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Review

Coal to Biomass Transition as the Path to Sustainable Energy Production: A Hypothetical Case Scenario with the Conversion of Pego Power Plant (Portugal)

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Abstract: Fossil fuels, especially coal, contribute to carbon emissions, hindering the EU's decarbonization goal by 2050. This article proposes converting the Pego Coal Power Plant into a biomass plant as a potential solution. Biomass, a renewable resource abundant in Portugal, can transform the Pego plant into a sustainable energy source, reducing greenhouse gas emissions and combating climate change. It also reduces rural fire risks and ensures regional social and economic stability. The study explores the feasibility, limitations, and socioeconomic impacts of this scenario. This solution prevents plant closure, reduces environmental impacts, and promotes sustainability. Aligning with Portugal's 2030 Agenda and global climate change efforts, converting the Pego plant serves as a valuable example of renewable resource utilization for climate change mitigation and regional stability. The study's results offer insights for policymakers and stakeholders in developing sustainable energy transition strategies. Adopting such solutions can help countries achieve decarbonization goals while promoting social and economic development.

Keywords: biomass alternative; biomass energy; coal replacement; decarbonization

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1. Introduction

Energy is crucial for the progress of organizations and countries, as most activities require energy consumption [1]. This has led to increasing energy demand in both developed and developing countries, with China and the US as top producers and consumers [2]. Given the link between energy use and economic growth, renewable energy sources can be seen as alternatives to fossil fuels, helping to reduce ongoing environmental damage [3]. Baz et al. [4] argue that growing reliance on polluting energy sources leads to complex problems, causing health and environmental issues that are hard to address. Many studies have investigated the relationship between energy consumption and economic growth, including those by Shaari et al., Park and Yoo, and Žiković and Vlahinić-Dizdarević [5–7]. Unfortunately, as Antonakakis et al. [8] point out, fossil fuels have driven global economic growth. However, recognizing renewable energy's importance in addressing climate change, researchers have examined how using renewable sources can support positive economic growth.

Currently, both private companies and governments are working hard to promote renewable energy use [9]. Developing and developed countries have built significant renewable energy production capacities, supported by government policies [3,10,11]. For example, Indonesia is analyzing how biomass waste can contribute to diversifying energy sources, and how this approach can increase the circular economy and the decarbonization of the energy production [12]. Along with local and regional actions, international environmental agreements that rely on state cooperation have become important, highlighting climate change as a global issue [13,14]. Mainly, state leaders' strategies focus on replacing fossil fuels with renewable energy options, such as biomass [15–17]. Biomass has shown success in both environmental and economic aspects, with techniques such as cofiring with coal (a highly polluting fossil fuel), demonstrating its potential [18–21]. For example, the United Kingdom has encouraged biomass use for electricity generation by introducing Renewable Obligation Certificates to motivate the adoption of cleaner energy sources [22].

Europe is highly vulnerable to climate change effects. As a result, Europe has launched various initiatives to encourage mitigation efforts, such as the European Adaptation Strategy and the Mayors Pact for Climate and Energy [23]. Introduced in 2013, the European Adaptation Strategy aimed to create solutions for climate change challenges and reduce its impacts [24,25]. Climate change has harmed not only Europeans' health but also the economy, causing yearly losses [26–28]. This has increased Europe's urgency to act [29]. Started in 2015, the Mayors Pact for Climate and Energy aimed to voluntarily join local and regional authorities' efforts to meet the European Union's climate change goals [30]. All pact members are dedicated to cutting greenhouse gas emissions, improving their territories' resilience, and understanding their local environmental situations [31,32].

The Kyoto Protocol, an international agreement under the United Nations Framework Convention on Climate Change (UNFCCC), was adopted in 1997 and took effect in 2000 [33]. Its main goal is to decrease greenhouse gas (GHG) emissions [34]. The protocol includes three market-based mechanisms for better results: International Emissions Trading, Clean Development Mechanisms, and Joint Implementation [35]. A study by Kim et al. (2020) found that the Kyoto Protocol helps the environment by lowering CO_2 emissions but negatively affects the economy. The study indicates a trade-off between reducing carbon emissions and fostering economic growth [34]. Figure 1 shows the evolution of CO_2 emissions over the past 61 years, from 1940 to 2021.

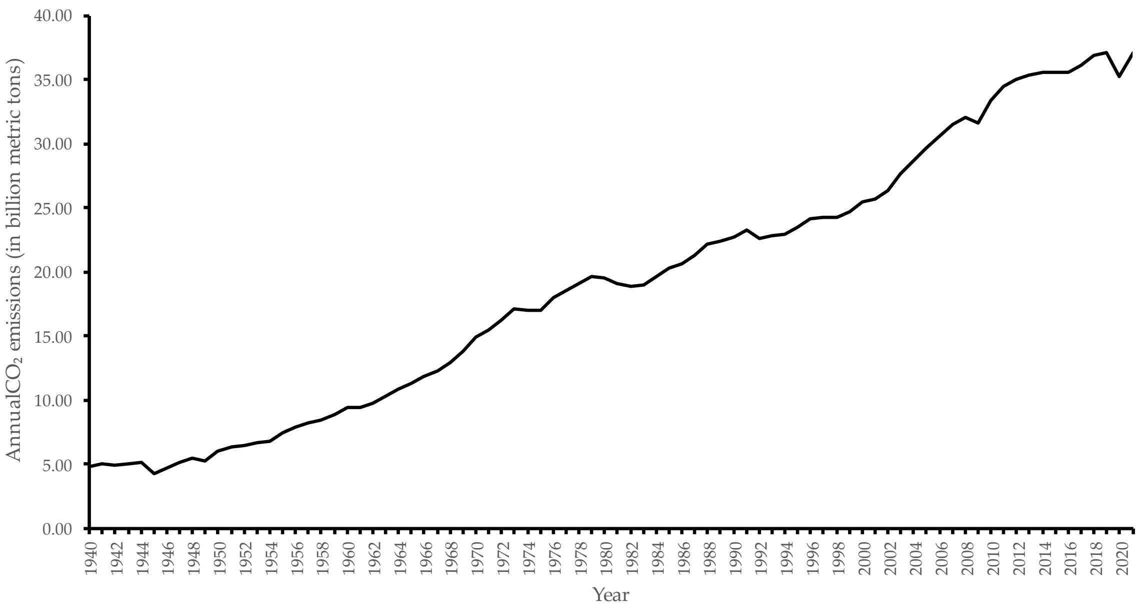

Figure 1. Annual CO_2 emissions worldwide from 1940 to 2021 (adapted from https://www.statista.com/, accessed on 15 March 2023).

Portugal ratified the Kyoto Protocol and joined the UNFCCC to address climate change and has improved its environmental policies. Carvalho et al. [36] state that Portugal was the first southern European country to create and publish an integrated climate change assessment in 2002. Although Portugal's GHG emissions are low compared to other countries, it still feels climate change effects, making national policies important. The

National Strategy for Climate Change, approved in 2001, has three key instruments: the National Program for Climate Change, the National Plan for the Allocation of Emission Licenses, and the Portuguese Carbon Fund. These tools aim to reduce emissions, encourage renewable energy use, and adapt to climate change impacts. Portugal has also promoted sustainable transport and developed a national energy efficiency plan. However, Carvalho et al. [36] say that the measures' renewal was not as effective as hoped, because the National Plan for the Allocation of Emission Licenses lets industries negotiate with each other and maintain their emissions. The Portuguese Carbon Fund was created to align Portugal's efforts with the Kyoto Protocol's goals [37,38].

This research aims to thoroughly examine the current understanding of coal and biomass energy and their environmental impact. Coal, a significant energy source, conflicts with the European Union's decarbonization goal by 2050. With Portugal's abundant biomass resources, this study suggests a sustainable solution for shutting down coal power plants, using the Pego Coal Power Plant as an example. The study assesses the potential benefits and limitations of replacing coal with biomass in a hypothetical scenario, considering economic and social effects. The Portuguese government has already announced the closure of coal power plants, including Sines in 2020 and Pego in late 2021. However, the proposed solution could reactivate the power plant, lower greenhouse gas emissions compared to coal, help fight climate change, reduce rural fire risks from waste biomass, and maintain regional social and economic stability.

2. The Paradigm of Carbon-based Energy Production

2.1. Biomass Energy

The use of fire has a long history in human civilization, with evidence of controlled use dating back 300,000 years. Early fires were fueled by organic materials, such as wood, which greatly influenced human societies and cultures. For much of history, organic materials were the main fuel source. Recently, fossil fuels have become the dominant energy source, driving industrial societies and modern technologies. Due to environmental concerns and fossil fuels' limited supply, there is increasing interest in biomass as a sustainable alternative energy source for power generation, especially given the negative effects of greenhouse gas emissions from widespread fossil fuel use [39,40].

Bioenergy from biomass is the main form of renewable energy in the European Union, accounting for about 60% of total renewable energy consumption. Biomass is considered CO_2-neutral because the CO_2 released during the combustion or conversion process is reabsorbed by regrowing biomass through photosynthesis. Unlike coal carbon, biomass carbon is part of the current carbon cycle and is produced in today's atmosphere [41–43]. The use of biomass for energy is becoming popular, especially in the heating and power sectors in the EU and worldwide. Forest biomass, including tree components, such as trunks, bark, branches, needles, leaves, and roots, is the main nonfood biomass source [44]. However, increasing demand has led to competition among industries, highlighting the need for better resource efficiency [45]. Biomass can come from various sources, such as natural forests, plantation forestry, crop production, algae production, residues, industrial processes, municipal waste, and land clearing [46]. Biomass stores solar energy as chemical energy, which can be harnessed by breaking chemical bonds between carbon, oxygen, and hydrogen molecules through biological and thermochemical processes [47]. These processes produce useful forms of energy, such as electricity, heat, or biofuels [48,49].

Biomass has emerged as a critical alternative to conventional fossil fuel resources due to its versatility and capacity to provide energy and various other products, positioning it as a potential solution for sustainable energy production [50]. Biomass can be sourced from an array of origins, encompassing regrowth forests, plantation forestry, annual crop production, algae production, industrial processes, municipal waste, and land-clearing operations [51]. The chemical energy stored in biomass can be harnessed by breaking the chemical bonds between adjacent oxygen, carbon, and hydrogen molecules through both biological and thermochemical processes [52]. This conversion enables the production of useful forms of energy, such as electricity, heat, or biofuels [53]. To circumvent deforestation, habitat degradation, and biodiversity loss, it is imperative to sustainably produce, process, and utilize biomass while minimizing greenhouse gas emissions and conserving ecosystems [54]. Biomass fuels have not been widely adopted for large-scale power plants, primarily due to their lower heating values compared to fossil fuels, which can be attributed to their high moisture and high oxygen contents [55–57]. Various biomass energy sources, such as wood pellets, wood chips, torrefied biomass pellets, and charcoal, are commonly employed for energy generation [58–60]. Derived from organic matter, these materials are acknowledged for their potential to contribute to sustainable energy solutions [47].

Compared to fossil fuels, biomass fuels exhibit a higher proportion of volatile matter. Typically, biomass comprises approximately 80% volatile matter, while fossil fuels contain merely around 20% [50]. The heightened volatility of biomass can enhance its reactivity during combustion. However, to fully exploit this characteristic, combustion technology must be adapted to suit the unique properties of the biomass fuels in question [47,61]. Biomass is extensively employed in heat and electricity generation, with the majority of global bioenergy production being achieved through direct combustion [62]. In addition to direct combustion, biomass can be transformed into biofuels via thermochemical and biochemical processes. These biofuels, available as solids, liquids, and gases, encompass charcoal, bio-oils, methanol, ethanol, methane, and hydrogen, all of which can be harnessed for heat and power generation [63]. Thermochemical processes, including combustion, pyrolysis, gasification, and liquefaction, are employed for bioenergy production [64]. Advanced thermochemical processes, such as cofiring or cocombustion of biomass with coal or natural gas, fast pyrolysis, plasma gasification, and supercritical water gasification, facilitate bioenergy production [42]. These processes, characterized by elevated temperatures and pressure, result in the conversion of biomass into various biofuel forms, including solids, liquids, and gases [65]. Such fuels, utilized for heat and power generation, are regarded as environmentally friendly alternatives to traditional fossil fuels [42].

The employment of biomass as a renewable energy source depends on sustainable management practices, which take into account factors such as growth rate, land availability, and competition for its usage in other areas, such as food production [66]. Guaranteeing the long-term viability of biomass as an energy source necessitates careful consideration and management of its resources [67]. Globally, the estimated harvestable potential of biomass from agricultural, forestry, and industrial sectors (excluding energy crops) is roughly 50 EJ [68]. Nonetheless, this constitutes only a small portion, between 10 and 15%, of the current primary global energy supply [69]. The use of biomass resources for energy generation faces competition from other applications, including food, feed, and other products [70]. Consequently, it is essential to assess the trade-offs and prioritize the most efficient and sustainable utilization of biomass resources to ensure their long-term availability as a renewable energy source [71].

2.2. Coal-Fuelled Energy Production

Coal, one of the most prevalent primary fossil fuels, constitutes the major source of solid fuel worldwide, catering to nearly 30% of the primary energy demand [72]. It is extensively employed across various economic sectors. However, recent shifts in coal utilization have emerged, primarily due to environmental concerns and the growing prominence of renewable energy sources. Despite accounting for roughly 30% of the global primary energy demand, efforts to transition away from coal usage toward cleaner energy alternatives are increasing [73]. In recent years, the negative environmental impacts of fossil fuel use, including coal, have gained increasing recognition. Scientific research, policy debates, and actions by various stakeholders, such as international organizations and global leaders, have highlighted the detrimental effects of coal on air quality, water quality, climate change, and ecosystem degradation. This heightened awareness has spurred concerted efforts to transition toward more sustainable and cleaner energy sources, emphasizing the development and implementation of renewable energy technologies [74]. Governments prioritize the elimination of coal from the global energy supply to reduce greenhouse gas emissions, resulting in restrictions on coal mines, power plants, and related infrastructure establishment. Fossil fuel environmental impacts, including those of coal, have attracted significant attention from various groups, including scientists, policymakers, global leaders, international organizations, and other relevant parties. The signing of the Paris Agreement on Climate Change in 2015 has intensified the scrutiny of coal and amplified the focus on reducing its utilization as an energy source [75,76]. Figure 2 shows the annual global CO_2 emissions by fuel or industry from 1800 to 2021.

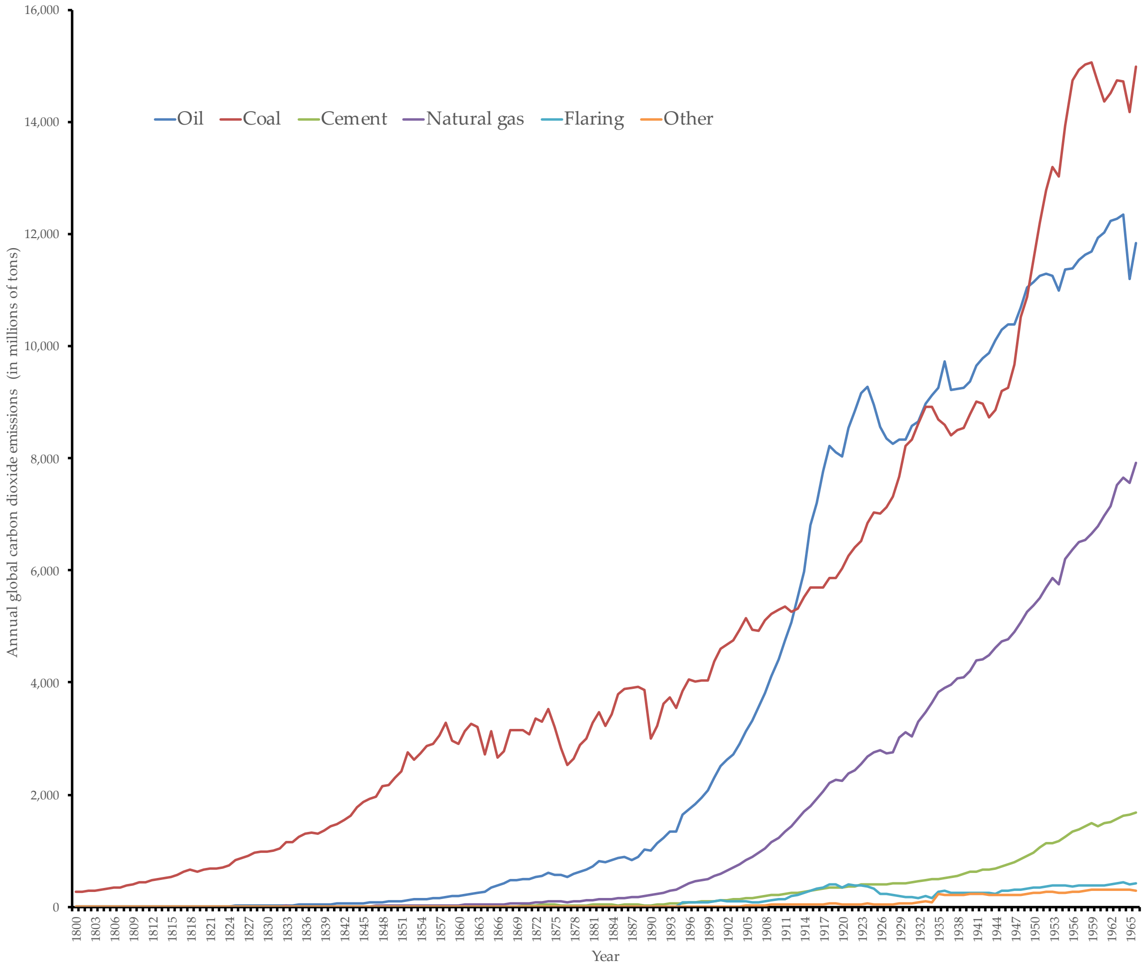

Figure 2. Annual global carbon CO2 by fuel or industry from 1800 to 2021 adapted from https://www.statista.com/, accessed on 15 March 2023).

Owing to its considerable CO_2 emissions per thermal energy unit generated, coal has emerged as a primary target in efforts to mitigate climate change [77]. Although coal continues to serve as a prominent energy source, its extraction and utilization have both direct and indirect repercussions on the environment and human health. The entire coal life cycle, encompassing mining, transportation, combustion, and waste disposal, influences air, water, soil, ecosystems, and human and animal health [78]. The transportation of coal contributes to air pollution and greenhouse gas emissions [79]. During combustion, coal emits various air pollutants associated with respiratory and cardiovascular problems, acid rain, and climate change. Furthermore, the disposal of coal ash and other byproducts can adversely affect the environment and human health. The cumulative impacts of coal usage present significant risks to ecosystems and human health, potentially intensifying consequences through cascading effects [74]. Burke and Fishel [80] suggest a Coal Elimination Treaty (CET) as a means to address carbon emissions stemming from fossil fuels. The CET serves as an instrument to empower states highly susceptible to climate change impacts and possessing ambitious climate objectives. However, the authors concede that numerous measures are required to restrict the global temperature rise to 1.5 °C, calling for a comprehensive, multitiered strategy and timely action.

In recent years, many countries have announced plans to phase out coal, with 15 European nations among those making such commitments. Some countries, such as Austria, Belgium, Sweden, and Portugal, have already achieved coal-free status [81,82]. The move away from coal is driven by factors such as the need to reduce greenhouse gas emissions, environmental impacts of coal extraction and use, and health risks from air pollution caused by burning coal. Additionally, the increasing competitiveness of renewable energy sources has made coal less attractive for energy production. This shift is essential for transitioning to a low-carbon economy and achieving the Paris Agreement's climate change targets [83]. The relative costs of different fuels are a significant factor in this trend [84]. Coal-generated electricity has become increasingly uneconomical due to the declining cost of alternative fuels, such as natural gas, wind energy, and solar power, in many regions. Strict air pollution regulations and the growing competitiveness of renewable energy sources are further decreasing coal's viability. Despite coal's historical importance and transformative impact on societies, its continued use has led to severe environmental and health consequences, including pollution, human-induced climate change, and resource depletion. As a result, phasing out coal is crucial for addressing these adverse effects and transitioning to cleaner, more sustainable energy sources. Figure 3 shows the distribution of greenhouse gas emissions worldwide in 2021 by major emitter.

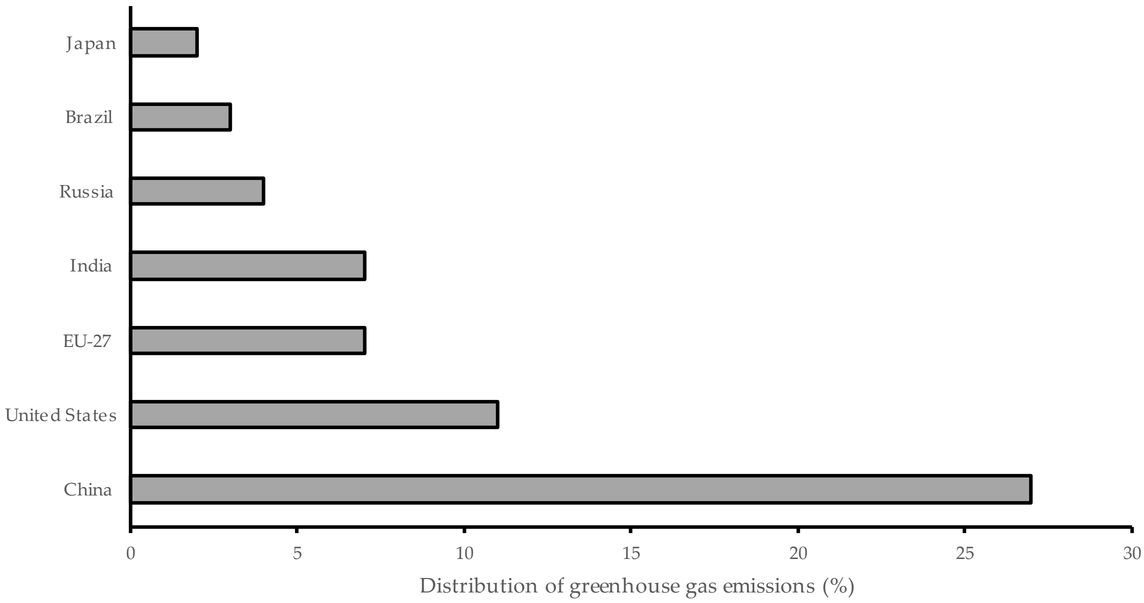

Figure 3. Distribution of greenhouse gas emissions worldwide in 2021 by major emitter adapted from https://www.statista.com/, accessed on 15 March 2023).

2.3. Biomass as an Alternative to Coal

Fossil fuel use contributes to various environmental issues, including air and water pollution, climate change, and ecosystem degradation [85]. As a result, there is an urgent need to reduce dependence on nonrenewable resources and transition to more sustainable and ecofriendly energy sources [86]. The search for less-carbon-intensive alternatives to coal has led to a growing interest in biomass, a potentially renewable and sustainable energy source with lower carbon emissions when combusted [87]. Research is assessing the technical, economic, and environmental feasibility of using biomass as a coal substitute in energy production. However, there are significant challenges, such as technical, economic, and environmental factors. Biomass properties differ from coal, requiring adjustments to combustion technology for efficient energy production. Additionally, the costs of biomass production and transportation can be higher than coal, impacting its economic feasibility. Sustainable biomass resource availability and competing uses, such as food production, must also be considered for long-term biomass energy viability. Furthermore, potential environmental impacts from biomass production and transportation, including land use changes and supply chain emissions, need to be addressed [88]. Coal power plants with a combined capacity of 35.4 GW are located in countries planning to phase out coal by 2030 or sooner, leading to these plants' expected shutdown [89–91]. In the power industry, biomass and waste can be used in two ways: as the sole fuel source in smaller combined heat and power plants or coutilized in existing coal-fired power plants to reduce net CO_2 emissions [73,92].

Cofiring biomass and coal has been demonstrated as a cost-effective technology for increasing biomass to energy processes in power generation. This can be done either by directly burning a biomass and coal mixture or by first gasifying the biomass to create clean fuel gas, which is then burned with coal. This method can significantly reduce greenhouse gas emissions. As some researchers, such as Demirbaş [73], suggest, cofiring biomass and coal provides technical, economic, and environmental benefits compared to other options. One primary advantage is that the plant always has coal as its primary fuel, ensuring 100% utilization even if the biomass supply is suddenly interrupted. This guarantees continuous operation and reduces the risk of power outages.

3. Energy Production Decarbonization and the Pego Power Plant

Various types of biomass can be used as an energy source for power generation in Europe, including agricultural surplus and byproducts, fast-growing energy crops grown in areas available due to reduced agricultural overproduction, and wood waste from forestry or wood processing [92]. However, concerns exist regarding the sustainability of transporting biomass over long distances. McIlveen-Wright et al. [93] report that carbon emissions related to transportation, measured in grams of carbon per ton of biomass per kilometer, would be 1.45 for sea transport and 31.7 for road transport.

Using biomass exclusively for energy production would require building many decentralized plants, which would be time-consuming and expensive and need substantial financial investments and storage capacities due to the fuel's seasonal availability [94]. However, using local biomass as fuel can boost the local economy by creating jobs and supporting rural development. Replacing coal power plants with biomass energy could also have a positive economic impact by offsetting job losses from coal plant closures [95]. To use biomass as an alternative fuel in coal-fired power plants, the biomass waste must have characteristics similar to coal, enabling the use of existing coal combustion systems [96].

When evaluating the transition of a coal power plant to biomass use, it is essential to consider both technical challenges and environmental impact. Using imported or deforestation-derived biomass may have external costs that should be factored in, making local biomass waste a preferable option. Transitioning from coal to biomass is not a one-size-fits-all solution due to limited biomass resources in some areas. However, for the Pego Coal Power Plant in Portugal, where biomass resources are abundant, switching from coal to biomass energy could be a feasible alternative.

To achieve goals, such as decarbonizing economies, it is important to implement public policies and engage society as a whole. Positive changes in human behavior can contribute to reducing greenhouse gas emissions by over 20%, making public awareness crucial [97]. In the European Union, 90% of the population sees climate change as a serious threat [98].

Portugal has taken a strong international stance on decarbonizing its economy and aims to achieve carbon neutrality by 2050 [99]. This goal aligns with the Paris Agreement, reflecting Portugal's commitment to the global effort of limiting temperature increases [100]. The country has set a target to phase out coal in energy production by 2023 [101]. The closure of its two coal-fired power plants, Sines and Pego, is critical to decarbonizing Portugal's economy as they accounted for 20% of the nation's greenhouse gas emissions [102]. The

Pego Power Plant underwent a retrofitting process in 2009 to reduce emissions and was overseen by a holding group consisting of three companies [103].

4. A Hypothetical Scenario Analysis

Biomass is the third most common renewable energy source in Portugal, and its production has significantly increased since the early 2000s. This growth is due to a strategic initiative starting in 2006, allocating 100 MW for electricity generation from forest biomass and an additional 150 MW for Public Interest Projects. In 2000, Portugal's biomass energy capacity was 427 MW, which rose to 891 MW by 2020. The Pego Power Plant, located in Abrantes, focuses on the biomass potential of the Médio Tejo region (Figure 4). Data from the 6th National Forest Inventory (2019) show that 46% of the Médio Tejo region is forested, 10% more than the rest of the country.

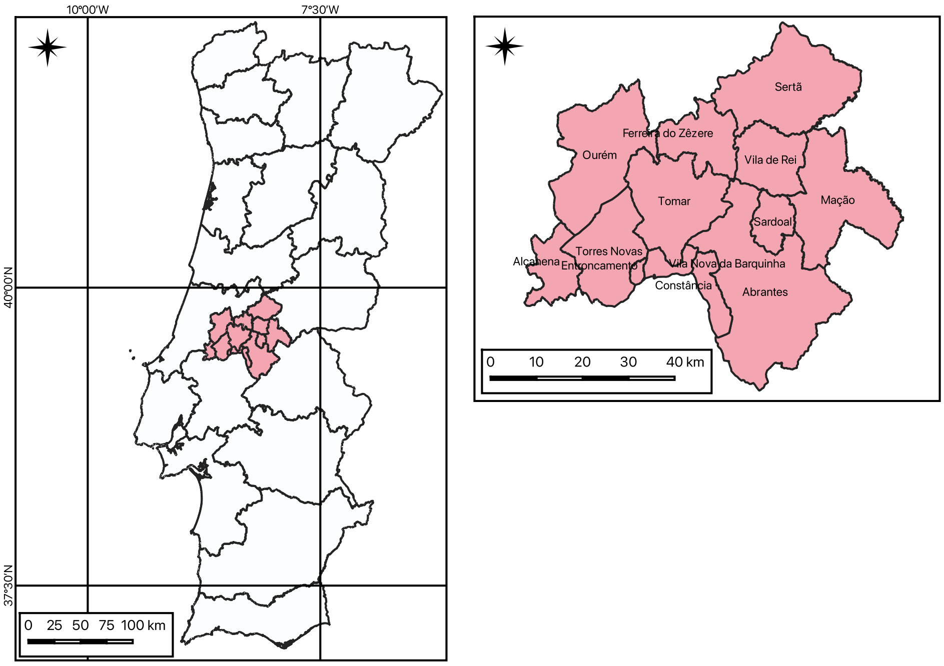

Figure 4. Location of the Médio Tejo region.

To estimate the biomass yield in Portugal's Médio Tejo region, the two primary tree species, maritime pine (Pinus pinaster) and eucalyptus (Eucalyptus globulus), were taken into account, as they comprise 80% of the total forested area in the region (information available at https://www.icnf.pt/florestas/flestudosdocumentosestatisticasindicadores, accessed on 15 January 2023). The growth volume for these species stands at 2933 Mm^3 for maritime pine and 3332 Mm^3 for eucalyptus, with a total living biomass of 1954 kt and 2628 kt, respectively [104]. If the total biomass required to transition the Pego coal-fired power plant in Portugal to biomass is less than the annual growth volume of these species (6265 Mm^3), it could be deemed theoretically sustainable for a consistent biomass supply [105–107].

To estimate the biomass needed to replace coal, data from the DGEG–Direção-Geral de Energia e Geologia on the 2019 coal balance sheet were analyzed (accessed on 12 November 2022, available at https://www.dgeg.gov.pt/en/statistics/energy-statistics/coal/), as public data on Pego's coal consumption were unavailable. The total volume of bituminous coal used for energy generation was divided between the two coal-fired power plants in Portugal in 2019, considering their installed capacities. According to REN reports, Sines had a capacity of 1180 MW and Pego 576 MW, totaling 1756 MW (accessed on 12 November 2022, available at https://www.ren.pt/en-GB/investidores/relatorio_anual).

In 2019, the total coal used for energy production was 2,101,758 tons. Assuming both power plants had similar efficiencies, Sines used 1,412,339 tons (67.2%) and Pego

689,419 tons (32.8%). To support this assumption, greenhouse gas (GHG) emissions from each plant were compared. Between 2008 and 2017, Sines contributed 12% of national GHG emissions and Pego 5%. This similarity supports using an installed capacity to estimate coal consumption at each plant. According to the CO_2 emissions control by the EU (accessed on 23 March 2023, available at https://climate.ec.europa.eu/eu-action/eu-emissions-trading-system-eu-ets/union-registry_en#tab-0-1), the Pego Power Plant emitted 1,018,548 tons of CO_2 in 2019 and 875,259 tons in 2020.

To maintain the same electricity production, 689,419 tons of torrefied biomass (with a heating value of 21 GJ/t, like coal) would be needed. This translates to 904,862 tons of dry biomass, which has a calorific value of 16 GJ/t. With a reference density of 450 kg/m^3 for dry biomass, this amounts to 1.98 Mm^3, less than the yearly growth volume of maritime pine and eucalyptus in the Médio Tejo region. Therefore, it is feasible to run the Pego plant sustainably using only local biomass. However, this estimate does not consider other existing biomass uses in the region that might compete for energy purposes.

Switching from coal to biomass would require some changes to existing equipment. Main components, such as the boiler, turbines, and generators, could remain from the original coal plant, but modifications would be needed for fuel feeding and processing systems. Biomass used in the plant would require torrefaction, a process that improves its quality and compatibility as a fuel but also necessitates a torrefaction facility.

The closure of the Pego Power Plant was in 2021 (coal power production, remaining natural gas power production active). These consequences may include negative impacts on local employment. According to the SABI platform (accessed on 12 November 2022, available at https://login.bvdinfo.com/R0/SabiNeo), the Tejo Energia project employs 140 people across three companies. The unemployment rate in the Médio Tejo region was 5.6% in 2020, which might increase if the plant closes (accessed on 12 November 2022, available at http://www.pordata.pt). The potential consequences of this transition would not only impact the direct employees of the Pego plant but also those involved in ancillary roles, encompassing coal storage, transportation, and outsourced services. Nevertheless, the conversion of the Pego facility from coal to biomass might serve to attenuate the loss of jobs and repurpose existing resources. This adaptation could preserve a substantial portion of the plant's infrastructure and employment prospects while simultaneously generating new, indirect job opportunities across diverse sectors. Given that Tejo Energia constitutes one of the most significant employers within the Médio Tejo region, the plant's conversion proves to be of paramount importance for sustaining local employment.

The closure of a major employer in a region with limited alternative opportunities can result in substantial social impacts [108]. Loss of employment can have detrimental effects on the workers, their families, and the local economy, as well as community infrastructure [109]. Increased unemployment can give rise to issues, such as emigration [110], heightened crime rates [111], poverty [112], and social exclusion [113]. Job losses can have cascading effects on other economic sectors, such as local commerce and service industries, resulting in diminished demand for goods and services and a decline in economic activity [114]. Consequently, it is crucial to develop public policies aimed at addressing unemployment, creating new employment opportunities, and transforming industrial areas [115]. Such policies may encompass vocational training and requalification programs [116], fiscal and financial incentives for new investments [108], and establishment of business clusters in emerging sectors [117].

5. Conclusions

The utilization of coal as an energy source has been widely acknowledged as a major contributor to climate change, necessitating a transition toward more sustainable energy alternatives. In alignment with this imperative, Portugal has declared its objective to phase out coal consumption. However, the cessation of operations at the Sines and Pego coal-fired power plants could engender negative consequences, particularly at the local level. To address this concern, a study was conducted to explore the potential conversion of the

Pego Power Plant into a biomass-fueled power plant. The results of the study indicate that this solution is consistent with Portugal's policies and objectives delineated in the 2030 Agenda, as well as with international endeavors to mitigate climate change. The abundant availability of biomass resources, particularly in the Médio Tejo region where the Pego plant is situated, renders this conversion a pragmatic and viable option. The shift from coal to biomass would reduce greenhouse gas emissions, diminish the risk of rural fires, and have a favorable impact on the local economy, encompassing the preservation of social and economic stability in the region. Consequently, it is essential to perceive such policies as opportunities for advancement, not solely from an environmental standpoint, but also in terms of economic and social development. The identification of practicable solutions, such as the conversion of the Pego coal-fired power plant to a biomass-fueled power plant, is critical to safeguarding both current and future generations and ensuring a stable energy supply in Portugal.

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