Energy System Modelling for Green Development of Africa

Grant Agreement N° 101118278

D4.2 – Recommendations for new policies and markets

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Lead Beneficiary: UMP

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D4.2 – Recommendations for new policies and new markets

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Reviewer	EnGreen SRL and ECREEE

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Executive summary

Deliverable D4.2 – Recommendations for New Policies and Markets – is a strategic outcome of the EMERGE project (Energy Systems Modelling for Africa's Green Development). Its purpose is to rigorously, comprehensively, and factually translate the results of energy systems modelling activities, detailed analysis of transition scenarios, and stakeholder consultation processes into structured and actionable recommendations for public policies, regulatory frameworks, and market mechanisms. These recommendations aim to effectively support, accelerate, and guide the energy transition in African countries, in line with national priorities and international climate goals. This deliverable focuses on three EMERGE pilot regions: Morocco, Mali, and Mozambique.

Based on the results previously produced within the EMERGE project (notably deliverables D1.1, D1.2 and D5.1), this report mobilizes a combination of EMERGE tools developed within WP3 and a qualitative analysis of public policies and policy labs to inform strategic choices leading to low-carbon, resilient and inclusive energy systems by 2050–2055. The methodological approach is based on an integrated approach covering technical, economic, environmental and institutional dimensions, enabling the formulation of operational recommendations, based on evidence and directly applicable to the national and local contexts of the pilot sites.

The analysis highlights that all three pilot regions possess significant renewable energy potential and strategic assets—such as solar and wind resources, hydropower, critical minerals, agricultural capacity, and human capital—yet face persistent barriers. These include fragmented governance, regulatory instability, limited access to finance, infrastructure gaps, skills shortages, social acceptability challenges, and vulnerability to climate impacts. Addressing these obstacles is essential to unlocking investment and scaling up renewable energy deployment.

Developing scenarios using EMERGE tools demonstrates that accelerated energy transition pathways – characterized by high electrification rates, large-scale deployment of renewable energy, improvements in energy efficiency and the gradual substitution of fossil fuels – can significantly reduce primary energy consumption and greenhouse gas emissions, while preserving security of supply and economic viability.

Based on these results, the deliverable formulates strategic recommendations across four main dimensions:

- Policy and institutional frameworks, emphasizing governance coordination, long-term policy stability, social inclusion, and capacity building.
- Regulatory reforms, including improved grid access, support for self-consumption, energy storage, smart grids, carbon pricing instruments, and the introduction of regulated sandboxes to test innovative solutions.
- Market development and business models, such as independent power producers (IPPs), power purchase agreements (PPAs), industrial and tertiary self-consumption, energy communities, agrivoltaics, and green hydrogen value chains.
- Financing and investment mechanisms, aimed at reducing perceived risk, mobilizing local and international finance, and aligning public incentives with private capital.

The results of the public policy workshops confirm the relevance and feasibility of the proposed measures, ensuring their alignment with local priorities and stakeholder expectations. Overall, deliverable D4.2 provides a structured and operational roadmap for integrating EMERGE's findings into national policies, promoting market adoption of renewable energy technologies, and supporting a just, inclusive, and sustainable energy transition at the pilot sites.

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Abbreviations

Table 1 : List of abbreviations

Abbreviation	Definition
AfriLabs	African Technology Innovation Hubs
ANRE	National Agency for Energy Regulation
AU	African Union
BrainIT	Brain Information Technologies
CEPIA	Climate and Energy Policies Impact Assessment
CIRCE	Fundacion CIRCE Centro de Investigacion de Recursos y Consumos Energeticos
CDD	Cooling Degree Days
ECREEE	Ecowas Centre for Renewable Energy and Energy Efficiency
EMERGE	Energy System Modelling for Green Development of Africa
ESEIA	European Sustainable Energy Innovation Alliance
HDD	Heating Degree Days
HV	high voltage
KER	Key exploitable results
IPPs	Independent Power Producers power producers
LV	Low-Voltage
MV	Medium Voltage
ONEE	National Office of Electricity and Drinking Water
PV	Photovoltaic
PPAs	Power Purchase Agreements
TSO	Transmission System Operator
VHV	very high voltage
WP	Work Package
UEM	Universidade Eduardo Mondlane
UNIZAG	University of Zagreb, Faculty of mechanical engineering and naval architecture
UMP	Université Mohammed Premier

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1. Introduction

1.1 Objective

This deliverable, D4.2, entitled "Recommendations for New Policies and Markets," marks a crucial milestone paving the way for future project deliverables. Its primary objective is to formulate recommendations on new policies and regulations to accelerate the energy transition in African countries. D4.2 also proposes measures to facilitate market adoption of various renewable energy technologies and investor-friendly business models. This deliverable builds upon previous findings regarding energy legal frameworks, instruments governing the energy sector in Africa, their comparison with European policies, and the obstacles and requirements of the energy transition by 2050 in the EMERGE pilot sites (Morocco, Mali, Mozambique) identified in deliverables D1.1, D1.2, and D5.1 of the project.

1.2 Document structure

Deliverable D4.2 opens with a summary and is organized into several sections, each addressing a specific aspect of the deliverable:

- Section 1. Introduction: This section presents the objective of deliverable D4.2, its alignment with associated tasks and deliverables, and describes the structure of the document.
- Section 2. Methodology for developing EMERGE recommendations. This section presents the methodology used to develop relevant and contextualized recommendations for the three pilot sites of the EMERGE project (Morocco, Mali, and Mozambique).
- Section 3 Scenario development using EMERGE tools: In this section, prospective scenarios are developed to examine the evolution of energy systems at the pilot site level. The EMERGE tools are then used to analyze, in an integrated and comparative manner, the technical, economic, and environmental impacts of the options and measures considered, in accordance with the specific objectives defined for each scenario.
- Section 4 Development of strategic recommendations based on the proposed measures: This section summarizes the strategic recommendations developed from the analysis of the proposed measures and their potential impacts.
- Section 5 Recommendations for new policies implemented to accelerate the energy transition: this section defines the guiding principles that shaped the development of strategic recommendations of an institutional, regulatory, technological and financial nature, enabling the anchoring of the results of the EMERGE project in public policies adapted to the three EMERGE pilot sites (Morocco – Mali – Mozambique).
- Section 6 Regulations aimed at accelerating the energy transition: This section is dedicated to the development of regulatory proposals for pilot countries, based on an in-depth analysis of national legal frameworks in the energy sector and their alignment with European policies, strategies and regulatory frameworks.
- Section 7 Guidelines for the deployment of renewable technologies and associated business models: This section provides guidelines and recommendations for deploying renewable energy technologies across the three pilot sites, addressing new business models, market opportunities, and key lessons learned from the EU experience in accelerating the energy transition in Africa.
- Section 8 Policy Labs: This section presents the results from the Policy Labs, interactive multi-stakeholder dialogue spaces established to test, refine, and validate policy recommendations tailored to the three pilot sites of the EMERGE project. This work aims to translate technical analyses into operational policy guidelines, while also assessing the feasibility and applicability of the proposed measures in local contexts.

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- Section 9 Conclusion: This section presents the conclusions of deliverable D4.2, summarizing the main results and highlighting how the recommendations made, new regulations and the deployment of renewable technologies contribute to the appropriation and use of the tools developed within the EMERGE project.
- Section 10 References: This section presents all the references used in the document, offering an exhaustive bibliography of the sources consulted in order to ensure traceability and scientific rigor.

1.3 Partner contributions

This subsection details the structure of the document, as well as the detailed contribution of each EMERGE partner to this document:

Table 2: Table of contributing partners

Partner	Country
University of Zagreb – Faculty of Mechanical Engineering and Naval Architecture (UNIZAG FSB)	Croatia (HR)
EnGreen Srl	Italy (IT)
African technology innovation hubs (AfriLabs)	Nigeria (NG)
European Sustainable Energy Innovation Alliance (ESEIA)	Austria (A)
ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE)	Cape Verde (CV)
UNIVERSIDADE EDUARDO MONDLANE (UEM),	Mozambique (MZ)
UMP: University Mohammed Premier	Morocco (MA)
Artelys	France (Fr)

- UMP prepared the structure and main content of this deliverable as the lead partner for the T4.3 project, with contributions from UNIZAG FSB. UMP synthesized the findings regarding policy and regulatory barriers, conducted a comparative analysis, and compiled a preliminary list of lessons learned and recommendations based on the identified barriers and opportunities.
- UEM, UMP, ECREEE, and UNIZAG FSB provided analyses of the energy regulatory framework in their respective countries (Mozambique, Morocco, Mali, and the EU).
- Artelys and ESEIA contributed to the drafting and finalization of the document by providing observations and comments.
- ENGREEN and ECREEE reviewed the deliverable's content.

1.4 Relationship to other tasks

Deliverable D4.2 is developed within the framework of the coordination of T4.3 of WP4, which aims to build on engagement methodologies developed within T1.2 and to work on the involvement of experts in the co-design process to produce policy recommendations and roadmaps for the clean energy transition.

WP4 aims to:

• Engage users and experts through a co-design approach for capacity building;

• Organize Participatory laboratories as part of feedback and training activities, as well as EU-AU exchanges and AU-AU study visits for transcontinental and transnational knowledge transfer;

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- Provide a set of guidance recommendations for the analyzed case studies that accelerate the energy transition;
- Develop a roadmap for R&D and strategic development of three pilot sites, including plans for replicating EMERGE solutions.

Deliverable D4.2 builds on several key results produced during previous phases of the project, namely Deliverable D1.1 (Knowledge base and engagement methodology) and Deliverable D5.1 (Pilot projects and use cases), thus establishing the foundations enabling the database infrastructure to effectively meet the diverse needs of the EMERGE consortium and its stakeholders.

The work carried out in **D4.2** is in close collaboration with the various pilot projects and will focus on making regulations more favorable not only to the establishment and expansion of African clean energy systems, but also to the creation of regulatory sandboxes to test innovative solutions (related to the analysis in T1.3). This, in a virtuous circle, can also promote the establishment and expansion of these systems. These sandboxes will aim to leverage the best EU regulatory frameworks, thus contributing to the rapid implementation of effective European regulations. This will be done in close collaboration with T4.2 and through co-design workshops. EMERGE will also draw on its stakeholder group and highly experienced consortium to engage with regulatory bodies and high-level decision-making bodies (KER 5).

1.5 Inspiring principles in EMERGE

The EMERGE project guarantees full compliance with Horizon Europe's cross-cutting principles and requirements, systematically integrating the principles of Do No Significant Harm (DNSH), gender equality, inclusion, Open Science, and research ethics. These dimensions are taken into account from the design phase and throughout the implementation, monitoring, and evaluation of actions in WP4, including demonstration activities, to ensure a positive environmental impact, equitable stakeholder participation, and transparent dissemination of scientific results for the benefit of society.

Do No Significant Harm (DNSH)

The project contributes to the transition to low-carbon and resource-efficient energy systems in partner African countries, ensuring strict adherence to the principle of Do No Significant Harm. Demonstration projects implemented at pilot sites aim to reduce dependence on imported fossil fuels, increase the integration of local renewable energy sources, and improve the energy efficiency of infrastructure and end-use applications.

Particular attention is paid to the resilience of energy systems to climate constraints and energy access challenges, in line with the priorities of the European Green Deal and the Sustainable Development Goals. The tools and methodologies developed incorporate quantitative indicators—emission reduction (tCO_2e), energy savings (kWh), share of renewables (%), energy cost reduction, and improved supply reliability—to ensure a rigorous assessment of technical, economic, environmental, and social impacts.

This evidence-based approach makes it possible to formulate recommendations tailored to national regulatory frameworks, while strengthening the potential for replication and scaling up in other territories with similar socio-economic contexts.

Gender Dimension

EMERGE integrates a gender perspective across all aspects of the project, in line with the EU Gender Equality Strategy 2020-2025 and Sustainable Development Goal SDG5. The project ensures balanced

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representation of women in consultation, training, and decision-making activities, recognizing the diversity of perspectives as a key factor in scientific quality and societal relevance.

The consortium applies a zero-tolerance policy towards any form of gender-based discrimination and incorporates dedicated monitoring mechanisms to guarantee the effective and equitable participation of women throughout the project. This approach strengthens the inclusivity, scientific credibility, and social acceptability of the solutions developed.

2. Methodology for developing EMERGE recommendations - Policy perspectives derived from simulations of the EMERGE toolkit

2.1 Introduction:

The energy transition represents a development opportunity, given that the pilot sites (Morocco, Mali, and Mozambique) possess the resources necessary for this transition. These resources are primarily minerals used in the manufacture of batteries for electric vehicles and other green energy production technologies *(wind, solar, etc.).* Global demand for these minerals far exceeds supply, representing a vast market of potential suppliers. In addition to these minerals, the pilot sites also possess other significant assets: agricultural and forestry capacity, energy potential, and human capital. These resources offer these countries the opportunity to implement a beneficial economic transformation for their people and to play a major role in the global economy.

The energy transition offers enormous opportunities to African countries, particularly to the EMERGE pilot sites (Figure 1). **[1]** These mainly involve:

- To address the energy deficits suffered by its populations;
- To develop its immense mineral resources needed for the energy transition;
- Becoming a leader in the green transition;
- Reconciling the energy transition and economic transformation and charting new paths to prosperity.

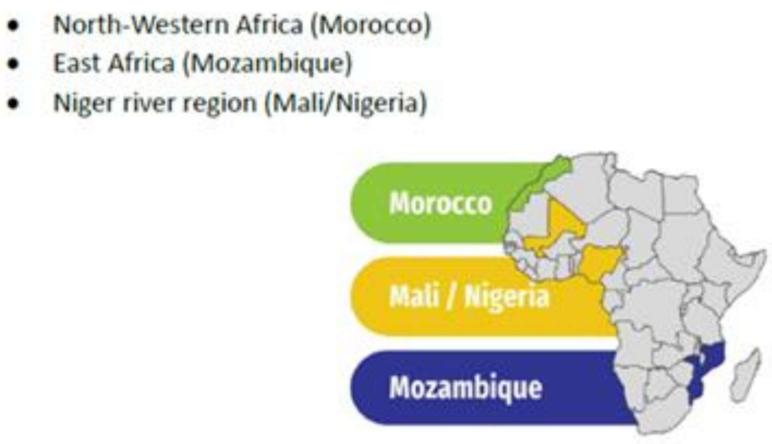

Figure 1: EMERGE map of pilot sites

The methodology is based on a combination of technical analyses, scenario building and consultation with stakeholders, and is broken down into several complementary stages:

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- **Identification of opportunities, obstacles and requirements:** Analysis of technical, regulatory, economic and institutional constraints related to the energy transition on pilot sites (Morocco, Mali and Mozambique).
- **Scenario development:** Definition of plausible energy transition scenarios using the EMERGE Toolbox developed within the project, taking into account local specificities, needs, energy and climate objectives.
- **Definition of measures (actions):** Identification of concrete measures to achieve the objectives set for each scenario, including technological, regulatory and economic actions.
- **Formulation of recommendations:** Development of policy and strategic recommendations based on the proposed measures, aimed at supporting decision-making and the deployment of the identified solutions.
- **Validation and adjustment:** Evaluation of the feasibility and applicability of the recommendations through exchanges with stakeholders and validation exercises (Policy Labs).

2.2 Obstacles to the energy transition

2.2.1 Obstacle to the energy transition: The case of Morocco

Morocco, officially the Kingdom of Morocco, is a country in the Maghreb and the Arab world, located in northwest Africa. Its territory is bordered to the north by the Strait of Gibraltar and the Mediterranean Sea, to the south by Mauritania, to the east by Algeria, and to the west by the Atlantic Ocean. Its capital is Rabat. Demographic data for Morocco is managed by the High Commission for Planning **[2].** The last official census, conducted in 2024, estimated Morocco's population at 36.828 million, in addition to an estimated diaspora of 4.5 million people. Morocco covers a total area of 716,550 km² and its coastline extends for over 3,500 km.

Figure 2:The kingdom of Morocco map

a. Institutional obstacles

Although Morocco is an advanced country in the energy transition, it faces persistent challenges:

The problems preventing Morocco from seizing these opportunities are numerous. Among them are deficiencies in governance mechanisms, the lack of an integrated sectoral energy policy, the mismatch between vocational training and industrial needs related to the energy transition, and dependence on traditional energy sources (90.36% in 2021). These various problems constitute barriers or obstacles that must be addressed as a priority to capitalize on the opportunities offered by the energy transition They primarily include: **[3].**

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- Fragmented governance between ministries; The fragmentation of governance between ministries in Morocco creates institutional obstacles due to a lack of coordination and duplication of efforts, which hinders the provision of basic services and the implementation of policies**. [4]**
- Unstable or incomplete regulatory frameworks. Unstable or incomplete regulatory frameworks in Morocco constitute a major obstacle to investment and economic development. This situation is manifested by frequently changing laws, inconsistent application of existing regulations, unreasonable delays in the legal process, and bureaucratic complexity that hinders business planning and operations. This creates an unpredictable business environment and discourages both domestic and foreign investment.
- Lack of integration between energy, climate, and agriculture policies. The lack of integration between energy, climate, and agricultural policies is a major institutional obstacle in Morocco. This manifests itself in isolated sectoral approaches that fail to address problems holistically, exacerbating the climate and energy crises while hindering sustainable agricultural development. Challenges include underfunding of the energy transition, insufficient support for farmers, and the absence of coherent regulatory frameworks linking these three vital sectors**. [5]**

b. Economic and financial obstacles:

- **High initial costs for green technologies** make them inaccessible to poor populations and small and medium-sized enterprises. This problem is compounded by difficult access to financing and a lack of capital. Furthermore, a low level of industrial development and a limited availability of skilled professionals restrict the capacity for investment and large-scale implementation.
- **Low Mobilization of Local Finance;** The low mobilization of local finance in Morocco is due to several obstacles, including low levels of domestic resources and structural weaknesses such as a limited capacity to mobilize local revenue. Furthermore, barriers exist on the business side, such as reluctance to register in the formal sector and a lack of management skills, making access to financial institutions more difficult. Financial institutions themselves face challenges, such as insufficient guarantees from businesses and difficulties in loan recovery, thus limiting their capacity to finance the local economy**. [6]**
- **Dependence on subsidized fossil fuels;** Morocco's dependence on subsidized fossil fuels constitutes a major economic and financial obstacle (Net energy bill increase: +103.2% between 2020 and 2021) **[7] [8],** creating vulnerability to global price fluctuations, hindering economic diversification, and diverting funds from more sustainable sectors. This dependence is further exacerbated by the lack of a coherent energy policy, poor governance, and difficulties in accessing financing for necessary infrastructure **[9] [10]**
- **High perceived risk for investors.** The economic and financial obstacles in Morocco that lead investors to perceive a high risk include economic instability, limited access to finance and expertise, inadequate infrastructure, a complex regulatory environment, and low competitiveness in domestic markets. These factors create uncertainty, increase costs, and hinder business development.

c. Technical obstacles.

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- **Disparity in electrical infrastructure.** A significant disparity in the electrical grid exists between urban and rural areas (especially in the distribution network). This situation hinders social, industrial, digital, and economic development in these areas.

- **Skills gap for installation and maintenance.** The skills gap in technical expertise for installation and maintenance in Morocco is a major obstacle, caused by a lack of adequate training programs and low awareness of the technologies. To overcome this challenge, it is necessary to strengthen education and training programs, develop infrastructure, and foster international and local collaborations.

- **Low technological absorption capacity.** Morocco's low technological absorption capacity stems from several interdependent obstacles, including limited human capital (low-skilled personnel, lack of expertise) and socio-economic factors such as difficulties accessing financing and a small market. These problems hinder the transfer and adaptation of technologies, thereby limiting economic development **[11].**

- **Insufficient Technology Demonstration Centers.** The lack of technology demonstration centers in Morocco is a major obstacle within a broader context of challenges. This deficiency hinders the dissemination, adoption, and adaptation of technologies, as it limits opportunities for businesses and the public to experiment with and adopt innovations.

d. Social and environmental obstacles

- **Low awareness of climate issues.** Low awareness of climate issues in Morocco is a social and environmental obstacle stemming from immediate survival priorities, limited access to information, and a lack of support for a long-term vision. This situation exacerbates existing vulnerabilities, such as agriculture's dependence on extreme weather conditions, which can lead to economic instability and protests. To overcome this obstacle, it is crucial to improve climate education, strengthen community capacity, and promote the engagement of young people, particularly women, in decision-making.

- **Limited social acceptability of projects.** The limited social acceptability of projects in Morocco is due to factors such as a lack of consultation with stakeholders, poor management of impacts on local communities and the environment, and a feeling of exclusion among affected populations from decision-making. This can lead to protests, a lack of cooperation, and limits the impact of projects.

- **Vulnerability to droughts and floods.** Morocco is particularly vulnerable to droughts and floods due to a combination of social and environmental factors. These factors include climate change, poverty, rapid urbanization, poor land management, and environmental degradation (deforestation, overexploitation). These disasters lead to devastating consequences such as food insecurity, health problems, population displacement, and negative impacts on economic growth **[12].**

- **Natural resource degradation.** Natural resource degradation in Morocco is a major problem caused by human and climatic factors, leading to a loss of land productivity, a decrease in biodiversity, and negative socio-economic impacts. The main causes include unsustainable agriculture, overgrazing, deforestation, mining, and the effects of climate change such as droughts. This leads to increased risks of food insecurity, poverty, and population displacement.

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2.2.2 Obstacle to the energy transition: The case of Mali

The following obstacles are pertinent to the energy transition in Mali (figure 3):

- **Institutional obstacles** due to the diversification of in the responsibilities of the energy programmes, limiting who is really responsible for what and who is to monitor and evaluate implementation results. The inadequate coordination and information sharing between different projects, government agencies, the private sector and civil society organisations involved in the energy sector. Above all is the instability of institutions due to non-stable democratic governance system which always lead to constant changes of the mission and vison of technical and policy institutions. Weaknesses in institutions responsible for energy planning, regulation, and implementation are impeding the effective delivery of policy objectives

Figure 3: Mali map

- **Capacity Building and Local Content Development**: There is a need for skilled labor and expertise in the energy sector, particularly in emerging technologies. The lack of training and educational programs is limiting local participation in the promotion of sustainable energy systems
- **decentralization,** through the Government's desire to make Territorial Communities responsible for managing the socio-economic development of their respective territorial districts, all opportunities must be seized to decentralize energy services, while guaranteeing respect for cultural and territorial diversity, management participatory through the creation and management of preserving national unity and integrity. This involves appropriate transfers of skills and resources
- **transversal coherence**, in order to establish harmonious relationships on the one hand, between the energy sector and other sectors of use of energy services in the country and on the other hand, between the different sub-sectors of the 'energy
- **The lack of Legal and regulatory framework**: The existence of a clear legal and regulatory framework for the energy sector plays a fundamental role in strengthening investor confidence to attract private sector operators. Strengthening the legal and regulatory framework to align it with the National Energy Policy involves revising the legislation in force (Order No. 00-019/P-RM of March 15, 2000, and Order No. 00-021/ P-RM of March 15, 2000) and the establishment of new regulations, technical directives and standards. This includes the adoption of new provisions specific to the promotion of renewable energy and energy efficiency

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- **Gender** must be integrated into energy planning processes as women play a vital aspect in the energy supply and consumption, more specifically in the residential sector
- **International and Market Barriers**: the **f**luctuations in the global energy markets, including oil prices impact the energy sector, affecting revenue and investment flows.

2.2.3 Obstacle to the energy transition: The case of Mozambique:

The implementation of renewable energy systems as part of Mozambique's (figure 4) energy transition represents a strategic path toward sustainable development and long-term economic growth. This approach facilitates the liberalization of the energy sector, allowing independent power producers and private entities to participate in the production and sale of electricity, thereby reducing the historical dominance of Electricidade de Moçambique (EDM) across the entire value chain, including production, transmission, distribution, and sales **[25]**.

The abundant availability of renewable energy resources in Mozambique, particularly solar irradiation, wind potential, and hydropower capacity, provides a strong foundation for restructuring the national energy system. The transition to low-carbon energy sources is expected to stimulate job creation, enhance technological innovation, and improve energy security through reduced dependence on imported fossil fuels. Moreover, the expansion of decentralized and grid-connected renewable energy systems has the potential to significantly increase electricity access, thereby improving socio-economic conditions, particularly in rural and underserved regions.

However, despite these opportunities, several constraints continue to hinder progress. These challenges can be grouped into three main categories:

Financial constrains

- Renewable energy technologies, particularly wind power and battery storage systems, require high upfront capital investments;
- Limited access to affordable financing options makes it difficult for both governments and private actors to scale projects; and,
- Perceived risks in the energy sector discourage investors, further slowing the pace of renewable deployment.

Institutional and Regulatory Barriers

- Lengthy and complex licensing procedures delay project implementation;
- The absence of clear frameworks for independent power producers (IPPs) reduces opportunities for private sector participation;
- Incentives for renewable energy investment remain insufficient, limiting the attractiveness of the sector; and,
- The national utility, EDM, faces operational and financial challenges that constrain its ability to expand and modernize the grid.

Technical capacity and infrastructure limitations

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- Transmission and distribution networks are underdeveloped, restricting the integration of variable renewable sources such as solar and wind;
- Limited technical expertise and workforce capacity slow down the adoption of advanced technologies; and,
- Infrastructure bottlenecks make it difficult to ensure reliability and stability in electricity supply, especially when incorporating intermittent renewable sources.

<u>**Socio-Economic limitations**</u>

- **Expanding Access to Energy (SDG 7)**
  - **Current status**: Electricity access is around 60%, meaning nearly half of the population remains excluded from modern energy services.
  - **Challenge**: Expanding access requires massive investment in infrastructure (generation, transmission, distribution), especially in rural and peri-urban areas where poverty is concentrated.
  - **Limitation**: Renewable energy projects (solar, wind, hydro) being capital-intensive and often depend on external financing. Mozambique's fiscal constraints and high poverty index limit the ability to scale these solutions quickly.
  - **Implication**: The urgency of universal access under SDG 7 pushes policymakers toward cheaper, readily available sources—often fossil fuels—rather than long-term clean energy investments.

- **Abundance of Fossil Fuels**
  - **Resource reality**: Mozambique has significant reserves of coal and natural gas, which are perceived as the economically most viable sources to meet immediate energy needs;
  - **Economic rationale**: Exploiting fossil fuels provides revenue, jobs, and relatively lower-cost electricity compared to renewables in the short term;
  - **Limitation**: Heavy reliance on fossil fuels risks locking Mozambique into a carbon-intensive pathway, undermining global climate commitments and exposing the country to future stranded assets; and,
  - **Trade-off**: For a country with high poverty levels, fossil fuels appear as the pragmatic option to achieve SDG 7, but this creates tension with the broader energy transition agenda.

- **Rising Industrial Demand**
  - **Industrialization plans**: Mozambique is designing industrial development strategies that will sharply increase electricity demand beyond the "business as usual" scenarios;
  - **Challenge**: Meeting this demand sustainably requires rapid expansion of generation capacity which makes the current renewable projects insufficient to cover the expected surge at affordable costs;
  - **Limitation**: Without large-scale investment in renewables and grid modernization, fossil fuels will remain the fallback option to power industries, risking long-term dependency; and,
  - **Implication**: The mismatch between industrial ambitions and renewable capacity growth creates structural barriers to a clean energy transition.

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Figure 4: Mozambique

3. Scenario development using EMERGE tools

Developing scenarios is a key step in analyzing and guiding the energy transition. It allows us to explore different possible trajectories for the evolution of energy systems based on contrasting assumptions regarding demand, supply, public policies, technological advances, and environmental constraints.

In this context, the EMERGE tools presented in deliverable D3.1 are used to quantify the technical, economic, and environmental impacts of different energy transition scenarios [32]. They allow for simulations of changes in the energy mix, assessment of investment needs, analysis of greenhouse gas emissions, and evaluation of medium- and long-term security of supply. The results obtained with these tools thus provide a basis for decision-making in the design, evaluation, and comparison of sustainable energy pathways adapted to national and regional contexts.

3.1 Developing scenarios using the GREENADVISE tool

3.1.1 Case of Morocco

The Moroccan residential sector consumed approximately **12.38 TWh** of electricity in 2022 **[13],** representing **about 34% of the country's total electricity consumption.** This electricity consumption has **increased sharply in recent years.** This increase has been due to:

- almost total electrification (rural > 99% access to electricity);
- an increase in the number of household appliances and air conditioning systems in homes;
- Population growth and urbanization.

Using the GREENADVISE tool, we develop three scenarios for the residential sector in Morocco.

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- The first scenario: using PV, Batteries, Heat pump and the national electricity grid to power the residential sector.
- The second scenario: using wind turbines, batteries, heat pumps and the national electricity grid to power the residential sector.
- The third scenario: using PV, wind turbines, and batteries. Heat pump and the national electricity grid to power the residential sector.

To estimate electricity consumption in the residential sector, we used a spatial approach with ArcGIS.

We divided Morocco into six climate zones based on HDD (Heating Degree Days) and CDD (Cooling Degree Days) values. As figure 5 shows, the climate zones are:

- Zone 1: HDD+CDD <1000;
- Zone 2: HDD+CDD between 1000-2000;
- Zone 3: HDD+CDD between 2000-3000;
- Zone 4: HDD+CDD between 3000-4000;
- Zone 5: HDD+CDD between 4000-5000;
- Zone 6: HDD+CDD >5000.

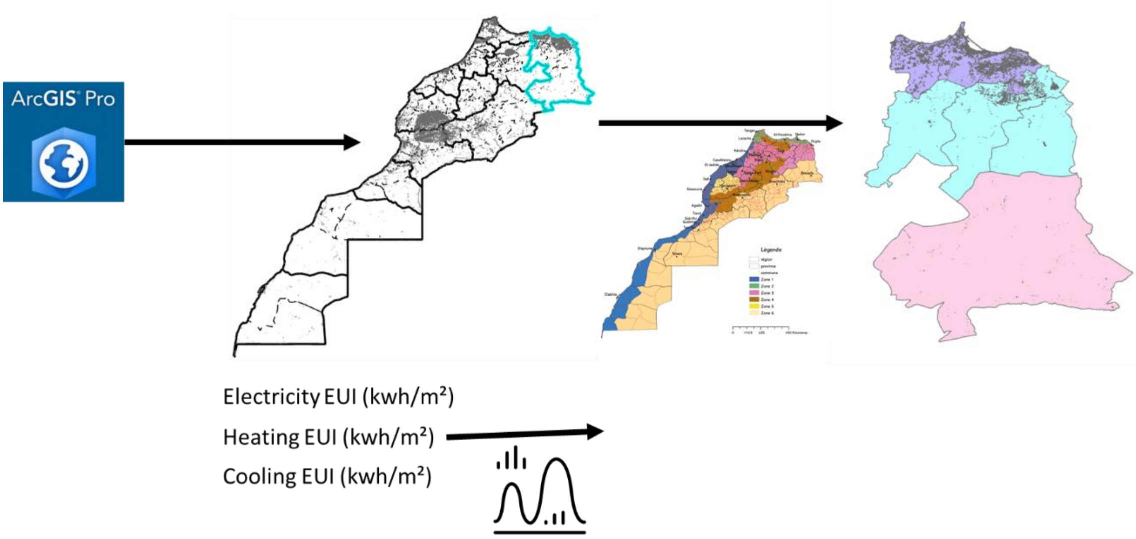

Figure 5: Climate zones of Morocco (six climate zones)

Preliminary study on the Oriental region of Morocco (population 2 million).

The inputs for the GREENADVISE tool are:

- Electricity consumption in the residential sector in Morocco;
- PV CAPEX: €900/kW
- Wind CAPEX: €1300/kW
- Battery CAPEX: €84/kWh
- Grid price (peak): €0.2135/kWh
- Grid price (off-peak): €0.11/kWh
- The electricity consumption profile in (kWh/m²);
- The heating profile in (kWh/m²);
- Cooling profile in (kWh/m²);
- maintenance cost of PV systems;

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- maintenance cost of wind turbines;
- Battery maintenance costs.

Results :

- **Electricity consumption in the residential sector:**

Using the ArcGIS tool, the living area in each zone is presented in the following table:

Table 3: living area in each zone

	OBJECTID	Zone3	SUM_COUNT_OBJECTID	FootprintSum_m2
1	1	Z1_Driouch-Nador-Ber...	155900	36071528,443428
2	2	Z2_Oujda-Jerada-Taouri...	60763	11151577,891144
3	3	Z3_Figuig	1314	257343,784491

Using the electricity consumption profile in (kWh/m²), we determine the electricity consumption of the residential sectors in each zone table 4:

Table 4: Electricity and thermal consumption in the residential sector in the eastern region of Morocco

Zone	Electricity	Thermal	Total
Z1 Nador/ Driwech/Berkan	410.39 GWh	217.56 GWh	627.96 GWh
Z2 Oujad/Taourirt/Guercif	159.95 GWh	84.80 GWh	244.75 GWh
Z3 Bouarfa Figuig	3.46 GWh	1.83 GWh	5.29 GWh
Toral	753 GWh	304,19 GWh	878,00 GWh

- **Capacity of renewable energy sources used to power the residential sector by climate zone and region**

The capacities of renewable energy sources used to power the residential sector by climate zone and region are presented in the following table 5:

Table 5: Renewable Energy Supply Scenarios by Region

Region	Total cunsumption (GWh/year)	PV (MW)	Wind (MW)	BESS (MW)

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Z1 Nador/ Driwech/Berkan	627.96 GWh	135.6	67.1	500
Z2 Oujad/Taourirt/Guercif	244.75 GWh	67.7	26.8	279.2
Z3 Bouarfa Figuig	5.29 GWh	1.3	0.6	5.7

➢ **Comparison between the scenarios:**

The outputs of the GREENADVISE tool are:

- Total CAPEX €;
- Total OPEX (20 years) €;
- Total Cost €;
- Net Profit + saved profit €;
- Total Profit (20 years);
- Net Profit-OPEX (20 years) €;
- ROI (20 years %);
- Payback time (years);

The results are presented in the following table 6:

Table 6: The best-case scenario in each region of eastern Morocco

Region	The Best scenario	ROI (%)	Payback (year)	CAPEX (M€)	Total cost (M€)	CO2 (%)
Z1 Nador/ Driwech/Berkan	**S1 PV+BESS**	314.78	4.82	233.96	263.82M	62.55
Z2 Oujda/Taourirt/Guercif	**S3 PV+Wind+BESS**	305.06	4.89	127.61	146.46	88.75%
Z3 Bouarfa Figuig	**S2 Wind+BESS**	358.28	4.40	844.76	2.71M	78.87%

The most economically advantageous scenario is chosen for each region in eastern Morocco, according to the return-on-investment period criterion.

3.1.2 Case of Mali

The GREENADVISE tool:

The tables 7, 8 and 9 below give the inputs and results for the model in Mali. The side is located near Bamako.

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Table 7: Input Data 1

Input Category	Parameter	Value
PV Generation	dataset	MEERA-2 (global)
PV Generation	year	2023
PV Generation	Pmax	8
PV Generation	tilt	15
PV Generation	azimuth	74.34
PV Generation	NOCT	47
PV Generation	γ	-0.4
PV Generation	capex	15000
PV Generation	opex	200
PV Generation	latitude	12.523396
PV Generation	longitude	-7.948952
Electricity Demand	annual_demand	9000
Electricity Demand	dip_hour	12
Electricity Demand	evening_peak	20
Electricity Demand	morning_peak	8
Price Data Inputs	buyback	0.3
Price Data Inputs	one_tariff	0.23
Battery Inputs	capacity	1
Battery Inputs	capex	500
Battery Inputs	efficiency	90
Battery Inputs	rated_power	8.5
CO_2 Emissions	Emission Inputs	{'country': 'Mali', 'emission_metric': 'Intermittent Gen (kgCO_2/kWh)', 'emission_price': '0.07020', 'emission_value': 0.702, 'mode': 'country'}
CO_2 Emissions	Thermal Emission Inputs	{'emission_metric': 'kg CO2', 'emission_price': '0.07000', 'emission_value': 0.27864, 'fuel_consumption': '', 'fuel_name': 'Residual fuel oil / HFO', 'fuel_price': 0.55, 'mode': 'fuels in kWh', 'system_efficiency': 0.6}
Grid	Grid Power Limit	inf

Table 8: Emission Summary

Metric	Value
[Electricity] The following data refers only to	Electricity
[Electricity] CO_2 emission before optimization [kg]	6318
[Electricity] CO_2 emission after optimization [kg]	0
[Electricity] Saved emission after optimization [kg]	6318

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[Electricity] Saved emission after optimization [€]	443.5236
[Electricity] Emission reduction [%]	100
[Electricity] External cost before optimization [€]	443.5236
[Electricity] External cost breakdown before optimization [€]	• Climate Change - 443.52 • Particulate Matter - 0.00 • Toxicity - 0.00
[Electricity] External cost after optimization [€]	0
[Electricity] External cost breakdown after optimization [€]	• Climate Change - 0.00 • Particulate Matter - 0.00 • Toxicity - 0.00
[Electricity] Saved external cost after optimization [€]	443.5236
[Electricity] External cost reduction [%]	100
Total saved on Emissions [€]	443.5236
Total saved on External costs [€]	443.5236

Table 9: The System financials

Metric	Value
Technologies Used	PV, Battery
Total CAPEX [€]	16000
Total OPEX (20 years) [€]	4000
Total Cost [€]	20000
Net profit + Saved Profit [€]	1257.37
Total Profit (20 years) [€]	25147.32
Net Profit - OPEX (20 years) [€]	21147.32
ROI (20 years) [%]	32.17
Payback Time [years]	15.13

CONCLUSION - RECOMMENDATIONS

- In Optimization, the total investment in selected technologies of €20000.00 is profitable within a 20-year period.
- The capital expenditure is €16000.00 and total operating expenses are €4000.00. The return on investment is expected within 15.13 years.
- Before optimization we have imported 100.0% of electricity from grid, while after optimization the technologies cover 60.1% of the demand, while the remaining 39.9% is still imported from the grid.
- We have dimensioned the electricity technology capacities well, and all the electricity consumption is met.
- We generate profit by selling excess energy to the grid and performing energy price arbitrage when prices are high, earning a total of €620.85.
- We save money on electricity bills by producing your own renewable energy and using smart storage, reaching total savings of €2070.00.
- To cover remaining demand not met by the technologies and by performing energy price arbitrage when prices are low, you spend €1433.49 on grid electricity purchases.

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- By reducing emissions, we have also reduced the external costs — which include hidden economic damage from pollution such as health care expenses, environmental degradation, and premature deaths.
- The estimated external cost before optimization was €443.52, while after optimization it dropped to €0.00.
- This means we have saved approximately €443.52 in hidden health and environmental costs — a 100.0% reduction in total external cost.
- This reduction helps alleviate pressure on healthcare systems and reduces long-term societal burdens caused by fossil fuel-based energy production.
- With renewable technologies, which are carbon neutral, you have saved 6318.00 kg, which equals 100.0% of your total CO_2 footprint; the rest comes from grid imports (0.0%).
- By producing more of your own clean energy, you help secure better health and a more resilient future.

By choosing renewable technologies and storage, you reduce pollution, protect local health, lower your electricity costs, and contribute to building a cleaner, more affordable energy system for everyone**.**

3.1.3 Case of Mozambique

Overview of Mozambique's electricity sector

Mozambique is categorized as a low-income nation, with a population estimated at around 36,387,428 inhabitants (Mozambique population 2026 - StatisticsTimes.com)[1]. Most citizens reside in rural or peri-urban areas, where access to modern energy services remains scarce. The country's electricity generation is largely dependent on hydropower, supplemented by smaller inputs from other sources, as shown in Figure 6. Each year, close to 20,000 GWh of electricity is produced, yet about 55% of this output is exported to neighboring states in Southern Africa, including South Africa, Malawi, Zimbabwe, Zambia, Eswatini, and Botswana **[26]**.

In Mozambique, electricity consumption within the residential sector represents a significant share of national demand, accounting to 46% connected to the grid, 2% to mini-grids and 8% to SHS out of 56% of Mozambican inhabitants with access to electricity **[31]**.

Households across the country cumulatively use close to 2,000 GWh of electricity each year, reflecting the growing need for modern energy services in both urban and rural communities **[27]**. This level of consumption highlights the importance of expanding reliable access to electricity, as it directly impacts living standards, supports essential household activities, and contributes to social and economic development.

[1] Acessed April 2nd, 2026 (01:35PM)

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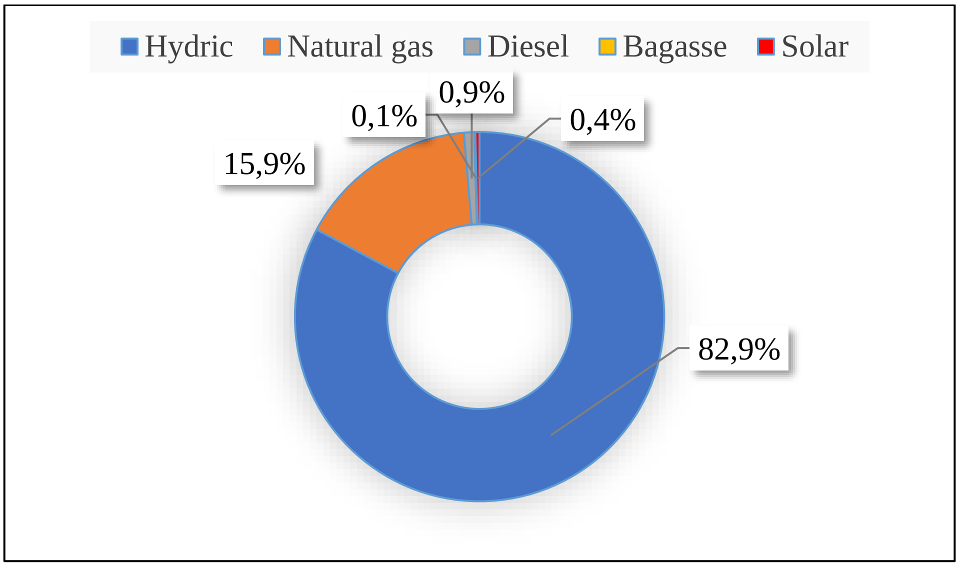

Figure 6 : Electricity generation technology mix

Characterization of the developed scenarios

To evaluate different renewable energy integration strategies, three distinct system configurations were developed. Each scenario explores how photovoltaic (PV) and wind power substations, combined with Battery Energy Storage Systems (BESS), can be connected to the electrical grid to enhance reliability and efficiency. The scenarios are presented below.

- **Scenario 1:** A PV power substation is designed with an integrated BESS, and the entire system is connected to the electricity grid.
- **Scenario 2:** A wind farm power substation is designed with an integrated BESS, and the entire system is connected to the electricity grid.
- **Scenario 3:** A PV power substation and a wind farm power substation are jointly designed and integrated with a BESS, forming a hybrid energy system that is fully connected to the electricity grid.

Key data entered for the simulations

To support the simulation analysis, GREENADVISE provided a set of key technical and economic parameters for three distinct scenarios. These inputs define the capacities, operational characteristics, and cost structures of PV systems, wind turbines, and BESS, as well as the associated electricity demand and tariff conditions. The main data inputs are summarized below.

Table 10: Key data entered into the GREENADVISE tool

Parameter	Scenario 1	Scenario 2	Scenario 3
PV capacity (MW)	32.7	N/A	32.7
Tilt (°)	30	N/A	30
Azimuth (°)	180	N/A	180
NOCT °C	51	N/A	51
γ (% / °C)	-0.4	N/A	-0.4
Wind turbines capacity (MW)	N/A	32.7	32.7
Rotor radius (m)	N/A	60	60

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Parameter	Scenario 1	Scenario 2	Scenario 3
Hub height (m)	N/A	90	90
Cut-in speed (m/s)	N/A	3	3
Rated wind speed (m/s)	N/A	12	12
Cut-off wind speed (m/s)	N/A	25	25
BESS capacity (MWh)	310.6	310.6	621.2
BESS purchase (€)	505,269	505,269	1,010,538
Batteries efficiency (%)	90	90	90
Batteries rated power (MW)	12.9	12.	25.8
Annual electricity demand (GWh)	43.6	43.6	43.6
Buy-back factor	0.6	0.6	0.6
Single tariff (€/kWh)	0.11	0.11	0.11

NA – Not Applicable

To estimate the investment requirements for each system configuration, the unit costs of key components were considered. The following table summarizes the equipment prices for PV panels, wind turbines, and BESS.

Table 11: Costs associated with the purchase of equipment

System type	Equipment	Price
PV System	PV panels	€270/kWp
Wind system	Wind turbines	€1200/kWp
BESS	Batteries	€120/kWh

Niassa Province, chosen as the focus area for the GREENADVISE's simulation, is among Mozambique's ten provinces and lies in the northern part of the country (see Figure 7). In 2023, its population was estimated at 2,349,195 people, yet only 31.1% had electricity supplied through the national grid. That year, the grid supplied approximately 76,682 MWh of electricity to Niassa, with households accounting for about 57% of the total supplied.

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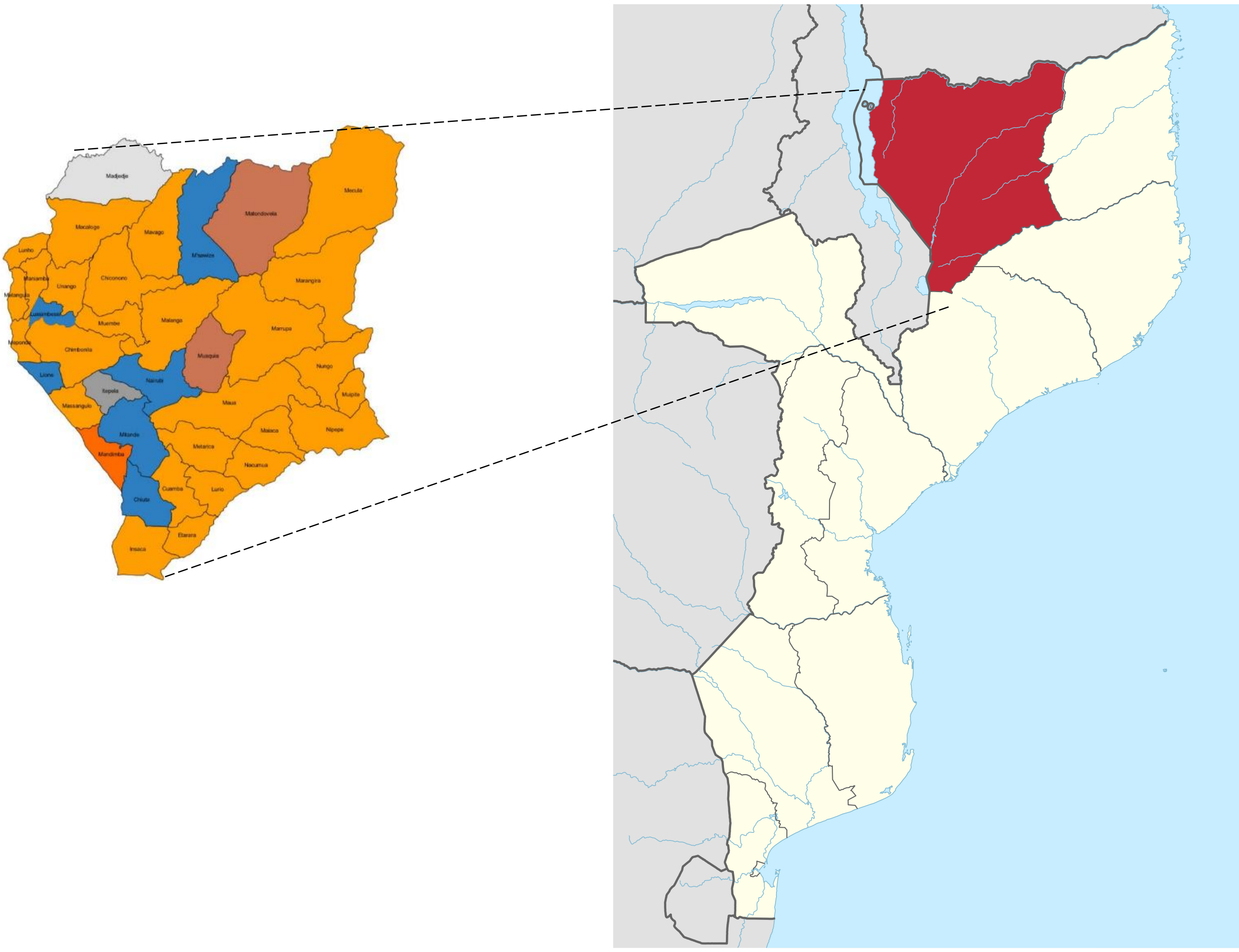

Figure 7: Niassa province location

GREENADVISE results

Financial results

The outcomes of the GREENADVISE modelling provide a comparative assessment of the three energy system scenarios. Key financial and performance indicators – including capital and operational expenditures, profitability, return on investment (ROI), and payback time – were calculated to evaluate the viability of each configuration. The summarized results are presented below.

Table 12: Financial information results

Metric	Value	Value	Value
Scenario	**1**	**2**	**3**
Technologies Used	PV + Battery	Wind + Battery	PV + Wind + Battery
Total CAPEX [€]	9,835,920.00	40,246,271.00	50,082,411.00
Total OPEX (20 years) [€]	35,301,520.00	156,942,940.00	192,244,460.00
Total Cost [€]	45,137,440.00	197,189,211.00	242,326,871.00
Net profit + Saved Profit [€]	5,226,630.74	-266,010.28	5,775,257.79

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Metric	Value	Value	Value
Scenario	**1**	**2**	**3**
Total Profit (20 years) [€]	104,532,614.71	-5,320,205.51	115,505,155.73
Net Profit - OPEX (20 years) [€]	69,231,094.71	-162,263,145.51	-76,739,304.27
ROI (20 years) [%]	603.86	-503.18	-253.23
Payback Time [years]	2.84	∞	∞

From the results outlined above, it is evident that **Scenario 1** is the only profitable option, yielding approximately €69 million in profit and achieving a payback period of below three years. This indicates that the initial investment is recovered relatively quickly, while Scenarios 2 and 3 fail to reach payback at all (are not feasible financially).

Technical results

The analysis of household electricity dependence under different system configurations highlights the impact of local generation and storage capacity. As renewable energy and battery integration expand across scenarios, the balance between grid reliance and self-sufficiency shifts considerably.

Figure 8 illustrates that as local energy generation and storage capacity increase across the scenarios, household reliance on grid electricity decreases significantly, shifting from a balanced dependence in Scenario 2 to near-total energy self-sufficiency in Scenarios 1 and especially Scenario 3.

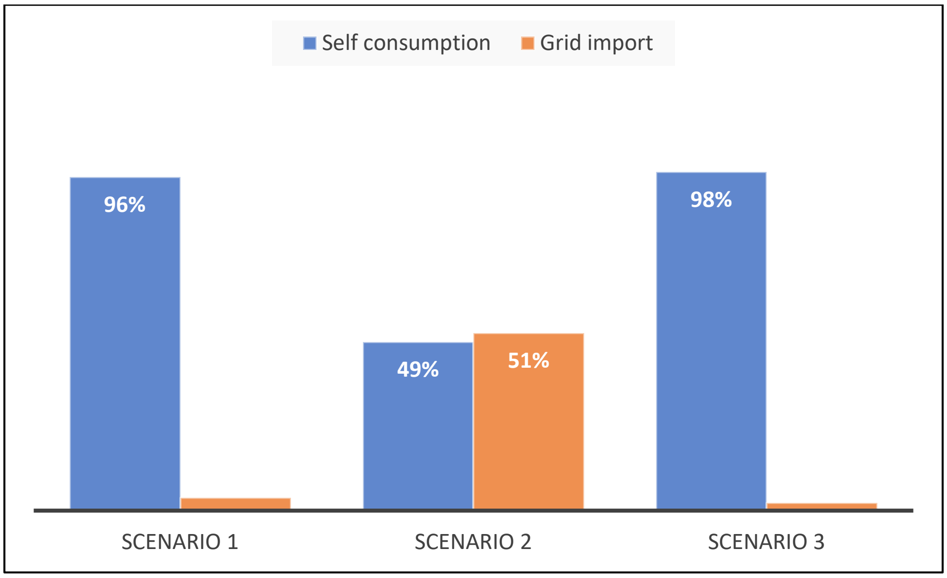

Figure 8 : Reliance on grid power for household use

The comparison between solar and wind generation in Niassa reveals clear differences in how each technology performs. Analysis of the simulation results shows that variations in energy output and consistency determine whether they are better suited as primary or supporting sources. The findings indicate that solar PV consistently delivers much higher and more stable energy throughout the year, making it a dependable and efficient main supply option. In contrast, wind generation remains lower and more irregular, though it can provide useful complementary support during certain months, as illustrated in Figure 9.

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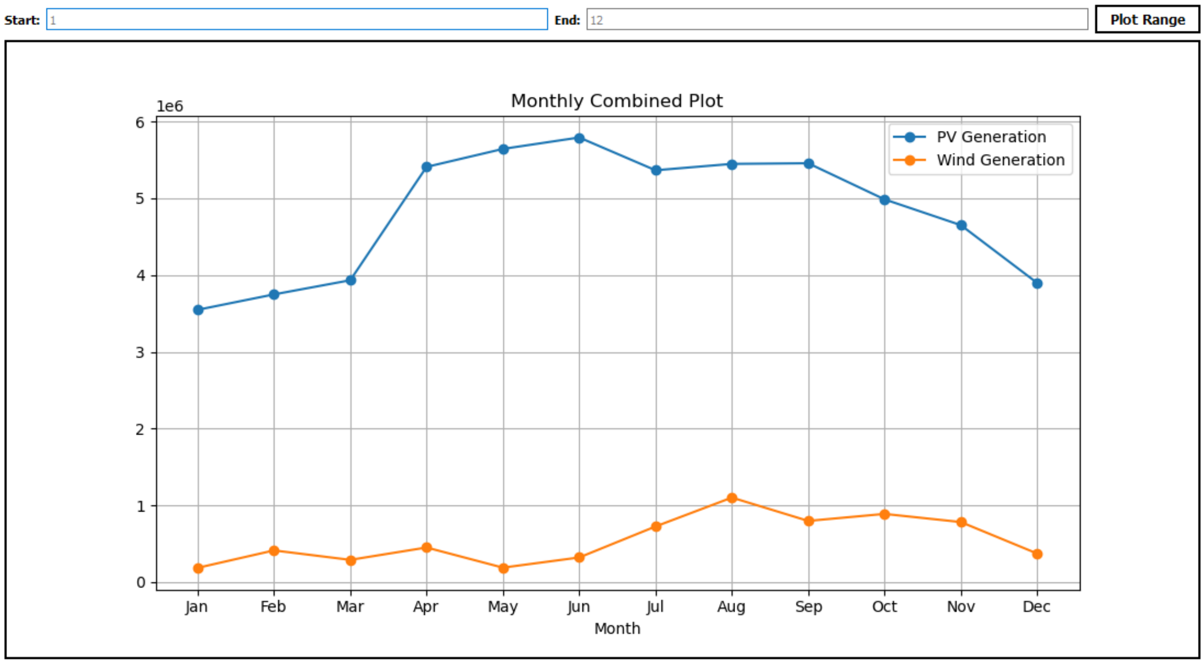

Figure 9 : PV and wind generation

Across all scenarios, the environmental assessment shows that electricity generation from renewable energy sources results in a reduction of approximately 10,364,349.6 kg of CO_2 emissions over the lifetime of the projects.

3.2 Scenario development using the CEPIA tool

The energy transition scenarios **(Table 13)** were developed using the **CEPIA** (Climate and Energy Policies Impact Assessment) tool developed by **Artelys**. The main objective of the study is to evaluate different energy transition pathways, over the period 2024–2055, enabling the reduction of CO_2 emissions in the EMERGE pilot sites (Morocco, Mali and Mozambique) while guaranteeing security of supply and the economic sustainability of the energy system.

Table 13: Prospective scenarios created by the CEPIA tool

	A: Strong economic growth	**B: Slowed economic growth**
1: Fast transition towards a low carbon economy	A1	B1
2: Low transition towards a low carbon economy	A2	

The assessment of different energy transition pathways was structured around two main components: energy consumption, broken down by sector (residential, industrial, transport, and agriculture), and the transformation system, representing the various energy production sources, including LPG (Liquefied Petroleum Gas), oil, wood, coal, natural gas, solar photovoltaic, wind, hydroelectric, and hydrogen. The basic data used included population, average household size, oil, natural gas, and diesel

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prices, the efficiency of gasoline, diesel, LNG, electric, and fuel cell engines, **initial (2024)** GHG emissions, sectoral growth rates, technology costs, power plant efficiencies, and emission factors from the databases integrated into the **EMERGE Toolbox** developed by **BrainIT**.

3.2.1 Scenario development: The case of Morocco

The baseline scenario A1 (business as usual) assumes a continuation of current trends, with a rapid transition to a low-carbon economy and strong economic growth. It anticipates average annual growth in electricity demand, a significant maintenance of fossil fuel power plants, and limited development of renewable energy sources. In this scenario, the electricity mix structure evolves slowly, leading to a gradual increase in CO_2 emissions by 2055.

The moderate transition scenario A2 (accelerated) is based on more proactive energy policy assumptions, such as "a smooth transition to a low-carbon economy" and "strong economic growth." This scenario anticipates more controlled demand growth, increased energy efficiency, private energy production, the introduction of electric vehicles, water desalination, and an accelerated deployment of renewable energy by 2055.

The ambitious B1 (In orbit) scenario, focused on a rapid transition to a low-carbon economy and a slowdown in economic growth, relies on a profound transformation of the energy system, carrying out major industrial projects involving the export of hydrogen and electricity.

Simulating scenarios using the CEPIA tool allows us to calculate and compare several key indicators, including the share of renewable energy in the electricity mix, total CO_2 emissions and total final energy consumption and by sector.

3.2.2 Scenario development: The case of Mali

Focusing on Mali, scenarios have been built using the CEPIA tool to cover two key economic sectors: residential and transport sector. The methodology used to develop these scenarios is detailed below.

- Residential sector (see Figure 10):
  - Two contrasted scenarios were developed to assess the long-term impact of cooking electrification in Mali. The *Ambitious* scenario assumes strong public policies and incentives promoting the transition from traditional biomass-based cooking (fuelwood and charcoal) towards electric cooking technologies, while the *Low* scenario reflects a slower transition driven by limited policy support and stronger economic barriers. All other assumptions remain identical between scenarios, including population growth, cooking energy needs, appliance efficiencies, and overall electrification rates. Population dynamics were derived from UNFPA projections, while missing sectoral data were complemented using previous studies covering African countries.

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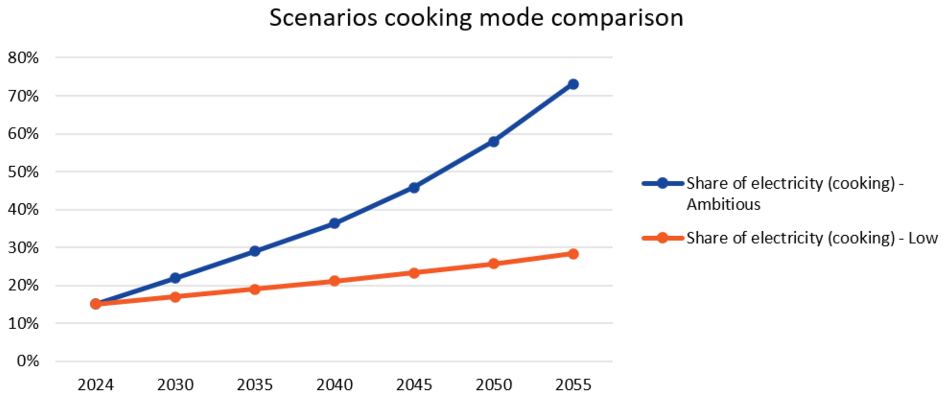

Figure 10: Residential sector: assumptions for Mali scenarios

- Transport sector (see Figure11):
  - For the transport sector, CEPIA distinguishes between passenger transport and freight transport. Two contrasted scenarios were developed around different levels of transport electrification and modal shift. The *Ambitious* scenario assumes rapid deployment of electric and hydrogen vehicles, a strong expansion of public transport systems, and a limited growth of individual car use. The *Low* scenario assumes slower electrification, greater penetration of gas-powered vehicles, and a stronger reliance on private cars. Population growth, mobility demand, passenger occupancy rates and freight transport volumes are assumed to be identical across both scenarios. Missing transport data were supplemented using values from previous African studies.

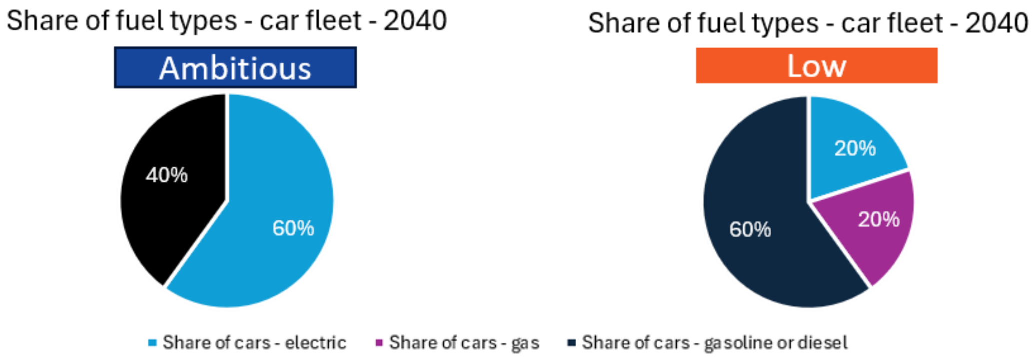

Figure 11 : Transport sector: assumptions for Mali scenarios.

3.2.3 Scenario development: The case of Mozambique

Table 14 provides electricity supply trend (2019–2023) and highlights a **steady growth in** power generation **over the past five years**, increasing from **7,089 GWh in 2019 to 8,588 GWh in 2023**, which denotes a rise of **21%**. Key features are:

- **Hydropower (produced by EDM):** while hydro contributed modestly (427 GWh in 2023), it has grown from 163 GWh in 2019. However, it still accounts for only a small portion of the total potential – it should be noted that most of hydro production, by HCB, is dedicated to export to neighboring countries.

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- **Independent Power Producers (IPP):** this represents an averaging of 2,500 GWh annually. Playing an important role in Mozambique's energy mix.
- **Imports (by EDM):** are relatively marginal, with around 80 GWh annually on average in recent years, suggesting a domestic sufficiency.
- **Hidroeléctrica de Cahora Bassa (HCB):** The dominant source, growing from 3,651 GWh in 2019 to 4,885 GWh in 2023. HCB's rising output emphasizes its strategic importance in national and regional electricity supply.

Table 14: Electricity supply trend in the last 5-years (Source: EDM, 2023)

FONTE DE GERAÇÃO | SOURCE OF GENERATION [GWh]	2019	2020	2021	2022	2023
Hídrica | Hydro [EDM]	163	352	476	420	427
IPP | IPP	2,491	2,511	2,574	2,497	2,511
Termica | Thermal [EDM	710	553	621	617	684
Importação | Import	74	64	69	80	80
HCB	3,651	3,784	3,955	4,532	4,885
Energia Total | Energy Total	**7,089**	**7,265**	**7,694**	**8,146**	**8,588**

The electricity supply trend supports Mozambique's expanding demand and electrification targets. The Diversification remains limited, with hydro (especially from HCB) and thermal dominating. The role of IPPs and low reliance on imports show progress in national energy security.

The electrification rate as of 2024 stands at about 54%, with ambitious goals (unlikely) of reaching universal access by 2030, as shown in Figure 12.

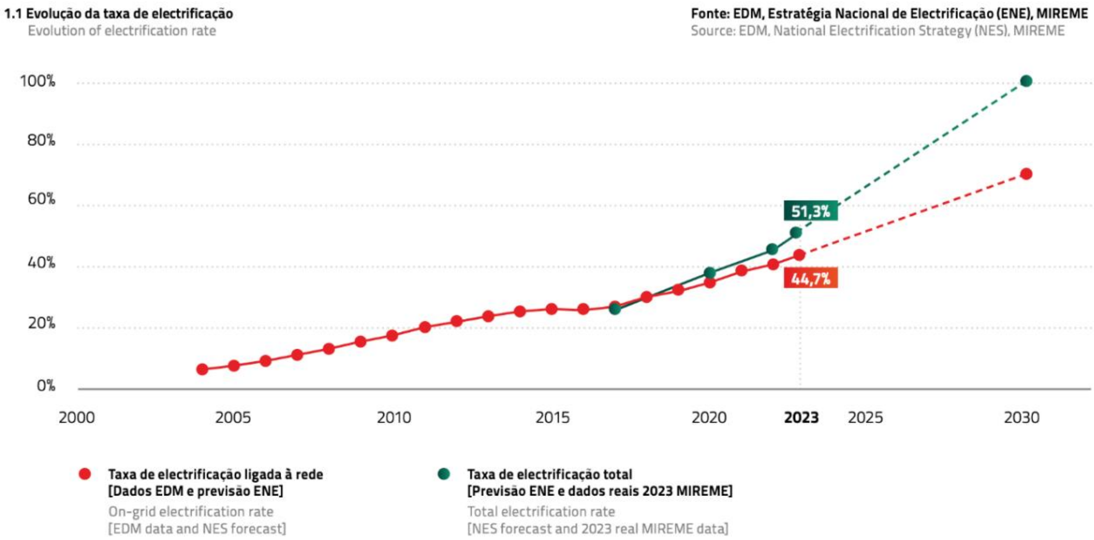

Figure 12: Evolution of electrification rate including the projection for ambition of universal access by 2030:

According to EDM statistical report, in 2023, hydropower contributed nearly two-thirds (62%) of total generation, followed by natural gas, which is the main fossil fuel source within the country, with over

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a third of total generation (Figure 13). Despite its vast potential in Mozambique, solar power remains underdeveloped at just 1% of the mix. Heavy Fuel Oil (HFO) and imports are minimal but highlight areas for potential displacement with clean alternatives. The limited diversity within the renewables (mostly hydro) may pose a climate resilience risk during droughts.

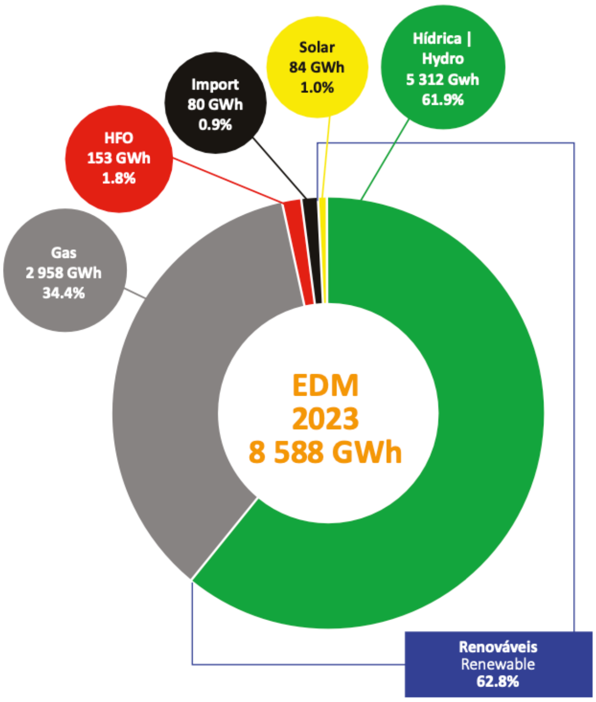

Figure 13 :Mozambique Energy Matrix by source for 2023. Source: EDM, 2023

Table 15 is drawn from the 'Mozambique's Long-term low greenhouse gas emissions development strategy (LT-LEDS)'; the following key trends can be highlighted for the energy sector:

- Power generation grows from 0.70 $MtCO_2e$ (2015) to 26.53 $MtCO_{2e}$ (2050) – a 38-fold increase.
- Other energy industries and transport are also major emission drivers.
- Overall emissions triple between 2020 and 2030, driven by economic growth and energy demand without low-carbon transition.

The implications are:
- The current trajectory is unsustainable without mitigation policies; and,
- A shift to renewables, energy efficiency, and clean transport is essential for decarbonization.

Table 15: BAU emissions projection for the Mozambique energy sector. Source: LT-LEDS, 2022.

GHG emissions ($MtCO_2e$)	2015	2020	2030	2040	2050
Power generation	0.70	1.58	8.72	15.04	26.53
Other energy industry	4.41	5.92	14.25	22.65	25.54
Manufacturing and industry	0.50	0.77	2.24	2.88	3.59
Transport	2.83	3.93	9.39	12.73	16.58
Other sectors	4.67	5.54	7.70	9.83	12.09
Total	13.12	17.74	42.30	63.12	84.32

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Based on the aforementioned sources of information, Table 16 provides selected indicators for reference year to be implemented in CEPIA tool.

Table 16: Selected indicators for reference year used in CEPIA tool. Case study: Mozambique Sources (EDM, 2023; INE, 2017; INE 2023; ALER, 3023)

		Mozambique	
		Year 1 (2024)	Unit
Demographics	Population	32,419,747	inhabitants
	Size of household	5	inhab/household
Electrical	Installed capacity of Wind in reference year	-	MW
	Installed capacity of Solar in reference year	75	MW
	Installed capacity of hydroelectric in reference year	2,192	MW
	Installed capacity of multifuel in reference year	110	MW
	Installed capacity of CCGT in reference year	464	MW
Transport	Modal share - bus	15	%
	Modal share - collective taxis	45	%
	Modal share - car	5	%
	Modal share - bicycle	1	%
	Modal share - motorbike	1	%
	Modal share - walking	28	%
Residential	Total electrification rate	54	%
	Share of LPG	4.7	%
	Share of Electricity	1	%
	Share of Natural gas	0	%
	Share of Charcoal	21.5	%
	Share of Wood	72.8	%
Industry[2]	Aluminum Smelter		
	Extractive Industry		
	Cement		
	Sugar cane		
	Fishing		
	Tobacco		
	Food and Beverages		
	Name of Subsector 8		
Electrical	Penetration rate of renewable energies on the interconnected grid starting in year2	8	%

[2] Not considered in this task

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Gas production	LNG Production		tons

The current energy statistics highlight the dominant role of hydroelectric power (2,192 MW) and traditional biomass in the residential sector. The energy mix remains heavily dependent on wood (72.8%) and charcoal (21.5%) in households, reflecting limited penetration of modern fuels like LPG (4.7%) and electricity (1%).

Transport patterns in Mozambique show heavy reliance on informal or shared transport modes, where collective taxis are leading with 45% share, followed by walking (28%) and lastly by bicycles and motorbikes, with only 1% each.

Based on the figures presented in previous sections, electricity generation, transport and residential subsectors were selected for scenario analysis using CEPIA tool due to their dominance in the Mozambican energy sector.

Two primary scenarios were considered using CEPIA tool :
• A1 – Strong economic growth with a fast transition toward a low-carbon economy.
• B1 – Slower economic growth with a moderate shift toward clean energy.
Table 17 shows that demographic projections anticipate a considerable population growth from approximately 32.4 million in 2024 to around 67.5 million by 2055. Household size remains stable at an average of five inhabitants.

Table 17: Evolution of population and average household size for BAU. Context Variables

Name of variable	Unit	2024	2030	2035	2040	2045	2050	2055
Population	10^3 inhab	32,420	36,634	41,397	46,778	52,860	59,731	67,496
Hhd Avg size	inhab	5	5	5	5	5	5	5

In the electricity sector, the A1 scenario forecasts 85–89% renewable penetration on the interconnected grid, supported by solar kit distribution and grid expansion. B1 scenario follows a less aggressive path, achieving 50–75% renewables by 2055, with added hydrogen production starting in 2035, as seen in (Table 18 and table 19).

Table 18: Scenario A1

Name of variable	Unit	2024	2030	2035	2040	2045	2050	2055
Penetration rate of solar kits	%	-	33	100	100	100	100	100
Share of Solar production	%	5	30	90	90	90	90	90
Export Capacities	MW	0	0	50	100	100	100	100
Penetration rate of renewable energies	%		85	85	87	88	88	89

Table 19: Scenario B1

Name of variable	Unit	2024	2030	2035	2040	2045	2050	2055
Penetration rate of solar kits	%	-	33	100	100	100	100	100
Share of Solar production	%	5	30	90	90	90	90	90
Export Capacities	MW	0	0	25	50	50	50	50
Penetration rate of renewable energies	%		50	50	50	50	63	75
Production of hydrogen		-	0.2	1.2	2.3	3.3	4.9	6.5

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Transport sector assumptions show a modal shift from diesel buses to electric, gas, and hydrogen-powered fleets. In A1, electric bus penetration reaches 50% by 2055, while diesel is reduced to 20%. In B1, the reduction is slower and less consistent.

Table 20: Transport sector indicators, providing different modal shares for scenarios A1

Name of variable	Unit	2024	2030	2035	2040	2045	2050	2055
Modal share - bus	%	25	24	23	22	22	21	20
Modal share - collective taxis	%	40	35	31	27	23	21	18
Modal share - car	%	5	6	7	9	10	12	15
Modal share - walking	%	28	29	29	30	31	31	32

Table 21: Transport sector indicators, providing: share of bus by fuel type: Electrical, gas, hydrogen, and diesel - Scenario A1

Name of variable	Unit	2024	2030	2035	2040	2045	2050	2055
Share of bus - electrical	%	-	2	5	15	25	35	50
Share of bus - gas	%	-	20	33	50	50	25	20
Share of bus - hydrogen	%	-	-	-	2	5	20	10
Share of bus - diesel	%	100	78	62	33	20	20	20

Table 22: Transport sector indicators, providing: share of bus by fuel type: Electrical, gas, hydrogen, and diesel - Scenario B1

Name of variable	Unit	2024	2030	2035	2040	2045	2050	2055
Share of bus - electrical	%	-	-	5	10	15	20	35
Share of bus - gas	%	-	10	20	30	50	75	55
Share of bus - hydrogen	%	-	-	-	-	-	5	10
Share of bus - diesel	%	100	90	75	60	35	-	-

Residential energy use under scenario A1 trends toward increased use of electricity and LPG, while reducing reliance on wood and charcoal. By 2055, A1 projects 15% electricity use and 10% LPG, while wood declines to 55%. B1 scenario accelerates LPG adoption but still shows considerable biomass use.

Table 23: Residential sector indicators, providing: shares of LPG, electricity, natural gas, charcoal, wood, and total electrification rate:

Table 23a: Scenario A1

Name of variable	Unit	2024	2030	2035	2040	2045	2050	2055
Share of LPG	%	5	5	6	7	8	9	10
Share of Electricity	%	1	2	2	4	6	10	15
Share of Natural gas	%	0	0	0	0	0	0	0
Share of Charcoal	%	22	21	21	21	20	20	20
Share of Wood	%	73	69	66	63	60	58	55
Total electrification rate	%	54.0	57.7	71.8	80.6	84.6	87.4	89.8

Table 23b: Scenario B1

Name of variable	Unit	2024	2030	2035	2040	2045	2050	2055
Share of LPG	%	48	48	47	46	45	43	40
Share of Electricity	%	2	8	14	20	27	34	44
Share of Natural gas	%	-	-	-	-	-	-	-
Share of Charcoal	%	22	21	18	16	13	10	8
Share of Wood	%	27	24	20	17	14	12	9
Total electrification rate	%	42.6	57.7	71.8	80.6	84.6	87.4	89.8

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3.3 Identification of the measures (actions) to be implemented to achieve the objectives defined for each scenario

3.3.1 The scenarios developed for the case of Morocco

In order to achieve the objectives defined for each scenario, we propose in this document a set of key actions and conditions for Morocco to be able to implement them.

The three scenarios A1, A2 and B1 are based on population growth of about 13% over five years, an increase of 13% in energy consumption for cooking and 5% for the transport of goods and logistics, a stable average household size of about four people and a discount rate of about 2%.

Scenario A1 also assumes continued reliance on fossil fuel power plants and significant development of renewable energies. In this scenario, the energy mix structure evolves slowly, leading to a gradual increase in CO_2 emissions by 2055.

Scenario A2 aims to reduce CO_2 emissions by 40% compared to scenario A1 by 2055. The measures to be implemented to achieve the targets defined for each scenario are:

- The significant electrification of energy uses, particularly in the residential, transport and industrial sectors.
- The 84% reduction in LPG consumption between 2024 and 2055 for scenario A2 compared to a 24% reduction for scenario A1
- The share of installed renewable energy in the electricity mix will reach approximately 89% by 2055 for scenario A2 compared to 96% for scenario A1.

Scenario B1 is based on assumptions of more proactive energy policies, including more controlled growth in hydrogen and natural gas production and an accelerated deployment of renewable energies to reach approximately 89% renewable production by 2055. Thus, this scenario incorporates a progressive reduction in the use of diesel, compensated by the development of electric vehicles and the use of H2 in various sectors, especially the transport and industrial sectors.

These actions will have an impact on:

- **Total energy consumption:**

A diagram showing the evolution of total energy consumption over time is proposed below (Figure 14):

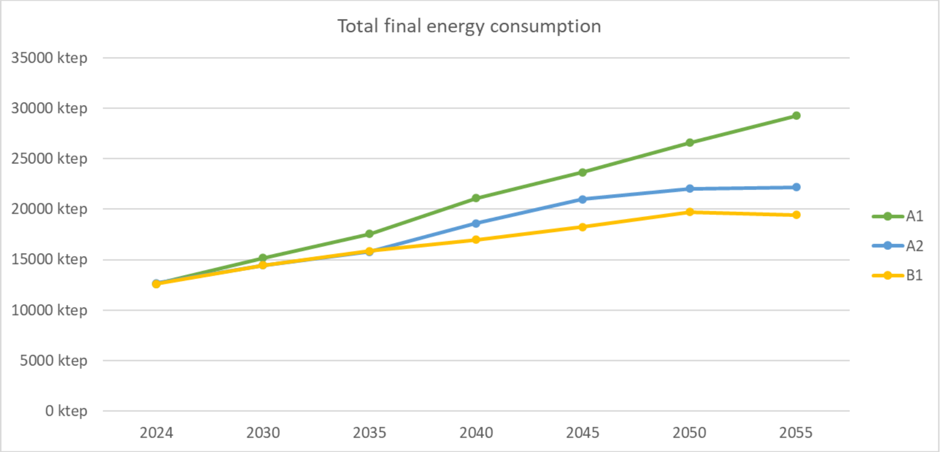

Figure 14 : The total energy consumption for each scenario

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- The total energy consumption for scenario A1 in 2055 will be 29,285 kTOE;
- The total energy consumption for scenario A2 in 2055 will be 22,173 kTOE; a decrease of 24% compared to scenario A1.
- The total energy consumption for scenario B1 in 2055 will be 19, 452 kTOE; a decrease of 33.6% compared to scenario A1.

- **Primary energy consumption:**

A diagram showing the evolution of primary energy consumption over time is proposed below (Figure 15):

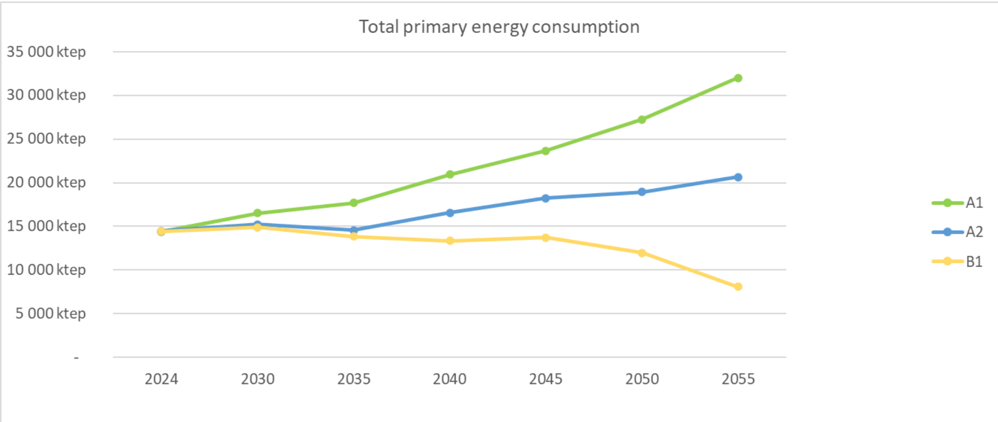

Figure 15 : Primary energy consumption

For the primary energy consumption, the following trends are observed:

- For the A1 scenario, it is assessed at 31,985 kTOE in 2055;
- For the A2 scenario, it is assessed at is 20,637 kTOE in 2055; therefore, achieving a reduction of approximately 35.4%;
- For the B1 scenario, it is assessed at 8,100 kTOE in 2055; therefore, a reduction of approximately 74.6%.

- **Greenhouse gas emissions :**

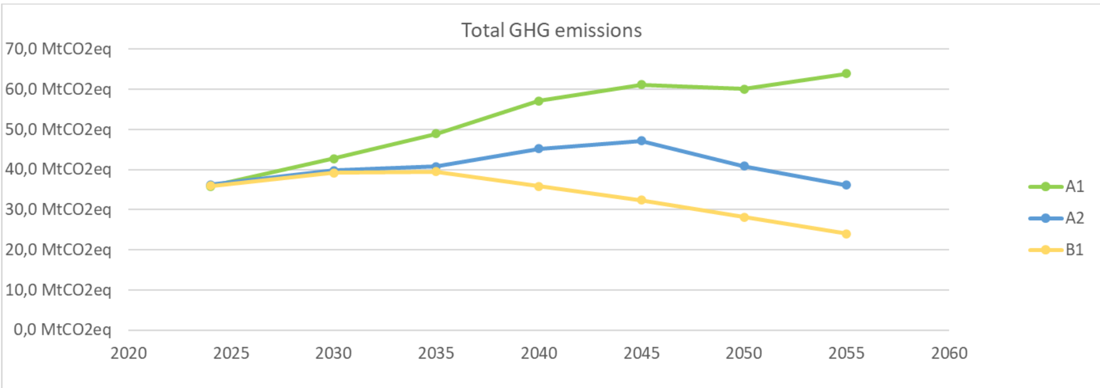

Figure 16 : Greenhouse gas emissions

As regards greenhouse gas emissions (figure 16), we note that:

- Scenario A1 reaches 63.9 $MtCO_2eq$ in 2055;
- Scenario A2 reaches 36.1 $MtCO_2eq$ in 2055; therefore, a reduction of approx. 43%;

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- Scenario B1 reaches 24.0 MtCO2eq in 2055; therefore, a reduction of approx. 62 %;

3.3.2 The scenarios developed for the case of Mali

Focusing on Mali Use Case, the scenarios built with CEPIA tool were detailed in Section **Error! Reference source not found.**. Below are some key outcomes obtained for residential and transport sectors.

- Residential sector (see **Error! Reference source not found.**17 and **Error! Reference source not found.**):
  - The analysis highlights the critical role of cooking technologies in shaping future energy demand. In the *Ambitious* scenario, the share of electricity in cooking increases from around 15% today to more than 70% by 2055, whereas it remains below 30% in the *Low* scenario. Due to the significantly higher efficiency of electric stoves compared with traditional biomass cooking devices, residential final energy consumption stabilizes and starts declining after 2045 in the *Ambitious* scenario, despite a population that approximately doubles over the modelling horizon. Conversely, in the *Low* scenario, continued reliance on fuelwood leads to a steady increase in energy consumption until 2055.
  - The scenarios also generate markedly different greenhouse gas emission trajectories. Under low electrification, emissions continue to rise as biomass remains the dominant cooking fuel. In contrast, accelerated electrification reduces dependence on traditional fuels and limits emission growth over the long term. The results therefore illustrate how cooking electrification can simultaneously contribute to energy efficiency improvements, reduced pressure on biomass resources, and mitigation of climate impacts.

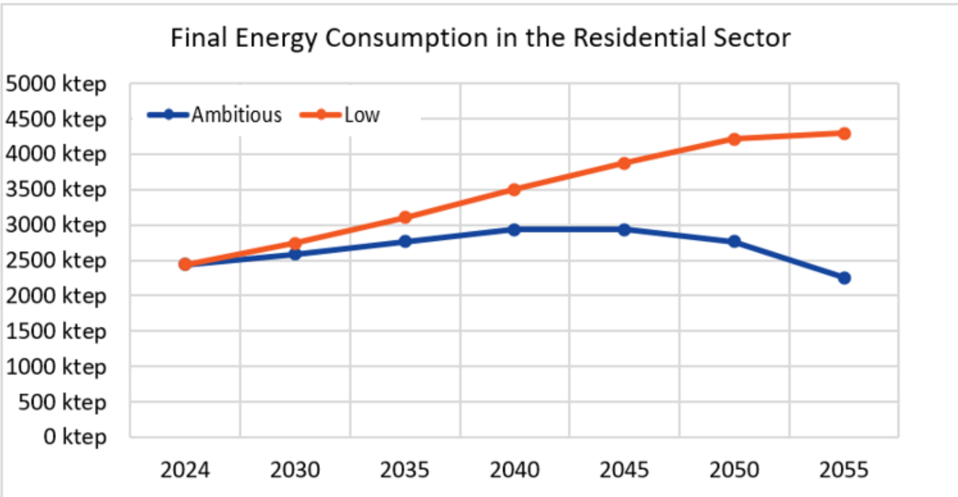

Figure 17: Mali scenarios – Final Energy Consumption in residential sector

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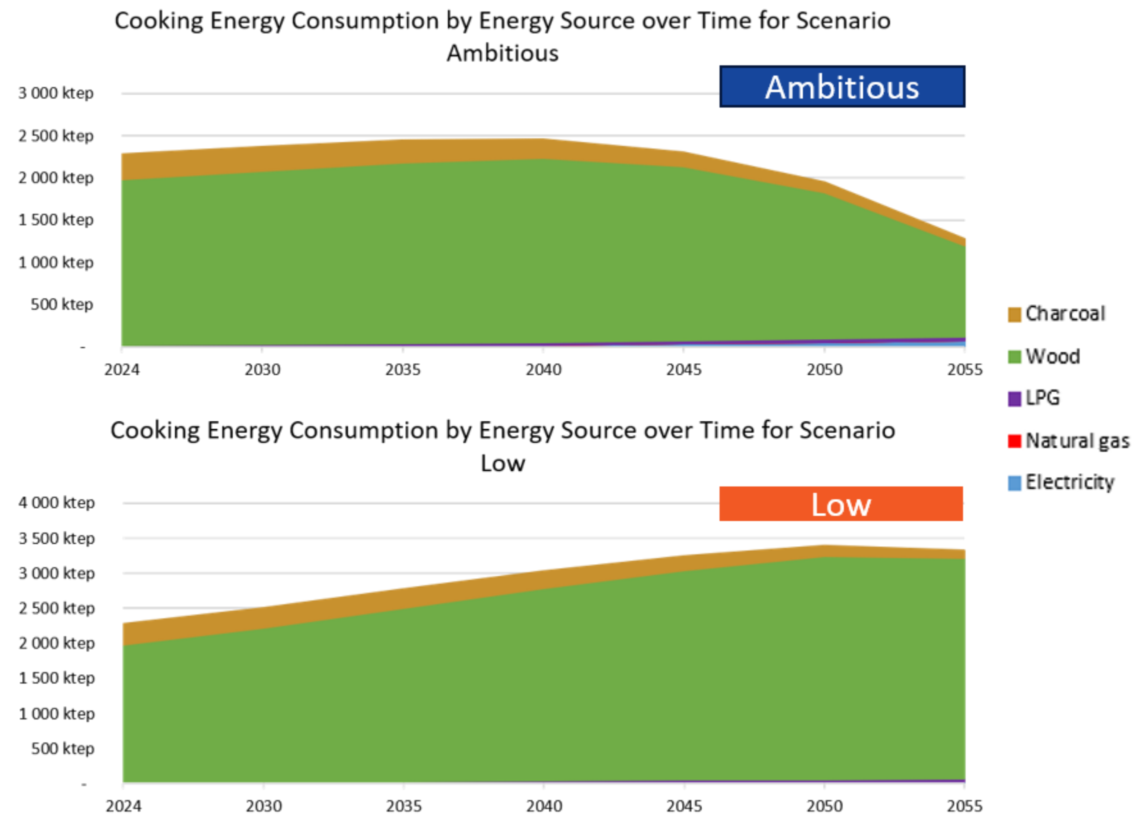

Figure 18 : Mali scenarios – Cooking energy consumptions by energy source

Transport sector (see

and

-):
    - The results show substantial divergence in future energy demand. In the *Ambitious* scenario, the combination of vehicle electrification and higher public transport use significantly improves overall transport efficiency, leading to a decline in final energy consumption after 2040. By contrast, the *Low* scenario produces a continuous increase in transport energy demand, reaching levels around 2.5 times higher than those observed in the ambitious pathway by 2055.
    - Changes in the vehicle fleet composition explain a large share of these differences. In the *Ambitious* scenario, electric vehicles progressively become dominant while oil products are gradually phased out. In the *Low* scenario, gas-powered vehicles gain a large share of the market and become the predominant technology by 2055. Freight transport contributes only marginally to total final energy consumption; therefore, the main drivers of energy demand evolution are passenger transport modal choices and vehicle efficiency improvements. Overall, the results demonstrate how electrification and public transport development can substantially curb future transport energy demand and associated emissions in Mali.

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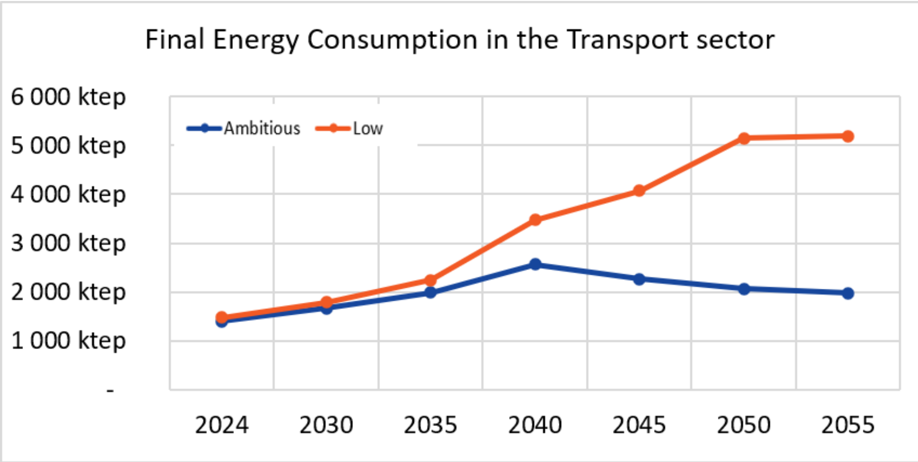

Figure 19 : Mali scenarios – Final Energy Consumption in transport sector

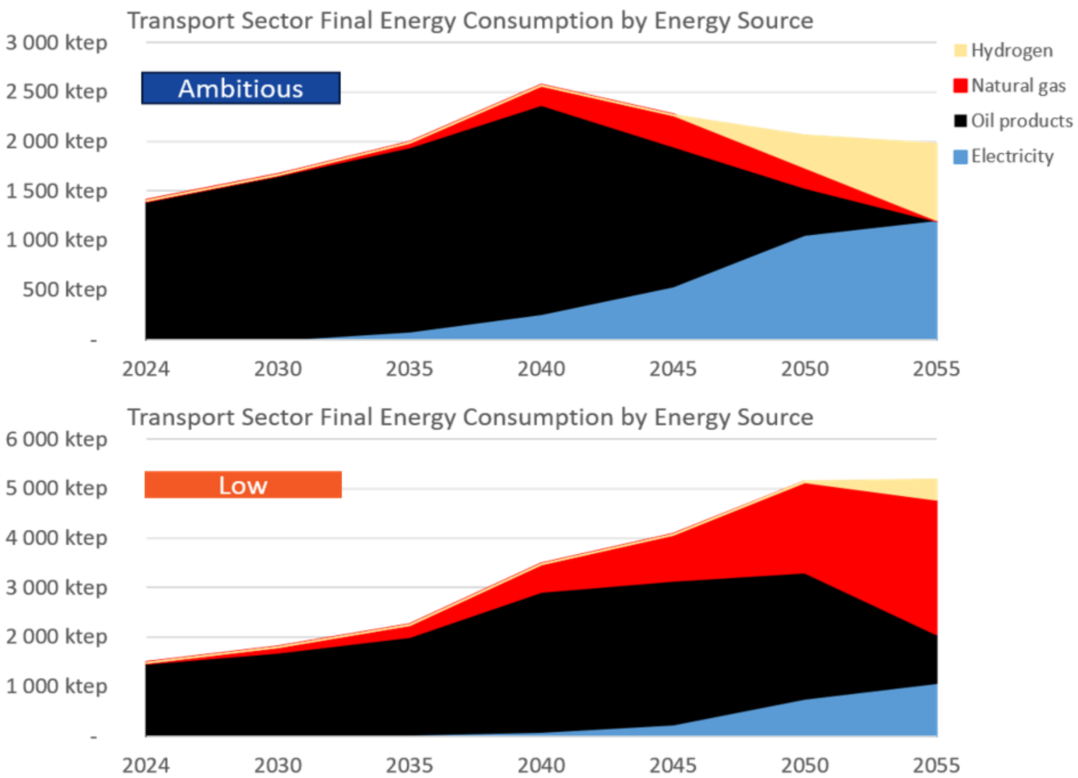

Figure 20 : Mali scenarios – transport sector final energy consumption by energy source

3.3.3 The scenarios developed for the case of Mozambique

- Scenario A1 shows higher electrification and cleaner energy adoption, with increasing consumption in residential and transport sectors.
- Sectoral demand trends suggest growing industrial and transport energy needs.

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Final Energy Consumption (Figures 21, Figure 22 and Figure 23):

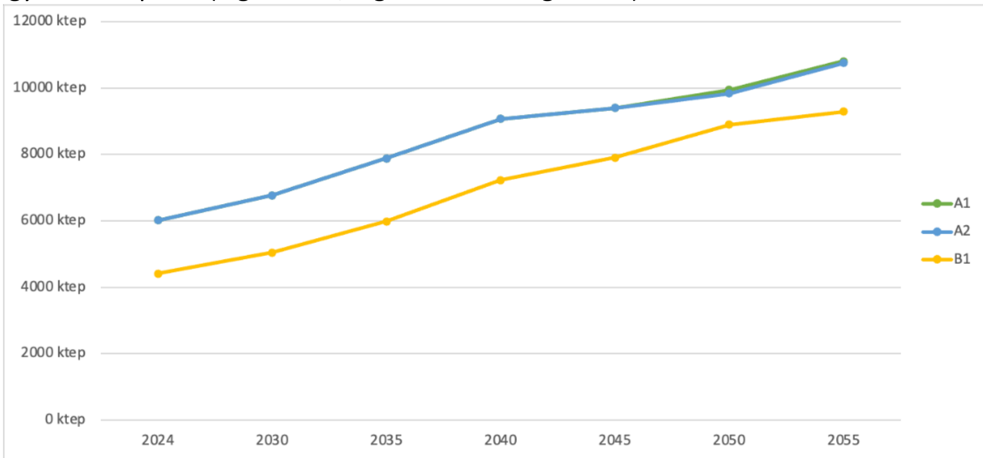

Figure 21 : Final energy consumption for the three scenarios.

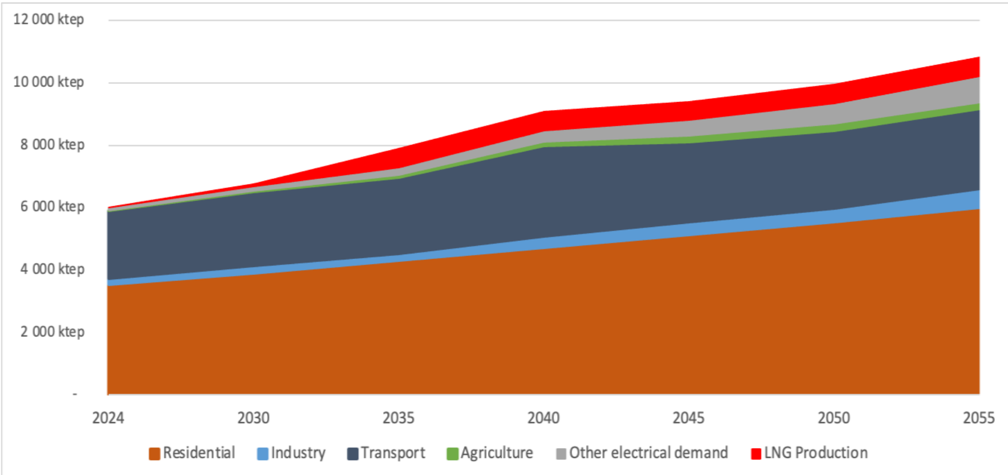

Figure 22 : Total final energy consumption per sector for scenario A1

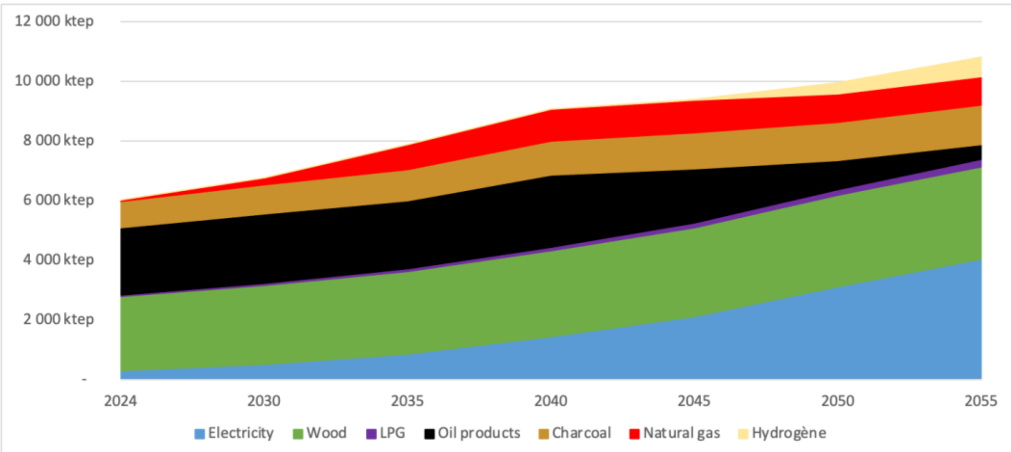

Figure 23 : Total final energy consumption per energy source for scenario A1

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Scenario A1 leads to significant improvements in energy efficiency and emissions reduction. It successfully achieves around a 40% reduction in GHG emissions by 2050 compared to the baseline. Energy consumption rises due to population and economic growth, but cleaner energy sources dominate in A1. Sectoral data shows transport and residential sectors benefiting most from clean transitions.

Primary Energy Use (Figures 24 and Figure 25):

- Shift from biomass and fossil fuels to solar and hydroelectric power is significant in A1.
- B1 still shows considerable reliance on fossil-based energy types.

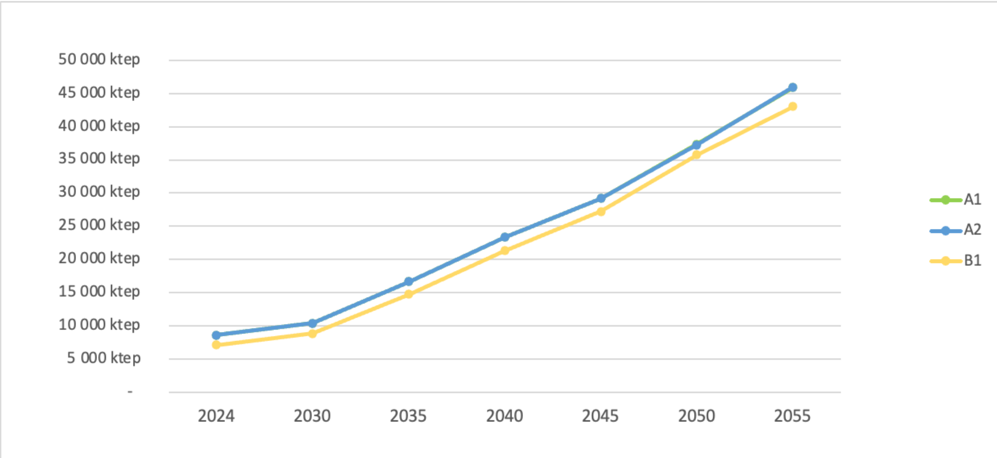

Figure 24 : Total primary energy consumption in scenarios

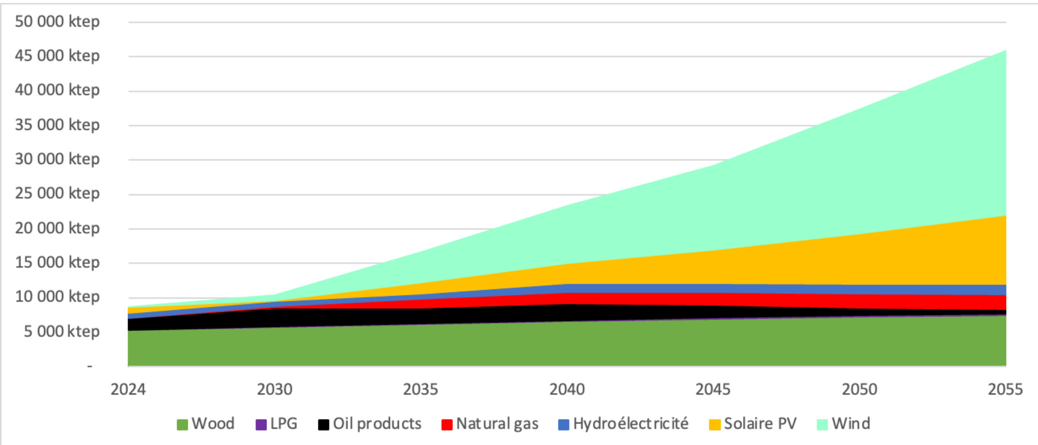

Figure 25 : Total primary energy consumption per energy type

Final and primary energy consumption highlight the effectiveness of policy-driven change under scenario A1, particularly in solar and hydroelectric integration.

GHG Emissions (Figures 26, Figure 27 and Figure 28):

- A1 achieves approximately 40% reduction in emissions by 2050.
  Emission declines in transport and residential sectors are most notable.

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- B1 shows less impact, indicating that slower economic growth does not necessarily guarantee emission reductions without targeted low-carbon policies.
- Scenario B1 shows partial improvements, but fails to reach the 40% GHG reduction target due to lower renewable adoption and sustained biomass reliance.

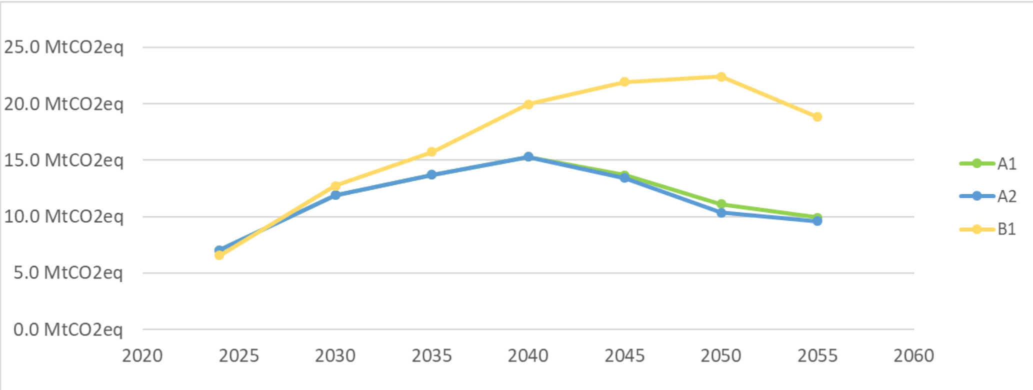

Figure 26 : Total GHG emissions for the three scenarios

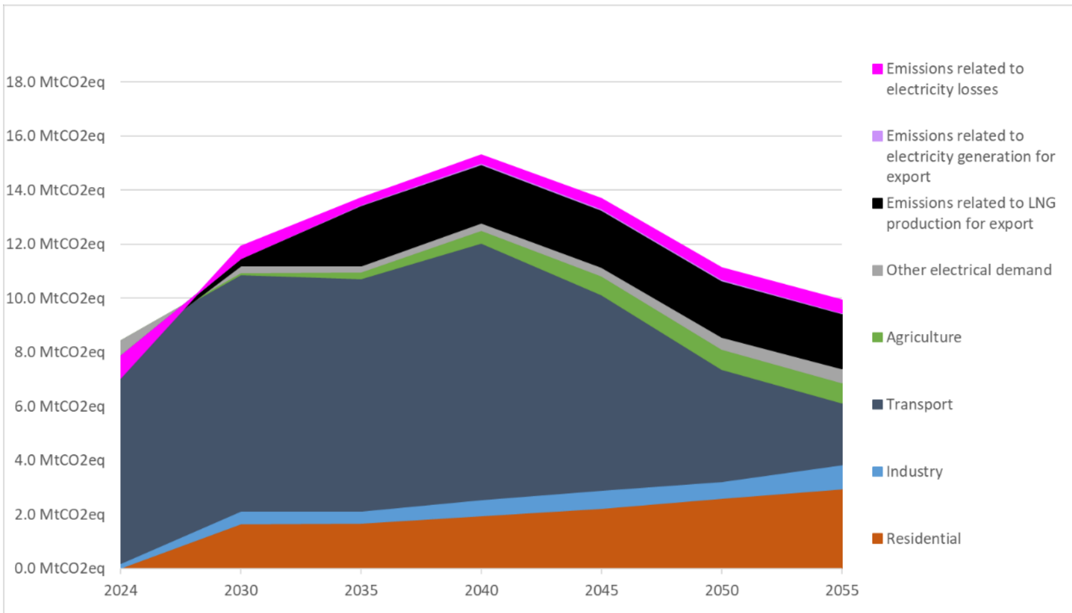

Figure 27 : Total GHG emissions per sector for scenario

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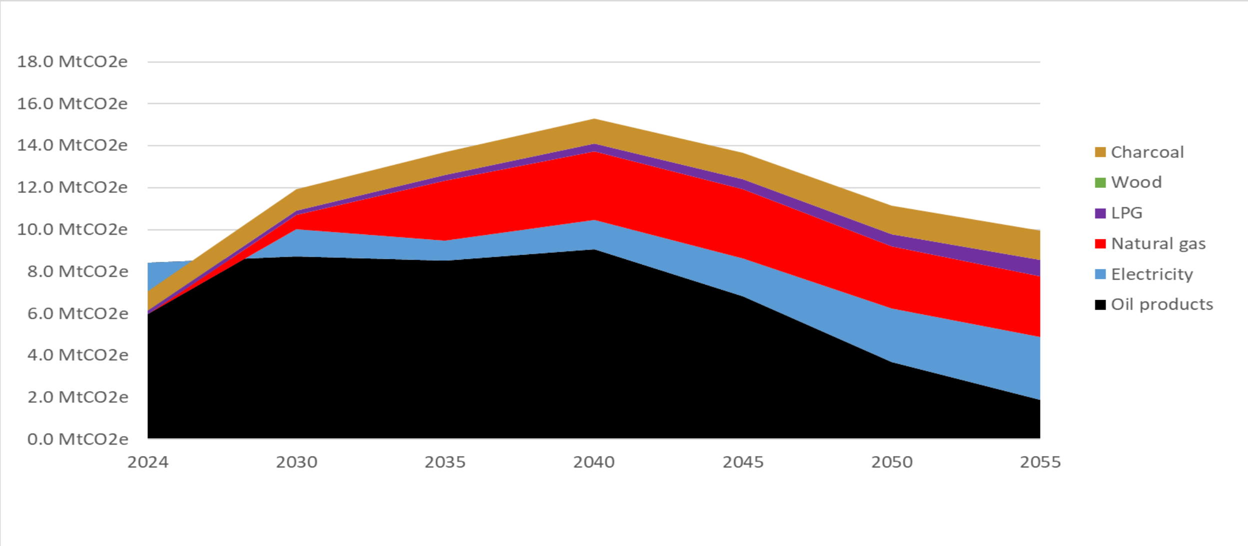

Figure 28 :Total GHG emissions per final energy consumption for scenario A1.

4. Development of strategic recommendations based on the proposed measures

The strategic recommendations presented in this deliverable were developed based on the results of study T1.3, supplemented by analyses conducted within task T4.2, legal assessments, and a comparative analysis of the EMERGE pilot projects and WP5 activities. Grounded in a thorough evaluation of the proposed measures and their potential impacts, these recommendations aim to support the development of policies and strategies that promote a sustainable energy transition. For each pilot site, they are presented in summary tables to facilitate comparison, adaptation to the local context, and implementation.

4.1 Developing strategic recommendations: The case of Morocco

Reference (2022)	Goals for 2055	Recommendations	Instruments
		Increase renewable electricity production	
• Share of renewable energy in the grid: 38% • Installed renewable capacity: wind 1.2 GW, solar 0.7 GW, hydroelectric 1.3 GW	The objectives of the baseline scenario for 2055 are made more ambitious in scenarios 2 and 3: • Increase the electrification rate from 89% to 95% by 2055 • Increase the share of renewable energy in the electricity mix by 86% (baseline	1 Accelerate the implementation of Noor Midelt II and other hybrid (solar + storage) projects 2 Developing wind farms in the southern and northern provinces while strengthening the electricity grid 3 Implement a dedicated storage deployment strategy (batteries and pumped-storage hydroelectric power plants).	• Competitive auction systems for solar thermal and photovoltaic power plants with battery storage (as in Spain and the United Arab Emirates) • Network development plan (e.g., the roadmap of the Moroccan ONEE) • Feed-in tariffs for hybrid renewable energy and storage systems

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	scenario), 89% (scenario 2) and 96% (scenario 3) by 2055 • Add 5 GW of new capacity (wind + solar) by 2030		• National energy storage strategy (inspired by the European Battery Alliance)

Transition to low-carbon transport			
• Predominant modal share: motorcycles 30%, cars 20%, buses 20%, walking/cycling 10% • The infrastructure for electric vehicles remains minimal	By 2055, the objectives of scenarios A2 and B1 in the transport sector are much more ambitious than those of the reference scenario: • Convert 15% of new vehicle sales to electric vehicles by 2030 • Electrify **25% of the public transport fleet** by 2030 • Increase the use of shared taxis from 18% to 52% • Increase the modal share of buses from 20% to 30 %, • Promote the use of electric vehicles by 2055 (buses from 50% for scenario A1 to 90% for scenario A2); • Promote the use of hydrogen in the transport sector by	4. Create low-emission zones and corridors reserved for electric vehicles in major cities such as Rabat, Casablanca, Marrakech and Agadir. 5. Offer incentives for the purchase of electric vehicles, including electric taxis and two-wheelers. 6. Investing in fast charging corridors 7. Launch of pilot projects for bus electrification 8. Using surplus renewable energy to produce green hydrogen (pilot projects in Ouarzazate and Ben Guerir).	• National incentive law for electric vehicles (e.g., Norwegian-style VAT exemption) • Public Transport Electrification Fund • Law on infrastructure deployment. • Green public procurement law mandating electric buses

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	2055 (45% buses for scenario B1);		

Improving the energy efficiency of homes and access to clean cooking methods			
• Electrification: 99.86% • Energy use: 61% electricity, 30% LPG, 5% charcoal, 2% wood	• Reduce LPG consumption by 23% by 2055 for scenario A1, by 84% for scenario A2 and by 88% for scenario B1; • Achieve **a 30% adoption rate for efficient stoves or electric cooking** in rural areas • Improve the energy efficiency of 50% of residential buildings by 2035	9. Expand **subsidized induction cooktop programs** targeting rural provinces 10. Launch a **national thermal renovation program** for urban housing built before 2000 11. Distributing **home solar systems** to scattered rural communities without a stable electricity grid. 12. Develop mini biogas networks using agricultural/animal waste for rural households.	• Reform of subsidies for cooking energy. • Renovation subsidy scheme. • Rural electrification via off-grid solar kits. • Building code relating to energy efficiency (update and application)

Decarbonizing key industrial sectors			
• Share of energy consumption by industrial sector: Food processing 23.1%, Chemicals 23%, Automotive 17.8%, Metals 9.1%	• 20% reduction in energy intensity across the 3 main sectors by 2030 • Transition from 15% of fossil fuels to renewable energies or clean fuels (hydrogen, biomass)	13 Offer **tax credits for upgrades to clean technologies** 14 Using **public procurement** to promote environmental standards in the supply chain	• Subsidies/loans for industrial decarbonization. • Tax credits for energy-efficient machinery • Roadmap for hydrogen with industrial zones. • Directive on green public procurement requiring the use of low-carbon suppliers in tenders.

4.2 Developing strategic recommendations: The case of Mali

To sustain the momentum, it is necessary to:

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- Expand Renewable Infrastructure: Accelerate investments in solar, wind, and hydroelectric power to meet rising electricity demands sustainably.
- Promote Electric Mobility: Introduce incentives for electric vehicles and expand charging infrastructure to further reduce transport emissions.
- Enhance Energy Efficiency in Residential Sector: Implement building codes, energy-efficient appliances, and community awareness programs.
- Strengthen Policy Frameworks: Foster public-private partnerships and streamline regulations to support innovation and adoption of clean technologies.
- Strengthen, capacity building for policy makers, the academics, civil society, and investment to promote sustainable energy
- Build a bottom-up roadmap that reflects local realities while contributing to regional and continental strategies

4.3 Developing strategic recommendations: The case of Mozambique

The table below presents a comprehensive set of recommendations designed to guide Mozambique's energy transition. Each recommendation is paired with its corresponding strategic impact, highlighting how targeted actions can expand electrification, diversify the energy mix, strengthen resilience, and foster inclusive development.

Recommendations	Strategic Impact
1. Prioritize Solar-Driven Electrification Expansion • Scale up utility-scale and decentralized solar PV systems; • Promote solar mini-grids and solar home systems in rural areas; • Integrate solar with storage systems to improve reliability.	• Accelerates electrification beyond current ~54%; • Reduces reliance on hydropower and climate vulnerability.
2. Diversify the Energy Mix to Reduce Hydropower Dependence • Promote solar and wind hybrid systems; • Continue gradually integrate natural gas as a transition fuel; • Encourage distributed generation systems.	• Enhances energy security; • Improves system resilience.
3. Accelerate Grid Expansion and Modernization • Invest in transmission and distribution infrastructure; • Deploy smart grid technologies; • Strengthen interconnections within the Southern African region.	• Enables large-scale renewable integration; • Reduces technical losses and inefficiencies.
4. Promote Clean Cooking Transition • Expand access to LPG and electric cooking solutions; • Introduce subsidies and financing schemes; • Implement awareness and behavioral change programs.	• Reduces deforestation and indoor pollution; • Improves health and living standards.

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Recommendations	Strategic Impact
5. Transform the Transport Sector • Electrification of public transport systems (buses); • Promotion of gas and hydrogen-powered fleets; • Development of charging and refueling infrastructure.	• Reduces fossil fuel dependence; • Cuts urban emissions significantly.
6. Develop Green Hydrogen as a Long-Term Opportunity • Support pilot projects starting around 2035; • Leverage renewable energy for hydrogen export markets; • Build regulatory and technical frameworks.	• Positions Mozambique as a regional energy exporter; • Supports deep decarbonization of industry.
7. Strengthen Policy and Regulatory Frameworks • Establish clear renewable energy targets and roadmaps; • Simplify licensing for Independent Power Producers (IPPs) and mini-grid developers; • Introduce incentives (feed-in tariffs, tax exemptions); • Improve institutional coordination.	• Attracts private investment; • Reduces project delays.
8. Mobilize Climate Finance and Private Investment • Access international climate funds (e.g., Green Climate Fund); • Promote public-private partnerships (PPPs); • De-risk investments through guarantees and policy stability.	• Accelerates large-scale deployment; • Reduces burden on public finances.
9. Invest in Human Capacity and Technical Skills • Develop training programs in renewable energy and system modelling; • Strengthen universities and technical institutions; • Promote digital tools such as energy system modelling platforms.	• Ensures long-term sustainability; • Reduces dependence on foreign expertise.
10. Integrate Climate Resilience into Energy Planning • Design infrastructure resilient to floods, cyclones, and droughts; • Diversify geographically distributed generation systems; • Incorporate climate risk assessments into planning.	• Protects energy infrastructure; • Ensures long-term system stability.

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5. Recommendations for New Policies to Accelerate the Green Transition

The results of the EMERGE Tools simulation highlight that strengthening the regulatory framework is an essential lever for accelerating the energy transition and improving the integration of renewable energies into the national electricity system:

5.1 Policy recommendations for Morocco

a. Regulation and governance

The simulation results highlight that strengthening the regulatory framework is a key lever for accelerating the energy transition and improving the integration of renewable energies into the national electricity system.

Firstly, it is recommended to **strengthen the regulatory framework** to facilitate the deployment of renewable energy installations and energy storage systems. This regulatory development should promote the integration of new technologies while ensuring the stability and security of the electricity grid.

The simulation also highlights the need to **simplify and expedite administrative procedures** related to energy project authorization. Reducing processing times, harmonizing procedures, and digitizing administrative processes would lower project development costs and increase their attractiveness to investors.

The results also highlight the importance of establishing **mechanisms for monitoring, evaluating, and controlling** energy policies. These mechanisms should be based on clearly defined performance indicators to regularly assess progress and adjust public policies according to observed results.

Furthermore, **better institutional coordination** between the relevant ministries, regulatory authorities, electricity network managers and local authorities appears essential to ensure coherent governance of the energy transition.

The simulation also recommends the development of **national technical standards** for smart grids, electric vehicle charging infrastructure, and various energy storage technologies. These standards will promote equipment interoperability and ensure compatibility with international standards.

Finally, it is recommended to enhance **the transparency of energy data** by facilitating access to information relating to production, consumption, grid capacity, and renewable resources. Improved data availability will enhance the quality of investment decisions and foster the development of new energy services.

b. Investment and market incentives

Simulations show that accelerating the energy transition depends heavily on the ability to mobilize public and private investment.

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To this end, it is recommended to develop **innovative financing mechanisms,** including green bonds, climate funds, public-private partnerships, and concessional financing mechanisms. These instruments will reduce the cost of capital and facilitate the implementation of energy projects.

The results also highlight the value of introducing **tax incentives** such as tax exemptions, tax credits or accelerated depreciation for investments in renewable energy, energy storage and energy efficiency technologies.

The simulation also highlights the need to implement **mechanisms for rewarding the flexibility** of the electricity system. These mechanisms should value the services provided by batteries, storage systems, active demand management, and distributed energy resources.

Furthermore, the results recommend a **gradual reduction of subsidies granted to fossil fuels** , while implementing compensation mechanisms designed to protect the most vulnerable households against the effects of this reform.

The development of **carbon markets** and green electricity certification mechanisms also constitutes an important lever for directing investments towards low-carbon solutions and strengthening the competitiveness of renewable energy sectors.

Finally, the simulation recommends increased support **for research, innovation, and entrepreneurship** in the areas of renewable energy, smart grids, energy storage, and artificial intelligence. Greater support for startups, research laboratories, and innovation centers will contribute to the development of a high-performing national ecosystem.

c. Access to energy and inclusion

The simulation results show that the energy transition must be accompanied by measures guaranteeing social equity and universal access to energy.

It is recommended to implement **social pricing programs** that allow low-income households to access reliable and affordable energy without compromising their standard of living.

The simulation also highlights the potential of **mini-grids powered by renewable energy sources** to improve electrification in remote areas where connection to the national grid remains difficult or expensive.

In the most isolated areas, the development of **off-grid solutions based on** autonomous or hybrid photovoltaic systems appears to be a particularly effective solution for ensuring sustainable access to electricity.

The results also highlight the importance of promoting **productive energy uses** in the agriculture, crafts, and small and medium-sized enterprise sectors. Access to modern energy fosters job creation, improved productivity, and local economic development.

The simulations also confirm the need to continue efforts to ensure **universal access to reliable, sustainable and affordable energy** , in line with the Sustainable Development Goals.

Finally, skills development is a key factor in the success of the energy transition. It is therefore recommended to strengthen **vocational, university, and technical training programs** to prepare human resources for new jobs related to renewable energy, smart grids, and digital technologies.

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d. Grid integration and decentralized energy

Simulations show that increasing the share of renewable energy requires a profound modernization of electrical infrastructure.

The first recommendation is to **modernize electricity networks** through the progressive deployment of smart grid technologies. These technologies will improve real-time network monitoring, optimize energy flows, and enhance service quality.

The simulation also confirms the strategic importance of developing **energy storage capacity,** particularly through stationary batteries, pumped hydro storage (PHS), and green hydrogen. These solutions help compensate for the intermittency of renewable energies and improve the flexibility of the electricity system.

The results also highlight the need to **generalize smart meters** and active demand management systems to promote more flexible consumption and better integration of decentralized production.

The use of **artificial intelligence** appears to be a major lever for improving the forecasting of renewable production, anticipating network congestion, optimizing storage strategies and assisting managers in real-time decision-making.

The simulations also recommend developing **microgrids and minigrids** to improve the energy resilience of rural areas, industrial sites and isolated communities.

In parallel, it is essential to **strengthen transport and distribution infrastructure** in order to accommodate increasing volumes of renewable electricity while maintaining the stability of the national grid.

Finally, the simulation highlights the importance of encouraging **individual and collective self-consumption**, as well as the development of local energy communities, which promote active citizen participation, improve energy efficiency and reduce losses on the grid.

5.2 Policy Recommendations for Mali

- Institutional policy diversification in the responsibilities of the energy sector to clarify who is to monitor and evaluate implementation results. An adequate coordination policy and information sharing between government agencies, the private sector and civil society
- Capacity Building and Local Content Development policies: There is a need for skilled labour and expertise in the energy sector, particularly in emerging technologies
- Legal and regulatory framework policies: The existence of a clear legal and regulatory framework for the energy sector plays a fundamental role in strengthening investor confidence to attract private sector operators. Strengthening the legal and regulatory framework to align it with the National Energy Policy involves revising the legislation in force (Order No. 00-019/P-RM of March 15, 2000, and Order No. 00-021/ P-RM of March 15, 2000) and the establishment of new regulations, technical directives and standards.
- Gender must be integrated into energy planning processes as women play a vital aspect in the energy supply and consumption, more specifically in the residential sector
- Co-develop policy and market recommendations with stakeholders.
- Identify and validate enabling frameworks for energy transition.
- competitiveness, where the aim is to make the price of energy accessible to the greatest number of consumers, while preserving a reasonable profitability threshold for energy service providers, and;

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- decentralization, through the Government's desire to make Territorial Communities responsible for managing the socio-economic development of their respective territorial districts, all opportunities must be seized to decentralize energy services, while guaranteeing respect for cultural and territorial diversity, management participatory through the creation and management of preserving national unity and integrity. This involves appropriate transfers of skills and resources.
- transversal coherence, in order to establish harmonious relationships on the one hand, between the energy sector and other sectors of use of energy services in the country and on the other hand, between the different sub-sectors of the 'energy

Specific recommendations are given the table below:

Table 24 Specific recommendations for Mali (2020-2036)

Mali	Key indicators	2020	2025	2030	2036
Acceleration of the pace of electrification	National electricity access rate	55%			90%
	Urban access rate to electricity	96%			100%
	Rate of rural access to electricity (connections to the network or mini-grid)	25%			55%
	Rural access rate to electricity - including stand-alone systems				100%
	Access to electricity in schools, health centers and administrative offices	100%			
	Technical loss rate	10%	10%	10%	10%
	Non-technical loss rate	10%	7%	5%	3%
Strengthening security of hydrocarbon supply	Share of hydrocarbons in the national energy balance (% of final consumption) - (objectives aligned with the objectives of the ECREEE and the trends planned by the IEA)	35 %			38%
	Creation of a larger national security stock of hydrocarbons in order to strengthen security of supply and increase energy security (m^3)	61607			65000
Increase in the share of renewable energy in the energy mix by promoting national energy resources	% (excluding medium and large hydroelectricity)	10%	14%	19%	25%
	% (including medium and large hydropower)	50%	59%	64%	70%
	Increase in the production of electricity from renewable sources (solar, bioenergy, small hydroelectricity) in mini-grids	8%	20%	35%	40%
	Bioethanol share in gasoline consumption	-	2%	5%	10%
	Biodiesel share in diesel consumption	1%			4%

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Reduction of biomass in final consumption	Share of biomass in the country's overall energy balance (% of final consumption)	70%			55%
	% of charcoal production using improved carbonization techniques (yield > 25%)	5%	40%	80%	100%
	Share of households using improved stoves for cooking with traditional fuels (in %)	70%	80%	90%	100%
	Use of modern cooking equipment and fuels (LPG, briquettes,biogaz) (% de la population totale)	34%	44%	62%	82%
Genre	% of women business leaders in the energy field	10%	15%	20%	25%
	% of women in decision-making positions in the energy sector	10%	20%	35%	50%

5.3 Policy Recommendations for Mozambique

To accelerate Mozambique's energy transition and ensure inclusive, sustainable growth, several policy measures should be prioritized:

Introduction of Feed-in Tariffs and Competitive Auctions: Establishing feed-in tariffs and well-structured competitive auctions will create predictable revenue streams for renewable energy developers. These mechanisms lower investment risks, encourage private sector participation, and ensure cost-effective deployment of solar, wind, and other renewable projects.

Clear Regulatory Frameworks for IPPs: Developing transparent and consistent regulations for IPPs is essential to attract private investment. Streamlined licensing procedures, standardized contracts, and clear grid-access rules will reduce delays and foster confidence among investors and developers.

Expansion of Rural Electrification Programs: Rural communities remain underserved, with electrification rates far below urban levels. Expanding mini-grids, standalone solar systems, and decentralized solutions will bridge this gap, improve livelihoods, and reduce reliance on traditional biomass. These programs should be supported by subsidies and community engagement to ensure long-term sustainability.

Creation of Green Financing Mechanisms: Access to affordable financing is a critical barrier. Establishing green financing instruments – such as climate funds, concessional loans, and guarantees – will de-risk investments and mobilize both domestic and international capital. PPPs can further leverage resources and accelerate project implementation.

Implementation of Local Content Policies: To maximize socio-economic benefits, policies should require renewable energy projects to incorporate local labor, skills, and materials wherever possible. This will promote job creation, foster technology transfer, and strengthen Mozambique's technical capacity to manage and expand its energy systems.

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6. Regulations aimed at accelerating the energy transition

This section summarizes the main findings of the analysis and translates them into recommendations aimed at strengthening and improving the legislative framework for the energy sector. The presentation is structured by country and organized around the themes examined in the preceding chapters. This section aims to capitalize on the main results of the analysis in order to formulate strategic and regulatory recommendations designed to strengthen and develop the legislative framework for the energy sector. It focuses on developing regulatory proposals tailored to the pilot site countries, based on an in-depth analysis of national legal frameworks for the energy sector and their alignment with European policies, standards, and guidelines, while taking into account national priorities in terms of energy transition, security of supply, and sustainable development**. [14][15]**

6.1 Regulations currently in force at pilot sites

6.1.1 Regulations currently in force in Morocco

In 2009, Morocco adopted an energy strategy focused primarily on renewable energy and the development of energy efficiency. This strategy, implemented through programs with specific objectives and accompanied by targeted legislative and institutional reforms, has proven its effectiveness and relevance, enabling Morocco to become an energy-producing country **[16] ,**

- **Law No. 13-09 relating to renewable energies**

In order to support the development of the renewable energy sector, Law No. 13-09 relating to renewable energies was promulgated by Dahir No. 1-10-16 of 26 Safar 1431 (February 11, 2010). **[17]**

Law No. 13-09 aims to **[18]**:

Promote the production of energy from renewable sources, its marketing and its export.

Strengthening the competitiveness of the national economy by promoting the decarbonization of industrial sectors, particularly those intended for international markets.

The development of a clean national sector, capable of seizing the opportunities offered by the energy transition at the national and international levels. Among the implementation measures of this law, the following should be mentioned:

- The subjection of energy production facilities from renewable sources to an authorization or declaration regime.

- The right for an operator to produce electricity from renewable energy sources on behalf of a consumer or group of consumers connected to the national medium voltage (MV), high voltage (HV) and very high voltage (VHV) electricity network, within the framework of agreements concluded between the network manager concerned and the operator.

- **Law No. 58-15 amending and supplementing Law No. 13-09 relating to renewable energies (February 11, 2010) [18]**:

Law No. 58-15 amends and supplements Law No. 13-09 (February 11, 2010) and its main principles are as follows:

• Increase in the installed capacity threshold for hydroelectric power plant projects, from 12 to 30 MW: Law No. 13-09 excluded projects with a capacity exceeding 12 MW from its scope, which hindered the exploitation of the maximum potential offered by the

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morphological and hydrological characteristics of the production sites. This threshold has now been raised to 30 MW, hence the amendment to Article 1 of Law No. 13-09.

• Possibility of selling surplus renewable energy produced: It is now possible to sell surplus electricity production from renewable sources, within the framework of installations connected to the national high-voltage (HV) and very high-voltage (VHV) networks, as well as to the medium and low-voltage networks, to ONEE (National Office of Electricity and Drinking Water) and distribution network operators. The operator may not sell more than 20% of annual production. The terms and conditions for purchasing the surplus are set by regulation.

• Opening of the low-voltage (LV) renewable electricity market: Access to the LV distribution network will be incorporated into Law 13-09 (Article 5), which until now has been limited to HV, EHV, and MV networks. This measure will allow for the development of the small and medium-sized industrial sector, particularly photovoltaic installations, and the creation of jobs in the renewable energy sector. Access to the LV electricity network will be subject to conditions set by regulation.

• Consideration of the opinion of the Basin Agency in the authorization procedures: For any project to install electricity production from a source of hydraulic energy, the granting of the authorization, which was not subject, under Law 13-09, to the sole technical expertise of the manager of the national transport network, will now also be subject to the opinion of the hydraulic basin concerned.

- **Decree No. 2-10-578 of 7 Jumada I 1432 (April 11, 2011) issued for the application of Law No. 13-09 relating to renewable energies**

• In order to establish and finalize the procedures relating to the preparation and submission of the application file for authorization, and pursuant to Articles 5, 8, 17, 18, 28, and 29 of Law No. 13.09 concerning renewable energy, Decree No. 2-10-578, issued for its implementation, was promulgated on 7 Jumada I (April 11, 2011). This decree defines and establishes exhaustively the rules and procedures governing: **[19]**

• The preparation and filing of the application files for authorization provided for in Chapter III of the aforementioned Law No. 13.09;

• The form and content of the authorizations provided for in Chapter III of the aforementioned Law No. 13.09;

• The terms and conditions for extending the validity period of the final authorization;

• The conditions and procedures for accessing and connecting to the grid an installation producing electricity from renewable energy sources. • The technical and financial procedures for connecting to the grid;

• The modalities of application of article 26 of the aforementioned law no. 13-09, relating to the contract setting the commercial conditions for the supply of electrical energy;

• The procedures for setting and revising the annual operating fee for a renewable energy electricity production facility, referred to in Article 29 of the aforementioned Law No. 13-09;

• The scales, tariffs and methods for setting and revising the annual operating fee for a renewable energy electricity production facility, referred to in Article 29 of the aforementioned Law No. 13-09.

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- **Decree No. 1-11-161 relating to Law No. 47-09 concerning energy efficiency, dated September 29, 2011 [19]**

  This decree:

  • Sets out the general obligations to which mandatory energy audit bodies and the entities subject to them are subject;

  • Sets the energy consumption thresholds that trigger mandatory energy audits: 1,500 tonnes of oil equivalent (toe) per year for companies and establishments in the industrial sector and 500 toe per year for the services sector, companies and establishments in the transport and distribution of energy, as well as for individuals;

  • Specifies the content of the mandatory energy audit by sector, as well as the procedures for its implementation and the presentation of its results;

  • Sets the frequency of mandatory energy audits at 5 years;

  • Defines the conditions and main procedures for issuing, renewing, and suspending the accreditation of auditing bodies and sets the validity period of this accreditation at 7 years; and

  • Specifies the control procedures for audit bodies.

- **Law No. 47-09 relating to energy efficiency; September 29, 2011**

  Law No. 47-09, or the "Energy Efficiency Law," aims to increase energy efficiency in the use of energy sources, prevent waste, reduce energy costs for the national economy, and promote sustainable development. It includes various measures, such as mandatory energy audits, minimum energy performance standards for appliances, and preferential tariffs (known as "super-peak" tariffs) for industries that voluntarily shift their energy consumption outside of peak hours. **[19]**

  This law establishes minimum energy performance criteria for electrical appliances and equipment powered by natural gas, liquid or gaseous petroleum products, coal, and renewable energy sources. It mandates energy audits for companies and institutions involved in energy production, transmission, and distribution, as well as energy impact assessments for new buildings and urban development projects. It also defines the role of energy services and facilities and establishes a technical control system. Decree No. 2-13-874 (October 15, 2015)

  Approving the general building regulations setting out the rules for energy performance of buildings and establishing the National Committee for Energy Efficiency of Buildings.

- **Law No. 48-15 relating to the regulation of the electricity sector and the creation of ANRE (May 24, 2016) [20][21]**

  Law No. 48-15 concerning the regulation of the electricity sector and the creation of the ANRE (National Agency for Energy Regulation) was drafted to clarify the missions and obligations of the transmission system operator and the distribution system operators, to create the ANRE, and to grant it the powers and procedures for carrying out its regulatory

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missions for the national electricity sector. Decree No. 2-17-746 concerning mandatory energy audits and energy audit bodies (April 10, 2019)

Energy-intensive establishments and businesses, whose consumption exceeds the threshold of 1,500 toe (tonnes of oil equivalent) for the industrial sector (including energy production companies) or the threshold of 500 toe for the tertiary sector, energy transport and distribution companies and individuals, are required to carry out a mandatory energy audit every 5 years.

- **Order No. 927-20 (April 2, 2020)**

  Making the application of Moroccan standards relating to photovoltaic products and solar thermal installations mandatory, March 11, 2020**. [22]**

- **Law No. 82-21 relating to the self-production of electrical energy: December 20, 2022 [23]**

  The main provisions introduced by this law are as follows:

  • Definition of self-producer: any natural or legal person under private or public law producing electrical energy exclusively for their own consumption. The self-producer is not required to produce the electricity by their own means nor to own it; they may also entrust the construction or operation of the self-production installation to a third party.

  • The right of self-producers to access the grid within the limits of their receiving capacity and the right to be supplied by the grid if necessary. Self-producers connected to the electricity grid are required to pay, in addition to the national grid usage fee, the tariff related to system and distribution services.

  • The option to sell surplus production, representing a maximum of 20% of the installation's annual production, to the national grid operator. The buyback rate for this surplus is set by ANRE. This limit can be revised at the request of the self-producer, according to the procedures stipulated by the regulations.

  • The possibility for the self-producer to store electrical energy from renewable sources and to access storage services.

  • The issuance of a certificate of origin attesting that the energy produced comes from renewable sources. These changes are fully in line with the missions of ANRE, which we will describe in the section dedicated to its missions.

- **Decree No. 3851-21 published in January 2022 [23]**

  Defining the ten-year trajectory (2022-2031), consisting of measures relating to the injection of electrical energy produced from renewable sources into the medium voltage electrical network.

- **Decree No. 2138-22 published in September 2022**
  Defining the areas in which private developers can carry out solar projects for individuals, in accordance with Law No. 13-09. It is important to emphasize the significance of these texts in the energy transition: they will contribute to guaranteeing the Kingdom's energy supply and its energy sovereignty, facilitate the management of the balance between supply and demand, and strengthen the attractiveness of the renewable energy sector for investment as well as the

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country's entrepreneurial fabric. Law No. 40-19 amending and supplementing Law No. 13-09 relating to renewable energies and Law No. 48-15 relating to the regulation of the electricity sector and the creation of the National Electricity Regulatory Authority (February 10, 2023) **[23]**

• It aims to diversify energy supply sources by increasing the share of renewable energy in the electricity mix, to improve the business climate, to strengthen transparency and to make the renewable energy sector more attractive for national and international private investment.

• The main changes brought about by this law essentially concern:

• The possibility of producing electricity from renewable sources is reserved for private legal entities.

• The procedures for processing authorization requests and the reduction of issuance times by the administration.

• The capacity of the national electricity grid, the methods used by the TSO (Transmission System Operator) to calculate this capacity, and its approval and publication by the ANRE (National Agency for Energy Regulatory Affairs). The connection of generation facilities will be limited to this capacity. • Definition of the concept of system services related to renewable energies, the costs of which will be integrated into the tariff for the use of the electricity transmission network and regulated in accordance with the provisions of Law No. 48-15. These services enable the national electricity transmission network operator (TSO) to maintain frequency, voltage, and cross-border exchanges with neighboring countries, using the resources available to the electricity system, and to manage the intermittency of renewable energies.

• Definition and modalities of capping energy production from renewable sources, allowing the TSO to impose on producers a reduction in their production of electricity from renewable sources, within a clearly defined limit, in order to preserve the security and integrity of the electricity network and to ensure the balance between the supply and demand of electricity.

• Commercial conditions for the sale of surplus energy produced from renewable sources by producers to ONEE and distributors.

• Conditions for exporting energy produced from renewable sources. - Possibility of storing energy produced from renewable sources.

• Certificate of origin attesting that the electrical energy used comes from renewable sources.

• The possibility for electricity distributors to acquire the electricity produced within specified limits.

The Government Council approved three draft decrees in Rabat on September 12, 2024, to accelerate the energy transition:

- **The first draft decree no. 804.24.2 relating to smart meters. [24]**

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These bidirectional smart meters will be a cornerstone for accelerating the implementation of smart grids in Morocco. Indeed, these grids will enable the integration of renewable energies and strengthen energy security by providing better control over the variable nature of these energies and optimizing their transmission from production sites to consumption sites, under the best conditions of safety and efficiency.

➢ **The second draft decree no. 761.24.2 [24]**

This decree establishes the conditions for granting a "certificate of origin" for electricity generated from renewable sources and designates the competent authority for issuing it. The decree aims to define the procedures for issuing certificates of origin proving that self-generated electricity comes from renewable energy sources and specifies the competent authority for issuing these certificates of origin, namely the Ministry of Energy Transition and Sustainable Development. This decree also incorporates internationally applied principles and standards to guarantee the validity of certificates of origin issued in Morocco.

➢ **Third draft decree, no. 153-24.2. [24]**

This decree implements Article 6 of Law No. 47.09 on energy efficiency, which defines the specifications for energy service companies. This decree, along with its implementing order, aims to encourage and activate mechanisms that incentivize energy savings, particularly by allowing energy service companies to conduct studies aimed at reducing energy consumption and improving the energy performance of equipment, based on the results of these studies.

6.1.2 Regulations currently in force in Mali

Thus, the National Energy Policy (NEP) is essentially focused on:

- **liberalization, disengagement** of the State from operational activities.
- The NEP calls for **an unprecedented level of investment** in future energy systems from the private sector. This requires new strategies to facilitate private sector engagement and participation. A political and regulatory framework as well as transparent and stable administrative procedures are essential to guarantee the involvement of international private individuals and local companies; table below gives specific existing regulation and policies.

CONTEXT

- National Sustainable Development Strategy, Ministry of the Environment, Sanitation and Sustainable Development (2017);

- Decree No. 2016-0056/P-RM of February 15, 2016, establishing the procedures for the development, approval, and implementation of national policy documents;

- Strategic Environmental Assessment (SEA) of the energy sector (August 2015);

- ECOWAS Renewable Energy Policy, ECREEE (2015);

- National Action Programme for Sustainable Energy for All, SE4ALL, ECOWAS (2015);

- National Report on the State of the Environment, Agency for the Environment and Sustainable Development (2014);

- Report on Mali's Overall Energy Balance in 2014, ESE-KT SARL (2014);

- National Sustainable Development Report for Mali (2012);

- National Strategy for Combating Climate Change (July 2011);

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- National Climate Change Policy, AEDD, 2011;

- Mali Energy Information System, MEE (2009);

- Energy Sector Policy Letter (LPSE), 2009-2012;

- National Adaptation Action Programme (NAPA), 2007;

- National Energy Policy (2006);

- National Environmental Protection Policy (1998).

PUBLIC PROCUREMENT / PPP / INSTITUTIONAL STRUCTURE

- Partnership agreement between AMADER/ANADEB/ECOPOWER SAHEL concerning the promotion of bioethanol stoves;

- Law No. 2017-028 of July 14, 2017, authorizing the Government to take certain measures by decree;

- Decree No. 2017-0427/PM-RM of May 18, 2017, concerning the allocation of public services between the Prime Minister's Office and ministerial departments;

- Decree No. 2017-0358/P-RM of April 26, 2017, establishing the specific responsibilities of members of the Government;

- Decree No. 2017-0057/P-RM of February 9, 2017, determining the implementing procedures for the law relating to public-private partnerships in Mali;

- Decree No. 2017-0050/PM-RM of February 9, 2017, establishing the Public-Private Partnership Unit;

- Law No. 2016-061 of December 30, 2016, concerning public-private partnerships in Mali;

- Collaboration Protocol between ANADEB and Malian Renewable Energy Agency (AER-Mali) (August 2016);

- Order No. 2015-3721/MEF-SG of October 22, 2015, setting forth the implementing procedures for Decree No. 2015-0604/P-RM of September 25, 2015, establishing the Public Procurement and Public Service Delegation Code;

- Decree No. 2015-0604/P-RM of September 25, 2015, establishing the Public Procurement and Public Service Delegation Code;

- Ministerial Order No. 2015-0279/MEF-SG of March 9, 2015, establishing the tax and customs regime applicable to contracts and agreements related to the Project to Support the Promotion of Renewable Energy in Mali (PAPERM);

- Decree No. 2014-0816/P-RM of October 27, 2014, suspending the collection of value-added tax, duties, and taxes on imported renewable energy equipment;

- Decree No. 2014-0406/P-RM of June 6, 2014, establishing the organization and operating procedures of the National Energy Directorate;

- De-risking Renewable Energy Investment, UNDP (2013);

- Investment Code contained in Law No. 2012-016 of February 27, 2012, and its implementing decrees;

- Agreement No. 01/2011/AMADER-ANADEB of June 24, 2011;

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- Decree 00-185, establishing and organizing the Electricity and Water Regulatory Commission, dated March 15, 2000.

- Ordinance No. 99-013/P-RM of April 1, 1999, establishing the National Energy Directorate, ratified by Law No. 99-022 of June 11, 1999

- Law No. 96-050 of October 16, 1996, establishing the principles for the constitution and management of the property of local authorities

- Law No. 90-110/AN-RM of October 18, 1990, establishing the fundamental principles for the creation, organization, and operation of public administrative establishments

- Ordinance No. 00-27/P-RM establishing the Land and Property Code / amending texts published in 2002, 2012, and 2016

6.1.3 Regulations currently in force in Mozambique

➢ **Renewable Energy Code (Ministerial Order No. 119/2023) [28].**

The Renewable Energy Code, approved in 2023 by Mozambique's Ministry of Mineral Resources and Energy (MIREME), represents a landmark step in the country's energy transition. This legal framework establishes comprehensive rules and procedures for the integration of renewable energy generation into the national grid, ensuring that new projects meet technical, safety, and operational standards. By doing so, it provides greater clarity and predictability for investors, developers, and regulators.

The Code is closely aligned with the New and Renewable Energy Development Strategy (EDENR 2011–2025), reinforcing national targets for expanding renewable energy capacity and diversifying the energy mix. It introduces mechanisms to encourage private sector participation, including streamlined licensing processes, incentives such as tax exemptions and feed-in tariffs, and clearer guidelines for IPPs.

Importantly, the Code also strengthens Mozambique's position within the Southern African Power Pool (SAPP) by facilitating cross-border electricity trade and regional cooperation. This enhances energy security, supports economic integration, and allows Mozambique to leverage its abundant renewable resources for both domestic consumption and export.

By combining regulatory clarity with investment incentives, the Renewable Energy Code is expected to accelerate the deployment of solar, wind, and other renewable technologies, reduce reliance on hydropower (which is vulnerable to climate variability), and contribute to a more resilient and sustainable energy system.

➢ **Resolution No. 62/2009 (Energy Sector Reform) [29].**

Resolution No. 62/2009 marked an important milestone in Mozambique's energy policy landscape, serving as one of the earliest frameworks to lay the foundation for renewable energy promotion and sector diversification. Adopted by the government in 2009, the resolution sought to modernize the energy sector by introducing reforms that would encourage private sector participation, improve regulatory clarity, and expand access to electricity across the country.

A central focus of the resolution was the diversification of energy sources, moving beyond the country's heavy reliance on hydropower. By promoting renewable alternatives such as solar, wind, and

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biomass, the framework aimed to reduce vulnerability to climate-related risks, particularly droughts that threaten hydropower generation.

The resolution was closely linked to the New and Renewable Energy Development Strategy (EDENR 2011–2025), which provided a long-term roadmap for renewable energy expansion. Together, these instruments emphasized the importance of rural electrification, recognizing that rural communities remained underserved and dependent on traditional biomass. The resolution encouraged the development of decentralized solutions such as mini-grids and standalone systems, paving the way for more inclusive energy access.

Beyond technical measures, Resolution No. 62/2009 also highlighted the need for institutional strengthening and policy coherence. It underscored the role of clear regulations, streamlined licensing procedures, and incentives to attract IPPs and other private actors into Mozambique's energy market.

➢ **Electricity Law No. 12/2022 [30].**

Adopted in July 2022, the Electricity Law No. 12/2022 is Mozambique's most comprehensive reform of the electricity sector to date. It replaces the outdated Electricity Law of 1997 and introduces a modern framework that reflects the country's energy transition priorities, the need for universal access, and the integration of renewable energy sources.

The Electricity Law No. 12/2022 modernizes Mozambique's electricity sector by creating a clear structure, prioritizing renewable energy, simplifying licensing, and promoting private investment. It is a cornerstone of the country's energy transition, ensuring universal access, resilience, and sustainability.

6.2 Proposed regulatory updates to accelerate the energy transition

The countries hosting the EMERGE project pilot sites can draw inspiration from the EU's regulatory harmonization efforts to streamline their own frameworks. Within the EU, reducing regulatory fragmentation between Member States has contributed to the creation of a unified energy market.

6.2.1 Proposed regulatory updates for Morocco

Morocco continues to make progress in strengthening its resilience to climate change within the framework of the Stabilization and Consolidation Mechanism. Measures must be implemented to:

- By improving the regulatory framework of the electricity market, this reform aims to encourage the production of renewable energy by the private sector, while strengthening the resilience of budgetary and financial systems to the risks associated with climate change, with the objective of promoting stronger, more resilient, job-creating and more inclusive growth.
- Introducing a carbon tax gradually will require a more in-depth analysis of its impact and more extensive consultations with public and private stakeholders.
- To establish a centralized digital platform for energy regulation. This would ensure transparency and consistency in regulatory procedures for various renewable energy projects.

6.2.2 Proposed regulatory updates for Mali

Legal and regulatory framework: The existence of a clear legal and regulatory framework for the sector plays a fundamental role in strengthening investor confidence in order to attract private sector operators. Strengthening the legal and regulatory framework to align it with the PEN involves revising the legislation in force (in particular Order No. 00-019/P-RM of March 15, 2000 and Order No. 00-021/

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P-RM of March 15, 2000) and the establishment of new regulations, technical directives and standards. This includes the adoption of new provisions specific to the promotion of renewable energy and energy efficiency.

6.2.3 Proposed regulatory updates for Mozambique

To accelerate the transition, the following regulatory updates are proposed:

- Development of specific regulations for energy storage systems.
- Simplification of licensing procedures for renewable energy projects.
- Introduction of net metering and net billing schemes.
- Strengthening of grid codes to accommodate variable renewable energy.
- Establishment of long-term renewable energy targets with binding commitments.

6.3 Framework for regulated sandboxes for experimenting with innovative solutions

6.3.1 Concept, advantages and legal prerequisites for regulated sandboxes

Within a controlled and temporarily relaxed framework, regulatory sandboxes provide mechanisms for testing innovative solutions that do not yet fully fit within existing regulatory frameworks. They aim to foster innovation while ensuring user protection and risk management. In the context of the EMERGE project, these mechanisms offer a conducive environment for experimenting with emerging technologies in the fields of smart energy systems, decentralized electricity grids, and renewable energy solutions.

The implementation of a regulatory sandbox is based on a progressive approach in three key steps.

1- Defining objectives: Regulators must first clarify their objectives, which are generally related to promoting innovation, reducing regulatory barriers, and understanding market developments. This step is essential as it guides the choice of tools, sets expected results, and takes specific constraints into account.

2. Identifying Barriers to Innovation: The sandbox aims to address several obstacles, including the high cost of compliance, regulatory uncertainty, and legal restrictions. However, not all innovations should be systematically encouraged; the primary objective is to remove barriers to relevant innovations.

3. Evaluating Alternative Solutions: Before resorting to a sandbox, regulators must analyse other options, such as innovation hubs, regulatory revisions, or the granting of exemptions. The sandbox should therefore be chosen as a suitable solution from among several available instruments.

Having presented the objectives and implementation methods of regulated sandboxes, it is now necessary to analyse their design. Indeed, the effectiveness of such a system relies on a clear, coherent architecture adapted to both regulatory and technological challenges. From this perspective, the design of a regulated sandbox revolves around five essential components, which determine its operation, relevance, and performance:

- Eligibility: This determines the actors authorized to participate in the system. Precise, transparent, and non-discriminatory criteria are essential to guarantee equitable access and promote diverse participation from market players.
- Governance: it defines the internal organizational structure of the sandbox, specifies the distribution of roles and responsibilities, and frames the main operational processes necessary for its proper functioning.
- Timetable: it specifies the different deadlines of the scheme, including the duration of the admission phase as well as that of the experimentation period.
- Test restrictions: these govern the scope, scale and methods of conducting experiments within the sandbox, in order to limit risks and prevent any potential negative impact.

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- Exit : elle englobe les résultats individuels des expérimentations (validation du test, interruption anticipée, etc.), ainsi que l'intégration des enseignements tirés et des connaissances acquises dans le cadre réglementaire élargi.

6.3.2 Implementation proposals for the EMERGE pilot regions

Within the framework of the EMERGE project, the establishment of regulatory sandboxes in pilot sites would allow for the testing of innovative solutions adapted to local specificities, particularly regarding energy access, renewable energy integration, and smart grid management.

The main implementation proposals are as follows:

- Selection of pilot regions with strong renewable energy potential and specific needs (rural areas, isolated sites, industrial zones);
- Establishment of a multi-stakeholder institutional framework involving public authorities, energy operators, universities, and start-ups;
- Definition of targeted pilot projects, such as smart microgrids, energy storage systems, or energy management platforms;
- Development of an experimental regulatory framework, including temporary exemptions and evaluation protocols;
- Deployment of monitoring and evaluation mechanisms based on performance indicators (technical, economic, and environmental). • Capitalizing on results to generalize best practices and adapt national regulations.
- Thus, regulatory sandboxes constitute a strategic lever for accelerating the energy transition, fostering innovation, and strengthening the competitiveness of regions within the framework of the EMERGE program.

7. Guidelines for the deployment of renewable technologies and associated business models :

7.1 New business models and market opportunities for Morocco

Morocco has assets that make it a favourable environment for investors. In this subsection, we propose new, high-value-added business models, for example:

a) Long-term private IPP and PPA

- **Investments in solar and wind power with long-term power purchase agreements (PPAs):** Investments in solar and wind power via long-term Power Purchase Agreements (PPAs) are strategic contracts where a producer sells renewable electricity directly to a buyer (company, community) for a fixed period (5-25 years) and price, offering visibility, competitiveness and energy security, while financing new green projects and reducing the carbon footprint, with market prices becoming increasingly competitive.

- **power producers** (IPPs) play a central role in the development of modern electricity systems, particularly in countries committed to the energy transition. An IPP is a private or semi-private entity that designs, finances, builds, operates, and owns electricity generation facilities, while remaining independent of the public grid operator. The electricity produced is typically sold to a single or multiple buyers, such as a utility, government agency, or industrial consumer, through long-term contractual arrangements.

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b) **Industrial and tertiary self-consumption** : Industrial and tertiary self-consumption, via rooftop solar installations, allows companies to produce and consume their own electricity, reducing their bills and energy dependence while complying with environmental regulations such as the Tertiary Decree (French regulation: **No. 2019-771 of July 23, 2019** , taken in application of the **ELAN law** (article 175)); the addition of storage improves the self-consumption rate by storing the surplus for nighttime or off-peak use, thus optimizing savings and competitiveness.

c) Energy communities and solar cooperatives: Energy communities and solar cooperatives embody a model of local energy production and consumption, enabling citizens to invest collectively in photovoltaic projects, share production and profits, offering a viable and attractive solution for rural and peri-urban areas by promoting energy autonomy, the circular economy and citizen engagement, while responding to environmental challenges.

d) Agrivoltaics and agricultural energy: Agrivoltaics is an innovative approach that combines agricultural and solar production on the same plot of land, offering a dual source of income (crops + electricity), thus diversifying farmers' incomes while securing them against climate risks. This combination is particularly beneficial in regions subject to water stress, as the panels create shade, reduce evapotranspiration and the crops' water requirements, while also protecting against extreme heat, thereby improving crop resilience.

e) Green hydrogen and associated value chains: Green hydrogen is a major strategic focus for decarbonization, requiring massive investments in its production (electrolysis), storage, and transport (pipelines, maritime) for export to demanding markets such as Europe. South-North partnerships position countries like Morocco as potential hubs thanks to their renewable resources and infrastructure. The value chain includes production from renewable energy sources, storage (liquid/gas), transport, and end use in heavy transport and industry, creating new energy hubs and geopolitical opportunities.

f) **Strengthening financial support and incentives for renewable energy:**

The EU's use of subsidies, tax incentives, and aid for renewable energy projects could inspire similar support mechanisms in Morocco. The Moroccan government could establish programs offering financing options, low-interest loans, or tax breaks for renewable energy investments. It could also expand existing incentives for solar and wind projects to include large-scale storage solutions, thereby ensuring a reliable energy supply. These measures could significantly boost private sector interest and make high-investment renewable energy projects more viable.

g) Investment in energy storage and network infrastructure:

European legislation often provides significant incentives for energy storage and grid modernization, enabling a more stable integration of renewable energy. Morocco could benefit from similar policies encouraging investment in battery storage and other storage technologies, particularly to address the intermittency of solar and wind power. Policies for modernizing and digitizing grids in urban and rural areas would also improve the reliability of energy access.

h) Improving energy efficiency standards:

EU energy efficiency policies, which set standards for buildings, household appliances, and industrial processes, can serve as a model for Morocco. Introducing mandatory efficiency standards and incentives for energy-efficient appliances would help reduce consumption and costs. For example, Morocco could develop its energy efficiency framework by setting ambitious standards for new

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buildings, requiring energy audits, and supporting renovation projects. Focusing on energy efficiency in public buildings could further reduce overall demand.

i) Environmental guarantees and social programs for local communities:

The EU's commitment to environmental impact assessments and "just transition" policies that support workers and communities affected by the shift to renewable energy offers valuable lessons. Morocco could adopt similar legislation requiring environmental protections and positive community outcomes in energy projects. For example, Morocco could expand existing social benefit programs related to energy projects to include training and job placements for local populations in the renewable energy sector, thereby ensuring residents have access to the new jobs created by these projects.

j) Encourage smart grids and digital energy technologies:

EU policies strongly support the digitalization of energy systems, particularly through smart grids and demand management technologies. Morocco could also invest in cutting-edge technologies to promote digital energy management, enabling more efficient energy distribution and real-time data monitoring.

k) Strengthening regional energy integration:

Like the EU, which has developed interconnections between its member states to optimize resource sharing and energy costs, Morocco could implement policies to support energy exports to the EU, taking advantage of its proximity to Europe.

7.2 New business models and market opportunities for Mali

Opportunities

- National Energy Policy (NEP) and related frameworks present several opportunities for the country's development. These policies bring about the opportunity to enhance energy security and diversification by attracting investments in various energy sectors, ensuring a more stable and reliable energy supply. The focus on sustainable development not only reduces greenhouse gas emissions, it also creates jobs within the green economy and promotes environmental sustainability.
- Encouraging private sector participation within the policy leads to economic growth, driving technological advancements, and fostering innovation within the energy industry. Improved energy access and equity, especially in rural areas, can enhance the quality of life for many Malians and support local businesses and industries.
- The integration of environmental considerations and climate change mitigation into energy planning through the Renewable Energy Master Plan helps reduce the country's vulnerability to climate impacts and supports overall sustainability. Research and development initiatives drive innovation and enhance collaboration between government, industry, and academia.
- By liberalising the electricity market, the Power Sector Reform Act aims to increase competition, improve service delivery, and attract further investments. Promoting energy efficiency and conservation can lead to significant cost savings for consumers and businesses, while encouraging sustainable practices.
- The Power Sector Reform Act aims to increase competition and improve service delivery by allowing more actors to participate in electricity generation, transmission, and distribution. Rural electrification initiatives improve access to electricity in remote areas, supporting economic growth and development in these communities.

7.3 New business models and market opportunities for Mozambique

Mozambique's energy transition opens the door to a wide range of innovative business models that can reshape the country's energy landscape. These models are particularly relevant given the

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challenges of rural electrification, affordability, and the need to attract private investment. By leveraging new approaches, Mozambique can accelerate clean energy adoption while creating sustainable market opportunities.

Key emerging models include:

a) Pay-as-you-go (PAYG) Solar Systems for Rural Households

PAYG models allow households to access solar energy without large upfront costs, paying in small installments via mobile money. This approach improves affordability, expands access in underserved rural areas, and reduces reliance on traditional biomass.

b) Mini-Grid Development Models

Privately operated or cooperative-led mini-grids can deliver reliable electricity to communities beyond the reach of the national grid. These systems encourage local ownership, foster community participation, and provide scalable solutions for rural electrification.

c) Energy-as-a-Service (EaaS) for Commercial and Industrial Users

EaaS models shift the burden of capital investment from businesses to service providers, who install and manage renewable systems while charging users for energy consumed. This reduces financial risk for enterprises and promotes adoption of clean technologies in industry.

d) Hybrid Systems Combining Solar, Storage, and Diesel Backup

Hybrid solutions enhance reliability by integrating solar PV with battery storage and diesel generators. They are particularly valuable for remote areas and critical facilities, ensuring continuous power supply while reducing fuel consumption and emissions.

e) Development of Carbon Credit Markets

Linking renewable energy projects to carbon credit schemes creates additional revenue streams by monetizing emissions reductions. This can attract international investors, strengthen climate finance flows, and position Mozambique within global carbon markets.

7.4 Key Lessons Learned from the European Union's Experience in Accelerating the Energy Transition in Africa

Throughout its energy transition, the European Union (EU) has developed a set of policies, governance mechanisms, and regulatory instruments whose experience can inspire African countries in overcoming the political, regulatory, and institutional obstacles hindering their energy transition. While these lessons cannot be uniformly transposed, adapting them to African national and regional realities can help strengthen the effectiveness of public policies. The five key lessons are presented below.

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e. *Establish a Stable and Predictable Regulatory Framework*

One of the main factors contributing to the success of the European energy transition has been the establishment of a stable, coherent, and predictable regulatory framework. The adoption of long-term objectives, enshrined in legislative and strategic texts, has strengthened investor confidence, reduced uncertainties related to regulatory changes, and created an environment conducive to the development of renewable energy.

f. *Strengthen institutional coordination and multi-stakeholder governance*

- Improve coordination between the ministries of energy, finance, environment, and industry.
- Involve local authorities in energy planning.
- Develop permanent consultation platforms with the private sector and technical partners.

g. *Create attractive financing mechanisms and reduce investment risk*

- Develop public-private partnerships.
- Mobilize international climate funds.
- Establish guarantee mechanisms to reduce the risk perceived by investors.
- Encourage green bonds and sustainable finance.

h. *Modernize electricity grids and invest in flexibility*

- Invest in smart grids.
- Develop energy storage (batteries, pumped hydro storage, hydrogen).
- Expand the use of smart meters.
- Strengthen regional interconnections between African countries to improve security of supply.

i. *Make the energy transition a driver of socio-economic development*

- Develop local skills in renewable energy professions.
- Support innovative SMEs and start-ups.
- Promote universal access to clean and affordable energy.
- Ensure that transition policies contribute to reducing energy poverty and achieving sustainable development goals.

8. Policy labs

The Policy Labs represent a cornerstone of EMERGE's stakeholder engagement and co-validation strategy, serving as the primary mechanism for translating technical modelling outputs into actionable, context-specific policy recommendations. Building on the participatory methodologies established in WP1 (D1.1, D1.2) and the stakeholder networks developed through WP4 and WP5 activities, the Policy

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Labs bring together diverse actors, including policymakers, regulators, utilities, private sector, academia, and civil society, to test, refine, and validate the policy proposals derived from EMERGE modelling exercises. The Labs are designed not as one-way presentations but as interactive dialogue spaces where stakeholders assess the feasibility, relevance, and potential impact of proposed measures, ensuring that the resulting recommendations are evidence-based, locally grounded, and aligned with both national priorities and AU-EU cooperation frameworks.

The Policy Labs also serve a critical function within EMERGE's exploitation and innovation management strategy (D6.2), directly contributing to the validation and refinement of Key Exploitable Results (KERs), particularly KER 5 (Steering policy recommendations) and KER 6 (Action plans for EMERGE cases and replication cases). By incorporating stakeholder feedback on implementation barriers, financing needs, institutional capacity, and social acceptance, the Labs ensure that EMERGE's policy recommendations and action plans are not only technically robust but also practically feasible and socially inclusive, in line with the project's commitment to the "Leave No One Behind" principles (D6.2).

The selection of tools that was presented in the Policy Labs (GREENADVISE and CEPIA), was guided by the level of interest expressed by local stakeholders during previous workshops and engagement activities (WP5, WP4), ensuring that the evaluation concentrated on the most relevant and impactful tools for each pilot region. The following table provides an overview of the three Policy Labs conducted across the EMERGE pilot regions:

Table 25: The three Policy Labs conducted across the EMERGE pilot regions

Event	Location and date	Host	Format	Stakeholder Groups
1st Policy Lab	Maputo, MZ 03/06/2026	UEM	Hybrid	government institutions such as Ministry of Mineral Resources and Energy (MIREME), Energy Fund (FUNAE), representatives of private sector, civil society, academia including doctorate students, and development partners including the German Agency for International Cooperation (GIZ),
2nd Policy Lab	Oujda, MA 24-25/06/26	UMP	Onsite	National Office of Electricity and Drinking Water (ONEE), Eastern Regional Multiservices Company (SRM), The Municipality of Oujda, GLEIN Company (Private Sector), Teacher-researchers, PhD students , African Partners from Mozambique - UEM, Cape Verde - ECREEE, Nigeria - Afrilabs
3rd Policy Lab	July 30, 2026	ECREEE	Presential and Virtual	Ministry of Energy, National Directorate of Energy (DNE), Energy du Mali (EDM), ECREEE staff, ECOWAS interns, Ecole National d'Ingenieurs

8.1 Purpose

The series of Policy Labs serves as interactive spaces for dialogue, testing, and validating policy recommendations tailored to the three EMERGE pilot sites (Morocco, Mali, Mozambique). Their purpose is to:

- Translate technical insights and data into actionable policy recommendations.
- Assess the feasibility, applicability, and acceptance of proposed measures.

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- Foster AU–EU knowledge exchange and strengthen cooperation on clean energy transition.
- Build a bottom-up roadmap that reflects local realities while contributing to regional and continental strategies.

8.2 Objectives

- Co-develop policy and market recommendations with stakeholders.
- Identify and validate enabling frameworks for energy transition.
- Ensure recommendations are feasible, inclusive, and aligned with AU–EU priorities.
- Provide inputs into EMERGE's final Clean Energy Transition Roadmap.

8.3 Methodology

In the three pilot sites (Morocco, Mali, and Mozambique), the public policy workshops adopted an interactive approach, following EMERGE's participatory design methods:

a) Analysis of data from the EMERGE toolbox and pilot case studies.
b) Interactive discussions where participants debated feasibility
c) Collaborative improvement to adjust recommendations, explore alternative scenarios, and propose new measures.
d) Validation and prioritization: Evaluation of the most relevant and feasible recommendations using a group exercise on Mentimeter.

The Policy Labs built directly on the co-design workshops and modelling activities previously conducted within the project (D5.2, M9), ensuring that stakeholder feedback was grounded in technical evidence and continuous engagement.

8.4 Policy Labs in Morocco

the policy Lab was held on June 24, 2026. UMP presented a set of policy recommendations derived from the modelling exercise. Participants subsequently took part in an interactive validation session using Mentimeter, enabling them to assess the proposed recommendations and identify priority actions through real-time voting. All recommendations were evaluated according to the feasibility criterion. On a 5-point scale: very low, low, moderate, high, very high. Also A ranking exercise where participants prioritized the recommendations, from most urgent and feasible to least urgent and feasible. A survey on short-term versus long-term priorities. A quick question in the form of a word cloud: "Main obstacle to implementation" (for each recommendation).The policy recommendations were grouped into four thematic areas:

8.4.1 Survey Results

The results of the survey presented by Mentimeter are given in the table 26:

Table 26: The results of the survey presented by Mentimeter -Moroco

a : Regulation and Governance

Theme 1. Regulation and Governance					
Recommendation	Very high	High	Medium	Low	Very low
Strengthen the regulatory framework to facilitate the integration of renewable energy and energy storage	5	18	8	1	0

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Simplify and accelerate the authorization procedures for energy projects	10	12	7	2	0
Strengthen coordination between ministries, regulators, network operators and local authorities	7	10	11	1	0
Develop technical standards for smart grids, electric vehicles and storage systems	7	13	6	0	4
Promote transparency of energy data and access to information for investors	7	3	13	2	4

b : Investment and Market Incentives

Theme 2 : Investment and Market Incentives					
Recommendation	Very high	High	Medium	Low	Very low
Implement innovative financing mechanisms (green bonds, climate funds, public-private partnerships)	4	14	10	2	2
Introduce tax incentives for renewable energy and energy efficiency projects	4	11	11	3	3
Gradually reduce fossil fuel subsidies while protecting vulnerable populations	4	10	11	5	4
Develop carbon markets and green certification mechanisms	10	12	7	1	0
Supporting research, innovation and start-ups in the fields of energy and artificial intelligence	13	13	4	0	0

c : Access to energy and inclusion

Theme 3. Access to energy and inclusion					
Recommendation	Very high	High	Medium	Low	Very low
Implement social pricing programs for low-income households	5	2	12	5	4
Encourage mini-grids powered by renewable energy	7	17	4	2	4
Deploying off-grid solutions in isolated rural areas	12	9	10	1	1
Supporting productive uses of energy in agriculture, crafts and SMEs	5	13	11	0	3
Develop training programs and strengthen local skills	10	13	5	2	2

-d : Grid integration and decentralized energy

Theme 4. Grid integration and decentralized energy					
Recommendation	Very high	High	Medium	Low	Very low
Modernizing electrical networks through smart grid technologies	8	12	8	0	3
Develop storage systems (batteries, pumped hydro storage, green hydrogen)	11	17	3	0	2

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Generalize smart meters and demand management systems	9	17	4	0	3
Develop microgrids and minigrids in remote areas	10	3	13	1	5
Strengthen transport and distribution capacities to accommodate more renewable energy	6	15	8	2	1

8.4.2 Key takeaways

- Strong consensus on the importance of strengthening the regulatory framework (High/Very High: 23 responses) and simplifying authorization procedures (High/Very High: 22 responses).
- High prioritization of research and innovation support (Very High/High: 26 responses), reflecting stakeholder recognition of the need for local technological development.
- Grid integration and storage emerged as a critical priority, with 28 respondents rating storage systems as High/Very High priority.
- Social inclusion measures received mixed feasibility ratings, with social pricing programs perceived as more challenging to implement (Medium: 12 responses) compared to off-grid solutions (Very High/High: 21 responses).
- Stakeholders emphasized that implementation barriers, particularly financing, institutional coordination, and technical capacity, must be addressed alongside policy development.

8.5 Policy Labs in Mali

The Policy Lab in Mali was held on 30 July 2026**,** from 09:00 to 12:00 GMT, in a hybrid format**,** with participants from the National Directorate of Energy (DNE) attending in person and other stakeholders joining online. The event brought together 22 participants representing government institutions, academia, and other relevant stakeholders.

During the workshop, the EMERGE project and its tools, CEPIA and GreenAdvice, were presented alongside an overview of Mali's energy sector delivered by the National Directorate of Energy. Participants were then introduced to a set of policy recommendations developed through the EMERGE modelling exercise. An interactive validation session was conducted using Mentimeter, allowing stakeholders to evaluate the proposed recommendations and provide feedback through real-time voting and discussion. The recommendations were assessed according to their **feasibility** using a three-level scale (high, medium, and low). Participants also completed a ranking exercise to identify the five most relevant policy recommendations for Mali**,** followed by discussions to collect additional stakeholder feedback on the main challenges to the country's energy transition, opportunities for renewable energy deployment, and the expected impact of the proposed measures.

The interactive session provided valuable insights for validating the EMERGE policy recommendations and ensuring that the Clean Energy Transition Roadmap for Mali reflects national priorities and stakeholder perspectives.

8.5.1 Survey Results

The results of the survey presented by Mentimeter are presented in Table 27:

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Table 27: The results of the survey presented by Mentimeter – Mali

A. Policy Regulation and Governance

Recommendations	Very high	High	Medium	low	Very low
A1: Strengthen the regulatory framework to facilitate the integration of renewable energy.	8	2	4	0	0
A.2. The existence of a clear legal and regulatory framework for the energy sector plays a fundamental role in strengthening investor confidence to attract private sector operators.	6	6	2	2	1
An adequate coordination policy and information sharing between government agencies, the private sector and civil society.	5	8	3	1	0
A.3. Capacity Building and Local Content Development policies.	9	2	6	0	0
A.4. Decentralization, through the Government's desire to make Territorial Communities responsible for managing the socio-economic development of their respective territorial districts	0	2	10	4	1
A.5. Integration of Gender into energy planning processes	8	2	2	3	1

B. Financing and investment mechanisms

B1. Setting up innovative financing mechanisms (green bond, climate fund and public-private partnerships).	12	3	1	0	0
B2. Introducing tax incentives for renewable energy and energy efficiency projects	11	4	2	0	0
B3. Strengthening the security of hydrocarbon supply	12	2	3	0	0
B4. Competitiveness, where the aim is to make the price of energy accessible to the greatest number of consumers, while preserving a reasonable profitability threshold for energy service providers, and;	8	3	6	1	0
B5. Supporting research, innovation and start-ups in the fields of energy and artificial intelligence.	15	1	1	1	0
C. Access to Energy					
C1. Access to Energy: Setting up social tariff programmes for low-income households	5	5	2	4	2

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Acees to Energy: Accelerating the pace of electrification	12	4	1	0	0
C2. Increasing the share of renewable energies in the energy mix through the promotion of domestic energy resources	11	7	0	0	0
C3. Access to Energy: Implementation of off-grid solutions in remote rural areas.	12	5	0	0	0
C4. Develop training programs	10	6	1	0	0
D. GRID INTEGRATION					
D1. Modernizing power grids with smart grid technologies	10	5	1	1	0
Scaling up the use of smart meters and demand-side management systems	14	4	0	0	0
D2. Strengthen transmission and distribution capacities to be able to integrate more renewable energy.	15	3	0	0	0
D3. Strengthening regional energy integration	6	9	3	0	0

8.5.2 Key Takeaways

- **Financing and innovation received the strongest support**, particularly research and innovation in energy and AI (**16 Very High/High responses**), innovative financing mechanisms (**15**), and tax incentives for renewable energy (**15**).
- **Grid modernization and renewable energy integration emerged as key priorities**, with transmission and distribution strengthening (**18 Very High/High responses**), smart meters (**18**), and increasing the share of renewable energy in the energy mix (**18**) receiving the highest ratings.
- **Expanding energy access was strongly supported**, especially accelerating electrification (**16 Very High/High responses**) and deploying off-grid solutions in rural areas (**17**).
- **Regulatory and governance measures were generally rated positively**, while decentralization received the lowest feasibility ratings (**10 Medium responses**), indicating implementation challenges.
- **Social measures received more mixed assessments**, with social tariff programmes for low-income households receiving the lowest level of support (**10 Very High/High vs. 8 Medium/Low/Very Low responses**).

Stakeholders identified grid modernization, renewable energy integration, and expanding energy access as the highest priorities for Mali's clean energy transition. In contrast, regulatory reforms, social pricing programmes, and decentralization received more mixed assessments, suggesting that these areas require further policy refinement and stakeholder engagement.

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8.6 Policy Labs Mozambique

The Mozambique Policy Lab was held on 10 June 2026, from 08:00 to 12:00, at Universidade Eduardo Mondlane (UEM) in Maputo, Mozambique. The event was attended by 23 participants, who joined both in person and online. The objective was to validate policy recommendations developed within the EMERGE project and collect stakeholder feedback to support the development of the Clean Energy Transition Roadmap for Mozambique. The workshop also included presentations on the current status of Mozambique's energy sector, demonstrations of the CEPIA and GreenAdvise tools, and an interactive policy validation session that enabled participants to directly evaluate the proposed policy recommendations. Stakeholder feedback was collected through **Mentimeter surveys**, focusing on:

- Key challenges facing Mozambique's energy transition;
- Renewable energy opportunities; and
- The feasibility and expected impact of the proposed EMERGE policy recommendations.

The feedback collected provided valuable insights for validating the EMERGE policy recommendations and refining the Clean Energy Transition Roadmap, ensuring that it reflects stakeholder priorities and Mozambique's specific needs.

8.6.1 Survey Results

The main challenges of Mozambique's energy transition are given in the table 27.

Table 28: Challenges of Mozambique's energy transition

Challenges	Stakeholder Assessment	Implication
Financing constraints	Ranked as the most significant challenge (6 responses), compared with Infrastructure (3), Skills (3), and Climate Vulnerability (1).	Greater access to climate finance, blended finance mechanisms, risk mitigation instruments, and private investment is needed to accelerate the energy transition. These findings reinforce previous EMERGE analyses, highlighting financing as a prerequisite for achieving Mozambique's clean energy objectives.

Barriers

Category	Stakeholder Assessment
Institutional	Fragmented governance (7), Weak coordination (6), Others (1)
Financial	Limited access to finance (8), High perceived investment risk (6)
Technical	Infrastructure gaps (7), Skills shortages (6)
Social	Limited awareness (11), Social acceptance challenges (1)

Stakeholders identified limited public awareness as the most significant social barrier, indicating that communication, education, and stakeholder engagement should accompany technical and financial measures to support the clean energy transition.

Table 29 : Renewable Energy Opportunities

Renewable Energy	Stakeholder Perception	Interpretation

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Solar energy	Highest-ranked opportunity (11 responses), compared with Hydropower (2) and Wind Energy (0).	Solar energy is considered the cornerstone of Mozambique's future renewable energy strategy due to its abundant solar resources, declining technology costs, and its strong potential to expand electricity access, particularly in rural and underserved areas.

Table 30 : Evaluation of EMERGE Policy Recommendations

Challenge	Recommendation	Stakeholder Assessment
Fragmented governance limits coordination and implementation.	1. Establish an inter-ministerial Energy Transition Coordination Platform. Expected benefit: • Better coordination • Faster implementation • Increased investor confidence	**Feasibility** was assessed as mostly moderate to very high. **The expected impact** was considered predominantly high to very high, although institutional strengthening was recognised as relatively more challenging to implement due to governance complexities and coordination requirements.
Investment requirements exceed available public resources.	2. Develop blended finance mechanisms and establish a National Green Energy Investment Facility.	**Feasibility** was assessed as mostly high to very high. This recommendation received the strongest feasibility assessment among all policy recommendations, reflecting stakeholder confidence in financing mechanisms as a practical intervention. **The Expected Impact** of this recommendation, mostly moderate, high to very high.
Skills shortages	3. Develop national programmes for technical, institutional and financial capacity development. Focus areas: • Energy planning • Climate finance • Renewable energy • Research and innovation	**Feasibility** was assessed as mostly moderate to very high, while the expected impact was considered high to very high. **The expected Impact** of this recommendation, was assessed high to very high impact by the majority
Infrastructure Development	4. Accelerate grid modernization, mini-grids, storage and smart-grid deployment. Expected benefits: • Improved reliability • Universal access • Increased renewable integration	**Feasibility** was assessed as mostly high to very high. Infrastructure Development received the highest overall **expected impact** ratings, highlighting its importance for renewable energy integration and improved electricity access.
Social Inclusion and Just Energy Transition	5. Ensure equitable access, gender inclusion and community participation.	**Feasibility** was assessed as mostly moderate to very high, while **expected impact** was considered moderate to very high.

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	Expected benefits: • Improved social acceptance • Job creation • Reduced inequalities	Participants recognised its importance but also acknowledged implementation challenges related to awareness, affordability, and stakeholder engagement.

8.6.2 Key takeaways

- Mobilising financing emerged as the primary priority, with stakeholders emphasising the need for blended finance, climate funds, risk mitigation mechanisms, and stronger engagement with domestic and international investors.
- Solar energy is perceived as the cornerstone of Mozambique's future renewable energy strategy, consistent with the country's abundant solar resources and potential to expand electricity access.
- Infrastructure development received the highest overall impact assessment, highlighting its critical role in enabling renewable energy integration and universal electricity access.
- Capacity building is strongly supported, particularly for strengthening technical expertise, energy planning, climate finance, renewable energy technologies, and energy system modelling.
- Institutional strengthening is recognised as essential for long-term success but is perceived as comparatively more challenging due to governance and coordination complexities.
- Stakeholders identified three strategic priorities for Mozambique's energy transition: mobilising investment, strengthening infrastructure, and building human and institutional capacity.
- Broad stakeholder alignment with the EMERGE policy recommendations supports a renewable energy-based transition pathway.
- Future engagement should broaden participation to include government agencies, regulators, utilities, civil society organisations, and local communities to ensure more balanced stakeholder representation and strengthen future policy dialogues.

8.7 Cross-Cutting Insights

Comparing the Policy Lab results across the three pilot sites reveals several common themes and regional specificities:

Common Challenges Identified

- **Financing constraints** emerged as a cross-cutting challenge across all three pilot sites, although with different levels of emphasis. Mozambique stakeholders identified limited access to finance and high investment risks as the main barriers, while Mali and Morocco strongly supported innovative financing mechanisms, green finance instruments, and public-private partnerships as key enablers for accelerating the energy transition.

- **Infrastructure limitations and grid integration** challenges were consistently identified as major technical barriers. Stakeholders across the three sites highlighted the need to strengthen transmission and distribution networks, modernize grids, deploy smart meters, and expand renewable energy integration capacity.

- **Capacity building and skills development** were recognized as essential enabling factors across all pilot regions. Stakeholders emphasized the importance of strengthening technical expertise, energy planning capacities, research and innovation, and local skills development to support the implementation of energy transition strategies.

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- **Institutional coordination and governance improvements** remain important priorities across the three contexts. While Morocco focused mainly on regulatory alignment and coordination between energy actors, Mozambique highlighted fragmented governance and coordination challenges, and Mali emphasized the need for stronger regulatory frameworks and stakeholder coordination.

Divergent Priorities

- Morocco, as the most advanced energy transition context among the three pilots, placed stronger emphasis on managing increasing renewable energy penetration through grid modernization, energy storage, smart grid technologies, and improved regulatory frameworks. Stakeholders also highlighted the importance of research, innovation, and technological development to support future system transformation.

- Mozambique's priorities reflect the need to accelerate investment mobilisation and expand energy access. Stakeholders identified financing mechanisms, infrastructure development, solar energy deployment, and capacity building as key pillars for the country's renewable energy pathway, while recognising institutional strengthening as a necessary but more challenging area.

- Mali's priorities were strongly centred on expanding electricity access, strengthening grid infrastructure, increasing renewable energy integration, and creating enabling conditions for private sector participation. Stakeholders showed strong support for electrification acceleration, off-grid solutions, smart meters, and transmission and distribution improvements, while regulatory decentralization and social tariff measures received more mixed assessments.

Common Enabling Conditions

- Across all three pilot sites, stakeholders confirmed that stable regulatory frameworks, clear governance structures, and predictable investment conditions are essential for attracting private sector participation and accelerating renewable energy deployment.

- Technical innovation, including smart grids, energy storage, digital solutions, and improved access to energy data, was identified as a key factor enabling higher renewable energy integration and system flexibility.

- A strong alignment was observed between stakeholder priorities and EMERGE policy recommendations, particularly regarding financing mechanisms, renewable energy deployment, infrastructure strengthening, capacity development, and inclusive energy transition pathways

- Stakeholder engagement and participatory approaches were validated as valuable mechanisms for ensuring that policy recommendations reflect local realities, increase ownership, and support the development of context-specific Clean Energy Transition Roadmaps.

Overall, the Policy Labs demonstrate that while the three pilot regions share common transition challenges, their priorities reflect different stages of energy system development. Morocco focuses on integrating higher shares of renewable energy into an evolving power system, Mozambique on enabling investment and expanding access, and Mali on strengthening infrastructure and accelerating electrification. These differences highlight the importance of tailored transition pathways while maintaining common enabling conditions, including financing, capacity building, governance, and stakeholder-driven policy design.

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9. Conclusion

The deliverable D4.2 represents a key milestone in the EMERGE project, offering a consistent set of strategic, regulatory, and market recommendations aimed at accelerating the energy transition in the project's pilot sites: Morocco, Mali, and Mozambique. Based on in-depth analyses of existing institutional frameworks, technical, economic, and social barriers, and simulations conducted using EMERGE tools, this document provides an integrated and forward-looking perspective on possible pathways for decarbonizing energy systems.

The scenarios developed using GREENADVICE and CEPIA tools have made it possible to assess the impact of different energy policies on final energy consumption, greenhouse gas emissions, investment needs, and security of supply in the medium and long term. These analyses clearly demonstrate that ambitious policies combining electrification of energy uses, large-scale deployment of renewable energies, improved energy efficiency, and the integration of storage solutions are essential to achieving climate goals while supporting economic development.

Based on these findings, this deliverable offers recommendations tailored to the national and regional contexts of the pilot sites, covering institutional strengthening, the evolution of regulatory frameworks, the mobilization of financing, skills development, and the adoption of new economic models. The introduction of innovative mechanisms such as regulatory sandboxes, energy communities, self-consumption with storage, and green hydrogen value chains appears to be a key lever for fostering innovation and the adoption of clean technologies.

Finally, the Policy Labs played a central role in validating and refining the recommendations, ensuring their relevance, feasibility, and acceptability to local stakeholders. Thus, deliverable D4.2 contributes not only to the formulation of data-driven and robust model-based public policies, but also to the creation of a framework conducive to replicating EMERGE solutions in other African regions.

This document reinforces the added value of the EMERGE project by providing concrete guidance for a just, inclusive, and sustainable energy transition, and serves as a strategic reference for policymakers, investors, and all stakeholders involved in the development of clean energy systems in Africa.

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