

Article

GHG Emissions Mitigation in the European Union Based on Labor Market Changes

Mihaela Simionescu ^{1,2,*}, Yuriy Bilan ^{3,*}, Piotr Zawadzki ⁴, Adam Wojciechowski ⁵ and Marcin Rabe ⁶¹ Institute of Management, University of Social Sciences, 9 Sienkiewicza St., 90-113 Łódź, Poland² Institute for Economic Forecasting, Romanian Academy, 13, Calea 13 Septembrie, District 5, 050711 Bucharest, Romania³ Faculty of Management, Rzeszów University of Technology, Al. Powstańców Warszawy 12, 35-959 Rzeszów, Poland⁴ Institute of Materials Science and Engineering, Lodz University of Technology, Stefanowskiego 1/15, 90-924 Lodz, Poland; piotr.zawadzki@p.lodz.pl⁵ Institute of Information Technology, Lodz University of Technology, Wólczńska 215, 90-924 Lodz, Poland; adam.wojciechowski@p.lodz.pl⁶ Institute of Management, University of Szczecin, 70-453 Szczecin, Poland; marcin.rabe@usz.edu.pl

* Correspondence: mihaela.simionescu@ipe.ro (M.S.); y.bilan@prz.edu.pl (Y.B.)

Abstract: The effects of the labor market on environmental issues are an actual problem at the global level, and recommendations are required to achieve equilibrium between labor productivity and environmental protection. Considering the ecological limits of work and the necessity of reducing the working time to mitigate GHG (greenhouse gas) emissions, this paper aims to assess the impact of the labor market on GHG emissions in the EU-28 countries. Using panel data models for 2007–2019, a positive effect of working time for employed persons on GHG emissions was detected. Labor productivity has a positive impact on emissions for most of the developed countries in the EU (old member states), while the effect is negative in the case of most of the new member states, which suggests that more efforts should be made by old member states to correlate labor productivity with a sustainable level of GHG emissions. As a novelty for research in the field, we assessed also the effect of targeted labor utilization on GHG emissions in order to describe the context of a sustainable economy that is an objective for each country in the EU. These results suggest that progress in GHG emissions mitigation might be achieved by reducing the working time for employed persons, which will also improve well-being. These recommendations could be useful also for other developed countries outside the EU that encounter the same difficulties.

Keywords: GHG emissions; labor productivity; GDP; labor utilization

Citation: Simionescu, M.; Bilan, Y.; Zawadzki, P.; Wojciechowski, A.; Rabe, M. GHG Emissions Mitigation in the European Union Based on Labor Market Changes. *Energies* **2021**, *14*, 465. <https://doi.org/10.3390/en14020465>

Received: 29 December 2020

Accepted: 13 January 2021

Published: 16 January 2021

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.



Copyright: © 2021 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

The connection between GDP and carbon emissions has opened up new approaches to dealing with climate change mitigation, including initiatives to slow down output growth. In this context, working time reduction might be a key policy measure to reduce emissions and protect employment. This study is the first to deal with the relationship between GHG emissions and working hours in EU countries. A similar approach was proposed for the US by Fitzgerald et al. (2018) to study the connection between average working hours and carbon emissions [1]. A strong and positive relationship between the two variables was observed in the US over the period 2007–2013. The authors considered more estimation techniques and various emissions drivers from political, economic, and demographic areas. Beside the benefits of reductions in working hours for emissions mitigation, social and economic benefits are enhanced, such as lower unemployment and well-being improvement.

The research hypothesis refers to the evaluation of the impact of various indicators related to the labor market (worked hours, labor productivity and target labor utilization)

on GHG emissions. The urgency of this investigation is justified by the necessity of developing climate change policies to alleviate the negative impact of employment on environment. These policies will differently affect workers, populations, sectors and regions. This tendency in policies supports the EU initiatives to a greener future. This interconnection between social, economic and environmental issues is in the middle of the European Commission's strategic vision for a competitive, sustainable and climate-neutral economy by 2050.

Our study is limited to the EU-28 countries in the period 2007–2019. The hypothesis stating the positive relationship between working time for employed persons and GHG emissions was supported by the empirical evidence. The EU policies should take into account sustainable development as enhanced by the reduction in working time.

After this introduction, the paper makes a detailed presentation of a literature review. The next sections describe the methodological framework and empirical results. The last part of the paper concludes.

2. Literature Review

The analyses of the connection between labor market development and the environment is a question that has not recently appeared to the scientists, but it increased its intensity in the last decade [2]. The main challenge is to find the main triggers and drivers of this impact, and exactly in this is the initial research question [3]. The diversity of the opinions spills over into intermediaries, such as the source of energy [4].

Starting with the sectorial analysis, the current research confirms that such traditional “non-ecological” sectors as petroleum companies are strongly affected by green-factor policies [5] affecting their capitalization, which creates not only soft social pressure, but is also a source of direct financial incentives [6,7]. The results provided by Filimonova et al. (2020) demonstrate that many investors support the idea that the petroleum companies with solid environmental performances are more promising, from the investment standpoint, than businesses with roughly the same financial performance but lower environmental indicators [8]. Within this context, on the one hand, Jonek-Kowalska (2017) confirmed that in the European Union the traditional coal mining industry tends to suffer from increasing economic and sector risk, and therefore it can be treated as a declining industry [7]. On the other hand, in many post-transition economies, such an approach is considered as a threat for energy security and local-regional economic development. This factor must negatively affect the process of energy transformation towards sustainable green energy. This issue was also discussed by Semenenko (2016) in the case of Ukrainian economy [9]. Additionally, these problems were analyzed by Balcerzak A. for the whole European union from the perspective of implementing the European 2020 environmental objectives at a macroeconomic level [10]. His research confirmed the long-term, difficult-to-change, structural diversity between the EU economies [11–13]. Thus, in their study, Jonek-Kowalska (2019) found an increasing share of renewable sources in the energy balance, but this growth is very slow in the EU and in Turkey in 1990–2017 [7]. The countries in question tend to choose the strategy, following which they decrease the share of coal, but at the same time increase their share of gas. The impact of the shift in the energy balance was not tested directly, but the existence of this impact is undoubted. This is supported by most of studies, i.e., Szyja, P. (2016) [14]. For example, Pimonenko et al. (2018) identified countries that are carbon dioxide emission leaders, and analyzed the key features, structures and indicators of the Eco-Efficiency Index [15].

The analysis showed that these countries ranked low in the Environmental Performance Index. Patrick Wijaya Tjoek and Pei-Ing Wu (2018) analyzed the relationship between economic development and environmental degradation, namely the level of carbon dioxide and sulfur dioxide emissions in Southeast Asia [16]. A similar study was conducted by Li Rui et al. (2019) for different provinces in China [17]. Going back to European economies, Chovancová and Tej (2000) carried out their quantitative evaluation for the link between the economic growth of the energy sector on the one hand and GHG

emissions generation by the V4 energy sectors (1995 to 2016) on the other [18]. The results these authors got demonstrate the presence of a strong decoupling between economic growth in the energy sector and GHG emissions produced by the same sector, and this might be considered as a positive effect.

There are currently many studies addressing the issue of reducing carbon dioxide emissions through the development of bioenergy, replacing natural gas with biomass products [19].

In its turn, the Granger causality test performed on the panel data shows the presence of a bilateral relationship between economic growth and energy use by biodiesel transport, and also between the economic growth and energy consumption of bioethanol transport [20–22]. The effects of international emissions trading (IET) were also assessed (i.e., Takeda et al. (2019)). Thus, Takeda et al. (2019) have proven that there is a possibility of welfare losses from IET, and it is not small at all for the exporters of permits [4]. More specifically, using the minimum wage and the wage curve models, the authors detected that exporters of emission permits might be disadvantaged, depending on the region. The authors also claim that PRC, for example, is more likely to experience economic damages under IET, while the Russian Federation would, most probably, benefit from IET. At the same time, we need to keep in mind that the implementation of these policies can really alleviate the labor market distortions simultaneously with emissions regulation, which means that all the regions would eventually benefit from IET.

A separate position is the low carbonization of the economy (Liao, et al. (2019), Hu, X., and Liu, C. (2016), Ouyang, X., and Lin, B. (2015)) [23–26]. So, Liao et al. (2019) analyzed the low-carbon supply chain management issues, and provided new tools for the selection of low-carbon electricity generator based on solar [23]. The new model integrating the social participatory allocation network (SPAN) and the analytic network process under the hesitant fuzzy linguistic environment was developed for the selection of low-carbon power producers and suppliers in uncertain situations. To better deal with the imprecise and uncertain information, the hesitant fuzzy linguistic term set is adopted to represent the quality information with linguistic expressions. In turn, Mahmoud Tnani (2018) found evidence that CO₂ emissions are positively affected by population size and the prices of photovoltaic systems, while environmental taxes, exports of high-efficiency technologies, R&D costs and innovation potential have a negative impact [27]. However, Marin, G., and Mazzanti, M. (2013) came up with brand new empirical data related to delinking income–environment relationships as regards CO₂ and air pollutants at the level of different sectors [3]. On the basis of the panel data set from the National Accounting Matrix, including Environmental Accounts (1990 to 2007), these authors have concluded that both decoupling and recoupling trends could develop in parallel with economic development. The total performance in terms of greenhouse gases (CO₂) is now not at all compliant with that established by the Kyoto targets. Thus, on the basis of econometric analysis, the same authors concluded that services usually demonstrate somewhat stronger delinking patterns as regards emissions in comparison with manufacturing. At the same time, the development of trade validates the presence of pollution in some cases, having at the same time negative implications when only trade within the EU-15 is separately considered. Most authors see the main mechanism for mitigating negative anthropogenic impacts in coal consumption regulation. Chen et al. (2018) in their study showed how the expansion of fossil fuel consumption, particularly that of coal, drives global socio-economic development and causes large-scale GHG emissions [28]. This paper analyzed and compared the GHG emission development pathways of China, the United States and India, and reflected on the motivations and mechanisms behind GHG emission reduction and whether these three major GHG emitters can control their coal consumption and promote GHG emission reduction. To achieve the goal of global GHG emission reduction, the international community should not only focus on coal conversion, but also increase international cooperation on mitigation efforts, as current globalized world anthropogenic climate change is a result of the economic development of all countries. However, the challenge of building sustain-

able energy systems should also be tackled from the microeconomic perspective, such as saving energy consumption in households. Within this context, Simanaviciene et al. (2016) assessed the energy-saving potential in households, applying the measures aimed at the behavior change of the population in the energy-saving direction [29]. The research showed that people's behavior related to energy saving is influenced by a number of macro-level and micro-level factors, which can be modified at the local and regional level.

Labor productivity and global production chains were considered [30]. Labor productivity is closely linked to many factors. For example, Resler, M. et al. (2018) examined the imperfect economic base, low labor productivity, and significant resource and energy intensity of production in the metallurgical industry of Ukraine [31]. Dykha et al. (2017) analyzed the possibilities of increasing labor productivity through raising venture capital and stimulating high-tech products [32]. These studies correlate in their results and discussion with Simas, M., Wood, R., and Hertwich, E. (2015), who introduced a consumption-based metric for productivity and reconfirmed that the offshoring of production to cheaper and more low-skilled, labor-abundant countries offsets, or even reverts, energy efficiency gains and climate change mitigation actions in developed countries [30]. In the literature, Kjellstrom, T. et al. (2009) had a look from the opposite side of the coin: they used certain physiological evidence on the effects of heat and climate guidelines on the secure work environment, climate modeling, and the global distribution of the working-age population to assess the effects of two climate-based scenarios on future labor productivity [2]. The authors concluded that the increased occupational heat exposure, which is subject to current climate changes, may significantly impact labor productivity and labor costs unless serious preventive measures are soon implemented. The same authors are also of the opinion that under such conditions, many workers would need to work longer hours and/or more workers would be needed. This effect can be mitigated to some extent by appropriate innovative capabilities usage [5]; however, the general conclusion about the overall impact of climate change on productivity has a strong theoretical background [33,34].

Global demographic trends also influence GHG emissions. As such, O'Neill et al. (2010) showed that slowing down the growth in population numbers can actually cause 16–29% reductions in emissions, and this is actually what's recommended as necessary by 2050 to prevent further threatening climate changes. Moreover, these authors have found that population aging and urbanization speed can seriously impact the emissions volumes in some regions of the planet [35].

The GHG emissions reduction policy is also relevant. Savitz and Gavriltea (2019) analyzed other important issues relevant to GHG emission reduction and adaptation to climate change [36]. The authors found that all three major sectors of economic activity, energy, agriculture, and industry and service, have impacted on GHG emissions, and all these sectors are also influenced by climate change. Potential impacts due to climate change are especially important for insurance companies due to the following: increased demand for environmental insurance products; increased demand for risk transfer; increased liquidity problems for insurance companies as a result of climate change risk; increased opportunities in GHG markets. These conclusions are in line with other studies on the links between gas emission and economic growth, for instance, those highlighted in Refs. [37,38], including those investigating the impact of low-altitude emissions from individual sources [39]. Therefore, the investigation of the relationship between climate change and the insurance sector provided in this paper allows for finding relevant risk management methods in the face of such phenomena as climate change.

The next valuable research question is in the direction of causality in the duality of environment safety and the labor market. Consequently, the representative study was conducted by Yoo, S. and Heshmati, A. (2019), who examined the influences of tightening environmental regulation on population employment and labor productivity (using a Korean manufacturing case study and its panel data, 2004 to 2015) [40]. Their results can be called somewhat predictable: environmental policies measured through the application of the LCGG (Low-carbon green growth) Act demonstrate some negative effects on labor

productivity and population employment in the most polluting industries. This correlates with Kjellstrom et al. (2009); however, authors went further and found out that the “green” sector usually experiences somewhat higher labor productivity and employment in comparison to other (not that green) sectors once environmental regulations come into force [2]. The overall trend is quite obvious: the environmental regulations tend to negatively influence the performance of non-green firms, primarily by increasing their costs; at the same time, within the green sector, these regulations promote both labor productivity and employment. Note, that the indicated causality nets are set only in the regulated, transparent economies. Vasylieva, T. et al. (2019) proved that increasing renewable energy (RE) by 1% led to a decline in GHG in the interval 0.166103–0.220551, and an increase in the Control of Corruption Index by 1%, provoked a decline in GHG by 0.88% (the case of Ukraine and the EU 2000–2016) [41]. Such a result is especially important for economies with high corruption and shadow economies, considering their impact on social and economic safety, including fair income distribution, as is proven in Refs. [42,43]. The same research hypothesis was approved by Bilan, Y. et al. (2019), who stated that developing affordable and efficient tools and mechanisms to promote RES implementation is necessary in order to decrease the related anthropogenic impact (CO₂ emissions in the first place), without experiencing any reduction in economic growth [44].

As such, the broad literature review revealed that despite the tremendous scientific interest in the topic, there is still a research gap in the assessment of the direct link between the labor market and GHG emissions.

3. Data and Methodology

As the main aim of the paper is to assess the relationship between labor market and GHG emissions, the variables used in this research will refer to indicators related to the labor market (working time for employed persons in hours per week provided by Eurostat, labor productivity in GDP per hour worked out from OECD whereby GDP is in USD, constant prices, 2010 PPPs, target labor utilization in hours per year calculated by authors using labor productivity, carbon budget per capita (in kg CO₂/cap) and carbon intensity (in kg CO₂/toe) provided by OECD and Eurostat) and GHG emissions (in thousands of tons of CO₂ equivalent) provided by Eurostat. All the indicators are registered with annual frequency in the period 2007–2019 for all the EU-28 countries. The macroeconomic data in the panel allow us to assess the impact of labor market quality on environment quality, so as to achieve equilibrium between human activity with economic value and the necessity of having a clean environment that can ensure good health for people.

Target labor utilization (*tLU*) is an indicator that reflects the number of hours worked that are required for a sustainable economy. For a country, *i*, the indicator is computed as:

$$tLU_i = \frac{CB/CI_i}{P_i} \quad (1)$$

CB—carbon budget per capita

CI—carbon intensity of an economy

P—labor productivity

In Figure 1, the evolution of GHG emissions in the period 2007–2019 is represented at the EU-28 level in order to observe the progress made in ensuring a cleaner environment with less pollution. This indicator plays the role of the dependent variable in our panel data models. According to Figure 1, the maximum value of GHG emissions in the period 2007–2019 was registered in 2007; after this year, the indicator decreasing by 2.16% in 2008. The minimum value was observed in 2014, this decrease being attributed to the decrease in CO₂ emissions by 5% in 2014 compared to 2013. The major contributor to global warming is represented by CO₂ emissions that account for almost 80% of GHG emissions in the EU-28. The GHG emissions are conditioned by economic growth, population effects, climate conditions and various industrial and transport activities.

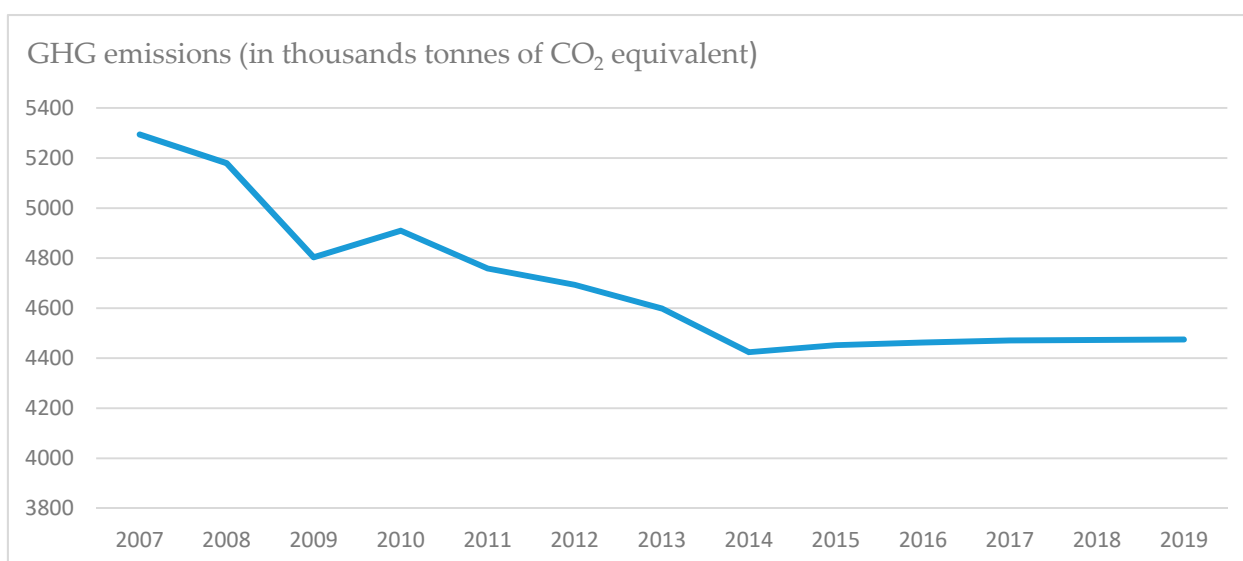


Figure 1. GHG emissions in thousands tons of CO₂ equivalent in the EU-28 countries (2007–2019).

The significant drop in emissions in 2009 is explained by the global financial and economic crisis that greatly reduced industrial activity. GHG emissions were high in Germany, the UK and France. Large decreases in emissions were achieved in the last 10 years by Lithuania, Estonia, Latvia, and Romania.

Within the EU, Germany and the Netherlands have the lowest working hours, while Greece has the highest working hours. Countries with fewer worked hours present higher levels of productivity, associated with better wealth per person.

Panel data models will be constructed to assess the impacts of indicators related to the labor market on GHG emissions. The cross-sections are represented by the EU-28 countries and the period refers to 2007–2019.

Let us start from a regression model based on cross-section and time series data (pooled ordinary least squares), without taking into account the fixed or random effects used in the panel approach (see Banaszewska, 2018; Zygmunt, 2018) [45,46]:

$$y_{it} = \beta_0 + \sum_j \beta_j X_{jit} + e_{it} \quad (2)$$

y_{it} —dependent variable for cross-section i at time t ; X_{jit} —the j -th independent variable for cross-section i at time t ; e_{it} —error term; β_j — j -th parameter; β_0 —intercept, $i=1, 2, \dots, N$; $t=1, 2, \dots, T$.

Changes in this general model will be made in order to estimate the fixed-effects panel models. This, in turn, would allow testing for individual effects. Considering a specific spatial effect that is constant in terms of time, the unobserved parameters could be modeled as fixed effects, which would appear with different values for each cross-section (β_{0i}). Unobserved heterogeneity can then be controlled, considering that it is unchanged in time and is eventually correlated with the regressors. The one-way fixed effects model is written as:

$$y_{it} = \beta_{0i} + \sum_j \beta_j X_{jit} + e_{it} \quad (3)$$

y_{it} —dependent variable for cross-section i at time t ; X_{jit} —the j -th independent variable for cross-section i at time t ; e_{it} —error term; β_j — j -th parameter; β_{0i} —unobserved individual effect for cross-section i and constant in time (it captures spatial fixed effects); $i=1, 2, \dots, N$; $t=1, 2, \dots, T$.

If the fixed-effects model includes individual constants, the random-effects model considers the constant as a random variable of mean β_0 . Moreover, the spatial differences are random deviations from this constant average.

$$\beta_{0i} = \beta_0 + \varepsilon_i \quad (4)$$

ε_i represents the error of the null average and constant variance σ_ε^2 .

The errors present a composite form:

$$u_{it} = \varepsilon_i + e_{it} \quad (5)$$

ε_i —error specific to cross-sections; e_{it} —random error.

4. Discussion

According to the Im–Pesaran–Shin test, the panel data in level form present unit root, but the data in logarithm form for all variables are stationary at the 5% level of significance.

More panel data models were estimated to explain the GHG emissions in the EU-28 based on number of worked hours, but in the end the pooled OLS (Ordinary least squares) regression was selected. In Table 1, the GHG emissions are explained based on worked hours to support our research hypothesis that was stated in the previous section. According to the Breusch–Pagan LM (Lagrange multiplier) test, there is no cross-section dependence (the value of statistic is 1.22, p -value = 0.189). For all the EU-28 countries, a positive influence of worked hours on GHG emissions was identified. A higher impact of worked hours on GHG emissions was observed in the case of Germany, where an increase in the number of worked hours by 1% determines, on average, a growth of GHG emissions by 3.053%. A high impact was also observed in the cases of the UK, Italy, France and Spain. On the other hand, the lowest influence of worked hours on GHG was registered by Cyprus, where an increase in the number of worked hours by 1% determines, on average, a growth of GHG emissions by only 1.82%. A similar performance was observed in the cases of Slovenia, Croatia and Lithuania (see Table 1).

Table 1. Pooled OLS regression to explain the GHG emissions based on worked hours in the EU-28 countries (2007–2019).

Variable	Coefficient	<i>t</i> -Statistic	Prob.
Constant	−4.528826	−1.606357	0.1096
LOG_HOURS Austria	2.374706	3.177634	0.0017
LOG_HOURS Belgium	2.523723	3.330355	0.0010
LOG_HOURS Bulgaria	2.323269	3.069366	0.0024
LOG_HOURS Croatia	2.095546	2.771682	0.0060
LOG_HOURS Cyprus	1.824839	2.421196	0.0163
LOG_HOURS Czech Republic	2.524953	3.352928	0.0009
LOG_HOURS Denmark	2.359422	3.062474	0.0025
LOG_HOURS Estonia	2.031629	2.673771	0.0081
LOG_HOURS Finland	2.370042	3.104394	0.0022
LOG_HOURS France	2.899233	3.816429	0.0002
LOG_HOURS Germany	3.053543	4.040827	0.0001
LOG_HOURS Greece	2.456113	3.294993	0.0011
LOG_HOURS Hungary	2.344663	3.083028	0.0023
LOG_HOURS Ireland	2.353352	3.078592	0.0023
LOG_HOURS Italy	2.896314	3.805309	0.0002

Table 1. Cont.

Variable	Coefficient	t-Statistic	Prob.
LOG_HOURS Latvia	1.887982	2.484152	0.0137
LOG_HOURS Lithuania	2.064334	2.695609	0.0076
LOG_HOURS Luxembourg	1.912182	2.511378	0.0127
LOG_HOURS Malta	1.535253	2.026685	0.0439
LOG_HOURS Netherlands	2.662444	3.505251	0.0006
LOG_HOURS Poland	2.807210	3.731150	0.0002
LOG_HOURS Portugal	2.357358	3.126832	0.0020
LOG_HOURS Romania	2.528473	3.324473	0.0010
LOG_HOURS Slovak Republic	2.236623	2.957027	0.0034
LOG_HOURS Slovenia	2.000971	2.652824	0.0086
LOG_HOURS Spain	2.803499	3.708347	0.0003
LOG_HOURS Sweden	2.329846	3.065572	0.0024
LOG_HOURS United Kingdom	2.914551	3.884871	0.0001

Source: own calculations.

We confirmed the hypothesis that there is a positive and significant relationship between GHG emissions and working hours, even if the intensity of this connection is still questionable. Previous studies identified the lower impact of working hours on emissions compared to our results. For example, Nassen and Larsson (2015) for Sweden and Stronge et al. (2019) showed that an increase of 1% in the working hours generates, on average, an increase of 0.8% in GHG emissions [47,48].

Our findings are also similar to the results obtained for the US by Fitzgerald et al. (2018) over the 2007–2013 period [1]. The authors proved a strong and positive relationship between carbon emissions and average working hours. Therefore, we may conclude that a working time reduction could contribute to emissions mitigation.

More panel data models were built for describing the evolution of GHG emissions in the EU-28 based on labor productivity, but in the end a fixed effects model was selected as the best. In Table 2, the GHG emissions are explained based on labor productivity to support our research hypothesis that was stated in the previous section. The test for redundant fixed effects indicated that the fixed effects model is better than the random effects model (statistic = 157.4, p -value 0.00). According to the Breusch–Pagan LM test, there is no cross-section dependence (the value of the statistic is 1.52, p -value = 0.165). In this case, there are countries wherein the labor productivity growth had a positive impact on GHG emissions (Germany, UK, Austria, Cyprus, Estonia, Luxembourg, Finland, France, Greece, Italy, Netherlands, Sweden and Slovenia), and countries exhibiting a negative impact of labor productivity on GHG emissions (the rest of the EU countries). The highest impact of labor productivity on GHG emissions was registered by France, where an increase in the labor productivity by 1% determines, on average, a growth of GHG emissions by almost 5.85%. A high impact was also observed in the cases of UK, Sweden and Finland. Belgium registered the strongest negative influence of labor productivity on GHG emissions. An increase in the labor productivity by 1% determines in Belgium, on average, a decrease in GHG emissions by almost 4.23% (see Table 2). In a similar study for the EU countries, Simas et al. (2015) explained that labor productivity has a positive impact on GHG emissions, but there are differences between exports and imports of produced goods [30]. However, there are countries wherein the increase in productivity generates decreases in emissions.

Table 2. Fixed effects model to explain the GHG emissions based on labor productivity in the EU-28 countries (2007–2019).

Variable	Coefficient	t-Statistic	Prob.	Fixed Effects in Cross-Sections
Constant	3.084282	2.602044	0.0100	-
LOG_PRODUCTIVITY Austria	0.418470	0.169037	0.8659	−0.645994
LOG_PRODUCTIVITY Belgium	−4.228235	−1.254570	0.2111	22.35009
LOG_PRODUCTIVITY Bulgaria	−0.697473	−1.760887	0.0798	3.637926
LOG_PRODUCTIVITY Croatia	−1.973733	−2.384460	0.0181	8.592227
LOG_PRODUCTIVITY Cyprus	1.649082	3.376769	0.0009	−8.203394
LOG_PRODUCTIVITY Czech Republic	−1.529256	−1.161062	0.2470	8.494610
LOG_PRODUCTIVITY Denmark	−2.870355	−4.242095	0.0000	14.57087
LOG_PRODUCTIVITY Estonia	0.571981	1.232132	0.2194	−2.507345
LOG_PRODUCTIVITY Finland	3.265985	4.334859	0.0000	−14.24606
LOG_PRODUCTIVITY France	5.846247	1.752436	0.0813	−24.65584
LOG_PRODUCTIVITY Germany	1.175201	0.617821	0.5374	−1.696959
LOG_PRODUCTIVITY Greece	1.554722	4.723170	0.0000	−5.316457
LOG_PRODUCTIVITY Hungary	−1.452678	−2.192440	0.0295	7.277454
LOG_PRODUCTIVITY Ireland	−0.246748	−1.159395	0.2477	2.294721
LOG_PRODUCTIVITY Italy	3.057773	4.059997	0.0001	−11.28358
LOG_PRODUCTIVITY Latvia	−0.308320	−0.880025	0.3799	0.652280
LOG_PRODUCTIVITY Lithuania	−0.631010	−2.231207	0.0268	2.656333
LOG_PRODUCTIVITY Luxembourg	0.188546	0.228106	0.8198	−1.496400
LOG_PRODUCTIVITY Malta	−1.763441	−1.804239	0.0727	6.080273
LOG_PRODUCTIVITY Netherlands	1.079677	1.113348	0.2669	−2.854071
LOG_PRODUCTIVITY Poland	−0.178439	−0.635034	0.5261	3.663037
LOG_PRODUCTIVITY Portugal	−0.652947	−0.475896	0.6347	4.048352
LOG_PRODUCTIVITY Romania	−1.044747	−3.784005	0.0002	5.915631
LOG_PRODUCTIVITY Slovak Republic	−1.710048	−2.574278	0.0108	8.241236
LOG_PRODUCTIVITY Slovenia	2.180342	1.690661	0.0925	−9.711269
LOG_PRODUCTIVITY Spain	−3.445807	−2.310405	0.0219	18.78657
LOG_PRODUCTIVITY Sweden	3.854284	2.834242	0.0051	−17.29007
LOG_PRODUCTIVITY United Kingdom	4.460316	3.769067	0.0002	−17.35418

Source: own calculations.

Labor productivity has a positive impact on emissions for most of the developed countries in the EU (old member states), while the effect is negative in the cases of most of the new member states, which suggests that more efforts should be made by old member states to correlate labor productivity to a sustainable level of GHG emissions.

More panel data models were constructed to explain the evolution of GHG emissions in the EU-28 based on target labor utilization, but in the end a fixed effects model was chosen as the best. In Table 3, the GHG emissions are explained based on target labor utilization to support our research hypothesis that was stated in the previous section. The test for redundant fixed effects indicated that the fixed effects model is better than the random effects model (statistic = 284.33, p -value 0.00). According to the Breush–Pagan LM test, there are no cross-section dependences (the value of statistic is 1.43, p -value = 0.127). Except for Malta, target labor utilization has a positive impact on GHG emissions. In the case of Finland, an increase in target labor utilization by 1% will generate a growth of GHG emissions by 2.52%, the highest percent in the sample (see Table 3).

The impact of target labor utilization on GHG emissions has not been previously evaluated in any study. As expected, the achievement of target labor utilization should generate a sustainable value for GHG emissions, but a value that is higher than the target will bring about a growth of emissions.

On the other hand, other factors that contribute to GHG emissions mitigation should not be neglected. Many developed countries still make efforts to abandon fossil fuels. For example, natural gas is substituted by biogas [49], coal is being replaced by charred biowaste [50], and biodiesel or vegetable oil is used instead of diesel [51]. Carbon-negative technologies are also profitable. Biowaste could be charred using waste heat in order to provide biochar that ensures a cheaper production cost [52]. Biochar improves soil quality, which might reduce the worked time in agriculture [53].

Table 3. Fixed effects model to explain the GHG emissions based on target labor utilization in the EU-28 countries (2007–2019).

Variable	Coefficient	t-Statistic	Prob.	Fixed Effects in Cross-Sections
Constant	7.595205	42.68101	0.0000	-
LOG_target labor utilization Austria	1.290708	2.325966	0.0210	1.198593
LOG_target labor utilization Belgium	0.887833	4.562631	0.0000	0.022864
LOG_target labor utilization Bulgaria	0.751750	4.321717	0.0000	−1.360586
LOG_target labor utilization Croatia	1.193971	6.566906	0.0000	−0.139935
LOG_target labor utilization Cyprus	0.780924	5.207532	0.0000	−2.734326
LOG_target labor utilization Czech Republic	0.984679	3.442137	0.0007	0.198950
LOG_target labor utilization Denmark	1.035592	7.693056	0.0000	0.110846
LOG_target labor utilization Estonia	1.329022	4.083331	0.0001	−1.026821
LOG_target labor utilization Finland	2.520250	5.235673	0.0000	3.748187
LOG_target labor utilization France	1.387689	3.519021	0.0005	3.297188
LOG_target labor utilization Germany	0.955921	1.446582	0.1496	2.397611
LOG_target labor utilization Greece	1.562980	6.447787	0.0000	2.624011
LOG_target labor utilization Hungary	1.189989	5.218068	0.0000	0.523914
LOG_target labor utilization Ireland	0.335334	3.472294	0.0006	−2.167776
LOG_target labor utilization Italy	1.503959	6.438319	0.0000	4.089052
LOG_target labor utilization Latvia	0.447631	1.561165	0.1201	−3.658754
LOG_target labor utilization Lithuania	0.373441	4.342400	0.0000	−3.283039
LOG_target labor utilization Luxembourg	0.566637	3.510276	0.0006	−3.367340
LOG_target labor utilization Malta	−0.168396	−0.934250	0.3513	−6.899195
LOG_target labor utilization Netherlands	0.946009	2.347054	0.0199	0.601370
LOG_target labor utilization Poland	0.244986	1.308398	0.1923	−0.796262
LOG_target labor utilization Portugal	1.158827	4.488078	0.0000	0.769669
LOG_target labor utilization Romania	0.659273	6.155120	0.0000	−0.498780
LOG_target labor utilization Slovak Republic	1.056760	4.857822	0.0000	−0.363325
LOG_target labor utilization Slovenia	1.539481	5.506877	0.0000	0.188531
LOG_target labor utilization Spain	1.028870	6.440760	0.0000	1.974870
LOG_target labor utilization Sweden	1.257058	3.422819	0.0008	0.384713
LOG_target labor utilization United Kingdom	1.548574	5.908787	0.0000	4.165770

Source: own calculations.

5. Conclusions

This research confirms the hypothesis that the decrease in the working hours will reduce the level of GHG emissions. However, the reduction in labor productivity has not mitigated GHG emissions in all the EU-28 countries. The labor productivity is dependent on the level of technology. In less developed countries from the EU (new member states), the increase in labor productivity will reduce GHG emissions, since the technological progress in industry is lower and does not bring higher emissions. In old member states, usually more developed, with a high technological progress that generates more emissions the increase in labor productivity will accelerate the growth of GHG emissions. An overall policy should promote shorter working hours in the EU economies. The reduction in working hours should not generate wage drops since it does not mean that productivity will decrease in all cases. The shortening of the working week should improve welfare and workplace efficiency, but also the environment, since GHG emissions drop.

Considering the differences between old member states and new member states, the analysis should also be made separately for the two groups of country- and design-specific policies for each group. This comparison will be the subject of a future study. In future research, the adjustment of working hours should be made to provide suitable welfare recommendations. A separate analysis for the country level could be developed to complete the panel data analysis. The GHG emissions should also be explained in the same model, using other variables related to actual challenges, such as the necessity of reducing heating costs [54–56]. Another future study should focus on an analysis at the industrial level in each country. This approach might direct us to practical recommendations in terms of alternative energy resources, government funding or subsidies for specific industries.

Author Contributions: Conceptualization, M.S. and Y.B.; methodology, M.S.; software P.Z., A.W.; validation, A.W. and P.Z.; formal analysis, P.Z., A.W. and M.R.; data curation, P.Z., A.W.; writing—original draft preparation, M.S., Y.B.; writing—review and editing, M.S., Y.B. and M.R. All authors have read and agreed to the published version of the manuscript.

Funding: This research was co-financed by the National Center for Research and Development project no. POIR.01.01.01-00-0281/20-00, entitled: Predictive energy management system EnMS.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

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

References

1. Fitzgerald, J.B.; Schor, J.B.; Jorgenson, A.K. Working hours and carbon dioxide emissions in the United States, 2007–2013. *Social Forces*. **2018**, *96*, 1851–1874. [\[CrossRef\]](#)
2. Kjellstrom, T.; Kovats, R.S.; Lloyd, S.J.; Holt, T.; Tol, R.S. The direct impact of climate change on regional labor productivity. *Arch. Environ. Occup. Health* **2009**, *64*, 217–227. [\[CrossRef\]](#)
3. Marin, G.; Mazzanti, M. The evolution of environmental and labor productivity dynamics. *J. Evol. Econ.* **2013**, *23*, 357–399. [\[CrossRef\]](#)
4. Takeda, S.; Arimura, T.H.; Sugino, M. Labor market distortions and welfare-decreasing international emissions trading. *Environ. Resour. Econ.* **2019**, *74*, 271–293. [\[CrossRef\]](#)
5. Bilan, Y.; Mishchuk, H.; Roshchuk, I.; Kmecova, I. Analysis of Intellectual Potential and its Impact on the Social and Economic Development of European Countries. *J. Compet.* **2020**, *1*, 22–38. [\[CrossRef\]](#)
6. Štreimikienė, D.; Mikalauskienė, A.; Mikalauskas, I. Comparative assessment of sustainable energy development in the Czech Republic, Lithuania and Slovakia. *J. Compet.* **2016**, *8*, 31–41.
7. Jonek-Kowalska, I. Transformation of energy balances with dominant coal consumption in European economies and Turkey in the years 1990–2017. *Oeconomia Copernic.* **2019**, *10*, 627–647. [\[CrossRef\]](#)
8. Filimonova, I.; Komarova, A.; Mishenin, M. Impact of the global green factor on the capitalization of oil companies in Russia. *Oeconomia Copernicana.* **2020**, *11*, 309–324. [\[CrossRef\]](#)
9. Semenenko, I. Energy security of Ukraine in the context of its sustainable development. *Equilib. Q. J. Econ. Econ. Policy* **2016**, *11*, 537–555. [\[CrossRef\]](#)
10. Balcerzak, A.P. Europe 2020 Strategy and Structural Diversity Between Old and New Member States. Application of Zero-unitarization Method for Dynamic Analysis in the Years 2004–2013. *Econ. Sociol.* **2015**, *8*, 190–210. [\[CrossRef\]](#)
11. Balcerzak, A.P. Europe 2020 Climate Change and Energy Objectives in EU-15. In Proceedings of the 11th International Days of Statistics and Economics. Conference Proceedings, Prague, Czech Republic, 6–8 September 2018; pp. 88–91.
12. Balcerzak, A.P. Cluster analysis of European economies in regard to Europe 2020 Climate Change and Energy Objectives. In Proceedings of the International Scientific Conference Quantitative Methods in Economics Multiple Criteria Decision Making XIX, 23–25 May 2018; Letra Edu: Trenčianske Teplice, Slovakia, 2018; pp. 7–14.
13. Balcerzak, A.P. Europe 2020 climate change and energy objectives in Central European countries. Measurement via taxonomic measure of development with generalized distance measure GDM. In Proceedings of the 36th International conference Mathematical Methods in Economics MME, 12–14 September 2018, Prague, Conference Proceedings; MatfyzPress, Publishing House of the Faculty of Mathematics and Physics Charles University: Prague, Czech Republic, 2018; pp. 7–12.
14. Szyja, P. The role of the state in creating green economy. *Oeconomia Copernic.* **2016**, *7*, 207–222. [\[CrossRef\]](#)
15. Pimonenko, T.; Lyulyov, O.; Chygryn, O.; Palienko, M. Environmental Performance Index: Relation between social and economic welfare of the countries. *Environ. Econ.* **2018**, *9*, 1–11. [\[CrossRef\]](#)
16. Tjoek, P.W.; Wu, P.-I. Exploring the environmental Kuznets curve for CO₂ and SO₂ for Southeast Asia in the 21st century context. *Environ. Econ.* **2018**, *9*, 7–21. [\[CrossRef\]](#)
17. Li, R.; Sineviciene, L.; Melnyk, L.; Kubatko, O.; Karintseva, O.; Lyulyov, O. Economic and environmental convergence of transformation economy: The case of China. *Probl. Perspect. Manag.* **2019**, *17*, 233–241. [\[CrossRef\]](#)
18. Chovancová, J.; Tej, J. Decoupling economic growth from greenhouse gas emissions: The case of the energy sector in V4 countries. *Equilib. Q. J. Econ. Econ. Policy* **2020**, *15*, 235–251. [\[CrossRef\]](#)
19. Myronenko, M.; Polova, O.; Prylutskyi, A.; Smoglo, O. Financial and economic aspects of bioenergy development in the context of providing energy independence of Ukraine. *Probl. Perspect. Manag.* **2017**, *15*, 243–253. [\[CrossRef\]](#)
20. Simionescu, M.; Albu, L.L.; RaileanuSzeles, M.; Bilan, Y. The impact of biofuels utilisation in transport on the sustainable development in the European Union. *Technol. Econ. Dev. Econ.* **2017**, *23*, 667–686. [\[CrossRef\]](#)
21. Popp, J.; Kot, S.; Lakner, Z.; Oláh, J. Biofuel use: Peculiarities and implications. *J. Secur. Sustain. Issues* **2018**, *7*, 477–493. [\[CrossRef\]](#)

22. Oláh, J.; Krisán, E.; Kiss, A.; Lakner, Z.; Popp, J. PRISMA Statement for Reporting Literature Searches in Systematic Reviews of the Bioethanol Sector. *Energies* **2020**, *13*, 2323. [\[CrossRef\]](#)
23. Liao, H.; Long, Y.; Ming, T.; Mardani, A.; Xu, J. Low carbon supplier selection using a hesitant fuzzy linguistic span method integrating the analytic network. *Transform. Business Econ.* **2019**, *18*, 67–88.
24. Hu, X.; Liu, C. Carbon productivity: A case study in the Australian construction industry. *J. Clean. Prod.* **2016**, *112*, 2354–2362. [\[CrossRef\]](#)
25. Ouyang, X.; Lin, B. An analysis of the driving forces of energy-related carbon dioxide emissions in China's industrial sector. *Renew. Sustain. Energy Rev.* **2015**, *45*, 838–849. [\[CrossRef\]](#)
26. Mariyakhani, K.; Mohamued, E.A.; Khan, M.A.; Popp, J.; Oláh, J. Does the Level of Absorptive Capacity Matter for Carbon Intensity? Evidence from the USA and China. *Energies* **2020**, *13*, 407. [\[CrossRef\]](#)
27. Tnani, M. Relationships between economic growth, CO₂ emissions, and innovation for nations with the highest patent applications. *Environ. Econ.* **2018**, *9*, 47–69. [\[CrossRef\]](#)
28. Chen, J.; Cheng, S.; Nikic, V.; Song, M. Quo Vadis? Major Players in Global Coal Consumption and Emissions Reduction. *Transform. Bus. Econ.* **2018**, *17*, 112–133.
29. Simanaviciene, Z.; Volochovic, A.; Cibinskiene, A. Features of energy saving potential in Lithuanian households. *Equilib. Q. J. Econ. Econ. Policy* **2016**, *11*, 145–157. [\[CrossRef\]](#)
30. Simas, M.; Wood, R.; Hertwich, E. Labor embodied in trade: The role of labor and energy productivity and implications for greenhouse gas emissions. *J. Ind. Ecol.* **2015**, *19*, 343–356. [\[CrossRef\]](#)
31. Resler, M.; Kurylo, M.; Logvinenko, M.; Makhinchuk, V.; Ivanyshchuk, A. Analysis of current trends in innovation and investment activity of Ukrainian metallurgical enterprises. *Invest. Manag. Financial Innov.* **2018**, *15*, 116–128. [\[CrossRef\]](#)
32. Mariia, V.; Dykha, N.P.; Tanasiienko, N.; Galina, M.K.G. Ensuring of labor productivity growth in the context of investment and innovation activity intensification. *Probl. Perspect. Manag.* **2017**, *15*, 197–208. [\[CrossRef\]](#)
33. Ilyash, O.; Dzhadan, I.; Ostasz, G. The influence of the industry's innovation activities indices on the industrial products' revenue of Ukraine. *Econ. Sociol.* **2018**, *11*, 317–331. [\[CrossRef\]](#)
34. Kharlamova, G.; Stavitsky, A.; Zarotiadi, G. The impact of technological changes on income inequality: The EU states case study. *J. Int. Stud.* **2018**, *11*, 76–94. [\[CrossRef\]](#) [\[PubMed\]](#)
35. O'Neill, B.C.; Dalton, M.; Fuchs, R.; Jiang, L.; Pachauri, S.; Zigova, K. Global demographic trends and future carbon emissions. *Proc. Natl. Acad. Sci. USA* **2010**, *107*, 17521–17526. [\[CrossRef\]](#) [\[PubMed\]](#)
36. Savitz, R.; Dan Gavriltea, M. Climate change and insurance. *Transform. Bus. Econ.* **2019**, *18*, 21–43.
37. Hnatyshyn, M. Decomposition analysis of the impact of economic growth on ammonia and nitrogen oxides emissions in the European Union. *J. Int. Stud.* **2018**, *11*, 201–209. [\[CrossRef\]](#)
38. Sansyzbayeva, G.; Tembulatova, Z.; Zhidbekkyzy, A.; Ashirbekova, L. Evaluating the transition to green economy in Kazakhstan: A synthetic control approach. *J. Int. Stud.* **2020**, *13*, 324–341. [\[CrossRef\]](#)
39. Piwowar, A. Challenges associated with environmental protection in rural areas of Poland: Empirical studies' results. *Econ. Sociol.* **2020**, *13*, 217–229. [\[CrossRef\]](#)
40. Yoo, S.; Heshmati, A. The Effects of Environmental Regulations on the Manufacturing Industry's Performance: A Comparison of Green and Non-Green Sectors in Korea. *Energies* **2019**, *12*, 2296. [\[CrossRef\]](#)
41. Vasylieva, T.; Lyulyov, O.; Bilan, Y.; Streimikiene, D. Sustainable economic development and greenhouse gas emissions: The dynamic impact of renewable energy consumption, GDP, and corruption. *Energies* **2019**, *12*, 3289. [\[CrossRef\]](#)
42. Bilan, Y.; Mishchuk, H.; Samoliuk, N.; Yurchyk, H. Impact of Income Distribution on Social and Economic Well-Being of the State. *Sustainability* **2020**, *12*, 429. [\[CrossRef\]](#)
43. Mishchuk, H.; Bilan, S.; Yurchyk, H.; Akimova, L.; Navickas, M. Impact of the shadow economy on social safety: The experience of Ukraine. *Econ. Sociol.* **2020**, *13*, 289–303. [\[CrossRef\]](#)
44. Bilan, Y.; Streimikiene, D.; Vasylieva, T.; Lyulyov, O.; Pimonenko, T.; Pavlyk, A. Linking between Renewable Energy, CO₂ Emissions, and Economic Growth: Challenges for Candidates and Potential Candidates for the EU Membership. *Sustainability* **2019**, *11*, 1528. [\[CrossRef\]](#)
45. Banaszewska, M. The determinants of local public investments in Poland. *Equilib. Q. J. Econ. Econ. Policy* **2018**, *13*, 105–121. [\[CrossRef\]](#)
46. Zygmunt, J. Entrepreneurial activity drivers in the transition economies. Evidence from the Visegrad countries. *Equilib. Q. J. Econ. Econ. Policy* **2018**, *13*, 89–103. [\[CrossRef\]](#)
47. Nässén, J.; Larsson, J. Would shorter working time reduce greenhouse gas emissions? An analysis of time use and consumption in Swedish households. *Environ. Plan. C Gov. Policy* **2015**, *33*, 726–745. [\[CrossRef\]](#)
48. Stronge, W.; Harper, A.; Guizzo, D. The Shorter Working Week: A Radical and Pragmatic Proposal. Autonomy and Four Day Week Campaign. 2019. Available online: https://docs.wixstatic.com/ugd/6a142f_36162778914a46b3a00dcd466562fce7.pdf (accessed on 1 September 2020).
49. Maroušek, J.; Strunecký, O.; Kolář, L.; Vochozka, M.; Kopecky, M.; Maroušková, A.; Batt, J.; Poliak, M.; Šoch, M.; Bartoš, P.; et al. Advances in nutrient management make it possible to accelerate biogas production and thus improve the economy of food waste processing. *Energy Sources Part A Recover. Util. Environ. Eff.* **2020**, 1–10. [\[CrossRef\]](#)
50. Mardoyan, A.; Braun, P. Analysis of Czech Subsidies for Solid Biofuels. *Int. J. Green Energy* **2015**, *12*, 405–408. [\[CrossRef\]](#)

-
51. Maroušek, J. Economic analysis of the pressure shockwave disintegration process. *Int. J. Green Energy* **2015**, *12*, 1232–1235. [[CrossRef](#)]
 52. Maroušek, J.; Kolář, L.; Strunecký, O.; Kopecký, M.; Bartoš, P.; Maroušková, A.; Cudlínová, E.; Konvalina, P.; Šoch, M.; Vaníčková, R.; et al. Modified biochars present an economic challenge to phosphate management in wastewater treatment plants. *J. Clean. Prod.* **2020**, *272*, 123015. [[CrossRef](#)]
 53. Maroušek, J.; Strunecký, O.; Stehel, V. Biochar farming: Defining economically perspective applications. *Clean Technol. Environ. Policy* **2019**, *21*, 1389–1395. [[CrossRef](#)]
 54. Jandačka, J.; Mičeta, J.; Holubčík, M.; Nosek, R. Experimental Determination of Bed Temperatures during Wood Pellet Combustion. *Energy Fuels* **2017**, *31*, 2919–2926. [[CrossRef](#)]
 55. Lenhard, R.; Malcho, M.; Jandačka, J. Modelling of heat transfer in the evaporator and condenser of the working fluid in the heat pipe. *Heat Transf. Eng.* **2019**, *40*, 215–226. [[CrossRef](#)]
 56. Hadzima, B.; Janeček, M.; Estrin, Y.; Kim, H.S. Microstructure and corrosion properties of ultrafine-grained interstitial free steel. *Mater. Sci. Eng. A* **2007**, *462*, 243–247. [[CrossRef](#)]