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# The impact of the green energy transition at the local level. How just is the fast implementation of decarbonization policy in West Macedonia?

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The stability of Earth's ecosystem is being seriously challenged by the pressing issues related to human-induced global warming and the climate crisis. However, the European political ambition of decarbonization (FIT for 55) has brought challenging circumstances for the European coal regions concerning job loss and regional economic decline. Until recently, coal activities offer direct employment to around 208,000 people across Europe, while local lignite-based activities put at risk almost 12,000 direct and indirect jobs in West Macedonia (W.M.) of Greece. For this purpose, the current study analyzes the impact of decarbonization policy in W.M. on the life quality of the local population and investigates the local factors' effect on the successful implementation of this accelerated green energy transition strategy at community level. The applied methodology examines the decarbonisation and coal phase-out strategies at both the European Union and Greek level along with the presentation of the initial results of the coal phase-out policy's implementation in the W.M. region. Accordingly, the attitude of the local community towards the decarbonization policy in the W.M. region is described. Finally, identification and emphasis on the knowledge transfer requirements for local communities to enable equitable societal engagement during the energy transition is highlighted.

## KEYWORDS

energy security, thermal power station, energy policy, just transition, local communities

## 1 Introduction

Climate crisis is nowadays becoming one of the major problems of mankind, challenging the stability of our planet's ecosystem. To confront the urgent problems associated with human-driven global warming and the risk of the looming depletion of natural resources, a fundamental shift away from conventional, carbon-containing energy resources, is imperative. However, for the last fifty (50) years the majority of European economies have heavily relied on indigenous coal to meet their energy needs. Actually, the EU's overall energy supply relied heavily on fossil fuels during the last 5 years (~70%), considering that nine EU member states extract coal, including lignite (brown coal), to fulfil their energy requirements. This is especially relevant to electricity production, since the exploitation of fossil fuels provides well-paying jobs and sustains extensive value chains across Europe taking also into consideration that the European coal industry is a vital source

of secure, indigenous energy. On the other hand, human-driven global warming and fuel scarcity become an increasing risk to the sustainability of the electricity supply of modern societies, dictating a significant transition from a conventional, centralized electricity generation system based on fossil fuels to a decentralized system depending on renewable energy sources exploitation. This radical change imposes a responsibility on governments, leading electricity providers and other stakeholders to secure electricity supply by formulating revised market policies, regulations and strategies. As European energy policy commands, this responsibility becomes more urgent for remote and developing regions. (Kaldellis et al., 2023).

In light of the climate-neutral policies implemented all around Europe, this paper examines the initial outcomes of the ongoing West Macedonia's (W.M.) fast energy transition. The W.M. region is a coal-industry-dependent economy facing fast delignitization policies. W.M.'s energy transition provides a valuable case for assessing the efficiency of climate-neutral policies put in place in several European regions, particularly at the local level. The primary research questions of this study focus on how decarbonization policies influence the local population's quality of life, as well as what is the impact of local factors on the effective implementation of these decarbonization activities.

## 2 Energy policy and implications at local level

### 2.1 Electrical sector decarbonization

As described in the European Green Deal (EGD), the European Union (EU) aims to be the first climate-neutral continent by 2050. To reach this ambitious goal, the decarbonization of the energy sector is crucial. The production and energy use are assumed responsible for more than 75% of the EU's greenhouse gas emissions since the EU energy system relies on fossil fuels. Therefore, the successful implementation of the EGD depends on the phase-out of unrestricted burning of coal, natural gas, and oil. (Zachmann et al., 2021).

According to the initial results of the decarbonization policy implementation analysis in W.M., various social issues, including the notable migration during the last 5 years that has triggered a new brain drain, raise local concerns regarding the quick pace of the green transition attempted. On the other hand, the timely and efficient implementation of EU initiatives, the community participation encouragement and the innovative approaches through new green energy investments may offer a promising solution to confront regional economic decline and job loss.

#### 2.1.1 Electricity generation and thermal power stations (TPS)

Given the strategic choice of the EU and Greece for complete decarbonization of their economy by 2050 (Fit for 55) and the acceleration of the relevant procedures after the (energy) crisis in Ukraine (Repower EU), dramatic changes in the power generation sector are taking place. For example, these procedures dictate the complete withdrawal of lignite power plants (including the recent (started its commercial operation in 2024) one of the Ptolemaida-5

unit in W.M.), as well as the further strengthening of Renewable Energy-based projects, while also preserving the role of natural gas in Greece's power generation mix.

Thus, in this context, over the past 5 years, the Public Power Corporation (PPC) has decommissioned most of W.M. TPS (see Table 1). As a result, during the past 5 years, lignite power plants of nominal capacity of roughly 3000 MW have been phased out in the W.M. Accordingly, in the near future, it is anticipated that another 1,400 MW<sub>e</sub> of lignite-based TPS will be retired (i.e., the remaining units of Agios Dimitrios and the Florina-Melitis unit). Furthermore, by 2028, the retirement of the new power plant of Ptolemaida-5 (660 MW<sub>e</sub>) is expected in accordance to the National Energy and Climate Plan (NECP). Moreover, no new TPS (even Natural Gas consuming ones) have been built in the area, while the new-installed wind and PV capacity is 1000 MW. Note that the total electricity generation of the wind and PV parks of W.M. is hardly replacing the annual yield of Melitis TPS. Furthermore, the retirement of W.M. TPS suspends the district heating network operation of the major cities of the area, i.e., Kozani, Ptolemaida and Amindeo (Kaldellis et al., 2009; Kaldellis et al., 2011).

It is well accepted that coal-fired power plants contribute significantly to impending climate change, as their associated carbon dioxide emissions (around 1.0–1.4 kg per kWh<sub>e</sub> generated (Kaldellis et al., 2009)) are key contributors to the global climate change. Figure 1 presents a comparison of greenhouse gases (GHG) emissions in EU countries that still continue to exploit their lignite reserves for electricity generation (i.e., Bulgaria, Germany, Greece and Poland) and EU member states with the highest GHG emissions (i.e., Luxemburg, Belgium and Finland). As shown in Figure 1, for the year 2022 the Greek GHG emissions *per capita* -from a consumption perspective-is almost equal to the EU average. It is also clear that countries with less dependence on coal for electricity production have higher *per capita* emissions than the EU average.

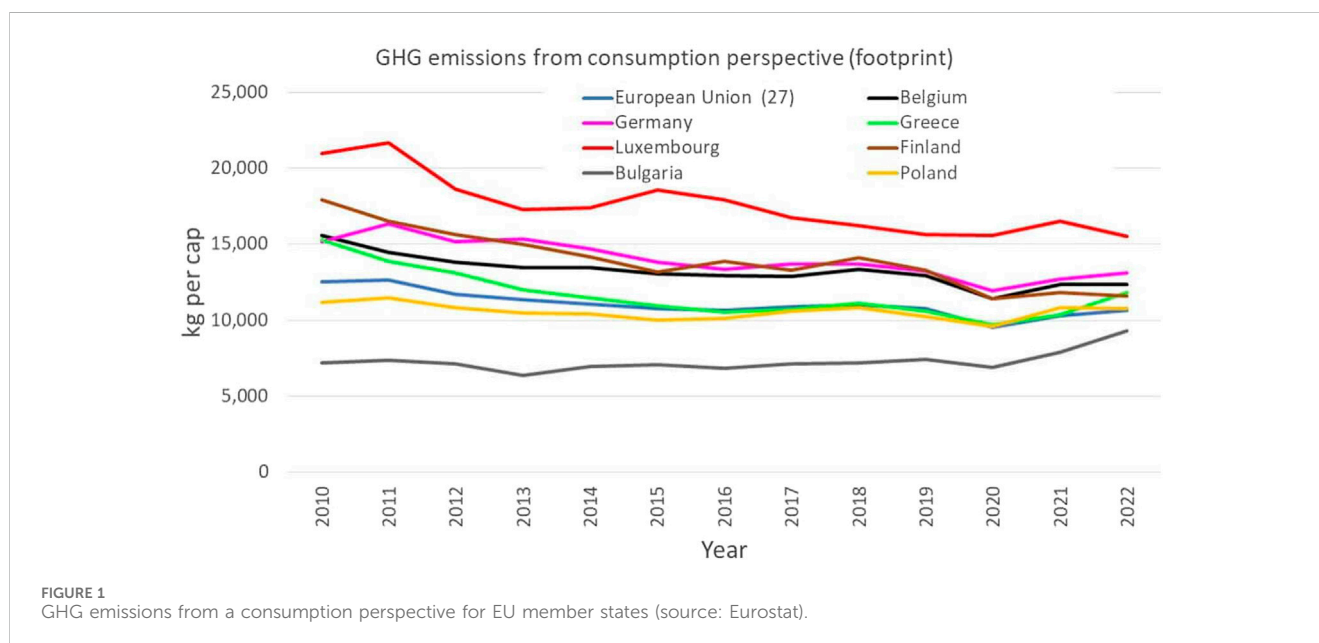
#### 2.1.2 The role of lignite in the local (West Macedonia) economy

At the EU level, coal electricity generation has declined by nearly one-third since 2012. From 2022 to 2023, the supply of brown coal fell by 24.2%, while the supply of hard coal decreased by 20.4%. The reduced reliance on coal has led to the closure of mines and to the shutdown of power plants in various areas throughout Europe. In 2021, coal-related activities provided direct employment for approximately 208,000 individuals in Europe, with 76% of these jobs being in the mining industry. This represents a nearly 37% reduction in the number of jobs indirectly associated with the coal sector compared to the figures reported in the EU coal regions report from 2018. (European Commission, 2025).

With a population of around 270,000 people, the prefecture of W.M. is one of the EU's less developed areas, covering an area of 9,541 km<sup>2</sup>. During the decade from 2010 to 2019, the *per capita* GDP of the Region of W.M. declined by 20%, reaching only 45% of the EU average. With a GDP *per capita* of €14,700, W.M. ranked seventh nationally and 215th amongst EU27 regions. According to the Hellenic Statistical Authority, the 2021 GDP is even lower and reaches €14,100 *per capita*. Moreover, a significant portion (24.5%) of W.M. residents are elderly, having reached the age of 65. The estimated economically active population (ages 15–64) in 2019 was about 113.4 thousand people, representing 67.2% of the

TABLE 1 West Macedonia lignite power stations status (end of 2024).

West Macedonia Lignite power station	Initially installed (MW)	Withdrawn units (MW)	Currently in operation (MW)
TPS of LIPTOL	43	43	0
TPS of PTOLEMAIDA (1–4)	620	620	0
TPS of PTOLEMAIDA-5	660	0	660
TPS of KARDIA	1,250	1,250	0
TPS of AG.DIMITRIOS (1–5)	1,595	~600	~995
TPS of AMINDEO	600	600	0
TPS of MELITI	330	0	330
TOTAL MW	5,098	3,113	1985



corresponding population, while the weighted average annual unemployment rate at that time reached 24.5%, the highest in Greece and the fourth highest in the EU. However, the weighted average unemployment rate for the third quarter of 2023 reaches 19.5%. This small decrease could be attributed to the population decrease (emigration) of the region. (Christiaensen and Ferré, 2020).

In the energy-related mining sector of the W.M. (activity developed until now by the once State-controlled PPC -now a totally private company) supports the direct and indirect employment of approximately 5,000 people encompassing:

- Regular staff in mining operations, factories and other supporting operations
- Temporary staff and
- Contractor staff (Perk and Zhou, 2020)

In relation to the changes in unemployment associated with the delignitization for the base year 2019, it is projected that around

12,000 workers in total will be impacted (both directly and indirectly) across the region, with the majority (about 11,000) residing in the Kozani and Florina Regional Units and the remaining individuals located in the Kastoria and Grevena Regional Units. Furthermore, the majority of W.M.'s employment is closely linked, directly or indirectly, to the exploitation of its natural resources, including land and mining. Regional Units will predominantly experience effects due to the indirect repercussions on the lignite value chain, as well as due to the induced consumption reduction stemming from a significant decrease in employment and income throughout the region. (Greece Just Transition, 2021).

### 2.1.3 Energy policy: European Green Deal, fit for 55, repower EU and NECP

The Greek National Energy and Climate Plan (NECP) attempts to incorporate European energy policy and the Sustainable Development Goals (SDG) of the United Nations. In this

context, the Greek State utilizes the NECP as a key tool for shaping the national energy and climate policy for the next decade.

One of the most noteworthy features of the updated (final submitted at the end of 2024) third NECP version is the target to decrease the national GHG emissions by 58.6% from 1990 levels (p. 92 NECP), in contrast to the initial (2019) prediction of a 40% reduction. To reach this ambitious objective, the primary focus is to increase the RES participation (from 22% in 2021 to 45.4% by 2030) in the gross final energy consumption, targeting at the same time 76.8% participation of RES in the national electricity mix by 2030. Additionally, it is predicted that the total national energy consumption will be the same between 2021 and 2030. (Kaldellis and Ktenidis, 2024).

Taking into consideration that the lignite-based TPS (installed capacity of 5 GW<sub>e</sub>) in W.M. provided 60% of Greece electrical power until recently, the phase-out of coal in less than a decade is a strategic decision. However, this decision has caused significant disruptions to labor market and coal value chain especially in areas that rely heavily on the coal exploitation.

Based on the first outcome of W.M. analysis, the significant migration over the past 5 years is emphasized, which has sparked a new brain drain and reveals local skepticism about the green transition's quick pace. Nonetheless, the on-time and effective implementation of EU initiatives and community engagement along with innovative applications in new green energy investments presents a promising alternative to the current challenging circumstances of job loss and regional economic decline.

## 2.2 Energy-economy-environment

Due to the regional value chain collapse, the direct effect of this energy transition shift is the loss of jobs in the decarbonization regions and the rising energy prices for most European countries. To this end, a significant concern of EU policy is to guarantee a socially fair development during the phase-out period for communities with coal-fired TPS activities. For this purpose, the European Union creates a special Just Transition Mechanism (JTM) to ensure that “no one is left behind.” To secure the budget for the period 2021–2027, the JTM is mobilizing approximately €55 billion, to financially support the coal regions and to prevent any socio-economic disruptions caused by the fast coal activities abandonment.

### 2.2.1 Energy security: The role of lignite and its contribution to Greece energy security

In the past two decades, Greece electricity sector, aligned with EU policy, has undergone significant transformations across nearly all aspects of electricity generation, transmission, distribution and pricing. Besides the significant transformation in the electricity production sector, Greece relies on imports for nearly all its oil and natural gas requirements, thus ensuring security of supply must be a central goal of national energy policy. In 2010, amidst the economic crisis, Greece's rate of energy independence was about 30%. In 2013, it peaked at 38% but subsequently experienced a decline, reduced in half by 2023 to hit 20%.

Greek lignite is considered an indigenous fuel of significant strategic value. Its strategic importance arises from its low extraction

costs, stable and manageable pricing, providing security in fuel supply. Additionally, lignite is essential for creating numerous jobs in rural regions that have particularly elevated unemployment levels. Lignite reserves of Greece are considerable, and it is predicted that they could adequately provide the main fuel for domestic electricity production for the upcoming 30 years, since, to date, only 1/3 of the country's known reserves have been used (Kaldellis et al., 2009). In 2023, lignite accounted for merely 10% of the country's total electricity generation (50 TWh<sub>e</sub>), down from 32% in 2018, see also Figure 2. (Kaldellis et al., 2023).

### 2.2.2 Environment: Environmental degradation and restoration

After the retirement of lignite based TPS, the planning and implementation of environmental conservation and land restoration projects in the W.M. Lignite Centre is a complex task that must tackle, among other challenges, the vast scale of mining operations. The primary focus of the applied environmental management strategy is the development of reclaimed land suitable for agricultural or recreational uses. Simultaneously, a significant effort is directed towards adhering to the laws and regulations that establish environmental quality benchmarks and outline optimal methods for pollution monitoring and management.

In a study conducted to reach out to young scientists' opinion about the implementation of decarbonization policy in W.M. (Kaldellis et al., 2023), young post-graduate students almost unanimously ask the coal activities-related land to be returned to the local community for environmental and social purposes. Additionally, there is significant concern among all participants (Figure 3) regarding the length of soil remediation and its consequences, including lignite self-ignition, emissions of carbon monoxide and particulate matter from open - pit mining, while special attention is given to slope stability of open mines.

### 2.2.3 Economy: The finance of decarbonization policies and energy prices

The strategical choice of deregulating/liberalizing the energy market was put into place to guarantee that all participants will be active in the energy transition. In the mid-1980s, a general agreement formed within political and business circles, who believed that “liberalizing” the energy market could enhance economic performance and overall wellbeing. Eventually, the decarbonization of the EU economy was implemented in terms of a deregulated/liberalized energy market. Even with all the measures for consumer protection active and the relevant regulatory framework, the energy market's liberalization and the protective provisions seemed inadequate during the recent crisis in Ukraine. In this situation, the imported natural gas supply cost increase raised the wholesale electricity prices and subsequently, as anticipated, the corresponding retail prices. Even though the electricity produced by RES in Greece approaches 50%, replacing fossil fuels, this evolution alone is not enough to protect the Greek consumers from the rise of electricity prices.

The rise in natural gas prices and the resulting increase of electricity prices are substantial according to past historical data (Ember, 2025). For households in W.M., particularly those with low income, the inability to afford the expenses of acquiring energy products significantly influences their quality of life and their welfare (Figure 4). Rising energy price reduces consumers' purchasing

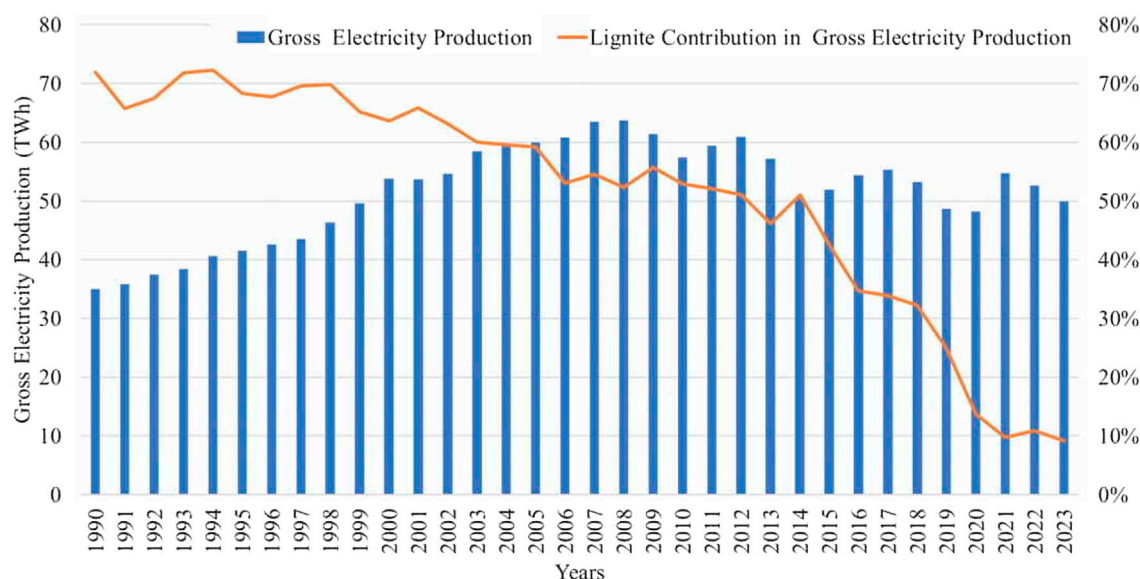


FIGURE 2  
Lignite contribution (%) in Greece Electricity Production (1990–2023).

### Environmental Impacts of Decarbonization

- Landslides / Slope stability
- Particulate matter increase
- Empty space / volume unknown capacity
- Soil restoration necessity

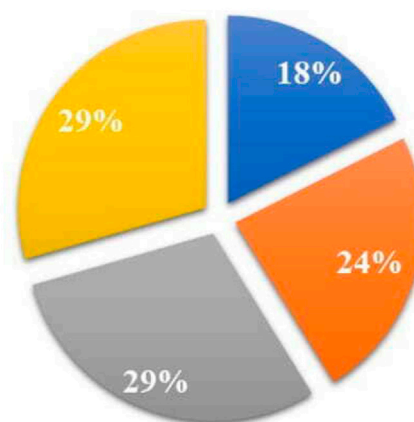


FIGURE 3  
Analysis of main environmental impacts of decarbonization process by post-graduate students of West Macedonia university.

power, causing individuals to struggle with meeting their essential needs and forcing young population of W.M. to leave their home/country triggering again a new brain drain. Moreover, it is important to mention that Greeks in general have the second lowest purchasing power in Europe.

### 3 The role of citizens in the fair perspective of local energy transition

There is a significant link between energy, society and policy formulation in contemporary society (Topaloglou et al., 2024),

(Michel, 2020). This link is recognized and mentioned in a relevant study that was addressed to young researchers living in W.M. (Kaldellis et al., 2023). This link is highlighted when the young researchers choose the economic and social dimensions of decarbonization in their region as the most important aspects of local energy transition. The respondents also mentioned the vast effort required and the challenges that arise during the implementation phase of the suggested decarbonization plan. Therefore, the main issues that the respondents have been skeptical of are the quick pace of decarbonization and the success of the suggested changes, as well as the feasibility level of the overall plan. This study (Kaldellis et al., 2023) targeted highly educated



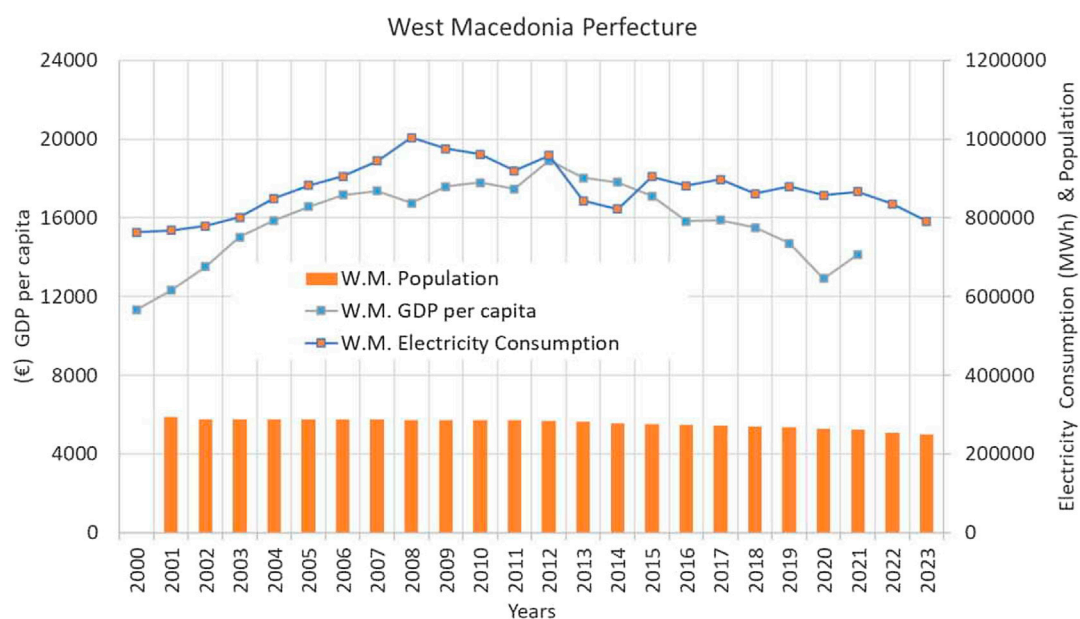


FIGURE 4  
West Macedonia Electricity Consumption, Population and GDP *per capita* (ELSTAT).

### Coal (% Total) Energy Consumption and GDP West Macedonia (% Total National)

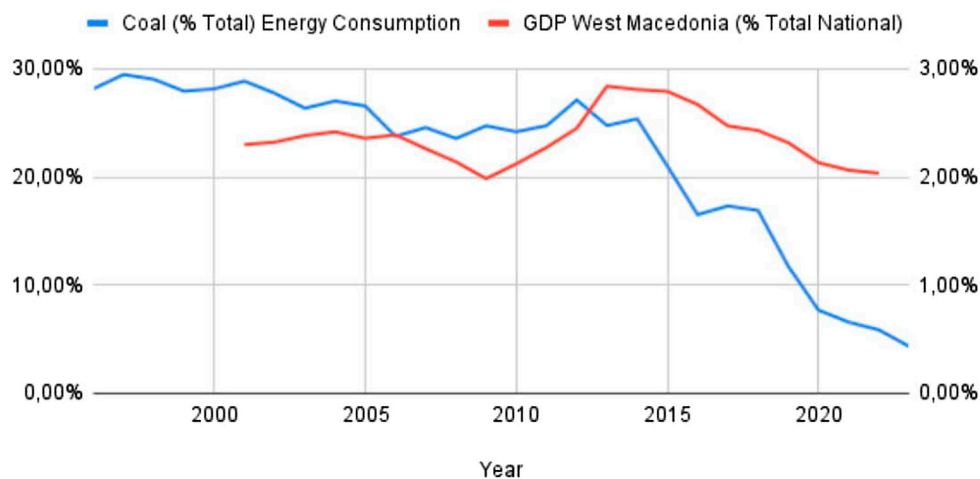


FIGURE 5  
Energy Transition Effects on West Macedonia Income (GDP); Coal Consumption at the left vertical axis and GDP value at the right vertical axis.

postgraduate students who were looking for suitable job opportunities in energy-related fields. The selection of respondents for this study was motivated by the complexity of the issues surrounding the energy sector in general and the energy transition in particular, which may need a deeper level of knowledge than the majority of the citizens normally possesses.

The participation of the local society during the planning and the implementation of the transition schemes is very important (Papadopoulou et al., 2024). This is imperative not only to

understand thoroughly the difficulties arising in the entire transition process but also to understand the significance of their personal role. Another important issue raised is the level of knowledge as a prerequisite to participate equivalently in the planning of local energy transition and the need to introduce energy transition aspects to local society. For the energy transition to also support a fair transition, citizens must participate with access to the knowledge/information needed to take decisions (European Commission et al., 2024), (Zafeiriou et al., 2022).

As shown in Figure 5, the delignitization of the National Power System has very serious consequences on the regional GDP of W.M. Furthermore, the local community's access to reliable and affordable energy services is essential for a just and fair transition. Finally, the access of the local community to the land that will be redistributed in the context of delignitization and the reciprocal benefits of the local society from the companies that are planning to exploit the area for green energy production is crucial as well.

## 4 Conclusion

The energy transition policy and the additional environmental pressure to speed up the transition have a great impact on local communities involved in the decarbonization process. To this end, the W.M. residents experience the transition outcomes in their everyday lives. More specifically, coal-industry-dependent communities are confronted with rising energy prices, delays in the reclaim of coal activities-related land to society, the loss of their income and the brain drain of their young scientists. In the current energy transition, knowledge transfer is also a very important issue. It is very important for the citizens to understand how local affairs strongly affect their lives. The local community's ability to understand its central role in the current energy transition is a fundamental issue of the energy sector liberalization and democratization. Local societies should have access to relevant information and the skills to decide about their participation in the energy transition of their region. In this context, the State authorities must ensure justice and fairness towards local communities' participation in the W.M. energy transition. Furthermore, the results of energy policy implementation should be evaluated on a regular basis by local communities.

Recapitulating, the main results of the current research demonstrate the significant impact of fast decarbonization on the life quality of W.M. citizens. Also, the fact that, at the local level, well informed residents may provide a substantial contribution to the energy policy strategy, especially in case they have access to the requisite knowledge. To this end, the energy transition attempted in W.M. prefecture should take into consideration the local community concerns and associated reactions. Moreover, time pressure should not lead to hasty political decisions surcharging local communities and ultimately sabotaging the successful outcome of the European green energy transition strategy. Stakeholders of the energy transition and policymakers should assess the outcomes of the up to now policy implementation, including the criticism at local

level, and utilize the results presented as a basis for reforming the current energy transition policy in the interests of local societies.

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