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Clean energy technologies in Western Macedonia: Opportunities for jobs and growth within the coal phase out era [†]

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Abstract: This study presents an overview of the role that clean energy technologies can play in the decarbonisation path of Greece's most carbon intensive region, namely Western Macedonia. The region has been requested to adjust its production model to the new requirements of the Green Deal Initiative, while simultaneously proceeding to restructuring its productive model towards a full phase-out of coal activities. The survey presented below will summarise the main findings and estimates on the clean energy potential, from a technical and research point of view and furthermore present assessments on the potential impact this could have on job creation and regional economic development in terms of potential investments. The studies' goal is to identify and promote actions to accelerate the innovation performance in the clean energy domain and, simultaneously, serve as co working space among key stakeholders from business, government, civil society and innovation, who share the vision for a sustainable future. Finally, the study highlights the importance of accelerating innovation in the clean energy domain—spanning from energy production, distribution and consumption.

Keywords: coal face out; clean energy; technical and research potential; innovation

1. Introduction

The region of Western Macedonia is heavily dominated by a carbon intensive power generation industry. Considering that it has been hosting 80% of the Greek lignite industry since the 1960's, the region has been requested to adjust its production model to the new requirements on the Green Deal Initiative, proceeding thus to a productive restructuring towards a full coal phase-out. Lignite activities affect the regional economy in a multidimensional way, which can be categorized into direct, indirect and inductive effects. Since the 1960's a monocultural Public Power Corporation-driven industrial economy involves directly and indirectly more than 16.000 people [1].

For the proper transition, funding is required. To this end, the **Just Transition Development Programme (JTDP) 2021-2027** [2] is in place aiming to revitalise economies of coal and carbon intensive regions, securing this way jobs affected by the shift to renewable energy sources and creating new jobs in sustainable economic activities.

Regional concerns such as structural problems, evidenced by high unemployment rates and the absence of foreign direct investments are addressed within the **Territorial Just Transition Plan for Western Macedonia**, which places particular emphasis on the impact of the decarbonisation process in several areas, e.g. the emissions reduction, increasing energy efficiency, or fostering innovation and technological research [3].

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The Greek government has set a goal of withdrawing all lignite power plants by 2028, with the majority of plants being withdrawn by 2023. This goal marks the formalization of Greece's transition to a differentiated and carbon neutral mixture in power generation.

2. Materials and methods

The present study employs a SWOT analysis to discuss all affected dimensions of the regional coal phase out plan. Below some concrete examples of **industries, pilot applications and initiatives** are depicted serving as a base for this analysis [4].

Carbon capture, utilization, and storage (CCUS): CCUS is a key technology for reducing emissions from energy-intensive industries. The Centre for Research and Technology Hellas (CERTH) has a research group focused on CCUS.

Circular economy and resource efficiency: The Greek National Circular Economy Action Plan includes measures to support the circular economy in energy-intensive industries, including the lignite mining and processing sector. The Cluster of Bioeconomy & Environment of Western Macedonia (CluBE) includes research on circular economy and resource efficiency, as well as the Renewable Energy and Energy Efficiency.

Energy efficiency is an important priority for Western Macedonia. The **Just Development Transition Master plan** is based on five key development pillars and the total financing is estimated at €5 bn [5]. The **Greek National Energy and Climate Plan (NECP)** includes a target to improve energy efficiency by 32.5% by 2030, compared to 2007.

The Eyes Hearts Hands (EHHUR) project steers the transformation of cities while considering local heritage and social context, while REGIO1ST funded under the LIFE scheme, has as goal to raise awareness about the Energy Efficiency First principle (EE1st) among regional governments and their agencies and supports them to make related decisions in their planning.

Renewable energy is dominant, given the region's abundant resources. The Operational Program "Environment and Sustainable Development" has provided funding for renewable energy projects, including the "Renewable Energy Sources (RES) and Energy Saving" funding program.

The Municipal District Heating Company of Amyndeio (DHCA) has a biomass combustion plant to serve Amyndeio's existing district heating system as well as its future extensions.

Wind generators have been installed in 7 different places in Western Macedonia, with a total power of 180.900 KW. Commercial or utility scale solar PV systems installed in the region should amount to 2GW, while Biogas CHP capacity in the region is low and below 5MW, which is yielded by three active biogas plants.

H2 Systems. The region has the potential to become an important player in the production and distribution of hydrogen, as it is home to significant renewable energy sources, to produce green hydrogen. The latest project envisages an electrolysis unit of 100 MW for the production of hydrogen. The Public Power Corporation (PPC) and Motor Oil are developing it through their joint venture "Hellenic Hydrogen".

Green HiPo project submitted in the framework of the "Projects of Common European Interest" ("IPCEI") aims to support research, innovation and early industrial development in the hydrogen value chain. The project "Western Macedonia Green Valleys of Hydrogen Production (WEMAGH2)" includes the creation of the first Hydrogen Valley in Western Macedonia and Southeast Europe located in an abandoned industrial complex (AEVAL), at Ptolemaida, as part of the **Innovation hub for green hydrogen** and energy storage in Western Macedonia. The H2 Innovation Hub, worth €18 million, is a pilot project, which will take place under CERTH's supervision and will be completed in 2024. It will include components such as: PV Park 0.5MW, Electrolyser, Fuel cell 0.2 MW (PEM), H2 station, Storage battery array of 250kWh and special laboratory infrastructure.

Several research and development organizations in the region are focused on hydrogen-related research. For example, CluBE, the Centre for Renewable Energy Sources and

Saving (CRES), and the University of Western Macedonia as the Aristotle University of Thessaloniki have research groups focused on hydrogen and fuel cells.

Smart Energy Communities and Cities. The STARDUST project is the first approved project for smart cities and communities in which CluBE and the Municipality of Kozani are cooperating with the regional development Organisation ANKO SA to transform the city of Kozani into a smart energy community. GOAL nZEBs is another project where four Partners from Greece and Albania collaborate in order to strengthen the possibilities for the cross-border cooperation between Greece and Albania in the nZEB sector and to enhance the potential for energy communities. There are also several pilot projects underway in the region that are focused on smart energy communities, including the Smart city of Kozani initiative, to cut greenhouse gas emissions by implementing ambitious measures to reduce the energy consumption of municipal buildings. The Regional Energy Community of Western Macedonia Ltd is another example where the University of Western Macedonia coordinated the establishment of a Non-profit Regional Energy Community (EC), established in 2021 in the search for energy solutions to mitigate covid19 and energy poverty effects. 13 municipalities in the region, the Regional Authority and the University of Western Macedonia are members of the EC. Furthermore it is noteworthy, that as of May 2022, 1,258 active energy communities were recorded in Greece, 246 of those are located in Western Macedonia.

3. Results

This study has shown that there are enormous clean energy potentials in Western Macedonia, taking into consideration techno and socio-economic aspects that affect or will be affected by the Decarbonization process.

Strengths [6]

Natural Resources including abundant solar and wind energy potential.

Skilled and well educated Workforce with strong tradition in engineering, technology, and scientific research.

Strategic Geographical Location serving as gateway to important regional markets.

Agricultural Potential: soil and climate favorable for high-quality export-oriented agricultural products.

Infrastructure Development with significant investments in transportation, logistics, and communication networks.

Entrepreneurial Mind-set: growing entrepreneurial ecosystem and a culture of innovation to foster the development of innovative startups, spin-offs and businesses focused on clean technologies and sustainable solutions.

Opportunities [7]

Funding Opportunities: The European Union has dedicated substantial funding to support just transition initiatives.

Cross-Border Collaboration: opportunity for cross-border collaboration in implementing joint projects and sharing best practices.

Renewable Energy Development will reduce dependence on fossil fuels and accelerate the transition to a more sustainable and low-carbon ecosystem.

Green Infrastructure including sustainable transportation systems, smart cities, and eco-friendly buildings.

Digitalization and Innovation: The region can leverage their skilled workforce and invest in research and development (R&D) to foster innovation

Circular Economy: opportunities for resource efficiency, waste reduction, sustainable production and consumption patterns.

Knowledge and Technology Transfer by collaborating to facilitate the transfer of knowledge, technologies, and best practices.

Weaknesses [8]

Economic Disparities within own borders as certain administrative areas may have limited resources and infrastructure to support the necessary transition and investments.

Infrastructure Gaps, particularly in rural and less developed areas, including energy networks, transportation systems, and digital connectivity.

Limited Access to Financing: Despite funding opportunities available, accessing financing can be challenging for small and medium-sized enterprises (SMEs) and entrepreneurs.

Brain Drain: significant emigration of skilled professionals in recent years, leading to a brain drain phenomenon.

Institutional Capacity: challenges in terms of administrative capacity, regulatory frameworks, and coordination mechanisms, e.g. to attract and facilitate investments.

Limited Awareness and Engagement of stakeholders can hinder effective participation and cooperation.

Environmental Challenges including pollution, habitat degradation, and climate change impacts can affect the viability of certain industries and hinder the transition towards more sustainable practices.

Threats [9]

Political instability and Policy uncertainty: Changes in government, inconsistent policies, and bureaucratic hurdles can create uncertainty and hinder investment attractiveness.

Social Challenges: the transition to a more sustainable economy should be inclusive and benefit all levels of society.

Limited Technological Capacity can hinder the integration of clean and innovative technologies needed.

Lack of Public Awareness and engagement can impede the implementation of policies and projects, leading to delays or resistance.

Dependence on Fossil Fuels particularly on coal can hamper the transition to a low carbon economy, since it requires significant investments and structural changes.

Climate Change Impacts pose threats to the region as its impact can disrupt economic activities, infrastructure, and ecosystems.

Global Economic Uncertainty: such as financial crises, trade disputes, or global recessions, can affect the investment climate and access to financial resources.

4. Discussion and Conclusions

The transition of Western Macedonia to a carbon neutral power generation model, involves apart from the energy sector, the wider economic and social sectors. Since lignite mining and electricity generation had dominated economic activities for many decades, clean energy solutions to support the economy and society are imperative, and thus EU funding for a Just Transition is key.

The SWOT analysis presented herein is based on a research analysis in the clean energy domain, which will serve as a tool for policy and decision makers to implement a successful strategy in the field in question.

The research analysis demonstrated key points for action. Simultaneously, it created the framework for further scientific inquiry to identify concrete research steps. Overall, the shift towards clean energy in Western Macedonia, involves diversifying the regions' energy mix, reducing carbon emissions, supporting affected communities, and promoting the development of clean and renewable energy infrastructure [10]. The transition requires a comprehensive approach that encompasses policy support, investment, research, and collaboration between government, industry, and local communities to create a more sustainable and resilient energy future for the region.

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