] and can be considered as a basic tool of regional economics [59,60]. A simple linear regression (so-called bivariate regression) is a linear equation describing the relationship between an explanatory variable (residential energy use per capita) and a dependent variable (HDI). We assume that the explanatory variable influences the outcome variable. In our case, the basic equation is [61]:

$$y_i = \beta_0 + \beta_1 x_i + \epsilon_i, \tag{1}$$

where: y_i denotes the HDI of some country in the sample indexed by $i \in \{1, 2, \ldots, n\}$, x_i denotes the residential energy use per capita of the same country, i denotes the variables involved to the model, n denotes the number of involved and significant variables determined during the backward elimination procedure, β_0 is the sample estimate for the vertical intercept of the regression line, and β_1 is the sample estimate of the slope of the regression line with respect to HDI. The term ϵ_i is residual in regression and $i \in \{1, 2, \ldots, n\}$.

The linear multiple regression Is:

$$y_i = \beta_0 + \beta_1 x1_{1,i} + \beta_2 x1_{2,i} + \cdots + \beta_k x1_{k,i} + \epsilon_i, \tag{2}$$

where k is the number of explanatory variables.

Here, we note that a satisfactory and widely accepted (and applied) fit may be made using a linear relationship. In this paper, the main research goal is not to find the best fit but applying the simplest trend to reveal the main relationships. In the path analysis, further steps are allowed:

- Step 1: Determination of the primary and secondary explanatory factors (narrowing the numbers of indicators regarding the multicollinearity, if necessary).
- Step 2: Estimating the impact of the primary variable and secondary explanatory factors on the dependent variable. A simple multivariate linear regression (as a next step of the path analysis) is run, along with all independent variables.
- Step 3: A bivariate regression model is estimated (analyzing the relationship between the primary explanatory factor and dependent variable).
- Step 4: Identifying the path strengths. On the one hand, indirect paths may go over the secondary variables; at this time, all paths have to be added together from the onset to the dependent variable, while the proper path sections have to be multiplied together, i.e., irrespective of significances. Later, the effects of the significant indicators are analyzed together with the revealed paths [62].
- Step 5: The β coefficients of binary linear regressions (step 4) are broken down into indirect and direct parts in an additive way. The main purpose is to determine the direct and indirect effect of the primary explanatory factor on the dependent variable.

The separate analysis of direct and indirect effects is important, because it allows us to measure to distinguish effects over time and, considering the impact of a selected policy measure, both in the short term and in the long term. Furthermore, it contributes to a deeper understanding of any state intervention and revealing the detailed mechanism of actions.

Of course, the above does not imply that the predetermined model determines the outcome, since it is the significance of the regressions and the strength of the direct and indirect paths that determines the validity of our initial hypothesis. This means that the null hypothesis outlined in the structure of the initial model needs to be validated and evaluated after the calculations have been carried out.

3. Results

The present analysis focuses on the main causes (primary and secondary explanatory variables) of the HDI in the European Union member states. The relationship between residential energy use per capita and HDI is examined by factors in the year of 2000, 2008, and 2018. The main purpose is to analyze (following Tóth and Kincses [59,60]) the direct and indirect effects of residential energy use per capita by applying the path analysis method ([63,64]). Zero-order linear correlations of the independent and dependent variables are broken down into two parts in the path models. One part is the effect that independent variables directly have on a dependent variable; the other part is the effect produced by independent variable(s) through other intermediate variables [65].

A path analysis is a series of estimations of ordinary least squares (OLS) built upon each other. The first part examines the impact the primary variable has on indicators of a secondary group. The second part examines the primary and secondary variables impacting the dependent variable. The result finds the last regression, where all variables are joined. The analysis shows the impact of significant indicators [62].

In this current research, the residential energy use per capita and other social, economic, and environmental indicators are involved as independent variables, explaining the HDI as a dependent variable. The energy use of the households has a direct and, through other variables, an indirect influence, which is also quantified in this paper. To the best of our knowledge, this method was not previously applied in a residential energy consumption survey. Furthermore, only a few research articles have been carried out with the direct purpose to reveal the direct and indirect effects of energy consumption of households on the human development and determine the causal relationships (e.g., [7,32]).

A list of indicators providing an overview is developed from the literature (e.g., [32,40,43]). The potential list of indicators used in a former analysis is critically considered, and a selection is made. Variables for the examined years (2000, 2008, and 2018) include: inequality of income distribution (%); urbanization (urban population, % of total population); manufacturing, value added (% of GDP); GDP growth (gross domestic product at market prices, 2010 = 100%); foreign direct investment, net inflows (% of GDP); carbon dioxide emission per capita (ton); methane emission per capita (ton); nitrous oxide emission per capita (ton); share of renewable energy in gross final energy consumption (%); heating degree days; and cooling degree days (more details in Table 1). With the residential energy use per capita, these are considered independent variables that may explain the proportion of HDI. Here, we note, that the GNI per capita (PPP and USD) is a core indicator of HDI, and the application of GDP (which is tightly connected to the GNI) would raise methodological issues. However, in the analysis, the GDP growth (gross domestic product at market prices, 2010 = 100%) is applied to capture the economic growth and reflecting on the changes.

There are more indicators in the single groups of variables, which are excluded from our system as a result of preliminary calculations (steps 1 and 2). At the start, we explain the spatial distribution of the HDI with a simple multivariate regression (along with all independent variables). The first results indicate insignificance and high multicollinearity for several indicators. In the next stage, the backwards elimination procedure is applied in the linear regression to narrow the number of indicators involved. The insignificant variables are eliminated.

Finally, the indicators of the model with the most significant explanatory force are used for the path analysis. In this model, neither the insignificance nor the multicollinearity appear as a problem. After the backward elimination procedure, there are eight indicators that remain and are later used:

Independent variables: residential energy use per capita (toe); inequality of income distribution (%); urbanization (urban population, % of total population); manufacturing, value added (% of GDP); GDP growth (gross domestic product at market prices, 2010 = 100%); foreign direct investment, net inflows (% of GDP); carbon dioxide emission per capita (ton); methane emission per capita (ton); and share of renewable energy in gross final energy consumption (%). Dependent variable: HDI. In relation to the single indicator groups, the following hypotheses were devised.

Hypothesis 1 (H1). *The higher the residential energy use per capita, the higher the HDI.*

Hypothesis 2 (H2). *The smaller the income inequality, the greater the urbanization, the greater the share of the manufacturing industry in GDP, the more significant the expansion (development) of GDP, the greater the share of FDI (net inflows) in GDP, the higher the carbon dioxide emissions per capita, the higher the methane emissions per capita, and the higher the proportion of renewable energies in the final energy consumption, and the higher the European Union member states' HDI.*

The results obtained in the different models and their significance should be examined in the light of our hypotheses. In the analysis, we assume the primary explanatory factor (residential energy use per capita) influences differences in secondary factors (economy, society, and environment), which, in turn, affect the dependent variable (HDI). We also presume the primary and secondary explanatory factors influence the dependent variable in an indirect and an independent mean (the arrows in Figure 2 are to illustrate this causal relationship).

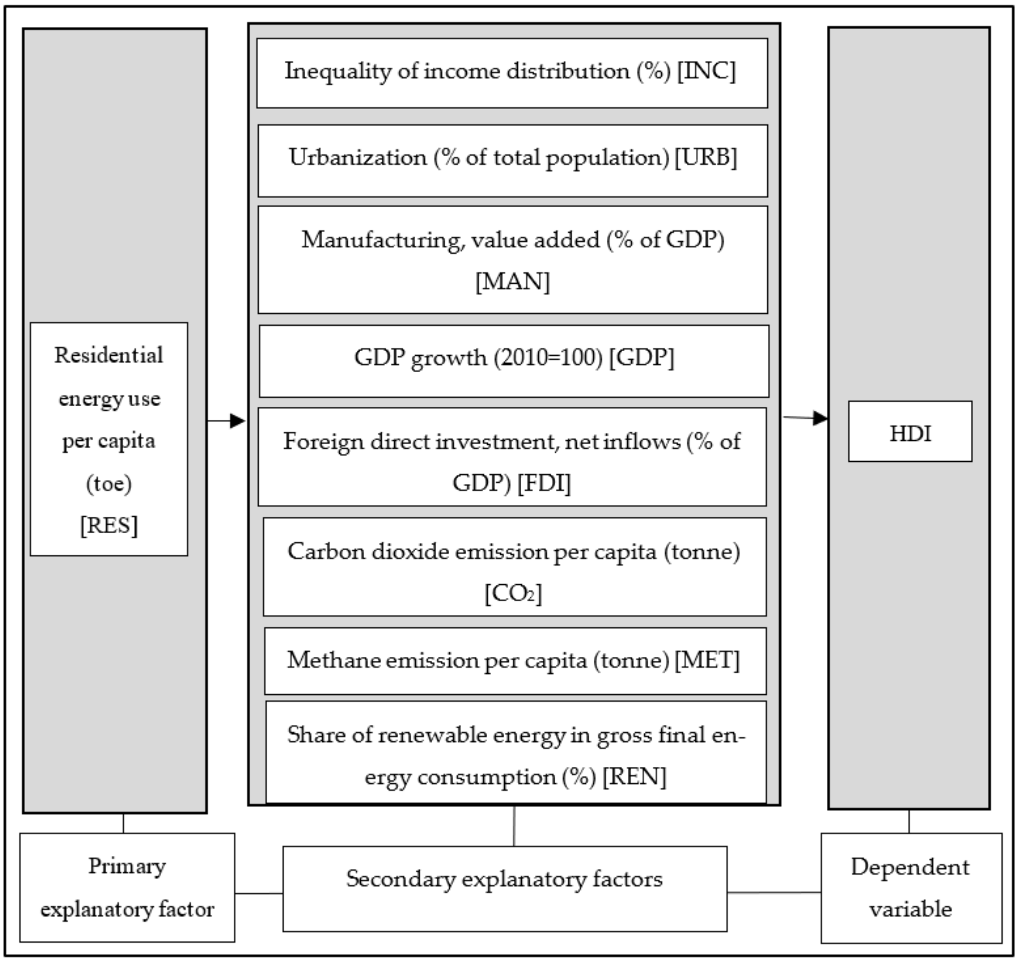

Figure 2. Causality relations of the groups of explanatory variables.

With the cleaned indicator set, the next step in the path analysis is a simple multivariate linear regression. This is run along with all independent variables (based on national data) explaining the territorial proportion of the HDI (repeating step 2). Our results are summarized by Table 2. An important point is that our variables involved in the analysis jointly explain the territorial proportion of the HDI with R^2 values of 0.58, 0.61, and 0.67. Due to this, significant differences occur over the years and are in the weight of the explanatory factors. In the end, residential energy use per capita and the urbanization have the most significant explanatory force in all cases.

Table 2. Regression results.

Coefficients	Denomination	HDI, 2000	Std. Error	HDI, 2008	Std. Error	HDI, 2018	Std. Error
β_1	RES	0.595 ***	0.047	0.698 ***	0.027	0.319 *	0.037
β_2	INC	−0.164	0.007	−0.190	0.006	−0.221	0.004
β_3	URB	0.193	0.001	0.211	0.000	0.468 ***	0.000
β_4	MAN	0.071	0.002	−0.031	0.002	0.313	0.001
β_5	GDP	0.214	0.001	0.154	0.001	−0.326	0.000
β_6	FDI	0.139	0.001	0.166	0.000	0.172	0.000
β_7	CO2	−0.377 **	0.002	−0.317 **	0.002	0.149	0.002
β_8	MET	−0.108	0.437	0.035	0.308	0.243	0.309
β_9	REN	−0.162	0.001	0.217	0.001	0.073	0.000
R^2		0.58		0.61		0.67	

Note: * 10% significance level, ** 5% significance level, and *** 1% significance level. Source: authors' analysis.

Table 2 shows that there is a significant relationship between the HDI and the explanatory variables based on multivariate regression results. Therefore, all variables included in the model are significant. However, in step 4, it may be the case that, for different clusters and different years, the regression models (that are built on each other) do not always show a significant relationship.

As a next step, the relations are analyzed among residential energy use per capita and HDI and, in the beginning, irrespective of their indirect or direct role (step 3). Table 2 illustrates steepness at a "simple" binary regression; R measures the closeness at this stochastic relationship. R^2 (adjusted R square) shows in percentages how the residential energy use per capita explains the dispersion of national distribution for HDI.

The results (Table 3) indicate the territorial distribution of residential energy use per capita explains itself in 46%, 49%, and 30% of the variances for HDI. These findings indicate that residential energy use plays a significant role in the territorial distribution of the dependent variable. Within the three examined years, the explanatory force of residential energy use per capita decreased slightly. In addition, in the regression and the steepness of these variables, being positive means that the residential energy use per capita growth has a push effect on the HDI, thereby leading to higher human well-being. Importantly, this effect is also valid in other directions: a decline in the residential energy use per capita negatively affects human well-being.

Table 3. Binary regression results between residential energy use per capita and HDI.

Coefficients	HDI, 2000	Std. Error	HDI, 2008	Std. Error	HDI, 2018	Std. Error
B	0.691 ***	0.033	0.714 ***	0.026	0.574 ***	0.031
R^2	0.456		0.490		0.303	

Note: *** 1% significance level. Source: authors' analysis.

Additionally, in the path analysis, the β-values were broken down into direct and indirect paths. First, there is an analysis of how the primary explanatory factor (residential energy use per capita) influences the secondary ones (step 4). The residential energy use per capita produces a significant effect on the urbanization and foreign direct investment, net inflows in 2000 (see Appendix A with Figures A1–A3; nonsignificant values are marked with italics and grey). The sign is positive, which means that the values of both indicators increase as the residential energy use per capita improves. In 2018, the residential energy use per capita has a significant effect on the carbon dioxide emission per capita and on the share of renewable energy in gross final energy consumption. The correlations in other cases are not significant at the 95% level of significance. We can conclude that the closest correlation is between the residential energy use per capita and the carbon dioxide emission per capita in 2018. Previously, we could see the largest β coefficient for foreign direct investment, net inflows and urbanization, respectively.

Regarding the effect of secondary explanatory factors on a dependent variable, it can be stated that, in 2000 and in 2008, the carbon dioxide emission per capita had a significant effect (See Appendix A, Figures A1 and A2). In 2018, the urbanization becomes significant (Figure A3). The key finding here is the carbon dioxide emission per capita and the urbanization have the most substantial effect on the HDI; they are the secondary explanatory factors.

Based on our models, the residential energy use per capita independently and significantly influences the HDI in all three years.

3.1. Direct and Indirect Impact on HDI

After identifying "path strengths" in our model (Figures A1–A3), we identify how the residential energy use per capita impacts the territorial distribution of HDI. The question to ask is, 'Does the residential energy use per capita directly or, through other factors, indirectly impact the human well-being (step 5)? As we have two groups of the independent variables (primary and secondary explanatory factors), so the β coefficients of binary linear regressions are broken down into indirect and direct parts by this procedure in an additional way. Table 4 shows the results.

Table 4. The roles of the direct and indirect paths in explaining the HDI (standardized β coefficients).

	HDI, 2000	**HDI, 2008**	**HDI, 2018**
indirect	0.152	0.027	0.255
direct	0.539	0.687	0.319
Total	0.691	0.715	0.574

Source: authors' analysis.

The coefficient of residential energy use per capita in 2018 shows the direct effect of the primary explanatory factor is 0.319. Indirect paths may go over the primary and secondary variables, and these are added together from the onset to the dependent variable, while the proper path sections are multiplied together (irrespective of significances). In 2018 the indirect effect is calculated in the following way: $-0.3 * -0.221 + 0.273 * 0.468 + 0.102 * 0.313 + 0.039 * -0.326 + -0.372 * 0.172 + 0.455 * 0.149 + 0.035 * 0.243 + 0.406 * 0.073 = 0.255$. In addition to the direct effect, the paths have the strongest effect where the residential energy use per capita influences the HDI through urbanization.

In the three years analyzed, the residential energy consumption does not hold only an indirect relationship to the HDI through other social, economic, and environmental indicators, but it does hold a direct relationship. Table 4 demonstrates the direct and indirect effects on the dependent variable. It can be stated that, if a larger residential energy use growth would be realized in the European Union, the effect would be appeared in the short term or visa versa, *reducing energy use puts at risk the human well-being achieved*. This is due the residential energy use having a direct effect on the HDI and not only indirect effects (which would take longer to appear in the human well-being).

3.2. Path Analysis Results—Country Classification Based on OMS-PCMS Division

In the second round of the path analysis, the calculations are run again in different country groups (Table 5). First, a simple multivariate linear regression is run, along with all independent variables explaining the territorial distribution of the HDI in OMS and PCMS. The variables involved in the analysis explain with R^2 values of 0.67, 0.81, and 0.67 the territorial proportion of the HDI in OMS in 2000, 2008, and 2018. In PCMS, the results of R^2 are −0.29, 1.00, and 0.81, respectively (the negative adjusted R^2 in 2000 means insignificance of the explanatory variables). Second, significant differences are found in the weight of the explanatory factors; between any two years, the largest differences can be found in PCMS. Third, these differences have changed significantly over the examined years and examined country groups.

Table 5. Regression results.

Coefficients	Denomination	OMS 2000 HDI	OMS 2000 Std. Error	OMS 2008 HDI	OMS 2008 Std. Error	OMS 2018 HDI	OMS 2018 Std. Error
β_1	RES	0.340	0.035	0.919 ***	0.019	0.152	0.036
β_2	INC	−0.513	0.008	−0.229	0.005	−0.125	0.007
β_3	URB	−0.057	0.001	0.162	0.000	0.307	0.001
β_4	MAN	−0.005	0.002	0.150	0.001	0.675 **	0.001
β_5	GDP	−0.388	0.001	0.332	0.001	0.295	0.000
β_6	FDI	0.347	0.001	0.054	0.000	−0.139	0.000
β_8	CO_2	−0.341	0.004	0.116	0.002	0.231	0.003
β_9	MET	−0.089	0.266	0.127	0.198	−0.323	0.385
β_{10}	REN	0.195	0.001	0.234	0.000	0.028	0.000
R^2		0.67		0.81		0.67	

Coefficients	Denomination	PCMS 2000 HDI	PCMS 2000 Std. Error	PCMS 2008 HDI	PCMS 2008 Std. Error	PCMS 2018 HDI	PCMS 2018 Std. Error
β_1	RES	0.335	0.418	0.174	0.174	−2.851	0.356
β_2	INC	0.385	0.045	0.273	0.273	−1.369	0.017
β_3	URB	−0.594	0.007	−0.221 **	−0.221	1.260	0.003
β_4	MAN	−0.620	0.013	0.189	0.189	0.156	0.002
β_5	GDP	0.040	0.002	−0.498 **	−0.498	−1.521	0.001
β_6	FDI	−0.406	0.014	0.294 **	0.294	−1.459	0.002
β_8	CO_2	0.569	0.015	0.212 **	0.212	2.097	0.007
β_9	MET	−1.082	8.659	−1.047	−1.047	2.376	2.519
β_{10}	REN	−0.892	0.004	0.136	0.136	2.887	0.004
R^2		−0.29		1.00		0.81	

Note: ** 5% significance level. and *** 1% significance level. Source: authors' analysis.

The relations are analyzed among residential energy use per capita and HDI as a next step (Table 6). The residential energy use per capita explains in itself in 69.6%, 68.6%, and 44.6% of the variances for HDI in OMS, while, in the other group, these numbers are 37.7%, 28.3%, and 26.9%, respectively. The importance of residential energy use per capita declined from 2000 to 2018 in both groups. In the regression, the steepness at these variables was positive in both groups in all three years.

Regarding the secondary explanatory variables, while the residential energy use per capita has a significant effect only on the GDP growth in 2000 and none in 2008. In 2018, it has an impact on the foreign direct investment and net inflows (OMS). In PCMS, a significant effect cannot be detected in any year (detailed results are in Appendix A, Figures A4–A9).

The results also indicate the effect of the secondary explanatory factors on the dependent variable: in 2000 and in 2008, none of the secondary explanatory indicators, while, in 2018, the manufacturing, added value becomes significant in OMS. In PCMS, 2008 is the only examined year when the secondary explanatory factors become significant, namely the urbanization, GDP growth, foreign direct investment, net inflows, carbon dioxide emission per capita, and methane emission per capita. Considering the model as a whole, in OMS, the residential energy use per capita independently and significantly influences the HDI only in 2008. In PCMS, this is not valid for any of these years.

Table 6. Binary regression results between residential energy use per capita and HDI (2 groups of EU member states based on East–West division).

Coefficients	OMS					
	HDI, 2000	**Std. Error**	**HDI, 2008**	**Std. Error**	**HDI, 2018**	**Std. Error**
β	0.846 ***	0.018	0.841 ***	0.018	0.695 ***	0.024
R^2	0.696		0.686		0.446	
Coefficients	**PCMS**					
	HDI, 2000	**Std. Error**	**HDI, 2008**	**Std. Error**	**HDI, 2018**	**Std. Error**
β	0.663 **	0.074	0.596 **	0.058	0.585 *	0.062
R^2	0.377		0.283		0.269	

Note: * 10% significance level, ** 5% significance level, and *** 1% significance level. Source: authors' analysis.

Comparing the results with the model focusing on the full sample (on 27 member states of the European Union), in OMS, the direct effect of the residential energy use per capita on the HDI was detected only in 2008 (Table 7). In 2000 and in 2018, the residential energy use per capita indirectly, through other social, economic, and environmental indicators, affects the dependent variable. In PCMS, the direct effect did not appear at all; in all examined years, the indirect effect was determinant. However, the partial slopes have varied continuously and to a large extent.

Table 7. The role of direct and indirect paths in explaining the HDI (standardized β coefficients).

	OMS			PCMS		
	HDI, 2000	**HDI, 2008**	**HDI, 2018**	**HDI, 2000**	**HDI, 2008**	**HDI, 2018**
indirect	0.507	−0.078	0.543	0.329	0.422	3.433
direct	0.340	0.919	0.152	0.335	0.174	−2.851
Total	0.846	0.840	0.695	0.663	0.596	0.585

Source: authors' analysis.

4. Discussion

The convergence of living standards for all EU member states requires a common equilibrium of HDI human well-being across Europe. For the EU goals of 'Fit for 55' to be implemented, continuing the human development convergence of PCMS to a common EU well-being requires (controversially) increasing residential energy consumption along current policy tracks. One of our previous research [10] confirmed that decoupling of HDI from residential energy consumption has occurred in OMS, which has not happened in PCMS. Increasing household energy consumption directly relates to HDI; an increase or decrease in consumption is translated into measurable improvement or deterioration of HDI in the European Union.

For PCMS to converge to the same HDI as OMS, the residential energy consumption must increase to a similar level as in OMS. If greater energy production and consumption is hard to accept, then alternative targeted policies need to create decoupling much more rapidly to allow for an increase in HDI and economic growth. Just as the authors assume convergence is still an EU target, they also assume 'Fit for 55' is not a tool to keep citizens' PCMS well-being lower than those in OMS. Therefore, it is important to unpack the direct and indirect relationships between energy use and HDI. This will assist in providing policy suggestions. The research questions and hypotheses provide the means for this task.

4.1. More Energy and Higher HDI: Research Questions and Hypotheses

The first research question established if there was a significant relationship between residential energy use and HDI and which factors influence this. The results indicate both a direct and indirect relationship. As shown in OMS, a certain threshold of energy consumption enables decoupling, but until that point, energy and economic growth go hand-in-hand to deliver improved human well-being. Therefore, the decoupling of energy consumption from economic growth is "thermodynamically possible" but remains an "unresolved policy challenge" [12]. The above analysis indicates many regions of the EU where HDI is still coupled to residential energy consumption. HDI reflects the well-being of society, and household energy consumption is directly tied to these factors and, as our results indicate, the influence of the well-being of residents.

The second part of the question identifies the significant factors connecting the level of HDI and residential energy use. These are shown in the analysis to be: inequality of income distribution, urbanization, manufacturing (value added), and GDP growth; foreign direct investment (net inflows); carbon dioxide emission per capita and methane emission per capita; and the share of renewable energy in gross final energy consumption. These are directly tied to the well-being of citizens in post-communist member states, meaning the more renewable energy, lower emissions and higher FDI, the further the countries are towards decoupling and higher well-being.

The second research question asks about the positive (push) effective energy use has on HDI. Statistical analysis confirms that the relationship between residential energy use per capita and human well-being is apparent even in countries with high human development (for HDI of 0.80 and above). The policy challenge in the 'Fit for 55' plan is to ensure further HDI growth (and human development convergence) in PCMS but reduce residential energy use through policies that assist the decoupling of economic growth from energy consumption. Decoupling economic growth and energy use to meet 'Fit for 55' projections require this decoupling before energy consumption parity with Western Europe.

Framing the two research questions with the two hypotheses provides the ability to quantify the relationship between the dependent and independent variables. In H1, 'The higher the residential energy use per capita, the higher the HDI' is true. The path analysis proves that the residential energy use per capita independently and significantly influences HDI in 2000, 2008, and in 2018 in the European Union. H1 is accepted.

Following this, it can be stated that, if a larger residential energy use growth happens in the European Union, the impact would appear in the short term. An increase in energy use leads to an overall increase in HDI. However, it is also true in reverse; reducing energy use puts at risk the human well-being achieved across the EU. This is due to the residential energy use having a direct effect on the HDI and not only indirect effects.

H2 is partly confirmed; assessing the indirect path, it can be stated that the residential energy consumption through the urbanization and the carbon dioxide emission affects the HDI in the European Union. The impacts are both short and long term. H2 shows that the results are much more fragmented when divided between OMS and PCMS. Except for one year (2008, OMS), a direct effect did not occur. However, other social, economic, and environmental indicators affect human well-being and the residential energy use per capita indirectly. That is, at the EU-27 level, both the direct and indirect effects are confirmed. However, in the separate division of OMS and PCMS, only the indirect effect is proven (except one year—2008, OMS; in 2008, in OMS, both the direct and indirect effect are confirmed). The reason for this cannot be determined. Nonetheless, the indirect effect is also important, as it shows that, at a regional level, the effects occur over the long term. Therefore, change over time is also important to consider.

4.2. Scenario Analysis—Creating an Equilibrium in Energy Use and Human Well-Being

The 2030 scenarios outlined at the start of the article outline three scenarios for the convergence of HDI within the EU. These are based on historical trends, and the impact of higher energy prices in the EU remains to be seen. Economic convergence was a primary goal in the unification of Europe and exists as an important social and policy goal. Convergence, as demonstrated in the results, is tightly tied to energy use influencing economic performance and human well-being. There are three scenarios outlined at the start of this article that provide paths towards convergence. Drawing on the historical analysis presented here, the third scenario appears the most likely: *HDI equilibrium*, PCMS residential energy consumption is allowed to increase so HDI converges on a reducing OMS energy path, thereby achieving an EU equilibrium for households, although increasing PCMS residential energy consumption runs counter to Fit for 55 policy projections. Stagnation or decline of human well-being seems an unlikely policy objective by PCMS politicians.

The policy goal of reducing residential energy use across all EU countries would reduce the well-being in PCMS. The spatial economic inequality within the EU is echoed in the inequality in energy use (since there is a direct connection between economic growth and energy use). OMS were able to decouple economic growth from energy consumption once their energy consumption reached a threshold; PCMS are not yet at this threshold, and thus, the linkage still exists. Therefore (and controversially), PCMS need to increase their energy use to the OMS level with the expectation that, once this is done, decoupling will occur. However, this runs counter to the assumptions in Fit for 55, which, if fully implemented, assumes that PCMS can reduce their energy use from their current levels. If the energy use is reduced, this holds the side effect that HDI will also decline (as shown by our results), thereby making the current policy package exacerbate the current spatial inequalities in the EU. This is why Fit for 55 is not fit for EU economic and social convergence.

However, the current energy crisis emerging in 2022 needs to be addressed in this study's findings. Even if the study was not designed with it in mind, the current historic high prices for electricity and gas may make the first two scenarios more likely, even if the historical trajectory indicates scenario one as a likely future, and the ramifications of lower energy consumption will decrease the well-being in the whole EU.

Central to the first two scenarios is a drop in energy use by OMS consumers, in 2022, this is likely to happen with high residential prices and policy interventions. More specifically, in scenario one, *energy equilibrium* holds the PCMS residential energy use as constant but with no convergence, thereby maintaining a lower HDI and EU spatial inequality. Scenario two, *HDI–energy disequilibrium*, envisions the perpetuation of spatial inequality even with residential energy use decline for both OMS and PCMS, including an HDI decline for PCMS. It remains to be seen how the dramatic energy price growth and rapid decline in OMS energy demand affects human well-being and whether the HDI level for the whole EU is lowered or only in PCMS.

It is beyond the scope of the analysis as to whether OMS HDI will decline because of the high 2022 energy price levels and demand reduction efforts. Since these are technically decoupled, the projection would be that the HDI will be maintained, but at such high prices, compounded with demanded reduction efforts, it will be important to assess whether HDI in OMS declines as the residential energy use declines. The impact of the current energy crisis demands further research into the well-being and the residential energy use connection.

5. Conclusions

The historical trajectory of increasing residential energy use to improve human well-being in countries is coupled. Within Europe, there is a decoupling in OMS, while PCMS are still increasing energy consumption to improve their HDI. The policy assumption in the Fit for 55 package is that energy consumption can be reduced across the EU. Since there is a direct connection between residential energy use and HDI, according to our findings, based on the historical analysis, reducing energy use will directly and indirectly decrease HDI across the whole EU. This is likely more pronounced in PCMS because of the factors directly tied to HDI, such as emissions and use of renewable energy, along with income inequality. For policies to be effective at decoupling residential energy use and well-being, a much greater awareness needs to be fostered between the spatial differences in well-being within the EU. The neglect of this will only perpetuate the present inequalities.

The expansion of the EU held as a central goal the convergence of living standards. Fit for 55 needs to be designed with the goal of an equilibrium of household well-being across the whole EU. Policy makers in PCMS will be politically challenged to reduce residential energy consumption when energy consumption and HDI are already below the OMS households. The convergence of well-being in the European Union will either: (1) need to be fueled by expanded renewable energy production (at an affordable level) and even higher, and more aggressive, levels of investments in energy efficiency and a greater reduction of income inequality or (2) household energy consumption and HDI in PCMS remain below the OMS households; citizens need to accept the spatial inequality in well-being.

There is a very real threat spatial inequalities of well-being (such as high levels of energy poverty and lower income and health) within the EU and even within PCMS will increase due to higher energy costs as the price for carbon neutrality increases for households. Unfortunately, these inequalities are already becoming more pronounced because of the dramatic rise in energy prices across the whole EU in 2022. Due to the war in Ukraine, the EU launched the more aggressive REPowerEU plan to speed up the implementation of Fit for 55 proposals. Assessing the impact of current energy crisis is beyond the scope of this paper, but the current findings can provide a research agenda in three areas to understand what the impact on residential households will be in the EU.

First, the primary and secondary variables that are shown to have a direct and indirect effect on HDI should be closely tracked. Particularly, economic indicators such as the manufacturing value added, GDP growth, and FDI. As businesses respond to high energy prices, a broader economic impact may be felt. Currently, OMS HDI is decoupled from energy consumption, but as economic activity declines and unprecedentedly high energy prices remain, it will be important to assess whether decoupling remains. Our findings point towards regional divisions within Europe, and this may become more pronounced, as exposure to Russian gas may deliver a bigger impact over others with less.

Second, the household factors identified earlier, such as residential energy use, income inequality, and urbanization, can signal the decline or improvement in well-being during the crisis. Likely, there will be a decline in HDI, and policy measures can be taken that can offset the specific factor(s) influencing the drop, such as financial support for low-income households to pay energy bills or carry out energy efficiency improvements.

For the third area, further research should address how well the current national efforts meet the Fit for 55 targets will deliver improvements in HDI and reduce energy poverty. The results of our analysis are unsettling if greater energy production and consumption are the means to raise HDI in PCMS households to the OMS level. Within the framing of Fit for 55, higher levels of energy poverty in PCMS should prompt consideration as to how higher energy prices will be affordable for a household with less discretionary spending and are already in energy poverty or now falling into it. If the current high prices from the energy crisis are also factored in, then the potential exists for a rapid expansion of vulnerable households and a sustained period of energy poverty. Regardless of policy interventions. This will likely reduce HDI and make convergence even further off for PCMS.

Policy recommendations to make 'Fit for 55' realistic and work for PCMS require a more concerted effort—and resources—to decouple economic growth from residential energy consumption. The current envisioned policies of the 'Fit for 55' package of expanding ETS to the household sector threatens to dampen the growth in disposable income of PCMS households, as more income will be redirected to pay for energy expenses. Increasing the cost of energy consumption in buildings threatens to imperil both households' health and financial resources and the human development convergence in the long term.

The spatial inequalities already present in the EU will be sustained because of the 'Fit for 55' requirements. From a policy perspective, 'Fit for 55' runs counter to economic and social convergence, which served as a basis for joining the EU for the EU member states and their people. Nonconvergence can, as an EU agency already stated, fuel anti-European sentiment, spread feelings of social injustice, and undermine the European project [2]. The current energy crisis is exacerbating these spatial inequalities. HDI needs to be included as a means to create effective policy options that lead to the convergence of household well-being across the EU.

Author Contributions: Conceptualization, M.C.L. and T.S.; methodology, G.T. and T.S.; software, G.T.; validation, G.T.; formal analysis, M.C.L., G.T. and T.S.; investigation, M.C.L., G.T. and T.S.; resources, G.T. and T.S.; data curation, G.T.; writing—original draft preparation, M.C.L. and T.S.; writing—review and editing, M.C.L. and T.S.; visualization, G.T. and T.S.; and supervision, M.C.L. All authors have read and agreed to the published version of the manuscript.

Funding: This publication is the result of research conducted for Central European University, Private University—CEU GmbH. It was made possible by the CEU Open-Access Fund.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Acknowledgments: The authors would like to thank the six anonymous reviewers for their useful comments and suggestions on the earlier drafts of this article.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

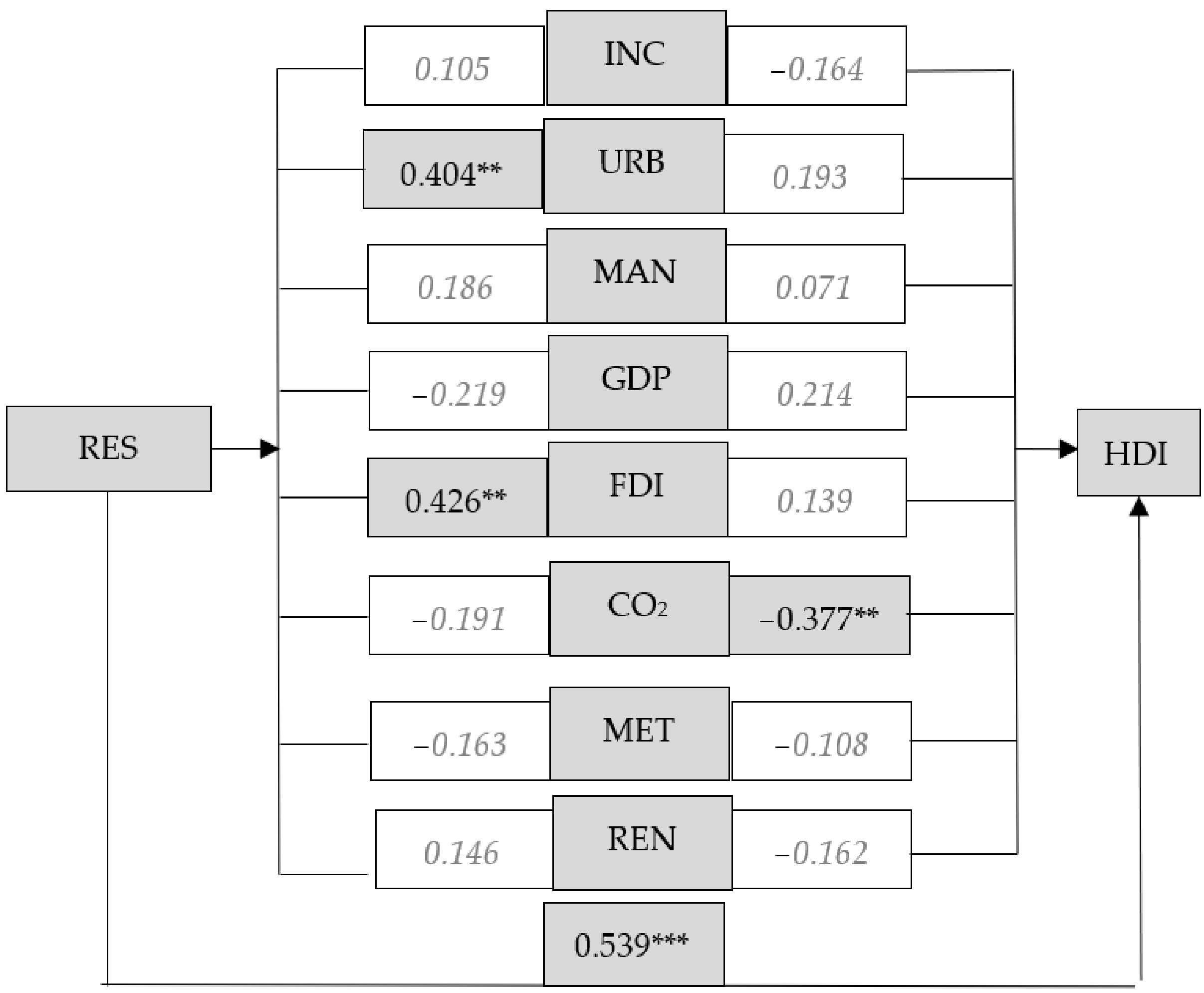

Figure A1. Role of the residential energy use per capita in explaining HDI of EU member states, 2000. Note: the insignificant values are marked with italics and grey. ** 5% significance level, and *** 1% significance level.

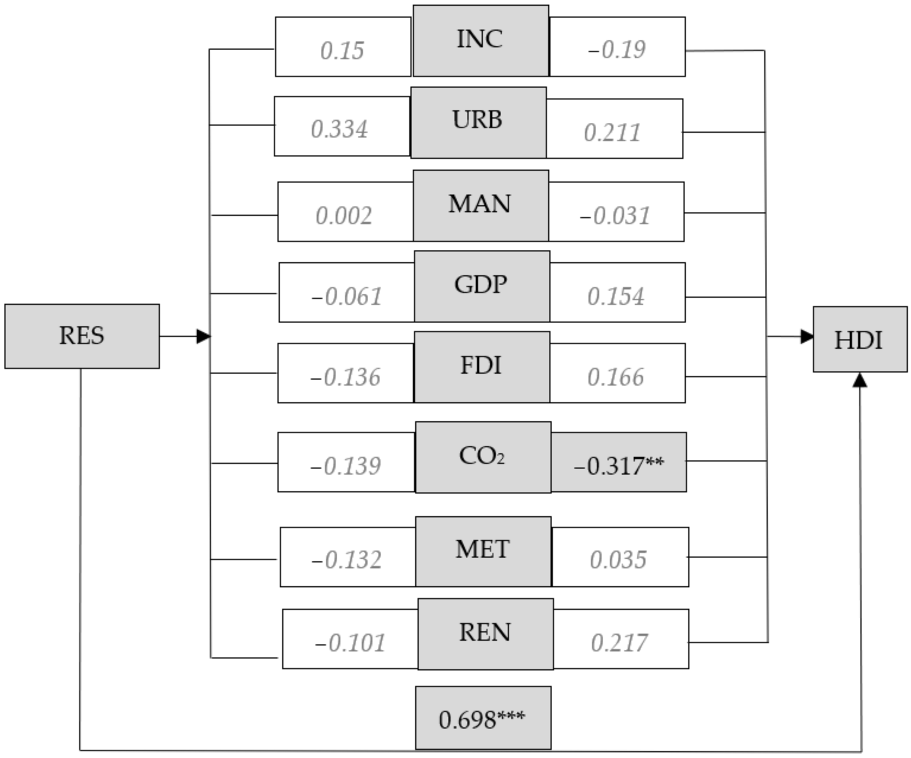

Figure A2. Role of the residential energy use per capita in explaining HDI of EU member states, 2008. Note: the insignificant values are marked with italics and grey. ** 5% significance level, and *** 1% significance level.

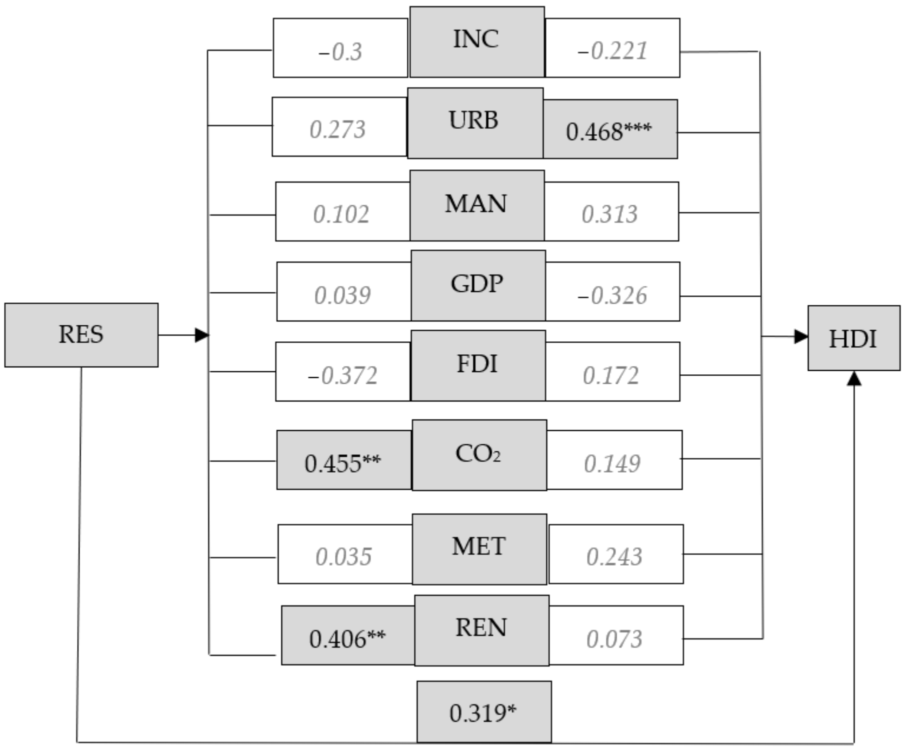

Figure A3. Role of the residential energy use per capita in explaining HDI of EU member states, 2018. Note: the insignificant values are marked with italics and grey. * 10% significance level, ** 5% significance level, and *** 1% significance level.

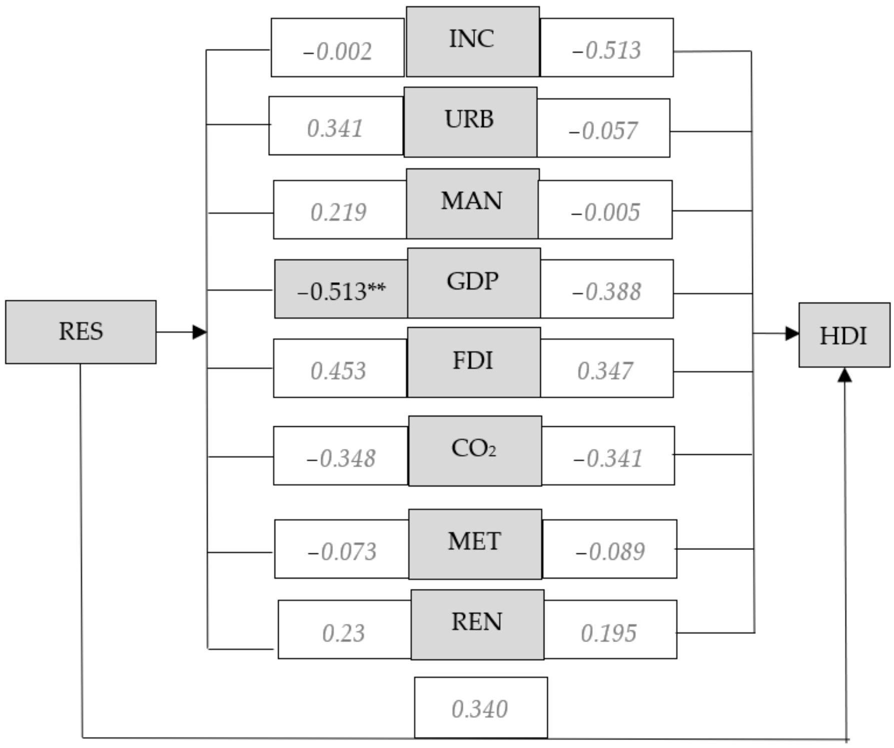

Figure A4. Role of the residential energy use per capita in explaining HDI of OMS, 2000. Note: the insignificant values are marked with italics and grey. ** 5% significance level.

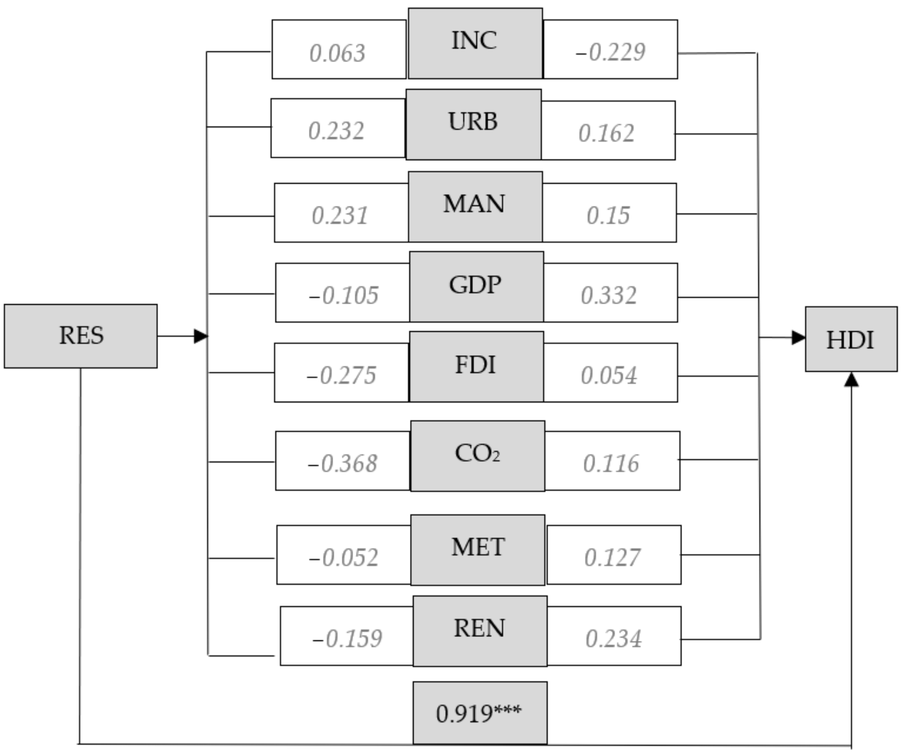

Figure A5. Role of the residential energy use per capita in explaining HDI of OMS, 2008. Note: the insignificant values are marked with italics and grey. *** 1% significance level.

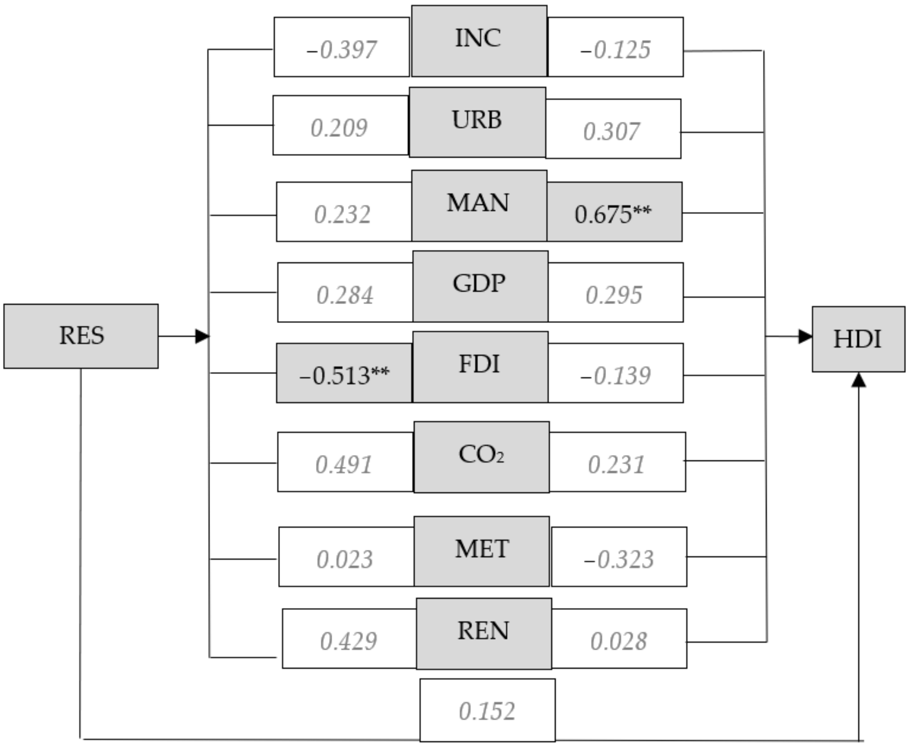

Figure A6. Role of the residential energy use per capita in explaining HDI of OMS, 2018. Note: the insignificant values are marked with italics and grey. ** 5% significance level.

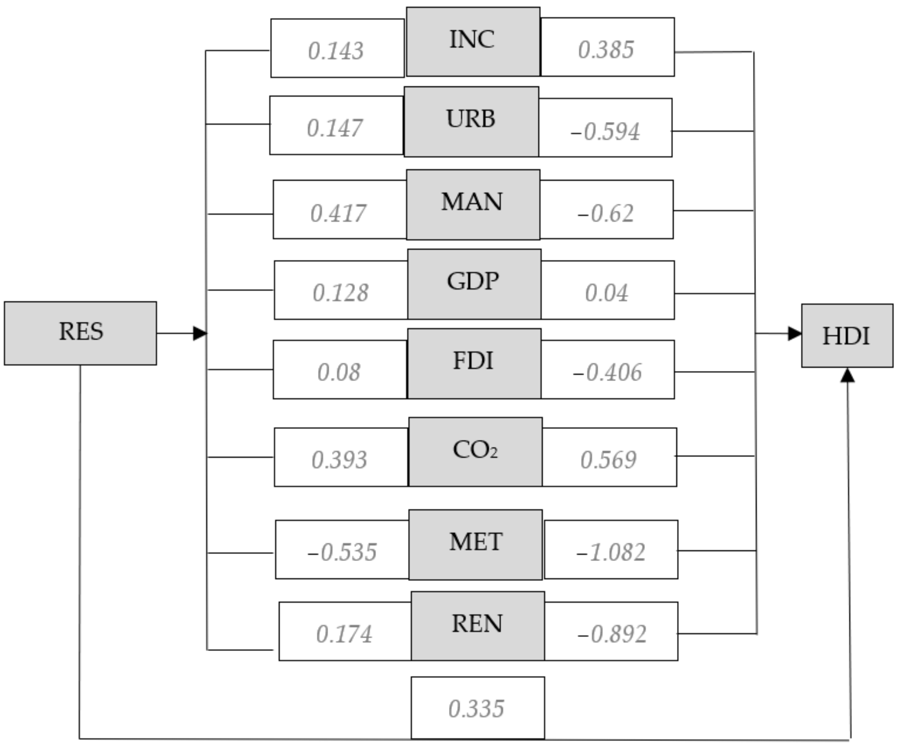

Figure A7. Role of the residential energy use per capita in explaining HDI of PCMS, 2000. Note: the insignificant values are marked with italics and grey.

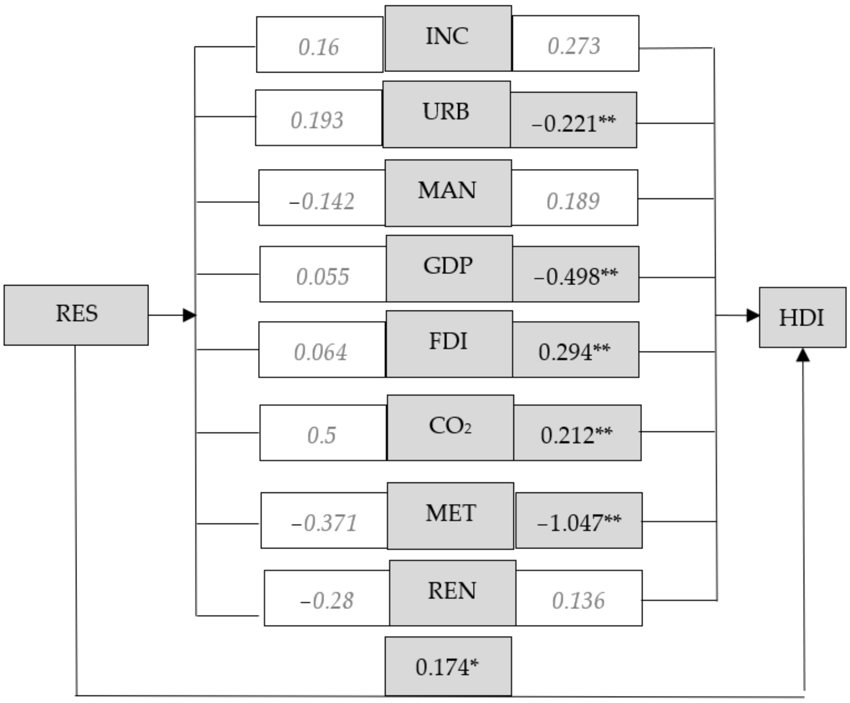

Figure A8. Role of the residential energy use per capita in explaining HDI of PCMS, 2008. Note: the insignificant values are marked with italics and grey. * 10% significance level, ** 5% significance level.

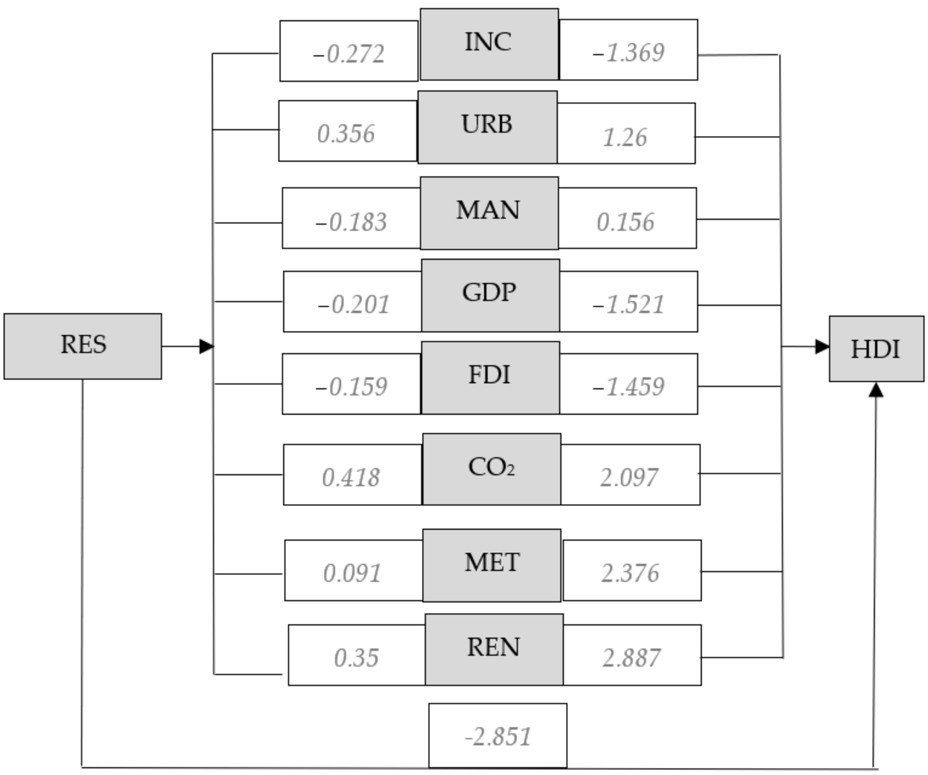

Figure A9. Role of the residential energy use per capita in explaining HDI of PCMS, 2018. Note: the insignificant values are marked with italics and grey.

References

1. European Commission. *"Fit for 55": Delivering the EU's 2030 Climate Target on the Way to Climate Neutrality. COM/2021/550 Final*; European Commission: Brussel, The Netherland, 2021; p. 15.
2. Measuring Convergence. Available online: https://www.eurofound.europa.eu/topic/measuring-convergence (accessed on 6 May 2022).
3. Ridao-Cano, C.; Bodewig, C. *Growing United: Upgrading Europe's Convergence Machine: Overview*; World Bank Group: Washington, DC, USA, 2018.
4. Bouzarovski, S.; Tirado Herrero, S. The Energy Divide: Integrating Energy Transitions, Regional Inequalities and Poverty Trends in the European Union. *Eur. Urban Reg. Stud.* **2017**, *24*, 69–86. [CrossRef] [PubMed]
5. Sebestyénné Szép, T. Energy Convergence of the European Union toward 2020. *Deturope* **2016**, *8*, 20. [CrossRef]
6. Evans, J.; Hunt, L.C. *International Handbook on the Economics of Energy*; Reprint edition; Edward Elgar Pub.: Cheltenham, UK, 2011; ISBN 978-0-85793-825-1.
7. Ouedraogo, N.S. Energy Consumption and Human Development: Evidence from a Panel Cointegration and Error Correction Model. *Energy* **2013**, *63*, 28–41. [CrossRef]
8. European Commission. Europe 2020 Targets 2017. Available online: https://ec.europa.eu/info/energy-climate-change-environment/overall-targets-and-reporting/2020-targets_en (accessed on 8 September 2022).
9. Eurostat Database—Eurostat. Available online: https://ec.europa.eu/eurostat/data/database (accessed on 1 February 2021).
10. Szép, T.; Tóth, G.; LaBelle, M.C. Farewell to the European Union's east-west divide: Decoupling energy lifts the well-being of households, 2000–2018. *Reg. Stat.* **2022**, *12*, 159–190. [CrossRef]
11. Szlávik, J.; Sebestyénné Szép, T. Delinking of Energy Consumption and Economic Growth in the Visegrad Group. *Geogr. Tech.* **2017**, *12*, 139–149. [CrossRef]
12. Semieniuk, G.; Taylor, L.; Rezai, A.; Foley, D.K. Plausible Energy Demand Patterns in a Growing Global Economy with Climate Policy. *Nat. Clim. Chang.* **2021**, *11*, 313–318. [CrossRef]
13. Csereklyei, Z.; Stern, D.I. Global Energy Use: Decoupling or Convergence? *Energy Econ.* **2015**, *51*, 633–641. [CrossRef]
14. LaBelle, M.C. *Energy Cultures. Technology, Justice, and Geopolitics in Eastern Europe*; Edward Elgar Publishing: Northampton, MA, USA, 2020; ISBN 978-1-78897-575-9.
15. Arto, I.; Capellán-Pérez, I.; Lago, R.; Bueno, G.; Bermejo, R. The Energy Requirements of a Developed World. *Energy Sustain. Dev.* **2016**, *33*, 1–13. [CrossRef]
16. Brecha, R.J. Threshold Electricity Consumption Enables Multiple Sustainable Development Goals. *Sustainability* **2019**, *11*, 5047. [CrossRef]
17. Jacmart, M.C.; Arditi, M.; Arditi, I. The World Distribution of Commercial Energy Consumption. *Energy Policy* **1979**, *7*, 199–207. [CrossRef]
18. Jacobson, A.; Milman, A.D.; Kammen, D.M. Letting the (Energy) Gini out of the Bottle: Lorenz Curves of Cumulative Electricity Consumption and Gini Coefficients as Metrics of Energy Distribution and Equity. *Energy Policy* **2005**, *33*, 1825–1832. [CrossRef]
19. Pasternak, A.D. *Global Energy Futures and Human Development: A Framework for Analysis*; U.S. Department of Energy, Lawrence Livermore National Laboratory: Livermore, CA, USA, 2000.
20. Steinberger, J.K.; Roberts, J.T. From Constraint to Sufficiency: The Decoupling of Energy and Carbon from Human Needs, 1975–2005. *Ecol. Econ.* **2010**, *70*, 425–433. [CrossRef]
21. Wu, Q.; Maslyuk, S.; Clulow, V. Energy Consumption Inequality and Human Development. *Energy Effic.* **2012**, *18*, 1398–1409.
22. European Climate Foundation. Cambridge Econometrics Exploring the Trade-Offs in Different Paths to Reduce Transport and Heating Emissions in Europe. Available online: https://www.transportenvironment.org/discover/exploring-the-trade-offs-in-different-paths-to-reduce-transport-and-heating-emissions-in-europe/ (accessed on 6 May 2022).
23. Sanchez-Guevara, C.; Núñez Peiró, M.; Taylor, J.; Mavrogianni, A.; Neila González, J. Assessing Population Vulnerability towards Summer Energy Poverty: Case Studies of Madrid and London. *Energy Build.* **2019**, *190*, 132–143. [CrossRef]
24. Thomson, H.; Simcock, N.; Bouzarovski, S.; Petrova, S. Energy Poverty and Indoor Cooling: An Overlooked Issue in Europe. *Energy Build.* **2019**, *196*, 21–29. [CrossRef]
25. Horta, A. Automobility and Oil Vulnerability: Unfairness as Critical to Energy Transitions. *Nat. Cult.* **2020**, *15*, 134–145. [CrossRef]
26. Martiskainen, M.; Sovacool, B.K.; Lacey-Barnacle, M.; Hopkins, D.; Jenkins, K.E.H.; Simcock, N.; Mattioli, G.; Bouzarovski, S. New Dimensions of Vulnerability to Energy and Transport Poverty. *Joule* **2021**, *5*, 3–7. [CrossRef]
27. Bouzarovski, S. Energy Poverty Policies at the EU Level. In *Energy Poverty: (Dis)Assembling Europe's Infrastructural Divide*; Bouzarovski, S., Ed.; Springer International Publishing: Cham, Switzerland, 2018; pp. 41–73. ISBN 978-3-319-69299-9.
28. Arto, I.; Capellán, I.; Lago, R. The Energy Footprint of Human Development. *XIV Jorn. Econ. Crítica* **2014**, 134–151. Available online: http://www5.uva.es/jec14/comunica/A_EEMA/A_EEMA_6.pdf (accessed on 8 September 2022).
29. Martínez, D.M.; Ebenhack, B.W. Understanding the Role of Energy Consumption in Human Development through the Use of Saturation Phenomena. *Energy Policy* **2008**, *36*, 1430–1435. [CrossRef]
30. Mazur, A. Does Increasing Energy or Electricity Consumption Improve Quality of Life in Industrial Nations? *Energy Policy* **2011**, *39*, 2568–2572. [CrossRef]

31. Nadimi, R.; Tokimatsu, K. Modeling of Quality of Life in Terms of Energy and Electricity Consumption. *Appl. Energy* **2018**, *212*, 1282–1294. [CrossRef]
32. Tran, N.V.; Tran, Q.V.; Do, L.T.T.; Dinh, L.H.; Do, H.T.T. Trade off between Environment, Energy Consumption and Human Development: Do Levels of Economic Development Matter? *Energy* **2019**, *173*, 483–493. [CrossRef]
33. Akizu-Gardoki, O.; Bueno, G.; Wiedmann, T.; Lopez-Guede, J.M.; Arto, I.; Hernandez, P.; Moran, D. Decoupling between Human Development and Energy Consumption within Footprint Accounts. *J. Clean. Prod.* **2018**, *202*, 1145–1157. [CrossRef]
34. Steinberger, J.K.; Roberts, J.T. *Across a Moving Threshold: Energy, Carbon and the Efficiency of Meeting Global Human Development Needs*; Klagenfurt University: Klagenfurt, Austria, 2009.
35. Dias, R.A.; Mattos, C.R.; Balestieri, J.A.P. The Limits of Human Development and the Use of Energy and Natural Resources. *Energy Policy* **2006**, *34*, 1026–1031. [CrossRef]
36. Krugmann, H.; Goldemberg, J. The Energy Cost of Satisfying Basic Human Needs. *Technol. Forecast. Soc. Chang.* **1983**, *24*, 45–60. [CrossRef]
37. Assadzadeh, A.; Nategh, H. The Relationship between per Capita Electricity Consumption and Human Development Indices. In Proceedings of the 6th IASTEM International Conference, Berlin, Germany, 29 November 2015; pp. 1–7, ISBN 978-93-85832-50-5.
38. Kanagawa, M.; Nakata, T. Assessment of Access to Electricity and the Socio-Economic Impacts in Rural Areas of Developing Countries. *Energy Policy* **2008**, *36*, 2016–2029. [CrossRef]
39. Ray, S.; Ghosh, B.; Bardhan, S.; Bhattacharyya, B. Studies on the Impact of Energy Quality on Human Development Index. *Renew. Energy* **2016**, *92*, 117–126. [CrossRef]
40. Jorgenson, A.K.; Alekseyko, A.; Giedraitis, V. Energy Consumption, Human Well-Being and Economic Development in Central and Eastern European Nations: A Cautionary Tale of Sustainability. *Energy Policy* **2014**, *66*, 419–427. [CrossRef]
41. Pasten, C.; Santamarina, J.C. Energy and Quality of Life. *Energy Policy* **2012**, *49*, 468–476. [CrossRef]
42. Sušnik, J.; Zaag, P. van der Correlation and Causation between the UN Human Development Index and National and Personal Wealth and Resource Exploitation. *Econ. Res. Ekon. Istraživanja* **2017**, *30*, 1705–1723. [CrossRef]
43. Sweidan, O.D.; Alwaked, A.A. Economic Development and the Energy Intensity of Human Well-Being: Evidence from the GCC Countries. *Renew. Sustain. Energy Rev.* **2016**, *55*, 1363–1369. [CrossRef]
44. Gaye, A. *Access to Energy and Human Development*; Human Development Report Office Occasional Paper: New York, NY, USA, 2007; Volume 25, p. 22.
45. Pachauri, S.; Spreng, D. Energy Use and Energy Access in Relation to Poverty. *Econ. Polit. Wkly.* **2004**, *39*, 271–278.
46. *The Global Innovation Index 2018: Energizing the World with Innovation*; Dutta, S.; Lanvin, B.; Wunsch-Vincent, S. (Eds.) World Intellectual Property Organization: Geneva, Switzerland, 2018; ISBN 979-10-95870-09-8.
47. Leung, C.S.; Meisen, P. How Electricity Consumption Affects Social and Economic Development by Comparing Low, Medium and High Human Development Countries. *Glob. Energy Netw. Inst.* **2005**, *12*. Available online: http://www.geni.org/globalenergy/issues/global/qualityoflife/HDI-vs-Electricity-Consumption-2005-07-18.pdf (accessed on 8 September 2022).
48. LaBelle, M.C.; Georgiev, A. The Socio-Political Capture of Utilities: The Expense of Low Energy Prices in Bulgaria and Hungary. 2016, p. 21. Available online: https://erranet.org/download/socio-political-capture-of-utilities-bulgaria-hungary (accessed on 8 September 2022).
49. Weiner, C.; Szép, T. The Hungarian Utility Cost Reduction Programme: An Impact Assessment. *Energy Strategy Rev.* **2022**, *40*, 100817. [CrossRef]
50. Nussbaum, M. *Women and Human Development*; Cambridge University Press: Cambridge, UK, 2000.
51. *The Quality of Life*; Nussbaum, M.; Sen, A. (Eds.) WIDER Studies in Development Economics; Oxford University Press: Oxford, UK, 1993; ISBN 978-0-19-828797-1.
52. UNDP Human Development Data (1990–2018) | Human Development Reports. Available online: http://hdr.undp.org/en/data (accessed on 4 June 2020).
53. World Bank World Bank Open Data | Data. Available online: https://data.worldbank.org/ (accessed on 27 June 2020).
54. Fan, Y.; Chen, J.; Shirkey, G.; John, R.; Wu, S.R.; Park, H.; Shao, C. Applications of Structural Equation Modeling (SEM) in Ecological Studies: An Updated Review. *Ecol. Process.* **2016**, *5*, 19. [CrossRef]
55. Tarka, P. An Overview of Structural Equation Modeling: Its Beginnings, Historical Development, Usefulness and Controversies in the Social Sciences. *Qual. Quant.* **2018**, *52*, 313–354. [CrossRef] [PubMed]
56. Wolfle, L.M. Strategies of Path Analysis. *Am. Educ. Res. J.* **1980**, *17*, 183–209. [CrossRef]
57. Alwin, D.F.; Hauser, R.M. The Decomposition of Effects in Path Analysis. *Am. Sociol. Rev.* **1975**, *40*, 37–47. [CrossRef]
58. Duncan, O.D. Path Analysis: Sociological Examples. *Am. J. Sociol.* **1966**, *72*, 1–16. [CrossRef]
59. Tóth, G.; Kincses, Á. Regional Distribution of Immigrants in Hungary. *Hung. Geogr. Bull.* **2010**, *59*, 107–130.
60. Tóth, G.; Kincses, Á. Regional Distribution of Immigrants in Hungary—An Analytical Approach. *Migr. Lett.* **2011**, *8*, 98–110. [CrossRef]
61. Murray, J.M. R Tutorials for Applied Statistics. Available online: https://murraylax.org/rtutorials/ (accessed on 3 July 2020).
62. Németh, N. Fejlődési tengelyek az új hazai térszerkezetben. *ELTE Reg. Tudományi Tanulmányok* **2009**, *15*, 151.
63. Klem, L. Path Analysis. In *Reading and Understanding Multivariate Statistics*; American Psychological Association: Washington, DC, USA, 1995; pp. 65–97; ISBN 978-1-55798-273-5.

64. Loehlin, J.C.; Beaujean, A.A. *Latent Variable Models: An Introduction to Factor, Path, and Structural Equation Analysis*, 5th ed.; Routledge: London, UK, 2016; p. 390.
65. Székelyi, M.; Barna, I. *Túlélőkészlet az SPSS-hez. Többváltozós Elemzési Technikákról Társadalomkutatók Számára. Negyedik Kiadás*; Typotex Kft: Budapest, Hungary, 2008.