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The Efforts towards and Challenges of Greece's Post-Lignite Era: The Case of Megalopolis

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Abstract: Greece has historically been one of the most lignite-dependent countries in Europe, due to the abundant coal resources in the region of Western Macedonia and the municipality of Megalopolis, Arcadia (region of Peloponnese). However, a key part of the National Energy and Climate Plan is to gradually phase out the use of lignite, which includes the decommissioning of all existing lignite units by 2023, except the Ptolemaida V unit, which will be closed by 2028. This plan makes Greece a frontrunner among countries who intensively use lignite in energy production. In this context, this paper investigates the environmental, economic, and social state of Megalopolis and the related perspectives with regard to the energy transition, through the elaboration of a SWOT analysis, highlighting the strengths, weaknesses, opportunities, and threats of the municipality of Megalopolis and the regional unit of Arcadia. The analysis is based on four main pillars, namely "clean energy", "smart agricultural production", "sustainable tourism", and "other (e.g., industry, technology, and education)". The integration of the "Energy Efficiency First" principle, the mitigation of household energy poverty (especially in a region with district heating installations), and collectively driven energy actions for engaging and empowering younger generations (e.g., in the form of next-generation energy communities) are among the solutions that are expected to have a significant contribution towards Megalopolis' just energy transition.

Keywords: just energy transition; sustainable development; renewable energy; energy efficiency first; next-generation energy communities; energy poverty; SWOT; lignite; coal; Megalopolis

1. Introduction

Our planet is facing a vast variety of hazards related to climate change. It has already affected the frequency and intensity of a great variety of meteorological phenomena, such as extreme temperatures, wildfires, heat waves, floods, and droughts [1,2]. The main reason is the grave augmentation of greenhouse gases (GHGs) in the atmosphere, and especially carbon dioxide (CO_2), which is related to the greenhouse effect [3]. CO_2 emissions derive from a variety of human activities related to the use of fossil fuels. For example, the use of gasoline for transportation is interwoven with the increase of CO_2 emissions. Nonetheless, electricity production is the sector connected with the highest GHG emissions (almost one-third of the CO_2 emissions globally are accounted to the power sector) [4], since fossil fuels continue to dominate in the mix of electricity production methods [5]. Therefore, one of the most effective ways to counter this phenomenon is the reduction of electricity production from fossil fuels, and especially lignite which is less efficient and more polluting [6,7].

This transition can be achieved through the increase of renewable energy sources (RESs) in the energy mix, such as wind, solar photovoltaics, hydro, bioenergy, and geothermal sources, as well as coal-fired power plants with carbon capture and utilisation/storage [8]. Despite the beneficiary effect of the transition from lignite to cleaner energy resources, there is also a negative side [9]. The transition will lead to the reduced operation of various lignite plants and eventually to their shutdown. In this respect, rising unemployment rate, increasing poverty, and declining professional opportunities for younger generations determine continuous degradation and rising depopulation in coal regions [10]. Literature underlines that in regions where the major economic sector is related to mining activities, people have a lower GDP/per capita than the national average, due to the limited development of other sectors and the exclusive dependency on the coal industry. These regions are characterized as "coal lock-in" economies, because coal mining activity is so dominant [11]. However, this is not the case in Greece since the region of Western Macedonia and the municipality of Megalopolis have a per capita GDP close to, or even higher than, the national average.

Local community perspectives in mining areas have been analysed in the literature [12,13]. Karasmanaki et al. (2020) investigated the attitudes towards new investments in lignite mining among residents living in Western Macedonia [14]. Moreover, Stognief et al. (2019) [15] analysed the economic resilience of German lignite regions in transition, defined as "adaptive capacity", using Holling's adaptive cycle model. Multi-level perspective framework has been adopted to analyse the sustainable and socially just transition [16,17]. The sustainable rehabilitation of surface coal mining areas has been investigated based on a PEST (political, economic, social, and technological) analysis [18].

Achieving a just energy transition is a challenge for countries that combine the extensive use of coal as a fuel for power generation with a significant history of coal mining [19]. Many European countries (e.g., Germany, Poland, Czech Republic, Bulgaria, Serbia, Greece, Romania, etc.) depend heavily on solid fossil fuels for their electricity production, especially lignite [20], since Europe's subsoil is rich in lignite resources (Figure 1). Therefore, a transition to a more environmentally friendly electricity production is necessary for Europe [21].

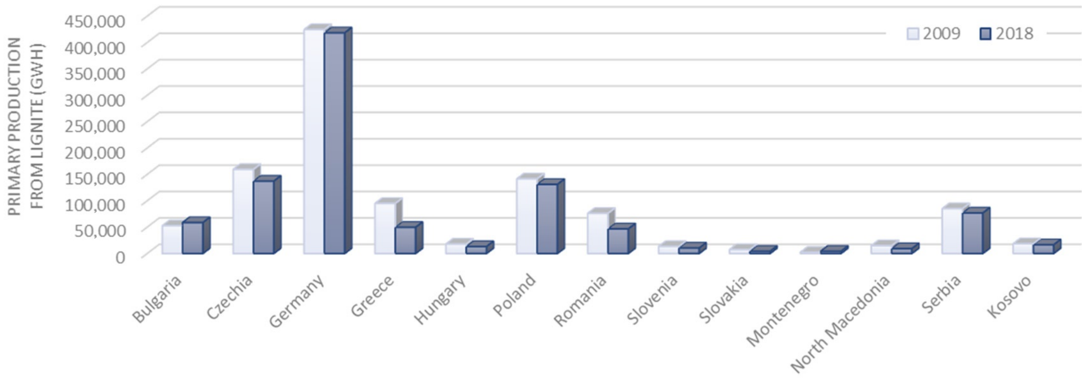

Figure 1. Primary production from lignite in European countries (2009 and 2018), *Source: Eurostat* [22].

In the European Union (EU), climate policies, high carbon prices, and the increased competition from renewables and gas in the power sector have contributed to a 15% fall in coal production in 2019 (compared to 2018 data) [23], especially in Germany and Poland [24,25]. Based on Eurostat data [22], the primary production in the EU-27 countries was 989 TWh from lignite and 763 from coal (including anthracite, coking coal, and other (sub-)bituminous coal) in 2009. These amounts decreased to 870 TWh from lignite and 486 from coal in just nine years, which is a reduction over 20%. On the other hand, in 2009 renewables and biofuels generated 23% of the EU-27's total primary production and in 2018 this production percentage reached 34%. In 2017, the EU generated more electricity from

RESs, like wind, solar, and biomass, than from coal, indicating that a transition process has already begun, and it seems to have great potential [26].

More specifically, the Energy Union [27] builds on five key dimensions for secure, sustainable, competitive, and affordable energy: (a) security, solidarity, and trust; (b) a fully integrated internal energy market; (c) energy efficiency; (d) climate action, decarbonising the economy; (e) research, innovation, and competitiveness. According to the European Green Deal, the European Commission's (EC) proposal to tackling climate, environmental, growth, and societal challenges states that the EU must be transformed into a fair and prosperous society, with a modern, resource-efficient, and competitive economy where there are no net emissions of GHGs in 2050 and where economic growth is decoupled from resource use [28]. However, by increasing the EU's climate ambition for 2030, coal regions could be left behind, unable to shift from their core activity (e.g., coal mining) to other more environmentally friendly industries. Thus, the process of a just energy transition involves major structural change in these areas.

Towards this direction, the EC introduced the Just Transition Mechanism [29]. Moreover, the initiative for coal regions in transition assists the communication among national, regional, and local stakeholders regarding the modernisation of the economy of the coal regions. This modernisation focuses on a clean energy transition, which also considers social fairness. In this manner, people who used to work in the lignite sector can obtain new skills and become capable of working in "greener" economies. This initiative delivers tailor-made assistance to 13 pilot regions in 7 EU member states, such as Asturias, Castilla-y-Leon, and Aragon (Spain); Brandenburg, Saxony, and Saxony-Anhalt (Germany); Karlovy Vary, Usti, and Moravia Silesia (Czech Republic); Silesia (Poland); Jiu Valley (Romania); Trencin (Slovakia); and Western Macedonia (Greece).

Greece has historically been one of the most lignite-dependent countries in Europe, because of the abundant coal resources in the region of Western Macedonia and the municipality of Megalopolis (Region of Peloponnese). Hence, extraction of lignite has a very long tradition [30]. However, the current climate and energy policies at national and European levels have transformed the use of lignite from a solution to the electrification of the country to an economic and political problem, along with the environmental and health calamities which have always been present [31]. During the 2019 UN Climate Action Summit, the Greek government announced that Greece, a traditional lignite powerhouse, will have decommissioned its entire lignite plant fleet by 2023; the only exception to this is the under construction Ptolemaida V 610 MW lignite plant. This plant was permitted in March 2013, the construction was set to begin in 2015, and the plant was scheduled to begin commercial operation in 2019. Due to the economic circumstances of the Power Public Corporation (PPC), construction on the new unit began in 2016 and it is now planned for 2022 [32].

If materialised, the plan will make Greece a frontrunner among coal-intensive countries. Although considered as a decisive step in the country's climate efforts, it is naturally linked to the massive deployment of renewables [16], currently perceived by many as a threat to the country's rich and diverse natural environment. The Greek coal regions are considered structurally weak, with high unemployment, low economic growth, and high levels of emigration [33]. As a result, these regions may not be capable of mitigating the socioeconomic consequences that will derive from the energy transition, due to their already weak economic and social base. As mentioned above, only Western Macedonia is included in the pilot program of the initiative for coal regions in transition. The municipality of Megalopolis and the regional unit of Arcadia need a support framework in order to achieve a just transition.

In this context, this paper investigates the environmental, economic, and social state of Megalopolis and the related perspectives with regard to the energy transition, through the elaboration of a SWOT analysis, highlighting the strengths, weaknesses, opportunities, and threats of the municipality and the regional unit. The analysis is based on four main pillars, namely "clean energy", "smart agricultural production", "sustainable tourism" and "other (e.g., industry, technology, and education)".

The rest of this article is organised into four sections. Section 2 provides an overview of the current delignitisation framework in Greece. Some notes regarding the methodological approach are presented in Section 3. Section 4 presents the opportunities and barriers that emerge with regard to the implementation of the energy transition for the case of Megalopolis, based on the SWOT analysis. The last section summarises the main points that have arisen.

2. The Delignitisation Roller Coaster in Greece: An Old Car and a Steep Slope Ahead

Lignite has been exploited for electricity generation in Greece since the early 1950s and has been a major socioeconomic growth driver for decades ever since. In 2009, lignite-fired generation covered 58% of electricity demand in the country's mainland interconnected system. A decade later, lignite covered a modest 10% [34]. This bold reduction can be attributed to two main drivers. First, the worsening lignite fields' quality and the ageing lignite plants, as reflected in the low calorific value (1000–1300 kcal/kg) of the Megalopolis and Ptolemaida fields and the high stripping ratio (which increased from 2.68 m^3/tonne in 1991 to 4.59–6.36 m^3/tonne in 2016–2017) of the remaining lignite fields [35]. Second, the gradual price increase of the European Allowances (EUA) to emit greenhouse gases since late 2017, which averaged €6 per tonne of CO_2 in 2017 and almost €25 per tonne of CO_2 in 2019 [36].

Apart from energy production, Greek lignite plants now contribute less in terms of capacity adequacy as well, with similar trends expected in the broader region in the coming decade [37]. The ten lignite-fired units in operation feature 2.80 GW of net capacity. Two units have been under Limited Lifetime Derogation (EU Industrial Emissions Directive 2010/75), and the other eight must comply with the new EU environmental standards, with some being accordingly bound to significant refurbishment. The Greek government has set a goal of withdrawing all lignite plants by 2028, with the majority of units—representing over 80% of the current installed capacity—being withdrawn by 2023 (Table 1) [38].

Table 1. Schedule of the installed lignite power plants, to 2028 [38].

<table>
<tr><th></th><th>2020</th><th>2021</th><th>2022</th><th>2023</th><th>2028</th></tr>
<tr><td rowspan="6">Decommissioning</td><td>Amyntaio 1 & 2</td><td>Kardia 3 & 4</td><td>Agios Dimitrios 1–4</td><td>Megalopoli 4</td><td>Ptolemaida 5</td></tr>
<tr><td>−0.55 GW</td><td>−0.56 GW</td><td>−1.1 GW</td><td>−0.26 GW</td><td>−0.61 GW</td></tr>
<tr><td rowspan="4">(closed)</td><td>Megalopoli 3</td><td></td><td>Meliti 1</td><td rowspan="4">(conversion for use with different fuel)</td></tr>
<tr><td>−0.25 GW</td><td></td><td>−0.29 GW</td></tr>
<tr><td></td><td></td><td>Agios Dimitrios 5</td></tr>
<tr><td></td><td></td><td>−0.34 GW</td></tr>
<tr><td rowspan="2">Commissioning</td><td colspan="5">Ptolemaida 5</td></tr>
<tr><td colspan="5">+0.61 GW</td></tr>
</table>

Renewables and natural gas will, therefore, be required to fill this gap in the coming years. This is exactly what Greece's National Energy and Climate Plan (NECP) [39] foresees for the period up to 2030, with renewables covering 61–65% of electricity demand in 2030, i.e., more than a twofold increase from today's contribution. Moreover, an increase in energy efficiency and improved forest management—tree planting and rational water management—are among the most promising options to strategically plan climate change mitigation and adaptation for Greece [40].

To put this in perspective, back in March 2005, lignite stations in Greece covered more than 60% of the demand, while RESs (except from large hydroelectric power plants) covered 2%. Even four years later, in 2009, the energy mix remained almost unchanged, with lignite-fired generation covered 58% of electricity demand in the country's mainland interconnected system, while renewables only at 5%. Important changes were initiated in 2010, when Greece set a 20% target for RES use the in gross final energy consumption in 2020.

In this direction, the country legislated accordingly and significantly boosted the distribution of renewables by 2013: 2.5 GW of high-tariff solar photovoltaics were installed in three years and the renewable energy share in the gross final energy consumption increased to 15% in 2013, compared to 8.5% in 2009. Further development in the period 2014–2018, however, was much less spectacular, with renewable energy share hardly touching 17% in 2018. This is due to the pre-agreed reduction of the Feed-in Tariffs, in parallel with the extra taxation that was imposed by the Greek government on prosumers' income from electricity generated with photovoltaics (PV) [41], as a measure to counterbalance the deficit that occurred to the Greek RES special account, which made investments less attractive [42,43]. With lignite combustion decreasing far quicker than the increase of renewables, the gap was bridged with natural gas and imports: in 2019, gas covered 33% of demand in the mainland interconnected system, compared to 26% in 2013, while imports climbed from 4% to 19% in the same period. In general, in 2019 lignite covered 20%, with almost the same amount supplied by renewables (except from large hydro plants). This change in the electricity mix helped Greece significantly reduce carbon emissions from electricity generation in the mainland grid, which dropped from circa 40 Mt in 2013 to 28 Mt in 2019.

Since the start of this commentary in March 2005, fifteen years later, in March of 2020, lignite covered less than 11% of the gross final energy consumption, while RES (except from large hydro plants) reached the 31% mark, even more than the natural gas share (27%), and the contribution of hydro plants 4% the same month [44]. Two months later, on the 20–21 of May 2020, from the 12 lignite units in operation in Greek territory at that time, only one was producing, i.e., the Megalopoli IV unit in Peloponnese. Even more surprising, on 8 June 2020, for economic reasons, no lignite unit was dispatched. This was the first time, after 60 years of uninterrupted lignite contribution in Greece's electricity mix, that this has happened.

3. Methodological Approach

The lignite centre in Megalopolis will eventually stop being the dominant economic sector and so it is necessary to design a development strategy which will promote existing and new economic activities. The overall philosophy of the adopted approach is presented in Figure 2. The proposed framework is composed by the integration of a participatory process within the SWOT analysis procedure, including six steps, as described in the following paragraphs.

- Step 1—Selection of Key Pillars: The Greek Government's post-lignite master plan for the areas of Western Macedonia and Megalopolis provides the overall transition process for the phasing out of lignite 38. The plan is based on three main principles: (a) employment protection; (b) compensation of the socioeconomic impact of the transition; and (c) energy self-sufficiency of lignite areas and the country at large. In Megalopolis, the main focus is to attract productive investments and create sustainable jobs that will cover those lost by phasing out lignite. The just transition will open a new chapter to Megalopolis and will create new opportunities for the economy and the society, especially under the following pillars, according to the master plan:

    1. Clean energy: Emphasis is placed on the construction of photovoltaic parks, with expressed interest in the construction of ~0.5 GW units.
    2. Smart agricultural production: Development of intelligent livestock and animal feed units, aiming at the further development of the livestock capacity of the area. Development of smart agricultural units for the production of exportable products, with emphasis on alternative forms of cultivation (e.g., hydroponics), as they are more environmentally friendly while at the same time they create jobs with increased added value.
    3. Sustainable tourism: Original theme park of adventure, entertainment, and education with interest from an international entertainment company.
    4. Other (e.g., industry, technology, and education): Creation of a model pharmaceutical industry, with the aim of restarting the heavy industry in the Peloponnese; public investment, business parks, etc.

- Step 2—Desktop Analysis: The above-mentioned pillars for fair development and fair transition in Megalopolis are further analysed, based on desktop analysis. Specific data and pieces of information about the environmental, economic, and social state of Megalopolis, as well as the potential opportunities and barriers for realising a just transition away from fossil fuels, have been identified.
- Step 3—Stakeholders' Identification: More than 18 experts and stakeholders (e.g., policy makers, financial institutions, project developers, and civil society) from the municipality of Megalopolis and the regional unit of Arcadia have been identified.
- Step 4—SWOT Analysis (first version): Following structured interviews with the experts and stakeholders, a first version of the SWOT analysis has been prepared. The aim is to identify and address the structural economic changes that should take place during the decarbonisation process. The main categories of the SWOT analysis are the following [45]:

    1. **Strengths:** The available resources and capacities of Megalopolis which can be used to achieve its objectives for fair development and fair transition.
    2. **Weaknesses:** Limitations, defects, and disadvantages in Megalopolis that will hinder the achieving of its goals. Similarly, to strengths, these are directly linked to the present situation, related to environment and organisation.
    3. **Opportunities:** Favourable factors or overlooked trends in Megalopolis that would facilitate the decarbonisation process and enhance the position of efficient energy consumption management and low-carbon energy technologies. These are triggered by the external factors which stem from society, markets, and policies.
    4. **Threats:** Any unfavourable situations and reactions to the process of phasing out coal that are potentially damaging to its strategy. This includes the barriers, constraints, or any external circumstances that may cause problems, difficulties, and delays.

- Step 5—Stakeholders' Engagement: The preliminary outputs from the SWOT analysis were discussed during a teleconference with the experts and stakeholders. Therefore, discussions with experts in the field and stakeholders were important to intensify and enhance the initial SWOT analysis, validate the results, as well as identify solutions that are expected to have a significant contribution towards Megalopolis' just energy transition.
- Step 6—SWOT Analysis (final version): Based on feedback from stakeholders' engagement, the final table of SWOT analysis has been developed for Megalopolis.

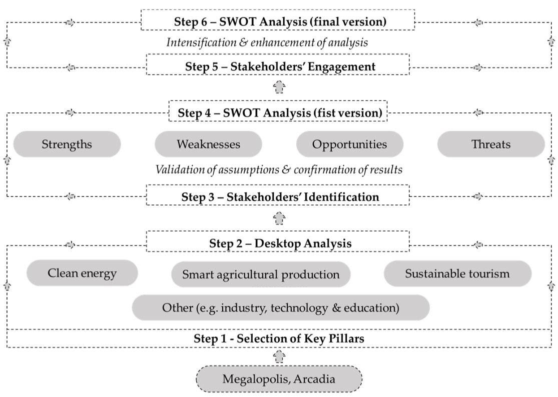

Figure 2. Methodological approach.

4. Results

This section summarises the results of the SWOT analysis of the clean energy transition in Megalopolis (Table 2).

Table 2. SWOT analysis of Megalopolis

Pillars	Strengths of Megalopolis	Weaknesses of Megalopolis	Opportunities of Megalopolis	Threats to Megalopolis
All pillars	• Existing post-lignite master plan for fair development transition • The average efficiency of lignite used for energy production is low (being among the worst performers), making the last steps in the transition easier	• High dependence of the local economy on the lignite industry activities, against other economic activities • High rate of job loss in the coal industry, leading to growing social inequalities • The repeated exposure to polluted air with major health impacts on population	• Great investment interest on energy sustainability • Empowerment of policies towards new economic activities • Utilising community, national, and EU funds • Financing options for coal regions in transition	• Ageing of the population, which could worsen the demographic trend • The crisis of the Greek economy and growing social inequalities due to the crisis • Rising unemployment and the absence of job creation
Clean energy	• Large solar energy resources • Promotion of collectively driven energy actions • High potential of biomass energy that could replace the coal-based heat and electricity production • RES projects such as hydro power plants are encouraged to be implemented • Already developed district heating system	• Need for improvement of funding conditions, legal framework, and administrative procedures • Low wind energy resources • Congested electricity network	• Mitigation of household energy poverty • Next-generation energy communities • Integration of the “Energy Efficiency First” principle	• Green versus green trap • Energy efficiency measures for buildings are not a strategic priority in the region • Natural gas dependence for central heating according to the master plan
Smart agricultural production	• The traditions of agriculture and livestock • Agriculture, forestry, and fishing are occupying the greatest share of total employment	• Low share of young farmers and high seasonality of workers (mostly from non-EU countries) • Limited professional training of the farmers • Links between agriculture and forestry, and research and innovation are rather limited • Low yield cultivations (€/ha) • Small average size of holdings	• New models like smart agriculture, precise agriculture, hydroponics, and organic agriculture • Increased agricultural production in the direction of smart farming, establishing farming research centre, and providing incentives to younger people • Utilisation of the primary sector for the development of the region and the creation of jobs for the processing and standardisation of local products • Possibility of agritourism • The lignite centre could host agricultural activities	• Impacts of climate change on the long-term farming projects • Technical knowledge is required for growing plants through hydroponics and other smart farming actions

Table 2. *Cont.*

Pillars	Strengths of Megalopolis	Weaknesses of Megalopolis	Opportunities of Megalopolis	Threats to Megalopolis
Sustainable tourism	• The variety of the natural environment • Take advantage of the proximity and easy access to Attica and mainland via motorway and railway • The centrality of Megalopolis to Peloponnese and its proximity to urban sectors (Tripolis, Kalamata, Sparti) • Its rich archaeological, historical, religious, and cultural stock.	• Limited exploitation of unused public areas • Distances of some communities with the centre of the municipality • Quality of roads and the residential infrastructure	• Post-mining sites can be converted into parks, museums, etc. • Design a new model of tourism development with strong regional identity towards sustainable tourism infrastructure & destinations	• The risk of degradation of the natural and built environment
Other (e.g., industry, technology and education)	• Work transfer programs and on-the-job training	• Lack of industrial tradition and visibility by investors • Lack of digital infrastructure • Limited mechanisms for increasing citizens awareness of environmental challenges and other development matters	• Possibilities to reuse the post operational lignite industry installations and buildings after the lignite mine closure • Megalopolis Business Park	• Lack of synergies • Delay in adopting innovations and new technologies • Tax levels and regulatory interventions also inhibit business development.

4.1. Strengths

4.1.1. All Pillars

Megalopolis is a rather small municipality in the regional unit of Arcadia, in the region of Peloponnese. Because of its abundant lignite resources, Megalopolis has become an important energy centre of Greece, since the power plants installed there are responsible for the electrification of the region of Peloponnese in total, which is inhabited by almost 1.1 million people [46]. The town of Megalopolis had four lignite power units, of which the two are still in operation. Each of these two have a net capacity of approximately 250 MW. In 2014, the total amount of electricity produced by Megalopolis' units 3 and 4 was 3056 GWh and in 2018 production was decreased to 2323 GWh [47]. Based on the post-lignite master plan, Megalopolis' unit 3 will be shut down in 2021 and unit 4 in 2023.

Another interesting fact is that the excavated amount of lignite is analogous to the amount of energy produced. For example, in 2017 the electricity production was increased compared to 2016 and there was a proportionate augmentation on the lignite production in Megalopolis. In 2016, the lignite centre of Megalopolis produced 6.1 million tons of lignite, whereas it produced 8.1 million tons in 2017, due to the increased demand for electricity [48]. Productivity is one of the key terms that affects the long-term viability of a coal mine and is measured as the annual production of coal per person employed. In Megalopolis, the estimated productivity is 12,736 tn/person, being among the most productive mines in Europe. However, it is lacking in terms of average efficiency, making the last steps in the transition easier. It is ranking below 30%, being among the worst performers. The reason behind that is the low quality of the lignite, which is creating high costs and a great deal of CO_2 emissions.

4.1.2. Clean Energy

The renewable energy potential and a low-quality building stock constitute the background of a possible low-carbon energy transition [49]. Megalopolis has plenty of sunshine. Therefore, the construction of a photovoltaic installation would be an efficient idea (yearly solar generation ranks between 1300 to 1400 kW_p/PVs). The construction of photovoltaic parks of ~0.5 GW is already planned, according to the existing post-lignite master plan. Engaging citizens through collective energy actions (e.g., through rooftop solar installations) can also reinforce positive social norms and support the energy transition.

There is the potential of producing energy from biomass. The most sustainable potential by biomass type in the region is forest (primary forestry production, field residues, and secondary forest residues). Other types, like agriculture, bio-waste, and post-consumer wood and dedicated perennial crops, have a lower supply in the region. Consequently, a biomass plant could be installed in Megalopolis, which could use the waste created by the aforementioned activities, in order to generate electricity and heat.

In addition, the construction of a hydro power plant on the Alfeios River, which flows into the mining site and through the Megalopolis basin, should be investigated. Moreover, this hydro power plant could take the form of a pumping storage complex. The mining site is an appropriate location for this project since the excavation site could be used as the upper reservoir of the installation.

The district heating system of Megalopolis started operating in 2007 and supplies the city with thermal energy for space heating and domestic hot water [50]. In this respect, the utilisation of existing infrastructure could be exploited, taking into consideration the schedule for the withdrawal of lignite plants.

4.1.3. Smart Agricultural Production

The regional unit of Arcadia is a rural area, which means that the economy, besides the energy sector, is based on traditional sectors, like farming and livestock activity. Agriculture, forestry, and fishing occupy the greatest share of total employment in the region. One incentive to attract young citizens in the rural and agricultural communities is by providing basic services and improving the quality of life.

4.1.4. Sustainable Tourism

The existence of significant cultural characteristics of the municipality and the variety of the natural environment is expected to further enhance the local economy in the future, especially in the tourism sector.

The proximity of Megalopolis with Athens, due to the relatively new highway, along with the proximity with other urban centres, like Tripoli, Sparti, and Kalamata (an Airport is located there), strengthens Megalopolis' tourism opportunities.

Megalopolis has a rich archaeological, historical, religious, and cultural stock. Ancient Peloponnese is characterized as the "Land of Legends" and has created a strong communication image through the brand "Mythical Peloponnese". The ancient theatre of Megalopolis (built in 370 BC), ancient Gortina (habited since 1600 BC), and many more, provide a strong opportunity for promoting Megalopolis' tourism sector. Megalopolis has Byzantine churches, monasteries, and castles which enhance the cultural and religious assets of the area. On top of that, the tourism product of Megalopolis can also include adventure activities, through the promotion of the Lousios River (rafting) and Lousios Canyon (hiking) which is approximately 30 min away, by car, from the city centre of Megalopolis.

4.1.5. Other

Work transfer programs and on-the-job training is a priority, including among others the following actions [51,52]: support workers who have appropriate skills and/or are willing to retrain; support the direct transfer and on-the-job training of workers with appropriate skills to move to an alternative local job, through the development of a regional worker transfer program; select younger workers with some post-secondary education to attend an integrated multi-purpose retraining program, because they are more likely to succeed due to higher ability to build on their skills; support workers who are willing to reallocate and pursue an alternative professional plan, by providing reallocation assistance programs.

4.2. Weaknesses

4.2.1. All Pillars

The importance of lignite in Megalopolis has made the area a completely coal-dependent economy and the prosperity of the town is gravely reliant on the lignite power plants. Consequently, an environmentally friendly transition, without considering the people that live in town and the preservation of their jobs, would be catastrophic for the local economy. In Greece, there are 1600 jobs in lignite power plants and 4900 in lignite mines, with a total of around 6500 direct working positions [53]. The Peloponnese coal-related industry occupies around 850 direct jobs. Moreover, there are more than 2400 indirect employees in the lignite mines in Greece. In Peloponnese, there are 200 intra-regional and 560 inter-regional jobs. The expected direct job losses in power plant operation, due to coal-fired power plant decommission in the coming years, could lead to growing social inequalities.

The lignite plants in Megalopolis produce more greenhouse gases than other plants in Greece in order to produce the same amount of energy. Specifically, the calorific value of the lignite fluctuates from 975 to 1380 kcal/kg in Megalopolis, from 1261 to 1615 kcal/kg in the area of Ptolemaida (region of Western Macedonia) [54]. In order that Megalopolis' units to produce one MWh of electricity, they emit 1.83 to 1.94 tons of CO_2, whereas the lignite plants in Western Macedonia emit 1.25 to 1.55 tons of CO_2. The repeated exposure to polluted air has major health impacts on population, both short- and long-term. Lignite is characterised as the most health-harming form of coal, due to the pollution resulting from its combustion [55]. In 2016, coal combustion caused more than 12,000 premature deaths in the EU and 3900 in the Western Balkans [56]. Seven out of ten deaths in Ptolemaida are related to cancer or thromboembolic disease (stroke, stroke, pulmonary embolism), while cancer cases have risen by 16% since 1950, and the number currently stands at 30.5% [57]. Consequently, life expectancy in the region has been falling.

4.2.2. Clean Energy

Reducing the pollution of ecosystems by the various activities of Megalopolis is a key pillar of the just transition initiative. Limiting the burning of lignite alone will improve the environment. However, actions aimed at diversifying the economy must be based on "green" technologies. RESs could support the diversification of the economy, but the promotion of greener sources of energy in Megalopolis requires the improvement of their funding conditions, legal framework, and administrative procedures.

One of the major issues of a just transition project is the transition itself, especially for a region such as Megalopolis. Megalopolis is situated on a plain. The average yearly wind speed is very low across the area of Megalopolis, ranging from 0–4 m/s. Hence, wind power installation would not produce the electricity required.

4.2.3. Smart Agricultural Production

The small size of Greek holdings (ca. 6.6 ha), the high average farmer age (55+), and the low output per hectare (ca. 2550 Euro/ha) are the main characteristics of Greece's agriculture sector [58]. Just 7% of the employees in the Greek agriculture industry have training, in contrast to 20% of their European peers [59]. These features hinder the enabling of innovation and creativity to flourish in the agricultural sector of Megalopolis. Moreover, links between agriculture and forestry, and research and innovation are rather limited.

4.2.4. Sustainable Tourism

In Megalopolis, some of the weaknesses that can hinder any development activity are: (a) the limited exploitation of unused public areas; (b) the distances of some communities with the centre of the municipality; and (c) the quality of the roads and residential infrastructure. Although major projects have been undertaken, for example the highway that facilitates access from Tripoli to Athens, there is a need for a better local road, water, and sewerage network. It will also strengthen the tourism industry as it seeks to create a new road network which connects all the archaeological sites of Megalopolis.

4.2.5. Other

The lack of digital infrastructure in the countryside, in combination with low internet connectivity, repels young citizens and young entrepreneurs. Improved connectivity raises the quality of life and standard of living because there are better provided services, better access to jobs, and better solutions to the environment. It can support economic development, by providing access to information, connecting people to businesses everywhere, and opening up new markets [60].

The lack of awareness of citizens about development and environment is linked to the reduced degree of awareness-building at the municipal and community level. Thus, whatever development venture will take place will not work. The social capital of an area is just as important as the human and natural capital. New models for the assessment of the sustainability of industrial investments are necessary [61]. It is also important to take actions that will strengthen the common municipal consciousness.

4.3. Opportunities

4.3.1. All Pillars

Megalopolis is capable of promoting sustainable development, due to the great investment interest in energy sustainability, the European initiatives for climate change, and the geographical position of the region. RESs, combined with smart farming and organic farming, can lead Megalopolis to a self-sufficient energy economy with minimal pollution production.

This de-industrialisation trend could free-up resources and funds which could be used for other economic activities. Lignite areas will continue to receive greenhouse gas emission allowance auctions through the Green Fund, including also actions, such as: declaration by the EC of lignite areas as special tax zones with specific tax incentives; the existence of special tax incentives for heating; and the existence of special support schemes for those who lose their jobs, until they are employed again in other working areas [48]. Through community, national, and EU funds, and other financing options for coal regions in transition (such as new lignite development programs with funding from the National Strategic Reference Framework, the Just Transition Fund, and the European Investment Bank), as well as financing tools such as the InvestEU (namely the Juncker Package) [48], Megalopolis could find a way to highlight its needs and derive some of these investments, providing opportunities for supporting sustainable projects.

4.3.2. Clean Energy

Mitigating household energy poverty is a key precondition, especially in coal regions such as Megalopolis. According to the latest data, more than 50 million people in the European Union (EU) experienced energy poverty in 2018 [62]. The local authorities, in close collaboration with the regional and local stakeholders, should consider a variety of solutions to incentivise behavioural energy efficiency, accelerate the building renovation, and support energy poverty policy implementation, by enabling programmes for energy-poor citizens [63]. Such programmes should also include, aside from direct financial incentives that target low-income households, other forms of financial support, such on-bill financing or tax-rebates [64,65].

The Clean Energy Package of the European Commission (EC) recognises and offers an enabling legislative framework for 'Citizen Energy Communities' [66] and 'Renewable Energy Communities' [67]. By 2030, the EU will have to increase renewables to 32% of the share of the energy supply and in order to reach this binding target, an explicit role for citizens and communities is foreseen. This is an important step forward towards "energy democracy", as not only does it acknowledge the role of democratically controlled communities in the energy transition but it will also make it easier for European citizens to set up their own renewable energy projects, protecting them from the big players of the energy market. The wider penetration of ICT tools provides opportunities for citizens' empowerment to collaborate and promote better informed decision-making [68,69]. Both the Electricity Market Directive and the new Renewable Energy Directive (RED) call for an enabling framework for energy communities, whereby Art. 22 (4) of RED II goes beyond encouraging a mere level playing field but rather calls for the promotion of renewable energy communities as a way to expand the share of renewable energy at national level. Community energy projects have increased rapidly, partly driven by renewable energy support schemes. In Europe, there are about 3500 so-called renewable energy cooperatives (a type of energy community) which are found mostly in north-western Europe [70]. This number is even higher when including other types of community energy initiatives (e.g., limited partnerships, community trusts and foundations, housing associations, non-profit customer-owned enterprises, public-private partnerships, and publicly owned utilities). Strengthening community energy projects in Megalopolis, and not only the construction of medium- and large-scale photovoltaic parks, will be the key to achieving the transition to "green energy" in accordance with the municipality's objectives. More specifically, next-generation energy communities (like those introduced within the framework of the H2020 POWERPOOR project) should be encouraged, making use of alternative financing schemes (e.g., crowdfunding). In this way, a sharing economy in practice for younger generations can be achieved. Community energy projects, implemented by the local authority, can involve young people (aged 18–29) through a rotation process (e.g., joining for 2–3 years and benefitting from the clean energy produced). The aim will be to provide them with financial support for their first years of studies, or with the essentials to create their first business in Megalopolis.

"Energy Efficiency First" or "Efficiency First" (E1st) can also play a game-changing role in the faster transition of Megalopolis, while creating local jobs and other economic opportunities. The E1st principle is an established principle of EU energy policy. It has entered from the policy debate to legislation with the Clean Energy for All Europeans policy package, first appearing in 2016 in the EC's communication of the package [71] and then in 2018 in the Governance Regulation [72], which in essence "means to consider, before taking energy planning, policy, and investment decisions, whether cost-efficient, technically, economically, and environmentally sound alternative energy efficiency measures could replace in whole or in part the envisaged planning, policy, and investment measures, whilst still achieving the objectives of the respective decisions … Member States should also encourage the spread of that principle in regional and local government, as well as in the private sector". The E1st principle balances demand and supply options in order to prioritise the least-expensive investments for the energy system from a whole societal point of view. It can be considered as an organising principle in which assessing the potential for energy savings and demand response becomes the first step in any energy-related decision. E1st is built on the common-sense approach that the municipality should try to reach its decarbonisation goals by using as few resources as possible [73]. Setting it as a requirement for Megalopolis creates additional resources for energy efficiency and demand response and moves forward such investments that would otherwise not materialise regardless of their economic performance. This is also validated by a recent study presented by Stavrakas and Flamos (2020), where it is shown that promoting a synergistic co-operation between the power supplier and the prosumer in Greece could lead to significant cost reductions and energy savings, paving the way towards "game-changer" business models that capture new value on the supply side by coupling it to the demand side [74].

4.3.3. Smart Agricultural Production

New technologies and well-trained workforces are the solution to protecting and managing the environment and tackling climate change challenges [75]. Therefore, new models like smart agriculture, precise agriculture, hydroponics, and organic agriculture can provide benefits to sustainable agriculture, increasing the efficiency and productivity of food creation, as well as potentially providing environmental and social benefits [76]. Particularly, the physical products that these models provide contribute to the income of farmers, agro-industry, and non-farm rural economy [77]. In other words, they do not target labour productivity in a classical economic sense, but instead imply a shift towards resource efficiency with labour intensity being considered a possible asset. Thus, their main novelty is that they use an equal amount of resources and provide more employment. This approach can also be implemented for livestock production. For example, emission per litre of milk are dependent on the efficiency of the cow. Therefore, increased efficiency should be pursued for every activity that is included in the agriculture industry. In addition, implementing these new models can be a major driver of a "green" economy and a concrete way to operationalise sustainable development, because agriculture and food systems utilise a very diverse range of resources, but also produce a very diverse range of outputs [78]. Consequently, they could reduce food losses and wastes along the whole food-chain process, especially at the transport and conservations stage where the emissions are very high. Finally, these models could increase diversity in the field and are a way to increase production and resilience of agricultural systems. Thus, farmer's income is increased and more secure.

In order to develop human resources and cultivate entrepreneurial behaviour among Greece's farmers, training benefits should be presented in terms of increased productivity, and how this translates to increased income. Facilitating smart farming in the area could be boosted by establishing a farming research centre, which will be hosted in some of the existing buildings of the lignite complex. Moreover, the Just Transition Fund should dedicate a significant part of its resources to the provision of additional incentives (in terms of training, land, organization, and capital) for younger people to engage in farming, since they are the ones who have inspirations, are open-minded, and more familiar with new technologies.

Peloponnese olives, wine, cheese, fruits, and vegetables of are some of the famous products in the region. Consequently, utilising the primary sector for the development of the region and the creation of jobs for the processing and standardisation of local products, as well as focusing on agritourism, is a strategy that combines two of the strongest sectors of the region; tourism services and food/beverage produce.

The lignite mines are located in a huge area, which will be emptied after the termination of the mining activities. This provides the opportunity to revitalise the area in a variety of manners. Since the lignite centre is in Megalopolis' basin, it could host agricultural activities or even become a forest.

4.3.4. Sustainable Tourism

The coal mining assets of Megalopolis can also offer contemporary tourist attractions. These activities include concerts, sporting events such as running and bike racing, and maybe the construction of a car racing venue (preferably for electric cars, which will be emission-free). Furthermore, a portion of this area could be used for waste management in the form of composting or recycling, or even by constructing a power plant, which will be powered by public waste. Interactions between technological solutions for managing waste and energy supply chains can vary significantly, depending on multiple criteria and different characteristics [79]. Furthermore, the shores of the Alfeios River can be restored in order for the river to become a rafting attraction. Another way to revitalise the environment would be the creation of a park close to the town of Megalopolis. The electricity generation installation could be transformed into a museum, which will display the way energy was produced before the use of RESs. Consequently, many people who used to work in the lignite centre may be able to retain their jobs.

The design of a new model of tourism development with strong regional identity should be considered. Sustainable development is not only the future development direction and trend, but also constitutes the only way ahead for tourism. A significant aspect of implementing sustainable tourism standards lies in their noticeable contribution to environmental protection and energy efficiency. The latest trend in tourism is destination sustainability (an area based on geographical, cultural, and other specifications) and certification. In this context, the Global Sustainable Tourism Council (GSTC) has developed a series of evaluation criteria for the sustainable tourism industry and destinations, recognized as the Goal Standard by the most significant tourism stakeholders on a global scale [80]. The introduction of new technologies in the tourism sector can support touristic infrastructure/accommodation in evaluating their energy and environmental efficiency, by means of designing appropriate indicators, producing comparative analyses, and providing best practices based on international sustainable tourism standards, thus enabling them to optimise their overall efficiency. At a subsequent level, new technologies can support destination management organization (DMOs), by collecting and utilising available data and local/regional action plans in the aim of evaluating and suggesting sustainable tourist destinations.

4.3.5. Other

In the area of the power plants there is a plethora of buildings, both administrative and industrial, which are involved in the plants' operation. When the power plant shuts down these buildings will be abandoned. Therefore, they could be transformed into research centres or innovation/entrepreneurship centres. The lignite area could unite all stakeholders and organise them into a joint action aimed at strengthening the productive fabric of Megalopolis. Megalopolis needs to develop a vision that first allows its universities to create linkages between research and energy transition, and second stimulates sustainable entrepreneurship.

Megalopolis' requirements for enabling the region's transition to a resilient low lignite-dependent economy are to strengthen business activities. The creation of the Megalopolis Business Park, which is part of the existing master plan, would be also beneficial for people who had businesses related to the power plants.

4.4. Threats

4.4.1. All Pillars

Megalopolis has a great share of its population, 50.22%, in the 20–59 age bracket, which is characterized as the most economically active cohort. However, there is a strong aging demographic phenomenon, as only 10.75% of the population are 0–19 years old and 39.02% are 60+ [30]. Figure 3 demonstrates the mean unemployment rate in Arcadia from 2001 to 2018. In 2009, financial crisis effected unemployment rates and in 2013 the first peak at 24.4% was reached. The next year the percentage falls to 19.9%, but in 2016 it reaches the highest level at 25.9%. Since then, the rate follows a stable downward slope. If no just transition is in place, lignite phase-out will result in the depopulation of Megalopolis since many inhabitants either work in the lignite industry or their businesses are heavily dependent on the lignite centre and the people who work there. In this respect, the threat of increasing unemployment and the absence of creating new jobs should be considered.

Figure 3. Mean yearly unemployment rate in Arcadia from 2001 to 2018, *Source: ELSTAT* [81].

4.4.2. Clean Energy

Megalopolis will lose its largest industry after the lignite phase-out, but RESs can maintain the position of Megalopolis in the power industry. Massive deployment of renewables is considered as a decisive step. However, at the local scale, it is also perceived by many as a threat to their rich and diverse natural environment. This green versus green pseudo-dilemma highlights how crucial a broad societal buy-in is [82]. Moreover, the current policies in the region and the existing post-lignite master plan for fair development transition are lacking in terms of energy efficiency measures for buildings.

Energy poverty is also directly linked with the operation of the district heating network. According to the master plan, the district heating network will be based on a gas distribution network as a final solution from 2022 onwards. This includes the construction of a liquefied gas (LPG) boiler for the period 2020–2021 and the natural gas network during 2021–2022, which will be directly connected to the buildings in the area of Megalopolis. Given the fact that natural gas is an exclusively imported fuel, alternative energy sources should be exploited for the operation of existing district heating networks and/or to new ones in Megalopolis.

4.4.3. Smart Agricultural Production

All the proposed practices in the agricultural sector can contribute to the creation of hundreds of jobs, but the lack of technical knowledge for growing plants through hydroponics and other smart farming actions remains a threat.

4.4.4. Sustainable Tourism

In the tourism sector, the risk of degradation of the natural and built environment should be considered. The relationship of tourism with the environment is complex as it involves many activities that can have adverse environmental effects [83]. For instance, the creation a theme park of adventure, entertainment, and education may also have negative consequences on the environment through new infrastructure creation, private car mobility, etc.

4.4.5. Other

The lack of synergies is also a threat. Dynamic processes should be promoted based on reassessment, redefinition, and learning of incentives and objectives through participation, multi-level governance, synergy between the state and society, and inter-regional and inter-company networks. As a result, cooperation and mobilisation of members of a community or municipality should be empowered.

As in the rest of Greece, ten years after the crisis, there is a lack of financing available for private sector business start-ups or expansion, as well as delay in adopting innovations and new technologies. Tax levels and regulatory interventions also inhibit business development.

5. Conclusions

Climate policies are tightening, therefore planning for the closure of the lignite mining industries has already began in Europe. Regions which depend on the industrial sector of lignite are facing an uncertain future. The question should not be if the post-lignite era will arrive, but instead how lignite-dependent areas should deal with it. The process of Just Transition describes exactly that: where we are going and how we get there. Just Transition is a development model and an integrated approach, which considers elements like infrastructure, public and social policies, taxation, education, social awareness, and participation. In addition, it should be locally designed, because a region's potential and needs are better known by the locals. This is particularly important for the coal regions in Greece, as one of the most lignite-dependent countries of Europe which has set ambitious goals for a complete decarbonisation of the country by 2028 (shutting down the lignite-fired power plants that are currently in operation by 2023).

The main objective when designing a development policy is to identify the keys to success that will promote the economy of the targeted region. In this context, the results of the SWOT analysis, presented in this paper, highlight the strengths, weaknesses, opportunities, and threats of Megalopolis. Its local economy is heavily dependent on coal and this has created obstacles to the region's efforts to cope with future economic challenges. The National Energy & Climate Plan, PPC's business plan and practice, as well as the environmental regulations of EU, all confirm that the lignite era in Megalopolis will be over by 2023. As a consequence, there is an urgent need for effective actions and policies that will support Megalopolis to create its own path towards regional resilience.

A strong, diversified economy is a commonly accepted solution. Megalopolis can be characterised as an economically vulnerable region. The region has high levels of unemployment and inactive population and its economic base is heavily dependent on the energy sector. On top of that, most of the economic, social, and environmental challenges are rooted in the dominance of Greece's PPC in the local economy. Particularly, if the wages of coal-related industry fall, this will immediately affect the locally available income. Therefore, educational and training programs, along with early retirement schemes, should be designed, which will protect both the income of the ex-miners and their families, and the income of the local economy.

The development process of Megalopolis should be based on energy, agriculture, and tourism. The terms and conditions are related to interventions in the infrastructure, entrepreneurship, institutional arrangement, and on concepts for creating a culture of public-private partnerships along with the social sector of the economy.

Megalopolis, and more specifically its lignite area, could play an important role in the transformation of Greece's electricity generation mix, with innovation and investment in "green" technologies gathering the most attention for this venture. The integration of the "Energy Efficiency First" principle, the mitigation of household energy poverty (especially in a region with district heating installations), and collectively driven energy actions for engaging and empowering younger generations (e.g., in the form of next-generation energy communities) are among the solutions that are expected to have a significant contribution to a just transition away from coal in Megalopolis.

It is also crucial to develop a mechanism that will support the development process considering the pros and cons of the available human capital. One basic vision of Megalopolis is to improve the attractiveness of the area as a place of residence and business activity, by promoting the principles of sustainability, resilience, and self-sustaining growth. In other words, Megalopolis needs to provide incentives to retain the age cohort 15–34 or even attract new residents.

There is also an urgent need for collaboration between the primary sector, research, and innovation. Technology is already available, practices are available, and scientific human resources are the greatest asset of Greece, and if synchronised through a common strategy they could promote the holistic development of Megalopolis. In other words, new higher value-added jobs will be created and attract new people, while at the same time the environmental impact of economic activity will be reduced due to the greener practices that will be applied.

The role of local authorities, communities, and organisations could assist with new initiatives. The effective orientation of the economy towards resilience demands the activation and cooperation of all the basic stakeholders of the local social capital. Thus, a common vision for the area could be designed looking at the post-lignite future, and a Business Park could provide the necessary know-how to achieve this vision and help to establish or expand Small and mid-size enterprises (SMEs) in Megalopolis, which will be characterized by innovation, competitiveness, and sustainability.

Megalopolis can achieve development in all aspects, economic, social, environmental, technological, and cultural, as long as it bases its strategic vision on: innovation, entrepreneurship, research, and synergies, as these are the foundations for transforming Megalopolis into a diversified economy and thus enhancing its regional resilience.

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